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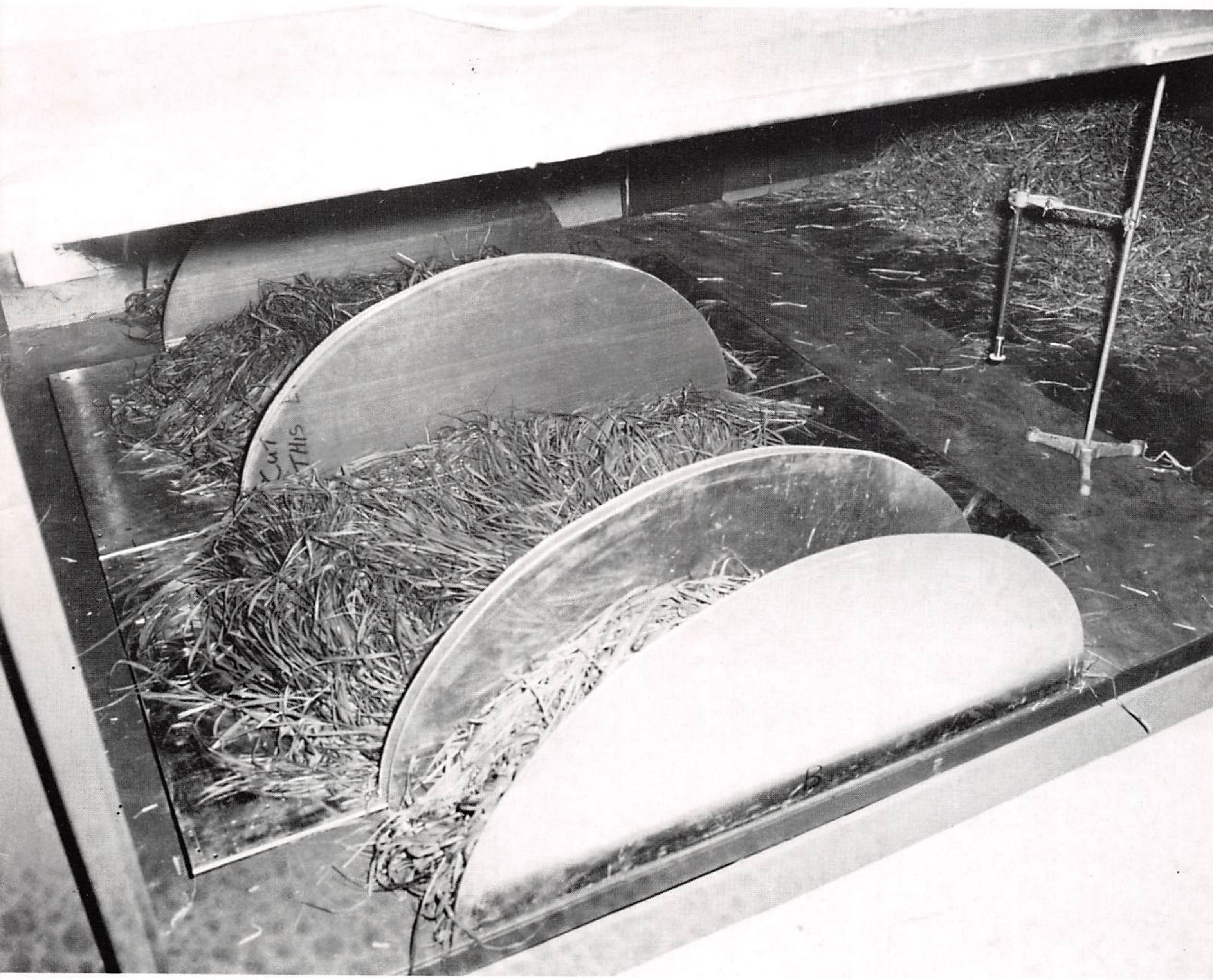

Wind tunnel research on grass swath drying rates

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Front cover:
The view through an inspection hatch of a wind tunnel showing a grass swath being dried in an experiment at the SCAE. These trials are being conducted to examine the effect of swath shape on the drying rate of the crop. (Photograph provided by SCAE).

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Editorial

Please copy

ORIGINALLY, there was no intention to include an Editorial in this issue of the Journal as the Editor's or Guests' offerings under this heading have been printed in most recent issues. However, two items have arisen with respect to the production of *The Agricultural Engineer* that are of importance to members.

Firstly, there is a questionnaire concerning the Journal content included with this issue. Please complete and return this so that your Editorial Panel know the consensus view. At present, a number of members declare "what the Journal should or should not include", all with ideas that are completely different.

Secondly, the whole question of Journal content is of little practical value if there is no choice of suitable copy available. You will note that this issue contains no refereed or technical papers outwith those given at conferences or meetings. The reason for this is quite simply that it was filled by all the remaining copy to hand that reached the standard required for this Journal. We have at present, two scientific papers being refereed, one scientific paper returned to authors for re-drafting, a number of technical papers promised for the Jubilee issue, one technical paper needing translation from a foreign script, no Conference proceedings, no Ag Eng Items and no anything else! [Since this paragraph was written, additional copy has been received].

For any sort of choice of items or theme to be followed, we really need enough copy to hand to fill three issues of *The Agricultural Engineer*. So I must reiterate my last Editorial appeal and ask members again to put pen or typewriter to paper, or even word processor to printer — following the Journal rubric as you do so, please! To misquote the words of a former Prime Minister, "Never before in the field of Journal publication has so little been received from so many for so long".

Finally, I should like to thank the recent contributors who answered my last call for papers, as without their help, this issue would not have appeared.

Machinery utilisation on arable farms

I Yule, T A Copland and J R O'Callaghan

1. Introduction

AFTER a period of expansion in the late seventies and early eighties the levels of profitability in arable farming have been reduced. In order to respond to this situation, the farmer must reduce his business costs. Part of this process is by making better use of farm machinery.

The purpose of this paper is to look at the costs involved in arable production and to examine the most effective ways of utilising machinery through a number of case study farms. Fourteen farms were chosen, nine in County Durham and five in Angus. Farm size varied from 100 to 660 hectares. A contracting business was also studied.

Soil conditions vary considerably between the two areas. On the Angus farms the soils are derived from Old Red Sandstone and are generally a light to medium loam. The Durham soils are much heavier and tend to be of a clay type with low hydraulic conductivity.

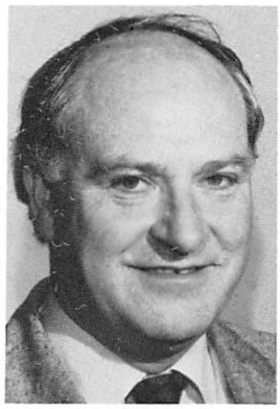
Climatic conditions are similar in both areas, being typical of the drier eastern regions of the UK. Annual rainfall in both areas ranges from 635–760 mm.

2. Mechanisation provision

The farms were arranged in order of size and numbered, the largest being farm No 1. Figure 1A shows details of the mechanisation provision in kW/ha on each of the farms. The lowest level is 0.87 kW/ha on farm No 1, a 660 ha farm using heavy tined cultivators for primary cultivation. The second lowest provision is 0.94 kW/ha on farm No 2, where ploughing is used and a large area of potatoes is grown, this farm is on lighter soil. The highest provision is on farm No 3, 2.98 kW/ha under a non-ploughing system using heavy discs as the primary method of cultivation. This farm's mechanisation policy is to buy larger machines, do some additional contract work, and keep them for over ten years. Farm No 9 also has a high power provision, using conventional methods of cultivation and undertaking some contract work.

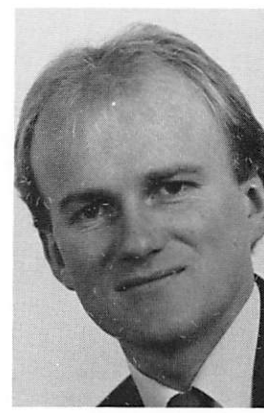
Figure 1B represents the annual tractor use in h/ha. The levels of use vary from 20.88–4.46 h/ha and of course relate to a number of factors, not just power provision. For example, potatoes tend to require more tractor hours than winter cereals. Similarly some crops, for example silage, have a requirement for a tractor with high pto horsepower to drive a forage harvester.

Figure 1C represents the repair maintenance, fuel and oil costs of the system on each farm. Figure 1D represents field machinery depreciation only, fixed equipment was not included. The replacement costs were calculated from data published by BAGMA (Anon, 1986).



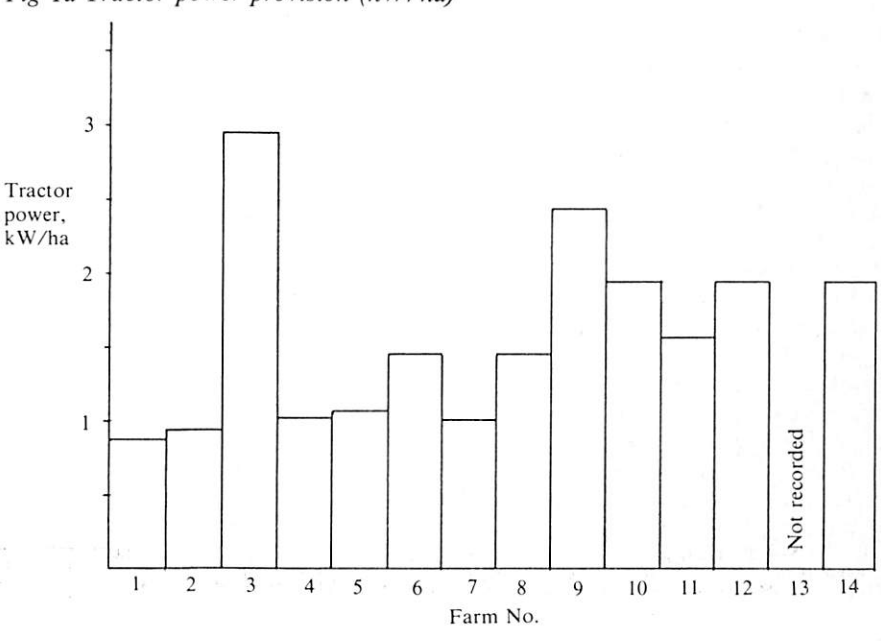
Jim O'Callaghan

Tom Copland



Ian Yule

Fig 1a Tractor power provision (kW/ha)



Ian Yule is Head of Information Technology at Durham College of Agriculture and Horticultire. Tom Copland is a lecturer in the Dept of Agricultural Engineering, School of Agriculture, University of Newcastle upon Tyne. Jim O'Callaghan is Professor of Agricultural Engineering at the same University.

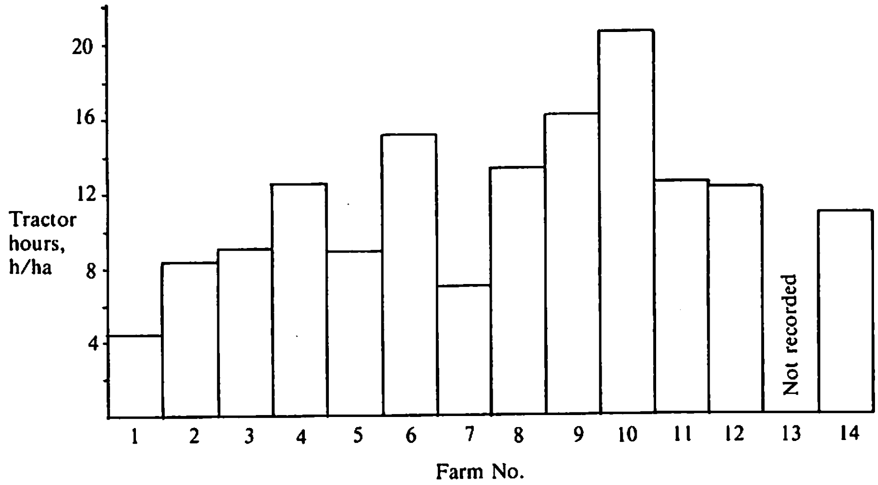


Fig 1b Tractor hours worked (h/ha)

Fig 1c Machinery running cost (£/ha)

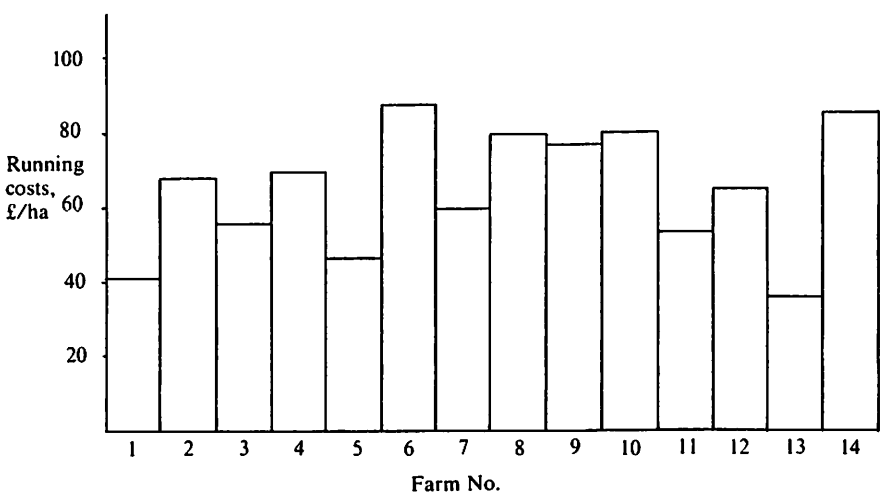
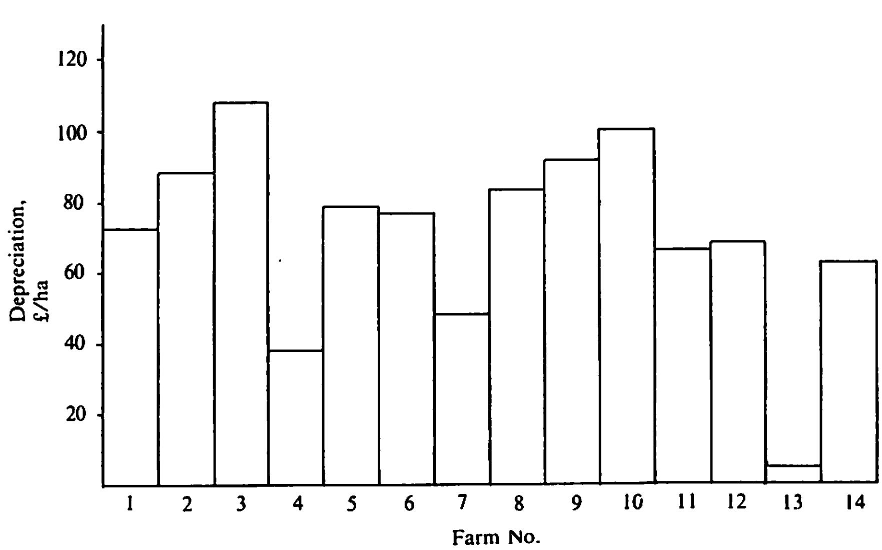


Fig 1d Machinery depreciation (£/ha)



On eight of the farms, the depreciation cost is greater than the variable component of the running costs (Figure 1C). This is a measure of the capital intensive nature of arable farming, and it is one area where farmers could cut their future costs.

Most of the farmers knew their machinery repair and maintenance costs. Many of the farms adhered to a strict policy on machinery maintenance. One of the clearest examples was farm No 2 where all harvesting equipment was checked and serviced, identifying the majority of faulty components before the start of harvest. Components such as belts being replaced regularly. Two combine harvesters were used; one was eight years old and the other seven, both cut around 200 ha per season. The total costs of repair and maintenance in the seasons 1982 to 1984 were £1.80/ha, £2.42/ha and £2.02/ha respectively. This gave the average cost per season of maintaining these machines over those three seasons at 1.55% of the original purchase price. The figures used for spares and repairs were taken from actual receipts.

3. Why have we such high provisions?

For today's situation some of the case study farms were "Over Mechanised" or perhaps a better term to use is "Inappropriately Mechanised".

Over mechanisation can occur from having too large a range of machines as well as over provision of one type of machine. This sort of "toolbox approach" can become uneconomic.

A number of historical factors should be taken into account before condemning farmers. For instance, with the initial tax allowances which were available for farmers buying machines, a new machine could be written off against tax in one year. A great incentive, especially if after a good year the farmer bought a machine to prevent paying tax at higher rates.

The relationship between inflation and interest rate has also changed. Figure 2 shows that widely fluctuating inflation rate during the seventies has settled down to around 4–5% over the last four years. During the seventies interest rates were often less than the rate of inflation which made borrowing very attractive.

