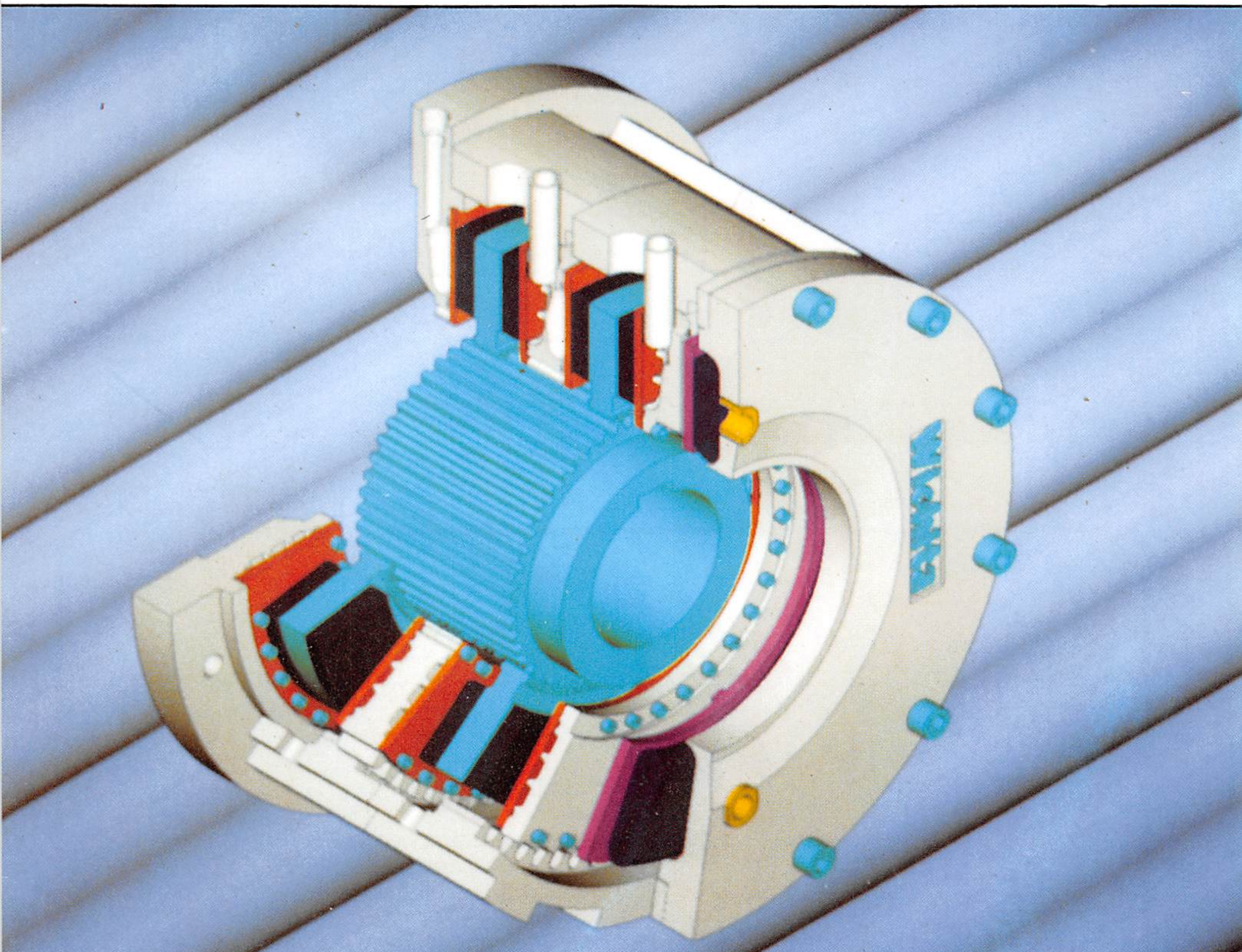
The Agricultural Engineer

Incorporating **Soil** and water

Volume 46 Number 4 Winter 1991



Machinery for organic production

AE 46 (4)

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Front cover: Sectional view of a Wichita Kopper water-cooled brake used on the Silsoe axle dynomometer (see page 130).

Journal and Proceedings

Contents

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The Institution of Agricultural Engineers

Economic factors influencing the agricultural environment

Part 2: Policy pressures and possible solutions

In Part 1 of his paper,* published in our last issue, D R Harvey presented an analysis of the economic forces affecting agriculture and their influence on farm and environment policies. In this issue he concludes with an examination of the possible responses to the policy pressures.

Since 1986, the current round of GATT (General Agreement on Tariffs and Trade) negotiations have been under way, with a major objective of reducing 'trade-distorting' support of agriculture around the world. The principle of a substantial reduction if not elimination of this support is broadly accepted, but the practical implications are still to be worked out. These negotiations now constitute a major pressure on the CAP. This is added to by the probability that newly liberalised Eastern European countries will seek membership of the EC, and any associated agricultural policy. It is impossible to accept major agricultural exporters into the CAP as presently constituted (Hungary exports about ⅓ of its agricultural production), so major reform prior to accepting these new members is also required.

Farm policy negotiators in the GATT have continued to argue over the appropriate measures to reform domestic agricultural policies and, thus, improve world markets for farm products. The accepted measure of agricultural protection is the 'Producer Subsidy Equivalent' or PSE, lately calculated in considerable detail by the OECD. Essentially this measure translates the spending by consumers and taxpayers to support farming into a percentage of the total value of farm output.

There are a number of more or less sophisticated adjustments to the calculations which need not concern us here. The point is that PSE measures have become a central focus of the GATT negotiations, as a reflection of the extent of protection around the world and as a possible target for negotiated reduction during the current GATT round. Although much of the negotiations is concerned with the necessary adjustments to an 'all-encompassing' PSE to reflect the trade-distorting effects of farm support, it is accepted that the PSE is a reasonable measure of the support to farming.

However, the following figures suggest otherwise.

Farming gets only small part of support expenditure – majority is 'wasted' in offsetting policy effects

Fig 10 shows the results of the present simple model of the CAP for the OECD's PSE estimates. Here the PSE expressed as a percentage of food expenditure amounts to about 15%, almost identical to the consumer and taxpayer costs identified above. However, the PSE substantially overestimates the farming gain from the policy, which averages less than 70% of the PSE for the EC as a whole.

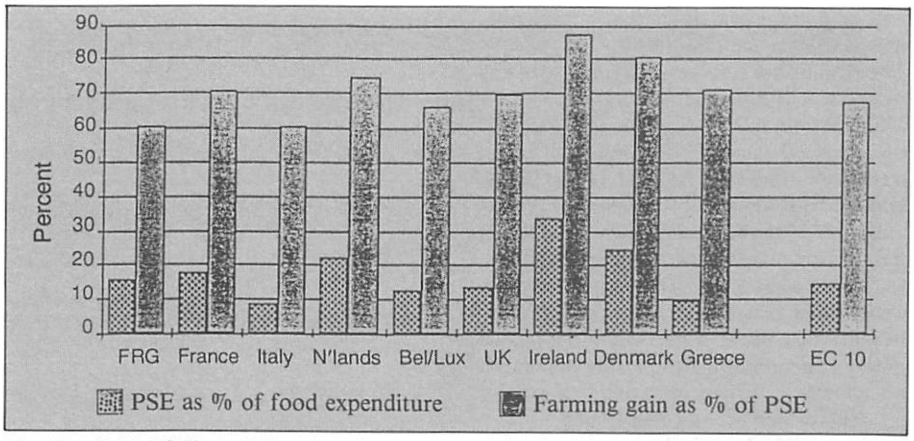

Fig 10 CAP PSE's and Farming Gains, 1986

The earlier and more detailed CAP model at Newcastle suggested that the transfer efficiency of the policy – farming gain as a percentage of PSE – was even lower, as shown in Fig 11.

In each pie diagram in Fig 11, the total pie represents the PSE, for the European Community as a whole and for the UK. The various slices represent the portions of the support pie which is wasted in one form or another before the farming industry gets its slice as 'Farming's gain' (which itself ignores the leakages to higher input costs, interest payments and depreciation before any gain winds up in farmers' business incomes).

The differences between these two sets of estimates are a result of: a) different estimates of the extent to which world prices would rise in the event of multilateral free trade; b) differences in the detail with which the policy is modelled; c) different conventions about the definition and calculation of the PSE itself[6].

In Fig 11, 'Instrument cost' refers to the spending on storage and processing necessary to support domestic prices at the farm gate but which do not otherwise benefit the farming sector, which is not modelled at all in the present simplified version of the policy. 'Resource cost' is the wastage which results from domestic market price support, which encourages greater production and denies other sectors the use of inputs and resources, and also denies consumers the benefit of lower market prices.

The majority of the wastage, however, occurs through the effects of the CAP on world markets (the 'Trade Offset') and the effects of other countries' support policies on the world market ('Policy Offset').

The Trade Offset says that one quarter

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**Paper presented to the Annual Convention of the Institution, May 1991.*

[6] Work is under way to re-develop the more detailed model so as to reconcile these different estimates, but this is likely to take some time unless additional resources can be found to assist with the work. For the present, the results can be taken as representing upper and lower bounds of likely effects of free trade.

of farm support spending simply offsets the damage CAP support does to world prices. The Policy Offset means that another quarter of the EC support bill is simply spent to offset the effects of other countries' policies. The equivalent measures from the current model for each of these effects are 12 to 16% in each case.

In the absence of these wastages, as would be the case under free trade, either our own farm sector would be better off or our consumers and taxpayers could avoid between 25 and 50% of their spending.

Price support cannot improve farm incomes ...

The history of the CAP, and of the development of the agricultural industry under its influence, demonstrate that price support cannot improve farm incomes.

All that this price support policy succeeds in doing is to raise costs of production and increase the wealth of the existing owners of the agricultural resources, particularly land and fixed capital assets.

... but reduction in present level of support would aggravate already serious economic pressures

Once locked into a system of high support prices, however, this logic raises very real problems of reducing the level of support. Such reductions will clearly damage the wealth of people in the industry, and they will resist this development. In addition, reductions in the level of support will aggravate the already serious economic pressures on the farm population, especially those with limited resources and with limited alternatives.

The options available to the Council of Agricultural Ministers to restrict either production or the level of taxpayer costs of supporting European Agriculture are highly constrained.

Although there are significant and possibly growing pressures on the policy, especially from the international and environmental perspectives, the concerns over the economic health and viability of the farm population are likely to remain paramount in the Council.

In addition, the still-embryonic political system of the European Community is characterised by significant problems: of 'free-riding'; of the shift of blame for unpopular decisions; of the avoidance of responsibility through the facade of shared responsibility; and of the monopoly over the agricultural policy by the agricultural ministers, with few of the checks and balances provided by most national government systems.

The European Summit meeting in February 1988, at least recognised the last of these problems, by insisting that CAP price fixing agreements have to be ratified by the European Finance ministers.

However, these problems seem to ensure that the development of the policy is likely to downplay, if not ignore, the genuine public interest. It may even develop pathological tendencies which damage the interests of the bulk of the farming population rather than promoting those interests.

Supply control – difficult to administer and isolates EC from world markets

Historically, the CAP has developed simply in response to 'crises', especially the budgetary cost escalation. This development has tended to lead to more supply control and quota-type mechanisms as the only politically acceptable way of resolving the conflict between budgetary pressures and the interests of the farming community.

Apart from the not inconsiderable administrative difficulties of this policy development, only the environmental and international pressures on the policy have any chance of changing this 'line of least resistance'.

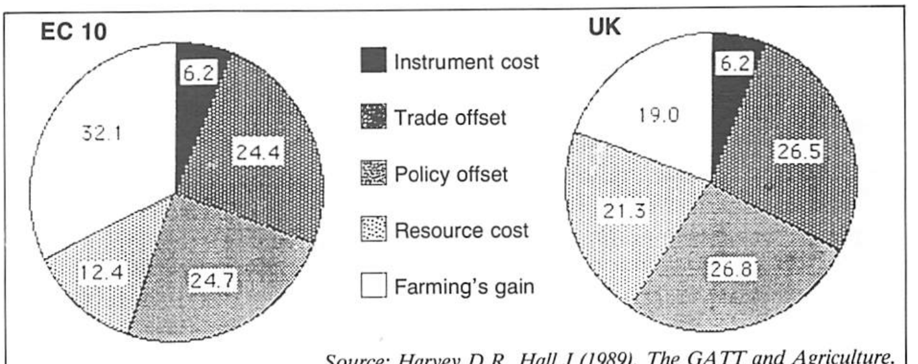
The set-aside initiative, which is currently only voluntary but proposed by Commissioner Mac Sharry in the latest Commission discussion paper as compulsory, seems a probable move towards supply control in the difficult and central cereals and oilseeds regimes.

However, the development of the CAP towards supply control isolates EC agriculture completely from world markets, against the interests of most of our trading partners and of the third world, and thus cannot be expected to receive support in the GATT negotiations. It is also inconsistent with the eventual expansion of the EC to include Eastern Europe.

Domestically, supply control amounts to central control over what farmers can produce, and in the light of increasing environmental concerns, how and where they produce it. It is difficult to imagine that such central control is technically possible, still less desirable either for the development of a healthy, prosperous and efficient industry, or for the continued maintenance and development of a diverse countryside.

An alternative system of supply control, advanced by some within the NFU, is to restrict nitrogen use. As a supply control measure, this suggestion suffers from the same disadvantages as more direct methods of controlling output, with the added problem of lack of any direct control over production levels.

Any artificial restriction on either output or input use imposes costs on the industry. 'Licences' to produce (or use inputs) will inevitably become valuable (since production will be more profitable, even only possible, with these licences). Overall costs of production will not be reduced through supply control, though those fortunate enough to be issued the licences will benefit from the value of these, offsetting the fall in value of other assets.



Source: Harvey D R, Hall J (1989). The GATT and Agriculture.

Fig 11 CAP waste for the European Community and the UK

Some environmental benefits may result from such licences, since land and other assets would be expected to decline in value, making their alternative use more attractive. However, this is critically dependent on the licences being independent of land. Otherwise, the supply control avenue promises a dichotomised industry in which those areas of land entitled to produce will continue to be farmed even more intensively, while other areas of land will be left idle, often to return to wilderness of dubious or uncertain environmental value.

PEG (Producers Entitlement Guarantee) – an alternative support system to avoid waste and fraud

There is an alternative. The estimates outlined above (Fig 11) on the efficiency of the CAP are very significant. They strongly suggest that it should be possible to support farming at its current level at three quarters to half of the current cost to consumers and taxpayers. Producers Entitlement Guarantee (PEG) is a policy suggestion which avoids this waste. The alternative combines both quotas and price cuts in Limited Support Payments. It is re-christened PEG here, since this is the title which has become accepted in some (limited) quarters on both sides of the Atlantic during subsequent development of the option in conjunction with colleagues in Cornell University[7].

[7] Lionel Hubbard (Newcastle), David Blandford and Harry de Gorter (Cornell University, USA) have also been involved in the current development of this proposal. This paper is a summary of two longer papers: The GATT and Agriculture: The Production Entitlement Guarantee (PEG) Option, DP 1/89, and PSEs, Farmers Incomes and Transfer Efficiency of the CAP and Alternatives, DP 3/89, both from the Department of Agricultural Economics & Food Marketing, University of Newcastle-upon-Tyne.

Under PEG farmers get a support payment as the difference between a PEG price and the free market price for a fixed quantity of production. Any production over and above this PEGed quantity per farm is sold on the unsupported open market at the going market price. All the other apparatus of the CAP, including the associated costs and fraud, would be eliminated. European market prices would then be world prices.

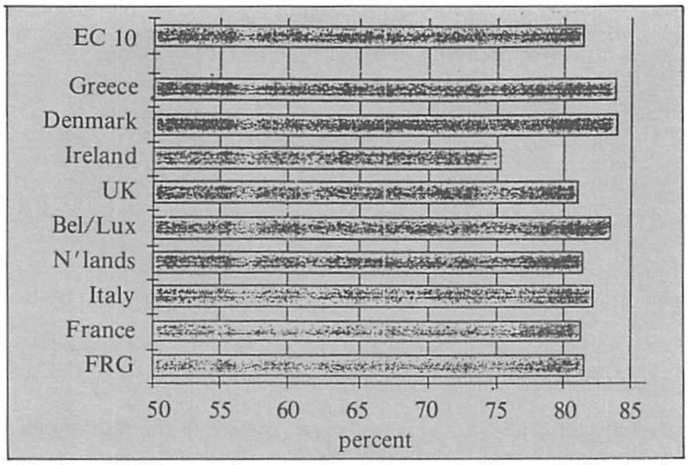


Fig 12 PEG Support limits as a percentage of 1986 production levels.

Agricultural support would be paid like the old British deficiency payment, from the exchequer as the difference between the market price and the support price for that limited quantity. This is the Producer Entitlement Guarantee – PEG – alternative, pegging support payments per farm. This can be done as part of an international agreement to eliminate farm policies which depress world prices. If this is done, world market prices will be fair prices, not the current distress selling prices. Estimates are that world prices would rise by about 15% on average, much more for milk, leaving wheat at about £85/tonne in the UK, or more with a stronger $.

The distribution of PEG limits can be used to direct public support towards people rather than products and benefit smaller producers proportionately more than larger farms, on both equity and environmental grounds. Alternatively, PEG limits could be distributed as a simple proportion of past production levels for all farms. The precise definition could be left to individual member countries to decide, in conjunction with farmers' unions and groups. PEG limits should be set nationally, like the current EC set-aside scheme, and could even be varied by region.

Fig 12 shows the proportions of current production which could be covered by such a scheme without leading to distortion of world trade or markets. These non-distorting quantities are simply defined as those quantities which would be produced in the EC under complete free trade. More than 80% of current (1986) production could be covered without distorting the free market. That could mean 80% of production for each farm, but it might be fairer to apply a uniform absolute limit per farm. Larger farmers are, after all, more efficient and should be able to compete at fair market prices, especially with a base line of support provided by the PEG.

With PEG, support cost would be higher but this more than offset by savings to consumers

The major problem with this proposal is the fact that it would lead to an increase in taxpayer costs of support if present levels of support were to be maintained for all farms.

According to present estimates the total tax cost would more than double from 17bn ecu (1986 FEOGA cost for the major products covered in this analysis) to 38bn ecu, **but** it is important to remember that the proposal **saves** the taxpayer, as a consumer, 38bn ecu, so that there is a substantial net reduction (of 15bn ecu) in the total cost of the policy even if all present agricultural benefits are to be maintained.

In fact, the present EC proposal to the GATT is that benefits (support) should be reduced by some 30% over the 1986 base. If support were to be limited to the non-distorting levels of production, the total taxpayer cost for the EC would be reduced to 32bn ecu, a reduction from the full compensation bill of 18%.

Fig 13 illustrates the extent to which existing support at the 1986 level could be maintained at 1986 FEOGA expenditure levels. It can be seen that, by concentrating support towards smaller farms, more than 80% of all EC farms could be completely protected from reductions in support levels without increasing tax costs at all. Even in the UK, given the large contribution made by the UK to the EC budget, the proportion is almost 75%. Clearly some additional budgetary transfers would be necessary in order to protect Irish and possibly also Danish agriculture.

PEG can also lead to environmental benefits

A senior economist with the NFU has complained that PEGs would do nothing to solve over-production problems or help the environment.

However, over-production is not a problem if the surplus waste competes effectively on a free and fair world market, as it would under PEG implemented through a genuine GATT agreement. Also, PEG can only help, although not solve, rural environmental problems.

The current policy encourages farm expansion and intensive production practices, to the detriment of the environment. Conversion to PEG would provide opportunities to reverse these tendencies and to combine more specific environmental policies with farm support programmes.

Wheat produced at £80/tonne simply does not buy as much chemicals and fertiliser, or pay as much rent, as it does at £110/tonne. North American production systems are ample evidence of this fact.

In addition, the capitalisation of present support levels into land and other asset values would be reduced, allowing environmental land uses to compete more effectively with agriculture. Furthermore, support targeted to people rather than tonnes offers more scope to tailor support to rural problem areas. There is still a strong case for pricing fertiliser and chemicals at their social cost rather than their (lower) private costs, and also for paying for non-productive aspects of the countryside. Neither of these is denied by the PEG scheme.

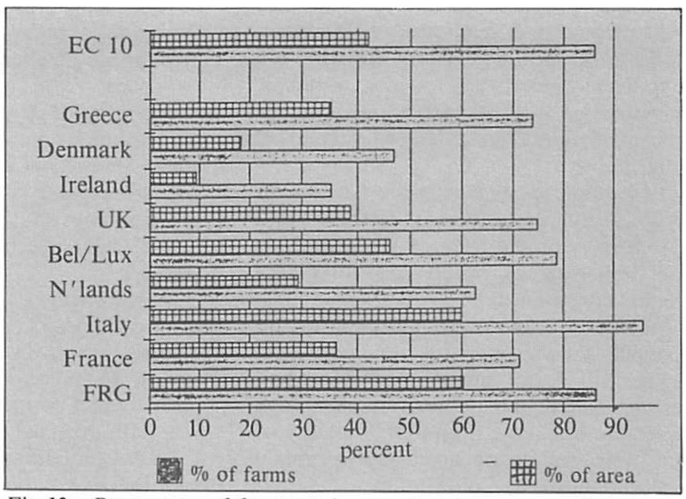


Fig 13 Percentage of farms and agricultural area covered under a PEG restricted to 1986 levels of tax expenditure on product market support.

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Harvey D R, Hall J (1989). PSEs, Producer Benefits and Transfer Efficiency of the CAP and Alternatives, *Discussion Paper DP 3/89,* Department of Agricultural Economics & Food Marketing, University of Newcastle upon Tyne.

Data logging for agricultural processing in Malawi

In Malawi the majority of tobacco barns are in remote locations and are operated continuously over 8-10 days, needing continuous data collection. S J Temple found that most general-purpose computer-based logging systems are designed for high speed logging of a few channels over a limited period. Two purpose-built systems have now been developed and they may well have applications elsewhere where many channels of data need to be collected over extended periods of time.

