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Volume 39, Number 3 AUTUMN 1984

AGRICULTURAL ENGINEERING TOWARDS 2000

The Institution of Agricultural Engineers

Journal and Proceedings

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Front cover:
Example of the use of Computer Aided Design Computer Aided Manufacture (CADCAM) by a manufacturing company
[Massey Ferguson photograph]

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Guest Editorial

Agricultural engineering towards 2000

B A May

THE Institution of Agricultural Engineers is primarily concerned with the application of engineering to agriculture in its broadest sense. In particular, the Institution aims to encourage the generation and dissemination of ideas which will contribute positively to the need for further developments in products and markets having an engineering content. Innovation is also sought in the field of product application within agricultural and food processing systems. A further major task of the Institution in the short term is to do all in its power to ensure that the profession of agricultural engineering continues to have a presence amongst the leaders of professional engineering activity in Britain. The Institution will need to do this in the interests of its membership and in support of the agricultural engineering manufacturing industry. This need arises at a time when the engineering profession in Britain is in the midst of significant change. Such development is brought about by the requirement for engineers to improve their position and standing amongst the professions and in society as a whole.

The successful practice of engineering involves an inter-disciplinary and inter-dependent team effort by a large number of people, many of whom would justifiably claim to be engineers, but who possess an extremely diverse range of engineering qualifications both formal and informal. In many cases, these qualifications will entitle the holders to become registered as Chartered Engineers, Technician Engineers or Engineering Technicians. In addition, there are those practising engineering with science qualifications and those without any formal qualifications at all. The Institution of Agricultural Engineers is maintaining a policy of attracting into membership those who are at the forefront of engineering product design development and application for the agricultural and food industries. To achieve this, it is necessary for the Institution to retain both registered and non-registered components in its membership structure. For example, the Institution is proud to include amongst its membership some of those farmers who have proved so innovative and successful in advancing and exploiting engineering ideas and products. Close farmer interaction with engineers has also been encouraged by the Institution because of the importance of the team approach in the successful application of engineering to agriculture.

(Silsoe College photo')

Perhaps the greatest potential benefit to the community of a professional engineering institution is the prospect of bringing together education, research and industry in productive, creative and competitive partnership. It is in this area that the Institution believes it should be placing special effort in the future. In Britain, education and research are being encouraged to relate more closely to industrial need. Many of those engaged in education and research are responding positively to this initiative. Courses in agricultural engineering are becoming more practical and more flexible while quality of candidates and performance standards continue to be upgraded. Agricultural engineering research now includes more development work and related to medium term product and market needs, which is often undertaken in close association with industrial partners. Overseas members of the Institution will know that similar developments are taking place in other countries as we move towards the year 2000.

The Institution of Agricultural Engineers thus provides a means for industrialists to keep in touch with and to gain advantage from work in the fields of education and research. This is a vital role for the Institution since it provides a means of fulfilling the potential benefits which education and research have to offer in a productive and profitable sense. The Institution intends to place emphasis on this role in future and the 1984 Annual Conference demonstrates emphatically the Institution's policy of co-operating closely with manufacturing industry.

In order to play its full part in the necessary forward planning for the development of the agriculture and food industries, the Institution has decided to spend the next year or so looking closely at the ways in which agricultural engineering might develop as we approach the year 2000.

The 1984 Annual Conference was the Institution's first major initiative in this direction, when some of the

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industry's leading manufacturers were invited to make a critical analysis of the future prospects for the agricultural engineering manufacturing industry. Some of the major factors likely to influence developments over the next 15 years or so were examined. The nature of these developments was also considered in terms of products, markets, performance and structure of the industry.

This idea of analysis within the agricultural engineering manufacturing industry is not new. The industry has been thoroughly studied and reviewed in recent years. Individual studies have been made and reports issued by a foremost Department of a learned society and a university department. What was new about the ideas of this conference is that the Institution of Agricultural Engineers invited representatives from the manufacturing industry itself to present their views about future developments in, and prospects for, the industry.

The Conference was not intended to be about the technology which is likely to be available for commercial exploitation over the next 15 years or so. This is regularly considered by the Institution on other occasions — at Conferences and Branch Meetings. On its own, the technology is of little value without the means and knowhow necessary to ensure its effective and profitable application in commercial practice.

Perhaps it is these issues that must feature more regularly and prominently in the minds of professional engineers if they are to improve their position and standing amongst the professions and in society as a whole.

The Group Concept

J W G Young

Introduction

I AM delighted to have this opportunity to speak to you and to discuss the "Group Concept" as it could apply to Agricultural Engineering Towards 2000. Before looking forward to the next few years I would like to spend just a few minutes looking at the agricultural machinery industry, and to analyse the way it has been performing over the last decade or so.

Exports

Exports have steadily declined from the peak of 1977 (fig 1). It could be argued that this has been due to a recession in world trade, and particularly in the developing countries which have been traditionally one of the main trading areas for UK companies. However, this decline coincided with the advent of British Oil. The balance sheet of UK Limited has continued to strengthen since that time with the result that our currency has strengthened, thus making it increasingly difficult to export. This, combined with the fact that the under-developed countries have become comparatively poorer, has meant that there has been less money to spend on farm equipment. Exports dropped dramatically from £127M in 1982 to £107M last year.

John Young is Chief Executive of the Wolseley-Hughes Agricultural Division and based at P J Parmiter & Sons Ltd, Tisbury, Salisbury, Wilts.

This paper was presented at the Annual Conference entitled: Agricultural Engineering toward 2000, held at the National Agricultural Centre, on 9 May 1984.

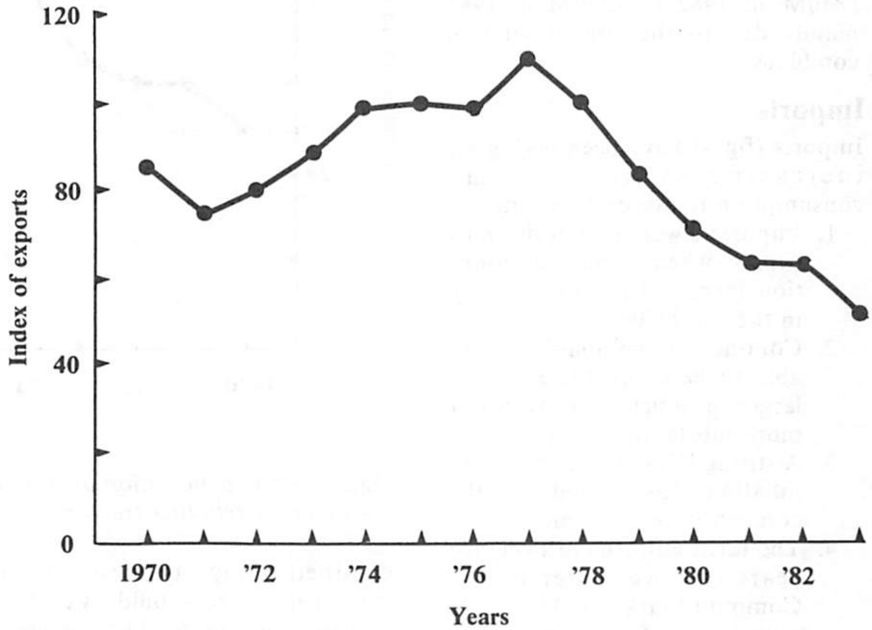
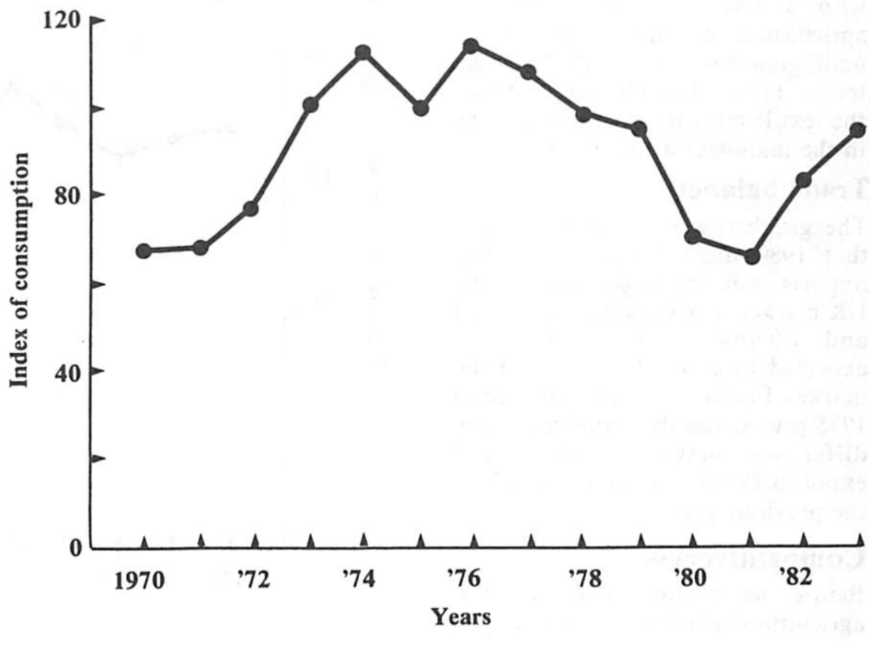


Fig 1 Exports of agricultural machinery (1975 = 100)

Consumption

UK consumption, as we know, rose rapidly soon after we joined the Common Market (fig 2). However, it has now returned to the level of 1972 and, as an industry, we were slow to react to this increased business. Having seen two good years, most companies increased production facilities extensively to accommodate the business. None of us identified the "Sales Boom" and we failed to identify fully the reasons for the extra business. No sooner had we provided

Fig 2 UK consumption of agricultural machinery (1975 = 100)



these extra facilities than the market declined sharply. Again, many were slow to react and consequently we are now in a situation where there is surplus capacity.

UK consumption increased from £340M in 1982 to £399M in 1983 mainly due to the rise in sales of combines.

Imports

Imports (fig 3) have been taking an increasing share of home consumption for several reasons.

1. Importers were in a position to supply when home consumption increased so considerably in the early '70s.
2. Continental companies were able to be competitive due to larger production runs for a more substantial home market.
3. A strong UK currency and high inflation has added to the competitiveness of imports.
4. The tariff adjustment over five years as we entered the Common Market, ie 12½% UK reduction in five years against 2½% European, had an effect.
5. For some reason, many British businesses fail to realise the significance of the "breakeven" formula and the effect of keeping volume up. The Continentals do understand this, and more importantly, so do their Governments.

The value of imports last year amounted to £206M compared with £184M the previous year.

Production

With the reduction in both home consumption and exports coupled with a rise in imports, the UK agricultural machinery Industry has undergone a severe decline. In actual terms, it has reduced by 62% and only the textile industry rivals this decline in the manufacturing sector.

Trade balance

The graph (fig 5) illustrates clearly that 1980 marked the point when imports took the larger share of the UK market. The trend has continued and during 1983 imports are expected to account for 53% of the market. Figure 5 has been adjusted to 1975 prices, and the actual monetary difference between import and export is £99M compared with £57M the previous year.

Competitiveness

Before we assume that the UK agricultural machinery industry has declined only because of its inefficiency, one should dwell for a moment on fig 6. The results of inflation and exchange rates have been combined to determine their influence on competitiveness since 1980. On the assumption that we were competitive in 1980, then it is clear that by the end of 1983 we had lost that advantage in almost every country except for the USA. It is important to note that the countries where we have lost competitiveness are those that are our main competitors, not only in the UK but also in world markets. It follows that not only have they found it easier to sell their goods in the UK, but that UK manufacturers have found it increasingly difficult to compete in international markets.

These general comments relating to the Agricultural Machinery Industry could well be applied to UK manufacturing as a whole. There is no doubt that an oil based economy encourages a strong currency, and that the demise of exports and the increase in imports coincides with oil coming on stream. Our small "home" market does not appear to give us the incentive or courage to manufacture in sufficient volume to export much to Europe, and this is not helped by the relatively high cost of shipping across the Channel.

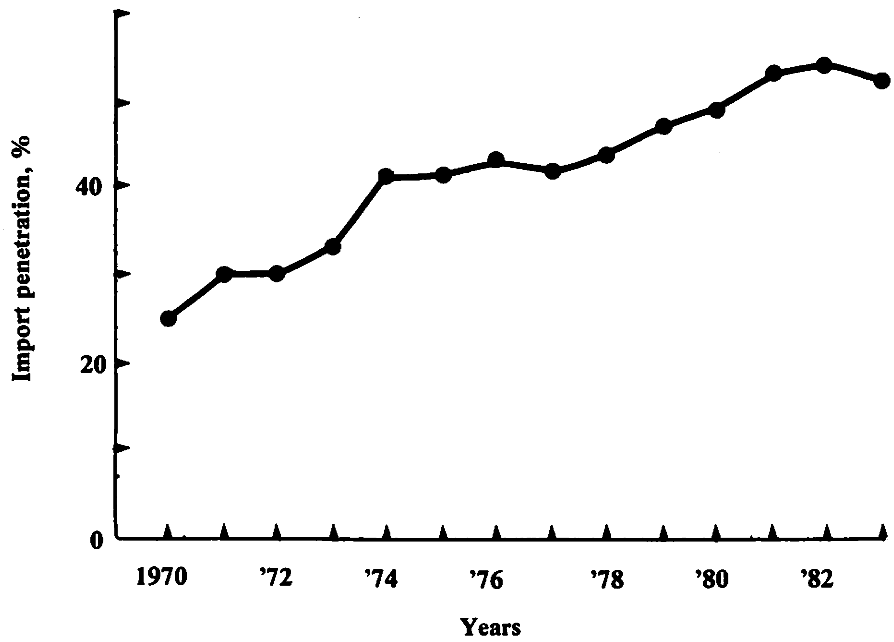
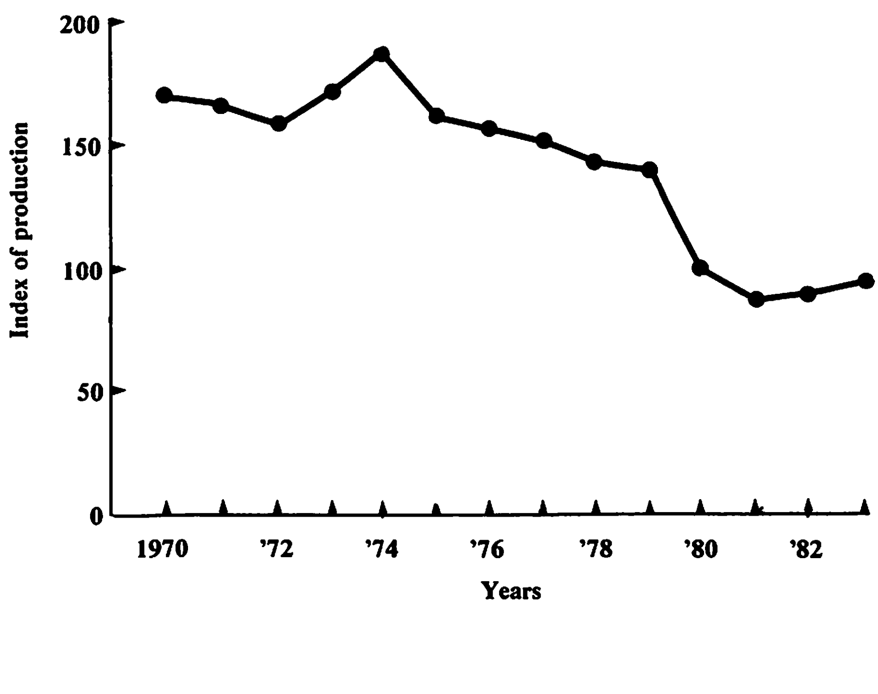


Fig 3 Import penetration as a percentage of the UK market for agricultural machinery, excluding tractors

Fig 4 Index of production of agricultural machinery (1980 = 100)



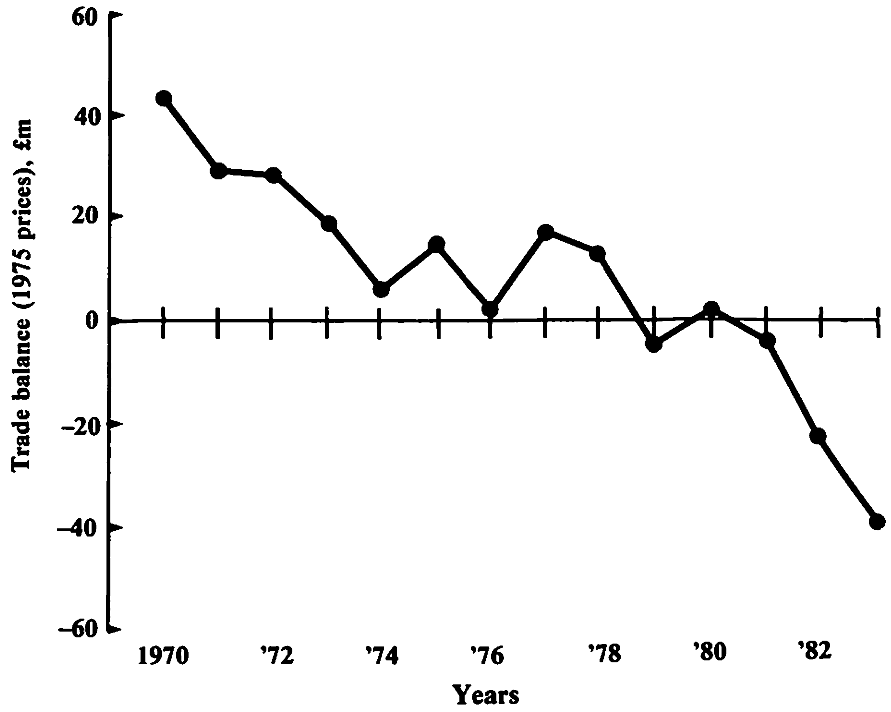


Fig 5 Trade balance in agricultural machinery at 1975 prices

Too often the City takes a short-term outlook which demands a quick return. It seems to me that they prefer to support "distribution" and will effectively convert this country into "a nation of shopkeepers". This attitude results in a lack of investment in capital equipment and is one of the reasons for low productivity. I cannot subscribe to the theory that this has been due only to the inefficiency of the British employee or the lack of foresight of the employer.