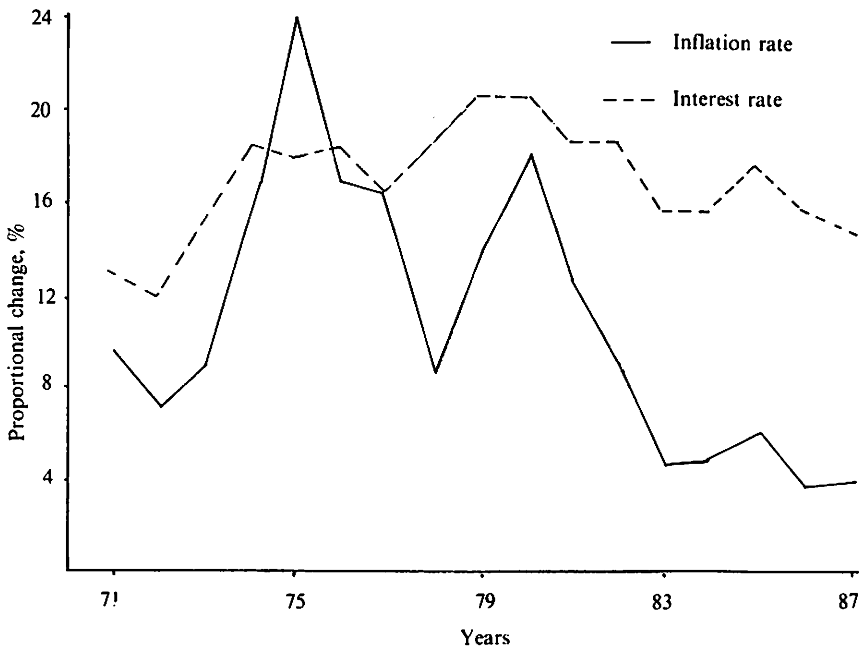


Fig 2 Cost of borrowing

During the eighties inflation has fallen while interest rates have remained high and with agriculture in a situation of reduced returns, this makes borrowing less attractive.

This relationship has had an effect on the replacement period for machinery. With low inflation it is better to keep a machine longer, while in times of high inflation it is better to change machinery more rapidly. Many of the farmers were anticipating keeping machinery for longer periods than they had in the past.

The tax position of individual farms was not considered when assessing the costs of the mechanised systems.

4. Gross margins on the case study farms

Table 1 shows the gross margins for winter wheat from the case study farms, the highest gross margin was £660/ha, this was achieved with variable costs of £189.09/ha. It is interesting that the highest level of inputs (in terms of variable cost) does not correspond to the highest gross margin. The highest level of input gave only the sixth best gross margin, while the best gross margin was achieved with the sixth highest level of variable costs. The last column in Table 1 gives variable cost as a percentage of output.

The use of fertilisers only varied within a band, 10% above and below the national average. Spray costs however, tended to be more variable as shown below:

Chemical spray cost:
- Winter wheat — 22–73 £/ha
- Winter barley — 28–64 £/ha
- Oilseed rape — 30–94 £/ha

The gross margin performance did not necessarily relate to the level of expenditure on sprays.

One way to measure the effectiveness of farming with mechanised systems is to examine whether or not a system achieves the aims expected of it. This can be measured by looking at timeliness losses that occur because the crop is not sown or harvested at the optimum time. A number of timeliness loss models exist which vary the losses in percent as the number of days deviates from the optimum sowing date. Penalties for sowing too early or too late vary considerably in practice. Table 2 shows the farmer's crop establishment aim and the actual performance. This was for the autumn of 1985 and spring of 1986 which, most readers will remember, was a season with very severe weather.

Winter wheat was a crop subject to timeliness problems and where losses of £81.70/ha were observed. The second highest loss was £63.25/ha, in both cases these losses were caused

Table 1. Costings (£/ha) of winter wheat on farms surveyed

	Output	*Var Costs*	*Gross margin*	*Var costs as % of output*
Farm 1	850	189	660	22
Farm 2	750	181	569	24
Farm 3	850	240	609	28
Farm 4	555	174	381	31
Farm 5	631	164	466	26
Farm 6	790	230	559	29
Farm 7	740	172	567	23
Farm 8	770	194	575	25
Farm 9	850	259	590	30
Farm 10	850	229	620	27
Farm 11	770	177	593	22
Farm 13	850	213	636	25
Farm 14	786	217	568	27

N.B. Farm 12 was not recorded

Table 2. Crop establishment/timeliness losses costs (£/ha)

	Oilseed rape		*Winter barley*		*Spring barley*		*Winter wheat*	
	Aim	*Actual*	*Aim*	*Actual*	*Aim*	*Actual*	*Aim*	*Actual*
Farm 1	15.96	8.47	26.69	6.80	—	—	11.05	3.08
Farm 2	—	—	—	—	0.58	4.75	2.36	2.36
Farm 3	—	—	8.19	8.19	—	—	0.80	0.80
Farm 4	4.80	4.80	3.33	1.93	—	—	2.56	8.04
Farm 5	0.21	0.21	1.57	1.59	—	—	15.29	46.81
Farm 6	3.25	1.94	2.47	11.56	—	—	24.75	56.87
Farm 7	3.71	3.71	0.97	4.32	—	—	0.96	81.20
Farm 8	1.45	1.04	1.10	—	0.60	3.18	3.58	63.25
Farm 9	31.86	75.70	6.80	6.80	—	—	3.19	2.06
Farm 10	—	—	12.31	6.27	0.45	2.79	1.39	6.41
Farm 11	—	—	0.50	1.67	0.83	5.29	1.07	2.05
Farm 12	—	—	—	—	0.11	6.63	—	—
Farm 13	1.30	1.30	0.75	0.75	—	—	0.55	0.55
Farm 14	1.95	1.95	9.19	9.19	—	—	1.48	1.48

by delay in sowing due to wet weather. Both of these farmers used conventional methods of cultivation, but surprisingly both were immediate neighbours of farm No. 1 whose timeliness loss was only £3.08/ha. All three are on very heavy land.

Both farms No 5 and No 6 grow potatoes on heavy land and use ploughs for primary cultivation. Large timeliness losses were incurred as labour for potato harvesting conflicted with the labour demand for ploughing and sowing of winter wheat. Ploughing in this situation has two main disadvantages:— 1. high power demand, 2. slow work rates. There was also evidence from the study that when tractors over 82–89kW (110–120hp) were used for ploughing they were not as well utilised as might be expected. An increase in power did not give a corresponding increase in output. Some tractors of 104 kW (140hp) in the study were only ploughing 20 acres (8 ha) per day on some of the Durham land. Farmers are faced with two alternatives: a) not to mouldboard plough or b) hire a contractor. The mouldboard plough was developed at a time when spring crops were grown and when winter weathering and rapid drying in spring were utilised, compared to now when in autumn the normal circumstance is to use techniques which retain moisture.

The gross margins of winter wheat indicate that operations outwith use of the mouldboard plough might be a viable alternative. Three farms in the study used alternative primary cultivators. Farm No 4 used a direct drill for some cereals. This was not a success in the very wet year of 1985 as the disc drill used tended to smear the soil and the heavy rain which followed resulted in the seedbed becoming water-logged in some areas with noticeable effects on germination. However in drier conditions, direct drilling could give better yields than conventional cultivations (Patterson *et al*, 1980).

Farm No 3, whilst avoiding use of the mouldboard plough, returned a good performance, having the fourth highest gross margin. This farm was organised into two blocks; one continuous winter wheat, the other continuous winter barley. All the straw was chopped with a precision chop forage harvester before being incorporated by heavy discs. The discs were 8 m (26′) wide and could

Table 3. Machine costs for crop establishment (£/ha)

	Winter wheat	*Winter barley*	*Spring barley*	*Oilseed rape*
Farm 1	30.03	32.61	—	24.91
Farm 2	49.06	—	45.04	—
Farm 3	53.96	53.96	—	—
Farm 4	40.80	27.60	—	21.06
Farm 5	40.77	39.70	—	54.32
Farm 6	40.53	45.60	—	47.56
Farm 7	58.18	67.27	—	67.04
Farm 8	26.01	26.01	37.14	54.59
Farm 9	72.08	79.32	—	62.57
Farm 10	37.09	37.09	—	37.09
Farm 11	35.97	47.35	—	40.19
Farm 12	—	—	52.28	—
Farm 13	67.33	67.33	—	109.73
Farm 14	39.67	39.67	—	46.46

work down to a depth of 20 cm (8″) and were pulled by a 186 kW (250hp) tractor. This machine was also used for subsoiling and pulling a 10 m chisel plough. A second tractor of 142 kW (190hp) was used for some of the less arduous tasks such as pulling a 10 m set of spring tine harrows and a 10 m roller. This tractor was also used to operate the precision chop forage harvester to macerate the straw.

Although the farm had a seemingly huge commitment in heavy machinery, the costs of establishing a seedbed were comparable to that of conventional cultivations with much smaller machines (table 3). Timeliness losses were very low and high yields were maintained in a mono-crop situation.

Farm No 1 was the third of the non-mouldboard ploughers. Not only did this farm achieve the highest gross margin but also had very few timeliness losses and with low cultivation/crop establishment costs.

The cultivation was based on heavy tined cultivators (Rollamech) pulled behind a 160 kW (215 hp) tractor and a 115 kW (155 hp) tractor. The machines were pulled at speeds of around 12 to 15 km/h to totally disrupt the cultivated layer. It was clear that in order to use these machines properly considerable draught power is required.

All the straw on this farm was burnt and the tined cultivator was used as soon as that operation was completed. The combines were fitted with straw spreaders in order to get a faster, cleaner burn. Burning was seen as a critical operation and if conditions were favourable, the combines were stopped and staff would burn straw in order to achieve a good complete burn. This was necessary because in dry conditions the tined cultivator did not incorporate any unburnt straw. Once the cultivator has been used after the straw had been burnt, the land was left so that volunteers and weed seeds could germinate. The subsequent cultivations and sowing were done in one day. A major advantage of this approach was the retention of soil moisture which the farmer saw as a major problem for the mouldboard plough in an autumn cultivation system. Even in the exceptionally wet year of 1985 a very dry period in October led to poor germination. The above system had a work rate of 28 ha per day. The major advantage of this type of system operated over extensive areas, was the use of large tractors at high outputs to achieve economies of scale.

One of the largest problems on arable farms is still the disposal of straw. From the last two examples the farmers may seem to have incurred a heavy penalty for going away from the mouldboard plough, but from Table 3 it is clear that these systems can compete with conventional cultivations in terms of cost and, if timeliness losses are taken in to account, they offer a viable alternative.

There is a need to look at alternative systems for establishing a crop for the smaller farmer and to work on the problem of moisture retention in dry conditions. If the farmer has both autumn and spring cultivations it is better to choose one system, be aware of its limitations and problems, then devise ways to cope with those shortcomings. For example, if the land is ploughed in dry conditions, the subsequent operations must be done as quickly as possible to stop additional moisture loss at each stage of cultivation.

5. Contracting

Work by Patterson *et al* (1980) demonstrated that primary cultivations accounted for an average of 72% of the total energy requirement for seedbed production. It could be argued that if a contractor is hired to carry out the primary tillage, a substantial cut in tractor provision can be made without affecting timeliness. On both farms No 5 and No 6 if a contractor had been hired to plough while potato harvesting was taking place, the cost would have been met through the saving of timeliness losses alone. The same argument could be put forward for farms No 7 and No 8. One farmer in the study now uses a contractor for all field work on his 110 ha farm. He has very little machinery of his own, only an old tractor and a grain drier. The total cost of contracting was approximately £13,000 per annum. All the work is done by one contractor which has two main advantages. Firstly, for the farmer as he does a substantial amount of business with contractor, is likely to be highly regarded as a customer. If he has a complaint then it is in the contractor's best interest to address the problem. Secondly, for the contractor, the major advantage is an increase in "planned work" which allows him to predict his mechanisation needs. The case study contractor did the majority of his work in this way and, provided both parties were prepared to take reasonable margins, it should be a stable business relationship. Eighty percent of this contractor's work was planned at least six months in advance.

For this size and type of farm, it is realistic to set up a mechanisation system? Bearing in mind that the first thing the farmer would have to do is to employ someone at a cost of £6–7,000 per annum, leaving only £5–6,000 for all mechanisation commitments. On this farm the cost of crop establishment was less than some of the others using their own equipment, good yields were achieved and gross margins were consistently high with few timeliness losses.

Larger farms would also do well to look at the use of contractors for such operations as ploughing and to some extent combine harvesting. High cost operations should be the first to be contracted out to others while being aware of the timeliness penalties that might be incurred. The depreciation costs of machinery can be high (figure 1D). For the case study contractor 80–88% of his combining costs were fixed costs.

6. Conclusions

1. There is a great deal of variation between farms, not only in mechanisation provision, but more importantly in the utilisation of the machines.
2. Most farmers have adequate machinery although on some farms the standard of machinery management is inadequate.
3. Non-ploughing systems are successful in the right hands, achieving good gross margins at lower costs.
4. There is a clear problem of utilising the full power of larger tractors when ploughing.
5. Farmers must cut their costs, but to cut fertiliser and sprays while the level of machinery investment is high is unsound. This would put a large investment at risk for a small saving.
6. High cost operations within a mechanisation system must be identified and remedial action taken.
7. Fixed costs: — Interest and Depreciation are most important.
8. In the current economic situation it is better to keep machinery longer, to reduce fixed costs.
9. The relative depression of grain prices is likely to decrease the optimum machinery investment in the future. This has obvious consequences for the agricultural engineering industry.
10. Each farm is different which makes the process of analysis even more important and it requires a greater understanding of the farming systems in order to put the analysis to good effect.
11. Each farm will have an individual optimum solution, and from that solution a system should emerge. The emphasis being very much on SYSTEM.

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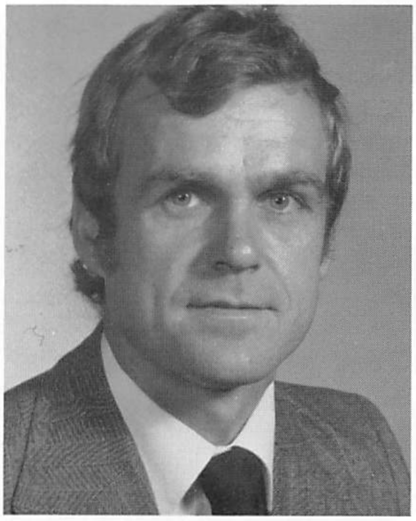
Computer vision in agricultural engineering

J A Marchant



Summary

THIS paper, which formed the subject of a lecture to the Electronics Specialist Group at Wrest Park on 17 December 1987, describes the characteristics of computer vision and outlines some potential uses in agricultural engineering. Advantages of the technique and typical problems are mentioned. One example, drawn from work at AFRC Engineering, is described in some detail to illustrate the main ideas.

1. The nature of computer vision

Computer vision is a powerful sensing technique well adapted to the control of computer based machinery. A typical system (fig 1) consists of a television camera, a large memory, a computer, and a video monitor. Whatever type of camera is used, the data from it is usually in a standard analogue form. This data is digitised and stored in the computer memory.

Typically each scan line will be divided into 512 elements or pixels having seven data bits (ie 128 possible levels) of intensity, and 512 lines from the total frame will be used. Thus approximately a quarter of a million bytes of storage is used for a frame of video data.

In advanced systems, like those of fig 1, the digitisation and storage occurs at the full output rate of the camera. Bearing in mind that 25 frames are produced in each second, this type of "real-time frame grabbing" requires fast analogue to digital conversion and direct data access into memory.

The computer is used to manipulate the data, perhaps to recognise and inspect objects viewed by the camera, to measure object features and possibly to control a machine as a result of the measurements.

The video monitor, although not strictly necessary, is useful to convince the user of the equipment that vision processing is proceeding correctly and, of course, in developing vision processing techniques in the first place.

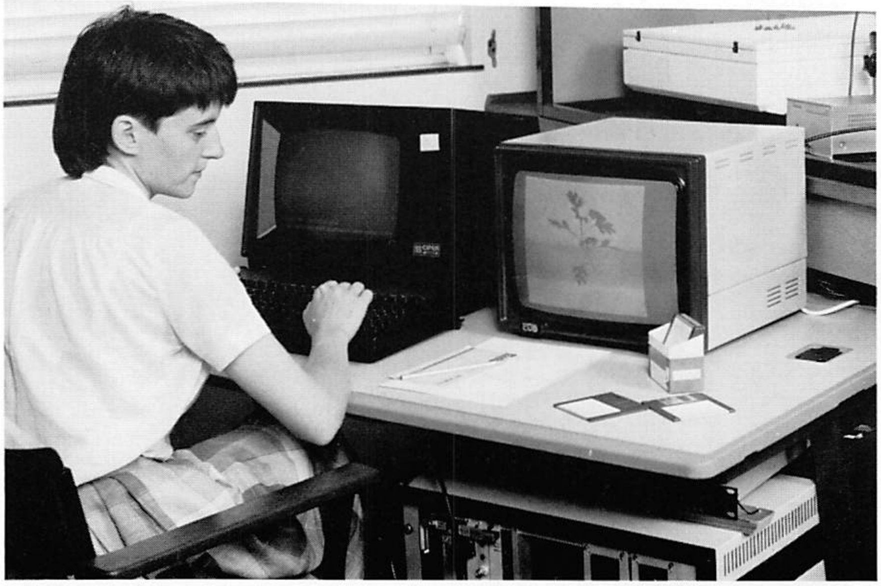
John Marchant is Head of the Control Engineering Group at AFRC Engineering, Silsoe, Bedford.

2. Uses in agricultural engineering

The growing volume of research literature on this subject suggests a large number of potential applications and the reader is referred to recent conferences for details. However, to gain some idea of the possibilities we only need to ask the question "when do we use our eyes?"

Perhaps in the long term topics such as animal recognition, animal behaviour, steering vehicles, recognising weeds, and selective harvesting may all be tackled successfully with computer vision. Certainly in the shorter term (and even at present) such tasks as produce inspection, guiding machinery for produce preparation and packing, and controlling processes using visual information will make use of computer vision.

Fig 1 A typical computer vision system



3. Advantages and problems

3.1 General discussion

A major advantage of computer vision is that it forms a completely non-contact method of sensing and inspection; hence the objects suffer no mechanical damage. There is also a great amount of data produced from a single sensor and much freedom in its positioning.