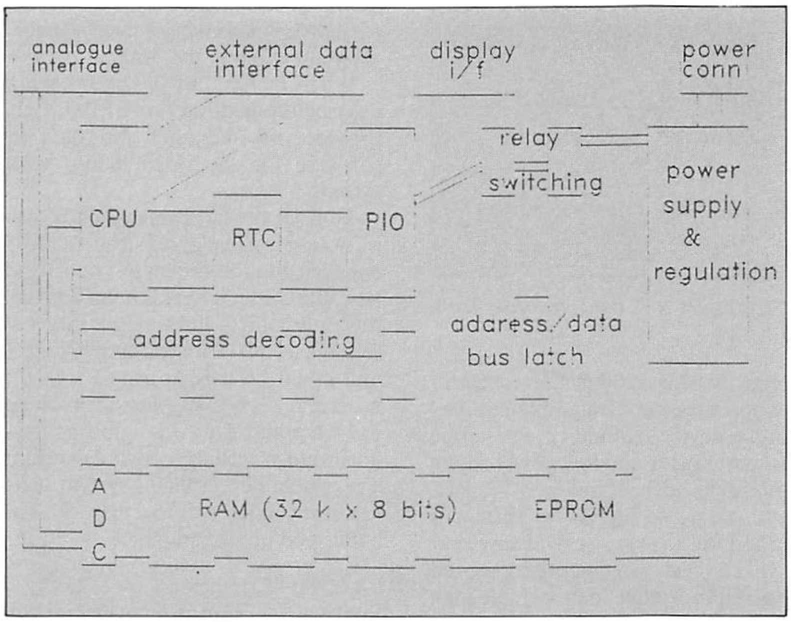

Fig 1 Schematic of data logging computer.

Malawi's major export crops of tobacco and tea are both leaf products. Despite their widely different fates, they are both processed by inducing biological changes in the leaf before a drying stage.

Careful measurement and recording essential

Throughout processing, air temperature and humidity as well as product condition are important parameters which must be monitored.

The various processing operations are highly susceptible to environmental variation, so for experimental work, where the whole environment cannot be controlled, it must at least be carefully measured and recorded. Input material is also highly variable, depending on growing conditions, crop variety, variation from one plant to another and from one small area of soil to an adjacent one where there has been a termite mound, for example.

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On top of this, the value per kilogram of produce is not high, especially when considered at the green leaf stage. This combination of factors has deterred researchers from using sophisticated instrumentation in their trials; in the commercial world only the most basic instruments (such as alcohol-in-glass thermometers) are used.

Instrumentation systems revolutionised with low cost computers

The advent of low cost digital computers in conjunction with low cost analogue to digital converters has revolutionised the cost/effectiveness of instrumentation. If low cost sensors are used, it is possible to develop systems which are affordable and useful in research and commercial environments. Systems were developed for data logging in tobacco barns and in a tea 'Manufacturing Research Facility'.

Tobacco barns

The Tobacco Industry Energy Efficiency Project, set up in 1985, aimed to reduce the amount of fuelwood used in the curing of flue-cured Virginia tobacco. To this end, a greater understanding of the processes occurring in a barn was required, and a data logging system was a major tool in the investigation.

The curing of Virginia tobacco is carried out in barns which are usually brick built. Initially the leaf is kept at around 35°C until the 'colouring' metabolic processes are complete. After this, the temperature needs to be raised quite rapidly to stop further metabolism, and to dry the leaf. Wood fuel is burnt in a furnace; the flue pipes are arranged around the floor of a barn to act as a heat exchanger.

Data logging system must run unattended, four, preferably six weeks

In Malawi the majority of tobacco barns are in remote locations, with no mains power available. They are operated continuously over 8-10 days, needing continuous data collection. Recording needs to be reliable even at 2am, as this is when the barn

Tobacco being loaded into the barns for curing. Tiers are normally made of poles fixed to the walls but these are suspended for continuous weighing.

operators are most likely to miss temperature fluctuations which reduce crop value.

Once the barn has been loaded with leaf, the points to be recorded are difficult for manual access. As it is difficult to get to a series of trial barns every week, or even every three weeks, a data logging system must be capable of running unattended and storing data for at least a month, preferably six weeks or more.

Initial requirements were for at least 16 channels of data per logger, and no commercial system was available at the time which would cope with all the constraints. A microprocessor based unit was designed, built and used. This is shown in schematic in Fig 1.

A Motorola 6805 derivative, the 146805 was selected as the processor. Low power CMOS (complementary metal oxide semiconductor) integrated circuits are used throughout, with CPU (central processor unit) sleep/wait modes to further reduce power consumption. Power is supplied by a pack of 5 rechargeable D cells, which last for 6 weeks. Data storage is on static ram – 32k allows for 6 weeks storage of hourly samples from 16 channels. An 8 bit CMOS ADC (analogue to digital converter) device was the major power consuming component in the system.

High impedance voltage level signalling from sensors was used for minimum power consumption. This tends to be susceptible to electrical noise but there is very little electrical interference in barns; the worst that was suffered was occasional processor resets through suspected lightning induced spikes, where the transducer leads acted as antennae.

Measurements of air temperature, flue gas temperature, humidity

Air temperatures up to 70°C were measured using semiconductor sensors with 10mV/C output. Flue gas temperature (up to 600°C) required thermocouples either with a semiconductor sensor for cold junction compensation or a specialised integrated circuit signal conditioning device. Humidity was sensed using low cost sensor and low power signal conditioning to give 10mv per % RH. As conditions are so highly variable, it is more important to have several low cost sensors which will give a good overall picture of the operation, rather than a single high cost, highly accurate sensor at one point only as this will be misleading.

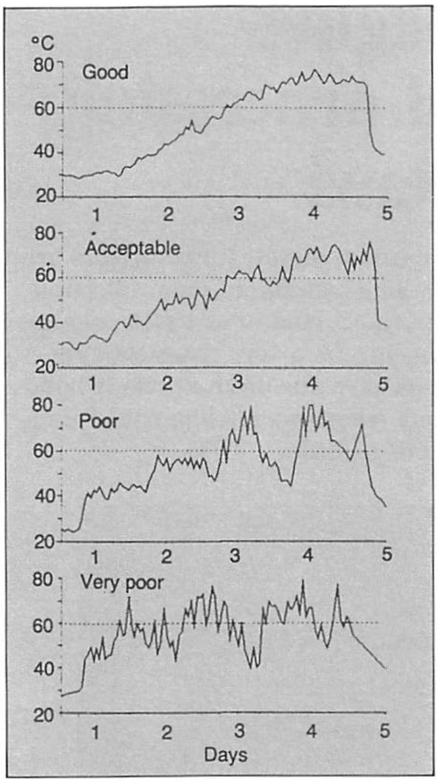


Fig 2 Examples of data records from tobacco barns.

Data were transferred from logger memory to a portable computer – initially this was a Tandy Model 100; later when the cost dropped, the PC compatible Amstrad PPC was used to get the data onto a PC compatible disk format.

A total of 32 loggers were made, and used regularly in the research program at various tobacco estates around Malawi.

The development system

Software was developed on a MS-DOS compatible PC, written in 146805 assembly language. The compiler was written in C, and produced files which could be downloaded through a serial link to a Softy ROM emulation/EPROM burner device. For testing, a lead from the Softy is connected in place of the EPROM (Erasable Programmable Read Only Memory) in the target system. The program is held in the RAM (Random Access Memory) of the Softy, but looks to the target system as its own EPROM. Small changes may be made to the program while in the Softy.

When the program has been tested, it can be programmed into an EPROM chip, to provide the operating and data logging software for the single board computer system.

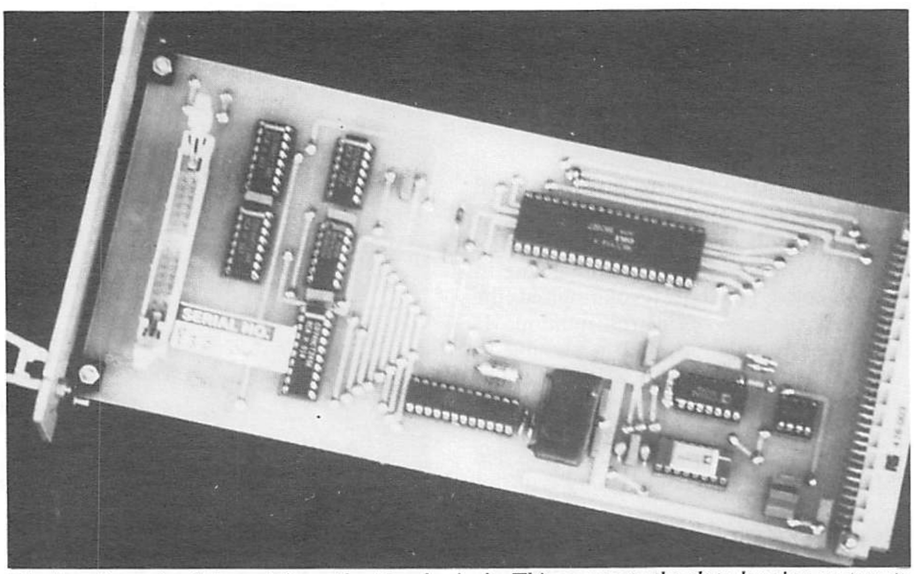
To trace the hardware result of program execution, an adapter was made which connected to the system bus of a Tandy 100 portable computer. This interfaced with the bus and control lines of the target system through a PIO (Parallel Input/Output) chip, and could be used to single step through instructions, checking the state of the system at each point. This was a powerful tool for hardware as well as software development. The whole development system used only low cost components together with standard office computer equipment.

Software – sampling every minute but recording hourly

A cross assembler running on a PC to produce 146805 code was developed in 'C'. Logging software was written on the PC in assembler. The program for downloading data from the loggers to the portable computer was written in 8085 assembler and Basic for the Tandy 100, and in C for the Amstrad PPC. The data storage format on the PC type disks is Comma Separated Value files, which can be read into spreadsheets for quick inspection and plotting of data, and is a common format for import into statistical analysis software packages.

Following a preliminary check by graphing in a spreadsheet package, the most common destination for any data considered worth showing to growers was plotted as a strip chart format, in several colours to distinguish between sensor channels. A colour ink jet printer was used for this, with software developed to plot channels in a way that demonstrated the operation of the tobacco barn most clearly. Examples of data records are illustrated in Fig 2.

Initial estimates were that events in a barn take place slowly, and sampling every hour would be sufficient to pick up the performance of the barn. Sampling at a much faster



The interface circuit board from the Numberjack. This connects the data logging system to the PC and performs analogue to digital conversion.

rate to determine optimum sampling intervals demonstrated that temperature fluctuations could happen very quickly, and that a 5 minute sampling frequency was necessary. A later version of the software sampled every minute, but recorded hourly maximum, minimum and mean values to give an indication of the temperature excursions from the desired operating point.

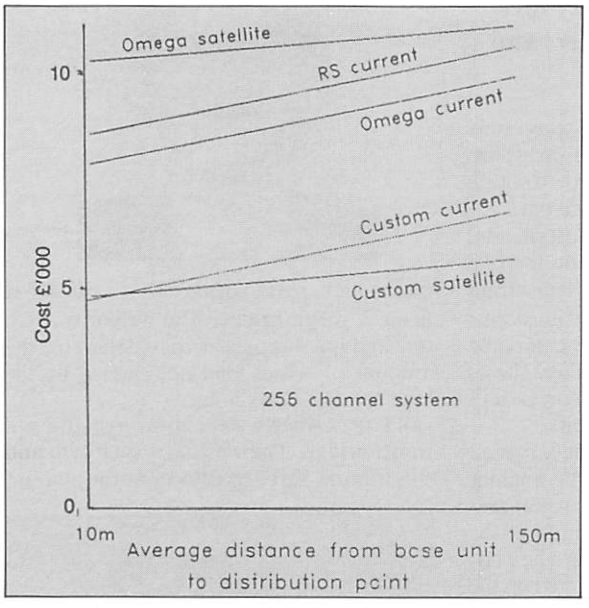


Fig 3 Cost comparison.

From the findings of the data logging system, an appropriate low-cost electronic instrument (non-microprocessor) was developed to help the grower.

Tea manufacture

The Tea Research Foundation (Central Africa) has built a Manufacturing Research Facility to investigate improvements in tea processing. To support this work, an Instrumentation Section was created with the installation of data logging equipment as its initial brief.

Tea leaf from the field is first withered for up to 18 hours, followed by maceration (chopping into fine particles), fermentation for up to an hour and drying which takes around 20 minutes.

Withering of leaf is a batch process, but the maceration, fermentation and drying stages which follow are normally continuous flow processes. The heat source for drying, usually a steam boiler, also needs its performance monitoring.

The process takes place in a factory building, with mains electric power available, allowing for the use of more computer power. Backup power is still required to carry the data logging system through fluctuations and brief power outages; 30 minutes backup is sufficient to enable standby power generation to be brought on line. If the power outage is for longer, the experimental run will be invalid anyway, so there is no purpose in providing for a longer backup period.

Basic features required of the data logging system

To cope with the data collection requirements, a total of 256 channels per system was designed for. Above this, the backup power requirements for the signal conditioning power became excessive. It is important that all sensors concerned with a process line are sampled together, and recorded together, to facilitate correlations and comparisons during the data analysis. The presence of electrical machinery in the factory means that there will be electrical noise, so high impedance voltage based sensor signalling is not possible. As a major part of system cost is cabling, this needs to be considered when choosing a signal transmission system.

New system needed to meet the specification

Commercial data logging systems were considered, as the higher cost might have been compensated by the shorter development time. However, there were none that would fulfil the specification within budget so a new design was required.

As cabling costs for the large number of sensors form a major part of the costs, initial plans were for a series of small, single board computers distributed around the process plant as satellites, each gathering data and relaying it to a central PC.

Fig 3 illustrates the differences in cost between commercial systems from RS Components and Omega, and custom-built systems for both current-loop signalling and satellite-logger configurations. The x-axis shows the increasing cost for greater distances between the base unit and the satellite or data distribution box.

From Fig 3 it can also be seen that the estimated cost of a custom configuration using central analogue to digital conversion, with sensor signals being transmitted from source to the central data logger, was not much more than a satellite system. Development time for the satellite system would be significantly greater so the final choice was for a central PC based data logging unit, receiving signals from sensors over 4-20mA loop. Sensor signal conditioning is powered through the loop, allowing all power supplies to be concentrated in the logger base unit.

The PC compatible chosen for the system was an Amstrad PPC, which provides a complete twin floppy disk system with screen and keyboard, the capability of being powered by backup battery and the expansion bus available through two D sockets. This is a very low cost system, and at the time of planning, was the best way of obtaining two 3.5" disk drive units together with power supplies and interfaces.

A self-contained portable unit – the 'Numberjack'

The Amstrad case was discarded, and the components of the PPC are housed in a metal case together with a card frame carrying the analogue to digital sub-system and the analogue inputs and multiplexers. This then forms a self-contained portable unit, named a 'Numberjack'. This is illustrated in Fig 4.

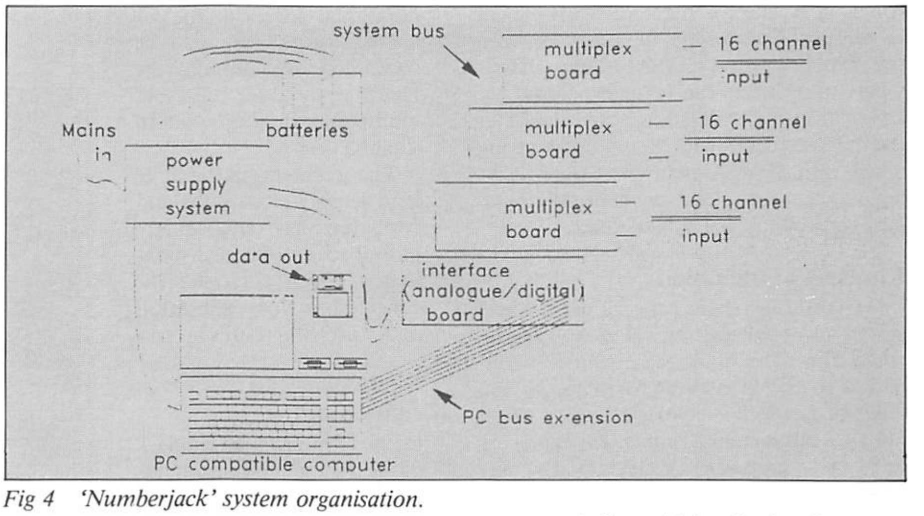


Fig 4 'Numberjack' system organisation.

The development system

Software was written using Turbo assembler and Turbo C on a desktop PC, connected by serial link to logger base unit. This allows for program development on a fast, hard disk machine, with testing on the target system complete with logging hardware. To trace or debug the software, the user screen shows on the target machine, while the source code, machine instructions and other information can be observed on the development system.

System offers background logging with facility for viewing and printing

Logging of data takes place in the back-

concluded at foot of page 130

A tractor wheel torque and weight transducer

C D Watt describes* the construction, instrumentation and calibration of a transducer that measures the torque and forces on a tractor wheel. The torque transmitted to a tractor wheel, the vertical load on the wheel and the horizontal thrust are measured using three force transducers and a position transducer.

It is relatively easy to design a transducer to measure the torque transmitted to a wheel (Anderson, Rowe, Spencer, 1974; Shropsire, Woerman, (Bashford, 1983). The main problem is in transmitting the torque signal from the revolving wheel to the tractor chassis.

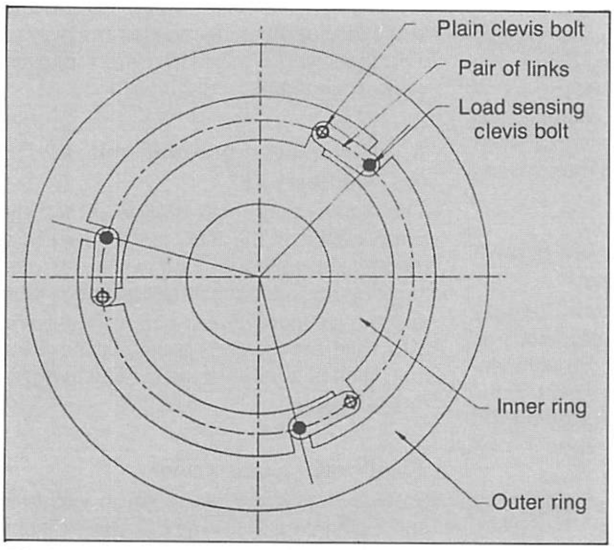


Fig 1 Schematic layout.

To measure the vertical and horizontal forces at a wheel is more difficult. There is no easily accessible interface between the revolving wheel and the tractor chassis where transducers can be incorporated.

The transducer described here combines the measurement of forces on the revolving wheel with the measurement of the wheel's angular position to determine the horizontal and vertical components of force.

Principle of operation

The transducer replaces the standard wheel centre and connects the wheel hub to the wheel rim. The outer ring, which is connected to the wheel rim, is joined to the inner ring, which is connected to the wheel hub, by three pairs of links. Each pair of links has a load sensing clevis bolt at one end and a plain clevis bolt at the other end. Each load sensing clevis bolt is orientated so as to measure the force being transmitted along each pair of links. The pairs of links are equi-spaced on and tangential to a circle between the rim and the hub. The three pairs of links form a mechanism that completely constrains the rim in the plane of the wheel. The side forces are resisted by low-friction pads. Fig 1 shows a schematic layout.

To calculate the vertical and horizontal forces acting between the rim and the hub the forces along the links are measured and their vertical and horizontal components are computed and summed. Fig 2 shows the measured forces and their components.

A shaft encoder is used to determine the angular position of the wheel and hence the direction of the measured forces. The shaft encoder is mounted on the mudguard above the wheel and the motion of the wheel is transmitted to it via a flexible drive. The signals from the load sensing clevis bolts pass through amplifiers that are mounted on the wheel and then through the flexible drive to slip rings which are mounted next to the shaft encoder.

As well as measuring the vertical and horizontal forces at the wheel the transmitted torque can also be computed by summing the forces in the three links and multiplying by the radius to the links.

The signals from the three load sensing clevis bolts and from the shaft encoder are passed to an onboard datalogger which performs the calculations for calibration and stores the results.

Equipment and calibration

Details are given in Table 1 of the tractor and instrumentation.

Each load sensing clevis bolt was calibrated on a specially designed test rig against a load cell. The calibration curves are shown in Fig 3.

Test procedure and data processing

With the tractor in normal trim the loads on the front and rear wheels were measured using a weigh bridge. The weight of each tyre and rim was measured to determine the amount of wheel load not carried by the load sensing clevis bolts.

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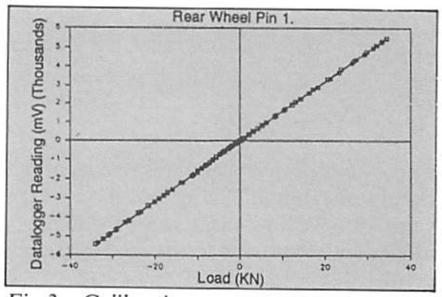

Fig 3 Calibration curve.

of wheel load not carried by the load sensing clevis bolts.

Test 1 Unloaded

The instrumented tractor was driven over a smooth level surface at low speed and the forces in the load sensing clevis bolts and

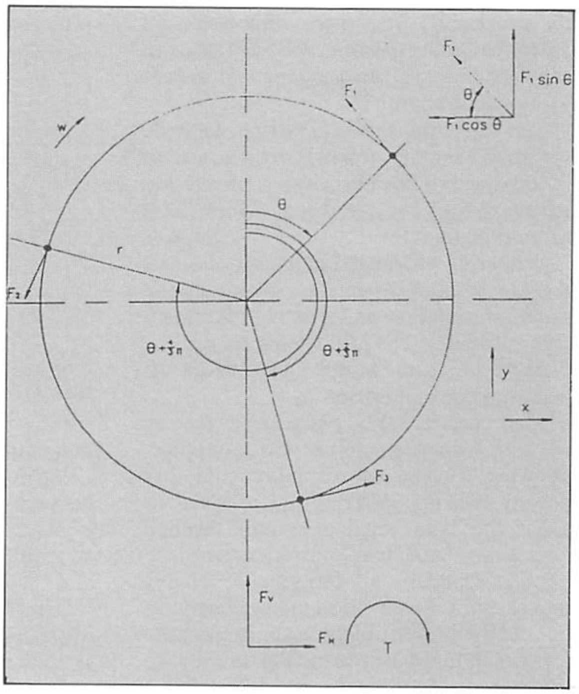

Fig 2 Force diagram.