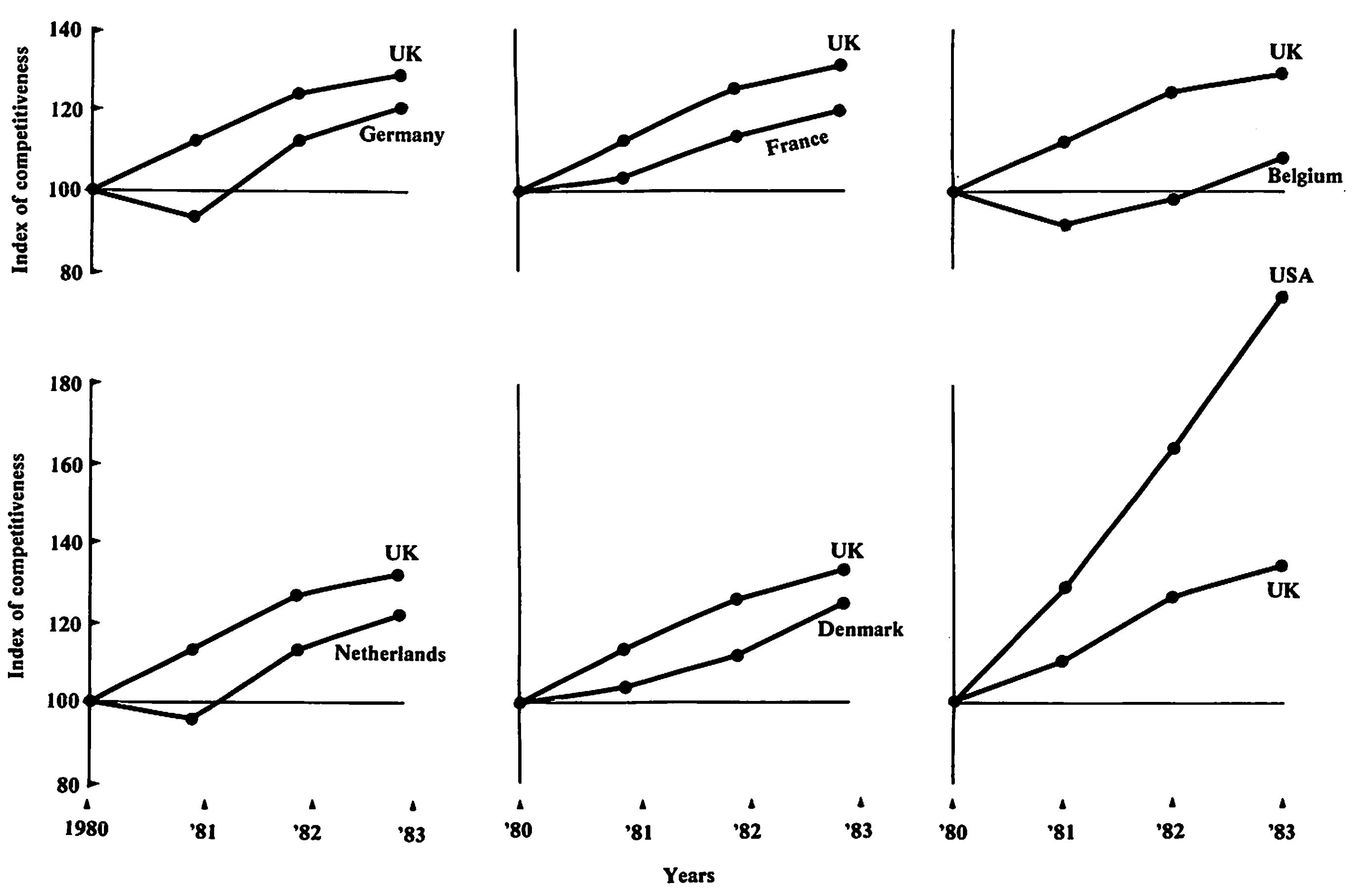
The lack of confidence by the City in manufacturing, together with the lack of long-term Government plans, has caused a reduction in research and development. This has created a tendency for our manufacturers to concentrate on relatively unsophisticated products with the result that our exports are directed towards developing countries. This ignores the prime market in Europe which has the ability to pay.

Business factors

In order to explore the opportunities for the Group Concept as it might apply to agricultural engineering as we approach the year 2000, we have to assume a number of factors for the next decade or so.

1. There is likely to be a variety of methods of achieving a result in farming which will lead to a

Fig 6 Inflation and exchange rate chart



proliferation of types of machines available.
2. The above trend will give a product a shorter sales life.
3. The trend towards Winter crops will continue, providing the problems of straw burning can be overcome, and sales will become increasingly seasonal.
4. European sales will probably decrease due to changes in the Common Agricultural Policy. Surely the high subsidies cannot continue and the aim must be to return to free world prices.
5. Legislation will continue to hinder both manufacturing and farming.
6. Sterling may stay at an unreasonably high level for some time due to the strength of the balance sheet of UK Limited.
7. There will be an increasing demand for equipment in developing countries due to increases in population, and world concern for the under-nourished.
8. Politicians in developing countries will expect us to support their demands for local manufacture.
9. Financing will play an increasingly important role both for home, and especially for export markets.
10. UK steel and proprietary parts suppliers will continue to contract, so creating increased purchasing problems.

The Group Concept

In order to see where the Group Concept fits into this situation, it is important to define accurately the meaning of a "Group". Is it a large collection of companies of differing interests under common ownership; is it a collection of companies of similar interests which are now manufacturing their products under one roof; or is it a collection of companies involved in a similar industry under common ownership but operating as autonomous units?

Let us take as the first case a collection of differing companies. In my opinion there is little advantage in a Group acting as "bankers" only to a diverse range of companies. Very little can be gained by this combination.

The second case, that of centralising production facilities, could be much more worthwhile as the overheads can be reduced dramatically. However, one should be reminded that on the occasions when this has been attempted in our industry the result has been disaster, and it was realised that individual companies and their expertise are better kept as autonomous units.

The third case, that of autonomous units under a common ownership, is the environment in which I am involved and is the way that the Wolseley-Hughes Group of Companies operate. It is therefore this group situation on which I can usefully comment.

Through a closer examination of the main functions of the company, it may be possible to establish the ways in which a Group situation can be beneficial in tomorrow's terms.

Administration

Due to the size of the administrative function, more sophisticated systems can be installed to reduce staff and thereby costs. The disciplines required in a Group are normally no more onerous than those required by a bank manager. Managers from the constituent companies, who have a common interest and a greater understanding of the factors affecting sales and costs, can meet regularly to discuss plans and formulate targets.

Being part of a large Group means that access is readily available to the best legal and financial advice, and this seems to have become an increasingly important pre-requisite in both home and export markets. Because of the pooling of financial resources the Group has more "pull" with the bankers, and this is clearly beneficial.

Buying power

A Group has substantial "buying power" and preferential rates can be negotiated on steel and proprietary parts whilst retaining the advantage of individual purchasing functions. Other less defined items such as advertising, transport and consumables, can be purchased at preferential rates with no additional administrative overheads.

Buying, I should remind you, accounts for some 40% of the total cost of machinery, and therefore any small savings have a marked effect on product costs.

Design

Whilst it is important for each company to develop its product range, regular liaison within the Group ensures that development in a similar market is averted. Parallel development is encouraged in many cases because competition involves many other companies and no appreciable gain in sales is to be achieved if one company discontinues the line.

Group use of computerised design facilities can be made available where an individual case for such a facility would be difficult to justify. Within the design and development sections, many special techniques have been established and these can be made available to other Group Companies with a particular requirement.

As I mentioned previously, there is a general decline in research and development. Due to the overall strength of our Group, we have taken the decision to increase our research and development by 25%, which will represent some 3½% of turnover. In order to encourage inventors to bring their ideas to the marketplace, the Group recently introduced a booklet entitled *Putting Farm Inventions into Practice*. This, in sheer cost terms, would have been difficult to justify as individual Companies.

Manufacturing

Techniques in the area are changing very rapidly and discussions with colleagues in sister companies have been invaluable. High technology machines have been purchased, knowing that joint and full use can be gained from them by the Group. The growing concern over the seasonal nature of our businesses is a problem faced by most small companies. In a balanced Group, better utilisation of manufacturing facilities can be obtained by sub-contracting to other Group Companies, and this helps level out manufacturing peaks.

Robot welding, together with its associated handling equipment, is working successfully at one plant. Obviously the experience gained from this, and other forms of high technology, can be assessed for further utilisation.

Productivity per man is one of the key words in manufacturing today and a Group situation helps stimulate competition. Each manufacturing manager is made well aware of the results that the more successful companies can obtain, and every effort is made to improve the situation.

It will be important to offer manufacturing expertise to many overseas areas and this is more likely to be found in Group Companies. Personnel can be seconded to overseas projects for long periods, and this can be achieved by moving staff around within the Group with only a minimal disruptive effect.

Sales

Combining sales forces would seem to have no benefit but market intelligence should be improved. Higher standards of Salesmanship should be achieved as seminars and refresher courses can be held on a Group basis. Although employed by separate companies, each salesman, being part of the Group, should recognise this interrelationship and act as a "part-time" salesman for the other companies.

Each company in the UK should be of sufficient size to have a "presence" in the home market and therefore combined sales forces should not be necessary.

On the export function it should be recognised that only a selection of the total product lines are normally sold. Most companies are too inexperienced or lack the knowledge and finance to export successfully in more than one or two markets. A combined sales force selling products under one name is able to represent and sell an exportable line of machinery more intensively in more markets. The product line may, therefore, be more important to customer and a stronger commitment is obtained from both parties.

The UK manufacturers, being smaller units, have little hope of obtaining this "presence" in overseas markets. This is something our European manufacturing counterparts, who have a much larger "home" market, are better able to achieve.

This combined export sales approach, which was only started two months ago by our Group, has proved so popular that several of the larger independent UK companies have offered their "lines" to us.

Training

Most small companies rely on recruiting their senior management skills from multi-nationals. In recent years the reduction in size of these companies has allowed this process to continue, and especially because the industry has been hit so hard. Training has been severely reduced and there is no doubt that some in-house training will be required to replace that previously provided by the multi-nationals. I think that a Group with a diverse range of products has much to offer University graduates and able students. There should be opportunities for a career structure in both home and export sales, technical design, and production departments.

Conclusion

The next decade or so will bring our industry many problems but also much excitement as well. Changes in the Common Agricultural Policy will probably encourage lower input systems — a challenge to our industry. Changes will take place in farming systems due to the increasing environmental lobby — straw burning might well be such an example; another challenge to our industry. We still have too many starving peoples in the world — perhaps also a challenge to us all.

Internal factors, such as the changing techniques in manufacture and communications will bring new opportunities. I am sure the break-up of British Telecom will herald a revolution in communications in the next 15 years. Increasingly, office machinery will be linked directly into the national and international telecommunications network. Computers will be more extensively used for non-financial aspects, and by a greater number of small users. As banks speed the transfer of cash, by direct debiting and other methods, postal services will diminish and businesses will be compelled to mechanise.

The effect of this instant data transfer will change attitudes, and there will be a corresponding demand for instant response. This will place pressures on the physical distribution network and suppliers will be forced to react immediately to demands. This will partly be accomplished by linked computers between customers and suppliers. Quality of service will become as important as quality of product.

There will be further developments in the use of raw materials, and the substitution of plastics for steel will continue as long as the oil availability/steel production cost equation exists.

The international debt crisis will deepen during the 1980s, but hopefully a more equitable method of sharing resources will evolve.

It will be a time for the brave, and for the well informed, and I think the Group Concept will help in this respect.

I believe, or certainly hope, that manufacturers, governments, bankers, and research institutes, will work closer together. The Government must recognise that if UK manufacturing continues to fall, then unemployment will reach such proportions that social pressures will be unacceptable. Well informed Groups are necessary to bring pressure to bear on Governments to resolve the problems in our industry.

If a Group is constructed properly it can: increase its market reputation and share; employ happier and more satisfied personnel; increase its productivity; provide a better career structure; improve the relationship with suppliers and establish a better "presence" in the marketplace. When there is little to choose between one product and another, there is no doubt that a "brand" or name which is well known takes priority. This is an undefinable property which lies behind the product and that often completes a sale.

I firmly believe, and this in spite of all the problems and traumas that may lay ahead, that the Group Concept will provide the best foundation for both manufacture and sales.

Prospects for the smaller company

G H Evans

1 Introduction

THE objective of this paper is to analyse some of the factors that may influence the success or failure of the smaller agricultural machinery manufacturing company over the next decade or two and to examine the steps we have to take if our prospects are to be worthwhile.

Before we go further, we should perhaps define what we mean by the smaller company. Do we measure it by number of employees, by turnover, by profit, by capital employed, or maybe even by market share? I believe we should be talking about that spectrum of our farm machinery industry, excluding tractors, and spanning those manufacturing companies that employ up to 100 people, and have a turn-over of up to £5M. This would include more than 90% of the companies within our industry which in total produce less than 34% of our total output (table 1). I hope you will forgive me if the distinctions between the smaller company and our total industry become rather blurred, but we are really talking about the same thing.

Table 1 Analysis by size of all UK establishments classified to the tractor and machinery industry, 1981

Size group	*No of enterprises*	*Total employment, thousands*
1– 10	441	2.0
11– 19	131	2.0
20– 49	49	1.5
50– 99	18	1.3
100–199	18	2.5
200–399	13	3.4
400 and over	6	17.6
Total	657	30.4

Geoffrey Evans is Chairman of A C Bamlett Ltd, Thirsk.

This paper was presented at the Annual Conference entitled: Agricultural Engineering towards 2000, held at the National Agricultural Centre, on 9 May 1984.

(Silsoe College photo')

2 What are the prospects for the smaller company?

They are influenced by two main sets of factors. First, the external which affect the agricultural industry that we serve and about which we can do very little, whilst the second are the internal factors that influence our performance, both individually and as the industry, and on which we can make some considerable impact — if we so choose.

It is important that we set about improving our prospects by a process of investment. If we fail to invest in our future, then our prospects will be no better and probably worse than they are today.

Our salvation is dependent upon taking action in five major areas:

i) planning for longer term growth rather than for short term expediency;
ii) investment in skilled manpower;
iii) investment in innovation and development of more specialised products;
iv) investment in a wider market;
v) planning some degree of rationalisation of our industry.

2.1 Planning for longer term growth

The managers of our companies have too many priorities forced upon them that lead to short term planning decisions. These priorities are sometimes of simple survival, often pressures from their banks or shareholders who are looking for quick profits rather than a long term capital growth. Overshadowing these immediate priorities are the ever changing views of politicians, at home, within Europe and in other parts of the world.

For our sound, long term future, we must adopt a certain idealism and give to our managers the support and confidence to carry through the five and ten year plans of company and industry strategy.

Idealism is often an expensive dream and I know that, in our own company, there are times when we have spent money developing products that have failed, or developing markets that did not materialise as we had hoped. However, we have held to our idealistic beliefs for the business and our industry and are now starting to get some worthwhile rewards.

Thirteen years ago we employed just a dozen people, we had no manufacturing facility, and our £0.25M turnover was made up of 90% imported products and only ten per cent home produced by subcontractors. Today, we have reached a position where we have 120 people generating the sales of £5M, of which 40% is home produced. Along the way, we also sold a major importing operation which had sales of over £3.5M. Over this period, we have stuck to our philosophy and ideals of redeveloping a worthwhile manufacturing entity.

Importing has been relatively simple, requires a relatively low level of fixed investment, and is profitable. We have re-invested those profits into a business with a really worthwhile manufacturing facility and with net assets now exceeding £1.5M, where none existed 13 years ago.

You may feel that I am something of a hypocrite to talk about prospects of our manufacturing industry whilst we have been, and still are, successful importers. But on any journey, you have to start from where you are and not from where you might like to be.

2.2 Investment in skilled manpower
It should go without saying that one's greatest investment should be in people with the best of training and experience for the job that has to be done.

The Royal Society, in its report in 1982, identified the lack of qualified manpower in our industry at both professional (graduate) and technician level as being a serious constraint. I believe this is very true and it is firmly indicated by the innovation shown in so many imported products, but is lacking in our home produced output.

The Agricultural Engineers Association, which represents the majority of companies within our industry, recognises the problem and is currently conducting a detailed survey into the requirements of its members for skilled manpower. Only then can our industry make some authoritative recommendations to those bodies responsible for the establishment of suitable educational courses at our universities and colleges.

I believe, however, that many of our smaller companies do not realise the tremendous benefits that they can gain by employing better qualified people. The trained agricultural engineer has such an important part to play in the smaller company, especially in the areas of design, development and marketing.

It was in 1978 that, in the reconstruction of our business, we made the positive decision to employ some younger and better qualified people. At that time, we did not really have the openings but, nevertheless, we were fortunate to obtain two very good graduates straight from the then National College at Silsoe. These two young men, who are now on the board of our company, contributd so much to our development that it encouraged us to pursue the policy. Today, ten per cent of our workforce are of graduate standing and occupy responsible positions right throughout the strata of the business, from general management, finance, marketing, design, development and production. There is a concentration of graduate engineers in our design and development department where we have seven. Our company future is in the hands of these younger, well qualified and enthusiastic people.

2.3 Investment in the product
If we accept that marketing is "getting the right product to the right place, at the right time, at the right price", then the importance of the product is obviously a major priority in the business. Without a good product, you just cannot have a good business. I believe that the smaller company has a positive advantage in that it usually has a better technical appreciation of what farming wants and is also better able and quicker to adapt to changing circumstances. These advantages should be exploited by choosing a specialist product area, with export potential, hopefully not conflicting directly with the multi-national product areas and avoiding the trap of becoming just another competitor in an already crowded market place.

My own company chose some 14 years ago to become a specialist in the sowing of seeds and the application of fertiliser. These two areas are related and use much of the same experience and technology. Initially, we entered this market sector with imported equipment but have subsequently been able to manufacture our own seed drills following the acquisition of the Barford seed drill business in 1979. Last year, 1983, we manufactured £1M worth of seed drills, are number two in the market place and have some technology ahead of our competitors. With the growth of this speciality, we have been able to withdraw from some product areas where we were manufacturing in small numbers and in competition with perhaps ten other manufacturers with very similar, and probably unexciting, machines.

I do not imagine we will ever totally withdraw from the lower value, simple items and one or two of these are a very useful safeguard to ensure a balanced business. But even in the lower value, simpler machines, we are adopting the policy of high specialisation, particularly in the way that we manufacture them. In this way, we gain a price advantage by way of lower manufacturing costs which enable us to sell in higher volumes and increase our end margin. The smaller items do not take tremendous resources from our product development budget and so leave us free to make the maximum investment in the chosen speciality.

The smaller company cannot afford to maintain fully developed products in a number of fields. It is just not possible to keep ahead of the competition if one has too many irons in the fire. The cost today of designing, building prototypes, development, tooling and penetrating the market, are too great and one's limited resources must not be spread too thinly, but concentrated into the speciality area. This, however, does throw up a problem for the smaller company in that a single product does not always in itself generate enough to sustain and develop the business operation. One often sees companies that start with a brilliant idea that is well accepted by

Fig. 1 The new CD4.0m Combine Drill from Bamlett offers 32 row, close spacing or 24 row, conventional spacing versions

the user, but in itself it doesn't generate the gross margin to build the sort of business that is going to be really effective in the market place.

