THE AGRICULTURAL ENGINEER

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Spring National Conference

Electronics in agriculture *Potato grading and inspection*

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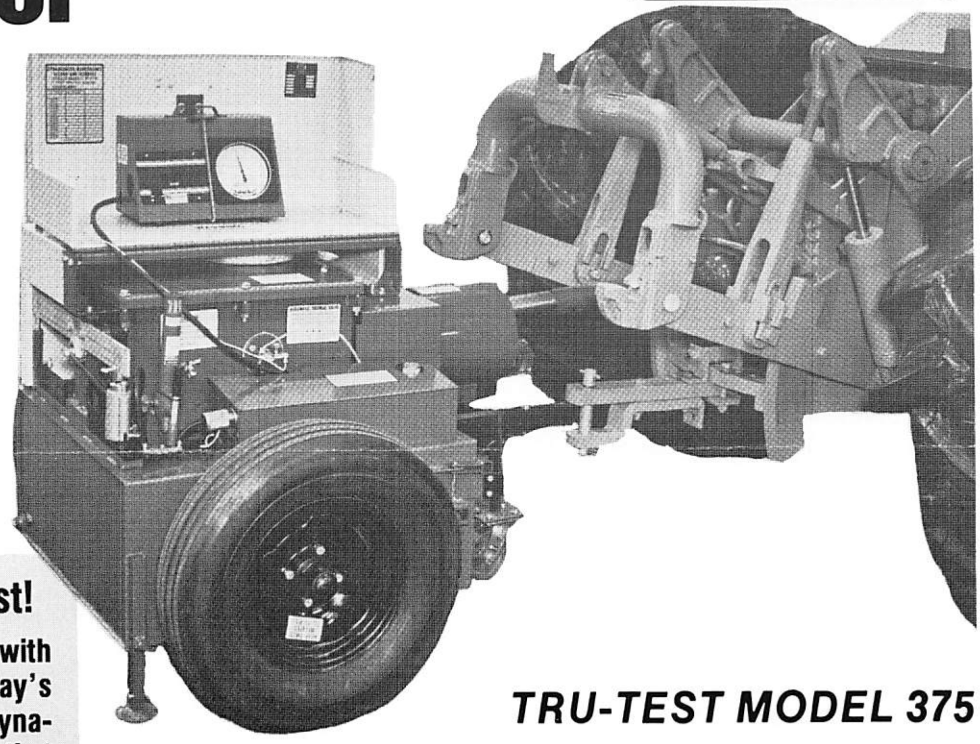

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Contents

Cover – A PDP – 8 computer and tele-printer mounted on a combine for experiments on grain loss control *(see page 42)*

Electronics in agriculture

D J Greig

THE lecture rooms and landings of Merz Court in the University of Newcastle are more accustomed to the resounding terminology of chips, microprocessors, VDU's and CMOS than were perhaps many of the 180 delegates who attended the 1980 Spring National Conference of the Institution of Agricultural Engineers, organised in association with the Northern Branch. It was, however, appropriate that, as we go into the '80s, these lecture rooms should, for once, be concerned less with all that is new in electronics than with the interests and trepidation of those who work in an industry which is seeking to apply the technology to good effect.

To many observers the introduction of modern electronics is synonymous with revolutionary, lower unit-cost production methods: food production does not yet seem entirely ready for such a revolution — but some areas of drudgery, routine monitoring with built-in control operation, information storage and retrieval leading to automatic or operator intervention in a cyclic process may lend themselves to adaptations of the new technology.

To many members of the population, looking from their controlled, often air-conditioned environment, the farmer and the agricultural scientist — responsible though they are for producing the world's food — appear as relics of the dark ages. This view stems largely from the adverse working conditions often found in farming. More than one speaker reminded delgates of the physically hostile environment surrounding most agricultural processes, and in particular surrounding livestock.

The purpose of the conference was to provide an opportunity to hear papers on specific selected aspects of electronics in agriculture and discuss the issues raised. Although our industry is not at the forefront of new electronic innovation or development it is increasingly finding itself in a position in which it can economically use established equipment and techniques from other industries. Industrial production processes may well be revolutionised by the 'chip', but the chip must meet agriculture more than halfway, before, in its adapted form, it becomes a useful and economic production resource.

Derek L Greig

The conference was conducted in two sessions. The five speakers in the morning session dealt with electronics associated with the dairy herd. Under the chairmanship of Professor Gordon Dickson, Head of the Department of Agriculture at Newcastle University, Andrew Grant, Ministry of Agriculture, London, described what the dairy herd and its manager might require of electronics. The succeeding three speakers then dealt with three practical approaches, ranging from the stand-alone DAISY computer system described by David Brooke of Reading University to the Automated Farm-Management system (AFMS 80) described by Peter Hollis and Robin Hindmarch of Fullwood and Bland Ltd. Mr Turner of Alfa-Laval Co Ltd, described his company's EDM 15 dairy herd management system. Edwin Mundy of Bridgets Experimental Husbandry Farm closed the morning session by summarising some of the successes and the shortcomings requiring further development — if systems are fully to support the herd manager.

The afternoon was devoted to the application of electronics to agriculture outside the livestock sector. Terry McCarthy of the Agricultural Engineering Department of Newcastle University dealt with those microprocessor components most likely to be applicable to agriculture and gave details of the successful use of such devices in a weighbridge and a psychrometric computer. John Palmer of the SIAE, in his paper, highlighted probable developments in electronics related to field machinery, about which there was much subsequent discussion, while George Weaving of NIAE dealt with a microprocessor system for environmental monitoring and control in greenhouses. To round off a very full day, Sidney Cox, Deputy Director of NIAE, concluded that there would be a steady expansion of computer based monitoring and control in all sections of agriculture and that personal computing systems will soon be cheap enough to be of real assistance in the farm office — if the software programmes are also made available.

In the lively discussion sessions the possibility of using implanted transponders for animal identification as part of a national scheme was well aired, as were aspects of the automatic control of tractors and implements and of harvesting machinery. The conference papers and an edited summary of the discussion appear on other pages in this issue.

The occasion provided an opportunity for electronics designers, producers and users, as well as interested bystanders, to meet together and discuss common problems and potential solutions. A great deal of this discussion took place around the commercial stands in the small electronics exhibition held in association with the conference.

There were no resolutions; it is difficult to draw firm conclusions; but the general impression was that many delegates went away slightly better informed and less apprehensive of the potential of the 'chip' and its 'revolution' than when they came.

Mr G Shepperson BSc (Agric) FIAgrE

THE Editorial Panel of THE AGRICULTURAL ENGINEER records with deep regret the death of Gordon Shepperson, who has been an active member of the Panel for a number of years. His breadth of experience, wealth of knowledge and his ready co-operation in helping to produce the Journal will be greatly missed.

The dairy herd ~ What is required of electronics?

A J Grant

Summary

THE benefits of applying automation and electronics to animal production are likely to be a reduction in labour requirement, improved management and greater control of the enterprise. This paper examines these benefits in relation to milk production. It attempts to identify areas where further automation may reduce the labour required to undertake the routine tasks associated with keeping cows. In addition, the possibility of monitoring the individual cow and using this information as a basis for optimising performance is discussed. Consideration is also given to the concept of controlling production from the dairy herd by using automation and electronics to monitor output and control input.

Introduction

THE measure of success of introducing automation and electronics into any sector of the livestock industry will be its acceptance by the user. Equipment may be purchased for status, convenience or the elimination of tedious and uninteresting work but the overriding consideration will be economic. This paper sets out to identify those areas where the application of this technology is likely to be of the greatest economic benefit. The area reviewed is restricted to milk production since the management of the dairy herd is complex, resulting from the need for a high degree of control over the individual animal. It is also the enterprise most likely to generate sufficient capital to finance investment in automation and electronics.

The dairy farmer looks to automation to improve his business in the following ways:—

1. The reduction of the labour requirement associated with the day to day task of keeping cows which may result in an increase in the number of cows managed per man.
2. An improvement in the performance of the herd resulting from greater accuracy and consistency for operations which have been automated, particularly in the areas of milking and feeding. Benefits here are likely to produce an increase in output per cow.
3. An improved profitability by using automation to monitor the dairy herd, analyse the data and effect decisions from the analysis to improve profitability.

The first section of the paper deals briefly with automation as a means of improving productivity. It is in this role that automation and electronics have already become established on the dairy farm. Later sections explore the potential of using automation as a means of both monitoring and controlling milk production. It is this last function that is just beginning to move from a concept to a reality.

A J Grant MSc NDA, Agricultural Development and Advisory Service, London.

Reducing the labour requirement

The lactating cow imposes a rigid discipline on the lives of dairy farmers; every day of the year begins and ends with milking. The extent to which milking dominates the working day is illustrated by an ADAS[1] survey which investigated the time spent by herdsmen in 20 herds on the various tasks associated with keeping dairy cows. A summary of the results is presented in table I.

Table I Labour data in milk production

Job description	*Min per cow/day**	*% of total time*
Milking	2.4	38
Milking preparation	0.2	3
Cow movement (marshalling)	0.3	4
Cleaning – parlour dairy equipment etc	0.7	12
Manure removal and handling	0.7	11
Cubicle littering	0.4	6
Feeding	1.1	16
Management	0.6	10
Total	6.4	100

**All times in man minutes*

Milking is clearly the dominant feature accounting for 38% of the total time. The time spent milking generally becomes greater as herd size increases. Milking can therefore be readily identified as an area where automation is likely to have considerable application.

The extraction of milk from the cow involves a relationship between man, machine and animal in which consistency and accuracy of operation are essential. Automation not only reduces the labour requirement but also ensures a high standard of accuracy and consistency which is particularly important in terms of feeding and determining the cessation of milk flow prior to the removal of the milking unit.