Unlike the human eye, imaging is not confined to visible light, for example x-rays and infra-red wavelengths have been used. Combinations of the primary colour components (red, green and blue) more suitable for feature identification than the mix used in the eye are also possible with suitable electronic manipulation of the data. Also, any equipment embodying computer vision is inherently flexible, for example a machine grading potatoes could, with suitable re-programing, be used for inspecting oranges. Thus the development costs could be spread over the much larger volume of sales generated by having more than one application area. A less obvious advantage is that the artificial intelligence resident in the computer can be used to simplify the mechanical design. In the next section it will be seen how a computer vision system has taken over the role of a mechanical singulator which will result in a faster, less complicated grading system.

These advantages are not without some problems. As mentioned, a single frame of video data occupies 256 kbytes of memory and five years ago this would have been a severe problem. However the dramatic fall in the cost of memory has been matched by an equal rise in the capacity of memory chips. The intrinsic cost of sufficient memory for a useful system is now only tens of pounds (however the cost of putting it on to a computer card and interfacing it to the system is considerably more than this). Hence memory size and cost is no longer a problem.

On the other hand, speed of processing still is a problem. It is this area where, for example, the inspection of agricultural objects is particularly demanding. Produce like potatoes and carrots are of very low unit value and to make economic sense they have to be inspected at high throughput rates. The next section describes work that AFRC Engineering is doing jointly with Loctronic Graders Ltd. The requirement is to measure various size and shape parameters of potatoes at speeds of 40 tubers per second. Because of the need to measure in three dimensions, this may require 16 views of each object which gives a potential data rate of 256 kbytes per view x 16 views/object x 40 objects/second, totalling about 170 million bytes per second to be processed. How such a rate is handled will be left until the next section but in some vision processing applications, the above data rate is a realistic requirement and forms a significant research problem.

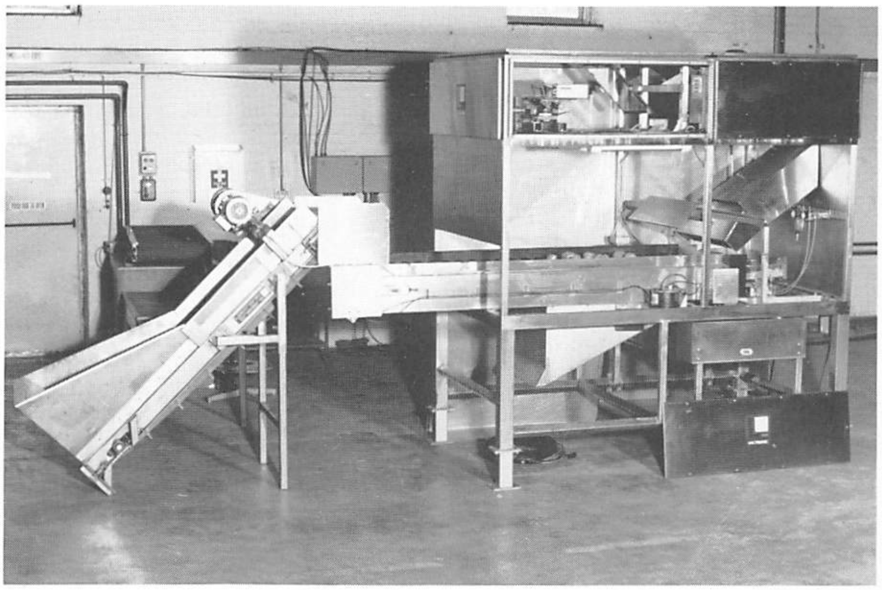


Fig 2 Potato grading machine fitted with computer vision system

Another problem, and perhaps the biggest one for the future, is that of image interpretation. While the television camera is a good substitute for the human eye, the computer is a very poor one for the human brain. Simple dimensional measurements are relatively easy but often classifications of agricultural objects are done using subjective measures. For example we might need to decide which part of a scene was a cow and knowing that cows have four legs look for objects in the scene having four legs. Unfortunately this rule would lead to the laboratory workbench being classified as a cow and any attempt to milk it would be wasted. Thus the problem remains of how we encapsulate for example, the "cowness" of a cow in the numerical form required by all computers.

3.2. An example — high speed potato inspection

This project .as been running at AFRC Engineering since mid 1987 and is the object of a contract with Loctronic Graders of Danbury, Essex. Previous work by Loctronic has led to a method of presenting objects to a vision system such that

Fig 3 Roller table for object presentation

nearly all of the surface is exposed (figures 2 and 3). The mechanical handling system makes no attempt to singulate the objects although the rollers effectively confine their positions to rows parallel to the roller axes. One function of the vision processing software is to track each object to decide if they are touching each other and, if so, to calculate the touching positions. This effectively replaces a mechanical singulator.

Work in conjunction with Essex University has provided fast vision processing systems for blemish detection and colour grading of a range of produce. The objective of the additional work at Silsoe is to develop algorithms for size and shape determination on potatoes (for example for the selection of baking quality specimens). Target throughout is 15 tonnes/hour or about 40 potatoes per second.

Problems have been overcome in a number of areas but only one, that of processing speed, will be described here. Obviously details must remain confidential between contractor and client but the general principles are discussed below.

A number of methods have been employed to solve the problem, viz.

a) View a large number of potatoes at once. The field of view over which potato images are recognised contains four rows of up to ten potatoes in each.
b) Reduce the data to the minimum amount necessary. Information on shape and size is wholly contained within the outline. A unit has been designed to encode the shape of the outline of each potato. This reduces the data content from 256 kbytes per view to only about two kbytes. The time for this data reduction phase is critical and so the unit has been built in hardware rather than programed in software. The time for boundary encoding is about 2 ms per roller. Of course the decision to take the hardware route should be made with care, as the development time is far greater than for an equivalent software solution and the result much less flexible. Another consideration is that improvements in computing devices may well mean that an off-the-shelf module will become available shortly after the in-house one has been designed and tested or even during the development phase. Alternatively processing speeds may well increase in the meantime and make a software solution feasible.
c) Operate on the remaining data using fast software. This generally means writing special purpose software, often in assembler rather than a high level language.
d) Share the processing load. If certain design methods are used, such as employing a suitable computer bus, more than one processor can be used in a system. In this work six processors are used, one for overall supervision, one for each row of potatoes in the field of view, and one to operate the reject mechanisms. As with memory, the intrinsic cost of processing is small, for example, a Motorola 68000 processor chip costs less than £20, but the cost of mounting it along with support electronics and interfacing is considerably higher and depends on production volume.
e) Use fast processors. The processor used in this work (Motorola 68000 family) operates at about 1.5 million instructions per second on 32 bit data.

These approaches are appropriate at the time of writing, but in the future full parallel processing, in the limit using one processor per pixel, special purpose vision processors, and off-the-shelf hardware units may well be a design option.

4. Concluding remarks

It has proved very useful to have a computer vision system based on a standard computer bus. The AFRC Engineering Laboratory system uses the VME bus which is well supported by a range of computer subsystem manufacturers. This makes it possible to buy from stock standard modules such as processors, memory, interfaces, frame stores etc. thus saving development time and avoiding re-invention. It is also possible to update such a system easily by merely plugging in new cards and re-writing some software. This is very important in an area where hardware becomes outdated so quickly.

In order to solve real vision processing problems, the development of special purpose software is essential. Standard commercially available software may be useful in the early stages of a research programme but these types of algorithms are fairly trivial to write anyway. This makes it necessary to use a language that allows good access to the computer hardware. The Control Engineering Group at AFRC Engineering uses FORTH or C. The latter appears to be becoming the standard vision processing language while the former leads to much shorter development times (in the experience of the Group) in the initial phase of algorithm production.

In addition, for solving real problems in real time it is necessary to understand the fine details of microprocessor operation. This may not be so important in the initial phases of a research project but in order to develop the high speed potato grading algorithm, it has been essential to use the Control Engineering Group's expertise with microcomputer systems as well as all the other disciplines involved such as physics, optics, mathematics, and algorithm design.

Developments in the harvesting scene

T Freye

1. Introduction

THE challenge for the future for all farm machinery manufacturers is to provide the tools for the farming community in order to meet its future demand.

The most important single machine for gathering in the world's harvest — is the combine harvester. As the total world yield continues to increase the number of harvesting units manufactured each year is declining. Fig 1 shows the number of combines sold from 1977 till today in North America, Western Europe and Overseas excl Brazil. Within 10 years the numbers of units sold declined in North America by 75%, in Western Europe, by 40% and overseas excl Brazil by 50%.

The development of the baler market in Western Europe looks quite similar: the total number of units has dropped by 50% and the round baler market exceeds the conventional baler market today as shown in fig 2.

A reason for the declining numbers of combines is the increasing capacity of the machines. In Western Europe the share of giant and large machines increased from 40% to 55% between 1981 and today. Reflecting the farm sizes and the infra-structure of the UK, more than 80% of all combines are within the "large" and "giant" range, which includes combines of approx. 112kW engine power and above.

The annual increase in combine engine performance linked to the largest machine in the Claas product range also shows a considerable growth of 4.8% as given in fig 3 (Busse 1981).

Theo Freye is Head of Product Management, Claas GmbH, W. Germany.

We have to recognise that increasing the capacity is just *one* answer to improve economics of operation. We also see that our farmer customers of tomorrow will be even more forward thinking than today and develop new skills.

- The farmer must concentrate on quality of product as well as quantity.
- The farmer must learn the skills of marketing his products and recognise and respond quickly to the

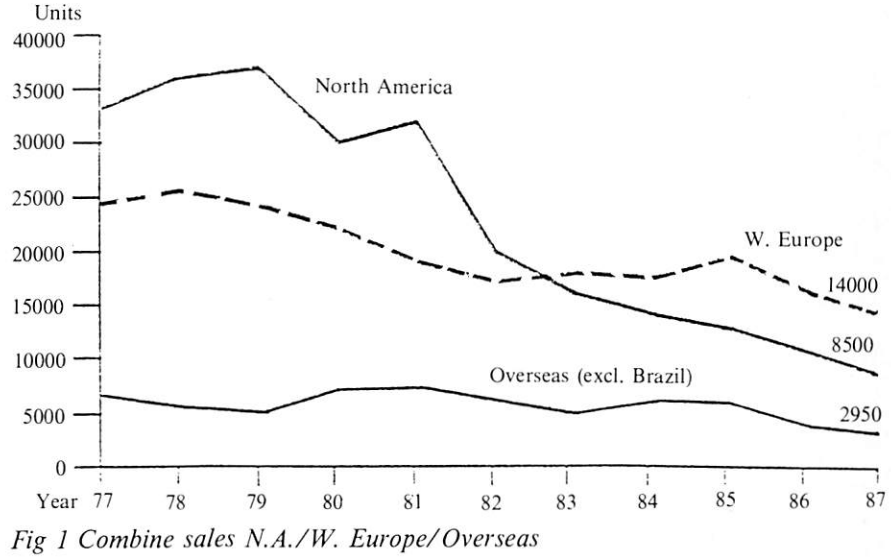
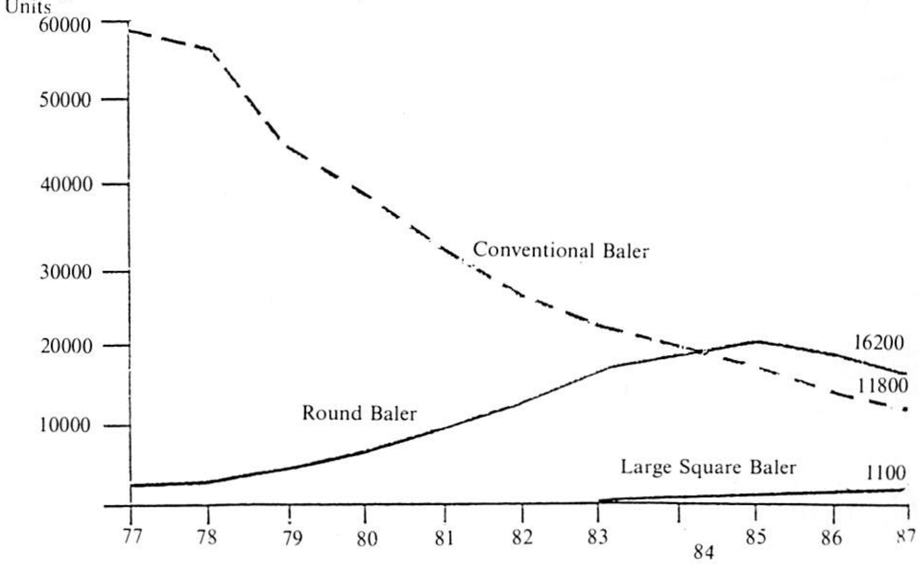


Fig 1 Combine sales N.A./W. Europe/Overseas

Fig 2 Baler market, W. Europe



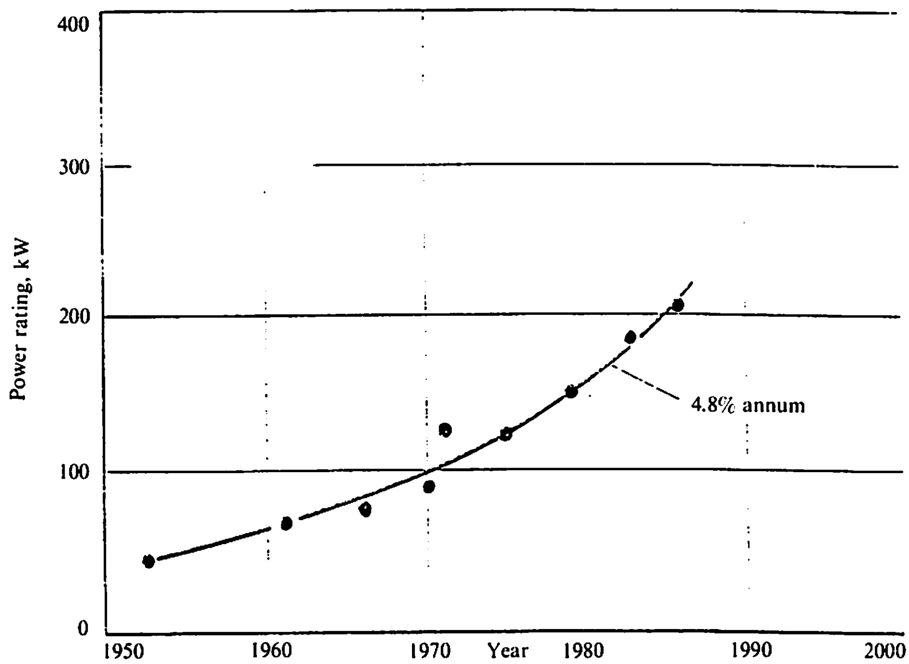


Fig 3 Annual increase in combine engine performance

changing needs of his customers.

— Finally, the quality of the end product must be met at a reasonable level of cost.

Those manufacturers who want to be major contenders in the market place by the year 2000 will have to meet the above requirements of their farmer customers.

2.0 Perfecting existing technology

2.1 Optimising performance

A survey of machinery utilisation which was conducted in Germany, shows on average only about 65% of the harvest time available is actually utilised for combining the crop. The proportion of 'down' time is mainly influenced by the operator. Therefore, combine design must enable the operator to fully utilise the combine's potential capacity. A quiet and well laid out cab helps to avoid unnecessary breaks. Electronic equipment such as loss monitors, automatic steering systems and built-in computers support the operator and help to maximise the output. For example, ten years ago the length of wiring in a combine amounted to 160m, today for a similar size of combine, there is nearly 1000m of wiring on a standard version.