Extra muscle is needed and there is a strong case for the smaller business to add on some one else's developed product, either by way of a manufacturing licence or a sales licence of another home based or even overseas manufacturer. This additional product should ideally be in the same speciality area that had previously been chosen for the company's own products, so that the marketing effort can be more effective, and at the same time, adding to one's credibility in that speciality area. For example, in our own case we have taken a licence to sell a well developed seed planter for maize and other row crops, from an American manufacturer, and so enhance our reputation as seed sowing specialists in some export markets, particularly West Africa. In those particular export markets, we sell a range of related equipment all in our own name and in our colour, which make a greater total impact. As this market exercise develops we will manufacture the simpler parts of the planter without making too much demand on our own development resources.

Continuing innovation is necessary if we are not to be caught out by changing farming practice or unexpected competitive action. The drive for innovation must be part of the ongoing idealism of the smaller company. There is more practical help available today than ever before from our national agencies, the National Institute of Agricultural Engineering, Silsoe College, and the Universities, the British Technology Group, and not least, the Government, through the Department of Trade and Industry, who are able to offer considerable financial support. The latter is determined to do everything possible to stop the decline of our manufacturing industry — we should accept this help.

2.4 Investment in wider markets

Our home market is over supplied with most types of equipment and future growth is limited. Many of our smaller companies are cutting their own and their competitors' throats by making very similar products in inadequate quantities. There may be enough profit to exist but there is unlikely to be enough profit to invest in the product development necessary to leave the competition behind.

The temptation, when things are tough, is to add another product to the range that is offered on the home market, but I would suggest that, in the longer term, it would be more advantageous to develop the overseas market for your existing products. Exporting is not easy, but is the long term solution to increasing volume and from there on, profits.

The products that a company has dictates the area for the export effort. How to go about exporting is often a dilemma for the smaller company, but the first step is to make that positive commitment and decide what resources are necessary. Smaller companies should consider co-operation with others, providing there is no product clash, in a joint effort in specific markets.

Many of our companies under-invest in manpower for their export activity and my own company is certainly no exception. I think it is lack of commitment because of the feeling that results will not be achieved quickly enough to justify the outlay. This is where we have to summon up that idealism and have a go. If for example, we are achieving sales on the home market of £1M with two sales people on the road, then it is not unreasonable to have a third man exclusively on export, rather than expand the home sales team.

The best insurance for export success is a competitive product. I do not just mean competitive in price, although this is obviously a real help, I mean a product competitive in its design with innovative features ahead of the competition. With this sort of product, the buyers will listen and want to know more.

The less well known you are in the export markets, the better your product has to be. The bigger known companies can get away with the poorer product for a time, but the smaller company will not get off the ground. As an industry, we have delayed for too long in getting to grips with this problem and have allowed our European competitors to steal a march on us. Our belated entry into the Common Market put us at a distinct disadvantage and allowed the Continentals to get a good ten year march ahead of us by adopting a whole-hearted export approach.

2.5 Looking at rationalisation of our industry

The structure of our industry shows just how small are the majority of our companies, and if we are to be more successful in world markets we must develop larger and stronger units rather than the present proliferation of small businesses. The smaller companies may well have survived a little better during the recent recession than the larger, but I question whether they have advanced to a stronger position.

It is a sad fact of life that not enough of the smaller companies make the grade up to a size where they can really contribute to a stronger industry and compete overseas. A study of membership of the Agricultural Engineers Association shows that there is a continual ebb and flow of companies in the industry, particularly of the smaller size. With some notable exceptions, those that have survived are the bigger ones.

We have to develop our industry so that we can match our Continental competitors with companies of equivalent size, resource and resolve. There are two major areas of difficulty if one is to pursue this policy. The first is that the smaller companies are invariably owned by people to whom independence is a major satisfaction, even if their independence is maintained at a cost of insecurity and lost opportunity. The second major difficulty is that engineering in general, and agricultural engineering in particular, is not a profitable sector and therefore does not attract the investment from those organisations and people who might be expected to help us overcome the problem.

3 Conclusions

There are many of you who will view all that I have said as rather naive and obvious, which maybe it is.

However, the facts are that the competitive position of our agricultural manufacturing industry has worsened over the past decade, import penetration has increased and has now passed 50% of our home market, and there are as many companies engaged in the UK industry as there were ten years ago, whereas in Germany, for example, the number has halved. A study of the membership of the Agricultural Engineers Association shows that, whereas total membership is much the same — at about 250 — as 1950, only 40 of today's members remain from those of 30 years ago.

Ours is an industry of easy come and easy go. There are new businesses opening up every month; these are usually small concerns starting with high hopes but often without either much substance or experience of our industry, and it is these that form the 'easy go' element of the statistic. The highest fall-out is usually within five years.

Not enough small companies make the transition to medium size and hardly any to the 250 plus category necessary to have enough muscle in an international market place.

The idealism and investment in planning, in people, in products, and in markets that I have outlined, is essential if the smaller company is to have any real prospect of survival over the next decade. The choice is ours.

Starting a new company

D I McA Elder

1 Introduction

IN order to start a small manufacturing business, there are a number of aspects to consider. For instance, a market for the product will need to be identified; or, conversely, seeing a gap in the market may indicate the product to be developed.

From marketing strategy or product design through to the financial make-up of the company, judgements will be required at every stage which will affect the viability of the venture.

For example, there are many ways in which a product could be launched on to the market — from a very inexpensive letter to the press, to a highly expensive advertising campaign. The costs associated with the different methods will reflect on the cash requirements of the business and can be calculated. However, the returns from one method of launch or another is a matter of conjecture and will have a pronounced effect on the prosperity of the company.

The most important criteria for the success of a new company is an understanding of those aspects of business which will have the greatest ramifications on the individual branches of the venture.

2 Product marketability

Before starting a new venture, it is very important to study the marketability of the product concerned. Probably the most difficult thing to assess is the sales potential in the first year of a new venture. This is particularly difficult to judge when not only a new product but also a new concept is to be introduced by a new company. It is undoubtedly more difficult to estimate sales correctly with an entirely novel product than for a product which already has an established market.

David Elder is Chief Executive Director of Griffith Elder & Co Ltd, Saffron Walden.

This paper was presented at the Annual Conference entitled: Agricultural Engineering Towards 2000, held at the National Agricultural Centre, on 9 May 1984.

(Silsoe College photo')

2.1 Established market

With a new product entering an established market, competitors may be identified easily. It is possible to obtain some information about other products and to assess the present market size. Estimates of the potential market can be made, and by talking to potential customers and analysing why they have not already taken up the products presently available, it will be possible to identify the areas where most impact can be made, either by changes in designs or in marketing techniques. Perhaps the product capabilities are not suitable or there is price sensitivity. Packaging will also influence buying trends.

2.2 New market

For an entirely novel idea, potential market size is far more difficult to gauge. The reasons why customers would purchase the product must be scrutinized very carefully. The idea may have been thought of before and discarded. But perhaps the situation has changed and now there is a need where there was none before. Or perhaps technological advances have created new possibilities or price reductions. Whatever the reasons, it is necessary to make sure that they are genuine.

2.3 Competition

Often the reason for starting a new venture is because the entrepreneur has identified a gap in the market. With any product entering a market, competition is likely to be present. If this is not the case at first, very quickly competitors will enter the same field as they see the initial success of a new idea. When a new concept is introduced, it will have an effect on other products, even though they may not be in direct competition.

A study of the competition and of the areas from which it is most likely to come will be a valuable exercise. Firstly, finding out the quantities of competitive products sold will give an indication of present market size. It will also indicate which companies will be most competitive. Analysis of the products should show up any weaknesses and also where a new product could have advantages which are not presently available elsewhere.

A study of competitors methods of marketing may also help in formulating marketing strategy.

2.4 Sales forecast

With as much information about the market place as possible, an informed judgement will need to be made regarding the proportion of the market which is expected to be obtained in the first year of sales. The financial value of those sales can then be estimated.

Of course, one person's opinion will differ from another and it will be necessary to have confidence in the fact that the product will sell and is needed by potential customers.

Having formulated quantities of first year sales, projections then need to be drawn up month by month of exactly when the sales will become a reality.

For a new business starting from scratch, it will be doubtful whether sales will be forthcoming for at least the first three months, and maybe longer. If a manufactured product is to be sold, then there will also be a lead time between the order and actual sale. Of course, if business can be generated before the company starts trading, then so much the better.

One of the many reasons for failure of a new company is the over projection of sales and the over optimistic view of when income first will be received by the company. Bringing initial sales revenue forward by only one or two months can drastically change the projected cash requirement of the business.

When formulating the projected sales income, two projections should be made — the optimistic view and the most pessimistic view. From this position the most likely outcome can then be forecast on a month by month basis.

Before going deeper into cash requirements, other aspects must first be considered, viz management skills and product manufacture.

3 Management

At an early stage some serious thought should be given to the management team. Although highly successful businesses have been built by individuals, not all entrepreneurs have all the management skills necessary, or indeed wish to shoulder all the responsibility entirely alone. It is often sensible to find other people with complementary skills who will join the venture at its start.

3.1 Organising

A manufacturing company, in particular, will require a great deal of organisation for timeliness of operations in order to minimise cash flow difficulties and yet be able to deliver on time. At the same time, sales of the products must also be accomplished as well as normal administrative duties. Where high technology is involved, then development work will undoubtedly also need to be carried out during the early stages of the business.

All these different skills will take up time and, to be able to achieve satisfactory results, personnel will be required to fulfil the different tasks. It may be possible to get assistance or advice on a part-time basis when required, though it could be beneficial to have a working partner with whom day to day problems can be discussed, and who will share the workload.

3.2 Range of skills

Starting a business will impose a far higher workload than is likely to be recognised by the beginner. If a business is to prosper, then the entrepreneur will wish to quickly grasp such subjects as basic accounting techniques, payroll, Value Added Tax, cash flow analysis and other skills which do not come naturally to everyone. Other areas such as management of employees, initial promotional campaign, advertising and demonstrating products, will also require a full understanding.

Many good ideas do not realise their full potential because the management mix has lacked in certain areas. Being able to have a change of mind and modify plans is a great asset. Mistakes are bound to be made and will require open-mindedness if they are not to prove disastrous.

3.3 Professional assistance

Professional advice and help will be required from time and a good rapport with the bank manager, accountant and a solicitor will make financial and legal matters more comprehensible. A wealth of knowledge can be gained from these sources and although in the short term they may prove to be expensive, in the longer term, good professional advice should save the company large amounts of money.

It goes without saying that the management team must have the determination to succeed. They must be able to express their views easily to each other and also to stick together in times of crisis. When money is invested by outside backers then the responsibilities are high.

4 Manufacturing

In deciding the best course to take in the manufacture of the product, a number of different criteria must be considered. There are certainly cash

Fig 1 Yield per Field on-combine weigher

flow advantages in using sub-contractors to make equipment, though these may in some cases be outweighed by advantages of in-house production.

When starting a business, avoid sub-contracting manufacture when the detail design of the product is also being undertaken outside the company. Internal product knowledge is likely to be weak in this case and there will be a temptation not to provide the facilities for repair and maintenance internally. Hence, the success of the new product will be too much in the hands of others. Delivery dates and quality control will be difficult to guarantee.

On the other hand, if the product is of already proven design, and the role of the company is to be in marketing, then no internal manufacture need take place at all, as long as the source of supply can be relied upon.

Usually, a new company with a new product would require a mixture of both sub-contract and in-house manufacture.

4.1 In-house

Essential skills in the technical operation would advisedly be found in-house from the start. Final assembly, inspection and test routines may then be carried out in-house and the company would automatically be creating a good base for a high level of quality control and also product repair facilities. New products invariably require modifications either to make them technically better and/or to simplify manufacture, reduce costs and increase efficiency. Working with the product during its manufacture will highlight the areas where improvements would be most rewarding.

In-house manufacture does not necessarily mean high expenditure on specialist equipment. Often it is possible to get second-hand equipment at very reasonable prices and also be able to manage in the early days without certain items. As the company generates business and individual work loads become too great, then better equipment can be bought to relieve the situation.

4.2 Sub-contract

Sub-contractors can be used for the manufacture of component parts and sub-assemblies. An allowance must be made for late deliveries and some rejects from sub-contractors. Where possible, it is a good idea to have more than one supplier so that production will not completely stop due to a problem with any particular one.

Once reliable sub-contractors have been found, they will provide a very valuable service for the small business. It is probable that the numbers of an initial production batch will not warrant either full time production staff or the expense of specialised machine tools for primary operations, for example, precision machining of materials or manufacture of printed circuit boards.

Quantities of parts can be called-off from a sub-contractor as required. An account should be set-up so that payment does not become due for a month or more after delivery. This is of tremendous advantage to cash flow. It may even be possible to ship finished goods out to customers before sub-contractors are paid.

All manufacturers are always looking for an even workload, spread throughout the year. In practice, this is not often possible in a new business. Sales are likely to fluctuate for many different reasons and so it is of great advantage to be able to call off parts when they are required without having a year round commitment. There is, therefore, merit in sub-contracting certain items.

4.3 Forecasting production

As the manufacturing processes take shape, premises must be found and costed. Costings are then required for tools, equipment and machines needed for production and a projection of the timing for each purchase.

Parts lists need to be drawn up and suppliers must be identified. This also applies to sub-contractors who will require drawings and plans to work to. The schedule of buying can then be detailed according to the sales forecasts.

Detailed costings which will be needed when purchasing starts should at this stage be prepared. It will also be a useful exercise to estimate assembly times, and identify the test routines and quality checks which will be required at the different stages of production.

5 Financing the business

The most important task for the entrepreneur is to bring all aspects of the proposed business together and formulate full cash flow forecasts, profitability predictions, and capital requirements. These projections cannot be sensibly prepared until the steps previously described have been completed.

5.1 Cash flow forecast

The cash flow forecast is simply a study of the everyday movement of money going out of and coming into the business. The usefulness of such a forecast, usually prepared on a monthly basis, is that it will show the most strained periods and also the times when there is likely to be surplus cash. Ultimately, the working capital will be related to the cash flow forecast which will indicate whether short term or longer term borrowing will be required for the different aspects of the business.

The cash flow forecast will highlight the maximum capital requirement, the month in which this will occur and the most suitable timing for cash injections.

The projection will include the timing of all purchases and expenses, including capital items, overheads, employee remuneration, production purchases etc, all suitably phased to take account of any credit that can be taken. It will also include income from sales, thereby a net surplus or deficit of funds each month can be ascertained.

When injections of capital into the business are also entered into the cash flow there will be the added expense of interest payments also to be shown.

Once the cash flow projection has been completed, it will be easy to see the effect of slower sales on the cash requirements.

5.2 Profitability predictions

Profitability is based on the expenses incurred and the sales achieved in any one period. For a new business, this should be done on a monthly basis. Profitability differs from cash flow in that it is not to do with when income is received or payment takes place, but is related to when a sale or purchase is actually made.

Purchases of production parts which will later become part of the product will not adversely affect the profitability, as they would be included as 'stock' and, therefore, have a value.

Costs which will be included are those directly related to sales and those which can be termed overheads, ie those costs which will not vary according to the number of sales achieved.

For each product which is sold, there will be elements of materials, labour, sub-contracted work, etc; whereas overhead costs will include promotion and advertising, telephone, electricity, rental, running of vehicles and others, such as administrative salaries, etc.

At the start, there will also be expenditure incurred before trading starts, such as professional fees, market research, product development, and fitting out premises. These charges can be expressed as one off costs and will affect the profit/loss in the first month.

At this stage, it would be advisable to complete a second profit prediction, using the expected worst forecast for sales. This will indicate the extent of the risk involved. There may be ways in which the risk could be minimised and these must be explored.

5.3 Professional services

Having made initial attempts at a cash flow forecast and profitability prediction, it would be advisable to discuss the project with both a bank and an accountant. Their help in ascertaining whether your assumptions are sensible and projections are realistic should be of great value. No doubt, certain of the original plans and thoughts will have to be scrapped or modified. Certain aspects of the proposition may well require severe changes in order to achieve sensible borrowing levels and profitability within timescales which will attract an outside backer.

5.4 Capital requirements

After modifying initial plans with the help of both bank and accountant, these two professional services will then be able to assist in suggesting methods of raising the capital in order to start the venture. Any particular bank is only likely to describe its own schemes and so it may be worth discussion with more than one. On the other hand a good accountant will have knowledge of a number of different ways in which capital can be raised and may also know of private individuals wishing to invest in new businesses.

From the cash flow forecast and the profitability predictions, the financing requirement of the business can be ascertained. Considerations of what the capital is required for will influence which form it should take.

There are two basic types of capital: equity and borrowed money. Equity will normally be in the from of shares in a limited company and is of a fairly permanent nature. Usually, it is the shareholders in the company who will benefit from any profits and, in the same way, the equity capital is most at risk if the business fails. Borrowed money commits the business to interest payments and total repayment at some fixed time. The lender will usually take a charge over the assets of the business in case of failure so that priority will be given to repayment of the loan.

It is rare for the founders to be able to finance the whole business from their own resources and so nearly always outside capital funds will be required. It is possible to find both equity and borrowed money from other sources, although generally any outside backer will require a proportion of the funding to come from the founders themselves.

Bank overdraft is the simplest form of loan and is suitable where short term money is required to finance seasonal stocks and debtors. If, on the other hand, the projections suggest that longer term borrowing will be required, then fixed term loans, or release of some of the equity to an investor, may be more appropriate. Often a combination of the different options is most suitable.

6 Legal aspects

When suitable finance has been arranged, there remain the legal aspects of starting the business.

Formation of the company can adequately be undertaken by an accountant, or, if preferred, a solicitor. All companies are required by law to be registered and particulars of the name, definition of the business (Memorandum), and procedural rules (Articles of Association) must be filed with the Registrar of Companies. It is advisable to take professional advice on these subjects.

Customers may wish to see the conditions of business upon which they will be trading with the company and so it will be necessary to formulate these.

Patent protection and trade marks may also be of importance to the company.

7 Conclusion

In this resumé of some of the considerations of starting a business, no mention has been made of taxation and its implications. Tax relief may possibly be available for money invested in a new business, but it will depend on the circumstances of the individual and, therefore, would have to be considered in that light. There is no doubt that as the company makes profits, some of them will be taken by taxation.

As business gets going, so the real financial figures can be entered against the projections and any fluctuations can then be assessed. If necessary, corrective action may be taken swiftly to save the company from disaster in the early stages.

The key to the success of the business will be in careful monitoring of its financial progress; the ability to be flexible and, if circumstances dictate, to change course.