The routine tasks associated with each cow at milking include the movement of the cow into the parlour, removal and examination of the fore-milk, washing and drying of the teats, attachment and adjustment of the milking unit, determining the end of milk flow, removing the milking unit, recording the quantity of milk, teat disinfection and cow exit from the parlour. With perhaps the exception of removal of the fore-milk and the attachment of the milking unit, all the remaining elements of the work routine could be performed mechanically under automatic control. The effect that automation of the various elements of the routine has on the performance of the parlour measured in cows per man hour is illustrated in table II.

To date reliable automation has been largely confined to the removal of the milking unit, milk transfer and the stored program in-parlour concentrate feeder. As a result maximum milking performance where a comprehensive work routine is practical, has been limited to about 70 cows per man hour. Success in automating other areas of the routine has frequently been limited by the idiosyncrasies of the cows. For example, automatic control of entry and exit of cows milked in rotary parlours is inherent in the design. Unfortunately success relies on the co-operation of the cow and this has not always been forthcoming. The development of automatic teat disinfection, a necessary extension of automating the removal of the milking cluster and cow exit from the parlour, has been delayed by problems of chemical corrosion and the difficulty of getting an adequate amount of disinfectant on to a moving target which varies both in shape and size. Fully automatic teat washing and drying has yet to become a practical proposition, a manual follow-up being required to dry udders effectively and deal with excessively soiled teats. This handling of the udder prior to the attachment of the milking unit is considered by many to be a very desirable practice.

The requirement of the farmer is not total automation of the milking process but that the mental and physical effort involved in handling each cow is minimised by the use of automatic equipment. This allows the herdsmen to concentrate on the anomalous cows among those being milked. To this end there is a need for reliable and effective automatic post milking teat disinfection, automatic detection and recording of

Table II The effect of automating parts of the parlour work routine on the maximum number of cows milked per man per hour

Elements of work routine	*Static herringbone milking parlour*		*Rotary milking parlour*	
Change cow	0.25	0.15	auto	auto
Identify cow		0.05	0.05	auto
Feed		auto	auto	auto
Foremilk	0.10	0.10	0.10	0.10
Wash teats	0.20	0.20	0.20	auto
Dry teats				0.10
Attach milking cluster	0.20	0.20	0.20	0.20
Remove milking cluster	0.10	auto	auto	auto
Disinfect teats	0.10	0.10	auto	auto
Record milk yield	0.10	auto	auto	auto
Miscellaneous	0.05	0.05	0.05	0.05
Total man/cow	1.10	0.85	0.60	0.45
Maximum number cows milked/man hour	55	70	100	133

**All times in minutes per cow*

clinical mastitis and the automation of at least part of the drying process of teat washing and drying.

The ADAS survey revealed that 12% of the average herdsman's time was spent cleaning milking parlour buildings, fittings and equipment. Automated systems are becoming available for cleaning the milk contact surfaces of milking plant but the removal of soiling from external surfaces of both equipment and buildings remain a tedious, unpleasant, and time consuming task. The development of a washing system operating intermittently under automatic control which sprays water on to surfaces subject to soiling during milking would be welcome, as would a conscious attempt on the part of manufacturers to design milking equipment whose external surface can be easily cleaned.

Feeding and manure handling accounted for over a quarter of the working day in the survey. Both tasks can be automatically controlled to allow a reduction in the labour requirement. The increased frequency of operation which automation of slurry removal and the concentrate feeding allows is of considerable advantage.

The development of automatic control of essential processes such as milking and feeding must be accompanied by reliability and service consistent with the vital role that the equipment has taken from the human operator. The farm environment is generally hostile to electronic components and nowhere more so than in the milking parlour. Equipment fitted here must withstand continual dampness, extremes of temperature, soiling from animals, dust from feed machinery and water from pressure washing. Whilst farmers are undoubtedly anxious to use electronic technology to improve productivity they must be assured of absolute reliability. The disciplines of dairy farming allow little time for unscheduled repairs.

Improving management

When electronics and automation are used as a means of reducing labour requirement, the application of the technology is easily identifiable and the benefits readily quantified. When used as an aid to management, essentially a process of making decisions, the application is not easy to define and the benefits harder to assess.

Figure 1 illustrates the basic flow of information as it relates to the management of the cow.

There is a simple cycle of production with milk and changes in body weight as outputs and with food, part forage and part cereal based concentrate, as the input. For this process to function efficiently the cow must be both healthy and fertile.

Using this simple model it is possible to identify the following ways in which automation and electronics might contribute to the management of a dairy herd.

1. The monitoring, recording and storing of information relating to the output, input and health of the animal.
2. The analysis and refinement of collected data to enable its use in the management of the herd.
3. Where possible to control automatically the implementation of management decisions. This area is primarily concerned with feeding.

Figure 2 illustrates the role of these three areas in the process of management. Before expanding these areas it would be helpful to distinguish between the roles of automation and computerisation as they relate to dairy herd management. Automation refers to the devices collecting data (eg automatic cow identification, milk recording, cow weight recording) or the control of a process such as concentrate feeding. Computerisation refers to the function of an information processing machine. The collection of data by automatic devices usually requires the use of a computer to analyse the data before use can be made of it. However, since computers are essentially business machines the farmer requires their adaption by the provision of suitable programs for use in the farm business. Automatic devices will usually require custom building for use on the dairy farm.

The contribution that automation and electronics can make to managing the dairy herd can be illustrated by examining each of the three functions previously identified.

Monitoring and recording

Animal identification is the foundation stone of any recording scheme to which automation brings improvements in accuracy and the ability to monitor continuously the activity of the individual animal. It is to be hoped that the current generation of collar borne transponders with their attendant problems of loss and damage will be succeeded by a cheaper miniaturised device possibly implanted within the animal. The problems of implants may be more ethical than technical.

The measurement of milk yield and body weight change of the individual cow are catered for in the systems already being developed. However, there is a need for the automatic collection of a representative milk sample from each cow to be used for the determination of milk composition and pregnancy and in the future it could form the basis for further monitoring.

Since the dairy cow partitions her food between her maintenance and the production of milk and body tissue, a knowledge of her body weight is particularly important. Unfortunately the weight of ruminants shows considerable variation, being affected by such factors as gut fill. A mean of several weighings made over a period of several days or a week is therefore required if an accurate assessment of body weight is to be obtained. This is readily achieved by automatic weighing of cows as they leave a milking parlour and is likely to produce a series of weighings which can be used as a basis for calculating feed requirements.

The remaining area where automatic recordings has a role to play is the maintenance of health and fertility. Three conditions require monitoring:

1. Physiological state, particularly oestrus.
2. Specific infection, particularly mastitis.
3. General ill health.

There are several characteristics of milk which might form the basis for automatic monitoring of health and fertility, notably changes in milk temperature and electrical conductivity which are associated with changes in udder health and oestrus behaviour. If automated systems are developed to aid diagnosis it is essential that they produce reliable information. The maintenance of health and fertility are essential to the profitability of milk production and the consequences of acting on incorrect information are therefore considerable.

The analysis and refinement of data

The use of automatic recording systems should provide a degree of accuracy of measurement rarely obtained by conventional methods. For example, without automation it is unlikely that milk yield recording would be undertaken more frequently than on one day a week. However, as the volume of data recorded increases it becomes more difficult to analyse and use it. The storage and processing of data is an obvious application for micro-electronic technology. Although information processing machines are widely available few have programs designed specifically to meet the needs of a farmer. Machines that are capable of handling automatically collected information are still at various stages of development.

The value of automation and electronics as a means of improving herd management will be largely dependent upon the availability of suitable techniques for the analysis and presentation of information. The development of such techniques will require a considerable element of practical experience.

The detail of the analysis required for dairy herd management will vary from farm to farm but the principles remain the same. The productive life of a dairy cow is governed by a number of cyclic events, oestrus, pregnancy and lactation. It is therefore possible to construct a "blue print" for the individual cow containing the sequence and relative timing of events and actions that must occur to ensure that the individual performs to her best advantage. It is the deviation of the individual from this optimum strategy that ultimately limits the performance of the herd. The development of electronic technology should be directed to the analysis of data whereby the anomalous cow is readily distinguished from her contemporaries. The accurate measurement of her performance is by automated recording, thereby allowing remedial action at an early stage.

Controlling production

Automatic measurement of the cow's output in terms of milk yield and body weight change and of the inputs, concentrate and possibly forage feed, should allow a form of controlled production. Marginal increases in feed input can be measured against marginal increases in milk or body weight output.

In practice the relationship between input and output is not as tidy as it might at first appear. For example measuring the quantity of food offered to the cow does not necessarily indicate how much she has actually eaten. Whilst it may be possible to measure intakes of concentrate feed relatively accurately, hay, silage and especially grass would be much more difficult, if not impossible. Outputs of milk and body tissue may vary in composition as well as quantity.

In addition the efficiency of the whole process is influenced by many factors such as frequency of feeding, the ratio of concentrates in the diet, stage of lactation.

The use of automation and electronics to control input and measure output should enable the scientist to evaluate these complex relationships and the farmer to benefit from them.