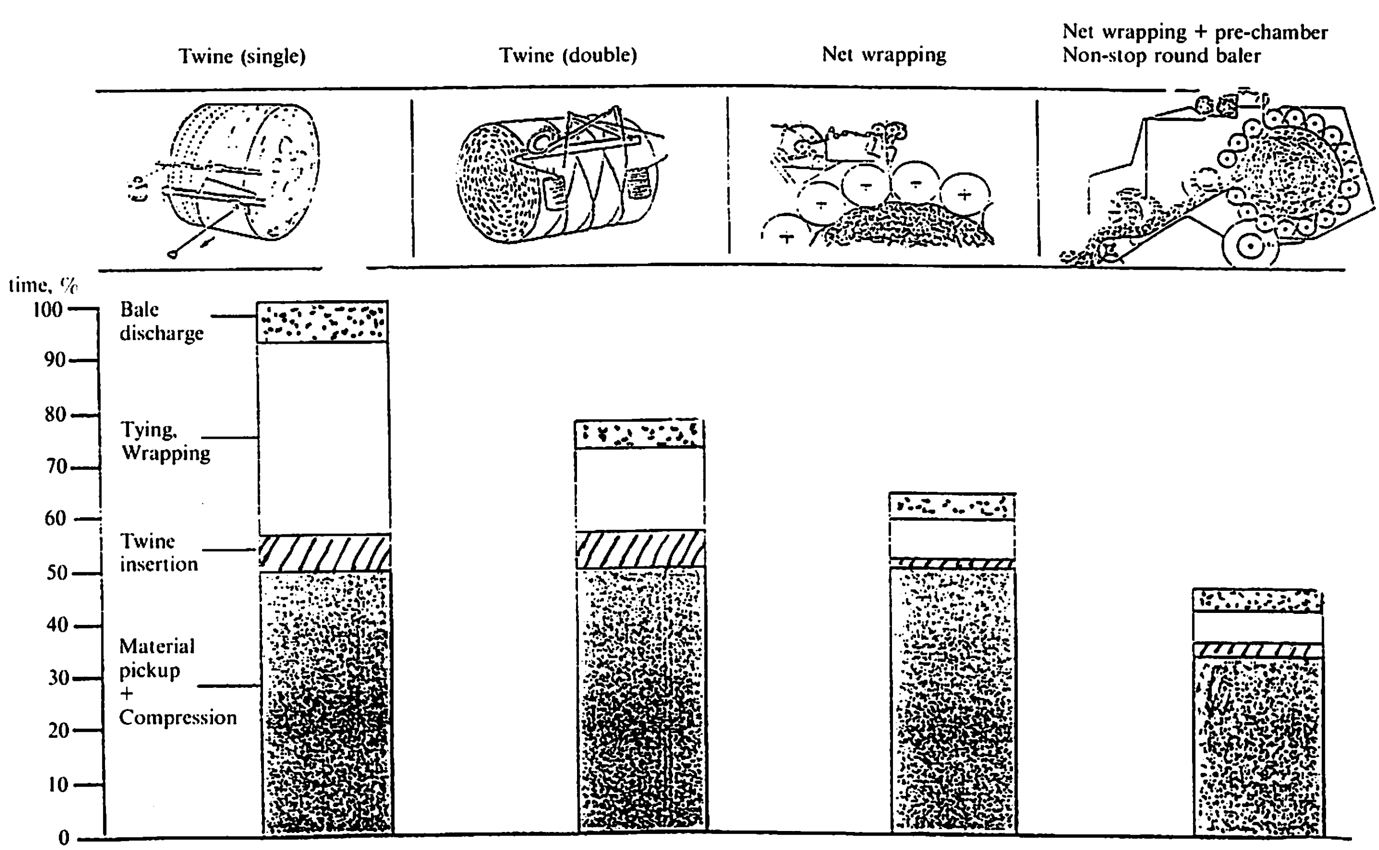
Another example is the application of the electronics in the development of the non-stop round baler, Rollant Rapid as shown in fig 4.

A round baler equipped with a single twine tying system needs a certain time to product a bale. This time can be broken down into:

— material pick-up and compression, followed by the baler stopping,
— twine insertion,
— tying and
— bale discharge.

Double tying and especially net wrapping systems help to reduce the down-time and so increase the performance. With the non-stop round baler, the time to produce a

Fig 4 Round baler performance



bale is cut by half. An electronic system which controls all single steps, combined with the net wrapping design, provides this non-stop operation. These improvements in round baler design have all been introduced during the past 5 years.

2.2 Catering for all conditions

The cutterbar design of a combine harvester is an excellent example of the way manufacturers react to the changing demands from their customers due to different crop requirements. Details are given in fig 5 (Caspers 1987).

Within a very short period the harvesting of new crops has increased significantly. This reflects the flexibility of today's farmer adapting to changing market demands very quickly.

Although rice and soya beans haven't entered the UK yet, other crops like beans, peas, rapeseed and grass seed can be harvested with a modern modified cutterbar. This cutterbar is based on a modular design using different components like knife-bar, intake auger, reel, dividers.

Work on hillsides is provided by special up-hill or automatic slope compensation kits like the 3-D cleaning unit.

Fig 6 Claas Commander combine with tracked undercarriage

2.3 Adaptability to future markets

The design of a machine should be such that it can be adapted to future needs, whatever these may be.

For instance, a modular design with well defined interfaces for all components ensures future exchangeability. The Claas company can retrofit combines which are 10 years old with a 3-D sieve conversion unit, the latter having been launched just four years ago.

3. Developing new concepts

Not only perfecting existing technology, but also developing new and better methods of harvesting will be a vital challenge for the next years.

One such example is the British *"Stripper Header",* in which the

Fig 5 Cutterbar modular design

	Trough	Knife-bar	Intake auger	Reel	Dividers
Grain	Standard	Double fingers	Standard multifinger	Standard	short/long
Rice	Standard	Double knife	Multifinger/rice	Standard	Rice
Soyabeans	Special	Double fingers flexible	Multifinger reinforced	Standard with anti-wrap guards	Soya
Sunflowers	Standard	Double fingers Seed pans	Standard	3-section tine covers	Divider plate
Oilseed-Rape	Standard with extension	Double fingers	Standard	Standard	Vertical rape knife
Pickup	Special	n/a	Standard	n/a	n/a

n/a = not applicable

functions of crop gathering and pre-threshing are combined. One outstanding feature is the knifeless design, which promises a troublefree operation. This is now being monitored very carefully in respect of:

- loss characteristics,
- crop versatility,
- weight impact on the combines, and
- working width possibilities.

A development which has created interest on the continent, is a forage harvester with a special threshing unit and cutterbar to harvest *cereal grain* for silage. The straw is left on the field, so a concentrated feed is produced.

One self-propelled forage harvester has been provided with 3 point linkage and pto shaft to give additional use for the operator (an important consideration for a contractor). This will enable the owner to reduce overall machinery costs through increased utilisation.

Soil compaction is a subject uppermost in many farmers' minds, especially after difficult harvests like 1985 and 1986. To reduce compaction, oversized tyres are getting more popular, for example Terra tyres cause half the compaction compared with a tyre of standard size.

Farmers today realise that reduced ground compaction helps to increase crop yield and to reduce overall cost, especially if less effort is required for subsequent tillage operations.

In a joint engineering venture with Caterpillar, Claas equipped a large combine with a special full track undercarriage as shown in fig 6. This design married the benefits of low ground pressure with the comfort and ease of operation of a wheel equipped combine.

The track consists of a rubber belt, which allows a speed of 22 km. For steering the standard steering wheel is used. The ground pressure is down to approx 0.5 bar.

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Choosing the right form of finance

R L Arnold

1. Introduction

THE methods of financing farm machinery have changed very significantly over the last decade. Statistics from a variety of sources show that finance houses have become more involved in this market than they have been hitherto and at the present time it is estimated that somewhere between 60% — 70% of agricultural machines sold are subject to a finance agreement.

The main reasons for the increase in finance house lendings in this market sector are as follows:

(a) a greater awareness of financing alternatives by farmers;
(b) farmers wish to spread the financial load;
(c) aggressive marketing at the point of sale by dealers; manufacturers and finance houses including low cost finance plans and
(d) income tax considerations.

This paper looks at the factors which influence the choice of financing arrangement, the types of financing arrangement presently available, how financing decisions should be made and finally gives some thoughts on future financing of farm machinery.

2. Factors covering financing choice

There are many factors which influence the choice of a financing method. Some are relevant to the profitability of the business, others concern personal preference and while highly relevant to the individual, are not considered here.

The more important factors are as follows:

(a) source of finance,
(b) nature of the investment,
(c) term of the facility,
(d) liquidity of the business,
(e) certainty of arrangement and
(f) net cost of finance.

2.1 The finance alternatives

Financing methods fall broadly into two categories. The first are those which give ownership of the machine either immediately or eventually to the user and the second fall in the various types of leasing where the title of the machine never passes to the user.

2.1.1 Ownership

Own resources including bank overdraft,
term loans, and
hire purchase.

2.1.2 Leasing

Finance lease:— (a) standard lease,
(b) balloon lease,
contract hire and
operating lease.

2.1.3 Making the right choice

Some of the factors influencing the choice of financing method which were listed in paragraph 2.0 will have a different priority according to the individual circumstances of the borrower.

The strengths and weaknesses of the alternative financing arrangements given in paragraphs 2.1.1 and 2.1.2 are shown in table 1.

When comparing the cost of finance of the alternative methods, one must ensure that:—

(a) like is compared with like,
(b) the taxation implications are taken into account and
(c) the timings of payments and the tax flows they generate are taken into account as they can significantly influence a cost comparison.

An example of a comparison of after tax costs finance is given in table 2. The comparison demonstrates

R L Arnold is Agricultural Investment Manager for Highland Leasing Ltd.

Table 1. Choosing the right form of finance

Type of finance	*Source of finance*	*Term of finance*	*Liquidity*	*Cost*	*Certainty of arrangement, term*	*maintenance*
Bank overdraft	Bank	Demand	×	✓	×	×
Term loan	Bank	1–5yrs	✓	✓✓	✓	×
Hire purchase	Finance house	1–5yrs	✓	✓✓✓	✓	×
Finance lease	Finance house					
(a) standard		2–5yrs	✓	✓✓✓	✓	×
(b) balloon		2–5yrs	✓✓	✓✓✓	✓	×
contract hire	Finance house	2–5yrs	✓✓	✓✓✓	✓	✓
operating lease	Finance house	2–5yrs	✓✓	✓✓✓	✓	✓

NB. No. of ticks denotes the relative strength of a facility.

Table 2. Comparison of after tax cost (£) of finance — an example machine cost £15,000, finance period — 3 years

	Hire purchase		*Lease*		*Contract hire*	
Marginal tax rate, %	27	55	27	55	27	55
After tax cashflow						
Year 1	5900	5900	5868	5868	4520	4520
Year 2	4645	3342	4284	2641	3300	2034
Year 3	(102)	(1142)	(716)	(2359)	3300	2034
Year 4	(1170)	(2385)	(234)	(477)	(1220)	(2486)
Total	9273	5715	9202	5673	9900	6102
Net present value	8112	5594	7951	5348	7941	5501

differences in annual and total cashflows depending on the type of facility chosen and the marginal tax rate of the borrower. It also demonstrates that there can be circumstances when the cheapest method of finance is not necessarily the best for the borrower. The overall conclusion must be that individual circumstances will dictate which is the best choice.

3. Financing farm machinery in the future

The economic circumstances confronting UK farmers at present are unlikely to change, at least for the better, in the foreseeable future. An up-to-date and efficient machinery park will remain a high priority of most farms as farmers seek to reduce unit costs of production and maintain timeliness so critical for profitable farming.

In these circumstances, financing methods which minimise the cashflow requirements and give a known future cost for a particular item are likely to become more popular. Contract hire and operating leasing will become more refined so that this known future cost will also include the maintenance and if necessary breakdown replacement of machinery.

Selecting the right field machines

D Baldwin

1. Introduction

SELECTING a machine could be likened to the selection of a horse for the Grand National; there are three ways in which it could be done:

a) with eyes closed and sticking a pin into the list,
b) opt for the favourite and
c) study the form, look at the breeding and make an informed decision.

While on the rarest of occasions options 1 and 2 may be used, let us consider only option 3, the informed decision. Such a decision may be made on both emotional and rational criteria and all too often what is liked takes precedence over what is needed. Needs should take priority.

David Baldwin is a Mechanisation Adviser for ADAS at Bury St Edmunds, Suffolk.

2. Define the right machine

The right machine is defined as:

a) one which can be justified and afforded,
b) one which is best suited to the whole farm system,
c) one which is best suited to the job in question and
d) the one which is best value for money.

2.1 Stage 1. A machine which can be justified and afforded

Recent changes to farming practices mean that planning for expenditure on machinery is not only more complicated, but it is of such importance that there is little room for error.

The farm accounts should quickly show what can be afforded, but at this stage a quick appraisal of the level of expenditure that can be

justified is the starting point. For example a budget for a combine harvester purchase, if bought for £50,000 with an anticipated trade-in in 5 years time of £20,000, on a 200 ha farm, is given in table 1.

The farm may be able to justify this expense or, alternatively, may need to consider other options; a cheaper machine or use of a contractor.

Further budgets may be compiled until a figure of expenditure which can be justified is reached, and *then* comes the question of whether the

Table 1 Budget of operating costs for a combine harvester (£)

Cost: 50,000 after discount
Value: 20,000 after 5 years (1000 ha)

	per year	per hectare
Depreciation	6000	30
Finance charge at 12%	3000	15
Repairs and maintenance	2000	10
Fuel	600	3
Other (inc tax, ins etc)	400	2
Labour	700	3.50
Total	12700	63.50

farm can afford that capital outlay. This is dictated by the profitability of the farm, its financial standing and whether other large investments are due to coincide.

2.1 Machinery replacement policy

A replacement policy should be developed to allow investments to be planned over a 12 year period.

A good policy aims to:

a) make maximum use of investment capital,
b) ensure regular replacement of machines over the period,
c) maintain the machine fleet in good order,
d) forecast the cash flow to avoid peaks of borrowing,
e) plan machine purchases in advance,
f) plan changes from a sound base and
g) take maximum advantage of discounts offered

Once level of investment for a machine can be seen to be justified, affordable and fitting in with the replacement policy of the farm, the next stage is a careful analysis of what exactly is required for the farm.

2.2 Stage 2. A system to suit the farm

On mainly arable farms there are periods of the year when the correct choice of equipment has a large influence on whether the work is completed on time or not. The autumn workload from harvesting to drilling, and crop spraying in the spring are obvious examples. Every farm has its own system of carrying out the work, and the type of farm and the techniques employed dictate the types of machines required. However, systems and techniques can change, as labour or cropping change and some systems become unsuitable. Straw burning is one such example. Therefore, here is the point to stop and take stock. If labour, cropping or farm size is to change over the next few years, new systems may need to be designed, and machine choice altered.

Factors within given systems, which affect the job to be done.

Harvesting: Crop types, grain quality, moisture content, labour availability and straw disposal.

Cultivations: Straw disposal, drilling dates, tractor sizes, drill types and costs.

Spraying: Timeliness, labour, safety, tramline width and crop/soil damage.

The above factors, and there are many more, can affect the way in which the operation is carried out and therefore dictate the needs of the machine. Furthermore, as the objective is increased efficiency, some systems themselves need to be analysed and revised in order to become more efficient. *Systems planning,* using desk top modelling, is very useful in this respect and the merits or problems of changed systems can be evaluated before any commitment is made.

2.3 Stage 3 A machine to suit the job

Only when due consideration has been given to perfecting the system should machine selection really be started. Typically the basic criteria for selecting a machine includes the following:

workrate/performance efficiency, work quality, fixed costs, operating costs, reliability, durability and compatibility with other machines.

A comprehensive list can be established with various factors expanded upon dependent on the job in mind. The main criteria upon which a tractor for cultivations is selected are shown in table 2. By cross comparing each factor against every other one, the priority of the criteria is established.

By repeating the exercise for a tractor required for spraying the priorities are different. It is important to identify the priority features for a given job.

Essentially the differences in priorities can be summarised as power and pulling capacity for cultivations, and low weight, high clearance, and fuel economy for the sprayer tractor.

Bearing in mind the preceding stages, a shortlist of possible machines can be considered and evaluated as to their suitability. If a choice is not easily made between any two or three machines, then the absolute cost versus performance of each should be assessed.

2.4 Stage 4. Value for money

In stage one, the budget for a machine showed where the main costs lie but are based on typical figures for each category. In this stage where two machines satisfy all the previous criteria, a closer analysis of costs will assist the final selection.

Purchasing a larger combine for example, may initially appear to be more expensive but the benefits of faster harvesting of grain at lower moisture contents can save on drying

→ *foot page 49*

Table 2 Criteria for considering tractor selection

Figures denote priority for a cultivations tractor and those in brackets for a sprayer tractor.

Power	3	(20)	2 or 4 W drive	2	(14)
Torque backup	4	(19)	Fuel consumption	18	(16)
Rto power	5	(13)	Depreciation rate	13	(12)
Hydraulic power	6	(10)	Road speed	14	(3)
Lift at arms	9	(18)	Weight	9	(6)
Tyre sizes/track	15	(4)	Turning circle	12	(5)
Operator comfort	10	(8)	Axle clearance	20	(2)
Reliability	17	(17)	Gear change/ratios	6	(11)
Availability of spares	8	(15)	Controls	7	(7)
Operator entertainment	1	(1)	Ease of servicing	11	(9)

Meeting farmers' future needs

P L Redman

1. Economic background

THE situation now widely recognised within the industry is shown in figure 1 (Anon, 1986). On farms where the variable inputs are being moved towards the optimum and as individuals have less influence over yield and price (income), it is the levels of fixed costs which need to come under closer scrutiny if the decline in net farm income is to be retarded. According to Cambridge University Statistics (1986), the dairy sector is the only slight departure from this general trend.

In the eastern counties of England, machinery costs represent 30–40% of so-called 'fixed' costs and on many farms these are more easily manipulated than labour and rent. It is also worth noting that for cereal enterprises machinery costs at least equate to the combined costs of fertilisers and sprays — inputs which are at the centre of so much attention in the cereal world.

Peter Redman is Senior Mechanisation Adviser with ADAS.

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costs and thereby increase margins. Insufficient drilling capacity can delay drilling and severely depress yields. Other examples are the benefits to overall yield by use of low ground pressure equipment or wide tramline bouts, and the balance of depreciation against the costs of spares and repairs, or of fuel consumption for a farm tractor.

3. Conclusion

In order to select the right machine a planned approach is needed in order to ensure the purchase:

a) can be justified and afforded,
b) suits the farm system,
c) suits the job to be done and
d) is value for money.

Ultimately everything relates to money and value for money does not necessarily mean buy cheap. Reliability, economy and suitability are too important to ignore and in conclusion the expression "You get what you pays for" is a good maxim.

Using mainly cereal farms as an indicator, it does appear that the growth of machinery costs (Anon, 1986) which are up 98% in real terms has far exceeded the growth in the value of output (+8%) during the period 1977/78 — 1985/86, depreciation being the major component.

This situation has led to various statements from economists urging that tenacious attempts should now be made to reduce the costs of machinery services and suggesting that these will have to be reduced by over one-third on many farms.