It is the personalities in charge that make or break a business, not the brass name plate on the wall.

A European view

M Bealing

Introduction

IN accepting the challenge, and the honour, of giving this paper, I am only too well aware of my limited qualifications to speak on such a wide-ranging subject. May I therefore hasten to say that this paper is a 'personal view', as I see it, not a definitive paper on 'the view'. Furthermore, I would emphasise that my view may well be influenced by northern Europe, and may not reflect the situation in southern Europe.

My qualification, if such it is, for standing here is that for 25 years I have worked for the Vicon Group of Companies. In this period I have seen Vicon grow from a small family manufacturer in Holland to an international company of some repute. My participation in this success story has also made me aware of the management style and activities of other European manufacturers, some successful and some not.

I refer to 'management style' and, as we look towards the future, I am convinced that one of the major changes will be in the management style, or policy, of companies. I believe that we can learn from our colleagues in Europe, for I see that successful companies there have been changing their policies in the last few years, and I believe this foreshadows the future for us in the UK.

It is a gross generalisation, but nevertheless true, to say that our farm machinery industry has been managed in a rather benevolent, even patriarchal manner. The origin and history of many firms, and the high proportion which are even now family firms, explains this. I think this must change to the much more professional management approach in the harsh competitive world of the next decade. Whilst this may be regrettable, I believe it is necessary for survival.

Michael Bealing is Managing Director of Vicon Ltd, Ipswich.

This paper was presented at the Annual Conference entitled: Agricultural Engineering towards 2000, held at the National Agricultural Centre, on 9 May 1984.

Much of my paper will thus seek to explain what I believe to be the common areas of management style, or policies which seem to be adopted by successful European companies. As engineers, you may well question the relevance of this to your own activities, but I believe it is of vital importance. Whether, as engineers, your responsibilities cover research, production or service, the parameters within which you operate will be dictated by the management style of your company. Even if you are working in the academic field or in a national research or advisory role, the management policies of the commercial companies with whom you have to co-operate will exert an influence.

Strategic planning

One of the apparent hallmarks of success is the very professional management techniques adopted, and at the top of this league I would place strategic planning and the clear definitions of goals and targets. If the company can decide where it wants to be in, say, ten years, then all decisions can be made to fit into this framework. Of course, any long-term or strategic plan has to be up-dated and modified periodically, but the mental discipline needed to prepare the plan is already half the battle in actually achieving it. Another major benefit will be that relative priorities quickly emerge as the targets are set against the resources available.

In setting strategic plans, it is always easy to become fogged by generalisation and platitudes. The plan must ultimately devolve into management ratios, which can then be used for the setting of targets and the monitoring of performance. Each company will decide its own critical ratios, but let me quote a few to illustrate their scope:

* market share, in the selected activities, in the selected countries, and hence sales volume;
* productivity, as sales per man, or added value per man;
* financing load, in inventories and receivables;
* profitability, in percentage on sales or return on investment;
* quality level, in warranty cost to sales;
* service level, stores first-pick level;
* annual growth target.

Thus a 'model' is created, both in financial and operating terms, which forms the framework against which decisions can be made.

Most successful companies I know have adopted such planning and the establishment of ratio targets, and combined these with honest 'strengths and weaknesses' analysis. You will certainly appreciate that if you know where you aim to be in the long-term, it is much easier to chart your course from where you are now, and your priorities for action are clear. Less successful companies appear to manage to survive 'today', and 'tomorrow' is another day.

I believe this professional management approach has been more widely adopted in Europe than in the UK, during the past few years — the reason for which is made-up of several factors. The higher employment costs have led to a greater degree of automation and mechanisation, which enforces longer-term decision-making. So-called industrial democracy has meant more careful forward thinking for presentation to employees. The 'export or die' attitude has involved companies in greater investment in overseas markets — again leading to longer-term decisions. And, finally, the higher social status of the manager has attracted a higher calibre of man into responsible positions.

Permit me now to examine three areas in a little more depth, and try to point up some of the influences which this management style will have on the activities of research and development, manufacturing and marketing.

Research and development

Having established the product matrix for future activities as part of the strategic plan, and the target market share aimed for, the first element of research and development will be to prepare a clear outline specification of the products which would enable the targets to be achieved. This will not only specify the size and performance desirable, but will set a target manufacturing cost (and hence selling price), a date for introduction and sales prospects in the anticipated life cycle of the product. This then creates the blueprint and a timetable for the product to which the designers must work.

The project will then be split into a number of phases, each of which is probably one season, progressing from first prototype, test machines, initial manufacturing, introduction, to market development and volume production. An investment budget will be prepared for each phase.

At the end of each phase, a critical assessment will be made of progress to date, the outline specification rechecked and updated, and the cost of the next phase assessed.

In this 'end-of-phase' procedure, it will be vitally important to ensure a good feed-back of information about performance, market research information and to re-cast the calculation of pay-back time. Management will then be in a position to make a clear decision to continue, to slow down or to accelerate the next phase.

Marketing departments will be involved at a very early stage in the decision-making procedures in research and development.

My impression is that adoption of this rather rigid procedure will enable companies to take faster strides in research and development. Because the probable outcome of a project is carefully monitored, the company is more willing to take risks than with the more prevalent trial and error approach.

One of the big steps in speeding research and development projects will undoubtedly be the introduction of computer aided design — very costly to install, but with an enormous increase in productivity once it is fully integrated in the design office. The next step is then computer aided manufacture. There will also be great strides in the development of computer-simulated testing, to speed the programme and reduce the vulnerability of field-test work.

Manufacturing

I have already referred to the higher employment costs in northern Europe. Not only are wages higher than in the UK, but the additional payroll costs of social services, pensions, holiday pay,etc are also considerably higher. This has led to an even greater emphasis on minimum manpower, and the search for ways to increase automation. Particularly for our seasonal business, a machine tool is more flexible than a man. The resultant higher capital investment does, of course, drive manufacturers to seek higher volume production runs, and this will lead to more original equipment manufacturing or dual-marketing agreements between otherwise competitive companies.

Furthermore, the advent of auto-transfer machines will have a great influence on the design of components and complete machines; and will mean a closer link has to be forged between the designers and the production engineers, so that the design is suited to the machines on which it will be manufactured, painted and assembled.

The purchasing departments will also assume a more important function, as bought-in components will have to be to closer tolerances, and possibly delivered to tighter schedules and packed in such a way as to facilitate presentation to the machine tools.

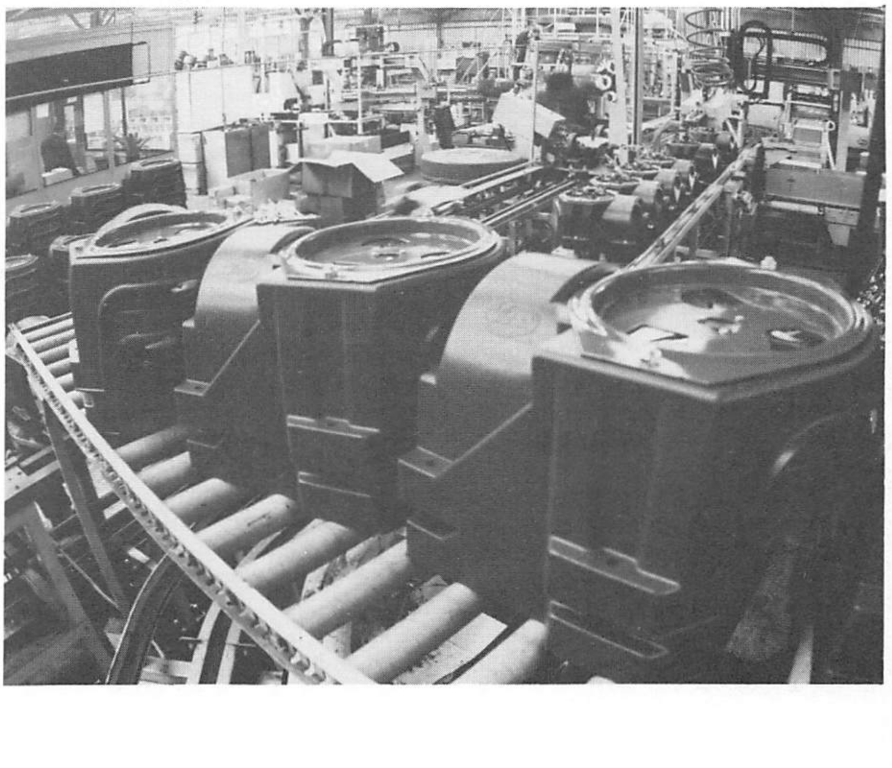
Marketing

Perhaps the most marked difference which I see on 'both sides of the water' is the more aggressive marketing which seems to be done by our European friends. Certainly the 'export or die' attitude has been more prevalent over the last 20 years. Even relatively small companies put a high priority on export, and several have grown from small to medium by establishing their own wholly-owned or partly-owned sales companies in overseas countries.

This policy has two direct benefits. Firstly, an 'own company' will strive harder to achieve sales than will a distributor. Secondly, the feed-back of information to the parent company on the market and the product performance is likely to be better.

I am continuously surprised at the considerable differences in the market place in different countries, even within Europe. Differences in the size of farms and the farming techniques, in the attitude and motivation of the ultimate

The auto transfer line for the production of fertiliser spreaders in the Vicon factory in Nieuw Vennep, Holland



customers, and in the type of dealers or distributors through whom we sell our products. Not only are European manufacturers more likely to have their own companies in different countries, but also the staff, both sales and engineering staff, are much more prepared to travel widely to 'see for themselves'. Of course, jumping in a car to drive from Germany into France is much easier than booking flights, and being fleeced in the process; but there is a much greater willingness to spend time out of the office.

If we are to succeed in the UK, then we, too, will have to adopt more aggressive marketing and, at the very least, begin to think of the whole of Europe as our home market.

Perhaps I may be permitted a final piece of special pleading. I firmly believe that the social status of salesmen in the UK has been too low, and this has inhibited us in recruiting the calibre of salesman we need to compete in this harsh world. I can only hope that this will change.

Forward Projection

What then of the future, as the millennium draws to its end? Taking my rather cloudy crystal ball firmly in hand, I see a polarisation of manufacturers in Europe. The successful companies will expand and grow with widening product ranges in carefully selected activities and crops. Although I believe the speed of innovation in a mechanical sense is slowing, there will be an accelerating speed in the electronics revolution in the control and monitoring of machines in use. Manufacturers will strive for higher volumes of production and longer life between major redesigns. There will be a rapid growth in investment in the latest design and manufacturing techniques, and there will be more original equipment manufacturing or dual marketing arrangements. These factors will create the polarisation to which I referred, as there will be fewer, but larger, major manufacturers, and there will be little place for the small-to-medium-sized company. There may well be an increase in the very small localised manufacturer or component specialist company.

To find a place in this European structure of our industry, UK manufacturers will have to improve the professionalism of their management, not only at senior level but throughout their companies. If I am right in forecasting the polarisation, there will really be no other alternative.

Farmers will become increasingly sophisticated and selective in their purchasing. The pressure on farm incomes may lead them to choose low input/low output operation; but this in itself does not mean a diminishing demand for machinery, and our challenge will be to produce the machinery with the cost benefits the farmer requires.

Our western manufacturing industry must look further afield for marketing opportunities, as our 'home' market is saturated, and we must make our contribution to solving the problems of the Third World.

Agricultural Engineering towards 2000

Discussion and Summary of 1984 Annual Conference

Questions following Paper 1, (J W G Young — The Group Concept)

W W James (Rycotewood College)

Q Does an agricultural engineering company involved in manufacture, require mechanical and electrical engineers for machinery development and production, and agricultural engineers for marketing and management?

A *The agricultural engineer should be directed towards sales and technical development whilst production can concern the mechanical and/or electrical engineer.*

G G Antony (Engineering Council)

Q J W G Young has solved problems of short-term finance which many companies experience. However, should not manufacturing be considered as an integral part of computer management?

A *Many engineering companies are "cash rich" because they have been unwilling to expand. In the early 70s, manufacturing companies had staff problems and full factories, but now there is spare capacity and fewer staff problems. Perhaps it would be better to use investment to employ more people and use more space once again.*

F Moore (Howard Rotavator Co)

Q An analysis of imported farm machinery, excluding combine harvesters, shows a high proportion of innovative products. Why have we lost this innovative ability, particularly with grassland machinery?

A *Most of the products imported here are produced in thousands in Europe, where companies only have to cross the water barrier for one of their export areas whereas our companies have the water barrier for every export area. The production of a specialised machine appears to be the niche for the British manufacturer in the future.*

R C M Smart (Howard Rotavator Co)

Q Is the water barrier an excuse for lack of innovation in the UK?

A *There is innovation in the UK, for instance the National Institute of Agricultural Engineering has been innovative on grass conditioner design, but such designs have been commercially exploited by European companies as well as British ones because more conditioners are made and sold in Europe.*

T C D Manby (Silsoe Consultants)

Q Are Groups in a better position to innovate than smaller companies? Why are some large companies and Groups less successful with innovation than others?

A *Parmiter as a single private company was geographically isolated by its location and small staff. The Group has a wider location of interest and gives greater consultative opportunities for its staff. Therefore the management of the Group is much better informed than that of the small company.*

Questions following Paper 2, (G H Evans — Prospects for the smaller company)

P L Shirtcliffe (Rycotewood College)

Q What is the relationship between colleges and the manufacturing industry? Is there a difference between colleges that train engineers for agriculture and those that train agricultural engineers *per se?* Do manufacturers include holders of diplomas and higher certificates when they quote numbers of graduates employed?

A *Yes, persons with higher certificates and diplomas are employed. My company employs five or six sandwich course students but they must each have a project in which they are fully involved. There is a need for closer liaison between colleges and manufacturers.*

J V Fox (Bomford and Evershed Ltd)

Q It is interesting to note that both J W G Young and G H Evans moved from importing machinery to manufacturing. What is the motivation for this when, in general, more money can be made from the importing business?

A *Manufacturing is an ideal as then there is control over one's own destiny. Life is more than just making money.*

R C Smart (Howard Rotavator Co)

Q Ultimately, will not manufacturing be more profitable than participation in the distributing trade?

A *External factors such as the geographical relationship of Britain with the rest of Europe will always effect the profitability of our exports. However we must continue to attract the 8½ million European farmers with our sales and not rely for a sufficient market from the quarter million British farmers.*

C J Great (Howard Rotavator Co)

Q Should there not be collaboration on exports between different companies? Howard Rotavator have a number of outlets abroad for their own products which could be used by another manufacturer to sell goods which did not compete with the associated companies' machinery.

A *This is a good idea.*

B D Witney (Edinburgh School of Agriculture)

Q In some countries, farm machinery has to meet certain testing requirements whereas none is required in the UK. Does this have an unfair influence on our export/import balance?

A *There are false barriers to trade with a number of countries including some within EEC.*

Questions following Paper 3, (DI McA Elder — Starting a new company)

M J Le Flufy (Silsoe College)

Q What motivated David Elder to innovate?

A *He was always attracted to agricultural engineering as he enjoyed working in the farm workshop. Therefore, when he chose to further his education, he obtained a place at Silsoe College. The student environment there was very conducive to stimulating ideas from people.*

J A Hellier (Ford Motor Co)

Statement: Not only has David Elder had a good idea, but he has carried out the vital task of market research to ensure that he has a marketable product. An idea is of no value if it has no practical potential. Colleges must teach students the importance of thorough market research.

T C D Manby (Silsoe Consultants)

Q (a) Why were 100 product units scrapped?

(b) How did he time the launch of his product to suit the market as the National Institute of Agricultural Engineering had unsuccessfully launched a similar device previously?

A (a) *Manufacture had been sub-contracted to a firm which did not construct the equipment to the robustness required and were also late on delivery. Now all sub-contracted parts are fully checked and delivery dates firmed up.*

(b) *The National Institute of Agricultural Engineering had carried out the correct market research but produced their equipment when electronic components were neither as cheap nor as reliable as today. Hence the devices did not satisfy the market need.*

K White (Compak Systems Ltd)

Statement: It is easy to underestimate the time and cost of a new innovation. It is also dangerous to obtain technological support or manufacture from outwith the agricultural engineering industry.

Questions following Paper 4, (M Bealing — A European view)

W W James (Rycotewood College)

Q What qualities do salesmen require?

A *Teach them first the product and then how to sell it. They should also be taught to think why the customer should buy the product.*

R Filbey (J Mann & Son)

Q Has not the art of selling lost discipline? If this was improved, inner reserves would be manifest.

A *It is agreed that better discipline is required.*

D Bryant (Rycotewood College)

Q Since machines are more flexible than man and tend to be regularly updated, what is the role of the factory hand in the year 2000?

A *Staff will not form metal but decide upon the shape only. Therefore the calibre of people will need to be greater as, for instance, more tool setters will be required. There will be as many jobs in servicing and selling.*

J Matthews (National Institute of Agricultural Engineering)

Q It would be helpful to hear more detail of his computer simulated testing and how far this will replace field testing.

A *Not only can one simulate variation in field conditions but the level of testing can be increased.*

Summary of Papers

J V Fox (Bomford and Evershed Ltd)

I SHOULD like to congratulate the speakers on their logical and forthright approach to a complex topic, as well as on their very able presentations.

There is no such thing as the UK agricultural engineering industry — rather, there are six hundred or so companies, large and small, with very little in common, except their customers. Therefore, we must recognise that each company or group is unique and independent, and is unlikely to fit into any convenient classification that we may try to devise.

Confidence is a vital ingredient in business and it cannot help if we, in the industry, take a line that is in any way defeatist. It is notable that none of the speakers has done so despite statistics that cannot be said to be encouraging, but they are absolutely right to be optimistic.

Comparing the total output of the agricultural engineering industry with total home consumption in UK, USA and France; the UK industry produced, in 1982–83, 119% of total home consumption, whereas in the same period the US industry produced 116% of US home consumption and the French industry produced 78% of French consumption. Thus, the UK is still a major force within the world agricultural engineering industry despite the restraints and problems that have beset us in recent years. There is no reason at all why we cannot once again lead the world if we are successful in improving the quality of our management and of our planning. It was interesting to hear all the speakers saying the same thing, in different ways.

Basically, they are all saying that it is people who count. Find a man with the right idea, the right designer to create the machine, the right engineer to manufacture it and the right salesman to sell it, then you have the absolute certainty of success. Repeat that across the country and you have a strong industry, ready to take on all comers. If our industry is beatable today, it only needs a little gain in quality, productivity, service and marketing to make it unbeatable. That gain is undoubtedly within our grasp as all we need are a few more of the right people, to join the many we already have.

John Young advocates the long-term view of manufacturing policy, investment policy and group structure. He suggests that the strength of a Group pays off in terms of in-house training and the ability to attract and retain able graduates, as well as in creating confidence in the market-place.

