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Incorporating Soil and water

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Journal and Proceedings

Contents

Front Cover: The new Caterpiller Challenger 65 tractor, See also page 64

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A comparison of the rolling resistance of single, tandem and dual wheels

A L Stadie, J R Dawson, N V Nguyen

Two experiments on the rolling resistance of towed wheels are described.

The first experiment was a comparison of a large single tyre with two smaller tyres in dual and then tandem formation at three vertical loads. The rolling resistance of the tandem axle was about 10% lower than for the dual arrangement. There was negligible difference between the large single and dual tyres.

Further studies with the tandem axle were then carried out to determine the effect of varying the load distribution on the front and rear tyres. The results show that the lowest rolling resistance was achieved with the load distributed almost evenly between the two tyres. There were indications that a slight bias towards more weight on the rear wheel may be beneficial.

Tyres for undriven wheels, such as those on trailers and implements or the front axles of two-wheel drive tractors, should be designed for minimum rolling resistance to minimise the energy wasted in overcoming motion resistance. On hard surfaces the effect of high rolling resistance is purely an inefficient use of power; on soft surfaces severe mobility problems can also occur. If this is the case then the ruts caused by wheeled machines will damage the soil structure and make subsequent cultivation operations more difficult.

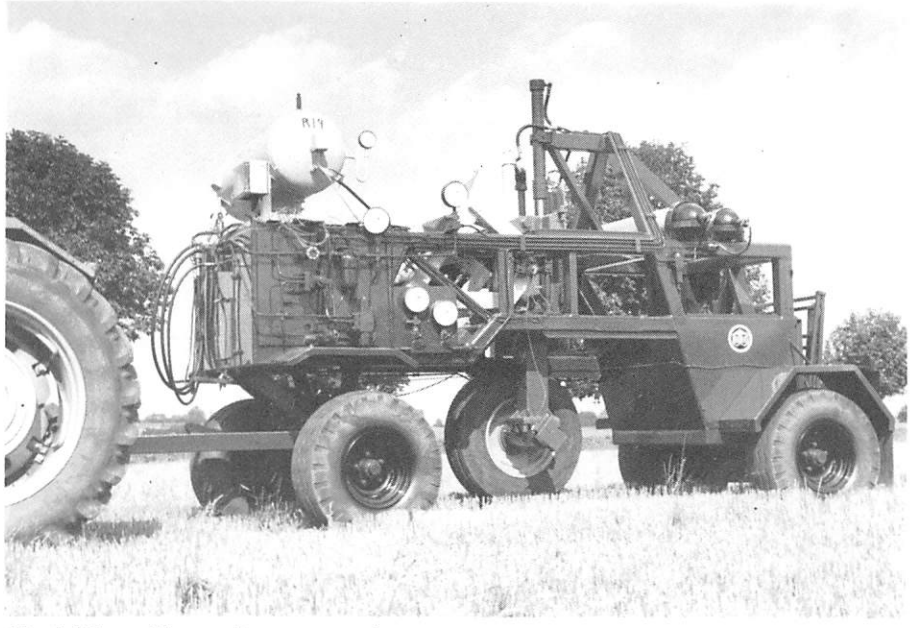

Fig 1. The rolling resistance test rig.

Over the last ten to fifteen years a number of experiments on rolling resistance have been carried out at AFRC Engineering (formerly NIAE). Soil bin experiments by Gee-Clough (1978) showed that the rolling resistance of multiple rigid wheels in sand was lower than for a single one of the same overall width. This assumed that the multiple wheels were acting independently of one another.

Later experiments by the same worker went on to investigate the effect of separation of dual rigid wheels again in sand (Gee-Clough 1979). This work showed that the coefficient of rolling resistance (CRR) decreased steadily as the wheels were separated until at three wheel-widths spacing the level was that expected for two wheels acting independently. However, the sinkage levels used were high compared with those commonly encountered with agricultural vehicles.

Field experiments to find the effects of tyre width, diameter, load, inflation pressure, aspect ratio, ply rating and con-

Avril Stadie was formerly a Scientific Officer at AFRC Engineering, Silsoe. She has now left the industry. Jim Dawson, right, is a Research Engineer and Vien Nguyen, far right, is a Scientific Officer, both at AFRC Engineering, Silsoe.

Fig 2. Tandem axle fitted to test rig.

struction on the rolling resistance of towed wheels have already been fully reported (McAllister 1983). These experiments showed that a reduction in rolling resistance could be made by reducing inflation pressure, reducing load, increasing tyre size and by the use of radial ply construction. The influence of aspect ratio was discussed and predictions made of the effect of various single and dual or tandem wheel arrangements on the performance of an 8t trailer or slurry tanker.

It has long been known (Bekker, 1956) that rolling resistance is reduced more by an increase in wheel diameter than by a corresponding increase in wheel width.

It is not always easy, however, to accommodate larger diameter tyres, particularly on trailers and in view of this it was decided to set up an experiment so that the performance of tandem wheels could be compared with dual and single tyres. Following on from this a limited number of tests were then completed to determine the effect of varying the load distribution on a tandem pair of wheels. These latter two experiments are covered in this report.

Equipment

In order to facilitate the study of the effects of tyre size, design, load and inflation pressure on the rolling resistance of tyres in a wide range of field conditions a special purpose test machine was designed and built at NIAE (AFRC Engineering). This machine (McAllister, 1979) consists of a four-wheel trailer with a test wheel mounted in the centre as shown in Fig 1. A system of transducers measures the forces on the test wheel in the vertical, lateral and longitudinal directions. Ballast tanks are fitted at the front and rear of the machine and the vertical force on the test wheel can be varied from 0-35 kN by means of a double acting hydraulic ram. The test wheel (size range from 700 to 940 mm diameter) can be changed easily so that a comparative investigation of a number of different tyres can be completed in a relatively short time.

More recently an axle beam has been designed for the test machine in order that the performance of tandem wheels can also be studied (Fig 2) The rig is towed by a tractor and can be operated in any normal field conditions. Data are processed on-line by means of a microcomputer mounted in a vehicle running alongside the test machine.

Table 1. Field surface and soil conditions for single, dual and tandem experiment

Field No.	Surface	Texture	Analysis clay %	silt %	sand %	Moisture content %	Dry Bulk density kg/m³	Cone index kPa
1	Stubble	Sandy loam	19.4	17.2	63.4	12.9	1433	1257
2	Grass	Sandy loam	19.8	20.8	59.4	15.6	1426	1827
3	Grass	Sandy clay loam	23.8	10.8	65.4	11.7	1291	2072
4	Stubble	Sandy clay loam	20.2	18.4	61.4	18.0	1354	965
5	Stubble	Sandy clay loam	23.0	11.0	66.0	16.9	1358	969
6	Burnt stubble	Sandy loam	18.2	13.2	68.6	10.3	1411	1343
7	After s.beet	Sandy clay loam	24.6	13.8	61.6	15.4	1641	2002
8	Stubble	Clay loam	27.0	46.2	26.8	37.4	958	1166
9	Stubble	Clay loam	33.0	44.6	22.4	41.6	905	1593
10	Stubble	Sandy clay loam	29.0	17.8	53.2	14.7	1426	945
11	After s.beet	Clay	50.6	36.0	13.4	27.7	1076	996
12	Stubble	Clay loam	39.6	24.0	36.4	22.5	1145	774

Table 2. Results of single, dual and tandem experiment

Wheel equipment	*Load*	*Infla. press*	*Field number and coefficient of rolling resistance (CRR)*												*Mean (excl.1)*
	kN	*kPa*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	
Single 13.0/65-18	12.5	126	0.105	0.074	0.072	0.125	0.088	0.051	0.098	0.064	0.105	0.080	0.099	0.108	0.088
	16.5	202	0.107	0.064	0.067	0.121	0.114	0.070	0.099	0.083	0.108	0.090	0.106	0.135	0.096
	20.0	303	0.141	0.074	0.066	0.131	0.124	0.055	0.093	0.074	0.090	0.102	0.114	0.131	0.096
Dual 7.50-16	12.5	126	N.R	0.083	0.081	0.090	0.097	0.069	0.090	0.079	0.086	0.095	0.102	0.110	0.089
	16.5	202	N.R	0.071	0.069	0.098	0.102	0.073	0.090	0.080	0.090	0.100	0.102	0.117	0.090
	20.0	303	0.120	0.065	0.062	0.104	0.118	0.074	0.086	0.088	0.088	0.114	0.103	0.122	0.093
Tandem 7.50-16	12.5	126	0.101	0.060	0.065	0.095	0.097	0.062	0.082	0.074	0.089	0.079	0.080	0.110	0.081
	16.5	202	0.096	0.055	0.052	0.082	0.095	0.072	0.086	0.067	0.073	0.080	0.090	0.099	0.077
	20.0	303	0.103	0.056	0.058	0.107	0.099	0.080	0.085	0.076	0.081	0.105	0.089	0.113	0.086

NR = *not recorded*

The two experiments:

A comparison of the rolling resistance of a single 13.0/65-18 radial tyre (Fig 3a) with two 7.50-16 8 ply implement tyres arranged in dual formation (Fig 3b) and then in tandem with equal load distribution on the two wheels.

The field condition data for these tests are shown in Table 1 and the loads and inflation pressures in Table 2.z

The effect on rolling resistance of varying the load distribution on a tandem pair of 7.50-16 8 ply implement tyres.

The field condition data for this experiment are shown in Table 3 and the loads and inflation pressures in Table 4.

Four different axle positions were used in these tests with load distributions of 60/40, 50/50, 40/60 and 30/70 on the front and rear tyres respectively. It was unfortunate that there was insufficient space between the ballast tanks on the test rig to achieve the 70/30 axle position.

Although the tyre carrying 70% of the 20 kN load was overloaded, the tyre manufacturers agreed that this condition could be used in the experiment. However, only one field condition was completed at the 30/70 position after agreement was sought.

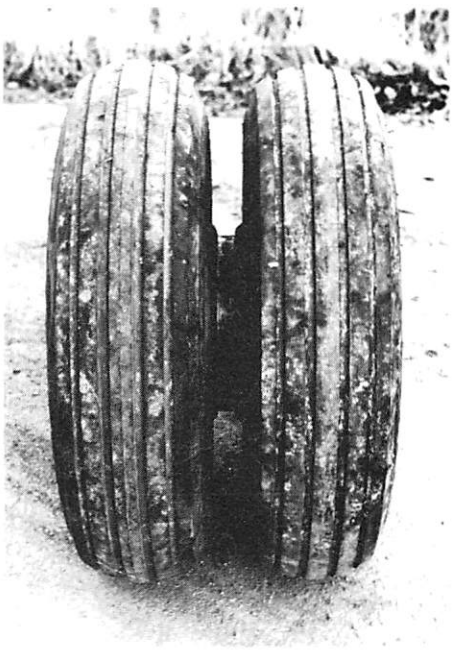

Fig 3a. (left) The 13.0/65-18 single tyre.
Fig 3b. (right) The two 7.50-16 tyres in dual formation

Table 3. Field surface and soil conditions for tandem weight distribution experiment

Field No.	*Surface*	*Texture*	*Analysis clay %*	*silt %*	*sand %*	*Moisture content %*	*Dry bulk density kg/m³*	*Cone index kPa*
1	Stubble	Sandy clay loam	32.8	19.4	47.8	15.7	1426	879
2	Stubble	Sandy clay loam	34.8	20.8	45.4	13.7	1420	582
3	Stubble	Sandy clay loam	32.2	17.2	50.6	13.7	1412	885
4	Stubble	Silty clay	42.4	45.6	12.0	16.8	1262	533
5	Stubble	Clay	58.0	36.2	5.8	16.9	1232	465
6	Stubble	Clay	52.8	31.4	15.8	17.4	1246	409
7	Grass	Clay	49.4	37.6	13.0	25.5	980	1578
8	Grass	Clay	45.8	34.4	19.8	33.2	1161	781
9	Stubble	Clay	48.0	21.2	30.8	33.0	1319	810

Results

The results of the single, dual and tandem experiment are shown in Table 2. Because there were some missing results for the dual arrangement the mean CRR is calculated for 11 fields only.

At a vertical load of 12.5 kN there was little difference between the large single tyre and the dual arrangement. However, at loads of 16.5 and 20.0 kN the dual pair was marginally better than the single tyre giving an overall reduction in towing force of about 3%.

In all cases the 7.50-16 tyres in tandem arrangement required a lower towing force than either the single or dual pair. The overall towing force required for the tandem axle was some 10% lower than for the dual pair and 13% lower when compared with the large single tyre.

Because of the superior performance of the tandem axle and the fact that rolling resistance decreases as soil becomes firmer the further tandem axle experiment was conducted. This was planned to study the effect of distributing the total load unevenly on the two wheels. It was considered that the towing force required for any particular load might be less if more weight were placed on the rear wheel, which was running in the track of the leading wheel of the tandem pair, than if the load were evenly distributed. The results obtained for the 8 sets of data in this experiment are shown in Table 4 and diagrammatically in Fig 4. They indicate that there is a marginal advantage in placing a larger proportion of the total load on the rear wheel of a tandem pair. However, there appears to be no significant gain in performance over equal load distribution with the more easily manageable equal tyre pressures.

Conclusions

- The coefficient of rolling resistance for a tandem pair of 7.50-16 wheels was lower than for a dual pair of the same size.
- There was little difference between the dual pair and a 13.0/65-18 single tyre.
- There is an indication that equal distribution of load on a tandem pair or a slight bias towards more weight on the rear wheel may give the lowest rolling resistance although rolling resistance is not significantly lower for a given load condition if a greater proportion is carried by the rear tyre of a tandem pair.

Acknowledgements

The single, dual and tandem experiment was conducted under the supervision of M. McAllister. Calibration of the test rig was carried out by J.D.Bodle (Instrumentation Department) and assistance with the field work was given by the late D.P.Heigho. The cooperation of farmers on whose land the measurements were made is also gratefully acknowledged.

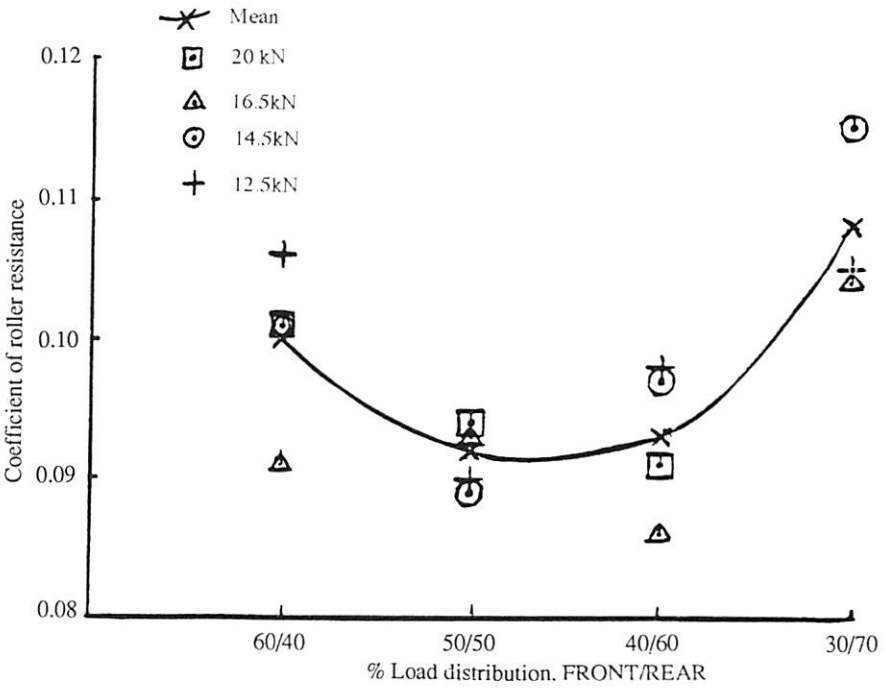

Fig 4. Coefficient of rolling resistance plotted against tandem axle position.

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McAllister M (1979). A rig for measuring the forces on a towed wheel. *J agric Engng Res*, 24 (3), 259-265.

Table 4. Results of tandem wheel weight distribution experiment

Load distrib. on wheels % Front/rear	*Total load kN*	*Inflation pressure kPa Front/rear*	*Field number and coefficient of rolling resistance (CRR)* 1	2	3	4	5	6	7	8	9	*Mean (excl. 4)*
60/40	12.5	172/103	0.098	0.116	0.148	NR	0.101	0.117	0.069	0.092	0.105	0.106
	14.5	227/124	0.083	0.100	0.129	NR	0.118	0.123	0.074	0.094	0.087	0.101
	16.5	276/152	0.104	0.094	0.105	NR	0.114	0.097	0.060	0.074	0.076	0.091
	20.0	372/200	0.129	0.108	0.124	NR	0.120	0.107	0.052	0.076	0.093	0.101
50/50	12.5	124/124	0.094	0.080	0.093	0.100	0.109	0.099	0.069	0.084	0.093	0.090
	14.5	172/172	0.098	0.086	0.104	0.082	0.103	0.067	0.063	0.096	0.094	0.089
	16.5	200/200	0.131	0.093	0.104	0.101	0.089	0.097	0.068	0.078	0.083	0.093
	20.0	276/276	0.128	0.069	0.104	NR	0.104	0.106	0.069	0.081	0.089	0.094
40/60	12.5	103/172	0.099	0.098	0.106	0.094	0.123	0.091	0.093	0.090	0.086	0.098
	14.5	124/227	0.086	0.100	0.114	0.113	0.123	0.081	0.079	0.097	0.095	0.097
	16.5	152/276	0.079	0.098	0.084	0.104	0.120	0.075	0.062	0.080	0.090	0.086
	20.0	200/372	0.072	0.100	0.082	0.117	0.120	0.129	0.060	0.081	0.080	0.091
30/70	12.5	103/227	0.089	0.118	0.081	0.123	0.149	0.122	0.081	0.088	0.110	0.105
	14.5	103/303	0.105	0.142	0.155	0.101	0.130	0.113	0.086	0.086	0.106	0.115
	16.5	103/352	0.116	0.096	0.125	0.092	0.119	0.098	0.084	0.100	0.091	0.104
	20.0	124/448*	-	-	-	-	-	-	-	-	0.108	-

*rear tyre overloaded

NR = *not recorded*

Engineers and Engineering – 1992 What does it mean to you?

J C Levy

Everyone in the Community will be affected to a greater or lesser extent by the completion of the internal market. However, because engineering is more closely linked to industry, manufacture and transport than any other profession it is vital that the implications of the Single Act are well understood by all professional engineers and their employers.

An internal market of continental scale based on free movement of goods and services within Europe will have a number of vital effects on Europe's competitive position.

Economies of scale

In the first place, economies of scale are needed to cover the gigantic rise in research and development costs which are characteristic of modern technology and which exceed the scope of national markets. Taken as a whole, the countries of the Community spend as much on research as Japan, but efforts are unnecessarily duplicated.

Increases in scale and rapid product development are also necessary in order to arrive at competitive cost prices in Europe, because these are also the strategic elements used by our competitors worldwide.

According to the Commission's findings, cost savings of 20 to 30 per cent are achievable through increased production volume in some key industries.

EC estimates of the effect of scale on production costs

Product	*Reduction in costs if scale of production doubled* %
Electronic and microcomputer components	30
Industrial plastics	25
Aerospace	20

In addition, a homogeneous infrastructure will be an important stimulus to the rapid application of innovative products and systems and of new technologies in Europe.

Small companies will also benefit

Advantages of scale and rapid application in the market will also foster the development of a good subcontracting and suppliers' climate - one in which high level specialisation can thrive. This will be equally important for the small and medium sized companies.

Economies of scale and European uniformity would remove many of the uncertainties and doubts which exist among financiers, constructors and those who exploit high technology development strategies.

The combination of free goods traffic and progressively homogeneous standards on a European scale would result in a great reduction in stocks, bring down cost prices and improve the competitive position. (By way of illustration: 30% of the capital in a company such as Philips is tied up in stocks.).

Consensus between economic partners is increasingly developing into an additional production factor. A really homogeneous Common Market would constitute the basis for such a European consensus.

The whole of the West European market will eventually become the backyard and serve as a base for external trade, just as up to now Lancashire and Devon have been home markets for companies in the Midlands. In the new environment, competition will ensure that only the fittest, lowest-cost companies will prosper.