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Table 1. Tractor and instrumentation used in the trials.

Component	*Make and model*	
Tractor	MF3090 with one front wheel and one rear wheel instrumented as described	
Load sensing clevis bolts	AJB Associates Ltd	CBA 0.75 uni-directional CBA 1.0 uni-directional
Slip rings		
Shaft encoder	Penny and Giles	IE/23
Amplifier	RS Components	RS308-815
Data logger	Campbell Scientific Ltd	CR7x

the angular position of each wheel were recorded. Typical data for the unloaded tractor are shown in Fig 4a.

Test 2 Loaded

A second tractor was attached to the drawbar of the instrumented tractor to act as a brake. The drawbar was equipped with a transducer to measure the horizontal draught force. The instrumented tractor was again driven over a smooth level surface at low speed towing the second tractor which had its brakes applied to give a steady draught force. The forces in the load sensing clevis bolts, the angular position of each wheel and the draught force were recorded. Typical data are shown in Fig 4b.

The datalogger was programmed to sample data every one second. The calibration figures for the three load sensing bolts were used to convert the signals from millivolts to kilonewtons. The angular position of the wheel was also recorded and converted to radians.

Formulae were then applied to calculate the vertical and horizontal components of force at each load sensing bolt and these were summed to give the total vertical and horizontal force on the wheel. The torque was also calculated.

The results of these calculations were stored in the datalogger as the test proceeded and then transferred to a computer for further analysis. A spreadsheet program was used to produce graphs of the forces and torques as required. Typical data are shown in Figs 5a and 5b.

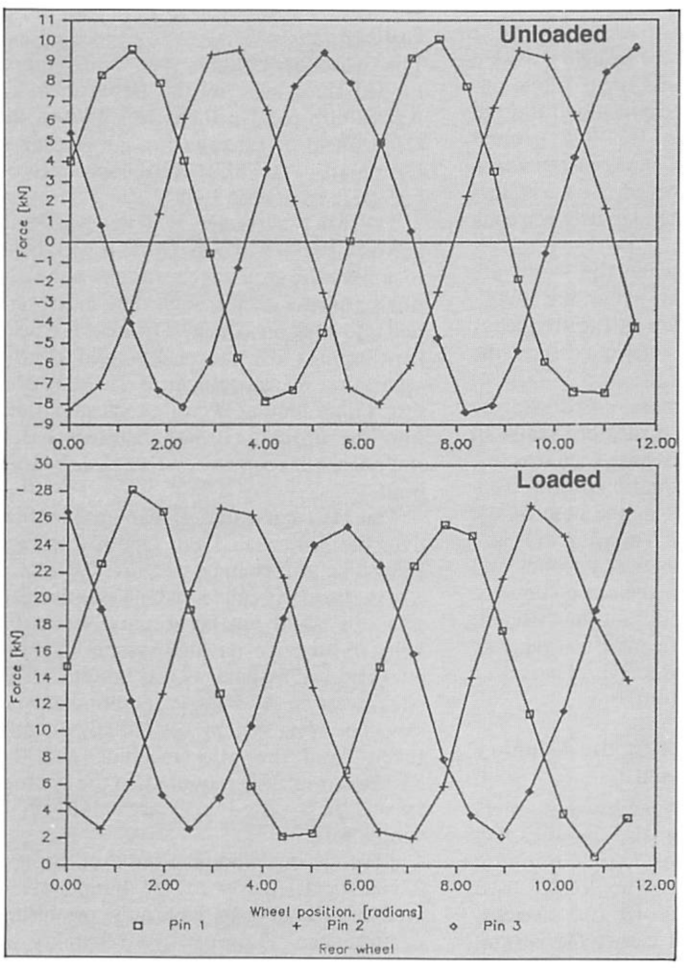

Fig 4a Unloaded pin forces; Fig 4b Loaded pin forces.

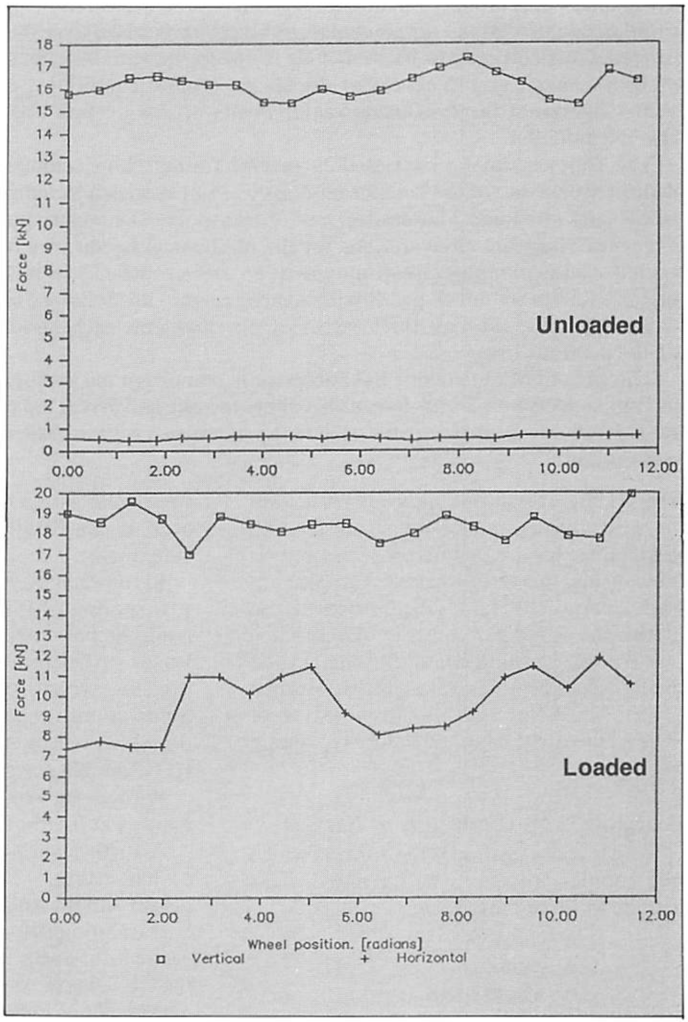

Fig 5 Rear wheel forces (a) unloaded; (b) loaded.

Discussion

The instrumented tractor is at King Saud University and further calibration trials are being carried out. Absolute calibration is difficult to obtain as there is no comparable equipment to act as a standard.

Conclusions

The Wheel Torque and Weight Transducer provides a method of measuring dynamic forces on driven tractor wheels. This enables a number of topics to be studied in more detail than has previously been possible.

Acknowledgement

The equipment was developed as part of a collaborative program between Silsoe College, UK and King Saud University, College of Agriculture, Riyadh, Royal Kingdom of Saudi Arabia.

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An overview of harvesting biomass crops

H D McLain reports* on the development at Loughry College of mechanical harvesting machinery and techniques for handling the willow coppice crop. He includes a brief review of other harvester developments.

Mechanical harvesting is critical to the successful exploitation of biomass from short rotation coppice. Many development problems have arisen over the years as willows have proved a difficult crop to harvest. This is due to the variability in growing habit (upright or bent), height and thickness of the sticks, ground conditions, etc. As harvesting is a winter operation the conflicting requirements of low ground pressure and traction are also encountered.

The coppice can be harvested in several forms: chips, chunks, whole sticks. As a dedicated end use for the coppice biomass was not specified Loughry opted for harvesting whole sticks tied into bundles for ease of transport. This makes possible a wide range of end uses. There are many options for the mechanical layout of a harvester which can be trailed, fully mounted, semi-mounted or self-propelled. It is not possible for one organisation to try out all possibilities hence Loughry has followed one line of investigation which has gone through three stages of development, each building on the experience of the previous one.

The current Mk3 machine has successfully completed harvesting trials at Long Ashton in 1989 and 1991 on 2- and 4-year old willow coppice and 3-year old poplars at Swanbourne in 1991. Some problems have still to be overcome with regard to operation on hilly, wet ground.

Harvesting of willow coppice is more akin to agricultural practice than forestry. To emphasise this the Department of Energy is now using the term 'Arable Coppice' in their literature. Harvesting is carried out during the period November to March, when weather and ground conditions are at their worst. The site must not be overly disturbed by the harvesting operation as at least 6 or 7 harvests can be expected before replanting is necessary.

Variable crop conditions at harvest

The first consideration is the **form** in which the coppice crop is to be harvested. This can be in three basic forms: –

- chips
- chunks
- whole sticks.

Cutting and chipping in one operation is attractive if the chips can be utilised in their wet state (50%) immediately after harvesting. However, piles of chips will not dry out and will heat up. This causes loss of dry matter (15-20%) and the production of fungal spores which are a health hazard. Chunks and whole sticks can be stored in a pile as there is sufficient airspace to allow natural air drying.

Next, is the matter of **row spacing**. Rows can be evenly spaced or as double rows. The Loughry coppice harvester is designed to operate with a row spacing of 1m; however, it can handle spacings a little either side of this.

In the early days of the Loughry work a row spacing of 0.7m was tried. While this could be harvested mechanically it did not leave sufficient space for low ground pressure tyre to travel between the rows. Some countries have opted for harvesting double rows with a wider gap between each set of double rows.

With a 1m row spacing the stools are planted at 0.5m or 1.0m within the row.

A further variable lies in the frequency of harvesting – and consequently in **the height and thickness** of the crop at harvest.

Harvesting of biomass crops can be carried out every 2, 3, 4 or more years. In the UK 2-4 year rotations have been selected. The height of these plantations varies from 4-7m and the diameter at the base of the sticks is 20mm-100mm. Variation in height and thickness occurs between clones and between sites. Even on the same site variations in weather conditions in different years can have a significant effect (eg very tall, 7m, 4 year old Bowles Hybrid harvested this year at Long Ashton).

Crop regimes for which the Loughry machines were designed

The design of the Loughry harvesters had to take into account also the spreading nature from the stool of *Salix X Burjatica Korso*. However, this is no longer used as it is too susceptible to rust attacks. Fortunately all current clones (eg Bowles Hybrid) are much more straight in their growth habits.

A harvester has to be designed to handle a particular range of ages and sizes of crop. It would be unrealistic to expect a single machine to handle every growth regime likely to be encountered. The Loughry machine has been designed for the following: –

Rotation:	2-4 year coppice willows or perhaps poplars.
Rows:	1m spacing.
Height:	4-6m.
Diameter:	20-100mm.
Bundles:	30kg Mk1 and 2; 200kg Mk3.

Harvester development at Loughry College

The work at Loughry has been jointly funded since 1981 by the Department of Agriculture for Northern Ireland and the Department of Energy (through Aberdeen University / ETSU). Three models of harvester have been built.

The Mk1 harvester – This was built between 1977-79 by J W Duff. It used belts to convey the crop which was cut with twin small diameter circular saws. The sticks were tied into 30kg bundles by 2 twines. The belts kept coming off the pulleys and bundle separation was a problem. It was only ever tested on a simulated crop of sticks pushed into the ground. It was realised that a re-design was required and a new harvester built.

The Mk2 harvester – The author took over the project in 1980. Due to the very branching growth habit of *Salix X Burjatica Korso* (formerly called SAG) it was decided that this could not be accommodated by belts so an open passage system with the sticks moved by packers was adopted. The sticks were cut by a single 760mm diameter saw. The tying system was initially directly taken from the Mk1 machine and the harvester was fully mounted on the tractor. It was first tested in March 1981 in a simple form.

After various modifications over the next 2 years particularly to the bundle tying system, this harvester gave quite promising performance. However, the reliability of tying was not good enough and the machine framework was not strong enough. By 1983

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it was known that an improved design was necessary.

The Mk3 harvester – The design of a new harvester was agreed in May 1986. The general principles of operation were similar to the Mk2 machine. However, a stop-to-tie regime was adopted to ensure reliable tying. To make such a system economic a bigger bundle has to be tied. A heavier machine is necessary which has to be trailed. The target bundle weight was 300kg; however, in practice 200kg has been the heaviest produced. The machine was first tested in April 1987 and has undergone further testing and improvement since then.

Basic components of the Mk3 coppice harvester

- Crop dividers in the form of contra-rotating augers with the sticks cut by a single large diameter saw (900mm diameter; now reduced to 800mm).
- First stage packing arms to move the cut sticks off the saw blade.
- Second stage packing arms to move the sticks further over to the bundle chamber.
- Third stage packing arms to pack the sticks into the bundle chamber.
- Hydraulically operated gates to clear the path for the 3 needles when the knots are being tied.
- Ejector to push out the tied bale when the tailgate is opened.

Good performance but still some problems

The harvester has had two good outings to Long Ashton in 1989 and 1991. Harvesting of 3 year old poplars at Swanbourne in 1991 was able to be carried out after a modification to allow the machine to handle the heavier sticks of varieties like RAP.

Harvesting at Castle Archdale in County Fermanagh in December 1990 showed that there are still some problems to be overcome before the machine can fully cope with the heavy surface water gley soils and steep slopes. The conflict between the requirements for low ground pressure and the need for good traction has to be resolved.

It has been found that every harvesting operation has brought to light new problems which have to be solved. The most difficult part of the machine to get right has been the bundle tying. However, another area which has unexpectedly given problems has been the cutting saw. Even when the power output of the hydraulic motor was significantly increased stalling problems still occurred. This was finally solved early in 1991 by reducing the saw diameter and fitting an oil cooler to the hydraulic system. It is felt that the development has now reached the stage where a manufacturer needs to be found to commercially exploit the results.

Other harvester methods and developments

The first harvester produced for willow coppice is probably the Dutch machine built by Ferdinand de Voss. It cuts 1 year old rods which are used for reinforcing dykes. The sticks are cut by twin saws and conveyed by belts (flax puller). Bunching is a manual operation.

The Loughry Mk3 coppice harvester.

Heavy duty brush cutters with saw heads are an effective (if time consuming) way of cutting the coppice sticks. The sticks are then manually stacked into bundles. Using brush cutting saws is a very useful means of making an opening for the harvester.

Between 1980 and 1982 Bord na Mona produced a harvester which cut a double row into chunks. The harvester was designed to operate on large square blocks of coppice grown on cut-away peat bogs. The product after air drying was to be fed into existing peat fired power stations. However, the project was abandoned as the willows did not grow well on the peat and it is rumoured that the power plants did not handle the chunks very well. They also had some mechanical problems with the harvester.

In Sweden, a single row side mounted harvester has been produced by ESM using twin saws to cut the crop and belts to convey and lift the cut sticks onto a platform at the back of the tractor. Around 2.5 tonnes are collected before it is deposited in a pile. They are currently developing a self propelled version of this harvester.

Bruks have built a large machine based on a forwarder. It cuts and chips approximately 1ha/day. The cost is around £300,000. Also in Sweden, a small company known as Agrifuels has built a machine for harvesting 1yr old sticks.

Here, in Britain, a harvester built on a dump truck chassis has been produced by Chris Mollet. It cuts 1yr old basket willows. Also Landmatch plc (N J Russell) have built a harvester for Greenwall. It uses belts to convey the cut sticks which are laid out by hand on the back. It harvests 2yr old basket willows which are used for making willow and earth banks.

Elsewhere, overseas, SREC in Italy have developed a harvester for *Robinia pseudo-accacia.* It cuts and chips single stems. It is currently undergoing further modifications. The Technische Universität München have developed a design for a machine to harvest and chip poplars. They are currently looking for funding to build a prototype. Some years ago there was harvester development work being carried out in North America but this does not appear to have been continued.

After the pioneering 1980s, the 1990s will see real commercial development of coppice harvesters

The 1980s have been the pioneering era for harvester development. Loughry College has played a significant role during this period. It has taken much longer than originally envisaged to get to the current stage of development.

There are a number of reasons for this: –

- the crop is variable and difficult to handle;
- there was no market for the product;
- there were insufficient willow plantations for harvesting trials;
- only one major problem could be dealt with each year (ie design modifications made after one harvesting season cannot be tested until the next winter and so on).

The 1990s will be the decade when current designs will be commercialised and new harvesters developed. Indeed, over the last 2 years many new designs have appeared. In Sweden large areas have already been planted with willow coppice. The pressure to harvest this economically will stimulate many small/medium companies to produce harvesters. By the end of the decade growers will be able to select from a range of machines the model best suited to their requirements.

The restoration of woodland drillsites

by D F Fourt

Exploration for oil and gas in the south-east of England was most active after 1980, with 46 boreholes completed by 1985. Planning constraints usually operated against selecting woodland sites but, where rig concealment, drilling target location, or local landscape factors were important, some were chosen. This short case study records some of the techniques used on four such sites; the site preparation and the subsequent restoration and replanting when the boreholes were abandoned.

During the planning stage, the application document provided information on the chosen site, such as vegetation cover, geological background, access roads and traffic levels, safety aspects, and effect on water courses, etc.

In the case of woodlands, preparation and restoration aims and methods were often detailed, covering land-forming, replanting species, etc, and a maintenance prescription over a 5-year period. In spite of the detail supplied, many applications went to Appeal, including some in the present study. It seems that if drilling was inevitable, the community preferred sites under agriculture, but hidden behind wooded belts, or copses, even if this meant the construction of more lengthy access routes.

Drillsite preparation

Recording and conservation

On two of the floristically rich woodland sites, plants such as primroses, bluebells and several orchid species, were lifted and replanted nearby. Transplanted groups of the rare sedge *Carex strigosa* were separately fenced, and badger sets also protected or avoided where likely to be disturbed. More detailed floristic studies were made on one site, before and on two occasions after the restoration process, to record woodland recolonisation.

In an attempt to maintain genetic continuity of tree cover, 40 stools of ash, field maple and hazel were conserved for replanting. The stools were topped to a 3m leg, then defoliated (in August), side- and under-cut using the 1m bucket of a 360° excavator, and moved to a trench, under canopy and kept moist. Subsequent replanting gave 31/40 success, with the added bonus of the square metre of inoculum of undisturbed soil.

Drainage, clearance and stump removal

Consideration was given to the diversion of ditches and collection from springlines. Ditches on heavy soils may be dry from April to December, yet carry substantial flow all winter. Later on, it was necessary to channel these drains into small settling lagoons, or soakaways, which could revert to become wildlife features after re-vegetation.

Clear-felling of the 1 hectare site was followed by removal of commercial timber, and the stacking of brash, and other debris. The remaining obstacles to top-soil lifting were the several hundred tree and or coppice stumps, which were uprooted using the bucket on a 360° tracked excavator.

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Adhering soil was loosened, and this large volume of woody material was allowed to dry for a few days, before adding to the brash stacks and burning.

Although decomposition in stacks would have better conserved site nutrient capital, storage space was usually limited, and some unburnt material, particularly large oak stumps, were taken away to landfill.

As can be seen, considerable, but unavoidable, machine activity was necessary all over the site causing considerable disturbance, before topsoil lifting could take place.

Topsoil conservation

Probably the most important operation in the programme, the topsoil removal and conservation, was carried out during the dry 'window' between May and September.

On the Brown Earth type soils present on the four sites, the organic-matter rich layer was only about 10cm thick, but poorly defined below. When only this shallow layer is collected, the even re-spreading by machine is difficult, and on one site where the contractors claimed there was little else, quite inadequate amounts were stored, such that, on restoration, the heavy machines only managed to re-cover one third of the site.

On the other sites, the view was taken that the whole of the lighter textured surface, amounting to 20-30cm, should be considered topsoil. As this layer was already incomplete, and mixed with topsoil from rootplate lifting, it was far from the tidy operation possible on arable or pasture sites.

The most successful method was to use the roll-blade on a Caterpillar D8 tractor, to shave off the surface to form windrows at 20-25m intervals. These were successively pushed downslope to the storage area, where the material was lifted with a tracked loading shovel, to form long stacks, around 3m high. This avoided further machine passes, while collecting all the litter, fire-ash, small brash, etc.

On some sites, a 360° tracked excavator, standing on the soil surface, used a wide bucket to scrape off the surface 20-30cm, pulling towards the machine. The loaded bucket was emptied into a 4-WD dump-truck, running on the cleared subsoil surface. With an experienced operator, this type of clearance could adjust to changes in texture and depth, as well as surface. This was important on the Wealden clays site, where an irregular pattern of partially filled-in

Fig 1. Greensand loam site. Four year old red alder on thin topsoil over mixed subsoil and glauconitic loams. About 7m in four growing seasons.

medieval iron-ore bell-pits covered part of the area.

The excavator method involved more machine passes, but results were considered acceptable as long as the soils were dry. Soils under woodland canopy are always much drier than adjacent and similar soils under pasture or arable, because of the interception effect, reducing the accession of rainfall to the shaded forest floor.

Subsoil conservation

Similar methods were used to lift the next 30-40cm, but as three of the sites were on geological clays – Wealden, London and clay-with-flints, a distinct textural change was recognised. In the subsoil layers, clay enrichment had taken place, and instead of dry material, some became plastic under machine handling, a much less desirable state. As before, this material was loaded onto dumptrucks with tracked loading shovels or excavator buckets for loose-tip stacking.

Site construction; Decommissioning

To form the drill platform, earth-moving machines carried out cut-and-fill on the two sloping sites, and local re-grading on the near-level sites. The surface was then covered with geotextile, and 30-40cm of DoT 1, a hard limestone road-mix aggregate. Various concrete structures were built, such as mud-pits, a drill-cellar, bases for water tanks, the rig base, and in one case a concrete ditch surround.

Drilling was carried out immediately after site completion, but the decision whether to restore a 'dry' or un-economic borehole can take several years. One site was restored the following summer, others took up to 5 years. It all depends on whether the geophysical and geological data collected from the borehole, when related to the inferences drawn from the original seismic survey, gave grounds for continued optimism on the presence of a 'pool' of hydrocarbons.

Once de-commissioning is decided, the concrete structures are broken up, the limestone base is lifted to remove the geotextile, and the site is re-graded to former contours. As suggested in R&D Paper 141 (Wilson, 1985) sites with slopes below 5° were recommended for ridge and furrow landform, below that gradient a contour layout was considered likely to be effective.