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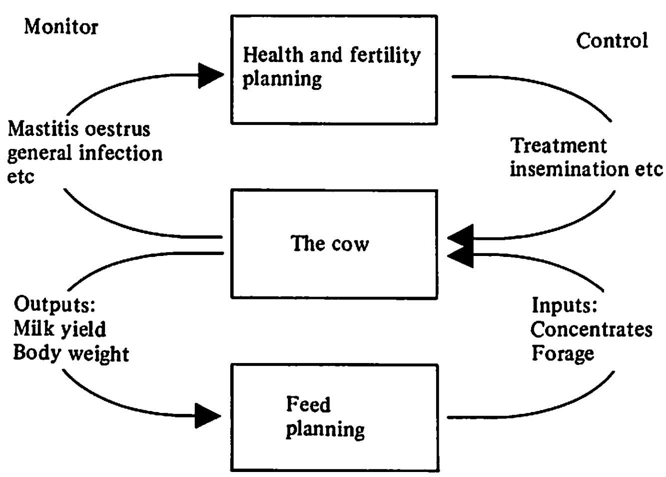
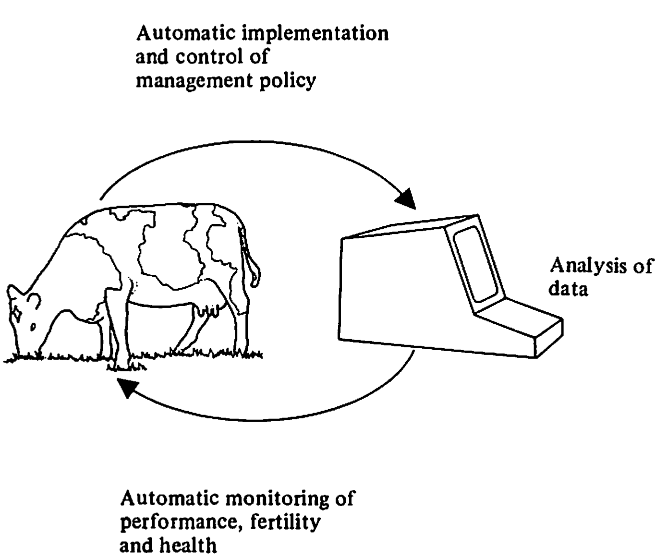


Fig 1 The flow of information required for dairy herd management

Fig 2 The application of automation and electronics to dairy herd management



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System design in dairy electronics

A J Turner

Summary

THE demands on management systems for the dairy herd vary widely in scope and sophistication. The development of an automatic data acquisition system and its connection to a management computer is described. The system makes extensive use of microprocessors and the consequences of this on the system design are discussed.

IN 1974, the Alfa-Laval Company Limited installed its first example of a dairy herd management system known as EDM 15. This was based on a microcomputer with 3K RAM, 6K ROM and a 0.25 Mb floppy disc. The system is used in conjunction with other hardware to perform automatic in-parlour identification of up to 512 cows, dispensing a pre-set ration, recording individual milk yields and operating parlour displays to provide warnings for the herdsman. Some simple analysis of the above data plus other manually entered events (primarily health and fertility) is carried out by the computer.

Over the past five years, these systems and other variants have been monitored very closely with particular regard to systems design, engineering, reliability and the social and economic effects which they had on farm management, staff and animals. In demonstrating the principle that computer technology could be taken into the milking parlour the EDM 15 must be judged a success. The nature of the installations on commercial dairy units precluded quantitative estimates being made of the contribution given by the equipment since adequate control and reference groups could not be established. In general, the acceptance of the equipment by farm staff was good provided that adequate training and understanding of the role of the equipment had been given. The threat to job security was more than offset by the increases in satisfaction given by the challenge of operating and interpreting the computer output and the removal of routine jobs such as regular milk yield recording. Without exception, the animals seemed to benefit from the consistent attention provided by the computer. On occasions obvious signs of stress were observed in both cows and men when the computer was not functioning.

With regard to engineering aspects, much has been learned and confirmed regarding the severity of the environment and the quality of materials and engineering necessary to make equipment function. The demands made on a manufacturer who wishes to achieve satisfactory times of MTBF and MTTR are very considerable.

This experience is of immense commercial value and cannot be obtained except by the long term development described above. On the basis of this experience and system problems identified in the EDM 15, it was decided to develop a second generation of equipment. The main system faults were identified as a lack of effective computer operating system and high level language. This made software modification difficult, the communication link used made attachment of additional types of peripheral hardware almost impossible and the data structure used in the computer combined with a lack of utilities meant that undetected errors and hardware malfunctions could cause irrecoverable data corruption. In view of the lengthy period for which much of the data was in use such as a 305 day lactation or one calendar year, these corruptions tended to accumulate and eventually become significant.

The second generation of equipment known as ALMICO (Alfa-Laval Milking Control System) was conceived to overcome these problems while remaining economically viable.

The system is designed on a modular basis to provide the twin benefits of flexibility in configuration and soft system degredation in the event of any particular module failing. Analysis of the range of functions which the modules should encompass was carried out by using market research techniques primarily. This showed a demand for improved management of the dairy herd by getting better information and controlling costs. Since the major single item of cost in a dairy enterprise relates to feed, it was a range of products in this area that was tackled first.

A range of three products was produced, one for the control of in-parlour concentrate feeding and two for out-of-parlour feeding. These perform an identical function but vary in the degree of information which they give and the ease with which they can be adjusted.

Extensive use of microprocessors is made and this gives the freedom to incorporate many results of behavioural and nutritional research in the system design. The alternative would have been simply to automate existing manual methods of doing the same job. As an example, the case of out of parlour feeding may be considered. Here, traditionally, concentrate is placed in front of the cows in a trough a number of times each day. Due to labour shortages this feed is often limited to one in number. Refinements may be added such as yoking the cows and dispensing individual rations of concentrate to give some control and prevent excessive consumptions by greedy cows.

There are many systems offered commercially which offer this limited degree of control. They achieve this by use of concentrate dispensing stations and identify transponders fitted to the cows.

However, it has been shown[1] that feeding large amounts of concentrates sometimes causes major changes to the pH level of the cows rumen. This has adverse effects on digestion and is often associated with outbreaks of Ketosis. Conversely, Campbell and Merilan[2] have shown that feeding seven times a day produces a greater quantity of FCM per pound of concentrate than feeding either twice or four times daily. This led to the design of a feeding programme in which food allocation was allotted to the cows on a continuous basis rather than at discrete times controlled by the clock. In practice, this means that the cow receives at least some food each time she enters the feed station. Collis[3] reports that this may be anything from six to 46 times each day, the mean value being 16 times. Thus in the Alfa-Laval "Snackfeeder" and "Alfa Feed" the little and often feeding pattern is both achieved and stimulated. In this respect, the Alfa-Laval feeding programme is unique and in tact represents a totally new level of control in cow feeding.

This control would not have been possible either economically or practically before the advent of the microprocessor. It is in the discovery of new techniques such as this that the true potential for microprocessor application is to be found.

The next area of development was that of milk yield recording. Once again, a range of products was planned with varying degrees of sophistication. This achieved two objectives, namely that of bringing the prospect of automatic milk yield recording within the range of the smaller herd and also to permit a controlled introduction of automation. The latter is achieved by field-installable enhancements to raise the level of the system. In simple terms the "Alfa Yield" product gives automatic milk yield recording based on a manual cow

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identification while the "Alfa Record" system uses automatic cow identification techniques. Both systems can be installed on either new or existing parlours.

Milk yield recording is an area where a system design has not only to be self consistent but also conform to the demands of outside influences such as the breed societies and milk marketing boards if it is to have any exterior commercial value. At this moment no milk yield records generated electronically are accepted by the milk marketing boards. Thus in producing such a system it is important that the demands of these bodies are recognised and designed in from the start. This has been the difficulty where devices such as milk meters have been imported from the USA and as such have not been designed for the British situation.

The ALMICO milk recording devices are based on the proven weighing bracket principle and also a custom designed milk meter. Another important system design point is that the milk yield recording unit or output measuring device should be capable of integration with the farmer's chosen feeding system or input control device. In control engineering parlance, this would be termed a control loop. However, the system which the farmer is trying to control is a biological one and as such may be expected to exhibit adaptive behaviour. An example of this adaption in the presence of an imbalance of feed intake and milk production is often observed in the weight loss of cows in early lactation. Thus in order to modify the response of the control system, a wider range of information is required. Cow weight is an example of such information and the ALMICO system design includes provision for such products.

A similar hierarchy to the range of milk recording products is under development for the purpose of animal weighing. This ranges from a simple manual weigh crush through to a fully automatic walk-through weigher with printed output and identification.

Other factors such as health and fertility also affect the input-output relationship of the dairy cow but the precise nature of the change remains at issue. Parameters such as body temperature or electrical conductivity of the milk are influenced by the health and fertility status of the cow. The magnitude of the changes produced by all but the most chronic attacks of illness is only of the same order as for example the effects of ambient temperature, exercise or oestrus in the case of the former and breakdown of the udder lining in the case of the latter parameter. For this reason, no products are currently under development in this area and Alfa-Laval is confining itself to a programme of basic research in animal physiology in co-operation with numerous universities and research institutes world wide. Our experience has been that the farmer who has access to such raw data as this is generally not aided at all in his management and may in fact simply be wasting expensive antibiotics and AI services.

Undoubtedly, reliable methods do exist for the determination of oestrus and mastitis for example, but the techniques of cell counting and hormone level determination are not yet applicable to the on-farm situation and may never prove to be so. In considering other indirect methods of determination, a promising technique would appear to be that suggested by Puckett[4]. This involves the use of a digital computer of significant capability and storage to look for correlations between observable parameters. This would have the effect of filtering out the incidence of the false positive and improve the accuracy of the information produced for the farmer.

It is hoped to give the ALMICO system this kind of capability by providing it with an interface to a management computer so that the vast amount of data from all the building blocks described above can be used as the input to sophisticated analysis programs in the management computer. Returned information in the form of status indications or additional action lists would form the output. A start on the development of such a link has been made with the co-operation of the Veterinary, Epidemiology and Economics Research Unit of the University of Reading. This Unit has developed a suite of management programs known as DAISY.

The intention of all this work is to produce a complete but modular farm data collection and processing system that will provide the farmer with the information he needs as a basis for both his day to day and long term management decisions. The system approach taken permits gradual introduction, controlled growth and the ability to add new developments to the system in the eighties and beyond.

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Book reviews

How to build a 'Cretan Sail' windpump

How to build a Cretan Sail' Windpump provides complete constructional details and assembly instructions for a Cretan type of windmill suitable for driving a Dempster lift pump. A lift height of 21 feet is envisaged. The mill was constructed for irrigation purposes in the Gambia during 1977 and was field tested for performance and robustness before being installed on site.

Constructional procedure is given in meticulous detail both verbally and by means of well-labelled drawings. Twelve photographs enhance the reader's appreciation of assembly and operation of the windpump.