Perhaps one of the most significant features in the offing is the access to, and publicising of, public contracts, worth some £200bn per year, to suppliers across Europe. This will open up for the first time to genuine competition a vast range of goods and services giving real opportunities not just to multi-national organisations but to small and medium sized enterprises too.

Encouragement for joint ventures and cooperative schemes

Co-operation between European firms is promoted strongly by the Single Act. Joint ventures and co-operative schemes are seen as means to achieve the economies of scale that small and medium sized firms need to grasp the opportunities presented by the market of 322 million people.

The *Small and Medium Size Business Task Force* is a Commission organisation which aims to provide support in this sector. It has established a data base to support corporate marriages named **'Business Co-operation Network'** or, in the obligatory Euro-speak acronym, BC-Net. This is to be the main clearing house for matching partners and it is of the utmost importance that the middle range of British business should be made aware of the opportunities which already exist.

Preparing for 1992 – what employers are doing

To build for 1992 and to take advantage of the opportunities which will be available to every Company, whatever its size, employers all over Europe are reviewing these areas:-

- European Community rules and practice for manufacture, construction and contracting. For example, invitations to tender are published daily in a supplement to the Official Journal of the Community. As the public procurement market opens up, this awareness will become vital.
- Single Market databases. For example, SPEARHEAD, available through Telecom Gold and Mercury Electronic Mail services, which make it possible for business men to study topics such as relevant legislation or standards on their own screens.
- The functions of agents or advisers in Brussels.

Professor Jack Levy is Director of the Engineering Profession at the Engineering Council.

- The options for doing business, including joint ventures, acquisitions, establishing local outlets. Looking for collaboration with other firms, including research and development projects.
- Local needs and identification of potential customers. Differences will remain in distribution systems and local business customs. It will certainly be a mistake to suppose that after 1992 France will cease to be France and the Italian market will cease to be Italian.
- Community law, for example in respect of intellectual property rights, patents, copyright.
- Development, context and system of European technical standards.
- Co-ordinated attention in the European environment to production standards, quality, design, marketing, after-sales service, management systems, to maintain a competitive stance.
- The functions and procedures of the two European Courts in Strasbourg (Human Rights) and Luxembourg (Level playing surface for all Member States). Understanding the social aspects of European legislation.
- Acquisition by staff of qualifications recognised by other European countries.
- Appropriate broad-based training for staff so that opportunities can be understood and grasped by the firm as a whole, not just by one or two people.
- Encouraging members of staff to learn a foreign language and giving tangible recognition if they do so.
- The implications of the freedom for capital movements and financial services and any new rules for fiscal harmonisation.

UK problem lies with poorly educated workers and managers

A recent CBI survey showed that United Kingdom manufacturers are still less productive than their West German counterparts. The survey disproved all of the old excuses; of poor industrial relations, too high tax, out-of-date machinery, which are usually put forward as excuses for the poorer performance of British industry compared with German industry.

The CBI survey came to the conclusion that poorly educated workers and managers were the problem.

The providers of education and training therefore have an important and distinct role to play in preparing individual engineers and employers to take advantage of the completion of the internal market.

In future, many more engineers will be moving freely about Europe. A European dimension in their education and training will be to their advantage and that of their UK employers.

The panel gives a check list of what the providers of engineering education – the professional institutions; and universities, polytechnics and colleges; the training boards and private organisations – should now be doing.

Check list of requirements of education and training

Become familiar with European Community sources of funding for education and training. Participate in European collaborative efforts such as COMETT (Community Action Programme for Education and Training for Technology) - a university/industry training partnership. Also ERASMUS (European Community Action Scheme for the Mobility of University Students) which enables students to take part of their course at a University/ Polytechnic in another European country.

Promote staff interchange for teaching and research. Short visits can be arranged under ERASMUS.

Promote sandwich placement schemes, European firms taking on UK students and vice versa.

Appoint a specific person in each department or faculty to keep abreast of opportunities and developments in Europe and to communicate them regularly to other members of staff.

Appoint or delegate a member of staff to become thoroughly familiar with the Brussels machinery for distribution of research and other funds. In some cases the appointment of an agent in Brussels can produce quick results.

Enlist the involvement of companies outside the UK in projects, student support/training, involvement with courses and research.

Develop links with equivalent organisations in other European countries.

Provide opportunities for students/trainees to become proficient in a foreign language, eg by options in courses.

Introduce a European dimension into courses eg, legal aspects, marketing aspects.

Develop credit transfer schemes on a European basis - eg. participate in ECTS (European Community Course Credit Transfer System) through ERASMUS.

Action by the individual engineer

There are at least two things that should be tackled by chartered and incorporated engineers.

First of all engineers should do all within the scope of their post to ensure that their employer is aware of the lists given here of the opportunities and requirements. Subsequently, where seniority and/or opportunity permit, they should then initiate and foster vigorous action on the various items.

Secondly, engineers should consider learning a foreign language. Proficiency in a client's language has both a practical and psychological effect in securing business. Reliance only on the client's knowledge of English is not the best formula for success.

Many effective methods now exist for learning languages with or without attendance at classes or language laboratories. There is also an Engineering Institutions Foreign Language Group (EIFLG) which exists to promote, encourage and support an interest in the study and use of foreign languages among engineers, scientists and technologists. Their address is given in the panel.

Action by the Engineering Council

The government machine is now geared up to provide more and better information for commerce and industry. The Engineering Council will assist these efforts in whatever ways it can, remembering that the Charter says that among its objectives is to "...encourage efficiency and competitiveness ... in the United Kingdom". The Engineering Council's role will be

continued at foot of page 40

Useful addresses

Department of Trade and Industry, Kingsgate House, 66 Victoria St, London SW1E 6SI	01 212 0400
EC Information Exchange on Standards and Technical Regulations	01 215 8144
Standards Policy	01 215 8079
Public Procurement Directives	01 215 4280
Enterprise and Deregulation Unit	01 215 5410
Engineering Institutions Foreign Languages Group 26 Durham Road, North Harrow, Middx. HA1 4PG	01 427 8042
The European Commission has now established a network of Centres for the European Business Information (EuroInfoCentres). There are four in the UK as follows:	
The Centre for European Business Information, Small Firms Service, 2-18 Ebury Bridge Road, London SW1Q 8QD	01 730 8115 or FREEFONE ENTERPRISE
The European Business Centre, Chamber of Commerce, PO Box 360, 75 Harbourne Road, Birmingham B15 3DH	021 455 0268
North of England EuroInfoCentre, The Northern Development Company, Bank House, Newcastle upon Tyne NE1 6XE.	091 261 5131
Centre for European Business Information, 25 Bothwell Street, Glasgow 2 6NR.	041 221 0999

Rock bed solar energy stores for greenhouses

R W Albutt shows that significant energy savings could be made but that the long payback period is too great for rock beds to be economically viable in the UK at present.

Essentially a rock bed is a container filled with gravel. The main elements of a rock bed system are shown in Fig 1. A rock bed may be cylindrical or box-shaped, oriented vertically or horizontally and positioned either above or below ground. It is connected to the greenhouse by ducts containing centrifugal fans for circulating the air.

A rock bed is an energy storage device used to extract and store heat from air circulated through it. It has two main uses. A rock bed can provide either heating or cooling for a greenhouse depending upon crop temperature requirements and the energy status of the rock bed.

Rock bed operation

With a rock bed in the system, when the air temperature in the greenhouse rises to the ventilation set point, ie the house needs cooling, air from the greenhouse is then circulated through the rock bed. The gravel is heated and the air passes back to the greenhouse cooled. This closed loop system also allows CO_2-enrichment periods to be extended.

Normally it is impractical to inject CO_2 into the greenhouse atmostphere when the vents are open for cooling. Thus a rock bed can be used to save energy and, for some crops, to extend periods of CO_2 enrichment which should result in greater yields.

Once the rock bed is fully charged it can no longer cool the greenhouse so air circulation to it ceases and conventional ventilation is used. It is possible to boost the temperature of a rock bed if a separate solar collector is used because this can operate at a higher temperature than the greenhouse.

When heating is required, for instance at night, air is once again circulated through the rock bed. However this time the heat flow is reversed with warm gravel heating the air as it passes through it back to the house. When the rock bed is discharged, or when it cannot maintain the necessary minimum greenhouse temperature, conventional heating systems are used.

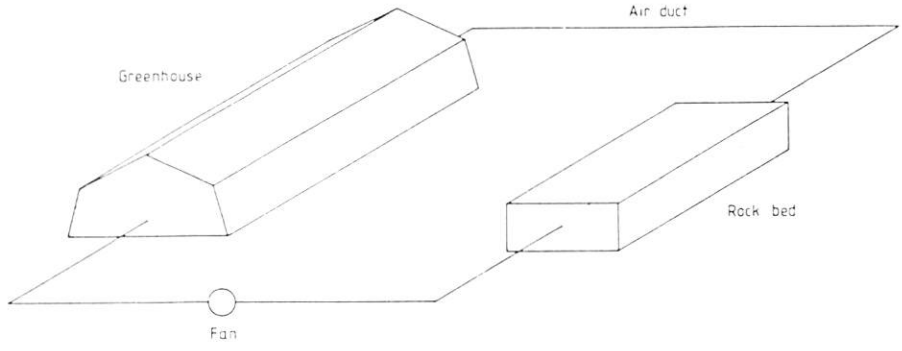

Fig 1. Schematic of rock bed thermal storage system.

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Continued from page 39

mainly one of information and encouragement to its various audiences. Among the activities it will undertake are:-

a. Voicing opinion to government departments when it appears that there are matters in relation to engineering where European integration could be more effectively pursued to the advantage of the United Kingdom.

b. Continually pressing the case for more and better continuing education and training. This policy is embodied in the Council's recent publication 'Continuing Education and Training – a National Policy for Engineering'.

c. Initiating a debate within the Engineering nstitutions on the opportunities for expansion of activities and membership post 1992. Encouraging mergers of institutions where members' interests are compatible, so that strength is gained through a joining of forces and resources.

d. Taking the lead in fostering developments in engineering education and training. Co-operating with education and training organisations and with industry in meeting employers' needs. Monitoring developments in education and training in other European countries and initiating equivalent action if appropriate.

e. Raising the sights of young people to pursue their jobs and careers in a European context.

f. Encouragement for all registered engineers to try to become fluent in a foreign language. This should link with policy on Continuing Education and Training.

g. Encouragement for degree and Higher National Certificate courses to include foreign language options.

h. Disseminating knowledge of the developing European situation to registered engineers, the engineering institutions and the industrial affiliates.

Factors affecting the size of a rock bed

Thermal capacity of the rock: This increases with increasing values of the density and specific heat of rock used. Ideally materials with as high a thermal capacity as possible should be used to minimise the volume of rock bed needed.

Solar radiation intensity: The higher the values of solar radiation intensity the larger the volume of rock bed which can be utilised. Monthly values of solar radiation incident at Kew, London are shown in Fig 2. These figures are an aggregate of both diffuse and direct solar radiation averaged over all weather conditions. Of the solar radiation incident on a greenhouse only approximately 33% produces an increase in internal temperature (Bailey 1977) after allowing for transmission losses, reflection off the crop and evapotranspiration.

Greenhouse heating requirement: The greater the heating requirement of a greenhouse the larger the size of rock bed required. Bailey (1977) provides a method for calculating the heating and fuel requirement of a glasshouse. Fig 3. shows the heating requirement of a greenhouse at Kew maintained at a daytime temperature of 20°C from November to April and 18°C for the rest of the year and 16°C at night throughout the year. The greenhouse is assumed to be approximately 0.5 ha and have a thermal transmittance of 6.2 W/m^2K.

Rock bed operating temperature range: Using the greenhouse itself as the solar collector, the greater the temperature range over which the greenhouse is operated, ie the difference between the minimum and maximum temperature set points, the greater the amount of heat that can be stored in the rock bed.

A specific example for the UK

The use of rock beds as thermal stores in greenhouses has been investigated in a number of countries. Studies of rock bed thermal energy stores conducted by Willits and Peet (1987a) in the USA, Garzoli and Shell (1984) in Australia and Zabeltitz (1986) in Germany have been examined. The feasibility of using rock beds in the UK has been assessed using a model developed in the USA but with climatic data for Kew.

To gain an idea of the likely volume of rock bed required, it is assumed that storage of one day's clear sky global radiation in June is required. From Fig 2., in June the incident solar radiation is 7.73 kWh/m^2, of which 33% is 2.55 kWh/m^2. For a tomato crop a typical temperature range would be from 16°C, the night set point, to 24°C, the ventilation set point during the day. Using values of 2250 kg/m^3 for the density of rock and 8.5×10^{-4} MJ/kg K for the specific heat capacity of rock (Beckmann and Gilli 1984):

Heat capacity per m^3 of rock bed = Density of rock x specific heat of rock x temperature lift in rock bed.

= $2250 \times 8.5 \times 10^{-4} \times 8$

= 15.3 MJ/m^3 or 4.25 kWh/m^3

Volume of rock bed required per square metre of greenhouse floor = Global solar radiation/ Rock bed heat capacity

= 2.55/4.25

= 0.6 m^3

Thus 0.6m^3 of gravel is needed per square metre of greenhouse floor. To lower the size of the rock bed would require rock of a higher thermal capacity or a larger operating temperature range for the store. Alternatively selecting a lower level of energy to be stored would also reduce the size of rock bed needed.

Predicted performance at Kew

Willits and Peet (1987a) developed a number of equations for predicting a rock bed's performance using average daily temperature and average daily solar radiation received on a horizontal surface as the variables. Wind speed, wind direction and cloud cover were omitted to keep the model simple. Using temperature and solar radiation data for Kew, graphs of the equations developed by Willits and Peet (1987a) are investigated below.

The greenhouse being modelled is large double layer polyethylene house growing tomatoes with CO_2 enrichment.

Fuel Saving

Fuel saving is calculated as the difference between the fuel used in a greenhouse with a rock store and one without. The monthly fuel savings expected at Kew are shown as points on the response surface in Fig 4. The maximum saving occurs in May. As expected the fuel savings increase with higher levels of solar radiation. The reduction in fuel savings at higher temperatures occurs as a result of the reduced heating requirement of short summer nights.

CO_2 enrichment time up nearly 50 per cent

When no venting takes place possible CO_2 enrichment time is assumed to be

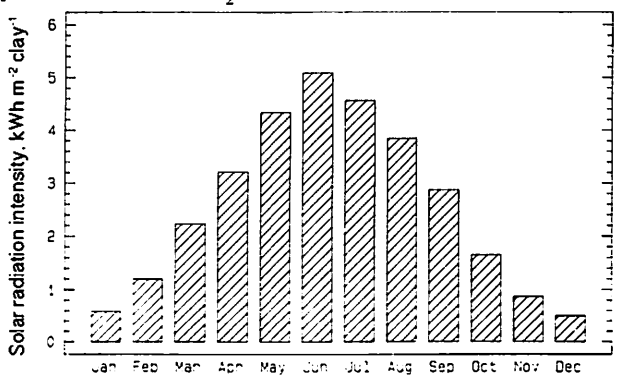

Fig 2. Mean daily solar radiation intensity on a horizontal surface at Kew.

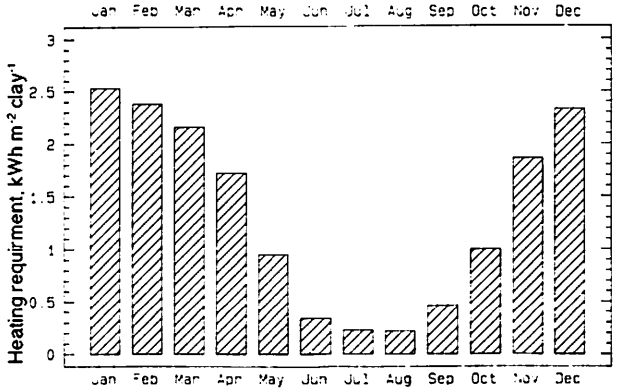

Fig 3. Mean daily heating requirement per square metre of greenhouse floor at Kew.

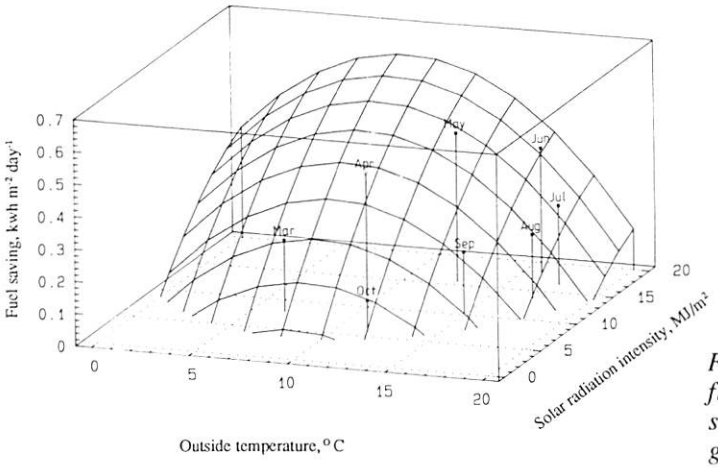

Fig 4. Mean daily fuel savings per square metre of greenhouse floor.

ture. Above this temperature and a higher percentage of the daily solar radiation is vented to outside in cooling the greenhouse. For Kew the collection efficiency maxima of 21.3% occur in June and September, see Fig 8. The efficiency dips in July and August as venting has to take place to avoid exceeding the upper greenhouse set point.

Rock bed benefits could give 14 per cent fuel saving

An estimate of the likely fuel saving to be expected from using a rock bed is given in Fig 4. Fig 9 shows the comparison between the fuel requirement of a greenhouse with a rockbed and one without. From this it can be seen that with a rock bed there would be no heating requirement from June to August. In contrast the use of a rock bed would be counter-productive from November to February.

Thus, using Willits and Peet (1987a) predicted fuel savings, a rock bed would be of benefit from March to October. Comparing the area under the two curves in Fig 9 over a whole year, the saving likely to be achieved is 14%. Zabeltitz (1986), using a "greenhouse as collector" rock bed system, found that solar energy actually contributed 12.5% of the total energy required in an experiment in Germany.

The typical fuel bill for an early tomato crop sown in late December, pulled out in late October or early November is £4462/0.1 ha (MAFF 1987). Therefore a 14% fuel saving would realise £625/0.1 ha.

But a twelve year pay back period

The economic feasibility of using a rock bed, based on a 14% fuel saving, is mainly dependent upon the cost of installation. The rock bed volume likely to be required is 0.6m³ per square metre of greenhouse

100%. On days when venting does take place it is calculated as the number of hours CO_2 levels are above 70% of the set point value divided by the maximum possible hours (usually total number of hours of daylight). Fig 5 shows that as temperature and solar radiation intensity levels rise the need for venting increases. With the vents open CO_2 enrichment may not take place so the percentage of CO_2 enrichment time falls. Willits and Peet (1987b) report a rock store giving up to 45% more enrichment time than that observed in a conventionally enriched greenhouse.

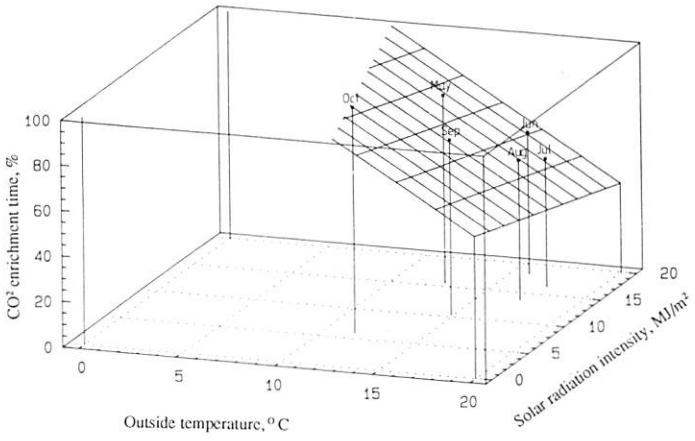

Fig 5. Mean daily CO_2 enrichment time

Extra electricity required

Measurements were made of the amount of additional electricity required to operate the rock bed over that needed for a control house without a rock bed. Fig 6 shows that the higher the outside temperature and the higher the solar radiation intensity, the more electricity that is needed to operate a greenhouse with a rock store. Of the monthly values plotted for Kew the maximum occurs in June at 0.07 $kWhm^{-2}day^{-1}$.