Those in the business of supplying agricultural equipment are all too well aware that this process is underway without the confirmation of the recent 'Annual Review of Agriculture 1988' which predicts that investment in machinery and vehicles will have fallen by 11% in 1987.

Although such generalised statistics cannot form a basis for decisions within an individual business — be it farming, dealership, or manufacturer — they do give the clear signal that machinery investments must be carefully judged. In the context of this paper the emphasis is on meeting real *real needs.* Buyers of equipment will need to develop a clear specification of the features required and suppliers will have to demonstrate that their products have the most favourable cost/benefit ratio. Independent consultancy services such as ADAS can fulfil various useful roles in this process.

2. Opportunities

Turning to the more positive aspects of this analysis: farms, like any other progressive business, will continue to invest, and in practice many opportunities exist to improve machinery operations — a good proportion of which can involve new equipment. These can be classified as:—

Improving *productivity*
Improving *effectiveness*
Satisfying *external* pressures

The following sections will attempt to identify some of these opportunities.

2.1 Improving productivity

2.1.1 Work rate

Traditionally, improvements in intrinsic work rate (forward speed × working width) have been the main thrust of machinery developments. The emphasis will continue to move away from these features although time critical activities such as spraying, some harvesting operations, to a lesser extent fertiliser spreading and, of course, equipment for contractors use, still need some attention. For example, forage harvesting rates can be improved by aggregating swaths and the 'stripper' header offers considerable potential. However, from ADAS Mechanisation Advisers farm planning exercises, in practice it is irrigation and spraying systems which are most often under capacity.

2.1.2 Reducing weather influence

The aim is to minimise the constraints imposed by weather conditions and thus allow more working opportunities for the same equipment. The application of liquids and traffic for essential harvesting are the most vulnerable activities. There is a need for slurry application systems free from drift and smell which are not heavily soil engaging, for spraying systems which are less sensitive to drift, for irrigation systems less affected by wind, for better wheel equipment on many farms, and for controlled traffic systems such as gantries for some operations at least.

Researchers, manufacturers and system designers can all contribute to improvements in these two areas.

2.1.3 Better organisation

This process starts with ensuring that the overall complement of machines and labour is matched precisely to the requirements of a particular farm and includes the detailed planning of specific systems — cultivations — spraying — harvesting, for example. Consultants such as ADAS can assist with these decisions by making an independent analysis using computerised techniques.

In many cases improvements can

be made by avoiding delays to key equipment by speeding up handling and transport. New investment is not always required, but some areas still to be fully exploited are reduced volume spraying, the use of supporting equipment such as bowsers and mixer tanks and intermediate bulk containers for fertiliser spreading, larger trailers for harvest transport and higher density baling.

2.1.4 Improved reliability (longer life)
Reliability is the key to many economic improvements in performance, in addition, extending life reduces depreciation charges. Better reliability improves work rates, avoids critical delays and allows the maximum effectiveness to be attained. As well as paying attention to basic design features aimed at reducing wear, extending maintenance schedules and easing the execution thereof, dealers can contribute by providing prompt and efficient back-up, managers can help by using planned maintenance schedules and operators can play their part with tip-top routine maintenance.

2.1.5 Operating conditions and information
Operation is vital to optimal performance and much has been done in this area, but not all conditions are dust free and some remain noisy. Processing and drying plants are often culprits. In the case of field operations in particular, operators are not always provided with the information required in a readily usable form.

The development of 'information systems' is well underway at the research level and some are now coming through onto the market. Examples emerging are:— tractor monitoring information systems "in cab"; displays of combine harvester performance monitoring; fault diagnosis and maintenance programming; systems to monitor, record and control slurry application. Enormous potential remains for the application of similar technology to spraying, fertiliser spreading, forage harvesting, etc.

2.1.6 Automatic control
In many ways this is complementary to the above in that minimising operator inputs can bring similar benefits. Perhaps more important than reducing labour is the opportunity to extend working time and improve control. Electrically powered operations such as processing plant, crop drying and storage systems provide the most obvious examples and can have the added advantage of using lower cost tariffs.

2.2 Improving effectiveness
There is more to be gained by improving the effectiveness of machines other than by increasing work rate. As the cost pressures mount, so does the case for precision in the application of expensive inputs such as sprays and fertiliser, likewise the need to avoid losses and wastage of both inputs and products at all stages. As competition increases, the market demands precise standards with the inducement of significant premiums and penalties, hence the effect of machines on product quality and the ability to grade to tight specifications gain prominence. There are ample opportunities for machinery development but it is tempting to skimp background research, essential product development work and testing in the quest to make early headway into new markets.

2.2.1 Reducing losses/wastage
The ability to recognise and quantify the levels of loss is an essential precursor to any attempt to limit waste or improve efficacy. Developments in information technology have much to offer in addition to making more effective use of existing equipment. The most notable example is the potential which remains to improve the operation of all kinds of crop store, not only to prevent losses but also to maintain valuable quality. Losses occurring during harvest are more noticeable and are under reasonable control, perhaps at the expense of harvesting rate in some cases.

Again, the application of sprays and fertiliser will benefit from continued attention. The various aids to the penetration of crops by sprays now under examination and development are intended to improve efficacy. Although fertiliser spreaders may have the intrinsic capability for even distribution, it is prudent to check occasionally, whilst integral weighing and area monitoring will allow more precise control of application rate.

In the case of forage, serious wastage can still occur in the storage phase, although this is largely within the influence of managers; losses post-opening are affected by unloading techniques. Big bale wrapping is attacking the same problem but the technique has yet to complete development.

2.2.2 Reducing damage
Potatoes, vegetables and fruit are the classic examples of crops susceptible to damage. Methods of reducing damage levels during harvest, storage, grading and packing have received considerable attention but in practice systems tend to evolve and rarely incorporate all the damage limitation techniques available. A quick and effective diagnostic service capable of identifying the main culprits in any system should make a valuable contribution.

2.2.3 More marketing opportunities
Those commodities such as fruit, vegetables and eggs which receive little if any processing prior to consumption need to be delivered to the point of sale as near as possible to their conditions at 'harvesting'. The avoidance of damage is an obvious factor, but maintaining tight control over conditions during storage and transport can also bring premiums — the so-called "cold chain". There is likely to be continuing demand for the design and supply of complete systems tailored to individual needs.

Grading of commodities according to some characteristic such as appearance, weight, size, density, can raise the proportion meeting the requirements of the premium market. Recent work highlighting the effect on hagberg values of grading wheat with a gravity separator represents another opportunity.

2.3 Satisfying external pressures
Few involved in agriculture now consider that the industry can operate without recognising the changing demands of the various other activities which take place in the rural environment, or without regard for the views of those who consume its products. Some farms, even if only a small proportion, will pursue alternative enterprises in response to the over supply in more traditional sectors. All will present new opportunities for mechanisation.

Being totally integrated in the countryside, some risk of pollution from agriculture is inevitable, notably from animal effluents, crop waste, unwanted chemicals, odour, and to a lesser extent noise. Improvements in the effectiveness and control of machines often brings beneficial side effects in this respect, but some equipment is directed specifically at containing pollution — such as low rate irrigation systems for foul water and chemical 'treatment' facilities. A better understanding of animal welfare is now developing to indicate a further contribution from engineers, not only in improving and controlling the environment for housed stock, but also in the provision of systems to identify animals, administer feed and medication, monitor performance and health and, in the longer term, to automate milking.

3. Conclusion

In spite of the mounting pressures on the industry and the resultant increase in competition for those supplying it, there are opportunities and challenges for all those involved, be they Farmer/Operator/Buyer, Supplier/Dealer, Manufacturer, Designer, Researcher or Consultant.

There is no panacea but there is much to be gained from teamwork to ensure sound decisions resulting in good products, good service, good information and more viable businesses.

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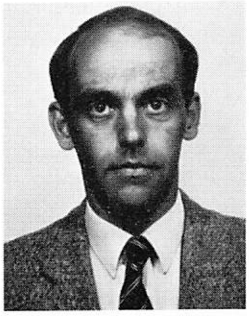
Spraying systems and legislation

A J Landers



Summary

THE Conference 'Spraying Systems and Legislation' held by the Western Branch to celebrate the Golden Jubilee was attended by 100 people. The object of the Conference was to identify the implications of the new Pesticide Regulations for machinery manufacturers, dealers and users of sprayers. There was also a review of the latest spray application technology.

The Agricultural Training Board and the National Proficiency Tests Council presented displays and, along with the Health and Safety Executive, participated in the discussion session.

1. Introduction

In his opening remarks the Chairman, Peter Morris, Principal of Lackham College of Agriculture, drew attention to the new legislation. "There is", he said, "a great deal of concern by the general public and farmers, about pollution in the environment. The current and pending changes in pesticide legislation will have an impact on all manufacturers, distributors and users of pesticides and pesticide application equipment".

2. The new legislation

Tom Cromack, ADAS Regional Agronomist at Bristol, outlined the main provisions of the Food and Environment Protection Act, Part III 1985 (FEPA) and the method of implementation. He explained that the Act will impinge on everyone who comes into contact with pesticides, the aims are:

a) to protect the health of humans,
b) to safeguard the environment,
c) to control pests safely, efficiently and humanely and
d) to give correct label information.

As from 1 January 1988, users must comply with the conditions of approval on the pesticide label. The label states:

a) the maximum rate at which to apply the pesticide,
b) the crop on which the pesticide is to be used,
c) the minimum harvest interval
d) the protective clothing to be worn and
e) the minimum dilution rate, although this is under discussion.

Users will be provided with as much relevant information as possible and it was stressed that recommendations, as well as conditions of approval, will be constantly under review.

There is a general obligation on all who supply and use pesticides to ensure that everyone knows how to use/apply pesticides correctly. For instance considerable tightening of controls on aerial spraying has occurred; certainly it is necessary to notify all those who can be affected. The draft code of practice is in fact being modified, and this will give guidance to the operator.

It was pointed out that advertising is now controlled as only approved products may be used.

The Certificate of Competence was outlined, and it was emphasised that a knowledge of how to use pesticides safely is required by:

a) the trade storekeepers selling products and
b) the suppliers and consultants who give farm advice about products, they will also require a BASIS certificate.

As from the 1 January 1989 this Certificate of Competence is also required by all persons who apply pesticides on land that is not within their control (contractors) as well as those born after 31 December 1964 whenever they apply pesticides.

3. Recent developments in application sytstems

Ian Rutherford, ADAS National Specialist in Crop Production Engineering described various

Andrew Landers is Senior Lecturer in Farm Mechanisation at the Royal Agricultural College, Cirencester, Gloucestershire.

Fig 2 The Willmot Light spray 1548HY, a low ground pressure spraying rig which allows the application of pesticides throughout the year with minimal crop and soil damage

developments in application equipment. He stressed the need for a robust, safe, efficient system.

Recent developments, such as passive and active boom suspension, monitors and controls, along with new boom materials have influenced sprayer design.

The use of droplet measuring equipment has resulted in a greater understanding of the right size drop for a specific target. The hydraulic nozzle does give good results, paradoxically its weakness is its strength because it produces a range of different drop sizes for different target areas.

The development of electro-static sprayers was also reviewed along with other methods such as air-assisted sprays to help deliver the droplet to the target.

The effect of FEPA on research and development and vice-versa was outlined. The pesticide label states the application system and the spray quality to use. Spray quality, as defined in the *BCPC Nozzle Selection Handbook*, includes key points about the nozzle's characteristics, namely type, angle, flow rate, pressure etc.

Ian Rutherford then went on to describe current levy-funded research being carried out by ADAS and AFRC on behalf of the Home Grown Cereals Authority. The performance of conventional sprayers, operating at various application rates with differing spray quality, along with the Airtec and Superjet nozzles and the Crop Tilter, were being researched. Trials were being carried out on the physical characteristics of droplets, spray deposition and efficacy and safety of different application systems.

4. A manufacturer's view

Clive Christian, a Director of Cleanacres Machinery, outlined recent developments from his company, namely the Airtec. The Airtec nozzle incorporates both a liquid and an airfeed, giving a fully adjustable range of droplet spectra.

Liquid is delivered by a conventional sprayer pump and air is supplied by a high volume, low pressure compressor. By keeping the air/water ratio the same and by lowering or raising both pressures slightly the droplet spectrum is easily altered.

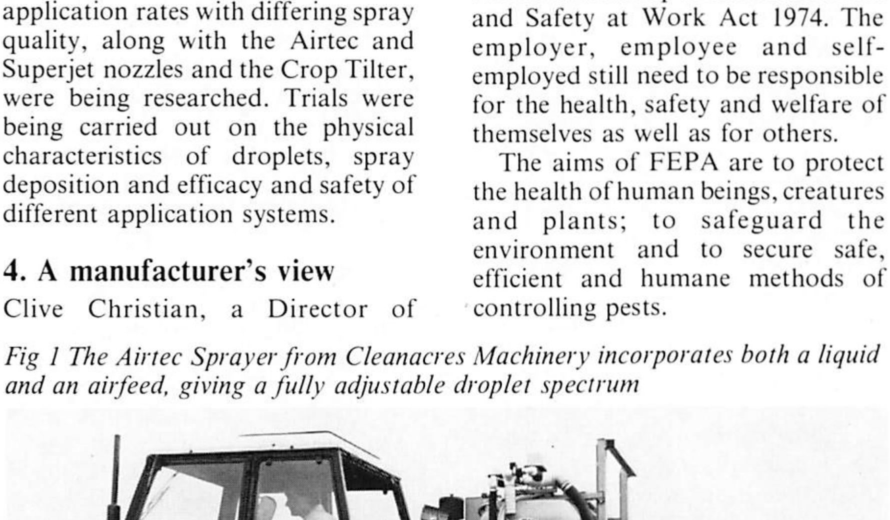
5. A contractor's view

Richard Devereux-Cooke, a Hampshire spraying contractor and President-elect of the National Association of Agricultural Contractors, discussed the practical implications of the Pesticide Regulations for all users.

He reminded the audience that FEPA has not superseded the Health and Safety at Work Act 1974. The employer, employee and self-employed still need to be responsible for the health, safety and welfare of themselves as well as for others.

The aims of FEPA are to protect the health of human beings, creatures and plants; to safeguard the environment and to secure safe, efficient and humane methods of controlling pests.

Fig 1 The Airtec Sprayer from Cleanacres Machinery incorporates both a liquid and an airfeed, giving a fully adjustable droplet spectrum



The responsibility for safe and correct use of pesticides lies with the operator, he must understand what he is doing, so correct training is vital. The application equipment must be properly used and maintained. Nozzles must be effective and accurate.

Pesticide disposal is a problem and the second draft of the Code of Practice needs to give clear guidance on this matter.

Richard Devereux-Cooke also suggested a novel approach to pesticide application by only spraying the middle of a field, leaving the headlands for set-aside, for spraying out residues or for game conservancy.

Operator training is very important: 'no person shall use a pesticide unless he has received adequate instruction and guidance and is competent to perform the duties required of him' states the Control of Pesticides Regulations 1986. But what level of competence is required? The National Proficiency Tests Council Test puts a base level on competence, therefore operators must be at that level or above.

The availability of operator training courses was outlined.

6. Discussion

A general discussion followed the four speakers. Representatives from the Agricultural Training Board (ATB), the National Proficiency Tests Council (NPTC) and the Health and Safety Executive (HSE) joined the platform party to answer many questions from the audience. The latter comprised farmers, consultants, machinery manufacturers and dealers.

The general impression was that most delegates went away with a better understanding of the new regulations affecting pesticide use on farms, and how the latest spray application control equipment will help them obtain better results.

Development of portable instruments for data acquisition and real time processing

Dou Zheng

Summary
BASIC methods of data acquisition and processing for agricultural machinery experimentation are discussed briefly. The development of real time processing of data is described and several new types of apparatus used for on-site tests are introduced.

1. Introduction
This paper was originally prepared for the International Workshop on Agricultural Machinery Test Technology, convened by the Ministry of Agriculture, Animal Husbandry and Fishery, People's Republic of China, and the Economic and Social Commission for Asia and the Pacific, Nov 1986, Beijing (Peking).

1.1 Data acquisition
In order to evaluate the performance of farm machinery, such as ploughs, rototillers, transplanters, combine harvesters, sprayers and trailers, it is necessary to conduct a large number of experiments. There are two important aspects in agricultural machinery experimentation: firstly acquiring data at the test site and subsequently processing data quickly to derive the results and conclusions of testing as soon as possible.

Dou Zheng is Deputy Head of the Research Dept for Test Technology and Microcomputer Application, Nanjing Research Institute for Agricultural Mechanisation, (NRIAM), Min of Agriculture, Animal Husbandry and Fishery, 100 Liuying, Nanjing, People's Republic of China.

In China before the 1970s, laboratory instruments such as dynamic strain amplifies, photo-oscillographs and pen-recorders were usually used for acquiring data. These instruments, supplied by ac power, have a single function and are not convenient for field testing. At that time, there was little choice but to equip various test vehicles with these instruments. Moreover, there were still some projects which were unmanageable because of the difficulty in keeping a test vehicle synchronised with the implements working in a narrow area or at high velocity. Data collection from field machines during that period was far from easy.

There were two ways to solve the problem, One of these was to send a vast amount of useful data to a fixed station by means of telemetry instruments mounted on agricultural machines working in the field. The data received were recorded and analysed. The second way was to make the instruments portable or self-contained, ie to concentrate many functions in a single case so that only one instrument handled the complex task with a subsequent saving in time and labour.