The author describes difficulties which arose during the building and testing stages, and explains how these were overcome. Operating characteristics are presented graphically for the "test" lift-height of 14 feet.

A noticeable omission from the book is a comprehensive summary of the materials required; the would-be builder is therefore faced with the task of composing his own shopping list.

Imperial units are used throughout.

The book is surely a valuable addition to the literature of windmills and windpumps; the reader is left with the impression that this well-described prototype will have a long working life and will comfortably do the job for which it was designed.

How to Build a "Cretan Sail" Windpump, by R D Mann, 79 pp + illus, 1979. Intermediate Technology Publications Ltd, £2.95 net. Available from International Scholarly Book Services, PO Box 555, Forest Grove, Oregon 97116, USA and I T Publications Ltd, 9 King Street, London WC2E 8HN.

BCS

A Chinese biogas manual

ANAEROBIC digestion is not a new technology. It has been used, although little understood, throughout the world, but nowhere on as comprehensive a scale as China, where there are estimated to be seven million digesters. This manual is a well balanced mixture of science and practical experience gained by construction of digesters in one Chinese province. The information contained is a complete guide to the building of low technology digesters.

Digesters are referred to throughout as bio-gas pits, emphasising the energy producing aspects of the process, which, despite its benefits of pathogen and pollution reduction and nutrient conservation, tended to be ignored until energy prices escalated. The other benefits of anaerobic digestion are mentioned at the start of the book but thereafter ignored despite their relative importance in rural communities. The sections on management and use of the gas provide much useful data, but the gas use section might not meet the approval of the Gas Council. The safety section again would probably not suffice in our over regulated society, but provides working rules for people who use some common sense.

The style is at times slightly awkward, but the book is copiously and clearly illustrated and well set out, generally a publication of which our agricultural advisory services would be proud.

A Chinese Biogas Manual, translated by Michael Crook, edited by Ariane von Buren, Intermediate Technology Publications Ltd, £3.95.

The Daisy dairy information system

D W I Brooke

Summary

THIS paper discusses the factors involved in the design of the DAISY system and considers the impact of microprocessors on the future development of such systems.

Background

THE Veterinary Epidemiology and Economics Research Unit which is part of the Department of Agriculture at Reading University has been investigating the economics of animal health for a number of years. The main activity concerned with dairying has been the Melbread Scheme which has been running since 1971 and now includes about 70 herds (Esslemont, 1975). The main purpose of the scheme was to collect data from actual commercial farms and analyse this to find out what indices provided the most valuable management information. If farms are going to co-operate willingly they must be given something in return, and so it was important that the Melbread reports should form useful management aids. The Unit thus has considerable experience in producing reports in a form that suits dairy farmers. Some three years ago it became clear that batch processing of this data was causing problems. The main problem was slow turnround. Monthly reporting was giving useful information, provided that data was turned round promptly, preferably within a day or two. The second problem was that of data errors. Once erroneous data had been put into the files, not only was it extremely difficult to eliminate, but the logical inconsistencies in a cow's history which resulted could prevent the program from running at all.

The obvious solution to these problems was to use an interactive system, with data being validated at entry time, and reports being generated on request. It was assumed at first that this would be best suited to a bureau service, but it turned out that there was a strong case for using stand alone on-farm machines, and the advantages of this were likely to increase as costs fell with the introduction of microprocessors (Veeru 1978). A minicomputer was hired in May 1978 and the basic system was written in six weeks and exhibited at the Royal Show the same year. The success of this demonstration enabled the Unit to obtain sufficient funds to proceed with the full scale development of DAISY.

Data requirements

Data storage requirements. From experience with Melbread together with the results of discussions with a large number of dairy farmers and others, the following data storage was decided upon:

Health and fertility records — up to 30 events
Yield and milk quality — weekly records
Weight and condition score — four weekly
Feeding group changes — up to 30 changes.

This amount of data storage is intended for a manual entry system. An automated system would generate daily data for yield, body weight, etc, but once any short term information has been extracted from these daily figures, only weekly averages need to be retained. This short term data processing could be carried out within the automation system, or by an additional module on the management machine which need not form part of DAISY itself.

Feed data. A feed formulation program is incorporated. The rations are on file and so are the dates at which particular rations were fed to each group of cows. By tracing through a cow's group history, the program can calculate what she was fed and its cost, thus enabling a continuous assessment of margin over concentrates to be made. This part of the program is still under development. The feed programs will link to the accounting programs and can also keep track of stock levels, linking to data from feed dispensers where appropriate.

Calculation of targets. An information system will tell the manager what is happening, but it will not tell him what ought to be happening. To assist him in setting targets, a whole herd model is provided, giving predicted performance levels, feed consumptions etc. Such a model does not of course give the "right" answer, because there isn't one, but it does predict in a consistent way, and provides a stable reference point against which the manager can compare his actual performance.

Choice of machine and language

Language. In March 1978 when the first design studies were begun the range of machines was much more limited than it is now. "Microcomputers" had not yet proved their reliability, they were limited in the bulk storage available, and were almost universally restricted to BASIC. The shortcomings of BASIC appeared excessive for a large data based system, except in the Hewlett-Packard implementation, which was too expensive for us, and so we had to consider a compiling language such as FORTRAN, COBOL or possibly CORAL. Rejecting 8-bit word length "micros" meant we had to use a 16-bit "mini". These machines all offered a reasonable FORTRAN compiler, and as this was the language in which Melbread had been written, and with which our programmers were most familiar, it was adopted even though it is not the most suitable language for data processing.

Hardware

In spite of weaknesses in the systems software, our final choice was for Computer Automation LSI 4/30 machines. These are modular both up and down their range, they were reasonably cheap and they provide a 64k address range at all levels. This equipment has proved very reliable, and we have learned to live with the software bugs. The main shortcomings have been a slowness on the part of the manufacturers to bring memory prices down and to introduce floppy discs of greater then 256k capacity, and the price advantage at the low end has not been as great as we expected, but we hope that all these points are in the process of being resolved.

New machines

Though it was undoubtedly the right choice to use a minicomputer at first, the impact of microcomputers needs to be taken into account for the next range of machines. Of course we should not forget that it was only possible for us to afford a machine at all because of the dramatic reductions that microprocessors had made in the cost of peripherals.

The data processing CPU is only a small part of the system after all. In looking for a new range of machines to run DAISY, the scene is dominated not so much by hardware as by the availability of system software.

Software alternatives

We would very much like to offer a system that was machine independent, but software portability is an elusive goal. We are being asked to make DAISY available on Z-80 based machines, which presumably means using FORTRAN under the CPM operating system. This

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could probably be done, but we would need two machines ourselves on which to develop and support the system and it would still take a lot of programming effort, even though the existing source is in FORTRAN. There could also be unforeseen problems in using an 8-bit processor to run a suite consisting of nearly 20,000 lines of source code. If we could be sure of the market it could well be worth our while, but there is considerable uncertainty about how fast such systems would be taken up. A second alternative is to wait to see what the impact of the 16-bit micros will be, but the hardware is not readily available yet, and judging from previous experience, the software will be a long way behind. CAP-MicroCOBOL is also attractive. It is portable, and it is available on quite a wide range of low priced machines, though unfortunately for us this does not include CA, and anyway it would impose a massive rewriting task, which would have to be paid for.

If we stay in FORTRAN, the choice then lies between looking for cost reductions in mini systems, going to Z-80 based machines, or waiting for the 16-bit Z-8000 or 68000, whilst if we can tolerate a change of source languages, MicroCOBOL remains a possibility. However, cost reductions in minicomputer system come from cheaper memory, peripherals and disc controllers; the cost of the CPU itself will not make much difference. Any change from our present range of machines to apparently cheaper micros will inevitably involve software costs, which will not be inconsiderable. Similar arguments apply to other management systems which are on the market, and the industry should beware of under-estimating just what is involved in producing a management system of the quality necessary for managing a modern intensive dairy herd, and hence of under estimating machine requirements.

The outlook on back up storage is very unclear at present. Winchester discs will undoubtedly prove their reliability quite soon, but no convention has yet appeared for keeping security copies. A Winchester with tape cartridge back up costs nearly as much as a conventional 10 Mbyte hard disc, and it takes much longer to back up to a tape cartridge than it does to change a disc platter. A decision on the question of bulk storage cannot be made for some months yet.

User interface

Considerable attention was given to making the programs "friendly" as well as robust. The input routines were designed to be used by non specialist operators. The user is prompted through the run sequence, and stops occur to allow operator action such as disc changing, resumption occurring on the basic of a simple "Have you done it now?" question, which only requires a yes/no response. Data is entered across the screen column by column, using the RETURN key, or the ENTER key where a numeric key pad is provided. Simple validation, eg of field size, maxima, etc. is provided field by field. Errors cause the cursor to reposition at the start of the current field beneath the error, so the offending item can be seen and corrected. Full validation of course cannot occur until all the fields have been entered. Items which are the same as those in the previous line of the current field can be repeated automatically with a singly RETURN key-stroke. This is very convenient if there are several codes for the same cow, or several entries on the same date.

Output is discussed in detail under "Reports". The design principle for all the output is that it should be in a form that is convenient for and readily understood by the person who is going to make use of it. Output is only produced when it is requested, and the amount is kept to a minimum. This however, does not mean that there is not sometimes a great deal of it!

Data base design

Since it could be assumed that disc capacity would be a short term limitation, the major constraint on design was that imposed by the operating system, and the most crucial requirement here is for random access record handling. The maximum data requirement discussed above is quite large, yet in practice many cow records are quite sparse, which ideally would mean using a variable record length random access system. However, our aim was to produce a working herd management system, not to do research in software science, and it was likely that disc space was going to be cheaper than programming time, and would certainly be cheaper to come by. We therefore decided to use one record per cow, and on our machine that means 510 bytes. Here we made our first mistake, as we assumed that we would only need one lactation record per cow on line. In fact, one needs a whole year's record per cow on line, ie two lactations. What we did was to put the cow's background data, genealogy, its various herd book and other reference numbers, its previous lactation summaries etc into this single cow record. With two lactations on line this data is thus wastefully duplicated, though if one takes into account the relative sparseness of the data file, it is not as wasteful as it looks. However, it would be better to have this background data on a separate file.