Collection efficiency related to outside temperature

Collection efficiency is calculated as the amount of heat stored in the rock bed in a week as a percentage of the average weekly solar radiation. From Fig 7 it can be seen that the collection efficiency is a maximum at a temperature of 14.6°C. If the temperature is below this point a higher percentage of daily solar radiation must be used to maintain greenhouse tempera-

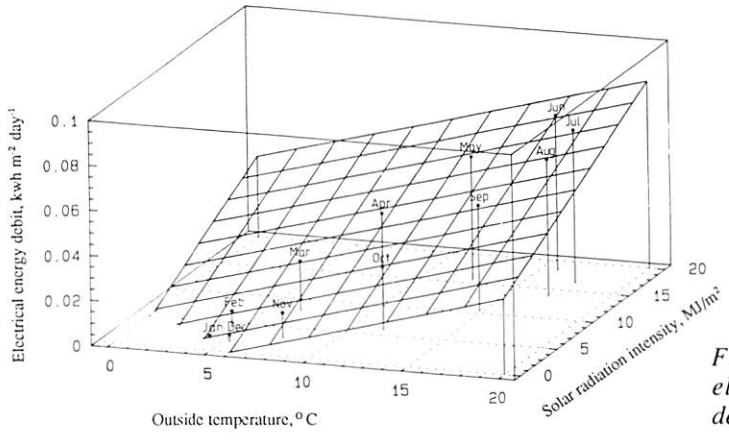

Fig 6. Mean daily electrical energy debit

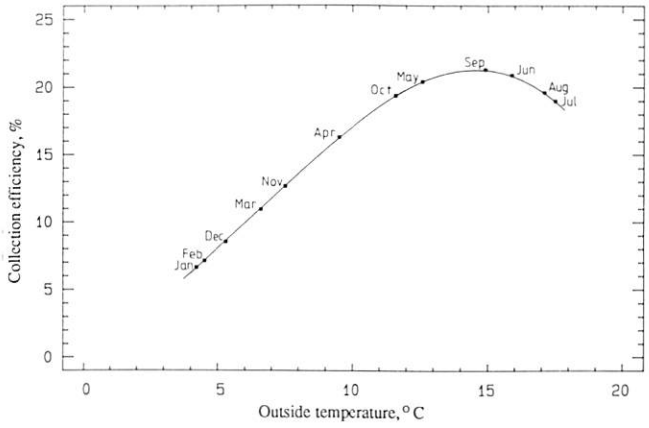

Fig 7. Collection efficiency compared with outside temperature.

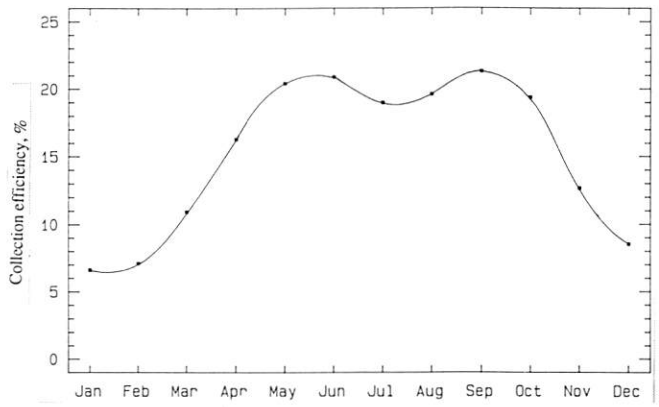

Fig 8. Collection efficiency compared with time of year.

floor. So, for a greenhouse of 0.1 ha, a rock bed of 600m^3 is required. The cost of the gravel at £12/m^3, will be £7200. Dividing the cost of the gravel by the fuel saving gives a pay-back period of 12 years. The additional costs of excavating a pit or building a structure to hold the gravel, and of the insulation, ducts, fans, electrical installation and dampers make the economic feasibility of a rockbed even more unfavourable. Therefore rock beds are not going to be cost-effective in the UK based on current fuel prices.

If the rock bed could be operated over a wider temperature range the size of the rock bed could be reduced. However this would require crop varieties with the ability to grow successfully in lower temperature regimes. Alternatively the air temperature entering the rock bed could be increased using an external solar collector (Garzoli and Shell 1984). This would reduce the volume of gravel required possibly saving more than the extra cost of the collector. Although there are cheaper alternatives to gravel, for example, hardcore is approximately £5/m^3. there would undoubtedly be airflow problems due to the lack of aggregate uniformity and subsequent compaction

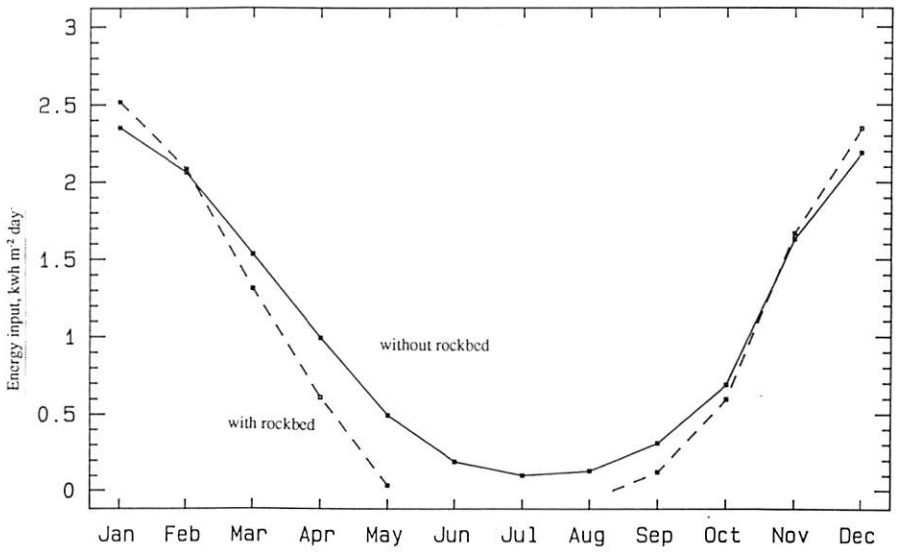

Fig 9. Comparison of daily fuel requirements of greenhouses with and without a rock bed.

Conclusion - not economically viable at present

Rock beds have been investigated in many countries, especially the USA. Fuel savings generally appear to be in the range 10-20%. The model used in this study predicts a fuel saving under UK climatic conditions of 14%. While these are significant savings they are far outweighed by the capital cost of installation. The cost of the gravel required would result in a 12 year pay-back period for a typical example in the UK. Therefore, this energy saving technique is not economically viable at present.

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The 'silent' revolution in materials processing

W L Philpott

Because of economic pressures resulting from over supply in the cereals sector and a series of adverse climatological conditions, a "revolution" is taking place in agricultural materials processing. Perhaps a "mini-renaissance" might be a more apt description. Like the Renaissance of the 15th century, the effect in the UK comes from without and has reached us somewhat later than in other parts of Europe.

The area in processing in which attitudes are being revised is in the use of "Table Separators". Historically these units were originally used in metallurgical processing but their use was transferred into the agricultural sector more than 30 years ago. Thus particular separation according to specific weight is not novel nor is it new. So the question to be asked is - what is the significance in these changes in attitudes? In order to provide a satisfactory answer to this question it is necessary to understand something about the basis of seed processing.

Whatever the final destiny of harvested seeds, whether they go as planting material or for animal feed or for the milling industry, the actual one is that chosen by economic circumstances based on the material quality and on requirements. In all cases, processing is the series of operations for the selection of the best quality true-to-type material separated from unwanted materials and contaminants.

The separating operation can only be carried out if differences exist between the wanted product and the other unwanted components of a material mass. These differences are of a physical nature and, obviously the greater the difference the easier can separation be achieved.

The main physical properties of seed and contaminants which can be exploited for separating purposes are as follows:

- size - length, width, thickness,
- shape - oval, round, long, flat etc.,
- specific weight,
- mechanical behaviour - ability to roll, slide etc.,
- surface texture,
- colour,
- affinity for liquids - used in electromagnetic methods,
- conductivity.

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In the context of this paper, the physical property in which we are particularly interested is the *specific weight.* Additional properties such as *mechanical behaviour* are involved to a lesser degree.

Types of table separator

Gravity table separators (pneumo-mechanical)
This group of machines separates material into fractions according to specific weight and surface texture by means of a positive (or alternatively negative) pressurised air bed, intensity of operation and table inclination (both longitudinally and transversely).

This group is sometimes known under the names of "specific gravity separator" or "gravity separator."

Fig 1 illustrates a "Heid" gravity table separator (positive pressure type).

Table separators (mechanical type)
This group of machines separates material into two fractions according to specific weight, surface texture and hardness (resilience or elasticity) by mechanical intensity of operation and table inclination.

Because this type of machine was originally designed for separations in the rice processing industry it has become known as a "Paddy separator:.

Fig 2 illustrates a "Ballarini" table separator (mechanical).

De-Stoners
This group of machines separates material into two fractions only according to specific weight and surface texture by pressurised air bed, intensity of operation and

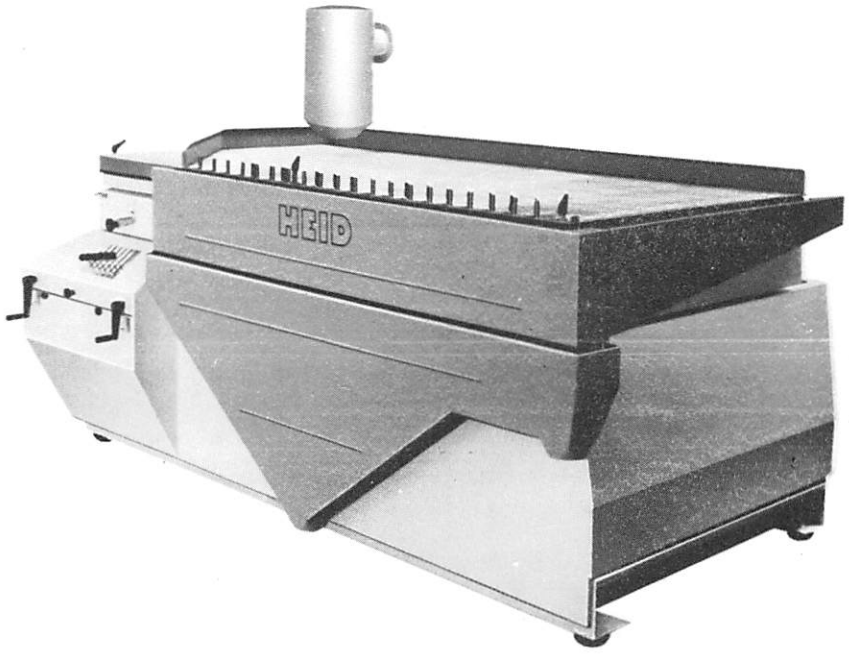


Fig 1. Gravity table separator (pneumo-mechanical)

table inclination (longitudinal direction only).

This type of machine is sometimes known simply as a "stoner".

Fig 3 illustrates a 'Ballarini" de-stoner.

Gravity table separators – performance and characteristics

The gravity table separator by virtue of its greater number of adjustments and its greater operating flexibility is used more often than the other two and hence merits further consideration.

Fig 4 illustrates the separating principles of a gravity table separator and the three material states mentioned in the figure are further explained below:

State 1 represents a material mass with particles of identical or very closely equal size but differing in specific weight. The heavier particles will migrate to the higher side of the deck and the lighter ones will move towards the lower side. Depending on deck shape, the mass will be segregated with a very small amount of 'middlings'.

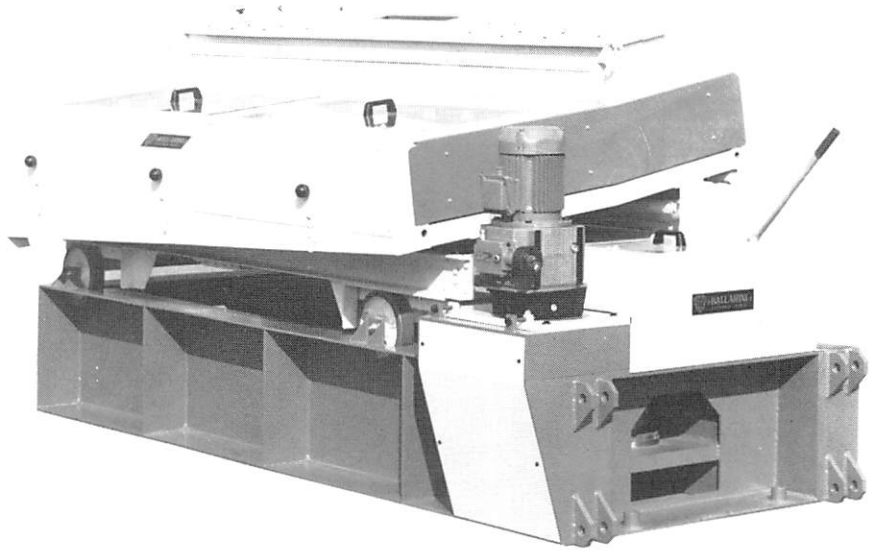


Fig 2. Table separator (mechanical)

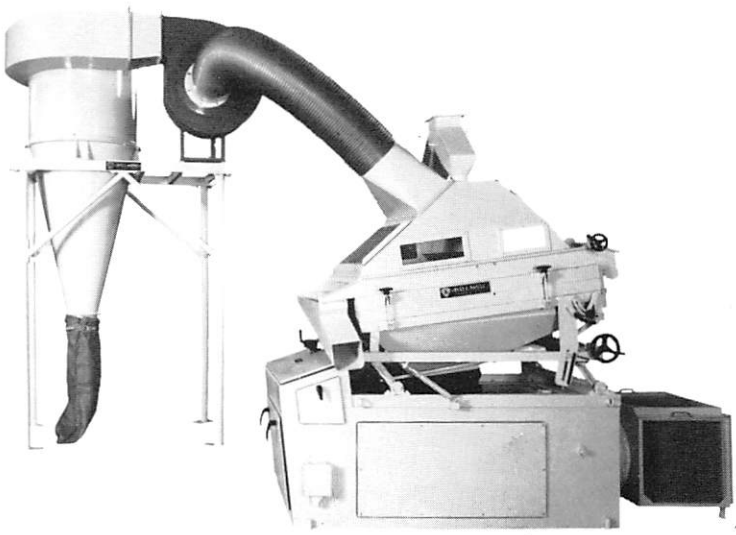
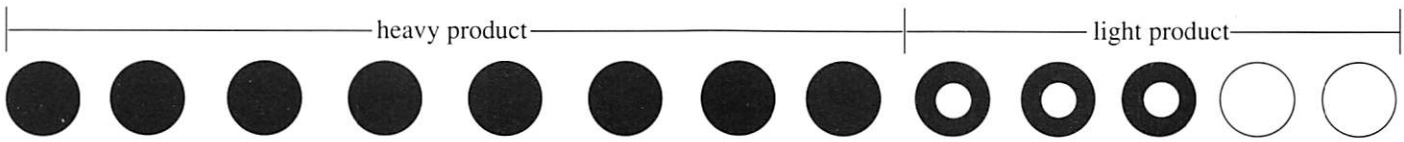


Fig 3. Stoner (pneumo-mechanical)

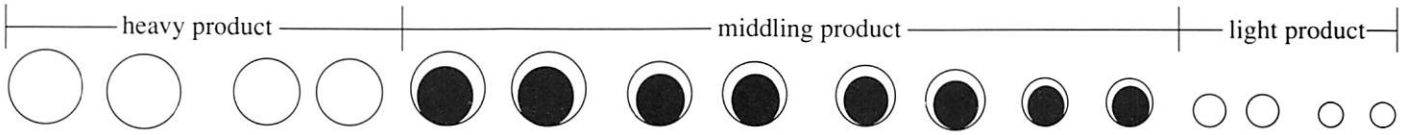
State 2 represents a material mass with the particles of different size but all having the same specific weight. The larger particles being the heavier, will migrate to, the higher side with the smaller ones moving to the lower side. The separation effected is similar to a size grading operation.

State 3 represents a material mass which comprises particles differing both in size and in specific weight. The heavier particles, irrespective of size, will move to the higher side and the lighter ones, also irrespective of their size, will move to the lower side. This is a common state of



State 1 – Particles of the same size but differing slightly in specific weight can be separated

State 2 – Particles of the same specific weight but differing in size will be graded according to the size of the particles



State 3 – Particles differing in specific weight and in size cannot be effectively separated on a gravity table separator

Fig 4. Indication of the separating capability of a gravity table separator (Adapted from "Seed processing and handling" issued by Mississippi State University)

material lots and indicates that the mass has not been effectively sorted according to size prior to being presented to the gravity table separator. With a material lot of this composition a wide band of "middlings" fraction would be produced.

Subjecting a particulate mass to forces from an airstream as shown in Fig 5, according to the "particle floatation principle", the heavier particles sink to the bottom layers, the medium weight form the central stratum and the light particles form the upper stratum. This fluidised separation of the particle mass induces "stratification" (see Fig 6).

There are some machines designed by one manufacturer, which use negative pressure (suction or aspiration) as the pneumatic fluidising agent but the more usual principle is the employment of the pressurised air system.

The stratified material mass then comes under the mechanical oscillating forces induced by the reciprocating motion of the machine deck in addition to the force from the airstream. Thus, "Stratification" is followed by "Separation". The heavier particles, which have "sunk" onto the deck surface because they are not affected by the airstream, come under the forces induced by the reciprocating motion and move to the higher side of the deck. The lighter particles come under the fluidising forces from the airstream and, being unaffected by the mechanical forces "float" to the lower deck levels - both longitudinally and transversely.

This separating action occupies the remaining zones of the table deck. The longitudinal deck inclination induces the material mass to flow towards the discharge end of the table which is at a lower level.

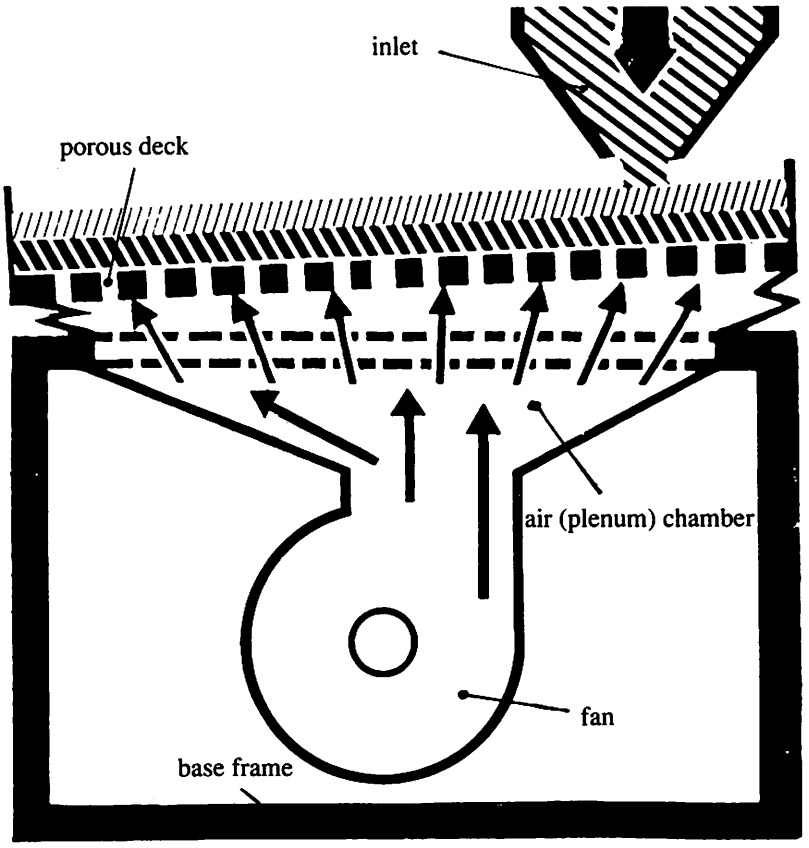


Fig 5. Diagrammatic cross section of gravity table separator

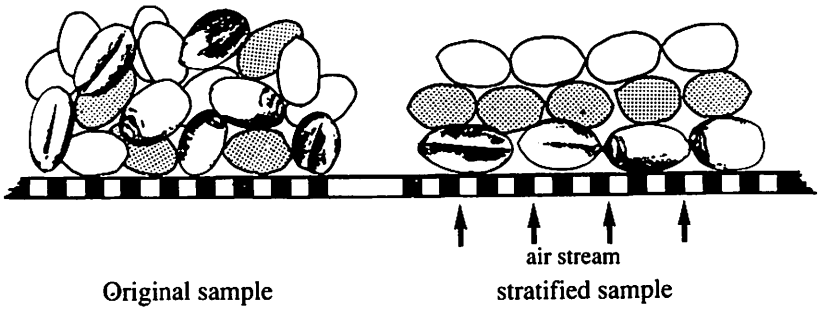


Fig 6. Stratification of particles through fluidising effect of air stream

Gravity table separators are normally provided with facilities for varying the following:

- longitudinal inclination,
- transverse inclination,
- frequency of oscillation (by rotational speed),
- velocity of air stream,
- amplitude of oscillation (stroke).