After the middle 1970s, some

instruments, used mainly for acquiring data in the field, were developed by the Nanjing Research Institute for Agricultural Mechanisation (NRIAM). These included the Y1B3 Portable Strain Pen-Recorder, the DLN2 Digital Tensile Force Meter and the YPS2 Digital Mean Value Strain Indicator.

The Y1B3 Strain Pen-Recorder powered by dry batteries and composed of a strain amplifier and a pen-recorder in a single casing, is convenient to operate and carry. The YPS2 Mean Value Strain Indicator also powered by dry batteries, is composed of a strain amplifier and a mean value calculator in one cabinet. Displaying the mean value with a liquid crystal display, the reading is very clear even under strong sunlight and this has proved to be a popular feature. The DLN2 Tensile Force Meter has many advantages over mechanical meters (for instance their higher accuracy, reliability and lower price), which it is now rapidly replacing.

1.2. Data processing
How is data processed and why is the real time processing very important?

Data processing (analysing) may be classified into two types: real time processing and off-line processing.

A farmers' proverb in China states 'do farm work in the right season'; similarly the experimentation of agricultural machinery has to be done in the 'right season' too. This problem becomes most acute in the South of China, where farmers have two or three harvests per year, and in the North of the country where the frost-free period is short. Scientists usually want to know as quickly as possible whether or not data collected in a particular experiment are reasonable, in order to re-run the trial during the transient experimental period if the data appear to have errors (Palmer 1985). Without the means of checking data in the field much experimental time can be lost.

Before operating a microcomputer, the idea of processing data in real time at the testing ground was not easy to undertake, and 'data processing' usually meant nothing more than a simple processing task such as computing the mean value.

In order to meet the urgent need for data processing, since 1983 a series of microprocessor based instruments with data processing functions have developed by NRIAM, eg the CX1 Microcomputerised Signal Analyser, the CX2 Microcomputerised Dynamometer for two-wheeled tractors and the CX4 Microprocessor Based Dynamic Strain Indicator (Dou Zheng, Fan Luyan 1985). These instruments have been widely used by many research institutes, universities, evaluation stations for agricultural machinery and factories of more than twenty provinces, municipalities and autonomous regions in China.

2. Three microcomputerised instruments

2.1. CX1 portable microcomputerised signal analyser

The CX1 signal analyser consists of a TP801 single board computer, the relevant interface circuits and a microprinter. Supported by software for real time processing, the CX1 synchronously acquires seven channels of analog signal and six channels of pulse signal, processes them in real time, then prints out the extreme values (max, min), average value (mean), standard deviation or root-mean square (sd), amplitude

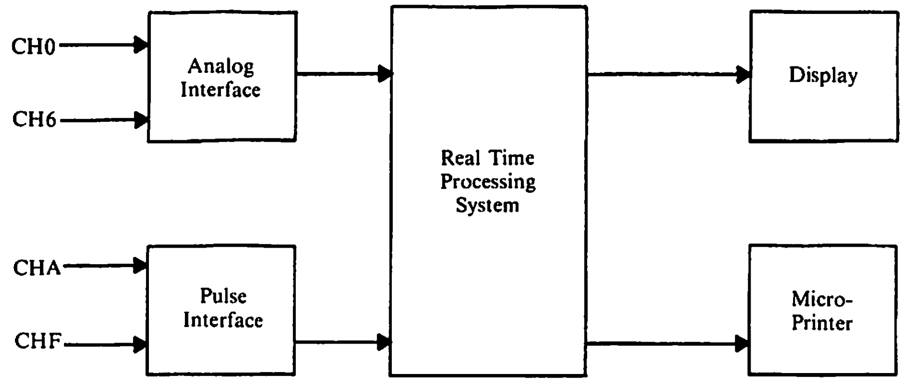
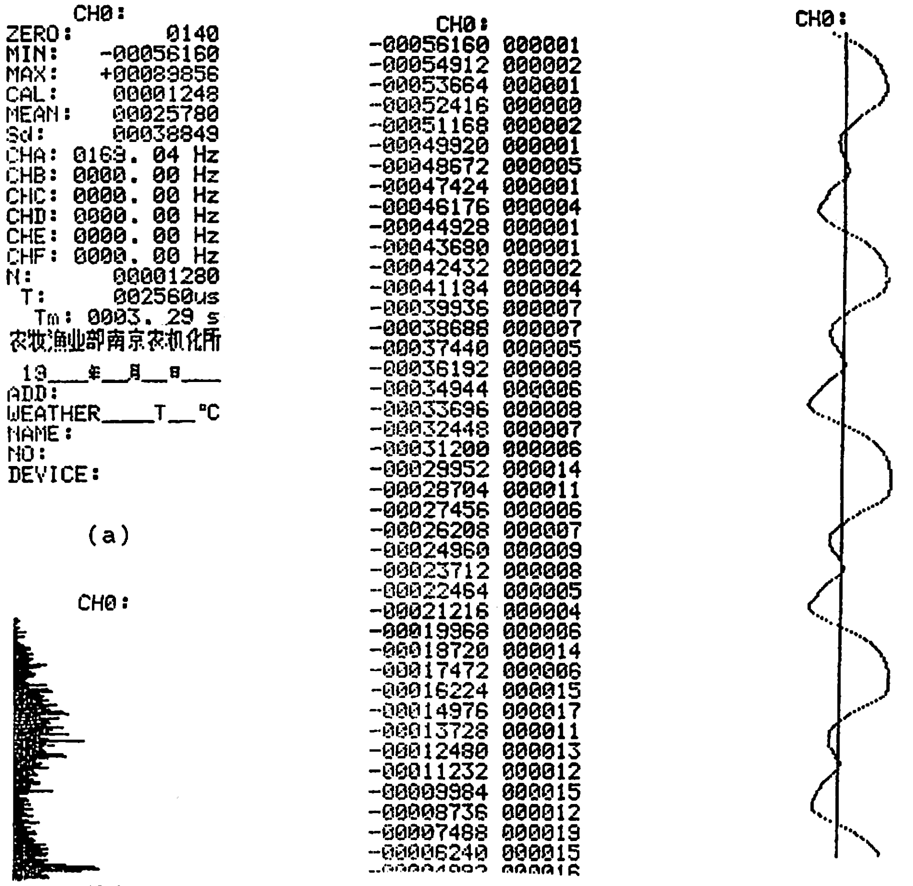


Fig 1 Block diagram of CX1 microcomputerised signal analyser

frequency distribution chart and table, and time history for analog channels. Moreover, count values are accumulated for pulse channels. Using the keyboard, the channel number, sampling period, calibration coefficient and zero point (manually or automatically) may be preset without programing since the keyboard has been redefined and routines solidified into EPROM (about 4 k bytes in total). The range of sampling frequency for the CX1 is about 0.5–5kHz, the input signal level for the analog channel is 0–5V, and its precision is better than ±0.5%. Combined with some secondary meters like signal conditioners, strain amplifiers or dc amplifiers, the CX1 is mainly used in field testing (data acquisition and real time processing). The precision and efficiency of data processing have been greatly improved by using the CX1.

The block diagram of the CX1 is shown in fig 1, and its results printed by the microprinter are shown in fig 2.

Fig 2 Results printed by CX1



(a) Statistical analysis
(b) Amplitude frequency distribution chart
(c) Amplitude frequency table
(d) Time history

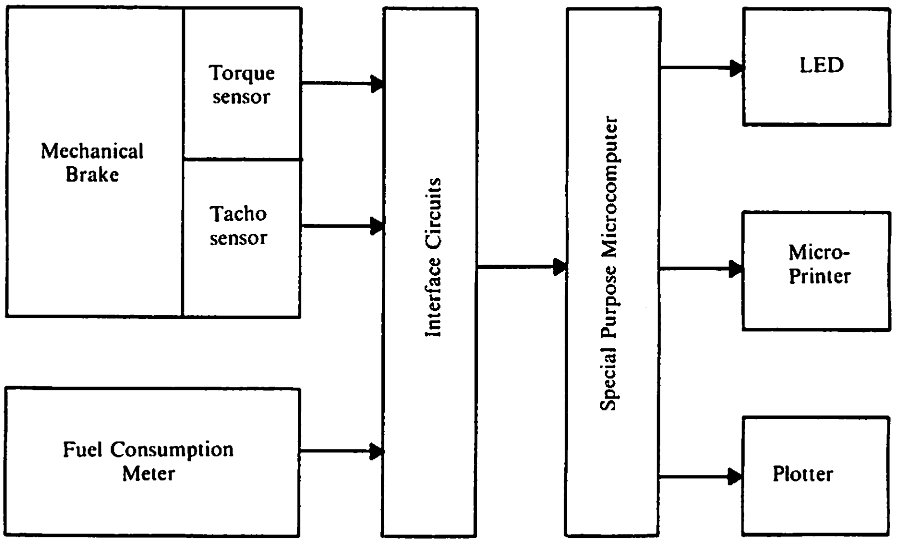


Fig 3 Block diagram of CX2 microcomputerised dynamometer for two-wheeled tractors

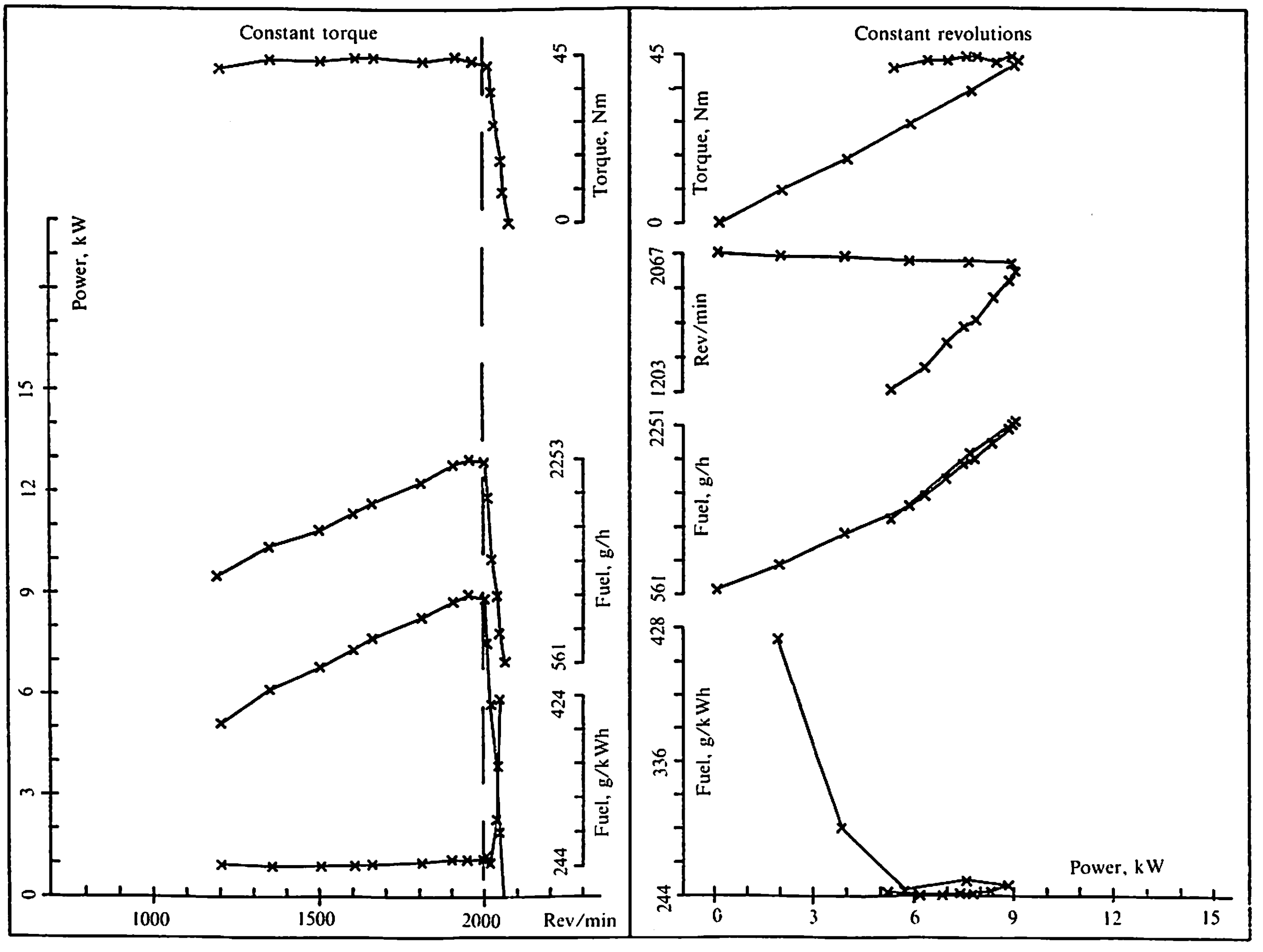
2.2 CX2 microcomputerised dynamometer for two-wheeled tractors
The CX2 microcomputer dynamometer for two-wheeled tractors is basically composed of a special purpose microcomputer for the dynamometer, sensors, a mechanical brake with water cooling (energy consumer) and a volumetric fuel consumption meter (fig 3). The apparatus is used in field conditions for testing the power, torque, speed and the fuel consumption of two-wheeled tractor engines.

The control signals for the special purpose computer to start and stop sampling of data (engine torque and speed) are given by two photo-electric sensors mounted on the fuel consumption meter. The computer starts calculating results immediately after sampling ceases and about one or two seconds later, the microcomputer automatically prints out the test results viz: pto torque (Md), pto speed (nd), pto power (Nd), fuel consumption rate (gd) and so on, (see Table 1).

Linked with a plotter, the CX2 draws up the characteristic curves of an engine, from as many as twenty calculated results stored in the computer's memory (fig 4). In addition, some points on the curve can be deleted if they are not reasonable, rearranged, or inserted with new points when necessary.

2.3 CX4 portable microprocessor based dynamic strain indicator
It has been mentioned that only by linking the CX1 with a strain amplifier, can strain measurement be undertaken. To improve the

Fig 4 Characteristic curves of engine, drawn by CX2 microcomputerised dynamometer for two-wheeled tractors



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Nd=0001.81 PS
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ne=2285.40 RPM
Me=0000.56KSM
Gt=005276 8/h
8d=002917 8/PSh
  =003973 8/KWh
 NO: 04
T =0014.14 S
nd=0669.21 RPM
Md=0002.93 KSM
Nd=0002.75 PS
  =0002.02 KW
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8d=002316 8/PSh
  =003154 8/KWh
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8d=001369 8/PSh
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  =002472 8/KWh
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Md=0006.56 KSM
Nd=0005.78 PS
  =0004.24 KW
ne=2113.07 RPM
Me=0001.95KSM
Gt=010476 8/h
8d=001820 8/PSh
  =002472 8/KWh
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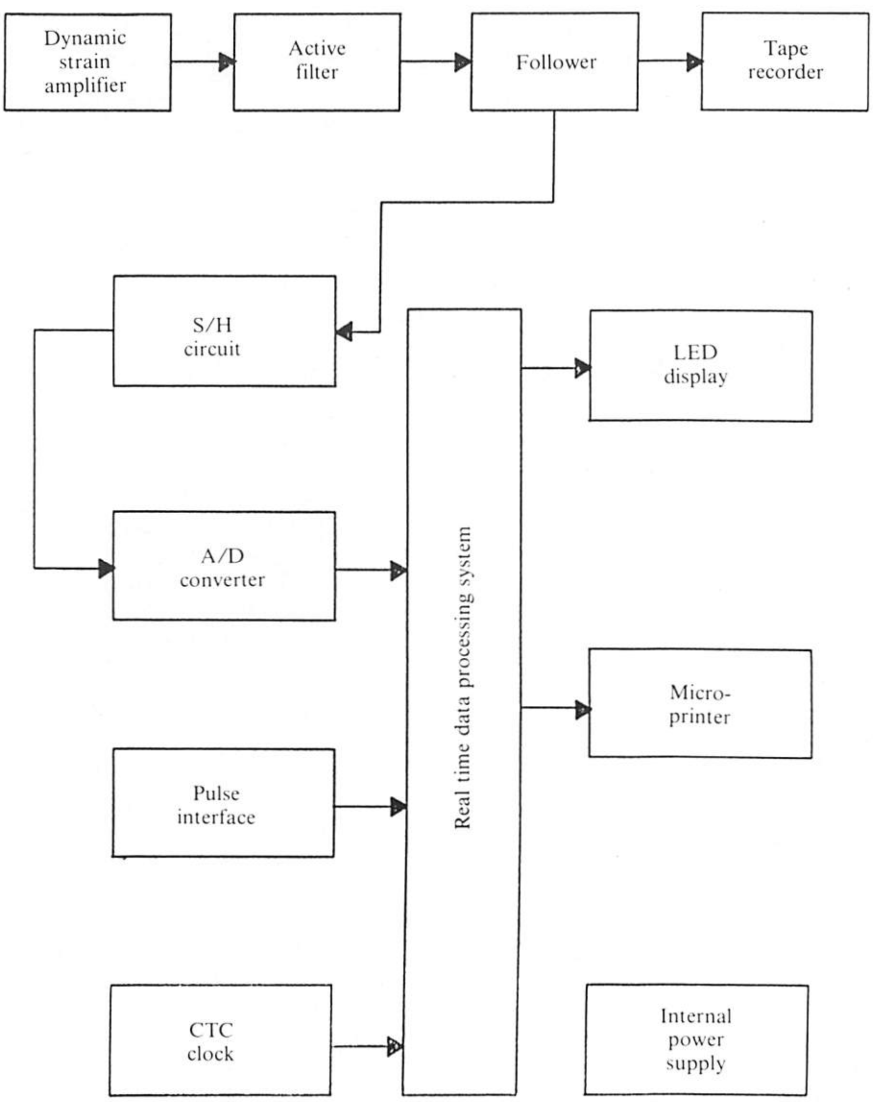
Table 1. Results printed by CX2

convenience of field experimentation, the CX4 microprocessor based dynamic strain indicator has been designed recently with the following: six channels of dynamic strain amplifier, active low-pass filter, sample-hold circuit and analog to digital converter, six channels of pulse interface, CTC clock, display, microprinter, internal 10 AH Ni-Cad battery and real time processing system based on the Z80

Fig 5 Block diagram of CX4 Microprocessor based dynamic strain indicator



microprocessor (fig 5). Using the chopper stabilised IC amplifiers gives the apparatus high stability (Dou Zheng 1980).