Five hundred and twelve bytes may seem a record size, but we still had to use every single bit in the record to get in the data we were asked for, and we have to pack several items into a word. The main culprit is the "Melbread" data, ie the health and fertility event codes and their dates. Such events tend to crowd together in early lactation, and so the time interval between events tends to be small. By allowing six bits for a time interval of up to 63 days since the previous event, we can get this interval and a three decimal digit code (ie 10 bits) into a single word; the actual date is then calculated by summing all previous intervals and adding this to the calving date. Since a cow record is one disc record, the whole data for any one cow is in core at one time, so such calculations are not burdensome. Intervals of greater than 63 days are entered by automatically creating one or more null event codes with 63 day interval. Events do not have to be entered in chronological order; the program inserts new codes into their correct place before writing the whole block back to the file. Packing in some form is employed for all the data types.

Directory

Cows are referenced internally by a three digit cow number. This may also be used as the actual cow number and we have managed to persuade all the present users, who now include some 40 herds, to accept this convention. Should it prove an insuperable problem to a particular herd manager, we could devise a suitable hashing algorithm to map the cow numbers used in the herd to the internal numbers. The archiving program will print on request a list of all numbers currently not in use, so difficulties seldom arise in practice. The directory contains the cow number and six flags for important items, eg in milk, in calf etc together with the relative record number within the data file, and it is always core resident thus permitting rapid access to any required cow's record. This has proved to be our second mistake; more data should undoubtedly have been included in the directory, notably calving date, and possibly also feeding group and lactation number. These items are the commonest keys for the first level of sorting, and their inclusion in the core resident directory would greatly reduce the number of unnecessary disc accesses during report generation.

Data validation

As discussed earlier, a prime aim of the system design was data validation at entry time. Every item that is entered is checked for logical consistency with the existing records for that cow, eg PD+ to a particular service requires the existence of records for the appropriate number of services; retained placenta or milk-fever can only occur within realistic times since calving; milk yield entries are converted to equivalent weekly percentage change in yield, and are flagged if this exceeds a predetermined value, and so on. This means that data which actually gets written to disc are probably at least as good as, and very likely better than is the case with purely manual records. A separate program is used to enter each type of data, eg health and fertility, milk and quality, feeding group changes etc. Each entry program contains an edit program for that type of data which performs the same checks, so it is not possible to break the logical rules by amending the data. These programs are large — the health and fertility data entry program only just loads into 64k bytes.

All data entry items that are accepted are printed out before they are written to disc, so a listing of the latest updates is always available. Two back up copies of each data disc are kept, and the programs will not run unless a back up copy has been taken within the previous seven days.

Reports

It is always a problem to decide how much freedom to give the user at report time. For example the system marketed by Farmplan has an elegant scheme whereby the user can select from all the items available and print those of current interest. DAISY has adopted the different convention of providing a very large range of standard reports, though these are of course only printed on request. These reports are designed to support a constant philosophy of desirable and effective dairy herd management practice. As far as possible there are two major versions of each report, one a summary on A4 size, and one a full report using all 132 columns.

In the cases where the user can usefully interest with the output program, a simplified output can be sent to the VDU before a decision is taken to print. The most powerful feature of the report generators is an optional multi-level sort. Thus cows can be sorted at a first level by, for example, cow number, lactation number, calving date etc and within this first selection they can be sorted again by any other criterion which is appropriate. For example, an action list of cows requiring veterinary attention might be sorted first by group, so it is easy to find them, and then by cow number so it is easy to identify them. When studying performance records, particular factors can be highlighted by a judicious choice of sort option. All these are in-care sorts and are processed faster than the printer speed, so they do not introduce delays. A list of currently available reports is given in the Appendix.

Environment

One of the assumptions made at the start of this work was that on-farm computers would become cost-effective, and DAISY was therefore designed primarily as a stand-alone "hands on" system. Of course it can be run as a bureau with terminals, but we argue in the feasibility study (Veeru 1978) that this will be more expensive and less satisfactory than stand-alone, and experience seems to confirm this.

An alternative which is possible, and which was considered from the start is that of several users sharing a single machine, but in single user mode. For this to work the users need to be reasonably close geographically and, perhaps more important, they must form a close knit group. One way in which this can be achieved is for the computer to be based in the vet's office. To take advantage of a management information system of the power of DAISY, management standards must be high, and the herd must already be under good control. Such herds will be receiving regular visits from their vets, probably weekly, so their data can be collected with little additional effort. Also, with tight management and control, weekly data entry and analysis from DAISY is satisfactory, provided turn around is fast, preferably on the same day. This system is running very well in two practices with a total of some 16 herds. It takes well under two hours to do a complete run for a single herd. One practice also runs its client accounts on the same machine.

The machine can also be sited at any convenient office for shared use. There is a group consisting largely of herds which are co-operating in the Estrumate trials, and these are processed on a machine at Reading. Where the herds are physically close, the farm secretaries come in and run their data themselves, which is the most satisfactory method, but outlying herds are run by Veeru staff, receiving data by telephone, and posting back the results.

In a herd which is under good management control, the loss of an immediate hands-on facility does not seem to be a serious disadvantage. It would be convenient if a manager could use the machine whenever he wanted to answer specific questions, but if he really needs to do this, the herd is probably in trouble.

There is beginning to be a demand from veterinary practices which have a heavy accounts burden for a multi-tasking system, permitting DAISY and accounts to be run simultaneously. Here one can almost make a case for a second machine, but it is still just cheaper to fit a large disc to a single machine. It does put greater pressure on the systems software however and such a system would need to be supported by a competent software house.

Links to automation

A powerful minicomputer could run a management system such as DAISY and control an automation system at the same time in a foreground/background mode. There is no way however in which this would be worth doing. The system design would be difficult, wiring costs would be high and centralisation would reduce reliability. What the microprocessor has allowed us to do is to put the intelligence where it is cost-effective. This means that a milking and feeding system, or indeed any production process system, can consist of a number of autonomous blocks which can function most of the time on their own. These blocks need to report only infrequently — probably daily — to the management data base and would only need occasional supervision and adjustment. The data rate between blocks is drastically reduced, and system integrity is increased.

Such blocks will undoubtedly be designed around stored program logic, ie microprocessors, though we should not forget that discrete logic can still provide a cheaper solution in certain cases. This does not mean that the installation becomes a "multi-processor system" any more than a computer and its peripherals are a multi-processor system. There is probably more microprocessor power in the peripherals than in the data processor itself in many modern systems, but none knows — or cares — about the presence of the others.

Problems can arise when a block needs to send data to the management system. This is not so much a timing problem, but rather the necessity for having the correct program and data file on line at the correct time, which once again is a problem of providing sufficient on line back up store. Since the automation blocks are autonomous they will probably only run a single program with a single storage file. The management computer can then interrogate the blocks as and when it is ready, and the problem is avoided. Should the management system fail to do this for some reason, it is quite a cheap solution to dump the files at the automation blocks to local printers; but if this is a rare occurrence the data could be scrapped.

With non automated systems, the weekly entry currently used on DAISY is adequate. No significant improvement in management control will really be possible until more information is available. We require yield, body weight and feed consumption daily, and probably temperature as well. No one of these is of much use without the others since all these factors have such a poor signal to noise ratio that extensive signal processing and cross-correlation is required for valid decision making. Given such automatically collected data with daily analysis, much greater management control will be possible, and managers will be able to spot trouble before if becomes serious.

Conclusions

DAISY is a powerful and successful dairy herd management system which satisfies most of the needs of managers and veterinary practices. Though designed for manual input, it is possible to accept automated inputs, but as much data reduction as possible should be performed within the automation system. To make full use of such comprehensive software, it is important to provide sufficiently powerful hardware on which to run it.

Appendix

Main DAISY facilities:—

1. Data management — Data input and editing
2. Action lists — Cows due to be dried off
   Cows due to calve
   Cows not served
   Cows PD — and not served since
   Cows served and not PD
   Abnormal events after PD
   Vet list
3. Recent events — Cows leaving herd
   Cows dried off
   Cows calved
   Cows having pregnacy/reproductive examination
4. Data review — Lactation graphs
   Lactation summary
   Quick data review (screen only)
   Print cow data
   Herd fertility summary
5. Brinkmanship — Herd milk production summary

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A microprocessor controlled farm management system

P Hollis and R W Hindmarch

Summary

THE authors discuss the difficulties presently facing managers of large dairy herds in the collection and recording of data essential to the efficient running of their enterprises.

An automated farm management system is described and a method of automatic cow identification discussed, which takes place in the milking parlour — to automate both concentrate feeding and milk yield recording.

On exit from the parlour, cows are identified and weighed on a walk through weigher.

All the information automatically gathered is routed via a parlour control unit in the milking pit to the management computer and magnetic disc store in the farm office.

IT is extremely important for the efficient management of a dairy herd to be able to collect as much information as possible both on the herd and on indidivual cows, during and following the milking process. For instance, milk yield recording, health records, fertility information, individual

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concluded from page 34

		Weekly management report Feed list for all cows Averages by group, lactation of month of calving
6. Cull sorter	–	Selection by various factors, runs interactively
7. Feed package	–	Ration calculator. All Bulletin 33 Feeds and others on file. Permits interactive ration calculation
8. Under development	—	Herd model for target setting and "what happens if" investigations.

References

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cow weights and feeding etc. As an example (Esslemont R J, 1978) taking a herd of 250 cows, if milk yields were to be recorded on two milkings per week the number of *manual* key entries into a computer would be in excess of 539,200 per annum; for milk quality (monthly) 52,800; for health and fertility, key entries would exceed 57,600 per annum; weight and score would be in excess of 67,200 key entries.

Genealogy and feeding and any other information would be in excess of 62,000 key entries, in all giving a total exceeding 778,000 key entries per annum for such a herd.