The first four variations can be made while the machine is running (a very important operating point), but the fifth variation can only be made when the machine is stationary. Some designs do exist without this last facility. Changing the stroke is only required when "a polyvalent" processing operation is carried out with granular particles having very different physical characteristics.

The operation of gravity table separators has always been considered a highly specialised one due to the many possible adjustments which are available.

Seed processing – UK, Europe, USA

In the UK the practice of using table separators has been very erratic, particularly where cereal seed processing has been concerned. Twenty years ago it was not unusual for the incorporation of some mechanical table separation in seed processing plants. Since then, however, there has been a decline except for certain periods when very specific problems have arisen such as the presence of ergot.

The most popular type used in the UK for cereals has been the mechanical-type table separator. In restricted sectors, such as the processing of pulses and grasses, the pneumo-mechanical type of gravity table separator along with the de-stoner have been used. In the horticultural and vegetable processing sectors, gravity table separators have always been used, but, because this is a more restricted market than cereals processing, the actual numbers involved are comparatively low.

The precise reasons for this decline in recent years is not very clear. There is, for example, the question of capacity requirement. When the maximum capacity required of processing equipment was in the region of five tonnes per hour, then table separator capacities were adequate.

However, more recently, air screen cleaner capacities have increased quite considerably and up to 15 tonnes per hour is now not unusual for certified seed quality standards.

There are also improved pneumatic separating systems in the latest designs of air/screen cleaners. These machines are quite capable of producing a final product adequate for many quality standards and without doubt reduced the demand for

sophisticated equipment which effects a separation according to specific weight.

In the USA the employment of gravity table separators, particularly of the pneumo-mechanical type, has continued. In plants for the production of quality seed in the USA it is usual for a gravity table separator to be included as part of the processing line. The precise reasons for this are not too obvious but the following could be contributory factors.

- tradition – the USA is the original home of the gravity table separator,
- the greater range of seed species processed in the USA compared with the UK,
- cost factors of investment and operation relative to seed quality are more favourable,
- the units are a home produced product and quantity has kept purchasing costs low compared with imported units from Europe into the UK.

In Europe the use of table separators of both types – mechanical and pneumo-mechanical has been more sustained. Here the reasons could be:

- there are several European companies manufacturing these units,
- the need for processing a greater range of seed species.

As far as the author knows only within the last year or so has a UK company manufactured gravity table separators of the pneumo-mechanical type.

Dramatic revival in UK use of table separators

In the past two years there has been quite a dramatic revival in the use of table separators. The reasons for this are not difficult to find.

- The over-production in cereal seed supplies has meant that seed processing merchants must look to the processing of other crops to maintain their levels of business. The basic equipment, normally sufficient for cereal seed processing. viz: air/screen cleaners and indent cylinder separators is inadequate for satisfactory processing of such crops as pulses, oleaginous seeds, maize and grasses, Thus the need for a polyvalent seed processing capability has induced the merchants to invest in gravity table separators to give them greater flexibility.
- There is a greater range of machines from the Continent and the USA available to the processor and prices are now very competitive.
- The move of farmers to process seeds for their own use.
- A greater awareness of the wider processing capabilities possible with gravity table separators. Until quite recently, these have been classed as equipment only suitable for merchants.
- A series of poor-quality harvested crops, due to adverse climatological conditions particularly with wheat, has usually mean't that crops were destined to be used as feed rather than the original intention of their being suitable for the milling industry. However, the versatility of gravity table separators, not generally and fully appreciated until recently, has meant that at least part of the wheat harvest can be recovered to a level acceptable as milling quality instead of the whole batch being relegated for feed.

In most of the foregoing reasons it can be seen that the wide range of operational capability of gravity table separators has been responsible for the increase in use of these units. A summary of these uses is presented in the accompanying panel.

A fuller realisation of the versatility of gravity table separators now means that anyone interested in processing, whether it be the merchant or the farmer, has a very desirable piece of equipment available to him to widen his scope of processing.

Range of use of gravity table separators

The practice of close-sizing of granular particles prior to feeding by the gravity table separator is well known.

Immature and shrivelled grain particles are lighter than fully matured ones and, therefore, segregation is possible. This applies across the whole spectrum of grain particulate separation.

For a general grain cleaning only a light pre-cleaning operation is necessary prior to specific weight separation. This is a very valuable processing asset to the farmer.

Removal of undesirable contaminants such as ergot, cleavers *(Galium aparine)*, etc from grain.

For the maltings industry barley cultivars with low-nitrogen content are recoverable.

An important processing technique is the opportunity to remove already germinating seeds. This is of particular importance in the processing of wheat, rye and oleaginous seeds. Grains of germinating wheat and rye are of a lighter weight so segregation is possible and milling quality material is recoverable from feed grain lots.

In existing seed processing installations it is possible to increase capacity by the inclusion of the gravity table separator in the processing line after air/screen cleaners and indent cylinder separators. The table separator will, in effect, act as a "fine tuning machine" to give the required end product quality.

In the feed milling industry broken pellets are removable from the whole product.

There may be other uses not yet exploited and, of course, table separators are also used quite extensively outside the agro-based industries. Already there has been a dramatic increase in the use of table separators in areas not previously considered.

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F H Schule GmbH, Hamburg, FR Germany.

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Programmable logic controls

SWR Cox

In this paper to the Crop Drying and Storage Specialists Group, Sidney Cox outlines the characteristics of logic control of industrial processes and he traces the developments since the early days of hard-wired systems up to the latest microcomputer-based programmable logic control (PLC).

The characteristics of PLCs are described, together with the method of programming them. Testing and diagnostic procedures are outlined and general areas of application to agriculture and horticulture reviewed.

Many industrial processes are controlled automatically by electrical and electronic equipment which switches components of the system on or off in accordance with a preset time schedule or in response to signals from sensors and actuators of various kinds.

'On' or 'off' input signals may be generated by manually, electrically, magnetically or electromagnetically actuated switches, by timers or by analogue sensors which trigger a switching device at a setpoint. Some switches have a latching or memory function and are set or reset by successive input pulses. Such switches can be combined to provide pulse counting functions.

Collectively, these various elements are employed to control the electrical power devices (motors, heaters, etc) which perform the specified operations.

This form of process control is known as logic control.

Although logic control is essentially concerned with starting and stopping sequences in a process, it can also incorporate and supervise closed loop control.

To take an agricultural example (Cox 1988), a logic control system can be programmed to regulate the flow of produce into and through a crop cleaning and grading line, starting and stopping loaders, conveyors and batching devices in the proper sequence and with appropriate time delays.

The control system can also incorporate continuous control of individual conveyor speeds, to avoid over- and underloading of the cleaning and grading sections. This requires closed loop operation based on feedback from sensors which monitor loading of these sections.

Analytically, the 'on' and 'off' states of each switchable element in a system are treated as the binary logic states 1(= 'on') and 0(= 'off'). The condition of the system at any time is determined by the logic states of all the switchable elements at that time. When a system requires many interrelated elements the minimal configuration can be calculated with the aid of Boolean algebra (Bostock, 1988), using the notation A and $\bar{A}$ for the 'on' and 'off' (*NOT* or *INVERSE*) state of element 'A' respectively. Combination of elements introduce the logic terms *AND* and *OR* together with their inverse, *NAND* and *NOR*. These refer to the input conditions under which each combination will generate an output '1'. Fig 1 gives some examples of combinations of two elements, using familiar symbols for normally open (NO) and normally closed (NC) electrical contacts. The 'normal' condition refers to their state before actuation, manual or otherwise. The Boolean

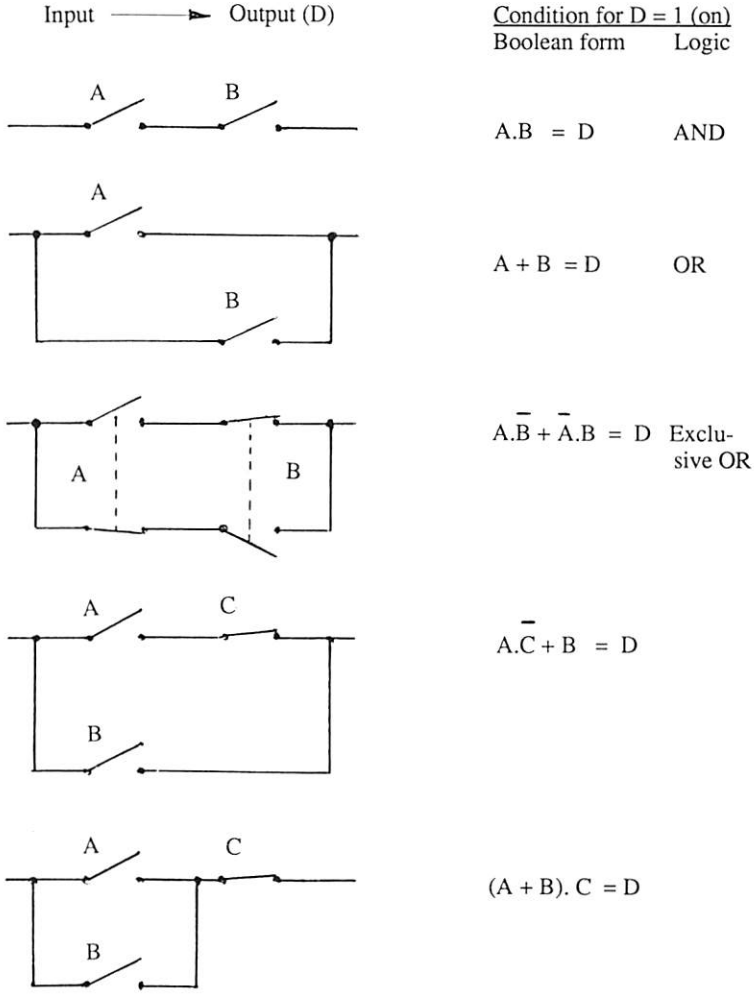
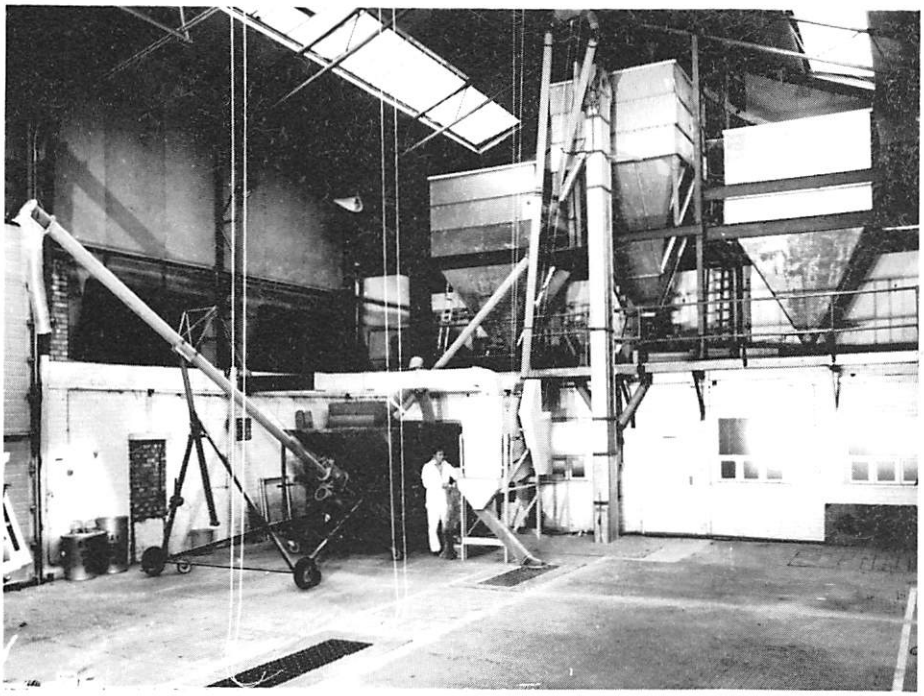


Fig 1. Some combinations of switches. A, B and C. Contacts shown in the normal (unactuated) state.

Sidney Cox, now retired, was formerly Deputy Director of the N.I.A.E. (now the AFRC Institute of Engineering) Silsoe.



An agricultural application of PLC — the grain handling facility at AFRC Engineering Silsoe *copyright AFRC Engng*

equations for these combinations are also shown.

Electro mechanical relays still widely used

Industrially, logic control relied heavily for many years on electromechanical relays with multiple sets of contacts and, in some cases, with mechanical or magnetic latching facilities. The speed of operation of these devices is not usually a limitation; they are robust, not too expensive and, when suitably sealed against environmental contamination, are normally very reliable over long periods. For these reasons relays are still widely employed.

However, the arrival of industrial solid-state (semiconductor) logic devices in the 1960s provided greater flexibility in design, as well as higher speeds of operation. Electronic switching made it possible to create a virtually unlimited range of "contact" configurations, free of contact wear, from a small range of basic units - *ANDs* and *ORs*, or *NANDs* and *NORs*, together with bi-stable (*SET* and *RESET*) switches and monostable pulse generators, providing single square-wave output pulses for driving bi-stables and counter assemblies.

The ability of electronic switches to operate from low voltage supplies also removed some of the problems previously associated with industrial electronic control.

Initially these solid-state logic units were sealed assemblies of discrete components, but by 1970 they were being overtaken by integrated circuits in the now familiar rectangular block format of the silicon "chip". Agricultural applications were soon found for both types (Cox, 1967; Cox & Harries, 1970).

The microcomputer – a "pre-wired" assembly of switches

The next step followed the development of the microcomputer in the mid 1970s. Until then the assembly of many logic systems - whether based on electromechanical relays or solid-state modules - required substantial amounts of hand wiring to connect the units in the configuration needed for a particular application. This, in turn, called for careful subsequent checking.

The microcomputer is, in effect, a 'pre-wired" assembly of many electronic switches which can be programmed to perform a vast range of logic operations sequentially, under the control of its internal digital clock. In principle, therefore, a single microcomputer-based logic controller can be employed for many different tasks, selected by entering the corresponding program.

There is evident potential for savings not only in the range of controllers needed but also in the cost of developing and testing a new or modified control system. In addition, the whole control unit can be light, compact and economical in its use of electrical power.

Programmable logic controllers

Programmable logic controllers exploit the capabilities of the microcomputer in the ways just mentioned. Currently, costs range from about £200 upwards, depending on size and facilities.

The general features of a typical PLC for smaller systems are shown in Fig 2. The main unit (PC 110) contains the central processing unit (CPU) of the computer,

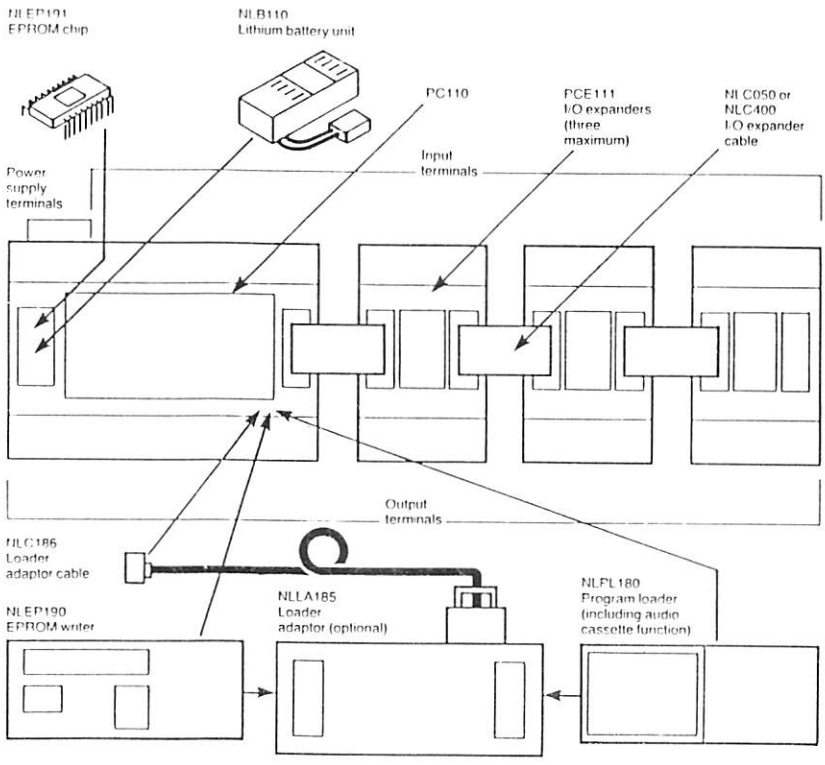


Fig 2. Block diagram of a PLC (MTE/Westinghouse)

which carries out the program instructions step by step, under the control of the built-in digital clock. The clock pulses are also employed (after frequency division to 10 pulses/second) to provide an input to any process timers that are built into the control system. In addition, the unit has memory space for program instructions and for data on the logic states of the system's inputs and outputs.

In operation, the PC 110 cyclically 'reads' the state of all inputs, steps through the program instructions and makes any required changes to the states of the outputs. The cycle time is short (20 ms for a full program complement of the 1024 8-bit 'words') but an input pulse must exceed this duration to ensure that it is read during the scan. Pulses of shorter duration can be extended with the aid of a suitable monostable pulse generator.

As far as external hardware is concerned, the PC 110 contains 24 pairs of input terminals and 16 pairs of output terminals. It can be linked to a maximum of three expander units (PC 111), each with 16 inputs and 8 outputs. Apart from the mains power supply and links to the PC 111s, the only wiring called for is that needed to connect the external switching elements to the input terminals and the electrical power devices to the external terminals.

The PC 110 weighs 2.8 kg, and each PC 111 weighs about 0.85 kg. Dimensions (mm) are approximately 180 x 260 x 160 (PC 110) and 180 x 130 x 120 (PC 111s). The maximum power consumption of a PC 110 with three PC 111s is 100VA.

Environmental protection

Since one of the most important requirements for a PLC is an ability to function reliably in industrial environments, this aspect is given priority. The unit must withstand a wide range of ambient temperatures and humidities - typically 0 to 55°C and up to 95% RH (non-condensing) in use - as well as dust and moderate mechanical impacts.

Immunity from electrical noise is also vital, therefore the power supply and input/output circuits must be specially designed to this end. Manufacturers normally quote noise immunity to a particular standard, such as NEMA ICS 2-330 or IEC 255-4. Nevertheless, they expect their PLCs to be sited away from high voltage, high power control panels and that noise suppression measures are applied to local sources such as large inductive loads. Input and output terminals are usually rated to withstand 1500 V ac relative to their mountings for 1 minute. Vibration limits and flame retardancy are also quoted by some manufacturers.

Noise immunity and electrical safety are promoted by the use of optoelectronic isolators in the input and output circuits. One of these isolators is shown in Fig 3. When the external input switch connected between terminal 0, 0 and the common earth (ground) terminal closes, it applies the voltage V to the photodiode which is mounted in parallel with the 390 ohm resistor. The diode then emits light which is received by the adjacent phototransistor. The optical coupling is depicted by the two small arrows. This phototransistor then passes on a logic 1 signal to the PLC's internal logic. At the PLC's output end the internal logic levels are similarly communicated to the external world. If PLCs are to be employed in particularly noisy regions (electrically) fibre optics links may be used to connect the main unit to the extenders for the same reason.