Geoffrey Evans, too, believes in the necessity of long-term planning, and of building an asset that has permanence and solidity. He identifies investment in skilled and qualified personnel as the key element in achieving success, and mentions that ten per cent of his company's workforce are graduates. He believes also in specialisation and innovation, and looks for continued co-operation between industry and the research institutes. He concludes that all of these criteria could be better met by an industry with rather fewer but larger companies than at present. How we could arrive at that situation is a point to ponder.

David Elder, in his excellent review of the trials and tribulations of a new company, speaks with the authentic voice of experience, some of it painful. His message was very clear; get the right people, make sure that you and they know exactly what to do and monitor progress continuously.

The keynote of Michael Bealing's paper is the need for, and importance of, professionalism in management. He highlights the importance of long-term strategic planning as a basis for monitoring progress and performance, and he makes the interesting point that most of the very successful European companies have given exporting a high priority and have established foreign subsidiaries to achieve effective penetration of their chosen markets. He concludes by taking Geoffrey Evans' hypothesis of fewer but larger companies a stage further with the forecast that the small companies will be put out of business by polarisation of the industry into large, growing companies and small, declining ones.

Can we draw up a blueprint of the successful agricultural machinery manufacturing company of the 1990s? It will be medium to large in size, with 250 plus employees and business of £10M plus at today's values and may be part of a Group. The company will have a highly professional management, with trained and qualified staff at all levels of the organisation. The management will work to a strategic plan, with an accounting system which constantly monitors performance against plan. Substantial resources will be devoted to research and development as the foundation of future prosperity. The management will be adaptable, with the ability to identify and respond to changing trends in the industry in which the company operates. Quality will be regarded as being critical to success. Aggressive marketing in home and selected export areas will take place with the aims to establish and maintain a major presence. The company will be competitive in terms of quality, specification, performance, service and, lastly, price and, of course, it will be profitable.

It is not known how many companies like this will exist in the UK in the 1990s but if there were only thirty of them, then the present trend would be reversed and this country would once again dominate the world agricultural machinery market.

The young people of the calibre our industry needs to achieve this small miracle are available in large numbers. Some of them are probably in this hall, or at least in the industry, but the majority are not. They are migrating into computer technology, electronic engineering, the sciences, the civil service and the armed forces. They are doing so because they have a wide choice of career opportunities open to them, and because they consider the agricultural machinery industry, if they think of it at all, to be a spent force, a low-technology backwater with no future.

They could not be more wrong and yet, paradoxically, unless we who are in the industry can convince them they are wrong, events will inevitably prove them right. It will be a self-fulfilling prophesy. We must demonstrate, by our confidence and our competence, that we do have a future, that our industry is the most fundamentally vital and important industry there is, and that it offers challenges and rewards worthy of men and women of high intellect. If we can build that image, then they will come and join us.

Questions following Summary of Papers (J V Fox)

D Bebb (Writtle College)

Q J V Fox considered that many young people considered agricultural engineering to be a low technology backwater with no future. This is probably true of many school careers officers as well, therefore there is a need to enhance the industry's image. Was there not a need for more intermediate qualifications in agricultural engineering as, in England and Wales, there were neither Higher Certificates nor Higher Diplomas? What qualities would be needed in tomorrow's work force?

D I McA Elder

A *The blacksmith's image of the past is being replaced now by a business/technological one.*

M Bealing

A *Careers officers must be sold the idea of challenge and fun working in industry.*

J V Fox

A *Companies themselves must create the right image. There is a requirement for people with intermediate qualifica-tions but all staff must be innovative and motivated.*

G H Evans

A *Nothing succeeds like success. There is a need for good intermediate technically qualified people. The lack of suitable qualifications in the late 1970s probably increased the rate of the decline of the agricultural engineering industry.*

J W G Young

A *The public image of the manufacturing industry is a very poor one in Britain, whereas in European countries it has a much higher status. The public image must be raised to that of our European partners.*

J G Beck (Sigmund Pulsometer Projects)

Q Various companies have succeeded with exporting ventures, but can this be improved to cover most companies? How can restrictions imposed by some countries on importing whole machines be overcome?

J W G Young

A *Traditional methods of selling may have to be replaced by a local input. Companies should seek for some form of sales rather than nothing.*

G H Evans

A *Such local input schemes described by John Young are already established in some developing countries. However, it is a difficult undertaking.*

J V Fox

A *Many countries need an agricultural engineering industry of their own rather than rely on imports.*

R C M Smart (Howard Rotavator Co)

Statement: There will be no improvement in the image of the industry or in the status of agricultural engineers without profit.

M Cowen (Lockwood Graders)

Statement: High technology means more employment — not less. There is tremendous scope for such work in the food processing industry.

J Matthews (National Institute of Agricultural Engineering)

Q What is the role of the Institution towards assisting the future of the British agricultural engineering industry?

J V Fox

A *Guidance for education.*

M Bealing

A *The training of people and advising on educational structures.*

J W G Young

A *Aiding communication within the various sections of the industry.*

P L Shirtcliffe (Rycotewood College)

Q How should the Institution promote closer relationship between education, research and manufacture?

G H Evans

A *Nothing more can be done unless a lot more people join the Institution.*

Correction Vol 39 No 1
Groundwater heat pumps

On p29, in the first sentence in column 3, the 300 m length of alkathene pipe is required for a **10 kW** installation and not for 100 kW.

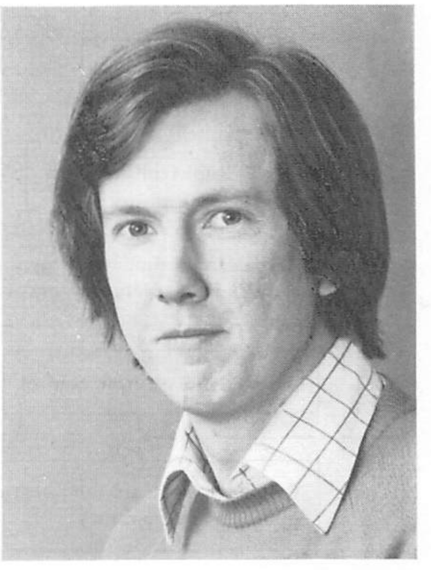
Interactive computer program for evaluating the control options for near ambient grain driers

E A Smith

Summary

A COMPUTER program, developed to illustrate some of the features of near ambient grain drying, was used as part of a display at the Smithfield Show to illustrate grain drying work undertaken at the Scottish Institute of Agricultural Engineering. The program was designed to run on a popular microcomputer which used a colour television screen to show the drying process. This paper describes the model used in the program but a complete listing of the program is available (Smith 1983a).

Various methods are used to control the fans and heaters in near ambient driers. Those which can be used in the program are a clock timer and a humidistat. The program calculates the energy used by the fan and heater to dry the grain; it also decides whether the grain will go mouldy and it calculates germination damage at the top of the bed. An interesting feature of the program is that it calculates the minimum energy required to dry the grain safely and an operator can try to achieve this value using the various control methods.



1 Introduction

A MAJOR problem with near ambient driers, such as on-floor or in-bin driers, is to decide how best to control the fans and heaters so that as little energy as possible is used to dry the grain. The computer program can be used to investigate various control methods used in practice, such as the clock timer and the humidistat. Grain deterioration is modelled in the program and, in particular, the occasions when mould growth occurs are calculated. Also, before the drying simulation starts, the program calculates the minimum energy required to dry the grain without mould growth. This energy consumption can be used by an operator as a target to aim at using the various control methods.

Because of the limitations of microcomputers, the drying model is less accurate than that used in drying research but it gives similar results. The program confirms much of the advice given on the operation of near ambient driers; for example, that most grain can be dried without using heaters (Smith and Bailey 1983) so such use is often unnecessary and expensive. It also illustrates the effectiveness of the recommended way of dealing with wet grain: reducing the depth and increasing the airflow. However, the program can also be used to explore the limitations of this advice. It has, for example, been suggested that grain with a moisture content of 20–21% is the wettest grain which should be dried in near ambient driers and that wetter grain should be dried in progressively shallower layers (MAFF 1982a). It is interesting to see how wetter grain than this can be dried using larger airflows and even introducing heaters.

All the energy requirements are quoted in kWh/t and moisture contents are expressed in wet basis terms.

2 Description of program

The main items in the program and the order in which they occur are shown in fig 1. The program initially requests the drying data, including the initial moisture content of the grain and the bed depth. Then the minimum energy required by a correctly sized fan to dry the grain, without mould growth, is calculated. If it is not possible to dry the grain safely using only the specified fan, a message is displayed that extra heat is required. This information helps the operator to select a good drier control. The computer then requests the type of control and the main alternatives use a clock timer or a humidistat.

During the drying calculation a diagram of the grain bed is drawn on the screen. This shows the drying front moving through the grain bed and the time passed since the start of drying, together with the energy used per tonne and the average moisture content at that time. While the drying process is being simulated the quantity of grain deterioration is determined.

When the drying front reaches the top of the grain bed, or the grain goes mouldy, the drying simulation stops and displays the final conditions, including the total energy consumption and final moisture content.

3 Drying model

In small computers the storage space and computing power are limited so it is necessary to use a drying model which can work under these conditions. One which is suitable is the moisture deficit model (Bowden *et al* 1983). It is based on the approximation used for many years by

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Edward Smith is in the Crop Conservation Section of the Scottish Institute of Agricultural Engineering, Penicuik, Midlothian EH26 0PH.

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practical drying engineers when representing a drying cycle on the psychrometric chart.

It is assumed that the moisture content of the grain comes quickly into equilibrium with the air. Equilibrium moisture contents are related to air temperature and relative humidity by an expression recommended by Nellist and Dumont (1979). Bowden *et al* (1983) gave the following form of the expression to represent barley:

$$M = 0.143 - 0.016\ell nT - 0.079\ell n\,(1 - \phi) \qquad (1)$$

Also it is assumed that the air maintains constant enthalpy throughout the drying process. The energy required to alter the grain temperature is ignored. Therefore the inlet air conditions can be related to the exhaust values by

$$c_aT_{ex} + (\lambda + c_vT_{ex})H_{ex} = c_aT_i + (\lambda + c_vT_i)H_i \qquad (2)$$

The air and grain are assumed to be at the same temperature. The exhaust relative humidity is assumed to be in equilibrium with the initial moisture content and temperature of the grain. Thus, using the psychrometric relationship between temperature, relative humidity and humidity, T_{ex} and H_{ex} can be derived from equations (1) and (2) when the inlet values, T_i and H_i, are given and assuming a moisture mass balance.

One effect of these assumptions is that the drying zone has zero width but, in practice, the zone increases in width with higher airflows due to the effects of finite heat and mass transfer rates. This limits the application of the model to cases where the zone moves slowly through the bed and the model cannot be applied to such cases as high temperature drying or drying with large airflows in shallow beds.

When the exhaust temperature and humidity are known, the amount of water removed from the bed during a time step of duration Δt is given by:

$$m = (H_{ex} - H_i)G\Delta t \qquad (3)$$

By adding the values of m from the start of drying, the total amount of water removed from the bed, m′, is obtained. The distance moved by the drying front is

$$\Delta x = m/[(M_{ex} - M_i)\rho] \qquad (4)$$

The size of the time step does not greatly effect the accuracy of the model (Smith and Bailey 1983). Smaller values of Δt greatly increase the computing time. However, smaller Δt also means more variability in the inlet weather conditions, and this makes the control of the drier more interesting. The average moisture content of the whole bed, M, is calculated from m′, the total amount of water removed from the bed from the start of drying:

$$M = M_o - m'/(L\rho) \qquad (5)$$

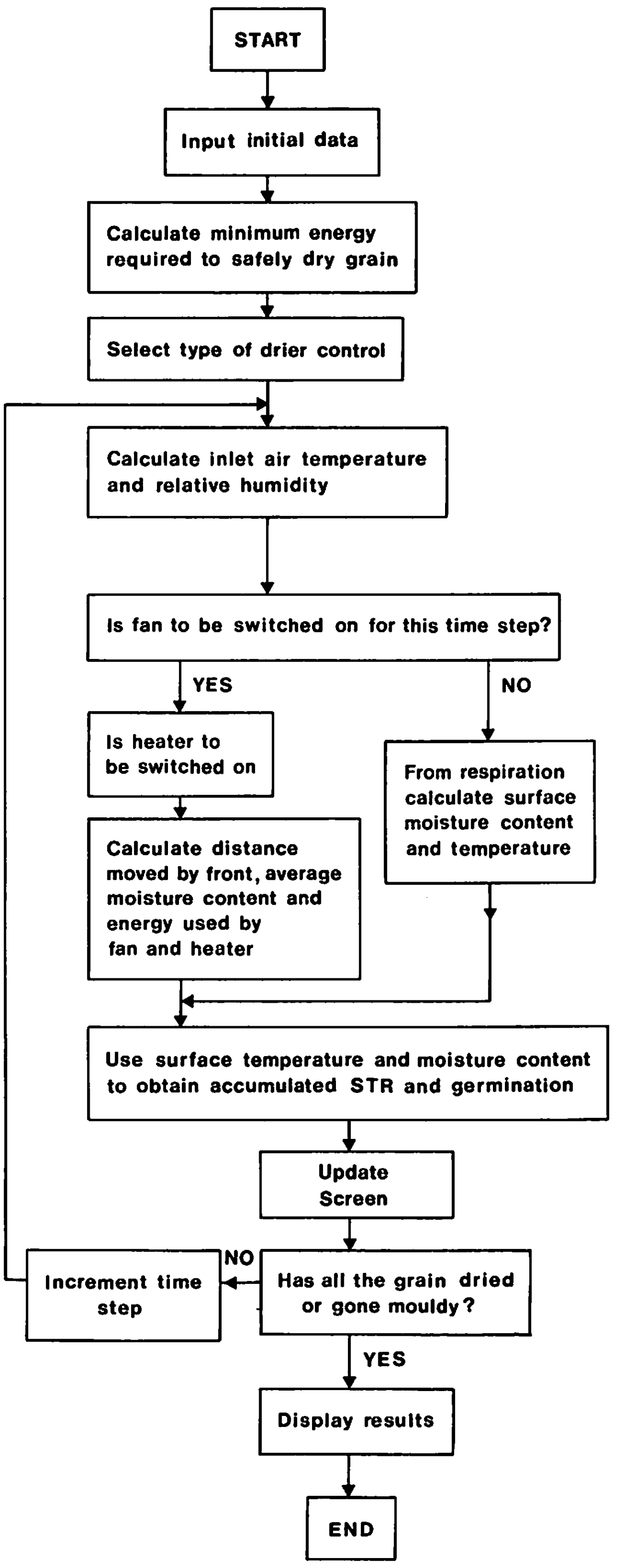
4 Fan power and temperature rise

Energy supplied to drive a fan also heats the moving air. The temperature rise and associated reduction in relative humidity is useful in low temperature drying. If the air is ducted over the fan motor, it is heated directly by the motor losses. In addition, it has been shown (Lamond 1982) that all the work done by a fan in friction and in adiabatically increasing the air pressure appears as an increase in temperature above ambient at entry to the grain as a result of a rise in enthalpy (assuming no energy loss through the duct walls). Thus, all power supplied to a fan is ultimately available as heat for drying.

The power supplied to the fan per unit inlet area, assuming 50% efficiency, is:

$$Q = 2\,p\,V \qquad (6)$$

Fig 1 Flow diagram of the drying program showing the main events and the order in which they occur.



Notation

B	modified moisture content (wet basis) used in respiration calculation
c	specific heat, J kg^{-1} $°C^{-1}$
C	critical decision period in which the fan is on for only part of the whole drying time
d	one of the six periods throughout each day when a decision is made on operating the fan
D	percentage loss of dry matter
E	energy consumption per unit air inlet area, J/m^2
g	percentage germination
G	mass airflow rate, kg m^{-2} h^{-1}
H	absolute humidity, kg water/kg dry air
K	used to calculate M_2 in respiration calculation
L	bed depth, m
L_d	distance moved by drying front during the whole drying time in decision period d, m
m	weight of moisture removed per unit air inlet area during a time step, kg/m^2
m′	total weight of moisture removed, per unit air inlet area, from the start of drying, kg/m^2
M	moisture content (dry basis), kg water/kg dry matter
M_1, M_2	used to calculate the time step in respiration calculation
N_d	number of times a decision period occurs throughout the drying period
p	static air pressure, N/m^2
Q	fan power per unit air inlet area, J m^{-2} h^{-1}
R	modified moisture content (dry basis) used in respiration calculation
STR	$\Delta t/t_m$, the mould index is the sum total of this value from the beginning of drying
t	time, h
t_c	clock time in 24 hour system, h
t_m	minimum time for mould to appear, h
T	temperature, °C
ΔT	temperature rise, °C
$\bar{t}$	time for viability to fall to 50% when grain is held in constant environment, h
Δt	time steps of four hours
V	air velocity, m/h
W	moisture content (wet basis), percentage
Δx	distance moved by drying front in four hours, m
y	relative frequency of grain deaths occurring at time t
ε	net fan static efficiency
λ	latent heat of evaporation of water, J/kg
ν	probit viability
ρ	dry bulk density, kg/m^2
σ	standard deviation of grain death distribution, h
τ	modified time step used in calculating the dry matter loss due to respiration, h
ϕ	relative humidity, decimal
Subscripts	
a	air
c	critical decision period
ex	exhaust from grain bed
i	inlet to grain bed
m	maximum value produced by fan
o	initial value
v	water vapour

where the pressure head p can be calculated from the grain resistance (Spencer 1969):

$$p = \frac{L\,a\,V^2}{\ell n(1 + bV)} \tag{7}$$

and where $a = 2.10 \times 10^{-3}$ and $b = 3.72 \times 10^{-3}$ for Midas barley. The resulting temperature rise is given by:

$$\Delta T = \frac{Q}{(c_a + c_v H)G} \tag{8}$$

5 Grain deterioration

The causes of grain deterioration which are modelled in the program are the growth of mould, germination damage due to ageing and heating due to respiration. Most other causes of damage are controlled by factors in addition to drying, such as hygiene in the grain store with respect to rodents and the storage temperature for insects and mites (Howe 1965, Burrell 1974).

In the program, the amount of deterioration is calculated only for grain at the top of the bed, since with on-floor driers this stays wet for the longest time and so will deteriorate most rapidly.

5.1 Mould growth

The time before the appearance of mould has been related to the grain temperature and moisture content (Bowden *et al* 1983) by the formula:

$$t_m = 67 + \exp\{5.124 + (39.6 - 0.8107T)[1/(W - 12) - 0.0315 \exp 0.0579T]\} \tag{9}$$

A fraction of this time $\Delta t/t_m$, called the storage time ratio (STR), is used up in each time step of duration Δt. Adding together the STR for each time step gives the accumulated STR which equals unity when mould growth has occurred.