The basic specifications of the CX4 are as follows:

Range of strain:	500, 2000, 10000 με
Linearity error:	±0.5%
Active filter	5Hz, 50Hz, 500Hz (±0.5 dB)
Sampling period:	200μs to 32.64ms
Zero drift:	±0.5%/4h, ±0.5%/10°C
Gain stability:	±0.5%/4h, + 0.5%/10°C

The modes of controlling data acquisition for the CX4 are manual, timed and remote operation (event). Because of this, the CX4 is the most suitable design of automatic measuring system for field experimentation (figures 6 and 7).

Fig 6 CX4 in field use

In addition, the CX4 has six channels of analog output (±5V), from which the signals can be sent to a tape recorder for future analysis by other instruments.

Other functions of the CX4 are similar to the CX1.

3. Conclusion

Real time processing is an effective way for on-site agricultural machinery experimentation. The advantages of using portable instruments are: saving in time, labour and money, improvement in test accuracy and flexibility of employing them in difficult environments.

However the functions of these instruments are fixed by routines, so that they are not suitable for every situation. With the latest generation of portable microcomputers, even this problem can be solved.

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Fig 7 Close-up view of CX4 mounted on tractor mudguard

FAMOS — for agricultural engineering?

Christine S Clark

Summary

FAMOS is a EUREKA project concerned only with industrial collaborative projects in the field of flexible automated assembly. The FAMOS initiative aims to strengthen Europe's competitiveness in world markets by producing effective contributions to the social, economic and technological progress through the encouragement of industrial and technological collaboration.

The aims, structure and benefits of FAMOS are described and the projects pertinent to agricultural engineering are outlined. The future need for FAMOS, pending the removal of European trade barriers in 1992 is highlighted. Further projects are actively sought with substantial funding available for their support from the Department for Enterprise through existing schemes.

Christine Clark is a Consultant Engineer with Taylor Hitec Consultancy of Manchester and is a member of the UK FAMOS Resource Team. She is a member of both the Institution Council and the Executive Committee.

1. Introduction

Flexible Automated Montage of Systems (FAMOS) is a leading EUREKA project which aims to strengthen Europe's competitiveness in World markets throughout

collaborative projects in the field of flexible automated assembly. Under FAMOS, assembly is considered to encompass all related activities from product design for assembly through to final product despatch. FAMOS, conceived through a French and German initiative in 1985, has proved to be highly successful in its first year and is now launched into a second ambitious year.

EUREKA projects (see this Journal, Vol 42, No 4, winter 87) are based on long term strategies. These aim to produce effective contributions to Europe's economic, social and technological progress, by encouraging industrial and technological collaboration within Europe. Projects on reaching fruition will demonstrate new technologies making real products at competitive prices for real profits.

FAMOS is quite different from other European high technology programmes such as ESPRIT, BRITE and RACE. These all involve research based projects only, where research and development must be pre-competitive and not directly related to products for sale.

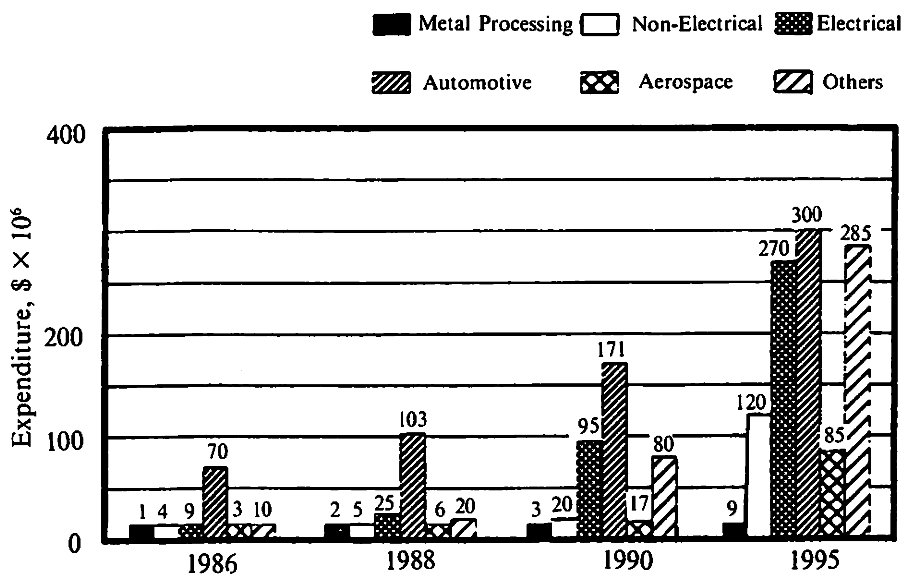


Fig 1 USA expenditure on assembly automation

2. The USA/Japanese connection

So far in the USA increased automation of assembly has been targeted at two areas in particular:

- the automobile industry
- the electronic and electrical industries.

In fig 1 the expenditure on automation in various industrial sectors is shown. In the automobile industry the expenditure on assembly automation is envisaged to rise from $70 million in 1986 to over $300 million in 1995. There is evidence of an ever increasing co-operation between American and Japanese firms. One example is the co-operation between General Motors and Toyota. The co-operation also encompasses the exchange of know-how in the area of flexible automated assembly.

In electronic and electrical technology the expenditure is expected to rise from $9 million in 1986 to $270 million in 1995. The reason for this can be found on the one hand, in the exceptionally strong competitive climate and, in so far as concerns electronic and electrical technology, in the rapid growth of this sector due to its increasingly important role in the economy.

It is not the traditional automation technology which is being used, rather assembly automation is being made particularly flexible through the use of new technological developments such as image processing systems, touch sensitive grippers etc. Similar large increases in expenditure are expected in other sectors, albeit with clearly smaller absolute numbers.

In 1986 over $97 million was spent in total on assembly automation in the USA. This figure is expected to rise to $1069 million by 1995.

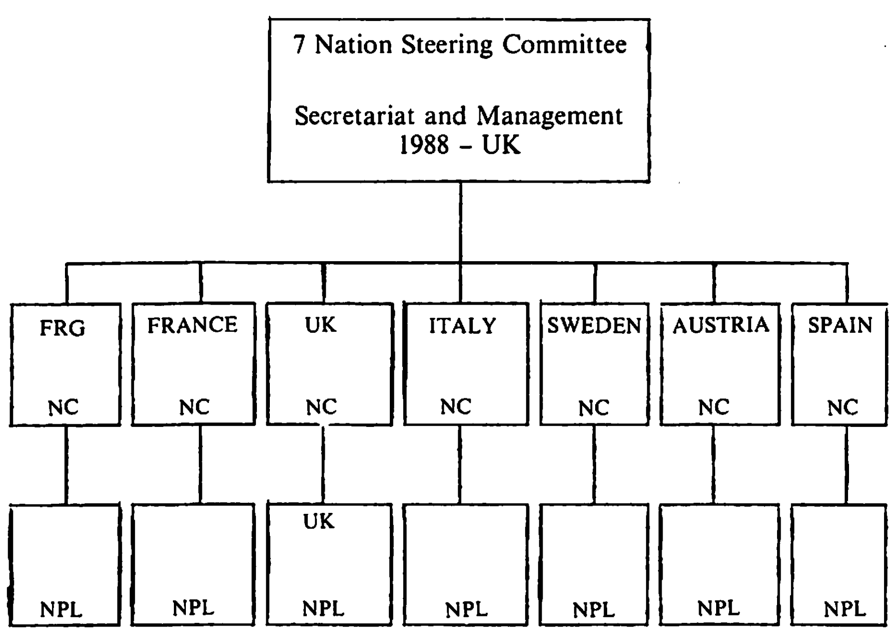
3. The aims of FAMOS

Europe can recapture markets lost to the Far East and North America, by concentrating on assembly. This facet of production has been largely neglected by those who implement automation technology yet it accounts for a major part of product costs. By the identification and realisation of advanced assembly orientated production systems, a variety of high quality cost effective products will ultimately be produced by both new and declining industrial sectors throughout Europe.

The facilities that emerge from the FAMOS projects will have the capability and flexibility to respond to changes in their product market areas, effectively and efficiently. Statistical information compiled during FAMOS's first year identified that, dependent upon the type of product, some 40% of manufacturing cost is associated with assembly. However, only 10% of manufacturing investment is in the area of assembly automation, — FAMOS exploits this anomaly.

The future aims of FAMOS are to

Fig 2 Organisation structure of FAMOS steering committee



NC = National Co-ordinator
NPL = National Project Leader

ensure that new enabling technologies, developed through the implementation of individual projects, become available to European manufacturing industry. Thus the cost of assembly will be reduced, allowing Europe to compete more effectively in world markets.

4. The FAMOS structure

The goals of FAMOS were clearly defined in a document, produced by a French-German expert team in October 1985. This was circulated to seven nations who had declared an interest; these were France, West Germany, UK, Italy, Spain, Austria and Sweden. The first meeting of the seven nations was held on 4th June 1986 in Stuttgart at the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA) where the organisational structure of the FAMOS Steering Committee (Fig 2) was established along with agreement that each nation would confirm its commitment by signing a "letter of intent".

The outputs from the Steering Committee meetings are transmitted by the NPL through their respective Resource Teams for processing in whatever area is appropriate. The Resource Teams are responsible for processing information on projects and technologies, thus ensuring that optimum exposure is given to major aspects of assembly technology requiring development and collaborative effort, plus ensuring that duplication of projects and effort is minimised.

Taylor Hitec Consultancy in Manchester have been commissioned by the Department of Trade and Industry to act as the UK FAMOS Resource Team.

5. Potential benefits

It is anticipated that the projects will produce special advantages in the spin-off to other products and processes from the development and adaptation of the technologies involved. Europe, being the world's largest consumer market, can therefore exploit every opportunity provided by the very latest in highly advanced technological know-how. With collaboration bringing together the finest European technological skills, the competitive power of industry will be improved to ensure that:

- products and processes moving to non-European countries will reduce;
- lost and endangered markets can be regained and safeguarded;
- consolidation of recovered products and processes is realised;
- strategically important technologies are developed and maintained.

By developing Europe as the home market to maintain its industrial manufacturing base, increasingly competitive products can then be exported into other world markets such as Japan and America.

The main benefits to a company, whether large, medium or small, entering into a collaborative project with industry of another country are:

- shared risk,
- shorter timescales,
- fast and effective technological advance and
- greatly improved competitiveness in world markets.

Amongst the UK projects now under way are: Perkins Diesels of Peterborough (whose project reached full EUREKA status in September 1987), Lucas, Thorn EMI and Plessey. Additional potential projects and collaborators are being actively pursued by the FAMOS Resource Team.

6. Definition phase in the first year

6.1 Initially, a number of pilot projects were selected which, to be of the maximum effect and influence, incorporated a wide and representative range of the relevant technologies as outlined below.

- Computer Aided Design (CAD) in the conception and detailed design of products conducive to advanced assembly automation methods and equipment.
- Improved assembly techniques and materials, such as new adhesives and bondings, simplified fastenings, self-locking components etc.
- Advanced automatic assembly equipment with significant flexibility, such as:
  - — industrial robots (with emphasis on improved performance and lower cost),
  - — other programmable transfer and handling devices,
  - — intelligent hoisting and conveying equipment,
  - — advanced sensing and recognition systems,
  - — orientation, feeding and dispensing equipment and
  - — self-governing tooling.
- New approaches to flow and control, eg:
  - — minimisation of floor space requirements through compact transfer systems,
  - — use of automatic guided vehicles (AGVs),
  - — sacrificial pallets and magazines,
  - — multi-purpose, flexible assembly cells,
  - — new concepts for parts and consumables feeding,
  - — computerised control, (demand and supply) e.g. Manufacturing Automation Protocol (MAP),
  - — centralised computer control, Computer Aided Manufacturing (CAM), Computer Aided Production (CAP) and
  - — computerised performance monitoring with fault diagnostics, auto-correction, etc.
- Computer aided systems for the design and evaluation of Flexible Assembly Systems (FAS) including:
  - — system and component design aids (CAD)
  - — visual modelling and dynamic simulation of systems and equipment (CAD software additions) and
  - — interrelation of plant and product design.
- Computer Intergrated Manufacture (CIM) orientated aids for the rational operation of flexible automated assembly systems, eg
  - — off-line programing,
  - — integrated processing of quality control data,
  - — application of methods in artificial intelligence for highly flexible industrial robots,
  - — standardisation of CIM interfaces, (similar to MAP),
  - — standardised Production Planning Systems (PPS) interfaces and
  - — on-line progressing and assembly control.

6.2 During the first year of definition a total of some 100 potential FAMOS projects were proposed. Seven of these were approved at the EUREKA

Ministerial Conference in Madrid on 15 September 1987 with a collective value of approximately 104.7M European Currency Units (ECU). Of the seven projects approved at Madrid, the following one may be of interest to agricultural engineers.

UK.

Perkins Engines Ltd.

Flexible high volume, high variety mechanical product assembly facility, suitable for engine/transmission application.

Enabling technologies include intelligent real time scheduling systems and low cost AGVs.

Collaboration with Italy.

Estimated project cost 10m ECU's.

Timescale three years.

Norway.

A proposal has recently been received from a large agricultural machinery and equipment company. Collaborators are being sought for this ambitious project whereby the company aims to increase its level of exports by 80%.

7. Developments in the second year

The second year of FAMOS has been launched by all seven original nations signing an agreement to continue to strive for new projects, and to encourage other EUREKA nations to join them in reversing the decline in European manufacturing industry. Norway, Finland, Eire and Denmark have now joined West Germany, France, Spain, Italy, Austria, Sweden and the UK with Luxembourg, the Netherlands, Portugal and Greece poised to join them in the near future. A considerable number of UK manufacturing companies will benefit from this expansion of participating countries.

This is a significant step towards European co-operation in the area of manufacturing technology, and in particular that of flexible assembly automation. The competitive capacity of Europe can only be maintained or won back in these areas if it is based upon a strengthening of collaboration. European firms and research institutes are urged to participate in projects in the field of flexible assembly automation. Since the development of enabling technologies is an expensive and resource consuming process, a new software tool, RD^3, was developed by the UK Resource Team to enable the project management function to be simplified.

The FAMOS initiative, by its very nature, has attracted a wide variety of projects, each of which seeks to address assembly related aspects of products and the techologies which surround their production. When considering the wide brief of industrial sectors and technologies involved in such pan-European multi-partner R & D projects, effective flow and management of information is of the utmost importance. Co-ordination of effort, transfer of benefits and the avoidance of duplication can only be effectively guaranteed with the creation of a central data-base.

The technology matrix RD^3 provides information from which an overview of projects, project elements, technologies and timescales can be established. Its most powerful role being to act as a tool for comparison between new and existing projects. This allows governments to avoid duplication of resource and financial assistance, on a European scale, and to monitor the areas of automated assembly technology that need to be addressed.

Establishing suitable communications networks has proved to be a vital factor in developing projects and none more so than in the area of collaboration. As a consequence of the benefits of collaboration and funding, many of the project proposals submitted are more ambitious under the FAMOS umbrella than in their originally conceived form. The earlier development of new, flexible automated assembly facilities and spin-offs in new technologies and products will provide on-going benefits to many industrial sectors in Europe. No other initiative in Europe has the potential or capability to provide the scale of practical results that FAMOS can produce in the area of flexible automated assembly.

8. FAMOS into the 1990s

The next phase will develop the principal project proposals, through the realisation phase into production system evaluation — the final stage of FAMOS.

In developing these proposals, Europe's strengths and weaknesses which have contributed to the decline in manufacturing sectors have been identified and the information used to assist in creating the "FAMOS reference model," this now forms one facet of the technology matrix RD^3. Further analysis of these factors will provide guidance for the Resource Teams in identifying and developing 40 to 50 advanced assembly orientated production systems spread over the whole spectrum of European manufacturing industry. Based on the value of currently defined projects, investment in excess of 645,000,000 ECU will be required to bring the facilities to fruition. The enabling technologies developed by FAMOS should be made widely available across European manufacturing industry, hence the final phase of FAMOS, i.e. evaluation, should provide the mechanism via which maximum application of these new assembly automation technologies is achieved.

Each participating nation should produce a manufacturing strategy in parallel with the foregoing to identify common areas of interest, in terms of product and process technologies. This will hone and sharpen Western Europe's ability to aggressively attack and recapture lost markets with increasing levels of confidence.

FAMOS has reached a critical phase in its development, with the expansion in numbers of member countries and the increasing numbers and complexity of project submissions. The impending removal of trade barriers, scheduled for 1992, increases the necessity for competitive European products and hence, manufacturers having facilities in place well before that date. This imposes an even greater urgency on the successful completion of the FAMOS programme.