Inputs and Outputs

Fig 3 makes the point that inputs are usually provided by 'dry' (voltage-free) contacts which generate a logic 1 *via* an internal dc voltage source (usually 24V). However, some manufacturers provide additional input circuits for ac mains contacts, which can be accommodated by virtue of the built-in optoisolator stage. Some manufacturers also supply a separate input module through which the signal from an analogue sensor can be repeatedly sampled and converted from analogue to digital form (A/D conversion, in short) for subsequent level comparison in the PLC.

Outputs are generally of three kinds:

- a relay contact which can be interposed between the load and an external supply of up to 240V ac (rms) or 30 V dc, with a maximum current rating of 2A (resistive load);
- a transistor output, for use with an external load supply up to 24V dc and 1 to 2A (resistive load);
- a triac output (bi-directional controlled silicon rectifier) for use with an external load supply up to 240V ac (rms) and 1 to 2A (resistive load).

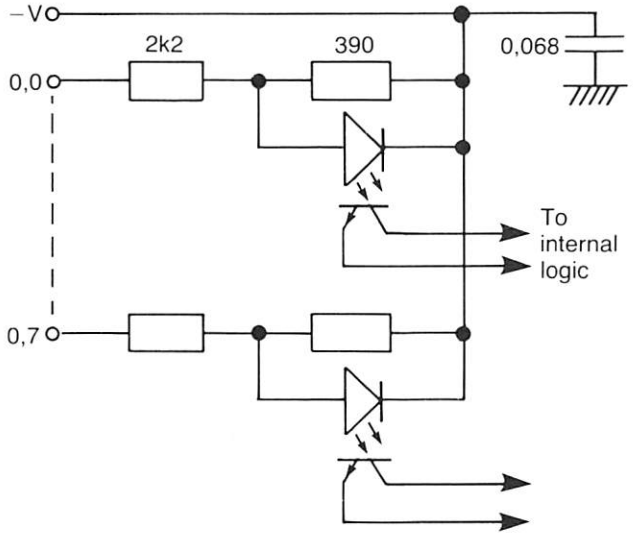


Fig 3. dc input circuit (MTE/Westinghouse)

Programming facilities

The PLC in Fig 2 has a user memory organised into 8-bit registers and divided into two sectors. The 1024 word program memory has internal capacitor back-up that will retain a program for up to 6 weeks at 25°C if the power supply is cut off. The plug-in lithium battery unit shown in the figure can extend this period to three years. A program can also be transferred for more permanent storage to an EPROM chip or to a standard audio cassette, using the EPROM writer and Program loader which plug into the front face of the PC 110, directly or *via* the adaptor.

The data sector of the memory has 64 8-bit registers, 9 of which are dedicated to inputs and 5 to outputs. Each bit in these 14 registers is coupled to one of the pairs of input or output terminals and registers the logic state at that point at any time. Thus there are 14 x 8 = 112 addresses (memory cells) available — sufficient for the 112 inputs and outputs of a PC 110 and 3 expanders. The first 3 registers (adresses 0,0 to 0,7; 1, 0 to 1, 7 and 2.0 to 2,7) are dedicated to the 24 input terminals of the PC 110 and these addresses appear at the terminals, together with green LED indicator lights which are illuminated when the input concerned is 'on'. The input registers reserved for the PC 111s are 5, 6, 8, 9, 11 and 12. Output terminals (with red LEDs) are allocated to registers 3, 4, 7, 10 and 13.

The remaining area of the data sector, which includes 16 registers with battery

back-up, is available to the user for programmed internal (software) contacts, timers, counters and other functions. For example, the programmer can assign a timer function to any available register by use of the appropriate program instruction. The first 7 bits of the register so addressed are used for counting down in 0.1s decrements from a preset number, also supplied by the programmer. The 0.1s timer pulses are produced internally, as stated earlier. Thus a time delay up to 127 x 0.1s = 12.7s can be created before the count-down reaches zero. At that point the register's eighth bit changes state to provide the timer's output. This output can be used to start the countdown in another register if a longer time delay is needed and the process can be repeated to the limit of available registers.

The software also provides two input "gates" to each timer. One is an Enable/Reset input, which starts the timer when switched on and resets it to its preset count when off. The other is a Time/Hold input which allows the timer to count down when on or to hold the current count when off. Count-down will resume if it returns to 'on', provided that the first input is still in the Enable state. A general counting facility can be created in the same way.

PLC programming – method similar to that for hard-wired system

The normal method of programming PLCs has been devised particularly for engineers familiar with relay networks. It is based on the preliminary drafting of these networks in the form of "ladder" diagrams, which are widely used by designers or hard-wired logic systems. The detailed program instructions and procedures employed subsequently vary from PLC to PLC, but they all bear a family resemblance.

An illustration of the programming sequence can be obtained from Fig 4 which provides examples of networks in ladder diagram form (assumed to be parts of a program of 31 steps), together with the corresponding program instructions and the keying sequence through which the program is entered *via* the Program Loader in Fig 2. On the ladder diagram contacts are shown as pairs of vertical lines, with a diagonal line through them if they are normally closed.

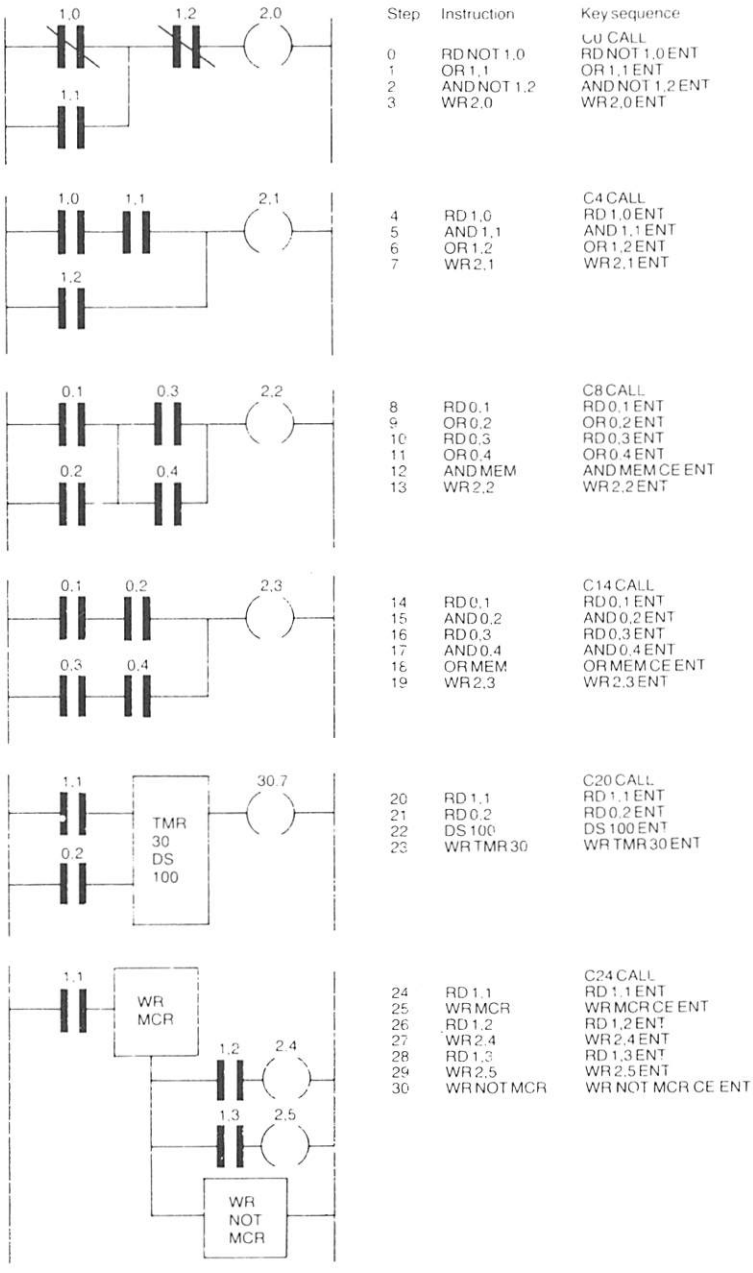
It will be seen that Boolean notation is not involved. As indicated earlier, the chief reason for using Boolean algebra is to minimise the number of elements in more complex installations, through manipulation of the Boolean equations shown in Fig 1. This is likely to be less important in smaller networks. Nevertheless, each "rung" of the ladder in Fig 4 corresponds to the Boolean format in Fig 1. The left-hand "rail" (vertical) of the ladder represents the power input to each network and the corresponding output device is linked to the right-hand rail. Output devices are shown as circles (or part-circles, as in Fig 4) if they are motors, relays and similar units, or as rectangles if they have logic functions, such as timers and counters. All except the last-mentioned have their memory address above their symbol. Therefore, taking the uppermost network in Fig 4 in Boolean terms this will be written

$$(1,0 + 1,1).\ 1,2 = 2,0$$

where 2,0 is equivalent to C in Fig 1.

In programming, the input instructions always start with RD (read) and output instructions start with WR (write). So, in the case of the uppermost network, the first three instructions refer to the input contacts 1,0; 1,1; 1,2 and the fourth to the output device linked to 2,0. (*Note* the diagram of Fig 4 refers to a smaller version of the PC 110, in which addresses 2,0 to 2,7 are assigned to outputs, unlike the PC 110 itself).

The fifth network shows a timer, assigned to register 30, and preset for a count-down from 100 (i.e. a 10s delay). This value is entered *via* the DS (data set) instruction. The address of the final bit in this timer (30,7) is shown as the output device. This would normally give rise to



Step	Instruction	Key sequence
		C0 CALL
0	RD NOT 1,0	RD NOT 1,0 ENT
1	OR 1,1	OR 1,1 ENT
2	AND NOT 1,2	AND NOT 1,2 ENT
3	WR 2,0	WR 2,0 ENT
		C4 CALL
4	RD 1,0	RD 1,0 ENT
5	AND 1,1	AND 1,1 ENT
6	OR 1,2	OR 1,2 ENT
7	WR 2,1	WR 2,1 ENT
		C8 CALL
8	RD 0,1	RD 0,1 ENT
9	OR 0,2	OR 0,2 ENT
10	RD 0,3	RD 0,3 ENT
11	OR 0,4	OR 0,4 ENT
12	AND MEM	AND MEM CE ENT
13	WR 2,2	WR 2,2 ENT
		C14 CALL
14	RD 0,1	RD 0,1 ENT
15	AND 0,2	AND 0,2 ENT
16	RD 0,3	RD 0,3 ENT
17	AND 0,4	AND 0,4 ENT
18	OR MEM	OR MEM CE ENT
19	WR 2,3	WR 2,3 ENT
		C20 CALL
20	RD 1,1	RD 1,1 ENT
21	RD 0,2	RD 0,2 ENT
22	DS 100	DS 100 ENT
23	WR TMR 30	WR TMR 30 ENT
		C24 CALL
24	RD 1,1	RD 1,1 ENT
25	WR MCR	WR MCR CE ENT
26	RD 1,2	RD 1,2 ENT
27	WR 2,4	WR 2,4 ENT
28	RD 1,3	RD 1,3 ENT
29	WR 2,5	WR 2,5 ENT
30	WR NOT MCR	WR NOT MCR CE ENT

Fig 4. Ladder diagrams and program entry (MTE/Westinghouse)

an input contact (30,7) in another part of the network. Note that inputs 0,2 and 1,1 are common to earlier networks.

The bottom diagram refers to a Master Control Relay (MCR) which can be called into play by a programming instruction but requires no user-allocated register. This instruction allows a single control circuit (operating contact 1,1) to generate a secondary input power rail, which is only energised when the MCR is on. Outputs 2,4 and 2,5 will be de-energised when the MCR is off.

The key sequence in the right-hand column of Fig 4 relates to the keyboard of the Program loader, which also has a display panel through which the programmer can check each keyboard step before entering an instruction in the PLCs' memory, or can search and amend existing programs in the memory. The display also provides error messages in the event of incorrect keyboard use or a malfunction of some kind.

More sophisticated programming units are available from most manufacturers, either in the form of special keyboard/LCD display units or of table-top computers. They are programmed to generate and modify ladder diagrams in response to menu-driven keyboard instruction, then to load the final program into the PLC *via* a standard communications link. They can also produce hard copy of the ladder diagram and program *via* a standard printer. Some can also be used on-line to the PLC in its RUN mode, for diagnostic purposes. In this application they display the ladder network and enhance the elements that are active at any time.

Diagnostics and program testing

PLCs normally perform a set of automatic diagnostic checks when their power is applied. These ensure that the hardware is functioning and that memory back-up has been effective. During program runs, testing of hardware should continue, accompanied by monitoring of user software. A "watchdog" timer should guard against processor failure and if an error is detected, outputs should be disabled. The program loader's display may be used to display run-time error messages as well as those displayed during program development

Given that the PLC is functioning correctly, program testing using simulated inputs is the next necessary step. Programming PLCs' is not difficult to learn but the ladder network on which a program is based may not always meet the process control requirement! Observation of the PLCs' input/output LEDs may help to diagnose the cause of a problem shown up by a simulated run but the most advanced programming units, with ladder diagram display capability, are obviously of great value in trouble-shooting.

Applications in agriculture

Many PLCs are embedded in industrial control equipment, housed in environmentally protective enclosures to IP65 or IP67 standards, together with other electrical and electronic units. These enclosures and their visible controls and displays frequently provide no clue to the presence of a PLC. Nevertheless it is now widely used in industry generally.

So far its application to agriculture and horticulture has been less pervasive, but this reflects the relatively limited scale of electronics in farming at present. However, PLCs have found applications in the spheres of crop handling, drying, storage and grading and, to a lesser extent, in the livestock sector.

A particular example of agricultural application is to be found in the grain handling facility at AFRC Engineering (Fig 5).

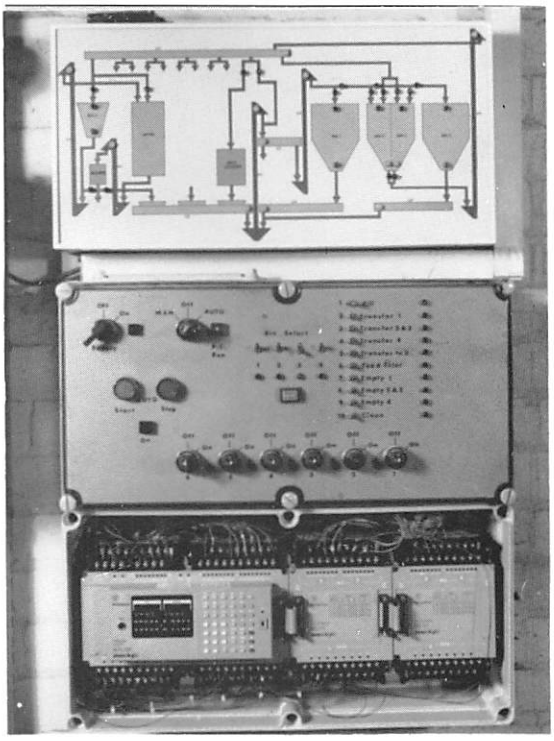


Fig 5. Control unit for grain handling facility (AFRC Engineering, Silsoe). At top – mimic diagram; in centre – electrical control switches and indicator lamps; below - programmable logic controller.

The Silsoe facility provides sufficient storage and handling capacity for experimental - and pilot-scale work on driers, cleaners and associated equipment. An underfloor conveyor with three access gratings feeds grain to the base of a vertical elevator and thence into any one of two 10 tonne bins or two 5 tonne bins. From the bins, the grain can be elevated to an overhead conveyor in the roof of the building from which it can be directed to either the experimental continuous-flow drier, the grain rewetting hopper or the grain cleaner. Extra outlets provide for the feeding of other equipment, such as small driers, which may be brought into the building for research or testing purposes.

The PC used in this application is an MTE PC110 plus 2 PCE111 Extenders. Main features are:

Inputs (up to 56)
- Bin selector switches.. 4
- Function switches 10
- Diverter sensors 14
- Bin full sensors 5
- Bin empty sensors 5
- Motor overload sensors.....8

Outputs (up to 32)
- Motor contactors 8
- Solenoid valves 2
- Alarm 1
- Diverter relays 7

Timers - 0 to 12.7
Counters - 1 to 127

The unit is programmed in relay logic using an NLPL program loader having a maximum capacity of 1024 steps. The existing program uses approximately 300 of these.

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Weed control – testing the effects of infrared radiation

S Parish

Techniques to replace the use of herbicides are being investigated for a variety of reasons. There are problems of weed resistance to herbicides; the costs of some spraying programmes and there is also an increasing interest in organic production.

Laboratory trials have been carried out on mustard and ryegrass plants exposed to medium wave infrared radiation. The mustard plants were killed and the ryegrass was severely affected. Useful data was obtained for future work on the development of infrared machines for weed control.

Before the adoption of herbicides, traditional weed control in row-crops depended on inter-row cultivations and hand hoeing down the rows. This latter operation was time consuming and expensive and it is still the problem of weeds in the crop rows which provides the challenge for non-chemical weed control.

Novel ideas for weed control

Effective weed control depends on the integration of available machinery and techniques (Parish, 1987), and novel ideas are continually being tested, including in thermal, electric shock, solarisation and air blast methods.

Electrical discharge methods are still at an experimental stage. There are two shock processes under development; the spark discharge type and the contact type (Diprose and Benson, 1984). Both require voltages of 20 kV, which gives rise to some safety problems. However there are no dangerous residues after the pass with the machine, and therefore no delay in following operations.

Thermal techniques are more established and infrared type machines are available using liquefied petroleum gas (LPG) as the fuel source (Van't Rood, 1984). An electrically powered infrared machine would not have the disadvantage of needing to exchange exhausted gas cylinders.

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Infrared weeders available but performance data incomplete

Although there are several LPG infrared weeders available on the European market, there is a lack of experimental data on their use. Published work has tended to concentrate on the results of field plot trials rather than laboratory based trials.

In order to investigate the effects of different wavelengths of infrared radiation on plant survival, an electrical infrared industrial simulator (IRIS) unit was used in laboratory trials at the West of Scotland College. Two plant species were treated with four different wavelengths, over three exposure times.

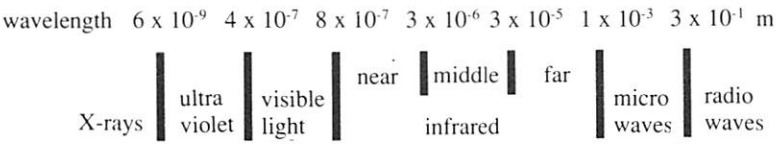

Fig 1. The position of infrared radiation in the electromagnetic spectrum (not to scale).

The position of infrared wavelengths within the electromagnetic spectrum is shown in Fig 1. Radiated energy from an emitter consists of a range of wavelengths and the peak energy wavelength depends on the nature and temperature of the emitter (Fig 2). Increasing the emitter temperature reduces the peak energy wavelength, increasing the energy intensity. When the energy radiated reaches plant tissue it can be reflected, transmitted or absorbed.

For efficient plant destruction, an emitter is required which produces a high energy intensity at a wavelength which is absorbed, rather than reflected or transmitted, by the plant tissues. Evidence obtained from work on some grasses by Hooper (1977), suggested that wavelengths of 1.44 and 1.93 microns should be effective on low dry matter tissue, as these coincide with the peaks of infrared absorption by water.

Trials with mustard and reygrass

White mustard and Italian ryegrass were selected for the experiments to represent examples of dicotyledon and monocotyledon plants. They also germinate reliably, an important consideration in experimentation. Results of germination tests showed 92% and 93% for the mustard and ryegrass respectively.