Restoration

London clay

Following re-grading of the benched slope, the clay-loam subsoil was collected from stack using dumptrucks and spread with the bucket of a light Type 580C Hymac 360° tracked excavator. As the machine moved across the site, contour ditches were opened at 25m spacing, and shallow (35cm) mole plough channels drawn downslope in the subsoil using a 2 mole toolbar on a 4-WD frame-steer tractor in the 120 HP class.

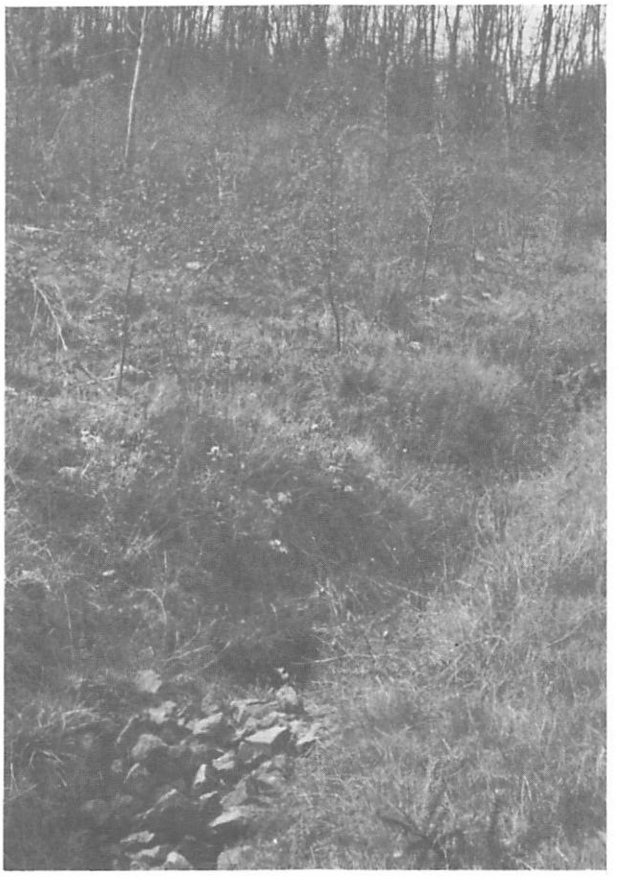

Fig 2. London clay site. Grass-sown, downslope ditch, with porous hard-rock dam to control erosion. Note tree growth, and abundant primroses on left, grass ride on right, undisturbed broadleaf woodland at rear.

The dark greenish-blue topsoil was brought from stack, and bucket lifted and spread using the Hymac excavator, standing on adjacent un-moled subsoil. This new surface was deliberately left rough, and after four seasons has slacked down, the dark anaerobic colours faded, the ferrous iron blue-greens becoming ferric browns. Much of the organic matter has oxidised, releasing nutrients to support a dense cover of grass and herbs, some from dormant seed, some blown or carried in.

The contour drain layout was collected into two downslope ditches, the run of which was broken every 5m by bank-level porous hard-rock-dams, to control erosion. These delivered into small settlement lagoons, to become wildlife features once silting had ceased and vegetation re-established.

Following standard rabbit fencing (Pepper and Tee, 1986) each 11m wide land was planted with edge rows of common alder, and mid-rows of ash, oak, cherry, hazel and field maple, and the conserved tree stools. The crop trees have established well but while the alder have reached 3-4m the others are still around 1-2m, probably because of a decline in nutrient (especially N) supply and because weed control was subordinated to conservation priorities.

Clay-with-flints

The minor regrading needed on this drillsite resulted in a slope of around ½° on average, barely enough to achieve flow in open ditches. With such low gradients drainage improvements would result from landforming to ridge and furrow (Wilson, 1985).

The subsoil and topsoil were taken from their stacks, and spread from dumped heaps with an excavator bucket. Because ⅓rd of the drill platform was to be retained for timber stacking, available soil amounts were increased. However, no drains were emplaced, in dry weather, and during the following winter re-wetting, the site became too soft for planting.

The following summer, when the surface had dried out, it was possible for a heavy 4-WD frame-steer tractor in the 120 HP class to make several passes with an agricultural two-winged tine set (Ransomes C90). This operation was closely followed by the opening of ditches, using a large V bucket on Type 580C Hymac 360° tracked excavator, working across the ripping lines. The surface was left rough, the ditch bucket dollops – of heavy clay – not being spread, but left as heaps.

The drains were collected at the low end and culverted under a new road to a soakaway dug down to the underlying chalk. This pond retains water during winter and spring of normal seasons and is of considerable wildlife benefit. The site was replanted in March of the following year at 3m × 3m spacing, with transplants of ash, oak and cherry, protected by tree shelters to avoid fencing. These have grown well, more than 75% being above the shelters in the third season. Good control of the predominantly *Holcus lanatus* sward being achieved by a December application of Propyzamide granules round each tree (Williamson and Lane, 1989).

It is generally agreed that close spacing (1.5m to 1.8m), and the inclusion of some alders, are beneficial on disturbed clays, and it is to be expected that canopy closure may be delayed by wide spacing.

Weald clay

At the time of writing, site clearance and minor regrading have taken place. Because of the low slope – at about 1° – it is planned to form 1.5m × 30m ridges, partly from spoil, and partly from reject stone and limestone base left on site. This should improve drainage (Wilson, 1985).

The subsoil will be dumped by each ridge and spread using an excavator bucket, and a similar system will be used for topsoil taken from stack. The ridges will be cross-ripped, probably with 2 winged tines on a low-ground-pressure Caterpillar D6, and the surface will be left rough.

Fig 3. Clay-with-flints site. Open ditch and mainly Holcus lanatus *sward, with wide-spaced and tree-shelter protected broadleaf tree cover. Previous forestry crop of larch and Douglas fir in background.*

Fencing will be carried out to exclude rabbits (Pepper and Tee, 1986), and there will be increased pressure on the local deer population to reduce browse and rubbing. Weed control should not be necessary in the first year, but it is intended to apply Propyzamide granules in December and subsequent seasons (Williamson and Lane, 1989).

The tree spacing will be 1.8m using transplants of alder, ash, oak and cherry, planted in March.

The forest open ditch system from the west will run across the site, and collect flow from the furrows. These will lead to a silt lagoon, on the edge of the site, with the outlet controlled by sluice, later to become a wildlife feature.

Lower greensand loams

The re-grading of this benched drillsite resulted in an irregular surface, sloping between 4°-8° NE, with spring line problems in the lower centre. The topsoil store had been collected from beneath the 40-year-old stand of mixed conifer-broadleaf, with moder type humus. However, when this was re-spread with an excavator bucket and blade, there was only enough to cover about half the area. The rest of the site was covered with a mix of sandy subsoil, and glauconitic loamy material from depth.

The erosion risk on this weakly structured light soil was recognised, and some control was achieved by power hydraseeding in October and again the following May. Reduced amounts of fertiliser and fixer were used, with a seed mix of bents, crested dogs tail, birdsfoot trefoil and medick (Wilson, 1985, p15) to produce a low palatability sward less likely to become a deer lawn. Early growth was slow but surface protection improved during the summer, to permit ripping to relieve machine compaction.

A heavy agricultural two-winged tine set (Ransomes C90) was drawn by a 4-WD Roadless 115 tractor. This old but powerful machine, with excellent ground holding, was able to work up and down slope during dry weather in June, loosening to 45cm.

The area was protected with a rabbit proof fence and the local deer population reduced, at least for the first three years. Fence damage due to the 1987 and 1990 gales allowed deer entry and once in, it has been difficult to keep them out. Planting took place the following winter with no preparatory grass control except along the roadside, which was to be planted with common oak. Some local ditching was carried out to deal with seepage lines.

On the topsoiled area, transplants of red oak were alternated with red alder, and over the rest of the area hybrid larch was mixed with common alder, the latter species to improve nitrogen inputs. The survival of the newly planted trees was good, at least 95%, due to effective ground preparation, and absence of competition in the first season.

Control of grass round larch, and oaks was achieved using Propyzamide granules in the first and two successive winters. In the third season invasion by gorse became a problem, reducing access, and increasing fire hazard. This was treated with Triclopyr in autumn with considerable success, but further applications may be needed (Williamson and Lane, 1989).

On the area lacking topsoil, the F.C. Research Branch compared control (untreated) plots with areas treated with sewage sludge, or fertiliser, with larch as test species. The sewage and fertiliser gave enhanced growth, the former at the cost of exceptional weed competition. A smaller trial of larch nursed with Italian alder, at close spacing, gave significant benefit to the larch.

On the main area, the red alder have grown to 7m in four seasons, overtopping the red oak, which have grown poorly, with some deer rubbing. The larch in common alder are growing well after a slow start, and both species are in the range 2-3m.

Discussion and conclusions

On these small and environmentally sensitive sites, some with conservation interests, restoration techniques were intended to accelerate the re-establishment of woodland canopy. These include topsoil conservation, relief of machine compaction, drainage, fencing, tree protection and control of grass competition. In forestry, the opportunity to improve drainage by land-forming, or open ditches, does not recur.

Disturbance of the organic nutrient store, with exposure to light, wet and dry cycling, and rainfall, results in a short flush, followed by a decline to deficiency levels, especially of nitrogen (N). This pattern is normal with clear-felling, and is more acute on mull, and moder humus types, where soil activity is higher, but the store smaller, relying, as it does, on annual leaf fall to maintain reserves.

In nature, tree regeneration, and an invigorated ground flora, help to conserve nutrients after canopy removal, but this can take time to develop on disturbed sites. The forester can help by closer spacing of the new tree planting, and by accepting regeneration of woody species such as birch, thorn, bramble, rose and willow. Nutrient capital, especially of N, is built up slowly, through leaf fall, from N fixation, mainly by alders and legumes, and rainfall accession. Woody canopy, even at low level, as in scrub, also increases rainfall interception, and reduces leaching losses.

The problem of gorse was mentioned – Its vigour on restored sites is a serious problem. The seeds may lie dormant in the soil for 200 years, and be triggered to germinate by disturbance or fire. Because it can fix atmospheric N, it grows rapidly, and can present the forester with access problems, as well as enhancing fire risk.

The survival of the newly planted trees was good, at least 95%, due to the emphasis on good ground preparation and the absence of weed competition in the first growing season.

It is considered that the transplanting of herbaceous species was probably worthwhile, but that moving the tree stools, though successful, was of less significance if re-planting stock was grown from indiginous seed sources.

The ponds have already become useful wildlife assets, with water plants, dragonflies and amphibians. Erosion risks have been controlled, and were negligible after the first season.

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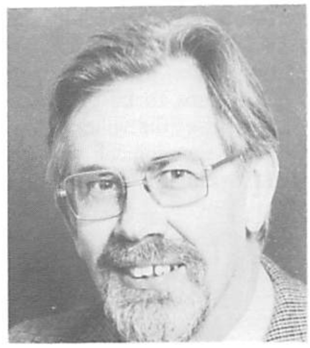
Reclaiming contaminated land in the City of Swansea

E M Bridges reports on the successful outcome of work begun 30 years ago in the former non-ferrous metal smelting area of Swansea.



Remains of White Rock Works, Swansea.

The City of Swansea has had a long and interesting industrial history which reached its peak of international importance in the middle years of the nineteenth century.

The industrial revolution, based on metal smelting, came early to the Swansea region with the development from 1717 onwards of the Lower Swansea Valley to become the world centre for non-ferrous metal smelting. At that time it brought undoubted benefits to the town.

Unfortunately, when the industry declined, a legacy of dereliction and pollution remained from this phase of the City's history. For almost 60 years the area was left derelict as there was no financial provision for clearance of the ruins of the former works or their massive waste heaps. On the surrounding hillsides the soils became contaminated with metals and eroded, so trees were absent and few other plants could be seen. As a result, the Lower Swansea Valley became known as one of the worst and most concentrated areas of industrial dereliction in Britain.

This year, 1991, is the 30th anniversary of the start of The Lower Swansea Valley Project, an ambitious scheme for the removal of the eyesores and restoration of the area to productive uses.

History of copper, lead, silver, arsenic, zinc

At different times between 1717 and 1924, copper, lead, silver, arsenic and zinc were smelted in 22 works spread along the tidal reaches of the river Tawe (Fig 1).

In the second half of the nineteenth century, following the invention of the *open hearth* method of steel making by Siemens, 10 steel and tinplate mills were established. Copper and lead, the first metals to be smelted, declined in importance after 1880, but then zinc smelting became more important as part of the production of corrugated iron and tinplate. After the 1920s, steel and tinplate assumed a dominating position in the economy of the district with four out of every five British tinplate workers employed within 20 miles of Swansea. These steel and tinplate works continued in production until the end of World War II with the last steel works closing in 1961 and the Rio Tinto Zinc works in 1974.

The legacy left by all this industrial activity included some 7m tonnes of toxic metalliferous slags, ruined buildings, derelict canals and railways with restricted access to the valley floor and unvegetated, contaminated and eroded the valley sides.

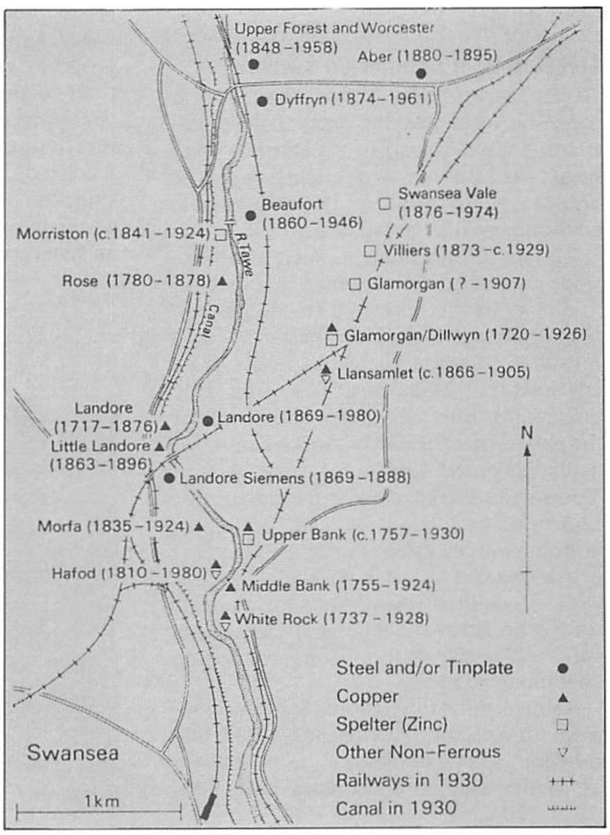


Fig 1. Former metalliferous works, Lower Swansea Valley.

Analysis of the problems

In 1961, the Lower Swansea Valley Project was set up with the financial assistance of the Nuffield Trust, Swansea County Borough Council, the Welsh Office and the University College of Swansea (Hilton, 1967). The aim of the project was *to investigate the physical, social and economic situation in the Lower Swansea Valley, to understand the reasons which had inhibited its development in the past and to provide the information necessary for its future development.*

From its inception the project was clearly seen as a first stage in which information was gathered and interpreted, leading eventually to the renewal of the devastated landscape and the development of new forms of land use.

The Lower Swansea Valley Project was unique in many ways as it was the first thorough investigation in Britain of the reasons for dereliction and its persistence.

The project brought together people from many disciplines who contributed their skills to unravel the history of dereliction and who established a wealth of data on the physical

Dr E M Bridges has until recently been a member of the academic staff of the University of Wales at Swansea. From January 1992 he will be joining the staff of the International Soil Reference and Information Centre at Wageningen, The Netherlands.

environment and human attitudes to the problems associated with derelict industrial land. Compilation of this information enabled draft plans to be proposed for the redevelopment of the valley.

To assist the geological, pedological and ecological investigations in the valley, aerial photography was flown in 1962 so that a map of the whole area could be compiled with sufficient background detail to act as a base map for the project. Individual plots with common problems were identified on the ground and depicted on the map. These plots then became the basis of plans for restoration.

The Marsh: zinc waste tips on right.

Development of tolerant species

In the early 1960s it was thought too expensive to remove the many toxic metalliferous waste heaps, so experiments were begun to find out how plants could be encouraged to grow in the inhospitable environment of the slag heaps.

The use of amendments such as sewage sludge, domestic refuse, pulverised fuel ash and inorganic fertilisers was investigated in a series of pot and field experiments with mustard, common bent grass and a grass ley mixture. This work was essentially empirical as little was known at that time of the physio-chemical factors which controlled availability and uptake of toxic metals. Trials were also made of different shrubs, known to be tolerant of acid conditions, atmospheric pollution, drought and exposure. In parallel with this work, plant species with an acquired tolerance of toxic metals were collected in anticipation of developing sufficient seed from these clones to vegetate contaminated areas.

Subsequently, the National Seed Development Organisation did develop a lead-zinc tolerant variety of *Festuca rubra,* known as Merlin and other varieties have been developed since.

Tree planting programme

As all native trees in the district had been killed by the fumes of the non-ferrous metal smelters, an important contribution to the visual appearance of the district was by planting trees. After liming and some fertiliser to encourage rooting, 100,000 trees including Japanese larch, lodgepole pine and birch were planted from 1963 onwards on the eroded soils, particularly along the eastern side of the valley. These trees now make a major impact and have encouraged wildlife to return to the area. Their growth has been slightly retarded by the contaminated soils, but they remain as an integral part of the restored landscape and are one of the most successful and inexpensive parts of the landscape restoration.

After the end of World War II, plans for reconstruction in Swansea had envisaged a predominantly industrial future for the valley, and this was reflected in the Project's proposals (Hilton, 1967). Events overtook these plans and although a 1968 draft development plan incorporated many of the findings of the Project and made a feature of the river Tawe, it too, was subsumed in an interim planning statement of a wider nature which proposed five 'parks': an Enterprise Park, a Leisure Park, a Riverside Park, a City Park and a Maritime Park, the last incorporating derelict docklands on the west side of the river.

Government funding speeds up pace of restoration

Restoration began on a small scale as part of the Lower Swansea Valley Project when the site of the former Llansamlet Arsenic Works was cleared and grassed over and trees planted on a small knoll. Its position alongside the main railway line made it a good site for a demonstration of what could be done to improve the visual appearance of the area.

No other significant restoration took place before 1966, the year of the Aberfan disaster, but thereafter government funds for direct land clearance became available. After a slow start, during which the Local Authority gradually acquired the land in the valley, the pace of restoration work quickened.

The City Council set up a small executive committee which could take decisions without going through the normal lengthy channels; as a result the City was able to respond rapidly to any opportunities for reclamation and redevelopment. The value of this was realised in 1980 when the first of the government's Enterprise Zones was located on restored land in the northern part of the valley.

Reclamation schemes were started only when financial assistance from the Welsh Development Agency was assured, so the pace of restoration reflected the availability of government funds.

The first major project, in 1967-68, was clearance of the tips of the White Rock Copper works. The metalliferous slags were transferred, at a cost of £129,210 (£3915 per hectare), to the site of the Upper Forest and Worcester tinplate works near Morriston where they were used to raise the level of the land above the floodplain of the river Tawe. The work was done with the knowledge that a major factory development would occupy the site, meanwhile the original location of the tips was hydroseeded and trees and shrubs planted. Thus one derelict site was used to restore another.

Reclaimed White Rock tip site.

Subsequent schemes gradually moved in towards the centre of the valley where the final major clearance scheme took place during the mid 1980s (Bridges, 1987), (Fig 2).

Year	Map code and name	Area, ha	Vol. m³	Cost, £
67-68	A – White Rock tip	33	183,000	129,210
67-68	B – Upper Forest; Worcester	16	200,000	295,391
69-70	C – Cwm; Winsh Wen, Llansmalet	104	65,000	109,289
69-70	D – Dyffryn steelworks	8	50,000	154,732
70-71	E – Swansea canal; Morfa I	11	180,000	162,567
70-76	F – Morfa II	4	63,000	110,204
72-73	G – Pentre-Hafod tip	5	112,000	403,616
72-74	H – Graig brickworks/Cohen	3	42,000	32,562
74-75	I – Rose and Spelter works	16	350,000	105,455
75-76	J – Glamorgan works	0.5	–	4,845
75-76	K – RTZ phase I	3.5	75,000	58,000
76-77	L – RTZ phase II	5.5	80,000	248,888
78-79	M – RTZ phase III, IV, Morfa/Glandwr	24.5	620,000	930,466
78-79	N – Lower gas works	13	189,000	166,350
78-79	O – Pluck Lake tip	15	32,000	30,000
78-79	P – Pentre tip	3	86,000	48,000
81-82	Q – Upper Bank tip I and II	15	1,172,000	329,712
82-86	R – BSC tip and lake	46.7	200,000	1,434,000
84-85	S – White Rock works	10	75,000	107,000
Total		336.7	3,774,000	4,860,287

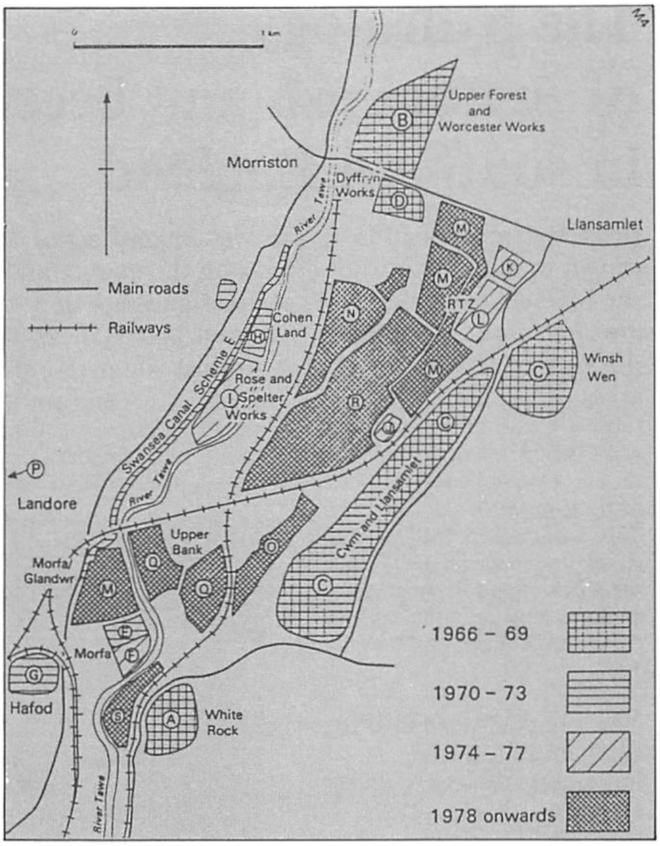


Fig 2. Reclamation schemes in the Lower Swansea Valley (1967-85).