5.2 Germination damage

The percentage of a grain sample which germinates in the ISTA test (International Seed Testing Association 1976), is called the percentage viability. Loss of viability due to ageing can be related to the grain moisture content and temperature (Roberts 1972, Nellist 1981).

Under constant environmental conditions the frequency of individual deaths in time can be described by the normal distribution:

$$y = \frac{\exp(-\nu^2/2)}{\sigma\sqrt{2\pi}} \quad (10)$$

where the probit viability $\nu = (\bar{t}-t)/\sigma$ and t is the time for which the grains are held at constant conditions and y is the relative frequency of deaths occurring at time t. Probit viability is lost at a constant rate under constant conditions. However, percentage viability or germination does not behave so well; in the early stages, relatively little germination is lost in each hour but the rate at which grains die increases until approximately 50% of the grains can germinate, after which the rate decreases. For this reason probit viability was used in the model. The standard deviation of the frequency distribution is:

$$\log(\sigma/24) = 9.983 - 5.896 \log W - 0.04T - 0.000428T^2$$

From equation (10) the percentage viability, or germination is:

$$g = \frac{100}{\sqrt{2\pi}} \int_{-\infty}^{\nu} \exp(-\nu^2/2)\, d\nu \quad (11)$$

In a layer of the grain bed, the change in probit viability over the j^{th} time step Δt is:

$$\Delta\nu_j = -\Delta t/\sigma_j$$

So the probit viability after N time steps is:

$$\nu = \nu_o + \sum_{j=1}^{N} \Delta\nu_j$$

An initial probit viability, ν_o, of 3.35 is used in the program and this corresponds to a percentage viability of 99.96%. Once ν is calculated the percentage viability is given by equation (11).

The simulation of germination damage due to ageing is accurate for storage conditions of constant temperature and humidity. It can be used as such in the program eg grain at 17% in a bed 5 m deep kept cool by low volume ventilation will suffer a reduction in germination from an initial value of 99.96% down to 93% in 175 days.

It is probable that germination is also calculated reasonably accurately if the temperature and moisture content are only slowly changing, provided mould growth does not occur. But with low temperature drying the time taken for the germination to fall by a noticeable amount is usually much longer than the drying time or the time for mould to grow; so its effects are not noticeable. But this result is dependent on the value of the initial germination. The value of 99.96% used in the program was typical of the values used by Roberts (1972) for seed storage conditions. Lower values will occur, however, and this will increase the rate of germination damage.

The effect of mould on germination damage is not well understood and the value of germination is unlikely to be accurate if the mould index (accumulated STR) is close to 1.0. Also the value of germination damage will not be accurate when the grain is drying relatively rapidly as in medium to high temperature driers or for grain near the air inlet of low temperature driers when a large heat input is used.

5.3 Respiration

Another cause of grain deterioration is the respiration or oxidation of the grain. This occurs most rapidly when the grain bed is not ventilated and is dependent on the temperature and moisture content of the grain. It is to prevent respiration losses that dried grain is ventilated with cold air during storage.

Carbon dioxide production has been measured for maize held under various conditions (Steele *et al* 1969) and related to dry matter loss. Formulae for calculating this loss due to respiration have been developed (Thompson 1972). These formulae for maize have been adapted for wheat (Morey *et al* 1981).

The dry matter loss is given by:

$$D = 0.0883 \exp(0.006\tau) + 0.00102\tau \quad (12)$$

where $\tau = \Delta t/(M_1 M_2)$ is the modified time step over which temperature and moisture content are assumed constant.

The modifier M_1 is:

$$M_1 = 0.103\,[\exp(455/B^{1.53}) - 0.00845B + 1.558]$$

and B is given by the two formulae:

$$R = \left[\frac{M + 0.01577\ell nT - 0.1431}{5.47 \times 10^{-6}(T + 45.6)}\right]^{1/2}$$

and $B = 100(R/(100 + R))$.

The modifier M_2 is:

$$M_2 = 32.3 \exp(-0.1044T - 1.856) + K$$

where $K = 0$ when $T \leq 15.5$ or $B \leq 19$

and $K = \frac{C - 19}{100} \exp[0.0184(T - 15.5)]$ if $T > 15.5$

or $19 < B \leq 28$

and $K = 0.09 \exp[0.0184(T - 15.5)]$ if $T > 15.5$ and $B > 28$.

The loss of dry matter, D, given by equation (12) results in a temperature rise in the grain of:

$$\Delta T = 120.95\, D \quad (13)$$

and an increase in the grain moisture content (dry basis):

$$\Delta M = 0.006\, D \quad (14)$$

In the computer program, respiration is only used to calculate the temperature rise in the grain when the grain is not ventilated. With wet grain this temperature rise can be quite rapid and this results in more rapid mould growth. The loss of dry matter from respiration during ventilation is less important than mould growth and it is ignored because unacceptable damage due to dry matter loss takes longer to occur than mould growth. A loss in dry matter of 0.5% is considered to be the maximum acceptable value (Morey *et al* 1981).

6 Program use

6.1 Data required

The program requests the initial moisture content (wet basis) of the grain and the depth of the grain bed. It is assumed that the air is blown vertically up through the bed and that the whole floor is perforated. However, the results will be very similar to drying with floor ducts.

The program then requests the nominal air velocity used in ventilation. The minimum recommended for grain at 20% wet basis moisture content in beds 3 m deep is 0.1 m/s (MAFF 1982b). Increasing this value greatly eases the problem of drying very wet grain and it will increase the energy consumption by only a small amount compared with using heaters. The limiting factor is the maximum electrical load available on the farm.

The temperature rise generated by the heater is then requested. The rise is added only if heaters are used in the drying control.

6.2 Weather

To simulate the variation in weather throughout each day the temperature of the ambient air is given by

$$T = \tfrac{1}{2}(T_{max} - T_{min})(1 + \sin(\pi(t_c - 7)/12)) + T_{min} \quad (15)$$

where t_c is the clock time in hours in the 24 hour system. At the start of drying $t_c = 12$. Three temperature ranges, representing different types of weather, are available in the program. These are listed in table 1.

Table 1 Temperature and humidity ranges for the three types of weather available in the program

Type	*Temperature, °C*		*Absolute humidity, kg/kg*	*Weather Station*	*Typical area*
	max	*min*			
COOL	12.8	10	0.0074	Wick (Sept)	Caithness
MILD	16.5	11	0.008	Turnhouse (August)	Lothian coastal plain
WARM	19.5	12.4	0.0087	Honington (August)	East Anglia

The absolute humidity is assumed to remain constant throughout the drying period. On average the absolute humidity varies little through the day but there is some variation about the mean and in extreme cases the absolute humidity can be double the average value. But these variations are linked to changes in the large scale weather pattern and are difficult to simulate.

6.3 Types of control

There are two methods of controlling the fans and heaters which are available in the program. The first is a clock control which operates the fan or heater at set times of the day. The other control uses a humidistat to switch on the fan or heater if the relative humidity of the air entering the grain bed is below a set level.

These controllers behave a little differently from those used in practice because it is assumed that the weather does not change from day to day. So with the warm type of weather in table 1, the relative humidity is never above 97% or below 61%. Also the drying model uses time steps of 4 hours so there may be several hours delay between the time set on the clock control and the time the switch is operated.

6.4 Display

During the drying calculation the main features of the process are displayed on the screen as shown in fig 2. The grain bed is shown with the inlet air duct and the position of the drying front as it moves through the bed. Drying simulations typically take 3 or 4 minutes. In the drying model, the front divides the bed into a region where the grain is undried and a region where it is in equilibrium with the inlet air conditions. In practice, the moisture content through the bed changes gradually with depth between the extreme values of the inlet and exhaust. The region where the moisture content changed most rapidly with depth is the true drying front. The calculated position of the front corresponds approximately to the centre of the true drying front (Bowden *et al* 1983).

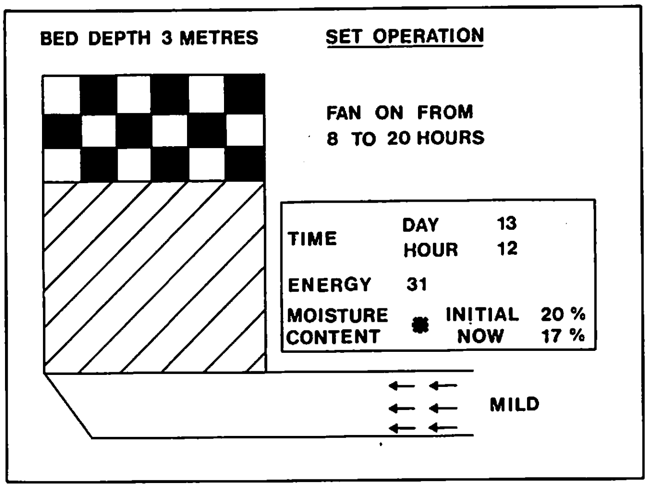


Fig 2 Display of the drying process shown on the television screen. The grain, initially at 20% wb, was dried by running the fan from 0800 h to 2000 h each day. After 13 days 12 h, 31 kWh/tonne had been used and the average moisture content had reached 17% wb. Mild weather, described in table 1 was used.

Also displayed are the time lapsed since the start of drying, together with the energy used (kWh per tonne of grain) and the average moisture content of the grain bed, at that time. The type of drier control is also indicated.

When drying is completed, either because the front has reached the top or the grain has gone mouldy, the final conditions are displayed. The drying time is shown together with the final moisture content, the mould index (accumulated STR) and the percentage viability. Then the energy used is given: the energy consumption (kWh per tonne) for the fans and heaters together with the specific energy consumption.

6.5 Reducing depth

It may be of interest to see the effect of reducing the bed depth on drying rates and energy consumption. To do this, it is necessary to know the airflow which a selected fan will produce for different bed depths. There are two equations which are used to calculate the fan static pressure and nominal velocity through the various depths. These are equation (7) and the equation describing the fan characteristic curve. For a centrifugal fan, the characteristic curve can be represented (Muir *et al* 1983) by:

$$p = p_m \ell n(3.337 - 2.337\, V/V_m) \quad \text{when } V/V_m \geq 0.31$$

and:

$$p = p_m\{\ell n(3.337 - 2.337\, V/V_m) - (0.31 - V/V_m)\} \quad \text{when } V/V_m < 0.31 \quad (16)$$

The value of p_m and V_m determine the fan size. A reasonable fan size would at its operating point produce an air velocity of 360 m/h through 3 m of grain. From equation (7), this requires a static pressure head of 960.8 N/m^2. At the operating point where the fan uses 97% of the maximum available power, the fan characteristic curve shows that the nominal airflow is 60% of V_m and the static pressure is 66% of p_m. So for this fan, $V_m = 600$ m/h and $p_m = 1456$ N/m^2. The relationship between the bed depth and airflow for this fan can be calculated from equations (7) and (16) and some values are given in table 2.

Table 2 Calculated values of nominal airflow and fan effiency for various bed depths. The size of the fan is such that $V_m = 600$ m/h and $p_m = 1456$ N/m^2

Depth, m	*Airflow, m/h*	*Fan efficiency, %*
1.0	496	37
1.5	454	45
2.0	417	49
2.5	387	52
3.0	360	53

Altering the bed depth also changes the power used by the fan. For the same fan as above, the effect of air velocity on fan power is

$$Q/Q_m = 1 - 1.28\,(0.75 - V/V_m)^2 \qquad (17)$$

This also affects the net fan static efficiency

$$\varepsilon = 100 p\,V/Q \qquad (18)$$

Table 2 shows the values of ε calculated using equations (7), (16), (17) and (18), when it is assumed that the maximum efficiency is 55%.

7 Minimum energy consumption using a fan only

Using the initial moisture content of the grain, the bed depth, the weather type and airflow, the program identifies a satisfactory fan, then calculates the minimum energy required to dry the grain without mould growth using the specified fan alone. If it is necessary to use a heater to dry the grain safely then the minimum energy is not calculated and a message is displayed that a heater is required. It is not recommended practice to use heaters when drying very wet grain (MAFF 1982b) but they can be useful if condensation is dealt with (Smith 1983b).

The air temperature varies sinusoidally over each 24 hour period, as described in Section 6.2, but it does not change from day to day. A decision on whether or not to ventilate the grain bed is made every four hours so there are six decisions per day. These decision periods are numbered 1 to 6, with period 1 the warmest and 6 the coldest so the periods are not in chronological order. In period 1 the drying zone will move the largest distance and in period 6 it will move the smallest distance.

For a grain bed 3 m deep and an airflow of 360 m/h, the temperature given by equations (8) and (15) during the mild weather defined in table 1 and the time of the start of each period are shown in table 3. Also shown is the distance, Δx, moved by the drying front during each period that the fan is switched on.

There are only six distinct periods throughout drying; period 3 starts every day at 0800 hrs and the temperature during it will always be 16.1° C, also the drying front will always move a distance of 0.04 m every time the fan is on during period 3.

Table 3 The temperature and distance moved by the drying front during each of the 4 hour periods for a grain bed 3m deep and an airflow of 360 m/h. The weather is MILD as defined in table 2 and equation (15). Drying always starts at 1200 hours.

Period (d)	*Time of start of period, h*	*Temperature, °C*	*Distance moved by front, m*
2	1200	16.7	0.043
1	1600	17.3	0.045
4	2000	14.6	0.033
6	2400	12.7	0.023
5	0400	13.4	0.027
3	0800	16.1	0.040

Drying continues until just before mould growth. During this time, each of the decision periods 1 to 6 occurs a certain number of times, N_d, such that:

$$\sum_{d=1}^{6} N_d \Delta t = t_m$$

which is the minimum time for mould growth. If the fan is on continuously for the time t_m, the total distance moved by the drying front during each of the periods d is L_d, where $L_d = N_d\,\Delta x_d$. The total distance moved using continuous ventilation is:

$$\sum_{d=1}^{6} L_d$$

This is the maximum distance which the front can travel using only a fan so if this is less than the bed depth, a heater will be required.

For example, if the initial moisture content is 20%wb and the temperature is as in table 3, then the minimum time for mould to appear, t_m, is 29 days. The minimum energy will be used to dry the grain if drying is completed in 28 days 20 hours. Each of the periods 1,2,4,5 and 6 will occur 29 times and period 3 will occur 28 times. Thus, the deepest bed that can be dried is:

$$29(\Delta x_1 + \Delta x_2 + \Delta x_4 + \Delta x_5 + \Delta x_6) + 28\,\Delta x_3 = 6.05 \text{ m}$$

If the bed depth were 3 m, it would only be necessary to blow during some of the periods. The best periods for this would be those in which the front moves the larger distances. Thus it would be best to blow continuously during periods 1 and 2 and blow for only 12 occasions in period 3. For this strategy the front moves a distance:

$$29(\Delta x_1 + \Delta x_2) + 12\,(\Delta x_3) = 3.03 \text{ m}$$

which is just enough to dry the whole grain bed.

In general, if the bed can be dried using a fan only, there is a critical decision period C. Every day, the fan is on continuously when $d < C$ and it is never on when $d > C$. During the critical decision period, when $d = C$ the fan is on for some of the days only. In the above example $C = 3$ because during period 3 the fan was on for only 12 out of a possible 28 occasions. The number of days the fan is on during the critical decision period is, in general:

$$N_c = (L - \sum_{d=1}^{C-1} L_d)/\Delta x_C$$

Thus, the minimum energy used to dry the grain safely is:

$$E = (\sum_{d=1}^{C-1} N_d + N_c)Q\Delta t \qquad (19)$$

8 Conclusions

The program described in this paper can be used to illustrate many of the features of near ambient drying. Therefore, it may be of interest to agricultural colleges, the Agricultural Development Advisory Service or to anyone interested in grain drying. A listing of the program is available (Smith 1983a). This was written for the Apple II microcomputer and uses its version of the Pascal language. The computer requires the Apple Pascal operating system to use the program. However, the drying model described in this paper could be modified for use on other microcomputers.

One way the program has been used is to show how proper control of the fans and heaters can greatly reduce energy consumption. It is also of interest to use the program to show the effect of reducing the bed depth, on the drying rate and energy consumption. The program can also be used to estimate the maximum safe depth at which grain of a given moisture content can be dried with a given airflow. This work illustrates the potential of microcomputers to summarize information gathered from research in agricultural engineering in a detailed and interesting way.

References

Bowden P J, Lamond W J, Smith E A (1983). Simulation of near ambient grain drying. I Comparison of simulations with experimental results. *J agric Engng Res,* **28,** 279–300.

Burrell N J (1974). Chilling. In *Storage of Cereal Grains and their Products* (C M Christensen, Ed). St Pauls, Minnesota: American Association of Cereal Chemists, 420–453.

Howe R W (1965). A summary of estimates of optimal and minimal conditions for population increase of some stored products insects. *J Stored Prod Res,* **1,** 177–184.

International Seed Testing Association (1976). International rules for seed testing. *Seed Sci Technol,* **4,** 3–177.

Lamond W J (1982). Thermodynamics of airflow in deep bin drying at near ambient temperatures. *Agric Engr,* **37,** 91–93.

MAFF (1982a). Grain storage methods. Grain drying and storage No 1 Agric Dev Adv Service publication B2415.

MAFF (1982b). Bulk grain driers. Grain drying and storage No 2 Agric Dev Adv Service publication B2416.

Morey R V, Cloud H A, Hansen D J (1981). Ambient air wheat drying. *Trans Am Soc agric Engrs,* **24,** 1312–1316.

Muir W E, Lamond W J, Ingram G W, Bailey P H (1983). Optimum systems for harvesting with in-bin drying in northern Britain. *J agri Engng Res,* **28,** 359–371.

Nellist M E (1981). Predicting the viability of seeds dried with heated air. *Seed Sci Technol,* **9,** 439–455.

Nellist M E, Dumont S (1979). Desorption isotherms for wheat. Dept Note DN/CDB/983/06010, Natn Inst agric Engng, Silsoe (unpubl).

Roberts, E H (1972). *Viability of Seeds.* London: Chapman and Hall.

Steele J L, Saul R A, Hukill W V (1969). Deterioration of shelled corn as measured by carbon dioxide production. *Trans Am Soc agric Engrs,* **12,** 685–689.

Smith E A (1983a). Microcomputer program for interactive evaluation of the control options for near ambient driers. Dept Note SIN/393, Scot Inst agric Engng, Penicuik (unpubl).

Smith E A (1983b). Maximum safe depth for barley in near ambient temperature driers. *Agric Engr,* **39,** 3–9.

Smith E A, Bailey P H (1983). Simulation of near ambient grain drying. II Control strategies for drying barley in northern Britain. *J agric Engng Res,* **28,** 301–317.