Fifty seeds were sown in potting compost in polystyrene trays, each measuring

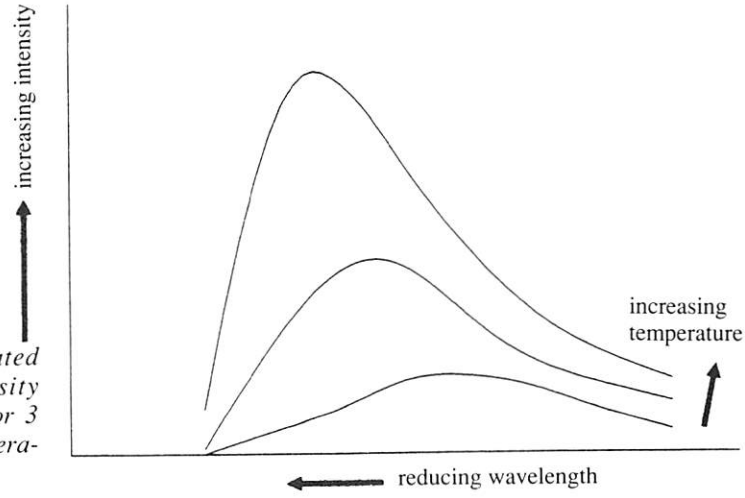

Fig 2. Radiated energy intensity from a body for 3 different temperatures.

210 mm and 160 mm. This rate of sowing gave the equivalent of approximately 1400 plants/m^2 in order to minimise random variation between trays.

The IRIS unit (Fig 3) was set with the emitter 200 mm above the surface of the compost in the trays. Trays filled with unsown compost were tested in the unit for heat damage. The distortion that did occur at the edge of the trays under two of the emitters was considered to be acceptable and caused no structural problems to the trays or plant contamination.

Four different emitters were used and details of these are given in Table 1.

Table 1. Summary of emitter characteristics (after Anon, 1982).

Emitter Type	*Class*	*Max running temperature °C*	*Peak energy wavelength m x 10^{-6}*	*Maximum intensity kW/m10^{-2}*	*radiant heat %*
Reflector heat lamp (SWB)	SW	2200	1.2	10	75
Tubular fused quartz (SWQ)	SW	2200	1.2	80	80
Tubular fused quartz (MWQ)	MW	950	2.6	60	55
Metal sheathed (LWM)	LW	800	3.0	40	50

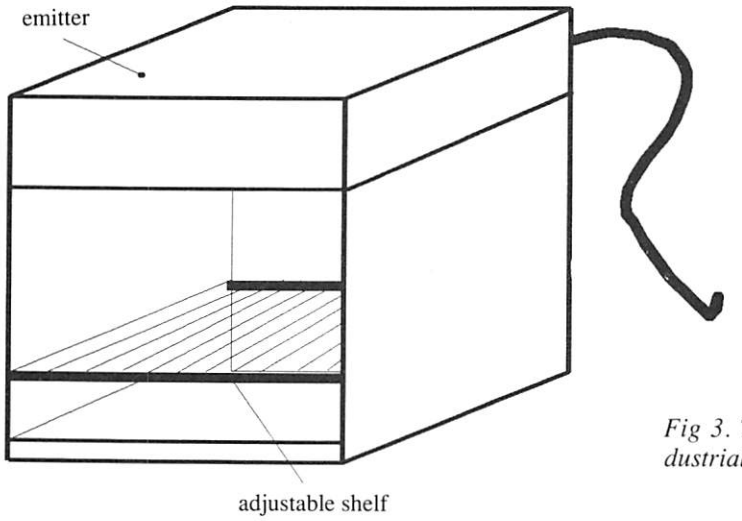

Fig 3. The infrared industrial simulator unit.

Pilot tests had indicated that exposure times of up to 20 seconds may be required to affect the plant growth. The effects at different growth stages were also investigated, so with 2 crops, 2 growth stages, 4 emitters, 3 exposure times, controls and 3 replicates, 160 trays were prepared. These were placed in a heated glasshouse and the compost kept moist, both before and after treatment.

Treatments at two growth stages

The plants were treated at either an early growth stage or a later stage. For the mustard plants the early stage was the cotyledon leaf stage, with the plant height approximately 40 mm (9 days after sowing), and the later stage was the 2 to 4 true leaf stage, with the plant height approximately 100 mm (15 days after sowing). For the ryegrass the two stages were the shoot stage, plant height approximately 70 mm (9 days), and the 1 to 3 leaf stage, plant height approximately 140 mm (20 days).

Twenty-five days after sowing, a subjective assessment of plant damage due to the treatments was made. The plants were then cut at the level of the compost surface, and the fresh weights recorded. The cut material was dried overnight in an oven at 100°C, and the dry weights recorded. The data analysis is based solely on the dry weights obtained.

Wave length, time required and growth stage assessed

The main interest was to define the most effective wavelength for killing plants, the time period required to achieve this, and the appropriate growth stage for the operation. The amount of energy required was also compared.

An analysis of variance was carried out and the table of means used to establish the comparative dry weight data presented in Fig 4. This shows that, for mustard, the MWQ emitter, the 20s exposure time, and the early growth stage give the most effective trends.

Where treatments seemed effective on ryegrass, the growth stage was not significant, probably because the re-growth following the earlier treatment compensated for the checking of growth by the later treatment. Observations made on the effect of the treatments on ryegrass indicated that even when the damage appeared severe, the plants were able to grow on (Table 2). On the other hand, the t-distribution showed that for mustard, the growth stage at the time of treatment is significant at the 99.9% level and more plants suffered total damage at the early stage than at the later stage.

The most effective emitter on mustard was the MWQ, although the SWQ was also effective at the early growth stage at

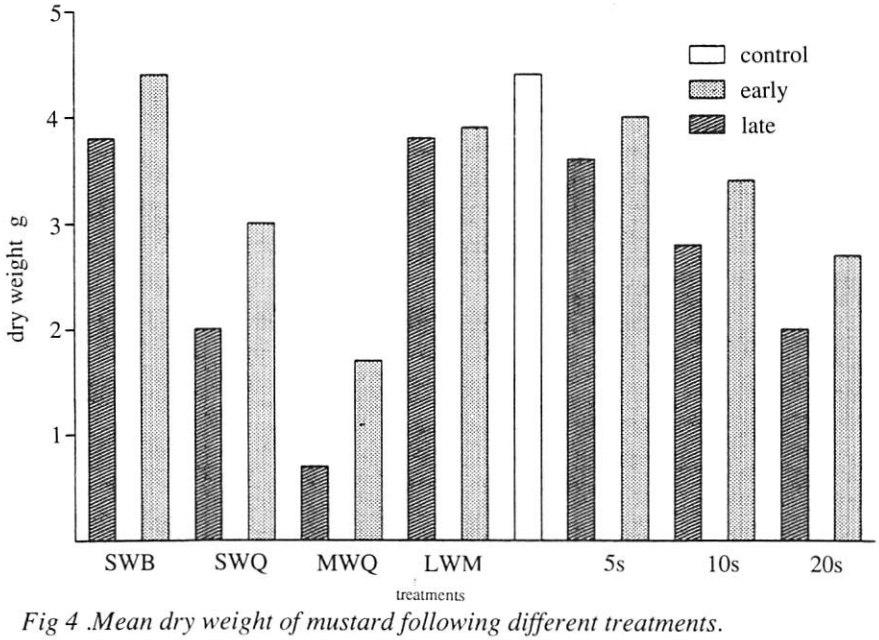

Fig 4 .Mean dry weight of mustard following different treatments.

Table 2. Observed damage to plants (% within treatment)

Observations	*Ryegrass*		*Mustard*	
	early	*late*	*early*	*late*
trays of plants severely affected	13 (36%)	11 (31%)	6 (17%)	7 (19%)
number of above showing regrowth	13	4	0	0
number of trays of plants suffering total damage (excluding those defined as severely affected)	0	0	7 (19%)	2 (6%)

20s exposure (Table 3). The MWQ was also more effective on ryegrass, but not significantly so (Table 4).

Closer analysis of the emitter characteristics enables a comparison to be made of power densities and radiant heat energy densities involved in each of the treatments (Table 5). The data can then be used to compare the dry weights obtained with the total and radiant energy expended. Fig 5 shows that, of those tested, the MWQ is the most effective emitter and 2.6 microns the most effective wavelength on the early mustard.

From these results, some guidelines can be proposed for the purpose of further development:-

- for mustard at the cotyledon leaf stage an energy density of 200 kJ/m²of medium wave infrared radiation is required to kill the plants.
- for ryegrass at or before the 3 leaf stage, 400 kJ/m² of either short wave or medium wave infrared radiation is required to affect severely the plant growth.

Table 3 Analysis of all data using t-distribution

Emitter	*Time, s*	*Early*		*Late*	
		Mustard	*Ryegrass*	*Mustard*	*Ryegrass*
SWB	5	0	0	0	0
SWB	10	0	0	0	0
SWB	20	0	0	0	0
SWQ	5	0	0	0	0
SWQ	10	***	***	0	*
SWQ	20	***	***	***	*
MWQ	5	***	***	*	*
MWQ	10	***	***	***	**
MWQ	20	***	***	***	**
LWM	5	0	*	0	0
LWM	10	0	**	0	0
LWM	20	0	**	*	*

note on Table 3 and Table 4

0	*no statistical difference between treated trays and controls*
*	*difference at the 95% level*
**	*difference at the 99% level*
***	*difference at the 99.9% level*

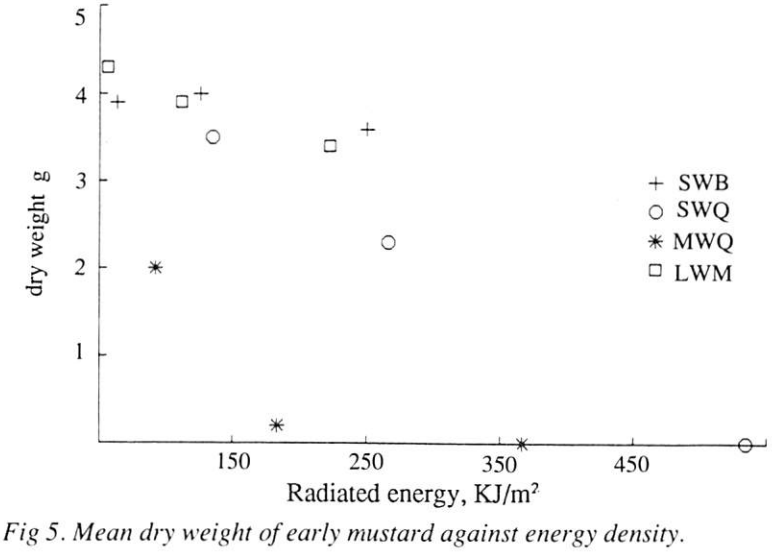

Fig 5. Mean dry weight of early mustard against energy density.

Mustard can be killed and ryegrass severely restricted

Use of the IRIS unit has established that mustard plants can be killed, and ryegrass growth severely restricted by infrared radiation. The energy required to achieve this is of the order of 200 to 400 kJ/m². The medium wave tubular fused quartz emitter proved to the the most effective, particularly on mustard and the short wave tubular fused quartz emitter was also effective.

Tests are planned to make comparisons with gas fuelled infrared units under similar controlled conditions. It may then be possible to assess the viability of electric infrared equipment for weed control. of the IRIS unit.

Table 4. Comparison of SWQ and MWQ from t-distribution

Time	*early*		*Late*	
S	*M*	*R*	*M*	*R*
5	**	0	0	0
10	***	0	***	0
20	0	0	0	0

M = Mustard : R = Ryegrass

Table 5 below. Emitter power and energy densities

Emitter	*Power rating, W*	*Intensity, kW/m²*	*radiant heat %*	*Radiated energy intensity, kJ/m²*		
				5s	*10s*	*20s*
SWB	1500	16.7	75	62.5	125	250
SWQ	3000	33.3	80	133	266	534
MWQ	3000	33.3	55	92	183	367
LWM	1960	21.8	50	54	109	218

Acknowledgement

The author would like to thankthe south of Scotland Electricity Board for the loan of the IRIS unit.

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The Work of the Soil Survey and Land Research Centre

I. Bradley

For fifty years the Soil Survey of England and Wales, since 1987 re-named the Soil Survey and Land Research Centre (SSLRC), has been describing, classifying and mapping the soils of England and Wales. At the Extra-ordinary General Meeting of SaWMA, held in the Survey's new headquarters building on the Silsoe Campus, the author, together with Arthur Thomasson, Head of Research and Development, outlined some of the more recent applications of Soil Survey information.

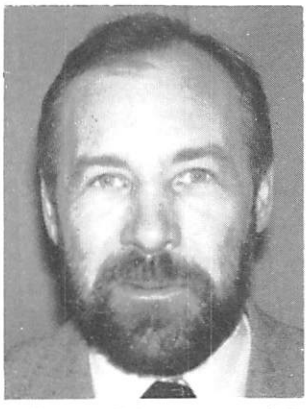
Support for continued programme of soil mapping

Map production is still the main role of the Soil Survey. The latest issues are one at 1:50,000 for the Market Weighton district of Yorkshire and one to similar scale for the Liverpool district. Several more maps are in the pipeline. However, beyond these, future planned contracts with MAFF do not include further map coverage on standard sheet lines.

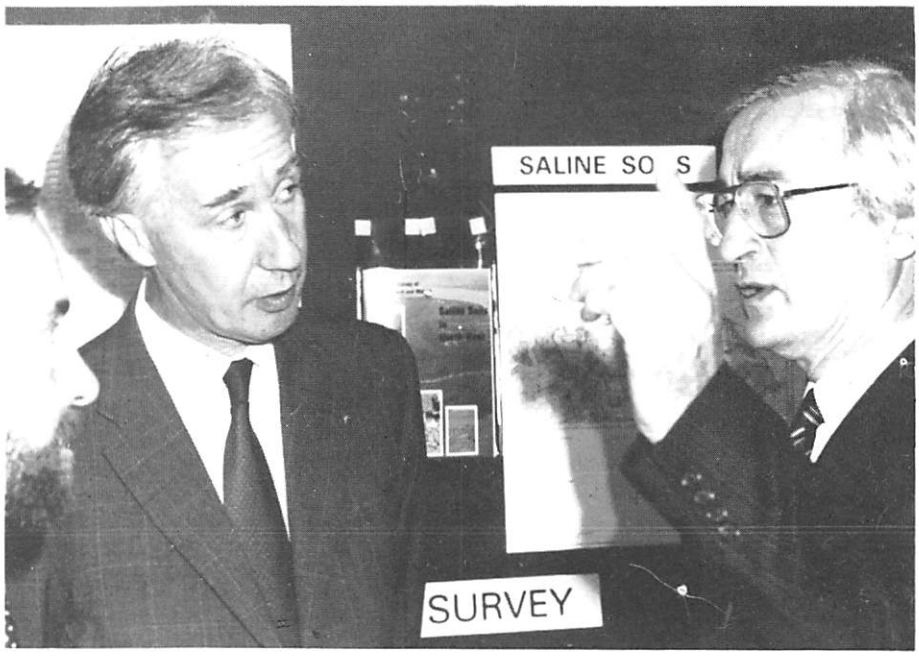
The Survey would like the mapping programme to be re-instated and there is much support for this from other workers in the field. Such maps are seen as an important basic source of information on the soils of this country. We still only have 25 per cent of England and Wales covered by detailed soil mapping.

Surveys answer questions of land use and management

Further to its map production work, however, the Survey has in recent years been extending its activities. It has expanded beyond the straightforward production of soil maps and simple explanatory texts.



Ian Bradley is Education and Professional Development Manager of the Soil Survey and Land Research Centre, Silsoe, Bedford



Director of the Soil Survey and Land Research Centre, Professor Peter Bullock (right) in discussion with The Lord Privy Seal, Lord Belstead at the opening of the Survey's new HQ building, Silsoe Campus in September, 1988.

Now we can not only ask, but also answer, questions such as – "What do the patterns mean?"; "What are the implications for a particular potential user of soil data?"

This has been a most important change in our approach. It is well illustrated by the example of two recent surveys. These surveys were both commissioned by MAFF and have dealt respectively with saline soils in Kent and with a national inventory of lowland peat soils.

Reporting on the peat survey, Rodney Burton, SSLRC coordinator of the survey, has highlighted the dramatic reduction in the extent of Fenland peat. Only one sixth of the original area of Fen peat remains and the prediction is that, with continued loss at present rates of wastage, only some 30 square miles will be left of the original 572.

Most of the peat losses result from the application of intensive agricultural practices. Peat loss is inevitable from the time that water tables are first lowered by drainage and, as the peat cover reduces, so-called skirt soils are produced with the textural characteristics of the underlying mineral soil coming more and more to the fore. With knowledge of the subsoils the inevitable changes in texture, acidity and so on and their effects on cropping and yields can be firmly predicted.

The question of crop suitability has been the basis of a number of the Soil Survey's projects. We are asked to answer requests for information about the suitability of a particular soil type at a specific locality for a particular crop. A

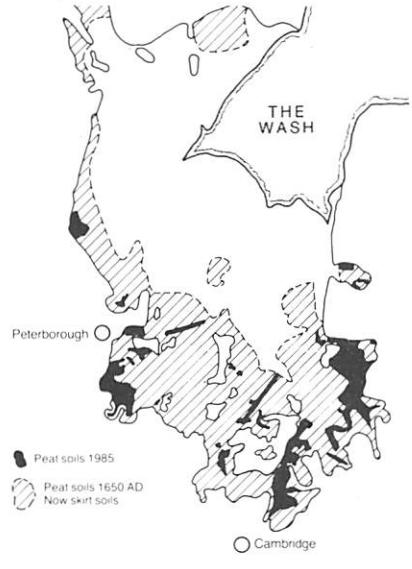


Fig 1. Data compiled by the SSLRC shows the extent to which the area of peat soil has declined in the Fens of Eastern England. Continuing losses are forecast.

national service has also lately been launched by the survey to assess the effects of *Set Aside* on individual farms - to offer farmers the chance to find out which of their land is the least profitable and which could benefit from fallowing.

Similar interpretations also form an integral part of the farm survey service offered by the Soil Survey to farmers, managers and land owners. This service provides a traditional soil map backed up by a report on various aspects of the land, drainage and cultivation requirements, droughtiness and wetness. The workability periods in autumn and spring when the land can be tilled without causing significant amounts of damage are given, together with information on the suitability for different crops on the farm.

Other aspects of the Survey's activities include topics such as the provision of land classification for rent reviews and land suitability for woodlands. In their various reports the Survey aims to provide the farmer with understandable information on his land which will help in the decisions on land management and use that he has to make.

Such information on land management is, of course, not only sought by farmers. The Survey is working nowadays on an increasing number of projects for non-agricultural interests: studies for the mineral industry - the quality of the sub-soil, the handling capabilities of the site; for the leisure industry - the "trafficability" for feet or for horses; for service industries - pipeline installation and maintenance; for forestry and woodland developments and so on.

Nitrate leaching assessment

A project undertaken for the Severn Trent Water Authority required the Survey to give a broad outline of areas likely to be a high risk for nitrogen leaching. This has been followed by detailed reports on the soils in the high risk areas and the management needed to minimise the problem.

Studies of nitrate leaching have been funded by the European Community, Water Reserch Centre and MAFF. Early results suggest that on high risk soils (mainly the chalk, limestone and sandland in Midland, Eastern and Southern England) nitrate losses equivalent to 30-40 kg N/ha are commonplace under winter cereals. Greater losses are found after potatoes, oilseed rape or vegetable crops.