Severe contamination adds to costs

Problems of severe land contamination had to be dealt with and this inevitably raised the costs of the work.

One of the most expensive schemes was the removal of the Pentre-Hafod copper tips at cost of £403,616 (£80,223/ha) to provide the site for a new comprehensive school.

The most extensive scheme undertaken was in the central part of the valley, north of the main railway line, which cost £1,434,000 or £30,706 per hectare to reclaim. This scheme involved the excavation of marshy ground containing toxic leachates from the surrounding metalliferous tips. Concentrations of up to 168 mg/kg cadmium, 3086 mg/kg copper, 8000 mg/kg lead and 89,000 mg/kg zinc were found; well over the recommended safe limits 15, 50, 500, 130 mg/kg respectively (ICRCL, 1989). The toxic material was sandwiched between layers of alkaline steel wastes to precipitate any metals which might come into solution and covered with locally derived glacial deposits to form a new plateau on which industrial redevelopment can take place. The site of the former marsh is now an attractive lake.

Other problems of land contamination were uncovered beneath the site of the Rio-Tinto Zinc works where a small culverted stream was grossly polluted. Subsequent diversion of the steam around the site has cured the problem, but inevitably added to the costs of reclamation (Bridges and Morgan, 1990).

Policy of not transferring contaminated material

Throughout the reclamation work in the Swansea Valley it has been a rule that the contaminated material should be confined to the former industrial area and made safe on site. The philosophy of this is simple; to remove it elsewhere would create another problem and spillage could spread toxic material between the two sites. Unfortunately, these dangers were not appreciated in the 1960s when the urban area of Swansea expanded considerably and the metalliferous slags were seen as a cheap source of hardcore for house foundations and driveways. Consequently, a recent survey found enhanced concentrations of toxic metals in domestic gardens throughout the urban area.

The polluted land of the former industrial areas in the Lower Swansea Valley now has almost completely been removed and the sites covered with clean 'soil material'. The resulting man-made soil has concentrations of metals now which are lower than in many surrounding urban areas (Bridges, 1991).

Key to success has been modern heavy machinery

The success of the restoration of the Lower Swansea Valley may be judged by the difficulty now faced in convincing visitors of the dreadful dereliction which used to characterise the area. The faith of the original members of the Lower Swansea Valley Project that something could be done has, over a period of 30 years, been realised.

In the end, the problems were not solved by ecological means, although the investigations provided much valuable information, but by the use of heavy machinery which was used to completely re-model the landscape of the valley floor.

The costs of repairing the damage of past folly is not cheap. The physical restoration alone has cost almost £5 million and a further £1.5 million has been spent on landscaping in the Enterprise Zone. During the last few months a new road scheme for the eastern side of the valley with a cross-valley link has cost a further £9 million. Investment in the former derelict dockland area for housing has amounted to £80m.

Originally, land reclamation developed in response to a rural problem. Mining of ironstone in the East Midlands left increasing areas of derelict land during the 1930s, so measures were taken to limit its impact in the late 1930s. During the Second World War the development of earth-moving machinery took place which could be used to avoid widespread dereliction with open-cast coal workings of that period.

At the present time, many areas on the coalfields of Britain have benefited by land restoration, partly funded by excavation of the coal left below ground (to support the mine roof) during traditional mining practice. Many of the lessons learnt in land restoration of these former mining areas have contributed to the success of land restoration schemes now taking place in urban areas where currently some of the worst problems of dereliction and soil contamination may be found (Bridges, 1990).

Experience in the Lower Swansea Valley has shown what can be done, given the foresight, correct expertise, money and patience to rid the landscape of eyesores left from past industrial exploitation.

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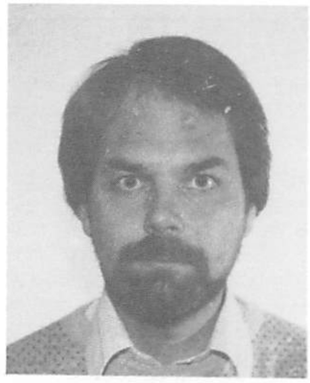
The hydrology of mature ash and beech plantations in southern England

Increased afforestation in the wet upland areas of the UK have been shown to have significant effects on the quality and yield of water from the forested catchments. New woodlands are now being planned for the lowland areas of southern England and P T W Rosier examines* the possible effects on the already limited water resources.



Mounting pressure to reduce agricultural surpluses, and to utilise the land in other ways is now being actively encouraged in the UK. One way to do this is to plant some of the land with broadleaf trees. This will help to increase UK wood production (about 90% of the UK's wood is imported), enhance amenity value and to conserve habitats (Blyth *et al*, 1987).

New woodlands planned for southern England – important to assess likely effects

It is well known what effects increased afforestation has had on the wet upland areas of the UK.

At Plynlimon in mid-Wales the paired catchment experiment operated by the Institute of Hydrology showed that the evaporation from the forested catchment would be twice that of the adjacent grassland catchment (Calder and Newson, 1979). The difference being due to the larger interception losses from the well ventilated forest canopy during and immediately following rainfall. Inevitably this would be reflected in a reduced water yield from the forested catchment.

The flow regime of rivers is also affected by land preparation for tree planting and subsequent felling (Robinson, 1986) and increased amounts of sediment (due to land disturbance) are also found in rivers (eg Johnson, 1988).

Because of the enhanced ability of trees to scavenge pollutants from the atmosphere (by being aerodynamically rough) upland streams have become more acidic and in turn there have been reductions in salmonoid fish stocks and other wildlife dependent on the rivers for their food supply (UKAWRG, 1988).

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** Paper presented at the Conference, 5 September 1991, of the Institution's Forestry Engineering Specialist Group.*

It is proposed that the new woodlands to be planted will be in the drier lowland areas of southern England. The tree species being considered are ash *(Fraxinus excelsior),* sweet chestnut *(Castanea sativa),* sycamore *(Acer pseudoplatanus),* poplar *(Populus* sp.), beech *(Fagus sylvatica)* and cherry *(Prunus avium).*

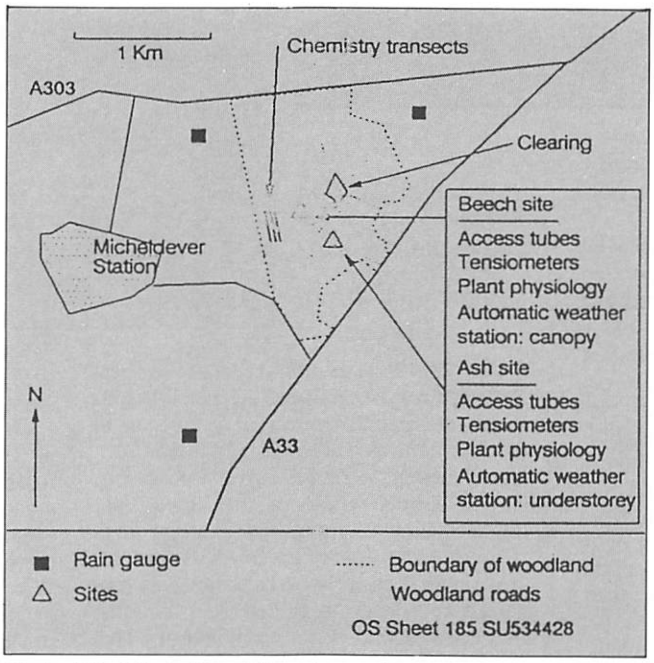

Fig 1 The Black Wood Experiment site.

The chosen areas contain major centres of population and also receive the least amount of rainfall, so any major land use change could have serious implications on groundwater recharge and local water resources.

The new plantations will generally be small, less than 5 hectares in size and probably be in irregular blocks. This form of patterning will give rise to a large number of field-woodland boundaries where it is anticipated that enhanced interception losses and chemical scavenging will take place.

Evaporative losses – interception and transpiration

For ease of convenience the two processes that make up the total evaporative loss are differentiated into separate components as the processes involved are different. The evaporation of water from the wet outer leaves during and immediately after rainfall is termed interception, this is a physical process. Transpiration is the movement of water by the roots and the subsequent transfer through the leaves involving physiological processes which are subject to complex control mechanisms.

Interception is calculated as the difference between gross rainfall measured in the open, or in some cases above the canopy, and the net rainfall which is the sum of the throughfall – water which falls through the canopy either directly or as drips from leaves and branches, and the stemflow – water which runs down the tree trunk.

The interception loss is dependent on the climate, mainly rainfall and the evaporative demand during rainfall and the structure of the vegetation, which will determine the amount of water it can hold.

From studies of coniferous trees in the British uplands typical interception ratios (the interception loss as a proportion of the annual rainfall) varies between 30 and 40%. See Calder (1982) for details of a number of studies carried out in the UK. In comparison, the variation in interception ratios for broadleaf trees is greater, varying between 10 and 35%. Hall and Roberts (1990) give details of a number of European broadleaf interception studies. To an extent this variation is to be expected as the results cover a range of species, ages, planting densities and climate zones.

The transpiration of trees is determined by more factors than interception is; for example climate, tree species, age, canopy structure and moisture content of the soil. The control of transpiration is by the stomata which limit the water vapour flow, and these respond to changes in atmospheric humidity deficit and increasing soil water stress. A knowledge of stomatal behaviour and leaf area index (the leaf area per unit ground area) combined with meteorological variables in equations such as Penman-Monteith (Monteith, 1965) are used to calculate the transpiration.

In his paper Roberts (1983) presented

information on both broadleaf and coniferous tree types from studies made in north west Europe and concluded that the annual values were very similar in both cases, with a mean of 330mm and a standard deviation of 35mm, which indicated that a strong physiological control was exerted on the transpiration.

The Broadleaf Experiment

Concern about any possible adverse affects on the already limited water resources in southern England led to the setting up of the Broadleaf Project to investigate 'the hydrological impacts of broadleaf woodland in lowland Britain'. The aims of the project are (and continue to be) to assess the effects of small-scale plantations on: –

- the water use;
- chemical fluxes of major and pollutant ions to the forest floor.

Two sites have been instrumented, Black Wood near Winchester in Hampshire (from April 1989) and Old Pond Close near Olney in Buckinghamshire (from May 1990). This paper will concentrate on the Black Wood site.

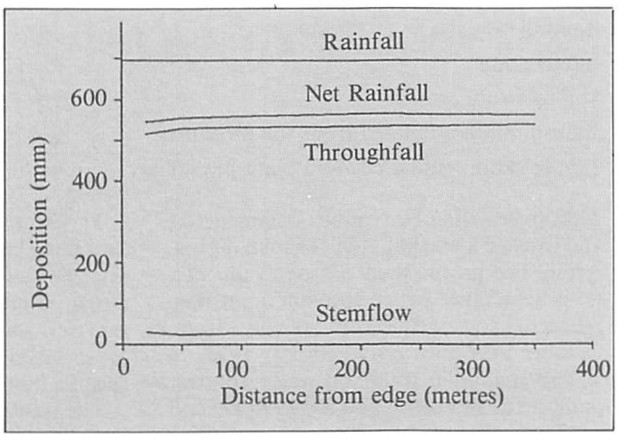

Fig 2 Stemflow and throughfall variation from a forest edge at Black Wood.

Black Wood is a 2.7km² Forestry Commission woodland, completely surrounded by agricultural land, (Grid Reference SU534428), Fig 1. It is primarily beech but with a small plantation of ash within it, and a small clearing near its centre.

The beech trees were planted in 1933 and are about 21m tall and have no undergrowth, but there is a leaf litter layer of 1-2cm thickness. The ash trees were planted in 1952 and are about 16m tall. The ash site has a vigorous undergrowth consisting mainly of Hazel *(Corylus avellana)* and Bramble *(Rubus* sp.), along with Dog's Mercury *(Mercurialis perennis)* and a number of other species appearing at different times of the year. The soil at both sites is of the Andover series (Jarvis, 1973) and consists of 25cm of a dark brown silty loam with small flints overlying a lightly stained chalk grading into in situ chalk at about 1.5m.

– Water use measurements – interception and transpiration losses

The plan of the Black Wood site (Fig 1), shows the water use measurements (interception and transpiration) that are being made at the main beech site and at the smaller ash site.

The **interception losses** are measured by two methods:

1. the use of a plastic-sheet net-rainfall gauge (Calder and Rosier, 1976) and
2. a network of randomly located throughfall and stemflow gauges (Neal *et al*, 1991).

The data from the plastic-sheet net-rainfall gauge is stored on a solid state logging system used to monitor the meteorological variables from an automatic weather station mounted on a 20m tall tower nearby.

The design of the random network comprises of instrumented plots (about 100m² area) at five distances from the forest edge (20 to 350m). At each distance there are three plots each containing eight throughfall (relocated after each data collection visit) and four permanent stemflow gauges.

Transpiration losses from the forest have been measured using two methods:

1. a soil moisture budgeting technique and
2. plant physiological measurements incorporated into a multi-layer transpiration model.

Soil moisture measurements are made using the Institute of Hydrology Neutron Probe system (Bell, 1976) at five randomly located access tubes at the ash and the beech sites.

Measurements were initially made weekly but preliminary analysis showed that fortnightly measurements for the budgeting technique are adequate.

To estimate transpiration by plant physiological methods requires a large data set of stomatal conductance, leaf area index (LAI) and meteorological measurements for use in the model. Stomatal conductance data from the ash and the beech trees were obtained from three layers within each canopy (and from four trees to improve the estimate) on a number of occasions throughout the summer of 1989. The LAI value was determined by the regular collection of leaf litter fall during the autumn of 1989 from both sites.

Data from two automatic weather stations producing hourly averages of solar radiation, net radiation, dry bulb temperature, wet bulb temperature, wind speed, wind direction and rainfall operating above and below the forest canopy were used in the transpiration model.

– Chemistry studies

From the random network (for interception measurements) measurements were made of the throughfall and stemflow chemistry to determine the chemical fluxes to the forest floor. From above the forest canopy rainfall measurements (which are uncontaminated from the surrounding fields) are taken to obtain the rainfall flux for both sites. Other chemical measurements are taken of atmospheric ammonia, nitrogen oxides and sulphur oxide at a range of locations throughout the forest.

Results

– Interception ratios – no noticeable overall seasonal pattern

From the grid of throughfall and stemflow gauges (at the beech site) the overall interception ratio (measured from May 1989 to January 1990) was 11%. No noticeable seasonal pattern was observed, although with the dry summer of 1989 the representativeness of this figure needs to be confirmed by a longer data set. However this figure is consistent with many other studies (Hall and Roberts, 1990).

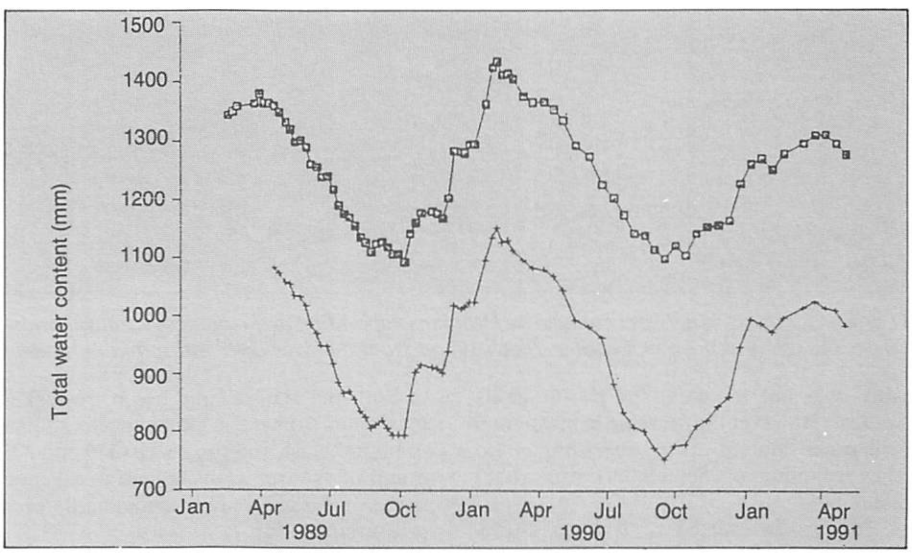

Fig 3 Time series of total soil water content beneath the ash (+) and beech (■) sites at Black Wood.

The average stemflow was 4.4% of the total throughfall but was seasonal varying from 2% in the summer months to 6% in the winter. Data from the random network does show a slight variation of net rainfall with increasing distance from the forest edge (Fig 2), although statistically this is not significant.

– Transpiration estimated from soil water content shows clear seasonal variation ...

The soil moisture budgeting technique used for estimating transpiration makes use of the decrease in total soil moisture content during the growing season. However there is some uncertainty in separating depletion in soil moisture due to transpiration and that of drainage.

To try and ascertain the direction of flow at different depths regular measurements of soil water potential (by mercury manometer tensiometers) were made during 1989 and 1990. Throughout much of both years the tensiometers were off scale indicating that the soil water potential was less than −1 bar. It is well known that chalk soils in this area have appreciable soil water conductivity at low soil water potentials (Wellings, 1984).

For the purposes of the analysis it is assumed that there is no drainage during the summer months and that all the soil moisture content changes are due to transpiration. Fig 3 shows the time series of the average total soil water content from the ash and the beech sites for 1989 and 1990.

In May 1989 (when soil moisture observations started at the ash site) the mean total soil water content of the profile was 1085mm (an average of five access tubes), and probably does not represent the profile at its wettest. However the decrease in mean total soil water content during the summer (to the beginning of September) was about 280mm.

The profile started to wet up during October 1989 and reached a maximum of 1150mm in February 1990. During 1990 the profile dried steadily from the end of March until October and showed a deficit of 340mm. About 80mm of this total can probably be attributed to drainage as the trees did not come into leaf until mid-May.

The beech site shows a very similar pattern to the ash site, for both 1989 and 1990. In 1989 the decrease in total soil water content beneath the beech site was about 250mm (from May until September). The profile was still wetting up during March 1989 (when the observations commenced) and reached a maximum of 1380mm during April. The profile then started to dry out until September (when the minimum was reached) and wetted up steadily from October 1989 until early February 1990.

The change in total soil water content pattern for the beech site for 1990 is very similar to that of the ash site.

– ... with good agreement with estimates based on stomatal conductance

Regular measurements of stomatal conductance from the ash and the beech sites were made during the summer of 1989.

There is a marked decrease in stomatal conductance with increasing specific humidity deficit for all three canopy layers in both the ash and the beech trees. The maximum stomatal conductance is similar in both the ash and the beech (350 and 320 mmol $m^{-2}s^{-1}$ respectively) and in all cases shows a gradual fall throughout each measurement day.

Measurements of stomatal conductance were made on three understorey species at the ash site (maximum of 100 mmol $m^{-2}s^{-1}$) and these were affected by the decreased soil moisture during the summer.

The stomatal conductance data, and estimate of leaf area index (LAI) from leaf litter and above canopy meteorological data were used in a four layer model to give estimates of transpiration from both the ash (including the understorey) and the beech sites from June to September 1989, see Fig 4.

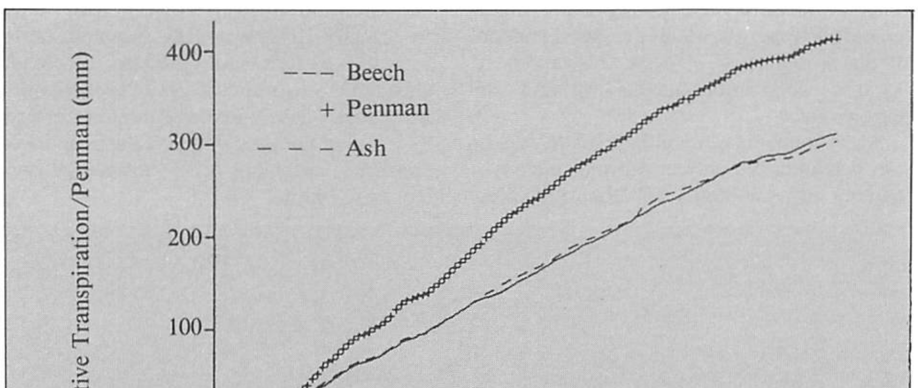

Fig 4 Comparison between cumulative Penman evaporation and cumulative transpiration from the ash and the beech sites at Black Wood from the four layer transpiration model.

Table 1. Comparison between transpiration estimates (mm) from soil moisture budgeting and plant physiological methods for the period 9 June 1989 to 26 September 1989.

	Ash	*Beech*
Rainfall	127.1	127.1
Interception	17.1	17.1
Soil moisture change	227.8	171.7
Transpiration estimated from soil moisture	339.7	283.6
Transpiration estimated from plant physiology	299.4	308.4

The transpiration values for the ash (including the understorey) and the beech are 299.4 and 308.4mm respectively. These estimates are below the Penman potential rate and show the effect of the reduction of stomatal conductance with increasing specific humidity deficit.

The transpiration estimates for the fully leafed period of 1989 (June to September) show good agreement between the two methods (Table 1).

There is a small difference between the two species which is surprising because the beech canopy is much denser (the LAI is twice that of the ash), however the understorey (of hazel, bramble and dogs mercury) at the ash site contributes about 30% of the total transpiration. It is possible that the transpiration from the ash site is an underestimate as it does not include the water use of the understorey prior to May. It has been observed that some of the understorey species are well leafed by early April.

– Forest canopy alters chemical fluxes

The flux of many chemical components through the forest canopy is highest nearest the forest edge (<50m) see Fig 5, and is especially so for chemicals that are cycled through the vegetation. For example, potassium and calcium show about four fold increases while sulphate and total nitrogen only show increases of between one and two times.

In general, the major and minor chemical elements do show large variations with time.

As a guide, stemflow concentrations > throughfall concentrations > rainfall concentrations.