Spencer H B (1969). Pressure drop in on-floor drying systems. *J agric Engng Res,* **14** 165–172.

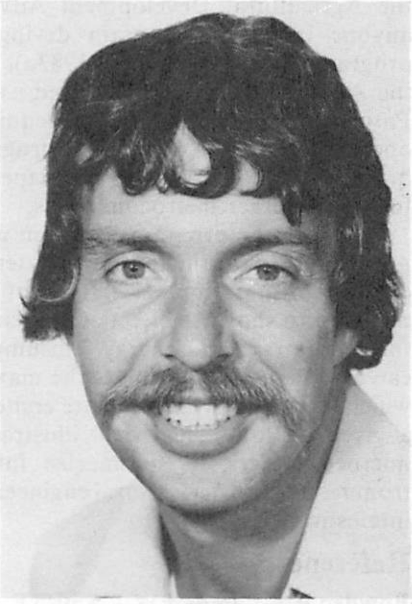
Thompson T L (1972). Temporary storage of high-moisture shelled corn using continuous aeration. *Trans Am Soc agric Engrs,* **15,** 333–337.

Agricultural energy research – report of a recent study tour

R E H Sims

Summary

THE findings of a study tour to Europe concerning energy substitution and conservation in agriculture are reported and put into context in relation to the New Zealand agricultural industry. Biomass fuels research is steadily progressing but no revolutionary technological developments were evident. Diesel fuel alternatives from natural oils/fats are of interest for developing countries and show some potential. The improved selection and operation of tractors and machinery on farms should continue to be encouraged in an effort to save time and costs with consequent fuel savings. Greenhouse energy conservation schemes have been satisfactorily achieved and new technology is being demonstrated. The potential exists for increased cooperation between agricultural energy researchers by means of information exchange and should be encouraged.



1 Introduction

AGRICULTURAL production systems have developed over the years to take advantage of the relatively low energy prices of the 1950s and 1960s. Agriculture has become virtually a means of utilising the land and natural resources to convert cheap but inedible fossilised energy into food. For many products, particularly from animals, this remains a largely inefficient process in terms of energy input/output ratios and gross energy inputs per hectare of land and per kilogramme of protein produced.

When world energy prices suddenly rose to their, arguably, more realistic levels following the oil shocks of the 1970s many oil importing countries, including New Zealand, undertook somewhat panic stricken measures. Within the agricultural industry, research and development programmes were instigated to investigate potential energy substitutes and, to a lesser degree, energy conservation technology.

Energy from biomass (in the widest sense of the term) was seen by many to be the saviour of the world. Somewhat over-enthusiastic researchers were quoted by the, at times irresponsible, media to have found all manner of solutions to the world energy crisis. The farming community was inspired to put rapeseed oil in their tractors; produce ethanol for their cars from cereals, sugar cane, fodder beet and even artichokes; use wood or sawdust to heat greenhouses or dry grain; and produce biogas from all types of feedstocks to power vehicles, cook food and generate electricity. Not since World War II had such efforts been apparent (fig 1).

Now that fuel prices have stabilised somewhat and it appears that the world economy will survive after all, these activities are only being maintained by enthusiastic hobbyists. The labour inputs involved, the costs of effectively taking land out of production, the inherent technical problems of utilising unproven technology, and the continuing debate over farming for food or for energy have suddenly become apparent. This has given us the breathing space required to consolidate the research and put the subject more into perspective (table 1).

To this effect, the government funded, New Zealand Energy Research and Development Committee contracted a multi-disciplinary study team to produce an overview of "On-farm energy supply and conservation" (Sims *et al* 1984). This project examined all aspects of energy use in New Zealand agriculture and horticulture and made recommendations concerning future research programme priorities.

On completion of the project report, a European study tour was undertaken by the author, a) to present the findings at international conferences and b) to discuss with staff from selected commercial, research and teaching organisations, their current projects, philosophy, and policy as related to energy in agriculture.

This paper summarises the conclusions drawn from these discussions. A more detailed report has also been published (Sims 1983).

The major subjects covered were:

1 biomass as an energy source with emphasis on straw, biogas production and wood;
2 alternative diesel fuels;
3 fuel conservation through improved implement
ing efficiencies;
4 greenhouse energy;
5 international policy and co-operation concerning research in rural energy.

2 Energy from biomass

The European Economic Com-

Ralph Sims is senior lecturer in agricultural/horticultural mechanisation and senior associate research officer at the Agricultural Machinery Research Centre, Massey University, Palmerston North, New Zealand. The study tour was sponsored by the Douglas Bomford Trust.

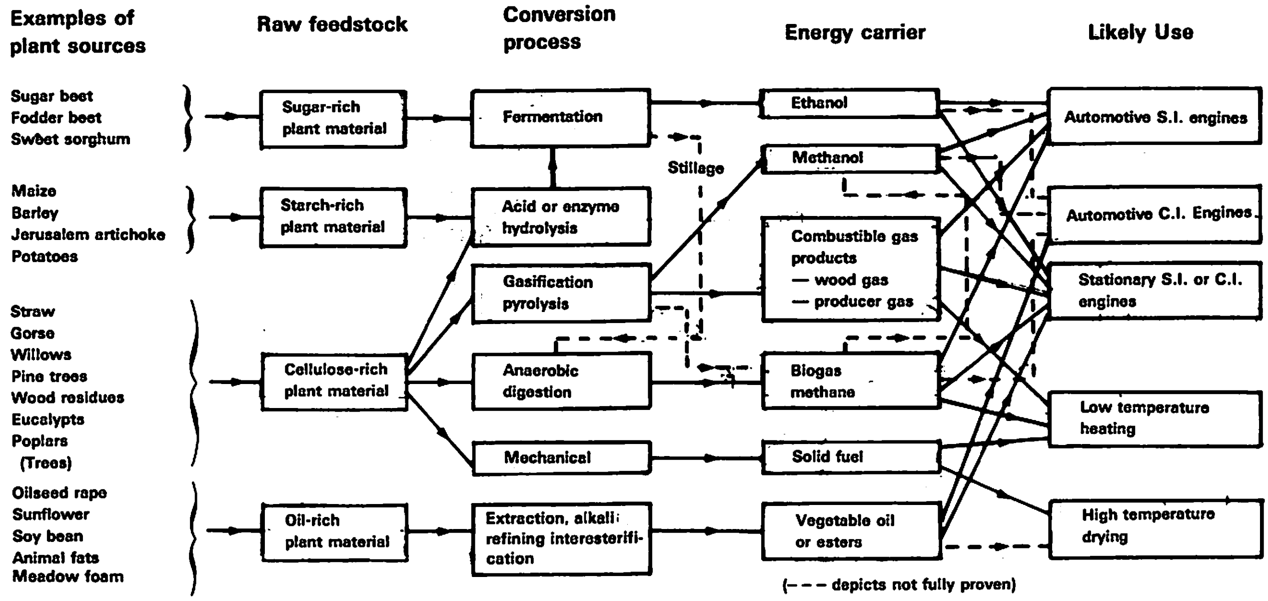


Fig 1 The potential for energy biomass systems in New Zealand

munity continues to recognise agriculture as a source of energy and to redirect part of its agricultural production research programme into supporting energy production research. This strategy is encouraged by the current surplus food production problem and by the anticipated but unproven potential for creating employment.

2.1 Cereal straw

The imminent banning of straw burning in the fields of certain European countries has created considerable interest in straw disposal and utilisation. A similar problem exists in New Zealand where, although straw density is far less than in most European countries there is very limited demand for it as bedding, stock feed, or as an industrial feedstock. Quantifying the available resource has been attempted in many countries, the most successful methodology being the square kilometre grid system as used by the research team from Silsoe College who are undertaking a major straw utilisation project for the Energy Technology Support Unit of the Department of Energy.

Table 1 Proven and potential indigenous resources for the future production of transport fuels in New Zealand

Resource	*Proven reserves, PJ*	*Indicated reserves, PJ*
Coal		
Lignite	2,000	53,000
Sub-bituminous	4,800	11,900
Bituminous	1,000	3,500
Peat (Chatham Islands)	450	3,000
Natural gas		
Maui field (off shore)	5,400	
Kapuni field (on-shore)	450	
Other fields	40	
Petroleum-based materials		
Condensate (from gas fields)	1,000	
Crude oil (McKee well)	40	
Oil shales		200–4000
Biomass (Renewable)		
Forestry biomass	60–80 PJ/year	200–250 PJ/year
Agricultural crops	4–9 PJ/year	6–15 PJ/year
Waste materials		
Industrial, On-farm and municipal	Minor	1–2 PJ/year

NB New Zealand's current transport energy demand is approximately 140 PJ per year of which agriculture consumes 16.4 PJ per year on-farm including off-farm transport.

Packaging, transport and storage of this commodity have been major limitations due to its bulk. Compaction into wafers or briquettes may be satisfactory for sale to domestic consumers but the cost would be prohibitive for on-farm or industrial applications. One outcome of the study tour was the commencement of a straw handling research project in New Zealand. Perhaps "Kiwi ingenuity" can overcome the problem better than the expensive automatic straw shredder/feeders available on the European market (fig 2)!

If straw is to be utilised to provide low grade heat, it must be able to be handled cheaply and conveniently and with minimum supervision. The time commitment factor is one reason why interest in straw burning has waned in Europe, even though thousands of burners have been sold. In addition, the poor efficiences, high straw consumption and high emissions from the cheaper single stage burners have reduced the demand. Superior two-stage gasification burners are now gaining in popularity but the extra cost makes them more marginal for burning straw. The French have sensibly instigated a test programme for solid fuel burners to assess performance claims and assist in further developments (Reynieix 1983).

For straw to be utilised for space heating, an infrastructure to merchant the commodity should be set up; the combustion and handling

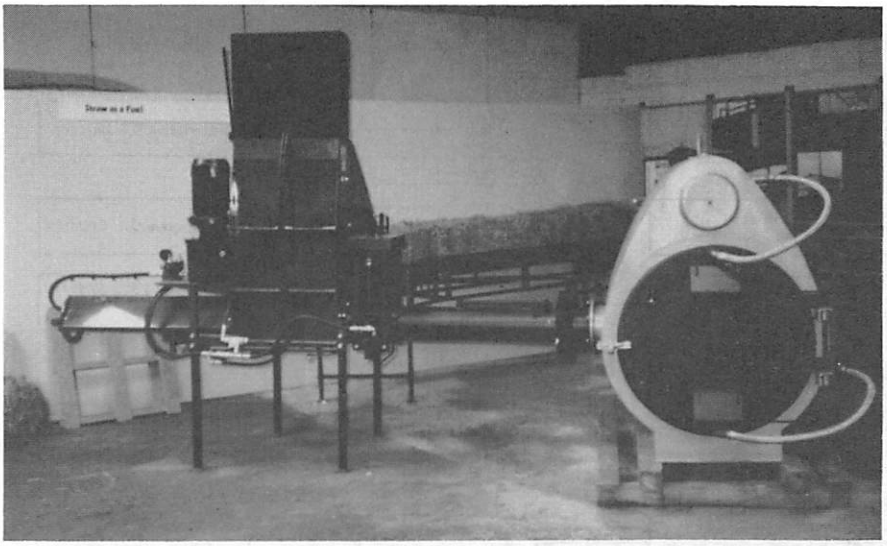


Fig 2 Expensive straw handling and burning equipment such as this demonstration unit is marginally economic for on-farm use

technology needs developing; local industries in a given straw producing region should be surveyed to assess the potential straw demand; and demonstration plants need to be set up to prove straw's value and its competitiveness with coal or wood.

2.2 Biogas

Considerable research has been undertaken on producing methane from a range of feedstocks such as animal manures, waste plant material or specially grown crops. The environmental impact of biogas production where a waste disposal problem exists (ie there is a negative feedstock value) makes it a particularly attractive proposition and also economically viable. Nevertheless, in spite of there being several hundred research and demonstration plants working throughout Europe, the technology has not yet reached a stage where it can be actively promoted to the farming community.

Apart from maintaining the digester, the biggest problem appears to be how best to utilise the gas once it is produced, and how to match demand to production without requiring expensive storage facilities. Co-generation of electricity is the most popular solution but not an economic one for New Zealand which has a surplus of mainly hydro-electric power (fig 3). Biogas from crops is being investigated in both Europe and New Zealand. However, unless treatment with acids, enzymes or bacteria can significantly improve production, then land availability, unreliable digestion processes and high capital costs would limit the acceptance of such a project commercially.

2.3 Wood

In Europe, wood is not generally a significant energy resource except in Scandinavia and specific areas such as the German Black Forest. Wood crops have high production costs and there are generally better uses for the land. The burning of prunings and green forestry wood residues have been demonstrated successfully, and the establishment of short rotation energy forests and coppiced trees are being evaluated. Methanol or ethanol from wood remains an uneconomic process, leaving low grade heat supply as the only practical use at this stage.

Harvesting and handling equipment need further development and evaluation, though tractor mounted wood chippers are now commonly used in Northern Europe. The sale of wood chips from the forest edge is considered feasible if coupled with an adequate distribution industry. However, the low energy density of wood chips limits the economics of transporting them long distances.

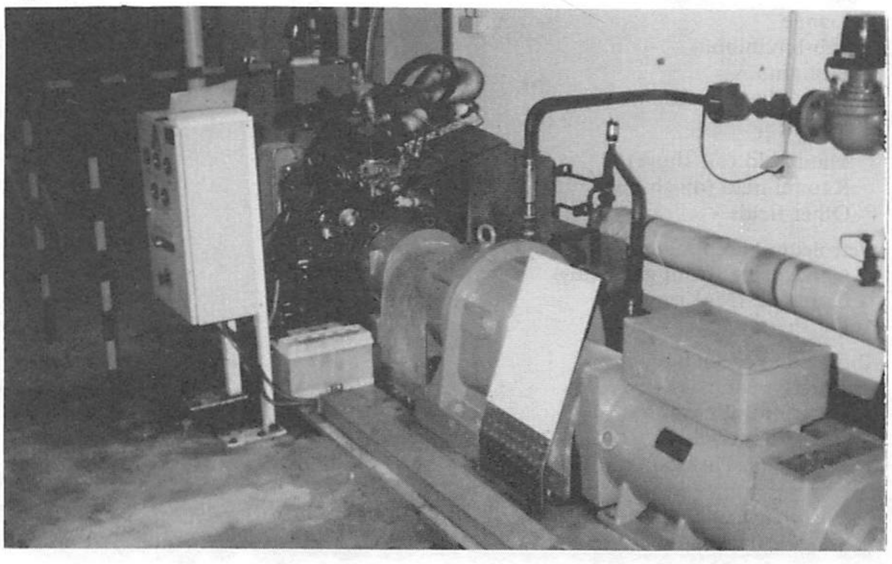
2.4 Conclusion

Markets for certain biomass fuels in Europe have been stimulated by sound research coupled with commercial demonstration projects which are designed to encourage the efficient use of energy resulting from new technology. In Britain, they are sponsored by government grants but once proven and accepted, would-be investors from industry are left to continue the momentum.

No breakthrough in technology which might lead to major advances in energy supplies from biomass was evident. However, the philosophy behind current research programmes and their funding should enable steady progress to be made.

One wonders, however, whether policy makers have tended to oversell the potential of biomass as an energy source being politically more popular and acceptable than say, nuclear power. Certainly, the research must continue but the use of straw, wood or biogas will never

Fig 3 Biogas from animal manure and silage feedstock is used to run the Volkswagon engine which in turn powers the 220 kWh generator. In this German research plant a third of the biogas produced is used to heat the digester.



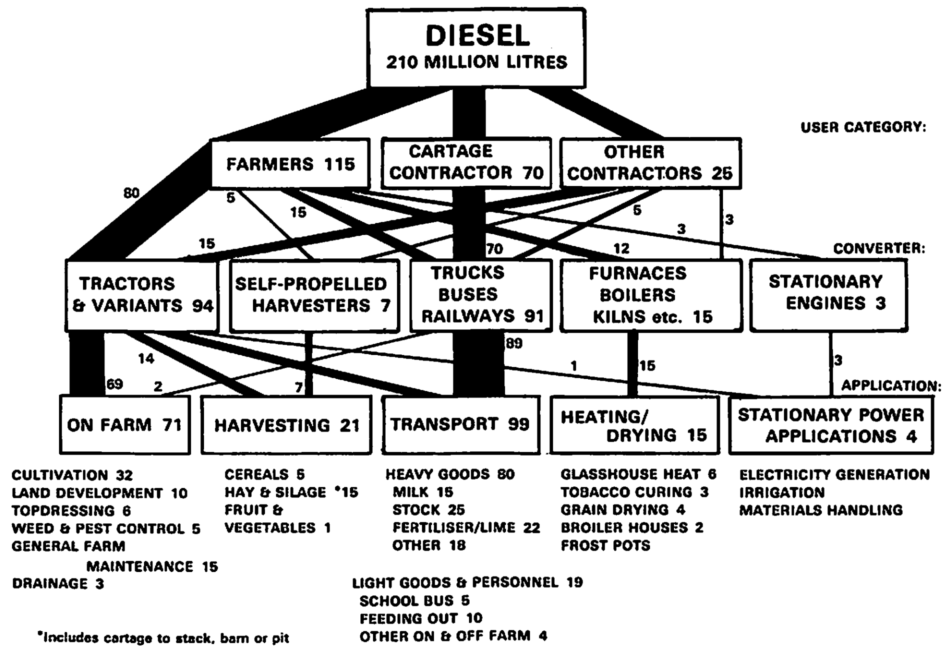


Fig 4 Estimated breakdown of New Zealand diesel consumption by end use on-farm and including off-farm transport

become a major energy solution for industrialised economies.

3 Alternative diesel fuels

New Zealand is acknowledged as a world leader on many aspects of alternative fuels research. Many thousands of vehicles have already been converted to compressed natural gas or liquid petroleum gas and distribution networks set up. The first natural gas to synthetic petrol plant is nearing completion and research activities on methanol/ethanol fuels have been commendable.

None of these fuels, however, appear suitable for use in compression ignition engines at this stage and, since diesel fuel is the "life-blood" of the agricultural and transport industries (fig 4), other alternatives have been investigated. The Liquid Fuels Trust Board (funded by a levy on all petrol sales) has co-ordinated the work effort in this area. A recent contract "Yields, costs and availability of natural oils/fats as diesel fuel substitutes" (Sims *et al* 1982) showed there to be only limited potential in New Zealand for vegetable oils as fuel, due mainly to their costs of production compared with ex-refinery diesel costs. However, the production of esters from inedible tallow (a by-product from the meat industry and currently exported in volumes equivalent to almost 20% of the automotive diesel demand) appeared promising from both the preliminary economic and technical assessments.