9. Conclusions

Europe's problem in global competition is one of fragmented supply, diluted resources and insular research and development. FAMOS must be used to create awareness of the benefits of industrial collaboration in terms of cost sharing and resource concentration.

The FAMOS initiative has uncovered the tip of an assembly automation iceberg. Uncovering the rest of the iceberg will provide a great challenge, enabling the assembly automation to be improved thus creating a significant impact on manufacturing industry.

Large scale application of the results of FAMOS could place Europe in a unique position to profit from its momentum. Japan and the USA have already recognised the significance of assembly automation and are planning accordingly. The rest of the world is now looking seriously at assembly as enabling technologies developed will render current 'state of the art' processes obsolete. For Europe to be at the forefront of competitive manufacture, FAMOS is the ultimate EUREKA collaborative project.

Considerable political energy has been demonstrated by the UK Government in support of FAMOS. Funding has been given to a number of qualifying projects. This has been organised and administered through the Department for Enterprise. Further industry led projects are being actively sought from all areas of manufacturing. Projects or ideas of any scale, related to assembly, can be considered. The Resource Teams are available to assist in their development. The potential benefits for the Agricultural Engineering industry are waiting to be placed; so collaborate now to prevent future "felling" by non-European manufacturers.

Everyone needs a standard

I J Duncan

WHEN I joined the Agricultural Engineers Association at the beginning of 1981, I had been concerned only with standards dealing with petroleum products and the design of electrical or alarm systems. At first, I did not appreciate the degree of detail involved in the development of standards for farm machinery, but in the last seven years I have learned of the immense amount of work that has been, and is being done by a small, highly technical and enthusiastic band of volunteers.

It is a matter for concern for some of us in the industry that the sales of standards to the 600 or so companies involved with farm machinery are so small. For instance, there are 108 current ISO standards dealing with farm machinery, and in 1985/86, only 15 copies were sold. It follows that many persons designing farm machinery do not know of the mass of information contained in these publications, and my object in writing this paper is to try to make engineers more aware of their value. The appropriate standard must be thought of as being as much a design tool as a drawing board or a computer. Perhaps it would be helpful to define a standard, and the Oxford English Dictionary states that it is a measure to which others conform, or by which the accuracy of others is judged, or a thing serving as a basis of comparison, or a degree of excellence. Most of the current standards for agricultural machinery

and equipment fall into one or more of the above definitions. I have heard many people question the requirement for standards, but I believe that they are valuable in two aspects of modern life. Firstly, they are essential where compatibility is required (eg. electrical plugs must fit into appropriate sockets) and these standards must contain as much detail as possible for the guidance of design engineers.

Secondly, they are helpful where a common principle is involved (eg every car must be fitted with some kind of safety belts) and these standards should contain as little detail as possible, otherwise innovation may be inhibited. Standards that do not comply with the above principles usually are not good, and every user of standards should try to ensure that the technical committees engaged in writing or revising them are told of any improvements that should be made. Of course, the existing range of standards is very wide and includes glossaries of terms and their definitions, units and mathematical symbols for quantities, classifications, signs and symbols, methods of measurement and of test, specifications for materials, products and systems which may encompass general performance, safety or dimensional requirements and codes of practice.

Most countries now have their national standards bodies and in the UK, by Royal Charter, the British Standards Institution (BSI) produces our standards. In the UK, the need for standards arose initially in the heavy engineering industries. For instance, the first subjects of British Standards were rails, steel girders, nuts and bolts, and steel sheet. Since 1901, thousands of British Standards have been published, and deal with the goods we buy, the way they are made, assembled, stored, packed, labelled and tested, and whether or not they are safe.

Within BSI, there are eight Councils, and the Engineering Council has 15 divisions. One of these deals specifically with agricultural machinery, and is identified by the letters "AGE". Several of the other divisions deal with subjects such as farm buildings, electric fencing, and conveyors, and their work is also of interest to our industry: The AGE division has 16 technical committees, covering many aspects of the industry, and each committee consists of a Secretary appointed by BSI, and a chairman and members appointed by member bodies, such as trade associations. BSI states that:— "it is important that nominated committee members should be willing, and in a position, to represent the views of their organisation as a whole, rather than personal or company views. They should be available to contribute to meetings regularly, and to be able to

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Iain Duncan is Technical Director of the Agricultural Engineers Association, London.

present cogently the technical and commercial views of their bodies, which are responsible for systematic and regular briefing of their representatives." These representatives are not paid for this work, and it is assumed that the nominating bodies or their employing companies will fund their salaries and travelling costs.

Each AGE technical committee is responsible for a work programme, which is built up during discussion of the requirements of that part of the industry, and usually falls into two sections: British Standards and International Standards. This work programme is presented for approval by the chairman annually to a policy committee which allocates the resources it considers necessary on the priorities as it sees them. The policy committee can dissolve a stagnant committee, or recommend the formation of new committees, always bearing in mind the resources allocated to the division. The work programmes are dealt with during each year by one or two meetings plus considerable postal comment and draft proposals; it may take 10–15 years to formulate a complex standard.

Over the years, the more organised manufacturers of farm machinery, while recognising the value of British Standards, have realised that International Standards are even more important to a trading nation like UK. As mentioned earlier, each BSI AGE Technical Committee has its International Standards work programme in conjunction with its International counterpart. For instance, AGE/6 is involved with the work of four International technical sub-committees of the International Standards Organisation (ISO).

ISO is the specialised international agency for standardisation and its current members are the national standards organisations of 90 countries. The scope of ISO technical work covers all fields of standardisation with the exception of electrical and electronic engineering which, by agreement, are the responsibility of the International Electrotechnical Commission (IEC). The results of ISO technical work are published and in the 1986 ISO catalogue, 8785 International Standards are listed. ISO is made up of a secretariat and a number of technical committees, committee 23 dealing with agricultural machinery. This has a number of sub-committees, which are the international counterparts of the AGE BSI technical committees (eg AGE/11 is the counterpart of ISO/TC23/SCI).

As a member of the European Economic Community regulations produced in Europe are applicable to the UK. These regulations are published as EEC Directives and must be applied by member nations within a stated time as national law. Up to now, these Directives have only applied to agricultural tractors in the area of agricultural machinery, although other machinery is bound to be covered in future. When the programme of tractor .directives listed in Directive 74/150/EEC is completed in the near future, the European Economic Commission intends to make use of national or international standards as the basis of European standards (CEN) to be quoted in future directives (Directive 83/189/EEC) and to continue to press for a reduction in internal barriers to trade. This work is monitored for the farm machinery industry by a European association of national machinery associations entitled Comite European des Groupements de Constructeurs du Machinisme Agricole (CEMA). The technical committee of this body takes a keen interest in the proceedings of the Commission in Brussels, and sends representatives to attend appropriate meetings to ensure that our technical views are given due consideration. It will also be necessary to monitor the activities of the developing European standards systems and to persuade these organisations to make use of international standards, wherever possible.

Two other international bodies publish technical recommendations and requirements which may affect the design of agricultural tractors and machinery. The first is the Economic Commission for Europe (ECE) of the United Nations in Geneva which has formulated highway code constructional requirements for all vehicles that move on the road, much having been incorporated into national legislation. The second is the Organisation for Economic Cooperation and Development (OECD) of the United Nations in Paris which has been involved in formulating safety constructional requirements for farm machinery. The activities of both of these bodies are monitored both by CEMA, and by the national associations such as the Agricultural Engineers Association (AEA), so that their direction of progress does not conflict with national and international standards.

If there are to be standards and technical legislation, then manufacturing industry requires these measures to be compatible or complementary, but not contradictory. In seeking to sell agricultural machinery to the rest of Europe or to export it, one of the main problems and areas of cost, is to ensure that it complies with the local legal and social requirements. A specification for a European tractor is slowly taking shape, but even within this specification, there are many minor national requirements which can make a designer's life a nightmare. The increasing use of international standards in the future should make easier the task of designing for overseas sales.

I realise that, by now, some readers will be bewildered by the complexity of this technical jigsaw, the pieces of which I have tried to arrange and will be asking why they need to know all this detail. In fact, a great deal of the detail has been omitted for the sake of clarity. A knowledge of the working of standards and technical legislation will shortly be as important to designers as information concerning the strengths of materials and methods of fabrication.

In 1982, the Government published a White Paper: "Standards Quality and International Competitiveness" (Cmnd 8621) which sets out proposals for a range of developments in the standards and quality fields. The objective is to improve the quality of British goods and services and help Britain retain a competitive position in domestic and overseas markets. BS 5750, the UK standard for quality management systems contains much helpful information on promoting a total quality approach and is the basis for the UK National Quality Campaign. The government is now making use on an increasing scale of British and International Standards in purchasing specifications, and in legislation. The Health and Safety Commission and Executive refer to standards (and codes of practice) in a variety of ways in the course of their regulatory work. The main purpose of these references is to provide a practical and realistic framework within which designers, manufacturers and suppliers (including importers) can operate in fulfilling their general duties under section 6 of the Health and Safety at Work (HSW) Act 1974 and other regulations. Reference to standards is helpful also to employers and employees in guiding them on safe working practices in compliance with Section 2 of the HSW Act. Reference to standards will also be made in the Regulations and Codes of Practice being formulated under the Food and Environment Protection Act 1985. The Consumer Protection Bill published late in 1986, deals with responsibilities for product liability, and indicates that, while compliance with British or International Standards is *not* a defence against liability, it may be persuasive evidence to help the manufacturers' case. It is to be hoped that the courts will accept that compliance with standards is at least an indication of the safety level which "persons generally are entitled to expect." In USA, compliance with standards is regarded as a defence under the 'state of the art' option.

It is hoped that the point has been proved that the formulation and use of standards is important to engineers today and it is becoming increasingly more so every year. If I hear from my friends in BSI that sales of standards have increased a hundredfold or more over the next five years, I shall know that some people have read this paper. In such circumstances, it will be unfortunate that I shall not receive a commission on BSI sales.

Matcon cones solve the problem of discharging fats coated animal feed pellets

P Cooper

WITHIN its plants, one of the top four feed millers in the UK has rectangular section bulk bins of 20 tonne capacity. A wide range of finished pelletised products are stored in these bins which are bulk out-loaded through slide valves onto a screening conveyor.

The greatest discharge problems have been caused by 8mm fats coated pellets. Even after quite short storage times of as little as six hours the pellets cake and set into a solid 20 t mass. Various methods have been employed to solve the problem, including aeration, air blasters, louvre vibratory dischargers and external hopper wall vibrators. All failed and the operators continued to hammer the bins which distorted the silo faces by up to 50mm and caused extensive downtime and bottlenecks — and did not cure the problems.

In 1981 a rectangular Matcon cone unit was designed to suit these bins and built to fit directly inside the silo hopper, as shown in fig 1.

The operation of the Matcon unit comprises two distinct actions, viz.

a) Lifting — the cone 'punches' up into the material and breaks the bridge and set of the material. The height of this movement is fully adjustable for different material conditions and discharge rates.

b) Vibrating — the cone also vibrates the material which creates flow of material through the annular gap created when the cone lifts.

For installation, the cone was lowered from the top of the silo, into the hopper and bolts were fitted through the hopper wall to support the unit. Pneumatic services were connected. Total installation time for a team of three men was six hours (as no silo modification required). The cone is controlled remotely from the bulk outloading control room.

After evaluating the performance of the first cone over the first two years, a further two Matcon cones have been installed.

Since the installation of the cones, the savings and benefits both direct and indirect have been substantial, viz.

a) Sticky, difficult and caking materialas are now being stored in bins to full capacity for extended periods with complete confidence.

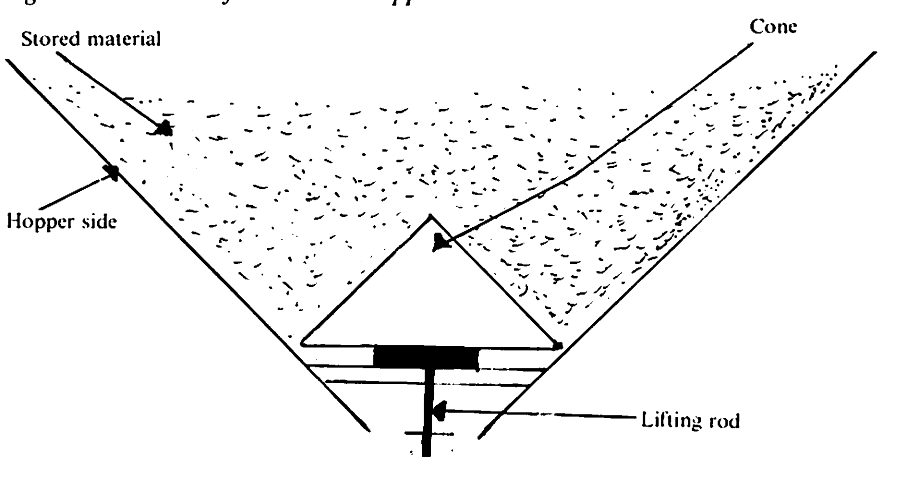
b) No further damage to hopper and silo sides through hammering.

c) No delay for client's wagons due to bridging of hopper contents, thus improving operator morale and client relationships.

d) Guaranteed full bin capacity and complete discharge thus maximising storage capacity.

Since their market launch in 1980, Matcon cones have successfully solved similar problems in mills and storage facilities around the world.

Fig 1 Matcon Cone fitted into a hopper



P Cooper is Sales Director of Material Control Engineering Ltd, Moreton-in-Marsh, Gloucestershire.

1987 MacRobert award

Citation by A Moulton

THE MacRobert Award, made since 1969, is the premier engineering prize in this country and is made annually in conjunction with the Fellowship of Engineering.

An Evaluation Committee considers submissions in relation to the excellence of achievement in areas, such as engineering, innovation, technical development, international competitive position and benefit generated to the nation.

This year the Award has been given for: "Design & Exploitation of Renishaw Probes for Metrology".

The Renishaw 3 axis touch-trigger probes and systems together with their software, provide fast 3-dimensional measurement information of a workpiece or component either in a Co-ordinate Measuring Machine (CMM): or in a Computer Numerically Controlled (CNC) machine tool, such as a lathe or machining centre. These probes, by lightly touching the workpiece and giving a signal, are capable of measurements up to an accuracy of one third of a micron.

The origins of the Renishaw business, now employing 600 people world-wide with sales exceeding £20M, are astonishingly recent. The touch-trigger probe was invented in the early 1970's by David McMurtry, now Renishaw's Chairman and Chief Executive, who had been employed by Rolls-Royce for 17 years, latterly holding the positions of Deputy Chief Designer and Assistant Chief of Engine Design for Rolls-Royce engines at Bristol. While at Rolls-Royce he was responsible for more than 30 patented inventions — so the probe, as an answer to problems in measuring aero-engine pipes, was one of many innovations from the fertile mind of this highly creative engineer.

Renishaw Electrical, as the company was known at that time, was founded in 1973 by David McMurtry and his colleague John Deer, now Group Managing Director, to produce and sell these probes, starting in the traditional pioneering way of assembling them in a room at home. Demand grew so fast that John Deer left Rolls Royce in 1974 to devote himself full time to Renishaw, followed by Peter Wells in 1975 as Chief Mechanical Designer, and by Peter Willis in 1976, as Chief Electronics Engineer. The migration of individuals from long established centres of technical excellence to start a new complementary wealth-producing enterprises should be welcomed, provided of course proper licensing agreements are pre-arranged.

The subsequent development of the range of probes and accessories include the Motorised Probe Head, which turns a standard 3-axis CMM into a 5-axis machine.

Another new product is the Renishaw Autochange System, allowing probe changers to be fitted to CMMs, much like the tool changer on a machining centre. There is also the new Laser Probe. These developments convert a CMM into a flexible inspection centre.

As even wider demand was perceived for probe systems for CNC machine tools, which could self-monitor and correct the manufacturing process itself. Unlike probes on CMMs, these probes are treated as tools themselves for automatic call-up from the machine's magazine or store. CNC machine tools with Renishaw probe systems, which include Inductive Transmissions and Optical Probe Signal Transmissions, show considerable savings: and are essential for unmanned operations.

This probe related business is handled by the Group's largest subsidiary Renishaw Metrology, and is based at "New Mills", Wooton-under-Edge, Gloucestershire where 350 staff are employed. This 19th-century one-time textile manufactory has been converted and landscaped to the highest standards appropriate for this high technology operation. The quality of the conversion has been recognised by a Civic Trust Award.

The Group as a whole is dedicated to future product innovations to maintain market leadership. Consistently 10%, and last year no less than 15% of turnover, is allocated to R & D. Patent protection is likewise strongly supported, including successfully fighting on infringement action in USA which has strengthened the Group's position in the market.

Training is given high priority. The Group sponsors "thick" sandwich courses in mechanical engineering, electronics and business studies. Graduates from these, together with the apprentices, will form a good nucleus of future innovators and managers. Importance is thus placed on furthering the links between education and industry, including open days with local schools to encourage young people to consider employment in industry.

In 1983, the year of the company's tenth anniversary, Renishaw obtained a quotation on the Unlisted Securities Market with sales of over £6M, 86% exported, followed a year later with a full listing on the London Stock Exchange. The yearly growth is such that current sales exceed £20M annually, of which 80–90% is exported. Subsidiary companies have been established in USA, Japan and West Germany to support these major markets.

In Renishaw we have an excellent example of a prospering new British business manufacturing an innovative engineering product, which is strongly exploited so as to establish world leadership in the field of metrology. Its roots are deeply planted in advanced technology.

Alex Moulton is Chairman of the MacRobert Award Evaluation Committee.

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