Within the rainfall, sea salt components (sodium, magnesium and chloride) are highly correlated. However this is not reflected in many other determinands. There are high concentrations of sulphate, nitrate and calcium which with a lack of correlation with sea salt components indicates the importance of pollutant sources for these components. Similar patterns emerge within the stemflow and throughfall chemistry.

Preliminary conclusions

– the presence of forest is unlikely to have deleterious effect

From a preliminary analysis of the data so far collected from the ash and beech plantations at Black Wood there are a number of interesting points to note.

The interception ratio of 11% from a limited measurement period is low when compared to other studies as reported in the review paper of Hall and Roberts (1990). It is probable that the dry summer in 1989 will have affected it, and that a much more comprehensive data set will be required to confirm the value.

In contrast the estimates of transpiration, by soil moisture budgeting and plant physiological methods, gave very similar results for both the ash and the beech trees (300mm). These results are consistent with other forest transpiration studies carried out in north western Europe (Roberts, 1983).

As such the results from this limited period would suggest that the presence of the forest is unlikely to have any deleterious effect on the local water resources (although the full impact of this work must await a much more comprehensive data set and a more thorough modelling programme).

– Trees confirmed as scavengers of atmosphere chemicals

What is clear from the chemical studies is the importance of trees in modifying the chemical fluxes to the forest floor. Previous work in the uplands on mist and cloud deposition (Fowler *et al,* 1989) confirmed the role of trees in the scavenging of chemicals from the atmosphere. However the results from Black Wood are surprising given the low altitude of the site. The chemical studies (from the many samples collected) highlight the need to obtain a comprehensive network of collectors to ensure that the chemical flux estimates are representative.

Acknowledgements

This work is supported by the National Rivers Authority, the Department of the Environment and the Natural Environment Research Council. I would like to thank all the staff who have assisted in the collection and analysis of data from Black Wood.

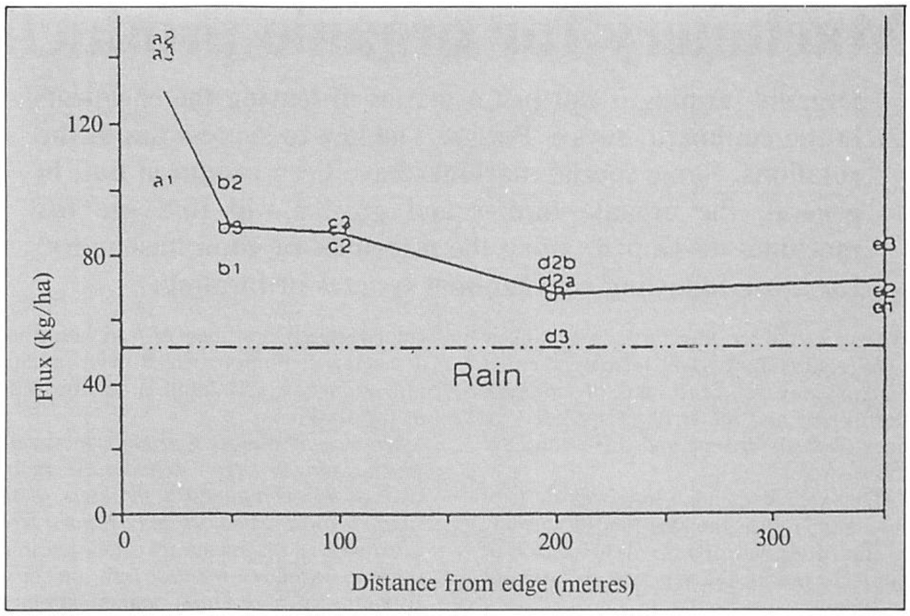

Fig 5 The net rainfall flux variation of chloride with increasing distance from the forest edge. (From Harding et al, *1991).*

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No fertilisers were used, except on one site where hydraseeding took place for erosion control. The incorporation of considerable amounts of limestone road-base should have been of benefit.

There was insufficient room for use of large box scrapers, most of the work being done with 360° tracked excavators, loading shovels, dumptrucks and ripping or moling tractors.

Acknowledgement

In general, the oil exploration companies deserve some credit for encouraging best practices, and it is a pleasure to record their efforts in this direction.

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Machinery for organic production

Organic farming is not just a matter of leaving the chemicals in the cupboard, says S Parish. The key to success lies in the rotations. Some special machines have been produced but, in general, the organic farmer and grower will find use for machines developed (along the principles of good husbandry) for those following conventional systems of farming.

When asked to consider the machinery likely to be required for organic farming, the first reaction may well be to think of scrapping the sprayer and the fertiliser spreader, go back 30 years in time and there you have the answer.

That view does fall a long way short of the mark, just as the idea that all farming in the fifties was organic shows a lack of appreciation of the concepts of organic farming.

However, with organic food now having a more respectable and possibly more profitable label attached to it, some farmers may be tempted to have a go. They should, however, be warned that it is not just a case of leaving the chemicals in the cupboard. Organic farming requires a different approach, and converting land to organic production is a gradual process in which there are few textbook solutions to the problems that will be encountered.

Farming journals have, in recent years, published many articles on the conversion process, and on the challenges of marketing organic produce. Few articles have focussed on the mechanisation aspects of organic production, and it may be pertinent to ask whether it is because there are so few differences? Is there any more to consider than leaving the sprayer in the shed?

The aim of this article is to consider the requirements of organic production, and highlight some of the machinery which has been developed solely with organic producers in mind. There have also been some machines developed for specific farming situations, which are also ideally suited for use in organic systems.

Definitions of organic farming

However, before looking in detail at the equipment, it is essential to consider what is meant by organic farming, and also to examine some of the standards which have been set to underpin the definitions.

Someone well-versed in organic literature reviews once announced that there were over a dozen different terms used to describe organic farming. These included non-chemical, conservation, ecological, biological, biodynamic and sustainable. However, all are open to interpretation and therefore further definition is required. The United States Department of Agriculture has a succinct definition, which most organic practitioners would admit is not too wide of the mark.

Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilisers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic farming systems rely on crop rotation, crop residues, animal manure, legumes, green manures, off-farm organic wastes, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests.

A broader embrace of the principles and practices of organic production has been published by the International Federation of Organic Agriculture Movements. These are listed in the panel above.

Principles of organic production

- to produce food of high nutritional quality in sufficient quantity;
- to work with natural systems rather than seeking to dominate them;
- to encourage and enhance biological cycles within the farming system, involving micro-organisms, soil flora and fauna, plants and animals;
- to maintain and increase the long-term fertility of soils;
- to use as far as possible renewable resources in locally organised agricultural systems;
- to work as much as possible within a closed system with regard to organic matter and nutrient elements;
- to give all livestock conditions of life that allow them to perform all aspects of their innate behaviour;
- to avoid all forms of pollution that may result from agricultural techniques;
- to maintain the genetic diversity of the agricultural system and its surroundings, including the protection of plant and wildlife habitats;
- to allow agricultural producers an adequate return and satisfaction from their work including a safe working environment;
- to consider the wider social and ecological impact of the farming system.

International Federation of Organic Agriculture Movement

Organic farming standards

Over recent years several organisations in Europe have developed sets of standards by which the methods of organic production can be judged. These standards guide the producer, for example by defining practices which are or are not acceptable, and those producers who are judged by the organisation to be able to meet the standards are awarded a symbol which can be used to market the organic produce. Produce with a symbol gives the consumers an assurance that they are buying the real thing, and not just an individual's view of what is organic. Standards and symbols also give retailers the confidence that they are selling what their customers want.

What then, are the criteria used to set the standards? It is impossible to summarise a fairly lengthy document with standards on all aspects of food production and processing, but a few examples may indicate the scope and level:

The most widely accepted standards were those of the Soil Association, but in order to provide nationally agreed standards in 1987, the government set up the United Kingdom Register of Organic Food Standards. These were published in 1989. The consumer, therefore, should now be satisfied that any food meeting the UKROF's requirements is truly organic.

- the feeding of ruminants must contain at least 60% (by dry matter weight) either fresh green food or unmilled forage;
- no herbicides are permitted for weed control;
- no chemical treatments are approved for crop storage;
- no additives are permitted for silage;
- rotations are required to maintain fertility and to control weeds, pests and diseases.

Crop rotations are the key

Rotations are the key to organic production. A successful rotation maintains the fertility of the soil, helps control the weeds, min-

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imises crop pest problems, and reduces risks to livestock health. There are few successful all-arable rotations, and at least one ley is included in commercial rotations, which are typically a minimum of 7 or 8 years. Two examples are given in the panel.

Each rotation has a balance of exhaustive crops, cleaning crops and fertility building crops.

Typical organic crop rotations

Winter wheat	3 year ley
Potatoes	Winter wheat
Oats	Winter wheat (undersown ley)
Swedes	Hay
Barley (undersown ley)	Winter wheat (u/sown green manure)
Grazing	Spring cereals (undersown ley)
Hay	
Grazing	

Machinery for organic farming – generally as for a conventional system

The machinery involved in an organic farming system may not be substantially different from that in a conventional system, but there are factors which require the detail of each mechanised operation to be considered.

– Soil cultivations – shallow turning, deep loosening

Care of the soil is intrinsic in organic systems, from both a structural and nutritional viewpoint.

To prevent leaching of nutrients and erosion, the soil should have vegetative cover for as long as possible within the rotation, and green manures are often used to achieve this, as indicated in the second rotation outlined above. Primary cultivations therefore need to be able to bury vegetation in a shallow depth of soil, to avoid disturbing the biological activity and soil aggregate stability (Lampkin, 1990).

Shallow ploughing is one possibility, but this is virtually impossible at depths of 100-120mm. Minimum tillage implements could also be used. These have the added advantage of reducing energy use, but also may lead to an increased pest and weed problem. Neither of these techniques helps overcome the effects of soil compaction at lower depths.

The concept of shallow turning and deep loosening has led to the development of the Weichel Rotorgrubber, initially for organic producers. This machine, shown in Fig 1, has a series of blades fitted to a pto driven rotor for shallow cultivation, combined with a number of subsoil tines for deep loosening. Similar effects may be achieved by other implements, for example a shallow plough with subsoiler tines, or a combination of implements.

The introduction of the ban on straw burning (which, of course, is a prohibited practice for organic production) is leading manufacturers to produce straw incorporation equipment. Much of this may well be suitable for the organic producer, who is always incorporating substantial organic residues of some kind. The shallow incorporation of residues also has implications for seed drill performance.

Organic crops rely on good root systems for their nutrients, and strong root systems require a well fissured subsoil, which can be provided by implements such as the Paraplow, now no longer in production, and the McConnel Shakeaerator. Both of these are machines developed for conventional agriculture, but because their concept of operation is to improve soil structure, they are of value to the organic farmer.

Rotavators are widely used in horticulture and their use is often advocated in organic systems to control weeds by frequent passes over the soil. However, their major drawback is the damage to soil structure and the impact on beneficial soil organisms, particularly earthworms. Where pto powered secondary cultivations are required the stirring action of the power harrow is to be preferred.

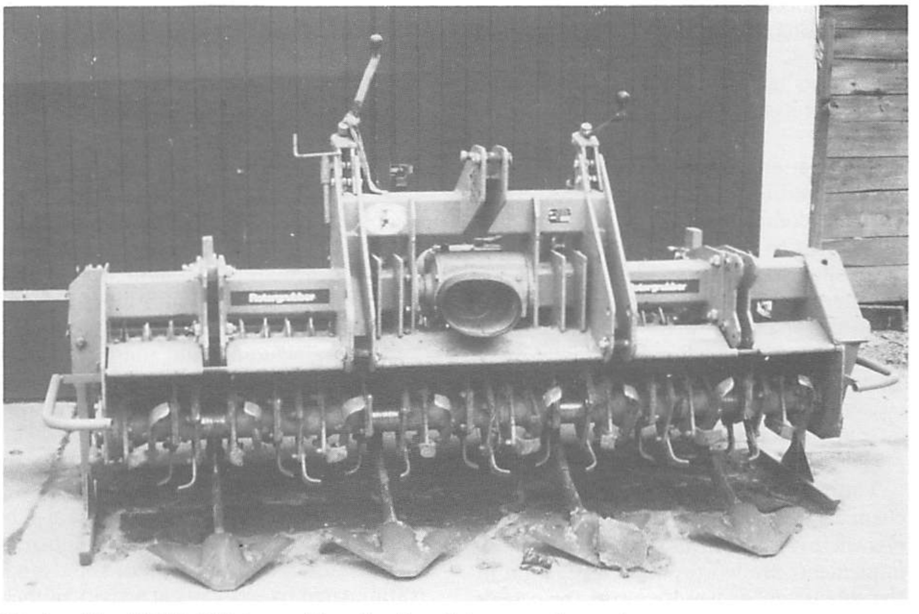

Fig 1. The Weichel Rotorgrubber developed for organic producers.

– Maintaining soil fertility

Artificial fertilisers are not used in organic systems, so the major input to the soil is from organic manures and slurries. As slatted floors are not in favour for organic livestock, the major input is from farmyard manure (FYM) rather than slurry.

To avoid leaching losses FYM should be spread in the late winter or spring. An even distribution from small sized pieces should be the aim, for more effective uptake of nutrients. The muckspreader design is important here, and those with blades which can effectively shred the muck will be more successful at achieving the desired result. Again, Weichel, a German firm, has considered the needs of the organic producer with its rear discharger spreader. The ECON side-discharge spreader can also produce a fine, even distribution.

One field technique for quick FYM incorporation into the soil is to use a side-discharge spreader running on unploughed land to run behind the plough and spread onto the ploughed area for subsequent harrowing in (Lampkin, 1990). However, this technique may impose severe restrictions on work-rates unless the operations have been carefully planned.

The aim of organic producers is to manage their manure effectively, and to compost where possible. Well composted material should be easier to spread evenly. A wide range of materials can be composted, and the aims of composting, which is a biological process, are to improve the carbon to nitrogen ratio, which gives more effective uptake of available nutrients, and improve the structure of the composted material for more consistent spreading.

Management of composted windrows requires control of moisture and aeration. Muck heaps exposed to rain and which are not turned do not achieve their potential nutrient value, due to leaching and denitrification losses. There is also the possibility of pollution problems.

Few farmers can afford to store manures under cover, and inexpensive specialist turning equipment does not exist. However, the use of front loaders for turning and aeration, and plastic sheeting to control moisture and prevent leaching can contribute to effective management.

Rock dusts and crop foliar feeds are also permitted inputs, which require the use of fertiliser spreaders and sprayers.

Pest control and weed control – some special machines and techniques

There are a number of permitted sprays for pest control, some of which require the operator to be certificated under the FEPA regulations.

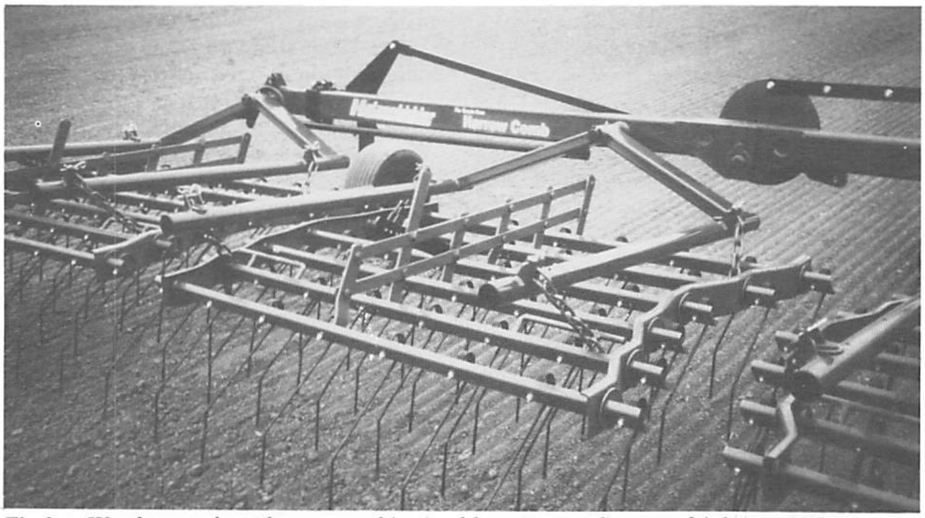

Fig 2. Weed control – the sprung thin-tined harrow can do a good job in cereals.

The control of weeds is an area in which there has been the most activity in developing and using machinery specifically designed for organic crop production. Lampkin (1990) sets out how the rotation plays an important role in the weed control strategy, by:

- alternation between autumn and spring germinating crops (and their respective weed complements);
- alternation between annual and perennial crops e.g. cereals and leys;
- alternation between closed, dense crops which shade out weeds, and open crops which encourage weeds;
- introduction of a variety of cultivations and cutting or topping operations (in particular the traditional cleaning crops, leys and green manures).

The wide range of machinery for non-chemical weed control is described in detail elsewhere (Parish, 1990a) but the more novel implements are worthy of investigation in the discussion of weed control for cereals and for row crops.

Various husbandry techniques used to help suppress weeds in cereals include using higher seed rates and taller strawed varieties to out-compete weeds, and timing the sowing operation to avoid peak weed competition.

Harrowing across the crop is an established technique, if timed correctly from crop growth stage and soil moisture considerations. Blind harrowing just prior to crop emergence, or harrowing the established crop after the three leaf stage are accepted techniques.

Although traditional drag or chain harrows can be used, a new generation of sprung, thin-tined harrows are now produced by several manufacturers. These have at least two banks of tines with approximately 5cm between adjacent lines. On some models the tine tension can be adjusted to modify the effect of the tine action. One example of this type of implement is shown in Fig 2.

In some parts of Europe inter-row hoeing in cereals is a common technique, but accurate drilling is required with unconventional row spacings. One method is to sow in 80mm rows, with gaps of 220mm for the hoe and around 320mm for tractor tyres, with the overall seed rate about 10% higher than normal, allowing for some crop damage.

Inter-row cultivations have been traditionally used in row crops, and although at one stage the success of herbicides reduced the use of hoeing implements, the current cost of herbicide programmes in some conventionally grown crops is leading to renewed use of a wide range of cultivators.

The designs of cultivators fall into several categories, including rigid and sprung tines on parallelogram linkages, ground-driven rolling cultivators, pto driven rotor blades and brush weeders.

The choice of implement depends on many factors, not least cost and work-rate. However, damage to the crop must also be considered in terms of both leaf and root damage. Indeed, the growth of some crops is stimulated by mechanical activity in their root zone, but for others it could be fatal. Crop protectors are available on many implements to protect the plants from mechanical damage, which can lead to disease problems, and from ingress of soil which can reduce the crop quality. The accuracy of hoes is crucial when considering work rates and effectiveness. The direction of mid- and front-mounted hoes is easier to control than those mounted at the rear, although for these it ought to be possible to design a guidance system to allow for their accurate high speed operation.

The rolling cultivators are more versatile in their ability to be used for directing soil either into or away from the crop rows. They can be used to ridge up, or cut down ridges, and their working effect on the soil can also be beneficial for aeration and water infiltration.

A new machine – the brush weeder

The newcomer to the scene in the last decade is the brush weeder (Fig 3) from the Swiss company Baertschi. This machine consists of a number of polypropylene brush discs, which are fitted onto a pto driven shaft in modules whose width matches the crop row width. The rotation of the brushes, working up to a 50mm depth, sweeps the weeds out of the soil, and brushes the soil off their roots.

A major advantage of the brush weeder is its ability to work effectively in adverse soil conditions in which other inter-row cultivations could not be used. The drawback is the slower rate of work. The effect of the brushes depends on the ratio between their peripheral speed and the forward speed of the implement, and the optimum ratio depends on the weed growth stage (Pedersen, 1990). The crop plants are protected from the brushes by long tunnels, and it is possible for the brushes to work close to the crop without causing damage to the plants.

Flame weeding for pre-emergence treatment

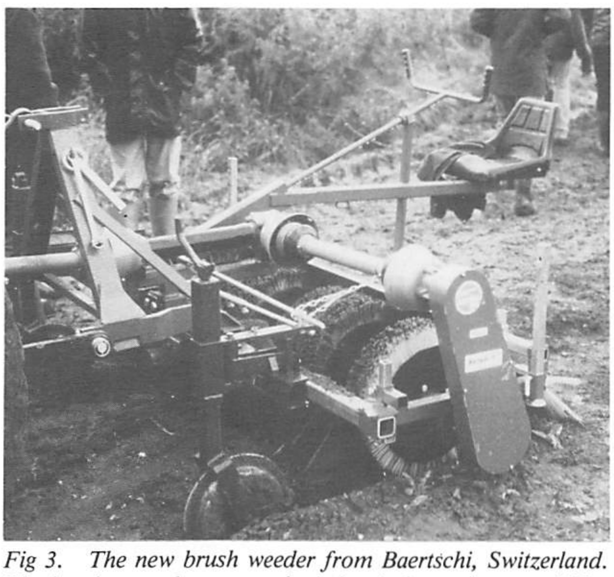

Fig 3. The new brush weeder from Baertschi, Switzerland. The brushes can be arranged on the shaft to suit row widths.

Flame weeding is a technique for weed treatment pre-emergence of the crop. The aim of the operation is to expose the weed seedlings to sufficient heat, just prior to crop plant emergence, to inflict cell damage which causes the plants to wither. A temperature of 100°C is fatal for most plants, although there are a number of resistant weeds. Some crops are also resistant to heat at specific growth stages, and the post-emergence treatment of maize is a common practice.

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Biomass Handbook

Eds Osamu Kitani & Carl W Hall
Publ Gordon & Breach, Science Publishers, N.Y. Price $349 876 pp
ISBN 2-88124-269-3

The preface begins with a sensible explanation of the term biomass and goes on to claim that the Handbook provides readers with a comprehensive and new knowledge of biomass and related systems. Certainly it appears to be comprehensive insofar as a single reviewer can judge the wealth of material contained. It is not easy, however, to find anything new. Indeed, a book of this nature is not the place for revelations. Appropriately, however, each chapter concludes with a lengthy list of references, enabling the reader to pursue his detailed interests to greater depth.

The book is well structured, comprising sections on the production, conversion and utilisation of biomass and on biotechnical aspects, statistics and some physical properties. After dipping into those subjects in which one has some knowledge, one feels that here is a valuable compendium which will be an excellent source of reference for newcomers to the Biomass field, or to those wishing to specialise in some aspect and requiring a firm base on which to build their work.