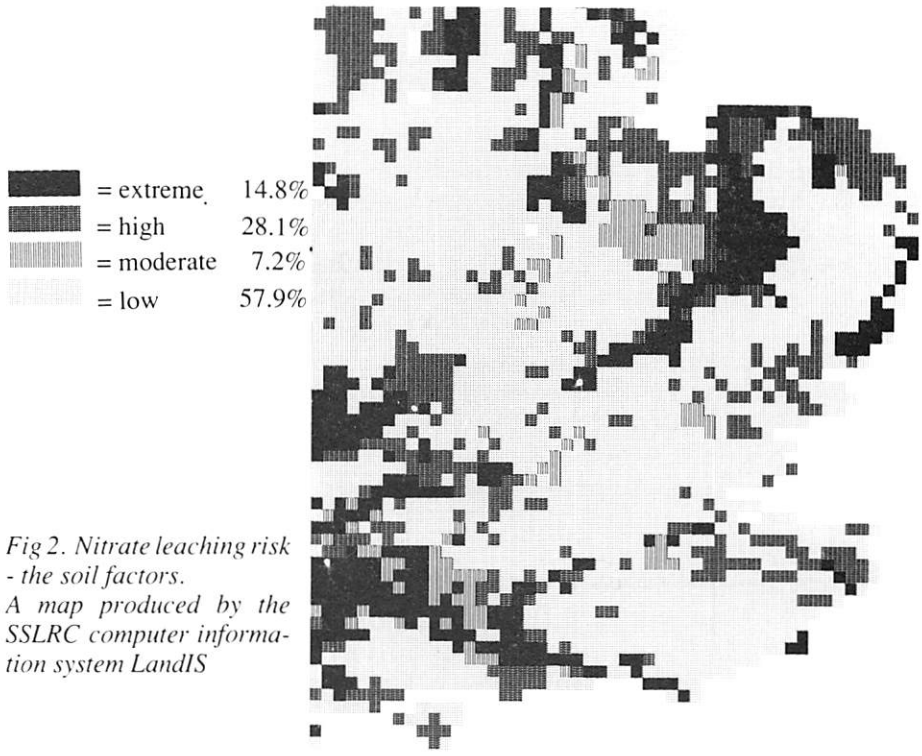


Fig 2. Nitrate leaching risk - the soil factors. A map produced by the SSLRC computer information system LandIS

In order to conform with EC water quality standards for human consumption, average leaching losses need to be brought down, for example, below about 20 kgN/ha in the dry areas of Eastern England. Such reductions are unlikely to be achievable on arable crops even at very low levels of N fertiliser use but initial results from SSLRC studies do indicate very efficient use of nitrogen and low leaching losses with grassland.

One must stress, however, that generally the land use implications for protection of groundwater supplies are currently in confusion. More grassland may be the answer but grazing cattle could add more leaching problems. Intensive livestock farming in Northern Holland and Belgium is already causing problems there with pollution of water supplies.

Computerised land information

One of the more recent developments at the SSLRC and now one of its greatest assets, is the Land Information System (LandIS). This computer based system has been designed to make soil survey data more accessible. It can provide agro-climatic data especially for agricultural land classification and crop suitability modelling. Various forms of map and line printer output can be derived integrating in various ways the soil, site and climate data on file.

LandIS is attracting interest in other countries and already the SSLRC has been contracted to advise overseas scientists on how to set up and run such systems.

The Soil Survey was located for nearly 40 years at Rothamstead Experimental Station. Then, in July 1987, the move was made to Silsoe Campus. This was to bring us into closer contact with a commercially orientated academic institution. Now, with 23 headquarters staff at Silsoe and a further 20 in the field, the 'new' Soil Survey and Land Research Centre is ideally placed to respond to the evergrowing demand worldwide for soils information - not only for agriculture, but also for all aspects of conservation and the environment.

Fig 3. A typical chart prepared by the Survey shows the effects of soil and climate on the opportunities for tillage and other work.

Soil series	Soil assess-ment	Type of Year	M.W.D.'s	AUTUMN SEP	OCT	NOV	WINTER DEC	JAN	FEB	SPRING MAR	APR	M.W.D.'s
Hanslope	bc	Normal	101				CALDECOTE 550 mm annual rainfall					33
		Wet	79									12
Faulkbourne	c	Normal	68				WALGRAVE 625 mm annual rainfall					15
		Wet	38									0

M.W.D.'s : Number of good machinery work days during the period indicated

Frequent opportunities for Autumn landwork

Frequent opportunities for Spring landwork

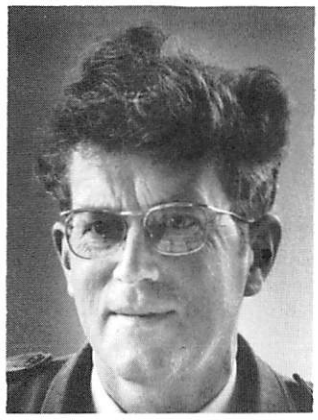
Little opportunity for landwork

Members' views on the Agricultural Engineer

D.S. Boyce reports on the results of the questionnaire

A questionnaire to determine members' views was enclosed in the Summer, 1988, issue of the Agricultural Engineer (AE). It would have been desirable if more members had returned a completed questionnaire, but, nevertheless, the results from those returned are of considerable interest.

The Editorial Panel would like to thank all those who took part in the survey, and in presenting this summary of results it is hoped that we shall encourage further comment and discussion both from those who have already responded and also from any other members who now feel they would like to contribute ideas to improve the Institution's publications.



Profile of members replying

Numbers: There were 117 replies representing 5.12% of the membership of 2285. 75 Fellows and Members replied, 5.90% from a total of 1272, so these two grades are slightly more fully represented. 83% of those replying were from the UK compared with an actual UK membership share of 78%. It would have been desirable if more replies had been received, but it is felt that any return in excess of 5% provides a useful guide to members' views, (the average return from unsolicited questionnaires is only 3%).

Employment: 37% of those replying were in the private sector (24% in industry, 10% consultancy and the remainder farming). Of the 63% in the public sector roughly half were in education and the remainder mainly in R & D, advisory and health and safety.

Publication experience: 15% of those replying had published one or more papers in the AE during the past 5 years. 31% had published elsewhere and 17% had given a paper(s) at Institution Conferences. 43% said they had material which they felt would be suitable for publication. The most common reason given for non-publication was lack of time, while many in the private sector cited the need for confidentiality.

Non-member readership: 24% of those replying said they circulated their copies of the AE to non-members. A total of some 120 non-member readers were identified and most of these were students, presumably potential Institution members.

Views on the AE

General: 82% found the AE interesting or moderately interesting; only 10% said it was uninteresting. 89% indicated in their view the overall impression given by the AE was very good or good; only 9% felt the overall impression was poor. There were a few suggestions for improving the overall impression, such as redesigning the front cover, changing to an A5 format, improving the layout and omitting pictures of authors.

Topics: The replies to topic interest were simplified by deeming a rating of 1-2 most interesting, and of 5-6 not very interesting. Rated most interesting were new products:- 49%; farm applications - 50%; and R & D - 51%. Those rated not very interesting were: editorial - 43%; manufacturing processes - 36%; and education and careers - 51%.

Level of papers: 46% of those replying felt that some of the papers published were too theoretical, a few felt a large proportion of the material was in this category, but 30-40% was the more usual. A number of those replying cited specific papers. Twelve and four replies respectively identified two specific papers concerned with specialized aspects of computing. The remaining six papers cited singly did not seem to have any common factors. Such papers seemed to be worthwhile for in depth descriptions of applications of new technology with a mathematical basis.

Many members have material to contribute.

In the replies concerning publication experience it is encouraging to note that many members not only have experience in preparing papers for publication but they also have considerable suitable material - provided they have the time to present it.

The non-member readership (the students) must be kept in mind and members should be encouraged to further this readership wherever possible.

AE generally interesting but sometimes too theoretical

The large number of replies stating that much material is too theoretical needs to be given careful consideration. It must, however, be kept in mind that there is a conflict between providing topical easy to assimilate descriptive material and the need to publish substantial original papers with an analytical basis, which may be only of interest to a few specialists.

This conflict of interests is highlighed in some of the general comments which members were invited to make on how they regard the AE. Many of these general comments are very helpful in clearly stating the conflicting objectives which must be reconciled in formulating an Editorial Policy of the AE and other Institution publications.

Some of the more pertinent comments are listed opposite. It must be stressed, of course, that these are individual comments and do not necessarily represent a consensus view.

Danny Boyce recently retired as a Divisional Head at the NIAE (now AFRC Engineering). He is a member of the Editorial Panel.

Some general comments

"I have felt very strongly, since 1956, that there is no reason for three journals. The Journal of Agricultural Engineering Research (JAER), the AE and the Institution's Newsletter. The JAER and the AE should be merged and the Newsletter expanded."

"The AE requires articles directed at the market, not failed JAER papers. Papers should be written in a technologically informative manner rather than pseudo-scientific - let others do this work. At the moment we are falling through the gap in the middle."

"The AE seems to fall between two stools. Chatty and personal interest stuff is well covered in the Newsletter and the highbrow intelligent in the JAER. The AE should not aspire to JAER which does a good job for its constituency. What is the AE's niche?"

"I value the AE for the range of papers published both in length and technical content. As the Journal of the I Agr E, I see it as critical that the 'refereed scientific papers " are maintained as a proportion of the contents."

"The AE should appeal to a wider audience than those in R & D at Silsoe. I prefer the format of the Sugar Beet Review."

"There is a dilemma. Authors of high quality scientific papers will only publish in reputable journals. To gain that reputation a high proportion of the papers need to have an appropriate scientific content which would result in the AE becoming a JAER lookalike. I prefer a wide span of contents but a span with the ends clipped off, i.e. not very detailed or abstracted scientific papers, (I believe there have been too many of these) and also too many that state the obvious."

"I would prefer the AE to incorporate most if not all the information in the Newsletter. It would then provide a useful source of information for members. At present it does not succeed as a poor man's JAER."

"Are you competing with the JAER for submissions? Could there be a clear difference to attract articles to the AE?"

"I would suggest you need two journals, one of interest to all monthly, and a second a technical report of R & D quarterly."

"I still am not sure if the AE is a fully refereed paper for publication purposes."

These comments highlight important issues. The first is the requirement of the AE to portray Institution members as professional engineers at the forefront of the application of advanced technology. This contrasts with the legitimate interest of many members requiring informative articles of general and topical interest which are "not theoretical". This implies description of applications, rather than mathematical analysis of principles.

The relationship between the AE and JAER is also pertinent. The idea that the AE is a "poor man's" JAER stems from members in the publicly-funded R & D sector. In fact, the circulation of the JAER is more restricted than that of the AE. The AE has to appeal to a wider readership with papers that are more directly relevant to the industry as a whole.

However, it must be seriously questioned whether in the UK there is either sufficient material or it is desirable to have two journals for refereed papers on agricultural engineering R & D. If public financial support for the JAER is withdrawsn there is undoubtedly a case for a single journal and the feasibility of such an approach should be very carefully considered. If, however, this could be realized, there would likely be scope for an enlarged monthly publication for short articles on new technical development and products, news of events and members and such like, which would have a broad appeal.

Alternatively, if it is not possible to publish all refereed papers in a single journal, the AE should identify a specific area for refereed papers which would appeal to as wide a readership as possible and encourage contributions to meet this requirement. Perhaps medium length review papers on topics of wide general interest would meet this requirement. It is important that any refereed papers that are published are well identified as such and that they are of a high standard.

Relationship with the Newsletter.

The relationship between AE and the Newsletter concerned many members replying to the questionnaire. Some felt that these should remain separate while others that they could be combined. This is, however, a matter of policy for the Institution with regard to the objectives of the AE, the financial support available, and the willingness of members to take editorial responsibility and of the membership in general to contribute material.

Contributions needed from Specialist Groups and Overseas

There were a number of suggestions for increased coverage of specific topics, for example, field engineering, soil and water, farm buildings and livestock. The merger with Soil and Water journal is meeting one of these requirements. Several members suggested that more attention be given to overseas topics. This seems quite reasonable in view of the number of overseas members and of UK members temporarily posted abroad and the importance of agricultural engineering in these areas. Every effort should therefore be made to encourage a member to take responsibility in terms of news and articles from overseas.

While not specifically mentioned by any of those replying to the questionnaire, the need to involve as many members as possible in providing material for publication is of great importance. For this reason it would seem desirable if it could become one of the specific responsibilities of the Specialist Groups to provide brief reports on new developments in their areas and periodically refereed technical reviews.

The Editorial Panel is grateful to the members who took the trouble to complete and return the questionnaire. A large number of opinions and views have been expressed and while it has not been possible to refer to them all specifically they have all been most carefully considered. It is hoped that the publication of these results will encourage further discussion.

Footnote from the Hon. Editor.
At this time of incorporation of the Soil and Water journal we do have a particular opportunity to introduce changes. We are seeking to act on consensus views of readers.

BOOK REVIEWS

Animal drawn wheeled tool carriers. Perfected yet rejected by Paul Starkey

Publisher: Friedr. Vieweg & Sohn, Braunschweig/Weisbaden, FRG, 1988
Marketed in the UK by John Wiley & Sons, Baffins Lane, Chichester, PO19 1UD.
ISBN 3-528-02034-2 £9.55 (paperback)

The concept of a 'biological tractor' aims at enabling developing agricultures to advance towards the versatility and convenience of mechanically-powered traction. The means of putting this into effect is a toolbar mounted on wheels and pulled by bullocks, oxen, horses or other draft animals, providing for multi-purpose use, the mounting of implements and the availability of a mechanical drive taken from a landwheel to operate seeders or other rotating mechanisms. Such toolcarriers for small scale farmers, of various levels of sophistication, have been developed for over 30 years.

Paul Starkey's well-researched book reviews the development of animal-drawn toolcarriers from 1955 onwards, in more than thirty countries. He distinguishes between *toolcarriers* and *toolbars*, the latter being of much simpler construction, of lighter weight and usually without a mechanism for raising implements clear of the ground, and he describes various approaches to toolcarrier design.

The concept is one which many people interested in agricultural development have found exciting, including, until 1986, the author. He then became aware of a marked discrepancy between the published reports on the performance of animal-drawn wheeled toolcarriers, which were generally very optimistic, and the actual uptake of the system in practice by small farmers. Whereas at research institutes and other officially-sponsored centres their use was claimed to offer major benefits, in no case was there evidence of continued use by practical farmers, even where the equipment had been provided at no cost.

The latter part of the book examines the reasons for this apparent paradox, 'perfected yet rejected', in the words of the sub-title, and goes on to make a very important point in relation to officially sponsored agricultural development in general. This is that successful implementation of new technologies at research institutes and other centres administered by aid agencies depends on favourable conditions which are not replicated in the local practical small scale farming. Because, understandably, the publications of such agencies are much more likely to report on success at the research level rather than failure in implementation by farmers, an entirely inaccurate picture of the real value of the technologies in question may be presented, as in the case of the animal-drawn wheeled toolcarrier.

Paul Starkey suggests that much more detailed study is necessary of the constraints affecting the small farmers to whom the transfer of technology is directed, if the lessons to be learned from this disquieting study are to be heeded. The involvement of small farmers at the early planning stages is essential, and he quotes a list of relevant steps in such a process of consultation. Though based on experience with animal-drawn wheeled toolcarriers, this approach is equally valid for other new technologies.

This is a very important book. In contrasting successful technology development at the official level with subsequent failure to implement the technology in smallholder practice, it presents a challenge to the planning of officially funded agricultural development schemes which demands urgent attention.

JACG

Copies may be obtained free of charge by organisations and individuals in developing countries concerned with development and appropriate technologies., from: GATE (German Appropriate Technology Exchange). Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), D-6236 Eschborn 1, Postfach 5180, FRG.

Soil microbial associations

Edited by V.Vancura and F. Kunc
Publisher: Elsevier Science Publishers, PO Box 330, 1000AH Amsterdam, The Netherlands. ISBN 0-444-98961-7, Vol.17, 498pp. Price US$155

Subtitled 'control of structures and functions', this is a translation of a 1987 text from the Czechoslovak Academy of Sciences Institute of Microbiology. It is volume 17 in a series entitled 'Developments in agricultural and managed-forest ecology'.

An ecosystem approach is taken and, after the introduction, six chapters follow:- nutrition and energy sources; structure of associations; mutual relations and functions in the rhizosphere; mechanisms of adaptation and selection; mutual relations among processes; cycling of mineral elements. Each chapter stands on its own with references appended and there are ample illustrations.

Although the work is not devoid of occasional faults in translation, on the whole it is a very clear presentation. Its appeal also lies in the combination of experimental results from both East and West, though the emphasis obviously rests on Eastern European data. It is well recognised that these countries have led studies of pedological processes and classification ever since the seminal work of Dokuchaev, and of microbial processes since Winogradsky.

It is admitted at the outset that planned omissions are:- details on symbioses such as Rhizobia Mycorrhizae; biochemical details of humus formation - on the legitimate grounds that these topics are amply treated elsewhere and would expand the text excessively.

In such a clear text the addition of a glossary would still be a helpful feature for the student, many of whom will not be specialist microbiologists.

At a time when there is considerable and growing interest in organic farming and agroforestry, this book fulfills a need for greater understanding of the principles underlying the successful pursuit of these enterprises with good management. However, the treatment of xenobiotics is rather scant. The rhizosphere effect is well brought out and, in particular, competition with pathogens. It would have been useful to the general reader to find a concluding chapter isolating the application of the data presented to the practical management of land.

The high price of this valuable book will result in its being largely a library source but it deserves wide exposure.

EJW

Energy savings in agricultural machinery and mechanisation

Edited by: G. Pellizzi, A. Cavalchini
M. Lazzari. Pub: Elsevier Applied Science, London.
ISBN 1-85166-236-7 £24

This book is the report of a study carried out under contract for the Directorate-General for Energy of the Commission of the European Communities. The specific aim was to outline and quantify the energy saving potential in the agricultural sector so that future energy demonstration projects can be tailored to identified needs.

The report is wholly bibliographical without any direct experimental analysis and in the reviewer's opinion this is a major disappointment.

It is a very thorough survey which examines energy requirements for growing various crops and the evolution of tractor manufacture and other machines.

However, apart from analysing in depth the potential for energy saving in tractors the rest of machine and mechanisation systems is rather poorly treated. In fact the conclusions and cost benefit analysis are most unconvincing.

The main merit of this book, is in the very well documented survey of existing information and research related to energy and its conservation. If it is considered as a text book drawing together fragmented data and presenting it on a directly comparable basis it is of particular value. In this context it will be a useful reference to most agriculturalists with an interest in mechanisation systems. It is well presented and easy to follow although a more positive sectionalisation would have helped.

If the reader is looking for an insight into future energy needs and savings they will be a little disappointed.

MJH

REVIEWS

Soils of the World

FAO UNESCO Wall Chart
Compiled by P. Lof, edited by H. van Baren
Publisher: Elsevier Science Publishers B.V.
PO Box 330, 1000AH Amsterdam, The Netherlands. 1987
ISBN 0444-42575-6. Single copy US$15, reductions for quantity

For all those who thought dirt was dirt wherever you found it, this FAO UNESCO poster entitled Soils of the World will come as something of a revelation. No less than 106 different kinds of soil are featured in full colour, each identified by its appropriate name or code in seven of the most commonly used classifications. The individual soil profiles are divided into layers or horizons and notes are provided to explain their significance, as well as the construction of the individual classifications quoted.

The photographs are excellent, many supplied by the International Soil Reference and Information Centre in The Netherlands. The soil colours are reproduced very well and in most cases the variations in structure from layer to layer are clearly visible. However, the absence from most of the profiles of a land surface does give them a somewhat disembodied appearance.

This poster will make a first class teaching aid and will serve to introduce many a student to the wide range of soils occurring around the world and identified on soil maps. It is a pity though that no attempt has been made to characterize the soils in layman's terms or to relate them to the ecosystem or landscape of which they form part.

The production of this poster may be admired for the diversity it reveals among soils but for many there will be little gain as far as concerns their practical knowledge and understanding of soils on the familiar ground of the farm, in the forest or on the hillside.

MGJ

International pesticide directory – Eighth edition

(Supplement to the Sept/Oct 1988 edition of International Pest Control)
Pub: McDonald Publications of London
OSSN 00208256 Price £20

This is a directory brought out each year in October. It is in three parts.

Part 1 is an alphabetical list of companies together with their addresses and their products arranged in alphabetical order. It uses a simple classification of pesticides to help the reader, for example, A acaricide, F fungicide, Fm fumigant etc.

Part II is an alphabetical list of pesticides which gives their active ingredients, an all too brief description of their uses as well as the names of the manufacturers and suppliers.

Part III provides a list of the active ingredients again in alphabetical order, together with the pesticides which are based on them.

The directory is well laid out and easy to use provided you have a reasonable knowledge of pesticides and the likely active ingredients. It is certainly comprehensive and will act as a good buyers guide. The price however, for a presentation in the same form as that obtainable in a glossy magazine, is certainly extremely high. This would seem to destroy the aim of the work which should be to impart its contents to a wide readership.

MJH.

FROM OUR MEMBERS

Generating local employment – the proper aim of Third World development projects

Sir, In his review paper "Agricultural engineering in 3rd world countries", Volume 43 nos 3 & 4, Professor May set himself an unenviable task, which could well justify a work of two volumes, let alone two articles.