Interest in natural oils/fats as potential fuels is fairly widespread throughout Europe for two major reasons, (a) the potential market from developing countries and (b) the foreseen rapeseed oil and olive oil "lakes".

The objectives of the tour were, therefore, to discuss the work to date with staff from interested organisations and to assess where current research could complement the Liquid Fuels Trust Board's programme.

The genuine interest and willingness to assist with future contracts, as shown by such notable organisations as Shell International Petroleum Company, Perkins Engines Ltd and Lucas CAV Ltd, was most gratifying. Their testing facilities surpassed anything that exists in New Zealand and initial co-operative programmes are now underway.

The French Petroleum Institute are undertaking a research programme along similar lines to New Zealand's and the interchange of information with staff proved most stimulating. Extensive fuel and engine tests had provided solutions to several combustion problems when burning esters as fuels, particularly that of the build up of phosphatides in the engine lubricating oil. Also a good correlation had been obtained between the carbon content of a fuel and deposit formation at the injector. This was a factor monitored in early New Zealand tests (Sims and Johnson 1981) but not confirmed. Since tallow esters have a particularly low carbon content, this correlation was of special interest. The higher carbon content of rapeseed oil was confirmed by the significant residues produced from engine tests at the Agricultural Engineering Institute, Braunschweig, West Germany and also by work at the Austrian Institute. At Braunschweig, a direct injected engine in a Fendt tractor has been worked successfully on 100% methyl esters of rapeseed oil, the deposit formation having been apparently overcome by advancing the injection timing by 4 degrees-though further periods of testing are required to confirm this (fig 5).

3.1 Conclusion

A considerable amount of time and money has been spent on alternative diesel fuel programmes around the world in the last five years. Now is the time for researchers to present and compare their findings at international meetings so that future efforts can be co-ordinated and the resulting advancement of knowledge used for energy planning, particularly in the less industrialised countries.

4 Operating efficiencies of tractors and implements

4.1 Tractors

Instrumentation to enable researchers to monitor tractors and implements working in the field is well advanced. It is only a matter of time before operating parameters such as wheel slip, fuel flow, and governor settings are presented to the driver to enable him to work his machinery in the most efficient fuel range. The Renault 'Econometer' already partly achieves this and other

Fig 5 This tractor has been run successfully for over 400 hours on rapeseed oil ethyl esters at LAF, Braunschweig, Germany

manufacturers will soon be installing on-board microprocessors to provide similar information.

Much of the research related to improving tractor fuel consumption is primarily aimed at improving and timeliness, thereby saving fuel in the process. For instance the commendable work at the National Institute of Agricultural Engineering in achieving a relationship between weight on drive wheels, speed of operation and available power in order to minimise soil compaction, also minimises the rolling resistance, thereby saving fuel (Dwyer 1983).

4.2 Crop establishment

The recent decline in the area of direct drilled crops in the UK, due to the increased risks attached with the system compared with cultivation was notable. The trend towards minimum cultivation operations has not fully been appreciated in New Zealand and direct drilling is still creating increased interest. Only a few comparative cultivation trials have been undertaken and more work is urgently required. Energy saving is not the prime consideration but any method of saving time and labour generally saves fuel as well. Many European cultivation machinery developments have been imported but limited evaluation work has been done.

It is interesting to realise that in certain intensive farming countries of Europe such as Holland, direct drilling is not practiced at all. It would be of greater interest to learn whether this is due to a lack of confidence in the system, insufficient promotion by machinery and chemical companies, or what.

4.3 Forage conservation

Once again, fuel saving *per se* must be given a lower priority than producing good quality feed. However, any method of reducing the number of operations involved in making hay or silage is likely to reduce fuel overall as well as to improve the dry matter yield and nutritional quality.

The range of mower/conditioners available enables the farmer to significantly speed up the drying rate of hay or silage. However, an evaluation of such machinery in New Zealand this summer (as yet unpublished) showed that the swath shape after conditioning had as much effect as the conditioning operation itself.

New Zealand tends to rely on conserved feed for maintenance rations during summer drought periods rather than as production rations in winter (though there are good examples of the latter as well). Consequently, the quality of the feed has been given insufficient emphasis and the inherent wastage involved has not provoked many farmers to try and improve their traditional hay or silage making systems. With new ideas such as big bale silage, mower/conditioners, and block cutters, filtering down from the Northern Hemisphere, improvements are anticipated.

The good climate largely eliminates the need for additives and, since most stock remain outside all year round, the demand for supplementary feeding is relatively low. Nevertheless, the New Zealand farmer can learn much from his European colleagues regarding pasture conservation and, following this study tour, a renewed effort was made to disseminate the relevant knowledge, thereby improving the feed quality whilst reducing the time and energy involved.

4.4 Matching tractors and implements

The effects of recent campaigns in Britain and Germany to improve the awareness of this problem by farmers and indeed by machinery dealers was considered to have been successful but the impact on fuel savings has not been monitored. Certainly it was apparent that energy awareness was in the minds of many Agricultural Development and Advisory Services staff. The Ministry of Agriculture in New Zealand is about to undertake a similar tractor and machinery efficiency promotion exercise but must update the advisory officers' knowledge first, if sufficient momentum is to be achieved for it to have a significant effect.

4.5 Conclusion

In many areas of agriculture, New Zealand farmers are considered world leaders but this is not the case when it comes to tractor and machinery operations and they tend to rely on overseas information where applicable to the local situation. The considerable research and extension efforts being made in Europe and the UK to improve the efficiency of agricultural field operations is of great benefit.

For energy conservation to be achieved on the farm, it must be developed and promoted as a method of improving efficiency and/or saving costs, rather than solely as a method of saving energy for energy savings sake. In many instances, energy conservation has been neglected and priority given to energy resource substitution. This imbalance is now being redressed.

The Food and Agriculture Organisation maintains an interest in the development of renewable energy and to promote this it has established a "Co-operative Network on Rural Energy". The objectives are to promote a more efficient use of traditional energy and to increase the share of new and renewable sources of energy especially for and from agriculture. It is also intended to benefit developing countries through the transfer of appropriate technologies, exchange of scientific information and organisation of professional training courses.

The network is divided into four sub-networks which deal with energy conservation, biomass, energy conversion technologies and integrated rural energy systems. Within each sub-network are a number of network "elements" such as energy, forestry and agricultural by-products. A range of meetings and conferences are organised by each sub-network and informal communication between research institutions is encouraged. The establishment of demonstration pilot projects using national and international assistance is a further objective of the organisation and Food and Agriculture Organisation staff assist with and co-ordinate such activities.

5 Greenhouse energy

The Northern European greenhouse industry was subjected to massive losses as a result of the rise in oil prices. It has been saved by an intensive approach to energy conservation in an endeavour to drastically cut the growers' fuel bills and the success of this effort was well evident.

Simple factors, such as sealing glass houses, blocking holes and placing heating pipes lower to the ground, produced major savings (fig 6). Other developments, such as inflatable double polyester skin cladding, computer controlled environment and heat recovery from industry and thermoelectric generating plants, are also being put into practice, following intensive research efforts. In addition, the substitution of alternative heat sources such as natural gas for oil, is being encouraged.

New Zealand growers, although they have a lesser demand for heat, have a lot to learn from their European counterparts. Consequently, the New Zealand Energy Research and Development Committee are intending to sponsor a workshop/seminar in an attempt to examine overseas technology, co-ordinate local research and promote energy saving techniques, such as thermal screens if and where applicable.

The concept of using full width gantries in a greenhouse in order to fully utilise the entire floor area is an effective way of indirectly reducing energy costs. One system as developed at Wye College in response to the Electricity Council's request had a height control and removable floor. It could be electrically or manually powered and was simple and cheap to construct.

Fig 6 Lowering the heating pipes in a greenhouse improves the efficiency and as in this example from Wye College also enables the pipes to act as "rails" for material handling

5.1 Conclusion

Simple practical solutions to reduce heating fuel costs will be readily accepted by less intensive greenhouse growers, such as the majority of those in New Zealand. Only in enterprises where heating is required for a large part of the year would costly new structures incorporating such solutions as solar heating be acceptable.

6 International co-operation on energy research

It was evident that there is good co-operation and communication between many of the research institutions of the various European countries working in the field of energy in agriculture. Indeed a session of the first international conference on "Energy in Agriculture" held in Milan was allocated to the subject (CESAT 1983).

Although Great Britain is a member country, it is less actively involved than others at this stage and possibly misses a lot of useful information as a result. Even more important perhaps is the tremendous contribution it could make to the network by increased participation from staff involved in many of the excellent current research projects being undertaken.

New Zealand's involvement in this co-operative network would prove difficult logistically. Nevertheless, the benefits to be gained could prove well worthwhile and tentative moves have been made to ascertain if joining the network could be a practical possibility.

Developing countries. The opportunities to assist developing countries with their energy supply problems are excellent but to meet them adequately, demands co-operation between research organisations and funding organisations. It is easy enough to define the developing country's problems and to make specific recommendations as to how establishing expertise may be of assistance but the problem of implementing such recommendations, where there are financial constraints, is more difficult.

7 Conclusion

The opportunities afforded by this study tour enabled many contacts to be made and much information to be gleaned. This information, where applicable, has been passed on to the appropriate people in New Zealand with the anticipation that it will act as a catalyst for future co-operation between individual researchers and organisations and their overseas counterparts.

The willingness by individual

researchers to exchange unpublished results from research programmes, is gratefully acknowledged. The stimulation from such discussions often enables research activities to be conducted with renewed enthusiasm and is to be commended. Following 2 or 3 years of relatively stable oil prices, complacency must not encourage support for energy research activities to be reduced. Rather, projects should proceed steadily as many problems remain to be solved. Governments and funding organisations could, however, well use this period to direct a greater proportion of their funds to stimulate energy information exchange which would enable the accumulation of knowledge to proceed faster in the long term.

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References

CESAT (1983). Proc 1st Conf "Energy and Agriculture" Milan. April. Gruppo dell 'Energia, Largo Richini 2/a, Milano Italy.

Dwyer M J (1983). Soil dynamics and the problems of tractors and compaction. *Agric Engr*, **38**, 62–68.

Reynieix M (1983). Platform tests of biomass fired equipment. Proc 1st Inst Conf "Energy and Agriculture" Milan, April. Vol 2, 113.

Sims R E H, Johnson C B (1981). Tallow, rapeseed oil and their esters as diesel fuel extenders. Massey Univ Agric Res Foundation, Research publ series No 2, 26pp.

Sims R E H, Johnson C B (1981). **Gendall P J, Johnson C B, Meister A D, Newton S D, Withers N J** (1982). Yields, costs and availability of natural oils/fats as diesel fuel substitutes. Liquid Fuels Trust Board rep LF2021, 273 pp. (PO Box 17, Wellington, New Zealand).

Sims R E H (1983). Alternative diesel fuels and energy in agriculture. European study tour rep, April/May 1983. Agric Machinery Res Centre, Massey Univ 51 pp.

Sims R E H, Martin G A, McChesney I G, Rennie N, Studman C (1984). On-farm energy supply and conservation. New Zealand Energy Research Development Committee. Main Series rep, 279 pp. (C/- Auckland Univ, Private Bag, Auckland, New Zealand).

BSRAE Association Members' Day on spraying technology

D Rackham

THE British Society for Research in Agricultural Engineering (BSRAE) Association held a Members' Day on Spraying on 17 May. The venue was the Scottish Institute of Agricultural Engineering at the Bush Estate. The farming public, together with members and guests of the BSRAE Association, were present to see and hear about the latest developments in spraying technology. A similar Members' Day held last year at the National Institute of Agricultural Engineering in Bedfordshire, where most of the work into new spraying technology takes place, proved very popular, so a second even was organised at SIAE to give those in the northern half of Britain an opportunity to see the way things are going.

Before lunch, five guest speakers each gave short talks on particular aspects of spraying. In the afternoon there was an opportunity to view exhibits from NIAE, SIAE and other organisations, some of them commercial, involved with spraying technology.

The first speaker, Martin Phillips from the Agricultural Development and Advisory Service, High Mowthorpe, compared the effectiveness of conventional hydraulic spraying with that of controlled drop application (CDA) techniques, based on a series of trials carried out by ADAS. Though many of the trials showed the efficacy of hydraulic spraying to be superior to that of CDA spraying, the difference was unlikely to show in crop yields. Martin Phillips concluded by pointing out the advantages of CDA: fast workrate due to low volumes of water, and the narrow spectrum of drop sizes.

CDA spraying has shown that, although in theory small droplet size is the efficient way of applying the chemical, practical difficulties, such as drift, often intervene. Electrostatic charging of the spray droplets relative to the target crop is one way of ensuring more spray finishes up on the plant, especially on areas like the underside of leaves. The second speaker, John Lake of the Spray Physics Group at the National Institute of Agricultural Engineering described the NIAE's work on electrostatics. This included two practical systems for charging agricultural sprays. One was a method for charging spray droplets produced by hydraulic nozzles. The second system used a spinning disc to produce the spray. A circular electrode spins with the disc, shedding any liquid which lands on it and keeping the high voltage parts dry.

The quest for higher work rates points towards smaller drop size, longer booms and higher speeds. All of these factors demand better control of boom height. In the third talk, Joe O'Sullivan, also of the NIAE, outlined his work on active boom stabilisation. Contemporary boom suspension designs are a combination of links, sprays and dampers which attempt to stabilise the boom passively — that is with no external power supplied. At the expense of additional complexity and therefore cost, active boom suspension (ie with a power input) offers the possibility of greatly improved boom control. Joe O'Sullivan described the NIAE system which uses ultrasonic transducers on each end of the boom to measure the boom to crop distance. The signal from these transducers, after modification by a microprocessor, is used to operate servo-valves which supply a hydraulic ram and rotate the boom so it remains parallel to the ground.

As a contrast to the high technology of the NIAE's work, the fourth talk was on 'weed wipers' by Dr Ken Davies of the East of Scotland College of Agriculture. 'Wipe-on' herbicide application refers to the technique in which the herbicide is applied directly to the weed plants without contact with the crop. Obviously, this technique can only be used in situations where the weed plant standards significantly taller than the crop. Of the two main types of wipe-on applicator, the rope-wick applicator and the roller, cost and convenience have favoured the rope-wick applicator. Dr Davies pointed out that at present glyphosate is the only herbicide cleared by the Pesticide Safety Precaution Scheme for use in rope-wick applicators. Other chemicals such as asulam, triclopyr and 2, 4-D have shown promise in trials.

An increasing awareness of the importance of timeliness in the application of agrochemicals has spawned many purpose-built vehicles for spraying — if moist conditions persist, the standard agricultural tractor is far from the ideal. Ian Rutherford, ADAS National Specialist presented the last talk on such spraying vehicles, in which he drew up what he saw as the ideal specification. The requirement for low ground pressure favoured low cost tracks as opposed to low pressure tyres, which are both expensive and susceptible to damage on stony soil. On the other hand, skid-steering can cause damage to the crop. Speed is vital, so a sophisticated suspension system is required. Payload is a major parameter — Ian Rutherford suggested 500 kg which may appear small but the trend toward lower application rates and the new techniques of CDA and electrostatics mentioned earlier promise

David Rackham is in the Cultivations and Liaison Section at the Scottish Institute of Agricultural Engineering, Bush Estate, Penicuik.

He acted as Convener for the British Society for Research in Agricultural Engineering Association Members' Day on Spraying Technology held at the Scottish Institute of Agricultural Engineering on 17 May 1984.

reductions in the quantity of water required.

After the five talks, there was time for questions from the audience. The majority of these centred round the merits of CDA relative to hydraulic spraying. It was clear that whereas some farmers had had great success with CDA, equally others were less satisfied with the technique and had returned to conventional spraying.

After lunch visitors had a chance to look around the exhibits. The SIAE's work on the pre-harvest spraying of glyphosate ("Round-up") to control couch was on display. This work was carried out in conjunction with the East of Scotland College of Agriculture and Monsanto Limited. The technique has shown many benefits. Control of couch grass was found to be more reliable when sprayed pre-harvest than when the stubble was sprayed. In addition, pre-harvest spraying, by desiccating any green matter in the crop, improved the performance of the combine harvester, as well as reducing grain moisture content by up to 2% wb. These gains, together with the yield increase in succeeding years, more than compensated for any wheeling losses and the cost of the operation. Wheeling losses can be further reduced by fitting crop dividers to the wheels of the spraying vehicle. The SIAE has designed and tested a set of crop dividers to fit a medium size two-wheel drive tractor.

Other SIAE work on display compared the soil compaction produced by a conventional tractor and mounted sprayer with that of a purpose built lightweight spraying vehicle. Both carried 800 litres of water but, whereas the rut depth behind the tractor was 90 mm, the ruts behind the purpose built vehicle were only 25 mm deep. Soil bulk density increase was considerably reduced by using this vehicle, the Chaviot from Heightcourt, which was on display as an example of a lightweight spraying vehicle.

The importance of timely spraying, mentioned by Ian Rutherford in his talk in the morning, was emphasised by the joint exhibit from the Scottish Agricultural Colleges. This summarises work done by the North of Scotland College of Agriculture on the effect of timely spraying and, in particular, the penalties of spraying at the wrong time.

The NIAE's work on spray boom suspension and electrostatics, both the subject of talks in the morning, were on display. The cross-flow fan assisted sprayer, developed from work done at the NIAE in the 1970s, was exhibited by the Scottish Crop Research Institute, who have used a commercial prototype machine for raspberries produced by Drake and Fletcher. The SCRI have found that the crossflow fan sprayer applying 350 l/ha has consistently given control of the large raspberry aphid equal to that of a conventional hydraulic sprayer applying 2000 l/ha.

Commercial firms also showed some of their latest equipment. Lely exhibited the Hydraspin CDA sprayer, which uses the Autoglide boom. This was developed at the NIAE and is patented by the NRDC. Isolation of the boom from the sprayer chassis in the horizontal plane means that boom yaw is greatly reduced.

The Spraycare System ES was demonstrated by CSC Ltd of Perth. Developed in conjunction with the NIAE, System ES can be fitted to any conventional sprayer to convert it to an electrostatic sprayer. Special charging heads are fitted to each nozzle of the sprayer and these are supplied with 4kV from a cab mounted control box powered by the tractor battery.

In addition to these developments, there was a variety of self-propelled and trailed sprayers on display. Of particular interest were the Chafer Pathfinder SP self-propelled sprayer, which is based on a Ford 4610 tractor fitted with row crop wheels. Cleanacres showed their fan assisted CDA sprayer with a tabular beam, on which each of the nozzles is fitted with a small fan to direct the spray down on to the crop.

While much of the agricultural sector is in recession, returns from cereal production are still good, so the incentive is there to develop and invest in improved spraying techniques. Spraying technology is very much a growth market.