Where it is appropriate, there is a basic explanation of the physics (particularly thermodynamics), chemistry, biology and biochemistry of 'biomass' materials. Large quantities of tabulated data of every sort provide a valuable numerical foundation for potential users of the book. The section on Biomass Utilisation should prove to be particularly useful for the student who is relying on serandipity to guide him towards a useful research topic: the 'six Fs' of Food, Feedstuffs, Fibre, Feedstock, Fertiliser and Fuel are all covered in such a way as to whet even the most unimaginative appetite.

The editors have given thought, not only to the definition, specification and use of biologically renewable energy sources, but also to the vital, if somewhat more peripheral, matters of densification, packaging, transportation and storage.

A wealth of information is given on biomass conversion by microbiological, enzymatic, thermal and chemical means. The development is discussed of single cell proteïn production from yeasts. Biomass conversion into food is a theme taken up with even greater vigour elsewhere in the book, where more conventional food production such as cereals, vegetables, fruits and forages for animals are introduced.

Biotechnology, in the context of biomass conversion, deservedly receives a whole section to itself; cell fusion, genetic modification and biocatalysis all being introduced. Bioreactors for batch and continuous operation are mentioned, as is the fascinating concept of 'artificial photosynthesis'. The emphasis on hydrogen and oxygen production from water perhaps conflicts with the use of the word synthesis, but each specialist has his foibles!

Altogether, this is a most useful and wide ranging book, which, to my knowledge, has already proved its value to a number of students of agriculturally related disciplines. Its high price may deter some librarians from considering it for their shelves, but I would regard it as a very desirable addition where readers require a starting point, a launching pad, for almost any study of biomass development and application.

BCS

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available in several European countries where organic vegetable production is more widespread than in the UK.

Most flame weeders are fuelled by liquefied petroleum gas (LPG) and aim the flame from the burner towards the ground at an angle of about 45° from a height of 100 to 150mm. Infra-red type equipment, which relies on heat radiation rather than flame contact, is now considered to be less effective. The flame contact machine designs are now becoming more sophisticated with purpose designed burners, pilot flames for headland turning, and shields to add the effect of radiant heat to the flame contact, and to help keep a stable flame in windy conditions.

For optimum effect the flame weeding operation needs to be carried out as close to crop emergence as possible, and timing is critical as a late treatment may adversely affect the crop.

A possible option – avoid returning weed seeds to the soil

Some farmers are trying to address the problem of returning weed seeds to the soil from the combine harvester. After all, if the weed seed has been separated from the crop, why return it to the soil? On modern combines the ability to bag off weed seeds has been lost, but one option suggested is to attempt to harvest with a closed bottom sieve, thereby collecting all threshed seed, which would then require dressing before going into the store. Whole crop harvesting is another alternative by which weed seeds would be removed from the field by the harvesting operation.

Other machinery requirements

One of the challenges of organic production is that there are no copy book answers and new ideas are being tried which pose their own particular problems. One example is the mixed cropping of cereals and grain legumes, which need to be selected so that they mature at the same time and can be harvested together. The challenge here is the combine harvester performance.

Grassland plays on important role in organic farming systems, and clover is integral to the fertility. The successful establishment of a clover/grass mix has been developed at the Scottish Centre for Agricultural Engineering using a combined drilling and broadcasting technique. This, together with the SCAE strip seeder for improving established leys, is an example of techniques suitable for organic production already being developed for conventional farming situations.

An AFRC report by Patterson and Bottoms (1986) has identified other potential developments in machinery for organic production, and the requirements for buildings have also been discussed elsewhere (Parish, 1990b).

Conclusions

The machinery requirement of organic production is not just a case of turning the clock back 40 years. There are many examples of machines developed specifically with organic production in moind. However, the manufacture of equipment solely for the organic sector is unlikely to be economically viable and therefore any development should also benefit conventional producers.

On the other hand, there have also been developments for the conventional farmer and grower, which enhance the principles of good husbandry, and are therefore adopted enthusiastically by organic producers.

With the environmental constraints outlined by O'Callaghan (1991) there is also scope for agricultural engineers to develop equipment to match the more stringent controls on pollution and animal welfare, which would also be welcomed by the organic sector.

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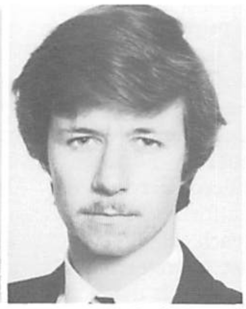
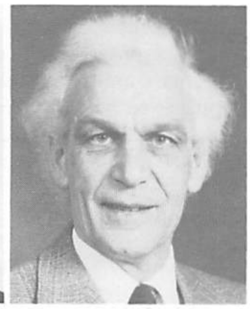
A fluid-driven rotary atomiser for the controlled drop application of herbicides by knapsack sprayers

C S Parkin, I P S Craig, J J Spillman

C S Parkin



I P S Craig



J J Spillman

With the growing concern over environmental and operator contamination from standard hand-held equipment, there is increasing interest in rotary atomisers for the controlled drop application of herbicides.

The current electrical drive systems are more complex and less adaptable than the standard knapsack sprayer and lance fitted with an hydraulic nozzle.

A new rotary atomiser has been developed that uses spray liquid pressure as its power source.

The specification

The atomiser was designed to provide a volume rate of 40 l/ha with a drop spectrum suitable for herbicide CDA using the spray liquid as a fluid drive. This required the atomiser to produce a drop spectrum with a Volume Mean Diameter (VMD) around 250 μm, (the accepted value for herbicide CDA) with a Volume Median Diameter/Number Median Diameter ratio less than 2. This would produce a deposit with a mean theoretical deposit of 40 drops/sq cm.

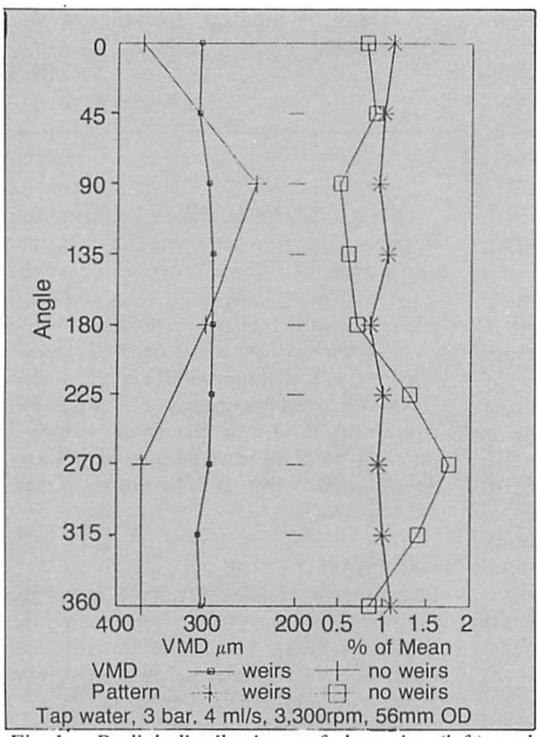


Fig 1. Radial distributions of drop-size (left) and volume (right) from a fluid-driven rotary atomiser operated with and without weirs.

A typical forward speed of 1 m/s, and a treatment width of 1-1.5m were assumed. A minimum orifice diameter of 500 μm was chosen on grounds of practicality. Diameters smaller than this have been shown to be prone to blockage.

With this specification a successful design should offer the advantages of CDA

- less spray drift,
- greater productivity through lower volume rates,

without the requirements of electric drives.

Dr Steve Parkin is Senior Lecturer in Agrochemical Application Engineering at Silsoe College, Cranfield Institute of Technology.

Dr Ian Craig is a Research Officer at the International Pesticide Application Research Centre, Imperial College, Ascot.

Professor John Spillman is Emeritus Professor of Applied Aerodynamics, College of Aeronautics, Cranfield Institute of Technology, Cranfield.

**Paper presented at Institution's Forestry Engineering Specialist Group, 5 Sept 1991.*

Design and performance

The design of the atomiser required the optimisation of the conflicting requirements of drive efficiency and spray application. The power available was limited because of the need, firstly, to restrict the flowrate to values suitable for spray application without liquid recirculation, and, secondly, to restrict jet velocities because of the minimum orifice diameter of 500 μm.

The atomiser consists of a 55mm diameter drum incorporating a Pelton Wheel drive mechanism. The drum diameter, and other main design features, were optimised as the result of experiments with a series of prototypes and the development of a semi-empirical model (Craig, 1991). A single jet of liquid strikes the internal face of the drum causing it to rotate, on miniature ball-bearings, between 2000 and 3000 rpm.

An even peripheral liquid distribution is required to provide a narrow drop spectrum. This even distribution is provided by a complex series of internal weirs. The value of these weirs to drop-size performance is indicated in Fig 1 where the performance of the atomiser with, and without, the weirs is shown.

Through a series of grooves and teeth at the drum periphery (Fig 2) the required drop-size spectrum is produced. The value of this system can be seen in Fig 3 where the drop-size performance without teeth and grooves, is compared with the performance with teeth and grooves.

The drop-size spectra were measured by a PMS laser optical-array probe (Parkin *et al,* 1980). The optimum design had Volume Median Diameters (VMDs) between 200 and 300 μm. As can be seen in Fig 4, within the normal knapsack sprayer operating range of 200-500 kPa, drop-size performance did not vary significantly.

Although increasing pressure increased rotational speed, it appears that the corres-

The fluid-driven rotary atomiser in use.

ponding increase in output also increased ligament diameter, thus providing a compensating effect. Only a small reduction in drop-size performance results, as shown by the increase in VMD/NMD ratio. Thus a close control of supply pressure is not required in order to control drop-size.

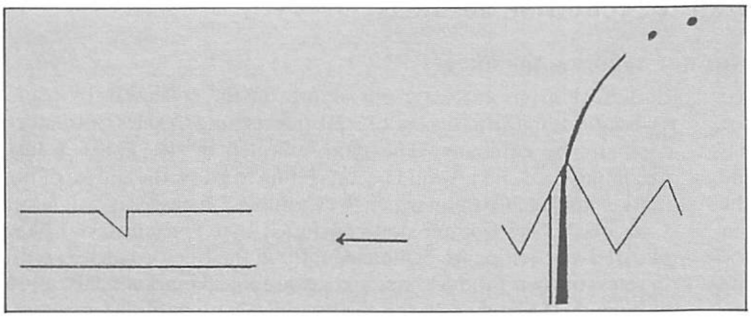


Fig 2 Detail of tooth and groove design on fluid-driven rotary atomiser.

The spray band-width was measured, using water-sensitive paper and an Optomax V image analysis computer. It was found to be 1.2m giving typical volume rates of 30-40 l/ha.

The drift potential of the fluid-driven rotary atomiser is compared with a conventional hydraulic nozzle in Table 1. As can be seen, there is less drift potential at a lower volume rate with a comparable VMD. This should provide lower operator and environmental contamination.

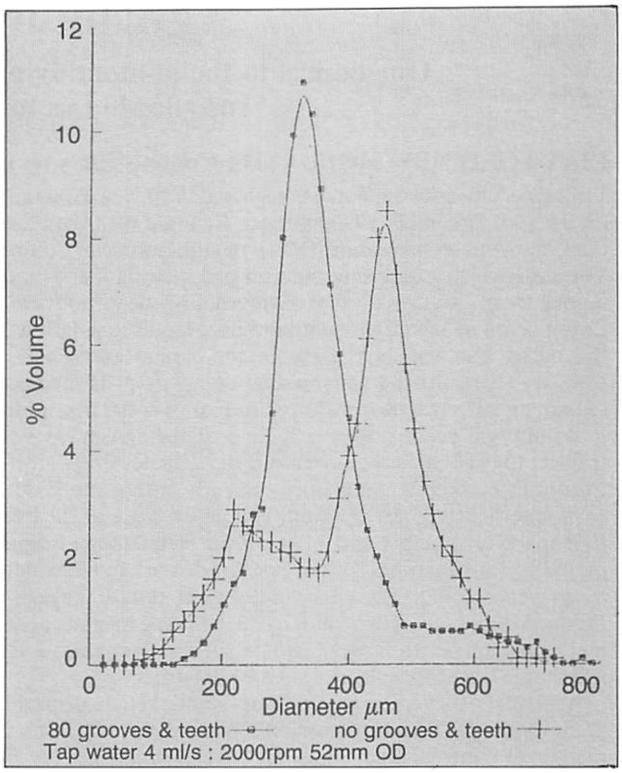


Fig 3 (right) Drop-size performance of a fluid-driven rotary atomiser with and without teeth and grooves.

Table 1. Comparison of drift potential between a conventional knapsack and a fluid-driven rotary atomiser.

	Rotary atomiser	*Hydraulic nozzle*
Type	Fluid-driven	80015 flat fan
Volume Median Diameter µm	240	234
Driftable Fraction Volume < 100 µm	0.3%	6.6%
Pressure	2.5 bar	2.5 bar

Potential for greater productivity and reduced spray drift

It appears that fluid-driven rotary atomisers offer the prospect of CDA herbicide application using conventional knapsack equipment. This should provide greater productivity and reduced spray drift without the use of electrically driven equipment, thus providing a flexible application system.

A device suitable for production and extended field use is now being developed in conjunction with a manufacturer.

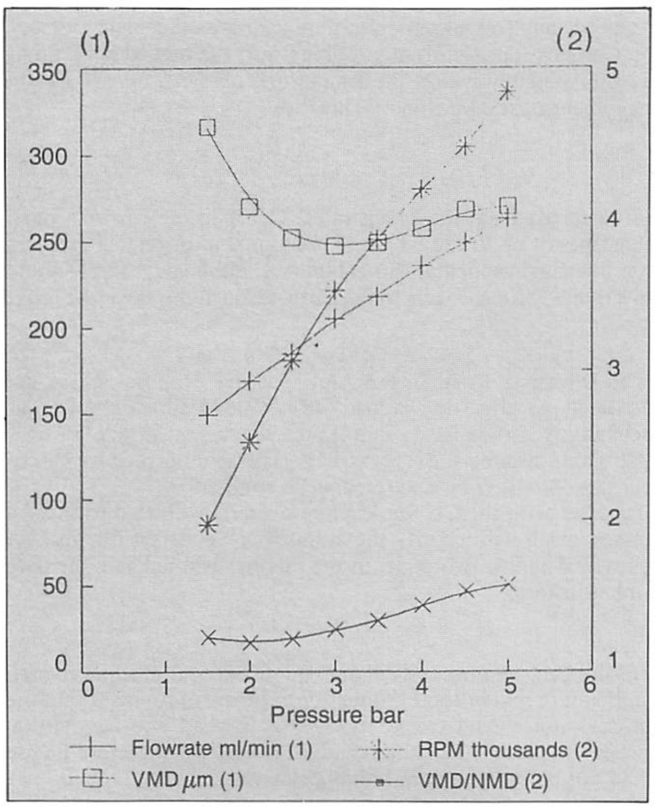


Fig 4 (left) Performance characteristics of a fluid-driven rotary atomiser.

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Parkin C S, Wyatt J C, Wanner R (1980). The Measurement of drop spectra in agricultural sprays using a Particle Measuring Systems optical array spectrometer, *Proc British Crop Protection Council Symposium,* Spraying Systems for the 1980s, Monograph, **24**, 241-249.

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Agricultural Machinery Law

Our thanks to the bi-monthly publication, *Farm and Garden Machinery Law* for allowing us to reprint the following abstracts:

FIAT-FORD NEW HOLLAND : Commission's reasons for not opposing the merger

The agreement between Fiat Geotech and Ford New Holland signed on the 19th December 1990 has been finalised with the blessing of the Competition Directorate (DG IV) of the European Commission. The deal which effectively places Ford New Holland under the management control of Fiat Geotech had been notified to the Commission in accordance with the EC Merger Regulations. From the outset Fiat will hold 80% of the capital and 100% of the ordinary shares of the new holding company N H Geotech. The remaining 20% will be transferred to Fiat over the next four years.

Within two years from the signing of the agreement Ford will transfer to N H Geotech, its 'European Affiliate Assets', ie its seven European marketing companies currently within the Ford Motor corporate structure. In addition, Fiat gets the use of the Ford oval trademark on tractors and of the Ford New Holland signs for a period of four years and of the Ford trademark in block letters for a ten year period. Ford has undertaken not to engage in the production and sale of agricultural and industrial tractors, agricultural machinery and earth moving equipment for five years – a period which one might have expected to be longer.

At a time of severe contraction in the market, structural change is inevitable but the Commission's reasons for not opposing the merger are interesting. First, they were satisfied that there is sufficient competition from other companies in the market for the acquisition not to result in the group holding a dominant position. However, the decision concedes that Fiat will have 24.6% of the total European tractor market (44.1% in Italy, 22.8% in France and 21.5% in the United Kingdom) and 34% of the EC market in combine harvesters. These figures are large enough but nobody is in a position to verify whether or not they are accurate because the Commission has currently put a stop on the collection by trade associations in the industry, of statistics relating to sales of tractors company by company. The data collected in the 1980s is fast becoming stale and it would be interesting to know the source of the market intelligence upon which the Commission based its estimates.

Secondly, the Commission concluded that Fiat and Ford New Holland's activities are complementary in the tractor market, both in terms of their product lines and geographical market penetration in individual Member States. Geographical compatibility is understandable (Fiat are strong in Italy, Spain and France: Ford New Holland in the UK, Denmark and Ireland) but both are producers of the main horse power models used in conventional farm work. A year ago a Fiat dealer would have had great difficulty in persuading his supplier that he wanted to sell Ford tractors on the grounds that the products from the two companies were 'complementary'.

As quid pro quo for the Commission's agreement to the deal Fiat have had to loosen their links with Federconsorzi (Fedit), the main agricultural marketing agency in Italy. This may create a more open environment for competitors but they will have to be very quick on their feet, especially as the Italian market is currently dwindling.

Finally, a quote to remember from the published decision. When talking about prices paid by farmers for combine harvesters the Commission says: "In addition, while some variation exists in the list prices of individual suppliers in different Member States, effective net prices charged to dealers and ultimate customers are broadly similar". In another context, this is a point which the industry has long been trying to get the Commission to accept.

The Decision was notified in OJ C 118/14 – 3rd May 1991.

Eurosafety standards : differences in trailer braking requirements

Mr Manfred Vohrer MEP (Germany LDR) asked the Commission if they were aware that, in France, trailers of agricultural vehicles may be fitted with a hydraulic brake as well as with an overrun brake, whereas German farmers are prohibited from using this safety device by national law, although it is more efficient compared with a subsequently installed air brake? Since, as a rule, tractors are already fitted with hydraulic systems, would this provide not only a safer but also a cheaper solution?

Commissioner Bangemann replied on behalf of the Commission:

"The Commission is aware of the situation in France and Germany with regard to the braking systems of agricultural trailers. While Community rules already exist for wheeled agricultural and forestry tractors, there are no such rules for agricultural and forestry trailers, or indeed, any sort of agricultural machinery other than tractors. The Commission is currently looking into the best way of filling this gap, possibly within the framework of the proposal for the amendment of the Machinery Directive".

Health and Safety fines : proposals to raise level of penalties

Proposals before Parliament will increase the maximum fine in a Magistrates' Court for a health and safety offence from £2,000 to £5,000. Also the Health and Safety Executive is being encouraged by the Government not to hesitate to ask that the more serious cases be transferred from the Magistrates' Court to the Crown Court. There fines of up to £20,000 have been known for related offences under the Environmental Protection Act, although readers should know that when a case gets to the Crown Court, the sky is the limit.

CE Mark of Conformity : conditions of use

The Commission Proposal for a Regulation concerning the affixing and use of the CE Mark of conformity on industrial products has been published in the Official Journal (OJ C 160/14. 20 June 1991).

The CE Mark has the purpose of signifying that the product on which it is displayed conforms to all the relevant Community Directives which apply to it. The Proposal says that the mark must be fixed 'visibly, legibly and indelibly'. The Mark should also be 'at least 5mm in height'.

The Directives listed in the Annex to the Proposal which are most likely to affect the industry are: 89/392/EEC – safety of machinery; 87/404/EEC – simple pressure vessels; 89/106/EEC – construction products; 89/686/EEC – personal protective equipment; 89/336/EEC – electromagnetic compatibility.

Together with the CE Mark manufacturers will need to show a number which will identify the authority responsible for product approval. The last two digits in the number will indicate the date of manufacture.

Cadmium ban : as protective coating

An EC Directive has been approved which bans the use of cadmium as a protective coating on metal surfaces. The Directive (91/338/EEC) is in the form of an amendment to the Dangerous Substances and Preparations Directive (76/769/EEC). The Annex to the new Directive lists the many industrial uses of cadmium to be prohibited, amongst which are equipment and machinery used in agriculture and in food production. The only proviso is that the ban does not extend to 'safety devices in road and agricultural vehicles' – para. 3.3 of the Annex. Presumably therefore its use would not be prohibited in braking systems.

European patents : How to apply

In 1990 the European Patent Office received 62,800 patent applications (10% more than 1989). The expected filings for 1991 is approximately 69,000. The EPO started in 1978 with the expectation that filings would be a mere 40,000 per annum. A leaflet explaining the process through which European Patents may be obtained has been issued in English. If you would like a copy, write to: *European Patent Office, Erhardtstrasse 27, W-8000 Munich, Germany. Tel: 010 49 23990. Fax: 010 49 89 2399 4465.*

Machinery Directive – 89/392 EC : Problems with rights to challenge safety requirements conformity

Each Member State in the EC will have the right to challenge the conformity of a machine to the essential safety requirements (ESRs) of the Machinery Directive as expressed in national legislation. It is likely that while a machine is being investigated all machines of the same make and design will be withdrawn from the market.

To prevent this procedure from becoming a means of protecting home markets the decision on conformity will be taken by a specially constituted committee. What some manufacturers and concessionaires fear is that attempts will be made to query the safety of machines for strategic marketing purposes and that by the time the committee has given the product a green light, as many as six months' sales may have been lost.

The obvious way to prevent safety officials from being too precipitant in the imposition of a restriction on the entry of imported machines is to require the manufacturer to be given reasonable compensation for his loss of market during the interim period before the committee gives its verdict. The problem is the converse of this argument, namely the Member States would see the entitlement to compensation acting as a disincentive on officials in the proper exercise of their judgement. Furthermore, real difficulties could arise in assessing the level of compensation payable, particularly where the product is new to the market and the amount of take-up is hypothetical.