It must be accepted that if one is recording at two milkings out of 14 each week, decisions would be based on only 14% of the total information available. Even this limited percentage involves in excess of 10,000 manual key depressions per week with a high risk of error on entry.

This is one of the reasons why for the past two and a half years, Fullwood and Bland Limited, have been working in conjunction with their associate company Ellesmere Electronics Limited, on a system of automatic collection and storage of information, based on a development by the National Institute of Agricultural Engineering, Silsoe, Bedfordshire. A suite of programs is being developed to provide analysis on a herd basis and individual cow basis to aid management of dairy herds.

This microprocessor based system is called the AFMS 80; that is the Automated Farm Management System for the 1980's. The first fully automated system on a 16/16 herringbone low level recorder installation for the Ministry of Agriculture Fisheries and Food, Bridgets Experimental Husbandry Farm, in the south of England is scheduled for completion in spring 1980, a second system to control two rotary milking parlours, a rotoradial and a rotary abreast is also at present being installed at the National Institute for Research in Dairying at Shinfield, Reading. A third development system is in operation at the Bedfordshire, College of Agriculture Farm at Silsoe, Bedfordshire, under the control of the National Institute of Agricultural Engineering.

The principal areas of milking parlour automation are:—

1. Cow identification.
2. Milk yield recording.
3. Cow weighing in a walk-through system.
4. Concentrate feeding in-parlour, using gravimetric feeders; and the feeding of concentrate in out-of-parlour feeder dispensers.

Cow identification

Each cow wears a plastics strap with a transponder around her neck, fig I. When the cows are standing in the parlour (fig II), each transponder II(b), is in close proximity to a manger energising coil II(c)(Street M J, 1979). The closure of the cow entry gate initiates the energisation of each manger coil in turn which has the effect of energising each transponder coded with a unique identification. The identification signal is transmitted by the transponder to an aerial II(d) in the parlour at a frequency of just under 27 megacycles per second. The signal is received and passed on to the identification microprocessor unit II(a) where it is verified. This identification is then available for any other part of the system which may require it, for example, automatic milk yield recording. The identification system operates sequentially, energising each manger coil in turn until all identities have been received and verified. The opening and closing of the entry and exit gates

Fig I Cow at feed in parlour. Transponder carried on the plastics neck strap is adjacent to the manger energising coil

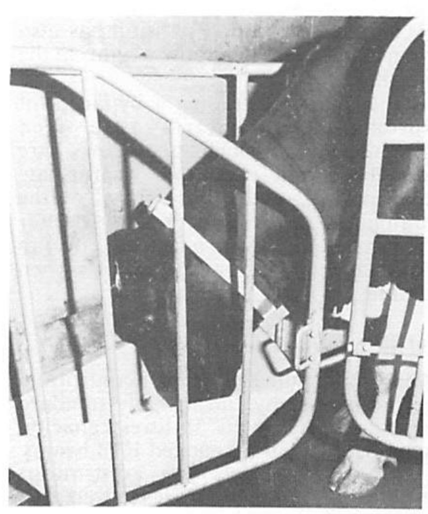
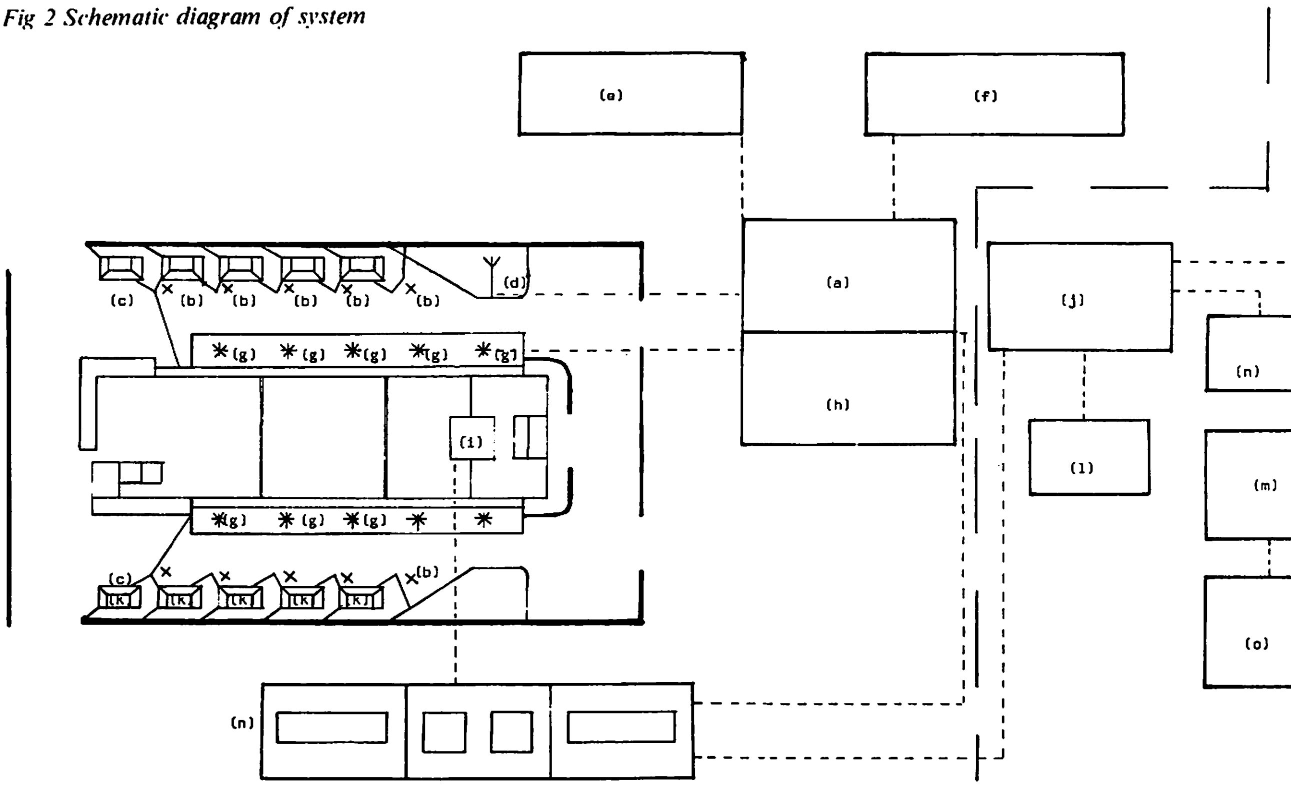


Fig 2 Schematic diagram of system



(a) Identification microprocessor unit; (b) Cow identification transponders; (c) Manger energising coils; (d) Aerial; (e) Weigh crate in exit passage; (f) Out-of-parlour feeders; (g) Strain gauged load beams; (h) milk yield microprocessor; (i) Parlour control unit microprocessor; (j) Farm management computer; (k) in parlour feed dispensers; (l) Floppy disc controllers; (m) Visual display unit; (n) Printer; (o) Typing terminal

automatically separates the sequence of events between groups of cows.

The identification microprocessor II(a) controls the following equipment (see fig II):—

(b) Cow identification transponders.
(c) Manger energising coils.
(d) Aerial.
(e) The weigh crate in the exit passage.
(f) Out-of-parlour feeders.

The external weigh crate (Filby *et al* 1979) also incorporates a transponder energising coil and the cows are weighed by means of a load cell as they walk over the crate.

Many problems are encountered when weighing animals on the move, but these have been overcome by transferring the readings to the management computer which analyses them, and rejects any spurious weights. Within any 7-day period the weight of all the cows is accurately recorded. Provision has also been made for reading cow weights at the weigher.

Out-of-parlour feeding is by means of automatic gravimetric type feed dispensers at which the cows are identified and fed the appropriate concentrates, under the control of the management computer. A further refinement is the inclusion of an automatic gate to protect the cows when feeding.

Milk yield recording

This is under microprocessor control and recording is by means of standard recorder jars (up to 33 litres capacity) supported on strain gauged load beams, II(g). This allows for continuous monitoring of the recorder jar weight.

When the teat cups are applied the weight of the jar is automatically registered and milking then starts. When the teat cups are removed, either manually or automatically, the gross weight of the jar and the milk is then registered and the milk yield microprocessor unit II(h) subtracts the initial jar weight from the gross weight giving the net weight of milk.

The continuous monitoring of milk flow from the cow will enable the replacement of current automatic cluster removal milk flow detectors, as the strain gauge bracket and microprocessor unit will accurately determine the time to remove the teat cups.

Provision is also made in this system for the logging of other variables, and for future commercial development. For example, milk temperature at the claw for possible oestrus detection and milk conductivity for possible mastitis detection, as and when this technology is sufficiently advanced.

Parlour control unit

The parlour control unit II(i) is the third microprocessor unit and has three essential functions:—

1. It allows intercommunication between the identification and milk yield recording sub-systems and the farm management computer II(j) in the farm office.
2. It is in control of dispensing parlour concentrates from in-parlour dispensers II(k).
3. It is the communications link between the milker and the farm management computer. It has a central control station for the milker in the pit with facilities for keyboard entry of cow identity stall position, feed ration etc. This keyboard facility is repeated along the pit for operator convenience.

Provision is made for notebook entries of individual cow information, for example, cow number — 'mastitis' or 'pregnancy events' etc. The operator communicates with the management computer by keying in the cow number and pressing the appropriate key signifying the note he wishes to send.

A 40-character alphanumeric display panel is located to the right of the keyboard. This is designed with large, easily read characters, and messages in plain language from the management computer sent via the parlour control unit are flashed continuously on the display relative to any individual cow in the batch. A light is located at each cow position and if there is any message relative to an individual cow the appropriate light is illuminated. The operator need only press the button next to the light freezing the message on the display. He acknowledges the message by again pressing the button, indicating to the management computer that action has been taken.