If the topic were ever to be expanded in a future work, then perhaps a more questioning stance could be taken, and an analysis made of some of the alternative ideas being attempted. More space could also be used to unravel some of the more paradoxical statements, for example the idea of centralised mass production of ox-ploughs. Surely there is a conflict of ideologies here?

Do not the facts show that something is going wrong; that despite 50 years or more of agricultural mechanisation in the less developed countries, the rural poor are even poorer and famines seem to hit even harder.

While acknowledging the efforts of locally based engineers, the emphasis of changes in agriculture in many countries derives from their many years firstly under colonial rule and latterly under the influence of aid programmes. The former obviously changed existing cultural patterns to plantations for the production of crops like cotton, sisal, sugar, coffee, tea and oils, trapping the people into a world-wide cash economy from which there has been no escape. Most of the governmental aid is aimed at maintaining the *status quo*, rather than developing processes to add value to those export crops for the benefit of the producers.

Like it or not, the engineer is implicated in these structures, whether as an employee of a manufacturer, or as a jet-setting consultant. Of course, questioning the structures rarely leads to career advancement, so the next best thing is seen to be doing one's utmost within their confines.

However, alternative approaches do exist, some even within conventional structures and they deserve a better discussion than I am able to offer here. It would be interesting to hear of other schemes through the auspices of this journal.

Highlighted in a recent Institution Newsletter is the initiative to rehabilitate abandoned Massey Ferguson tractors and implements in Mozambique. If the tractor is useful in Third World agriculture - and many would argue that it is not a sustainable power unit for poor, oil importing countries - then the planned maintenance and repair of existing machines is preferable to bringing in new ones at a higher cost and yet still likely to meet the fate of their forerunners. The viability of a similar scheme is being examined in Nicaragua, where in the past year Oxfam Canada, assisted by some UK non-government organisations to circumvent a US lending embargo, has been delivering spare parts for the repair of old British Lister-Petter engines, which are widely used on irrigation schemes, and for crop processing.

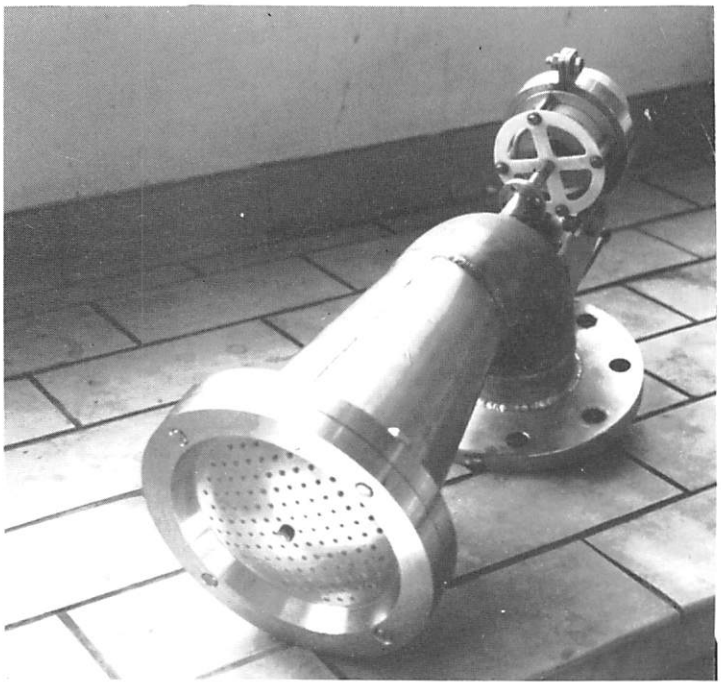
The solution for sustainable development in agriculture is not high value machinery in short-term projects, funded by aid administrations tied by the politics of the donor country. Nor is it to provide prestige turnkey installations at the request of unrepresentative governments. Unfortunately these are the very projects that pay the engineers' salaries, encourage overseas students to attend our colleges and lead to many problems of erosion, salinity, debt, landlessness, machinery graveyards, and a grinding downward spiral of poverty for the rural population in those unfortunate areas of the world.

Steve Parish
Dailly, Ayrshire

A pertinent poem for a Third World inhabitant was quoted by T L V Ulbricht in 1976 (original source being unknown).

I was hungry and they formed a committee
to investigate my hunger,
I was homeless and they filed a report
on my plight,
I was sick and they held a seminar on
the situation of the underprivileged:
They investigated all aspects of my plight
and yet I am still hungry, homeless and sick

- Editor



The Extramet granulation unit

New system for granulating fertiliser

Extramet Industrie of France report on their new system for granulating fertiliser.

Applying vibration to a flow of liquid as it is fed through the holes in a circular plate causes the solution to break up into granules which cool and solidify as they drop.

The granulation unit is known as a "shower" and by precisely adjusting the vibration frequency to the flow rate the process is said to ensure that the granules are extremely regular in size.

Another advantage claimed over traditional granulation showers is that the vibration prevents accumulation of fertilisers on the feed plate or wall of the unit - thus facilitating the continuous running of the plant and giving higher productivity of manufacture.

Under-liming: still a problem

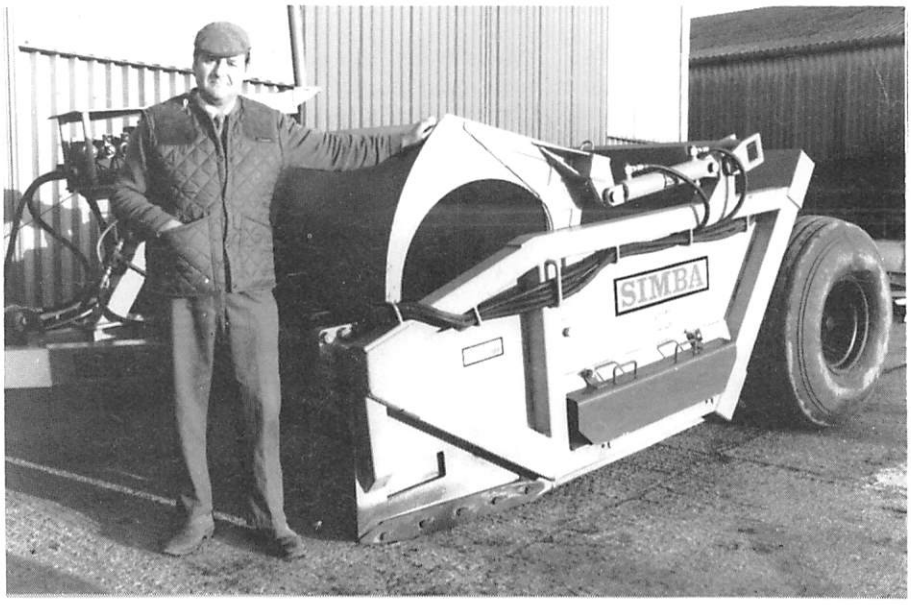
At the 1988 liaison meeting organised by the Agricultural Lime Producers' Council (ALPC) and attended by representatives from MAFF, ADAS, FMA, NFU, NAAC and several other organisations, concern was expressed at the extent of under-liming evident in the United Kingdom. With the possible exception of East Anglia, it seems that most arable areas are not applying sufficient lime to maintain the recommended lime-status of the soil. In grassland areas, particularly in the western counties, a significant proportion of the fields that were tested, exhibited soils well below the optimum pH level.

Acid soils are still a problem and are likely to remain so unless there is increased farmer awareness of the effect of acid soils on crop quality and yield, and hence profit.

As part of the programme to increase farmer awareness, ALPC has sponsored ADAS field trials to demonstrate the relationship between the economics of lime applications and profit for several crops. The results of the work on sugar beet and spring barley were published earlier this year.

Simba Ejector Scraper

Mr Keith Olivant, who farms 1400 acres at Wragby in Lincolnshire, with his Simba Ejector Scraper. "An ideal tool for levelling and landscaping", says Mr Olivant. In operation, a gate at the front of the scraper pivots open to allow soil to be scraped into the box. Once the machine is full, the gate is closed and the soil transported and then dumped and levelled.



Improved water supply through reverse osmosis

Alstar Engineering guarantee that their Nerogard-Nurseryman Reverse Osmosis System produces earlier growth and maturation in vegetables and house plants.

The system is claimed to reject up to 98 per cent of all salts and unwanted minerals and chemicals in the water supply. Units are available to suit all sizes of enterprise with outputs up to 500,000 gallons of water a day. Integral automatic sprinkler systems are also available.

Alstar Engineering Ltd., 2251, Coventry Road, Birmingham B26 3NX (021) 742 0622

Professor Brian D. Witney

Professor Peter Wilson, Head of the School of Agriculture, University of Edinburgh, is delighted to announce that Senatus, at its meeting held on 8th March, 1989, agreed to bestow the title of Honorary Professor on Dr. Brian D. Whitney, Director of the Scottish Centre of Agricultural Engineering and President of this Institution.

On behalf of the membership of the Institution, we congratulate our President on this signal honour.

Rhône-Poulenc pioneer a breakthrough in agrochemical packaging

An operator tips the Oxytril CM water soluble bags directly into the spray tank

New water soluble packaging for liquid agrochemicals has been developed by Rhône-Poulenc and will be used for the first time this spring for limited supplies of Oxytril CM herbicide.

Easy to handle, the new packaging allows the user to dispense the chemical with no risk of direct contact with the concentrated liquid. The herbicide is contained in a bag made from water soluble film, which is sealed within a secondary container with a pull-off foil lid, rather like a yoghurt carton but much larger. From this outer container the water soluble bag is tipped directly into the sprayer tank. Agitated by the tank pump, the protective bag quickly dissolves in water so that the chemical is mixed and ready for application.

Following a successful pioneer test trial in 1988, Rhône-Poulenc Crop Protection is now launching a broader national marketing evaluation of the new packaging. Between 20% and 30% of Oxytril CM supplies will be available this season in the new water soluble pack. Further information: Rhône-Poulenc Crop Protection, Regent House, Brentwood, Essex CM14 4TZ (0277) 261414

RICS approved course at Harper Adams

Harper Adams Agricultural College is offering a new degree course in rural enterprise and land management designed to provide highly skilled land agents for the Royal Institution of Chartered Surveyors.

The course, structured to meet the changing role of land agents and surveyors, combines traditional subjects with modern marketing, business management and communication skills. Successful completion will give graduates exemption from the written examinations of the Institution.

A novel feature of the four year course is a 12 month sandwich spell when students will work under the supervision of land agents.

Barrie Slatter, senior lecturer and chartered surveyor is confident that this new course will provide the profession with just the right sort of graduate. "Other colleges mounting rural resource courses tend to be biased towards the environment", says Barrie Slatter. "We have approached it from a different angle. Whilst equally sympathetic towards conservation issues our graduates will also possess a legal and commercial realism".

Didcot Rainlog

The Didcot Instrument Company has improved its highly successful Rainlog event time data logger even further by adding a user-friendly interface and new lithium battery system.

This means that the Rainlog now offers up to 4 years continuous operation from a single set of batteries, and for the first time ever it can be tested, initialised and operated completely remotely.

The Rainlog is a stand-alone solid state event recorder which has been designed for use in conjunction with a Didcot tipping bucket raingauge.

Both the Rainlog and the tipping bucket raingauge can be purchased directly from the Didcot Instrument Company, Abingdon, Oxon OX14 3LD and are offered complete with 3 year guarantee.

Launch of Integrated Hydro Systems

Integrated Hydro Systems is a new joint venture between Hydraulics Research of Wallingford and Hydro Scan of Ilkley, Yorkshire. The aim of the collaboration between these two highly experienced companies is to provide the water industry, both within the UK and overseas, with a comprehensive drainage analysis service combining flow monitoring and network modelling. Integrated Hydro Systems brings together Hydro Scan's experience of monitoring and analysis of drainage systems and Hydraulics Research's computer modelling packages and expertise.

Hydraulics Research at Wallingford was set up in 1982 to take over and extend the work of the British Government's internationally recognised Hydraulics Research Station. A major part of the company's work has been the development and application of computer modelling packages for urban drainage design and analysis, and Hydraulics Research's packages WASSP and WALLRUS have become the industry standard in the UK.

For a brochure giving further details of the work and expertise of Integrated Hydro Systems contact Ian McCarey, Hydraulics Research, on 0491 35381.

The new 760 Case trencher with 763 vibratory mole plough attachment supplied by L D Bourgein (Oxford) Ltd. (0865) 735420

A Challenger to Four-Wheel-Drive?

Featured in our front cover photograph is the Caterpillar Challenger 65 tractor now being offered in the UK.
According to Caterpillar Inc. the CHALLENGER 65 out-performs comparable four-wheel-drive tractors both in terms of traction and in minimising compaction. With rubber tracks, a maximum forward speed of 29.3 km/h, minimal vibration and differential steering via a conventional steering wheel this "tillage tractor" is certainly not the caterpillar crawler we know of old.

The rubber tracks, or belts as Caterpillar prefer them to be called, are reinforced with continuous strands of steel cable bonded into the rubber. These two belts are 622 mm wide, with a static footprint of 2700 mm in length, providing a total ground contact area of 3.35 m^2. The machine's operating weight of 15,500 kg results in a static ground pressure of 45.4 kPa (6.6 psi), under half that of similar sized four-wheel-drive tractors. Caterpillar claim that both the depth of compaction and depth of wheel ruts are also reduced by around 50%.

In independent field trials in the United States where around 200 Challengers are in use, yield increases in cereals, due to these reductions have been shown to be in the region of 0.4 t/ha. In the footprint area this results in a reduction in yield loss of around 37%.

More pull: less slip

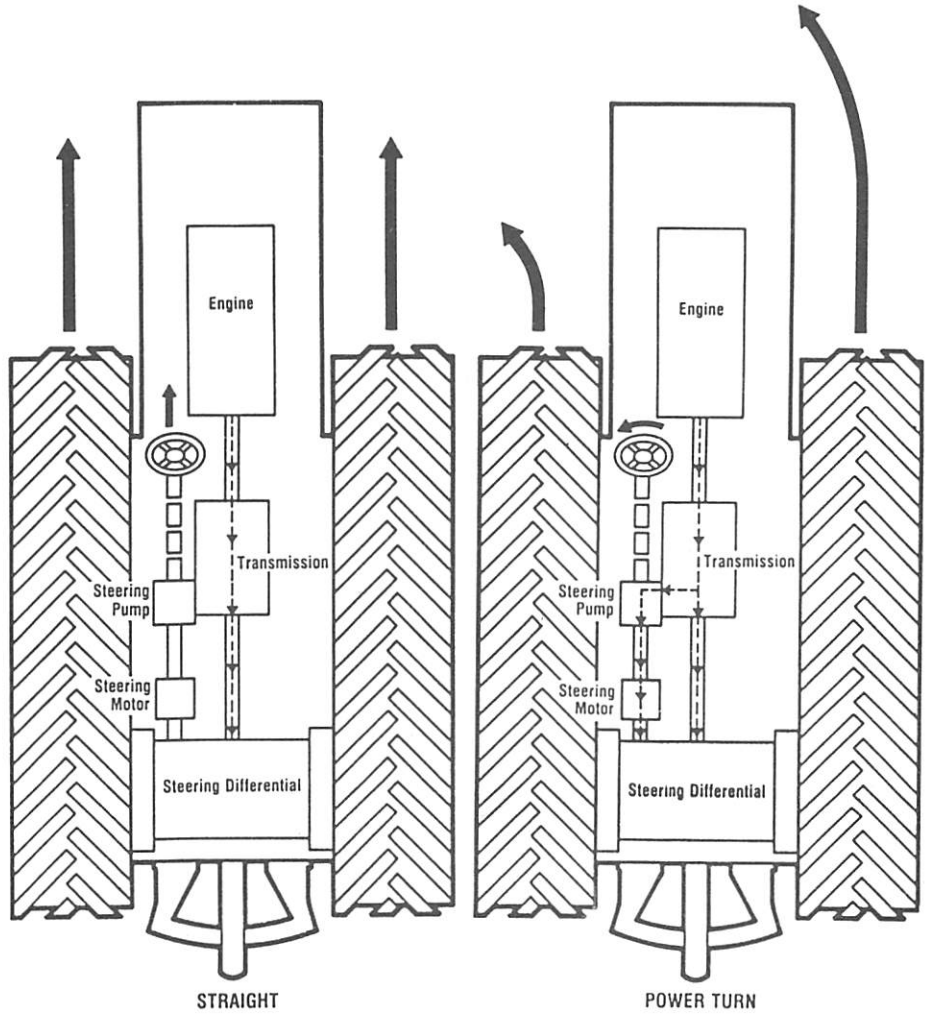
In Caterpillar's own trials, Challenger has been shown to have 15% more drawbar pull than a comparable sized four-wheel-drive and have 75% less power loss due to slippage. The ride on Challenger is said to be as good and in some situations better than a four-wheel-drive, particularly when traversing plough furrows, where the dual drive wheels and bogie-mounted midwheels, which are air-cushioned, spread the vehicle weight over the full belt-to-ground contact area.

The makers claim that the Challenger 65's traction system and its 2.15 m width allow it to work on sidehills up to 45° at normal tillage speeds. Challenger, having tracks or belts being made predominantly of rubber rather than steel, can be driven on conventional roadways at anything up to the maximum speeds. Caterpillar claim that loping, associated with tyred tractors is also eliminated.

Belts, although twice the price of tyres for a comparable four-wheel-drive tractor, last between 1.5 and 2 times as long. Retreading is possible for US owned machines, which is considerably less than replacement. It is not clear whether this option is as yet available to machines sold in the UK.

Differential hydrostatic steering

The steering system consists of a steering differential, overcentre hydrostatic pump, bidirectional hydrostatic motor and controls. Like most tractors, the differential receives mechanical input from the transmission.



The differential steering system of the Challenger 65.

When power is coming from the transmission only, the belts rotate at the same speed, driving the tractor straight forward or backward. However when the steering wheel is turned, the steering control starts hydraulic flow from the hydraulic pump to the steering motor. The steering motor drives the steering differential which speeds up one belt and slows down the other, producing turn. A speed difference of up to 9.7 km/h is available between belts giving a variable turning radius, dependent on forward speed. The slower the forward speed, the sharper the turning radius will be. Pivot turns with limited counterrotation make it possible for Challenger to turn in its own length of 5.7 m.

The engine used is the Caterpillar 3306TA, 201kW direct injection turbocharged diesel as used on many other Caterpillar machines and the transmission has 10 forward speeds (from 4.2 to 29.3 km/h) and two reverse (maximum 7.3 km/h). Gear change is clutchless and can be made on the move. An "inching" pedal is provided for hitching or accelerating heavy loads. Caterpillar claim that the increased performance from this engine coupled to the novel traction system can give savings in fuel used of up to 20%.

Will Caterpillar be introducing a smaller version of the Challenger more suited to UK agriculture? At present they are developing a larger version for the US market but if the demand is there, they may well consider coming down the way also.

Sales in the UK are being handled by Leverton of Maidenhead Road, Windsor, Berks, SL4 5HH (tel.0753 845325).

Donation to SaWMA from British Gas plc

The Soil and Water Management Association, now merged with the Institution, would like to record their grateful thanks for the generous donation of £500 received from British Gas plc.

The British Gas donation, part of its considerable spend on community involvement, is helping the transfer of SaWMA into the IAgrE and thereby ensuring the continuation of SaWMA's activities in promoting the highest standards in care and management of the soil.

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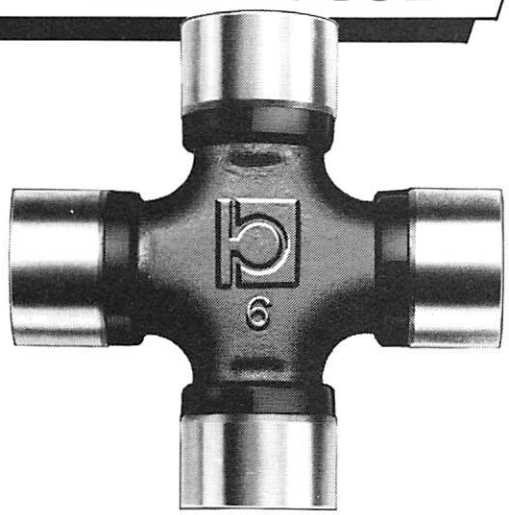

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