The result so far is an unsatisfactory impasse but clearly if the powers are used too liberally by an individual State, the other EC Members will need to bring pressure to bear through the Parliament or the Commission.

N.B. It is anticipated that the Mobile Machinery Directive which is an amendment to 89/392 (see FGML Vol 1 No 1) will be published shortly. Essential Safety Requirements will need to be satisfied by December 1995.

COSHH – Hazardous Substances data sheets : Machinery manufacturers not 'suppliers of substances'

Data sheets giving details of hazardous substances held on the premises are a requirement of the COSHH regulations. As a result some manufacturers have been asked by their dealers to provide data sheets for hazardous substances associated with the machines they are selling – eg paints, fuel, oil, inhibiting and hydraulic fluids etc. However, the Health and Safety Executive have advised the industry that machinery manufacturers are not regarded as 'suppliers of substances' in this context.

The HSE have produced a pamphlet which explains the relationship between the COSHH regulations and Section 6 of the Health and Safety at Work Act.

Nevertheless, if hazardous substances have been used and are incorporated into the machine as delivered, there would be an obligation on the manufacturer to mention this fact in the Operator's Handbook. Furthermore, any bulk delivery of hazardous substances to a dealership should be accompanied by a data sheet.

Farm & Garden Machinery Law
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Subscriptions: £40.00 pa (UK). £45.00 (overseas)

Health and Safety: Reducing injuries from handling, lifting, carrying

A three-year campaign to reduce the incidence of back-strain and other musculoskeletal injuries at work – the greatest single cause of absenteeism due to industrial ill health – has been launched by the Health and Safety Executive (HSE). Called 'Lighten the Load', the campaign will be the Executive's biggest-ever drive on a single occupational health issue.

"There is nothing 'normal' about being hurt by work," said Dr Tim Carter, the HSE's Director of Health Policy and Medical Services. "The great need is for people at work to be much more aware of the danger – the potential for accidental injury can be found in almost any workplace.

"Musculoskeletal problems are increasingly widespread," continued Dr Carter. "They include a variety of disorders affecting muscles, tendons, joints and bones, and are caused by bad working practice – especially in manual handling and lifting, in posture and in frequent repetitive movements. The pity of it all is that almost all of this is preventable, and prevention is what the campaign is all about. After all, work done safely means not only less suffering but also that the job is done more cost-effectively."

During the campaign HSE's inspectors, doctors and nurses, when visiting workplaces, will aim to bring together and encourage action from employers, equipment manufacturers and the health and safety professionals to help prevent the occurrence of work-related musculoskeletal disorders.

European Directives due at end of 1992

All aspects of the problem will be studied but each year of the campaign will tend to emphasise particular topics. The first year will concentrate on work-related upper limb disorders. In the second year the introduction of new regulations expected for manual handling and display screen equipment will bring an added focus to the campaign as the result of recent European directives. The theme for the third year will be ergonomic design in the workplace.

Employers and employees will be urged to work together to assess the risks and to prevent the causes of musculoskeletal disorders, drawing on specialist advice where appropriate. Family doctors will be asked to consider the work link of such problems in their patients and, in addition, HSE's Employment Medical Advisory Service will provide health advice to all concerned and help identify sources of specialist advice.

Attention will also be drawn to the services available through Job Centres to those suffering from a musculoskeletal problem which affects their ability to get or keep a job.

Two free booklets have been produced by HSE in support of the campaign. One, for employers, includes advice on why they should be concerned about musculoskeletal injuries caused by work on their premises, on the need to assess the risk and on how to deal with it. The other, for employees, contains guidance on recognising symptoms which may be attributable to work, as well as on who should be informed about them.

A free booklet for family doctors outlines the causes of work-related musculoskeletal disorders, how they arise and what a GP should do. In addition, there is a short HSE video about the campaign. This can be borrowed by organisations wishing to mount their own training and preventive drive.

Concrete waterproofing – a leaked story?

Sir, I am writing to express my concern at the contents of an article in the Autumn '91 edition of the *Agricultural Engineer.*

The article in question appears under the heading of "Pollution" on page 97, and lauds the use of a proprietary product (Xypex) claimed to prevent ingress of polluting materials into concrete structures. The article carries no indicated attribution.

I appreciate that pollution can mean all things to all men, but I would suspect that "pollution" to an Agricultural Engineer brings to mind firstly, slurry/silage effluent and secondly, possibly chemicals depending to some extent in which particular sector of the farming industry he is currently dealing with.

As a previous member of the Ministry's advisory service, and currently a private consultant, I have been and still am totally immersed in farm pollution problems and am always on the look out for methods and/or materials which might be of use in solving them. Currently one of the most pressing difficulties is designing an underground tank to take silage effluent which can be confidently given a 20 year life, without maintenance guarantee.

The article in question inferred that Xypex treatment of concrete could be the answer. However, on contacting the technical support service of the distributors (International Paints Protective Coating Division) I was informed that they were unable to give any guarantee of the treatments' effectiveness against silage effluent (I question whether they really knew what silage effluent was) and would certainly not contemplate a 20 year guarantee, anyway.

I am sure that everybody would agree that it would be foolish not to approach the manufacturers, before using any advertised product, to ascertain its effectiveness under particular defined conditions, but I still feel that the Editorial panel of a professional journal should exercise some degree of control over similar articles which could be misconstrued when examined in an Agricultural Engineering context.

A J Armitage, NDA, ND AgrE, MI AgrE
Consultant Agricultural Engineer
The Little House, 32 Dawlish Road, Teignmouth, Devon TQ14 8TG.

The Hon Editor responds:

We share Mr Armitage's concern about this matter. However, the story he complains of was actually submitted to the *Agricultural Engineer* by the company marketing the product. It appeared relevant to our industry and, subject only to one change of wording (in paragraph two, the company's phrase was 'is ideal'; this was altered to 'is claimed to be ideal'), the item was accepted in good faith and passed for inclusion – space permitting – in the News and Views section. Effectively, that is where it appeared except that in final production the decision was made to put it under a more specific banner of Pollution rather than just News and Views.

Mr Armitage's letter was received only a few days before going to print with this issue. We have passed his comments to the company, Messrs International Paint, at Gateshead and, we have been promised an explanation. We hope to publish their reply in our next issue.

continued from page 107

ground. The PC's system timer interrupt is used to initiate sampling of each of the 256 channels at 110ms intervals. The sampling and storage in memory of the running mean, maximum and minimum values actually takes about 44ms for all channels, allowing the use of the processor for other functions for more than half of the time. Every 5 minutes, the accumulated data are moved to a different storage location, and the running storage area is initialised. The data are stored to floppy disk, again in CSV format, at 5 minute intervals, and the files closed immediately. This is done to avoid damage to the files or loss of the data in memory in the event of any unexpected interruption.

While these processes are running in the background, the user is able to view the data on the screen in raw or engineering units, enable listing to the printer at 5 minute intervals, plot on screen or view on a remote monitor which may be plugged in at various locations around the factory area.

The background tasks are written in assembler, and the foreground, user interface sections in C. On startup, the C code calls an assembler routine which chains the background code into the system timer interrupt. On exit from the program, another routine removes this code from the chain and restores the system so that other software can run normally.

A configuration program allows the user to prepare a logging configuration file. This contains a description of each channel, in terms of sensor type, units of measurement, zero and full scale values together with a short description of the sensor location and function within the process plant.

Two purpose-built systems – may have further applications – for data collection and process control

General purpose computer-based data logging systems have been available for some time, with costs dropping and capacity increasing annually. However, most are designed for high-speed logging of a few channels, rather than collecting data from many channels over a period of a day up to six weeks. It is possible to find systems which will collect 4 channels for extended periods or 64 channels over short periods, but that seems to be about the practical limit.

A custom unit can still be used for general purpose work, but has added development costs. These can be justified in that the final system will exactly fit the logging requirements, and a hardware manufacturing capability is necessary to interface a wide range of sensors to a commercial system.

Two purpose-built systems have been developed in Malawi which may have further applications where many channels of data need to be collected over extended periods of time.

Both systems have capacity which might be used to control the process.

Scott Abbott Arable Crops Station

The RASE and the East of England Agricultural Society have joined forces to develop their services to members in the arable farming sector by establishing the Scott Abbott Arable Crops Station.

George Jackson, deputy chief executive of the RASE, writing in the October 1991 issue of RASE News, explains: "The project is the result of close discussions over a period of several years to identify an area of activity which would provide information to members whose farming systems needed practical, first-hand assessments with an emphasis not just on technological evaluation but on the financial implications of change. The project has been made possible by the collaboration and support of the William Scott Abbott Trust farm at Sacrewell, near Peterborough."

Objectives of this exciting initiative are:

- To evaluate systems and methods of crop production and their application into arable farm systems;
- To develop links with other organisations, in both the public and private sectors;
- To collect, collate and analyse relevant data and information from all appropriate sources;
- To communicate and promote the use of this information into farming practice through a membership scheme restricted to members of the two Societies;
- To undertake commissioned development, including product evaluation.

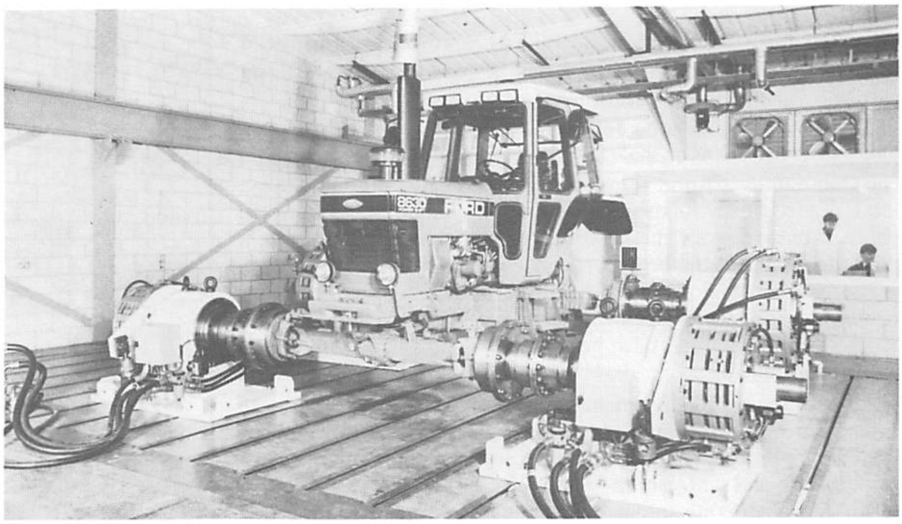
Axle dynamometer is a first for Silsoe

Believed to be the first of its kind in Europe, a new low-speed, high-torque axle dynamometer facility has been installed by Silsoe Research Institute at its Wrest Park headquarters in Bedfordshire.

Designed by Plint & Partners of Wokingham, Berkshire, with brakes supplied by Wichita Co of Bedford, the new dynamometer can be used for any purpose requiring a vehicle to be operated under controlled conditions, with pre-programmed variations in torque at each wheel. It will be used during the Institute's programme of research on tractors and other vehicles, and for carrying out performance tests for manufacturers to standard international codes.

The dynamometer will also be available under contract to manufacturers for performance evaluation or durability testing. As well as agricultural tractors, it will handle any slow-speed axle application for testing the output of gearboxes or geared motors, including heavy trucks, earthmoving vehicles, military and mining equipment, or complete drive trains.

The present tractor performance test under the OECD Code requires a drawbar test on a concrete test track, to determine the power available in each gear. This is time-consuming and expensive, with variable results due to ambient conditions. With the new, housed axle dynamometer, the same information can be obtained more accurately, more reliably and more quickly. Alternatively, actual working conditions can be simulated, with repeatable loading cycles.



and is capable of running at speeds equivalent to at least 40kph (25mph) on the road.

Four water-cooled, air-operated disc brakes are used on the dynamometer. Each rear wheel position can absorb up to 50kNm torque at speeds up to 20rpm, and up to 182kW power at high speeds.

Each front wheel position will absorb up to 32kNm torque at speeds up to 18rpm, and up to 137kW at higher speeds of up to 300rpm. Maximum total power absorption is limited to 250kW. Features include independent computer control of each brake, with fully integrated data logging.

The first research programme planned for the new dynamometer will investigate the integration of engine and transmission controls. This is designed to optimise vehicle efficiency and reduce fuel consumption.

The acquisition and installation of the axle dynamometer has been funded by the Agricultural & Food Research Council

Bioremediation studies in USA

Researchers at the US Department of Energy's Pacific Northwest Laboratory have been studying bioremediation, the use of a natural phenomenon as a remedy, to clean up chemical contamination at Hanford and other DoE sites. PNL is operated by Battelle for DoE.

Laboratory tests, conducted at Hanford, have shown that certain naturally occurring microbes can degrade more than 99% of nitrate contamination in groundwater and more than 93% of carbon tetrachloride pollution. Nitrates and carbon tetrachloride have been used extensively for chemical processing at industrial sites around the world, including Hanford.

If waste-eating micro-organisms are discovered in and around the chemical contamination, it will prove that they can survive and possibly clean up the environment. Scientists and engineers will analyse core samples to determine if existing micro-orgarisms can be stimulated to consume the hazardous waste, detoxifying it in the process. This information will be used to design the next test, which will involve stimulating the micro-organisms 'in situ' within the aquifier to destroy the wastes.

"This is an exciting first step toward field testing bioremediation for the clean-up of groundwater and soil at Hanford," said Thomas M. Brouns, project manager. "We know the process works in the laboratory, and these first samples from a contaminated area are expected to provide information on how to apply this technology in the field."

The drilling, which began in April, is part of the DoE's Integrated Demonstration Programme for Clean-up of Volatile Organic Compounds in Soil and Groundwater at an Arid Site. The programme is designed to consider a variety of technologies to clean up soil and groundwater contamination at DoE sites.

Portions of this contaminated aquifier also contain low-level radioactive waste. Researchers will be experimenting to see how these micro-organisms affect radioactive contaminants. Scientists and engineers believe that the bacteria may slow or stop movement of many radionuclids in groundwater.

Drilling at this site is expected to continue into 1992. DoE and PNL staff hope to begin using microbes to demonstrate clean-up of this contaminated test area at Hanford within four years. Funding for this project is provided through DoE's Office of Environmental Restoration and Waste Management.

NEWS AND VIEWS

New initiatives to link farming and the environment

In recent months two new initiatives have been announced concerned with measures to bring a closer understanding between farming and urban interests:

NCI – New Countryside Initiative – is an expert partnership between ADAS, MAFF, the Countryside Commission, Business in The Community's Rural Enterprise Target Team, and UK2000.

It is headed by environmental regeneration specialists Groundwork, whose extensive work in the country-town fringe has given it a unique insight into the problems and potential.

The NCI's prime aim is to help establish innovative, environmentally sound, farm-based enterprises to revive the ailing urban fringe economy and establish better relationships between farmers and town dwellers.

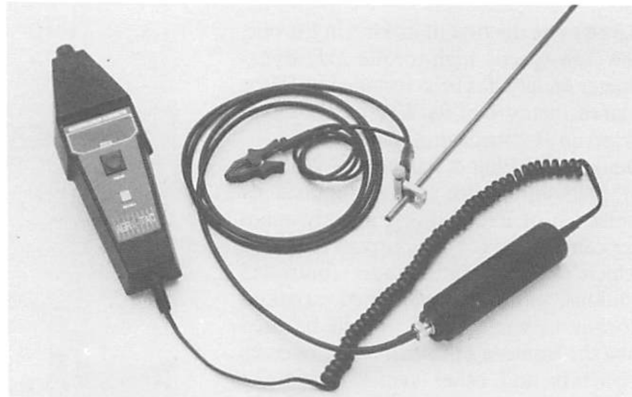
LEAF – Linking Environment and Farming – aims to promote farm practices which combine care and concern for the environment with the responsible and economic use of modern methods to produce safe and wholesome food.

LEAF will operate under the guidance of an advisory board drawn from a broad cross section of organisations involved in agriculture, the environment, conservation of the countryside and consumer affairs, including ADAS, FWAG, NFU, RSPB, Safeway and Sainsbury. The board will select farmers (volunteers) who have the necessary facilities, capabilities and 'desire' to act as 'contacts', to explain to visiting target audiences what they are doing and why they are doing it.

The aim is to have 12 LEAF farms by the end of 1991 but it is hoped that, over the next few years, this number will rise to several hundred.

Further information may be obtained on NCI from: Groundwork National Office, Bennetts Court, 6 Bennetts Hill, Birmingham B2 5ST, tel: 021 236 8565; and on LEAF from: National Agricultural Centre, Stoneleigh, Warwickshire CV8 2LZ, tel: (0203) 696969.

Diesel engine speed monitoring



A low cost, versatile and non-intrusive method of sensing diesel engine speeds – usually without need to stop the operating engine – has been introduced by Compact Instruments. Central to the system is a unique adaptor, developed to operate in conjunction with Compact's widely used range of hand-held digital, optical tachometers and fixed tachometer systems.

The system comprises a small transducer – which is clamped onto an injector pipe at a convenient location – and an in-line signal processing module. In operation, the transducer responds to internal pressure pulses created by fuel being pumped through the injector fuel line; the in-line processor provides a one pulse per revolution output to the tachometer which in turn displays the engine speed in rpm. A steady reading is provided over the standard speed range from approximately 350rpm to 6000rpm ... or even higher for special applications.

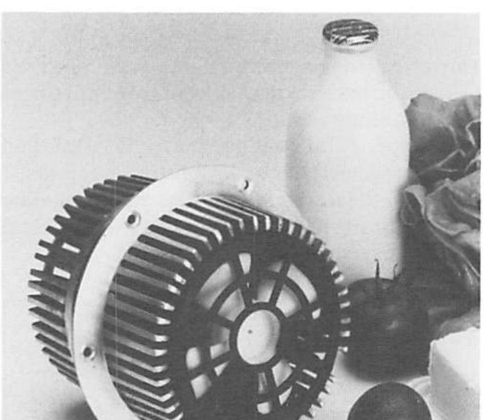
Compact Instruments Ltd, Park Road, Barnet EN5 5SA.

Six thermocouple compatability

New from precision electronics instrument manufacturer Comark Electronics is the uprated C9001 portable, battery-powered hand-held thermometer. The unit is now compatible with thermocouple types R and S, in addition to types K, N, T and J.

As with all Comark C9000 range instruments, the C9001 is certified dust and waterproof to IP67. A wide range of probes is available suitable for surfaces, air, liquids, solids and many other uses.

Comark Electronics Limited, Artex Avenue, Rustington, Littlehampton, West Sussex BN16 3LN. Tel: (0903) 771911.



The innovative 'Coolosan' cooling unit converts any shape of insulated space into a portable, robust refrigerator for transport, boats or caravans and can be used in a variety of industrial cooling applications such as collecting condensation in agricultural research and laboratory testing.

Powered by a standard car battery, the Coolosan does not use CFCs, liquids or gases and is able to cool any space with a volume of up to 60 litres.

Coolosan is available direct from Jepson Bolton & Co Ltd, 22 Conduit Place, London W2 1HS. Tel: 071 402 2806.

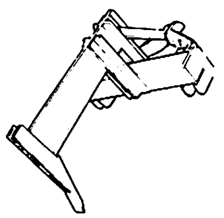
Perfect portions from Cloud One

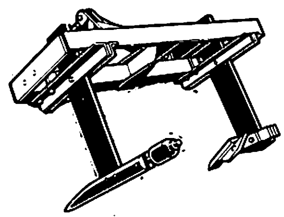
A new, simple-to-use unit dose packaging concept is launched by Cloud One Ltd.

The product, called Cloud, is a water soluble sachet which offers accurate portion/dose control in a convenient, flexible and transparent pack. Manufactured using a new family of Polyvinyl Alcohol (PVA) films, Cloud sachets are safe and hygienic to use and dissolve completely in hot or cold water. They are available in the weight range from only 5g to 25g at a low unit cost and are suitable for a range of powders or crystals for cleaning products, detergents, garden care, cosmetics, fertilisers, pesticides and industrial products. They are completely safe, clean and accurate.

Cloud offers a portion controlled accurate dose mechanism which reduces wastage, allows precise costing and has great potential for a wide range of applications.

Cloud One Ltd, Redkiln Way, Horsham, Sussex RH13 5QH. Tel: (0403) 65544.





ADVERTISERS INDEX

Nitrogen/Pesticides/Environment/Economics/Forestry – topics at forthcoming National Agricultural Conferences

The RASE programme of Conferences to be held in early 1992 at the National Agricultural Centre includes the following events of particular relevance to topics covered in recent issues of this journal:

Nitrogen Management in a Changing Environment:	Wednesday, 29th January, 1992
Stimulating the Rural Economy – New Approaches:	Wednesday, 5th February 1992
Pesticides in Water:	Wednesday, 19th February 1992
RICS Environment Conference:	Wednesday, 4th March 1992
Forestry in the Dark (the future in the lowlands):	Thursday, 5th March 1992

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Scottish Branch Conference

TRACTORS FOR TOMORROW

Wednesday 12 February 1992
at the James Watt Centre, Heriot-Watt University, Edinburgh

Chairman: Mr Charles Russell, Muirton Farm, North Berwick

The role of the tractor — Mr Alec McKee, General Sales Manager, John Deere Ltd

Developments in tractor transmissions — Prof Dr-Ing Karl Th Renius, Technical University of Munich

The suspended rubber track (SRT) tractor — Dr Andy Scarlett, Silsoe Research Institute

Lunch and video presentations

The development of the FASTRAC — Mr David Brown, Chief Engineer, JCB Landpower Ltd

Controls and electronics — Mr John le Page, Hydra-Tronic Services, Livingston

Tractor finance — Mr Brian C Tipper, Business Management Services, Cotgrave, Nottingham

Panel discussion

Closing remarks — Mr Douglas M Walker, President of the Institution of Agricultural Engineers, Managing Director of John Deere Ltd

Further details from the Conference Convenor:

Alastair Hunter
Scottish Centre of Agricultural Engineering
Bush Estate
Penicuik
EH26 0PH
Tel. 031 445 2147; Fax. 031 445 2778