Typical messages are:—

'Reject Milk — Colostrum' or
'Reject Milk — Antibiotic' etc

Notebook information from the milking parlour can be communicated to the management computer by the operator who simply presses the appropriate buttons. For example — stall number — suspected oestrus, suspected mastitis; or milking performance reports such as dry cow — milk dumped etc.

The message is echoed on an alphanumeric display to the left of the keyboard in plain language for verification purposes.

The system is designed to be self-monitoring and if there is any failure the system reports this to the operator and to management.

Packaging of systems

The three microprocessor unit sub-systems, that is, the identification, the milk yield recording and the parlour control unit electronics, are all housed in one cabinet fitted adjacent to the parlour. The link between these units and the management computer is by means of a single telephone style cable to the farm office.

Management computer

The management computer is a purpose built unit located in the farm office and is designed to allow continuous communication with the milking parlour via the parlour control unit.

The management system comprises:—

1. A microprocessor based management computing system II(j).
2. Floppy disc controllers II(1).
3. Visual display unit II(m).
4. Printer for hard copy information II(n).
5. Typing terminal II(o).
6. A 24-hour digital clock.

Data and programs or analysis of herd performance etc are held on floppy discs. Three floppy disc drive units are located in the management desk.

Management tasks are carried out automatically by the system so as to create, access, up-date and manipulate files which may be subsequently required for analysis or simply for listing purposes.

At each milking new space on the file is created for incoming data and the appropriate reference files are accessed.

The assimilation of this new data at each milking into aggregate files for weekly and monthly statements is part of the normal housekeeping operation performed automatically by the system.

Simultaneous communication is possible with up to six separate milking parlours, to one farm management computer via land line or telephone lines.

The management system is designed so that tasks such as data entry, data recall, data processing and analysis, all appear to be carried out concurrently with the operation of the milking process. This ensures that no constraints are placed on the normal routine of the milking operation, and allows for complete flexibility in management.

A suite of programmes is being developed on discs which it is considered the herd manager will require to efficiently manage his herd. These fall into two categories:—

(a) Information provided automatically in the form of reports such as "dated daily herd report" and "dated weekly report".

(b) Information required on request only, such as "individual cow query", "lactation summary", "dry cow list" etc.

The computer is programmed by floppy discs, and as new programs are created, such as farm accounts, payroll, etc, these can be provided to existing users to increase the versatility of their system.

This accurate analytical information, based on data most of which is automatically fed into the system, will allow the farm management to make speedy decisions with confidence. This will have the effect of increasing the efficiency of management for example, by pin-pointing from which cows to breed, which cows to cull, the most effective method of rationing of concentrate feeds and provision of individual cow and herd health records. All this information will be available on hard copy on demand, as required, *not as an historical fact some three to four weeks after the event.*

The AFMS/80 system has been designed in modular form. Thus farmers may choose whichever module from the system is best suited to their requirements. For example, a module recently launched is automatic milk yield recording. This can also be enhanced with a memory bank feed controller and together the system would provide for manual identification (using a keyboard), automatic feeding and automatic milk yield recording. This can be provided with a print out facility as required.

Whichever module is chosen, others can be added as and when required.

AFMS/80 can give an insight into the performance of the herd previously unobtainable except by employing large numbers of staff, and it is felt that the introduction of the system will make the management of large dairy herds much less of a highly skilled art and much more of a science.

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Electronics and the Bridgets dairy herd

E J Mundy

Summary

An automated farm management system based on microprocessors is currently being installed to assist in the recording of data and for use for management purposes of the 250/300 cow dairy unit at Bridgets EHF. Such a computer offers considerable potential for monitoring milk yield, health and controlled feeding of the individual cow. Bridgets EHF is setting out to evaluate the practical value of such a computer system, which is described, and to determine how such information can be used for management purposes. At the present time installation is not fully complete and certain difficulties have been encountered. Reference is made to problems of construction in relation to the environment of a milking parlour. It is not possible to draw any firm conclusions from experience so far gained.

Summary

BRIDGETS EHF is a farm of some 427 ha, the soils for the most part are relatively thin calcareous loams overlying chalk and typical of the soils of the Hampshire basin. Farming in this area is principally cereals and dairy cows.

The dairy herd at Bridgets numbers about 270 milking cows managed as a single unit, some animals of which are being used in experimental studies. The herd in its present form was built up in the late sixties and is predominantly Friesian but during recent years a number of pure bred Holsteins have been acquired.

A new 16/16 dairy parlour was brought into use in late 1978, this is of standard parlour design with a few additions. At that time it was decided to install the AFMS 80 being developed jointly by the National Institute of Agricultural Engineering, Ellesmere Electronics and Fullwood and Bland Ltd, aided by the National Research and Development Council. The development work in this particular area is being led by Dr Allen Burgess of the NIAE who is responsible for much of the initial work and design.

The installation at Bridgets is one of the first of its kind. As such one must inevitably expect to experience some of the development problems of a new concept and organisation.

The AFMS 80 in the Bridgets situation is to function within the new one-man operated parlour and to enable the herd manager and the technical staff to obtain the best output from the parlour and procure better detailed information and managerial control of the unit.

The system provides for:

1. Individual cow identification at the stall
2. Recording milk production at each milking
3. Control of individual feeding within the parlour with provision of out of parlour feeding
4. Individual liveweight recording at point of exit from the parlour.

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For management purposes the system provides a parlour control unit which is to be used as an "electronic notebook" to bring to the attention of the dairyman any particular aspect of an individual cow which requires his attention — for instance if action has to be taken regarding dumping milk, or oestrus due. In the same way information will be brought to the cowmans attention where the yield of a particular cow is deviating from its norm. It also allows the dairyman to enter information relevant to a particular cow.

Since the AFMS 80 provides for storage and collection of yield data it can be so programmed to control the level of concentrate feed made available to the cow in the parlour. It will thus be possible to feed cows individually according to production, liveweight and stage of lactation using the standard gravimetric feeders now available.

The possibilities subsequent to the accurate measurement of a cows performance either as a member of a group or as an individual are many — and it is this use of data available that is to be an important feature of the work at Bridgets.

It is still much too early to assess the success or failure of the plant at Bridgets and when such a conclusion can be drawn then it may reflect more on ability to manage the system than on the system itself. The co-operation of the parlour operator is most important. Time will give answers to such questions. But it must be true that the success of such a system once correctly installed will depend largely on the use to which it can be put.

Cow identification

The first requirement is an electronic aid of this nature is that cow identification can be captured easily and reliably throughout the animals life once it enters the dairyherd. The system at Bridgets uses a transponder mounted on a neck band which is energised by a coil. At Bridgets this is placed on the front of the parlour manger and also as a loop on the cattle weigher. As the cow lowers her head to the manger in the parlour or passes through the loop on the cattle weigher so the transponder is energised and transmits a radio signal which can be identified as peculiar to the individual cow. Two very practical problems arose during testing of this item:

1. Any construction stress within the transponders occasioned when it is assembled will make itself apparent over a period of use on the cow. It must be able to withstand the environment in which a cow lives and to stand up to the shocks to which it will be subjected.
2. The identification system is now proving to be reliable and the manufacturers are now recognising that each parlour and building will be different in structure and design and the amount of metal work it contains. The radio signal and aerial position can be affected by metal structures and this could lead to problems of correct signal identification.

Milk yield

Each jar is mounted on a strain beam which enables the weight of milk held in the jar before release to be accurately recorded. This information is stored in the computer where a print out for each milking can be obtained. The computer is programmed to retain such information for seven days and to summarise data for a permanent record as a weekly mean. Any cows whose yield on a given day differs from its normal pattern can be identified.

A practical consideration is that the parlour environment calls for particular attention to be given to adequate insulation to protect the components from the wet and humid environment of the parlour pit.

Parlour control unit

In the pit there is a small visual display unit of 40 alpha-numeric characters plus a key board and echo display so that direct entry of information into the management computer can take place from the pit, eg treatment for mastitis. Similarly information relevant to a particular cow will be made available to the parlour when a light by the individual cow standing is acknowledged. Thus such information as oestrus — due for service, mastitis-reject milk, will be instantly available to the milker. Particular points relevant to a cow can be fed back into the computer by means of the keyboard and be retained for reference for future milkings. Together with specific health information fed into the computer a complete dossier on the health of a cow can be built up and used to determine culling etc.

Feed units

The parlour gravimetric feeders are proving accurate and reliable and are to be connected to the computer so that feed may be directly related to stage of lactation and individual yield. There would appear to be no good reason why an out of parlour feeder could not be controlled in a similar manner.

Cow weight

As cows leave the parlour a walk through load cell weigher is incorporated in the exit race. This is fitted with an energising coil loop so that cows are individually identified and the cows weight recorded. It is considered that a 60% accurate capture of identity and weight is possible. By comparison with previous weighing the computer will reject weights which show substantial variation from the mean for that animal and which are clearly incorrect.

As the total information is built up so it is hoped the computer will be able to be used effectively for a wider range of management decisions.

The value of the application of electronics and microprocessor computers to the dairy unit depends on the skill and ability with which it is used. It can only give guidance as reliable as the information it collects or which is fed into it.

The operation of the unit at Bridgets is not sufficiently advanced to be able to draw any conclusions as to its commercial value. It is reasonable to expect that if used intelligently it should make parlour operation easier, but one can foresee difficulties if it is viewed with suspicion by any operator who may be called upon to work with it.

For management purposes there are undoubted advantages on offer in the use of its facilities to record milk yield accurately, identify animals peculiarities, monitor lactation against a herd or individual standard and control level of feed.

In this early stage patience is required in order to identify and rectify faults in prototype equipment and in the build up of information on the most profitable use of the facilities it can offer.

Management systems
(not operational until spring 1980).

The management system has been designed using advanced concepts to allow asynchronous communication with a number of peripheral devices including the parlour control unit. Interactive communication with the system by the herds manager and others is by the visual display unit (VDU) and the printer.

Herd data and programs for data analysis of herd performance are held for access on floppy disc drive units. Systems provision can be made for communication with other computing installations through post office lines under modern control.

The system works under a multi-task, multi-job executive such that particular tasks of data entry, recall data processing and analysis may appear to be obeyed concurrently with parlour operation.

The management system will therefore comprise:

1. Microprocessor system based management system
2. Floppy disc controllers
3. VDU terminal with keyboard
4. Printer
5. 24-hour digital clock.

Management analysis will provide:

1. Dated daily herd report
2. Dated weekly report
3. Dated monthly lactation report
4. Lactation summary
5. Individual query
6. Yield prediction
7. Feed calculation
8. Fertility record summary
9. Presentation of clinical records
10. Summary of pregnancy and fertility events
11. Summary of abnormalities
12. Update of basic herd data
13. Productivity analysis comparative performance.

The foregoing list includes facilities not available initially but which will become available. The task that Bridgets will have to face is one of practical evaluation of the programme in which Bridgets have played a great part in developing.

Cost

While the costs incurred in the production and installation of a microprocessor system at Bridgets may not reflect the normal production cost it is important that some cost evaluation is carried out.

Improvements in herd performance and management must give sufficient return to pay for the cost of a management system and this will be assessed in relation to the Bridgets herd.

It should be possible to extend the use of such a complete system beyond the immediate requirement of the dairy to embrace other aspects of farm management such as stocktaking records, preparation of accounts and wages etc. However, wider use, although holding considerable interest, is not featured in the current programme of development work at Bridgets but must follow the satisfactory performance within the dairy.

Letter

Agricultural medicine

THE object of this letter is to determine the potential professional interest in all aspects of agricultural medicine in the United Kingdom and hence to consider the possibility of forming a British delegation to the International Association of Agricultural Medicine and Rural Health.

Agricultural Medicine incorporates the recognition, identification, diagnosis, prevention and treatment of such conditions in man which are contracted or precipitated by his involvement in any aspect of agriculture, or land based work.

Those ideally placed to practise it are doctors in rural areas, together with their hospital colleagues; veterinary surgeons and agricultural engineers, backed by toxicologists, epidemiologists, environmental health officers, work science practitioners and others whose skills relate to occupational health on the land.

Considerable interest in the subject has already been demonstrated in Europe, a diploma being available from the University of Tours. The International Association of Agricultural Medicine and Rural Health, founded in 1961 has held triennial conferences both in the western and eastern hemispheres. Some 30 countries are represented and a quarterly journal is published in Japan. Important academic and clinical data has been assimilated.

In this country, occupational health is represented by the Health & Safety Executive, an advisory service, legislation limiting itself to regulations for minimum standards to control hazards with the provision of treatment in case of illness.

Occupational health services available in industry in general are provided privately. None exist in agriculture, one of our largest single industries; neither is co-ordinated formal teaching available in the subject. Limited research projects of high quality have been carried out, usually in isolation, without liaison with colleagues in clinical practise.

In Great Britain 80% of land is given over to varying agricultural work in areas of low density population. Those who work in it have an excellent record of productivity, producing two thirds of our food requirements. Both their, and our nutritional health depend on farming methods as they affect biological microprocesses from soil to food.

Fatality in farming is the highest group involving children. In 1978, 73 people died, of which 16 were children under 16 years of age. Morbidity of those in rural areas gives rise to concern, particularly for the very young and the old.

Man's use of hand held tools over a long period of trial and error produced optimum physiological relationships. The relatively recent introduction of large and complex machinery can result in psychic and physical stress.

The inefficient handling of toxic farm chemicals is productive. of human symptomatology and malaise of which more clinical awareness is necessary.

At the start of the century a small number of animal transmitted diseases were recognised. Now over a hundred are known and it is apparent that the animal world, now stressed in intensive production, is the nidus of much human infection. In areas of poor hygiene there is the added problem of intestinal antibiotic resistance.

The newly formed Rehabilitation Trust of Great Britain has given agricultural medicine its first official recognition. A short term objective is to study the rehabilitative needs of the agriculturist, a longer one is the founding of an Institute of Agricultural Medicine, to co-relate and encourage research, provide an information service and to teach.

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The microprocessor in agriculture - two applications

T T McCarthy

Summary

MANY future applications of microelectronics in agriculture will require relatively small systems without mass storage. The design/selection of such systems is considered and two current applications, both in the design/development stage, are briefly described.

Introduction

AGRICULTURE is beginning to come to terms with the application of electronics. The recent advances in microelectronics technology have produced microcircuits of wide ranging application — the most recent of these being the microprocessor. Microcomputers are programmable digital devices which, when connected to the outside world through appropriate circuitry, make available powerful logic and arithmetic capabilities in a small package at relatively low cost. Systems based on this technology are currently commercially available for dairy herd applications[1,2,3] — an application area where significantly different approaches are discernible. There are many other areas in agriculture where this technology can contribute to the overall control and management of an operation or process:

(a) **Field machinery**
There are many possible applications on tractors, combines etc[4] and there are indications that manufacturers are attemping to solve some of the transducer problems[5] which must be overcome before significant advances can be made.

(b) **Environment control**
During the next five years there will be significant developments in the commercial exploitation of microelectronics in livestock housing, greenhouses[6,7] drying and storage systems. The Dutch have been addressing the greenhouse problem for some time and many minicomputer based systems have been installed. The emphasis must now be on the derivation of suitable models for what are essentially distributed systems requiring adaptive control[8].

(c) **Portable instruments**
A likely growth area will be the development of hand-held moisture measuring devices for both cereal and forage crops.

It is important that due consideration be given to the design and/or selection for these possible applications.

System size

The current commercial applications all require mass storage (floppy discs), some are minicomputer based and others require from one to four microprocessors. Such systems cost many thousands of pounds and require a reliable mains electricity supply for their operation. One can envisage that many applications in environment control could justify such a capital outlay and provide a suitable power supply but such an approach will not in general apply to field machinery or portable equipment applications. The requirement will be for a low cost, well below £1000, battery powered system of high reliability.

System selection

For a low production new designs can be based upon single-board microcomputers which are produced by many companies (eg Intel, Motorola, National Semiconductor). However, many of these boards require a power supply capable of delivering, typically, 2.5 amps at a very steady +5V although one single board system (BLC-80/204) produced by National Semiconductor requires all of the following:

4.9 amps at +5V
0.18 amps at -5V
0.35 amps at +12V
0.02 amps at -12V

Such single-board systems do not include the interface circuitry to connect to analogue systems ie to make measurements.

If such systems are unsuitable then it is necessary to design a system starting at the chip level. Selecting a microprocessor chip is a bit like choosing a car: you *either* buy it because you like the name and the colour *or* you make a detailed comparison of the specifications of available systems. A list of midrange microprocessor chips is shown in table 1[10]: Architecturally however, most of these are equally suitable for systems requiring input/output at moderate speeds with a moderate amount of processing capability. For many applications therefore the decisions reduce to:

(a) Are there any special requirements eg high speed operation, lots of arithmetic processing involving multiplication, division etc, low power consumption?

(b) Are there suitable support chips/memory chips available with reliable delivery and backup from the manufacturer?

(c) Has a significant investment already been made in hardware, software, development systems etc. which would suggest the use of the same family of devices?

Many field/portable applications will be required to operate from battery speeds in what could be electrically noisy environments. This would bias the selection towards CMOS (complementary-metal-oxide-semi-conductor) microprocessors.

It is evident from table 1 that most of the units listed are NMOS with only two CMOS families: the RCA 1802 and the Intersil 6100. Table 2 provides a comparison of CMOS and NMOS technology: the low power, high noise immunity, wide temperature range of

Table 1 Selection of midrange multi-chip microprocessors (primarily 8—bit)

Manufact'r	*Device No*	*Semiconductor technology*
Intel	8080/8085	NMOS
Motorola	6800/02	NMOS
Zilog	Z80	NMOS
Ami	6800/02	NMOS
National	8080/8060	NMOS
Rockwell	6500	NMOS
RCA	1802	CMOS
Signetics	2650	NMOS
Intersil	6100*	CMOS
Synertek	6500	NMOS
Mos Technology	6500	NMOS
Fairchild	F8	NMOS
Hughes	1802	CMOS
Solid State Scientific	1802	CMOS
Harris	6100*	CMOS

*12-bit device

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Table 2 Comparison of CMOS and NMOS technology

Characteristic	*CMOS*	*NMOS*
Power requirements:		
Quiescent	1 – 100 microwatts	100 – 1500 milliwatts
Operating @ 1MHz	1 – 100 milliwatts	100 – 1500 milliwatts
Noise immunity (% of supply voltage)	30	10
Supply voltage range (volts)	5 ± 20% 8 ± 50% 3 – 20	5 ± 5% 5 ± 10%
Temperature range	-55°C – 125°C	0 – 70°C -55°C - 125°C Special selection

CMOS makes it very suitable for many agricultural applications. In the near future it is likely that RCA will bring out CMOS version of Intel's 8085 and Intersil a CMOS version of Motorola's 6809 thus making available architecturally more sophisticated units in CMOS.

System reliability

Design specifications must be based on the assumption that agriculture is a hostile environment. Agriculture will be a relatively low-volume market that will benefit from design/manufacture improvements made for automobile market — a high-volume market with similar environmental problems. The major automobile and microelectronics companies[10] are working together to produce systems to satisfy specifications such as:

Temperature:	-40°C to +125°C
Humidity:	100% RH
Random failure rate	0.1%/1000 h
Wearout lifetime:	10-20 years

Systems reliability, ie hardware and software together, can also be improved (at a price) by using redundancy, voting systems, self diagnostics etc. The everpresent danger of "re-inventing the wheel" must be avoided by being conversant with the developments in areas outside agriculture so that the most suitable can be adapted and applied.

Any system, however well-designed, will have a finite probability of failure and failures *will* occur. The problem of repair and maintenance is a serious one which suppliers to agriculture will have to face. The existing dealership network seems entirely inappropriate to this task; yet the farmer is entitled to, and should insist upon, proper after-sales service. How is this service to be provided and at what cost?

Two applications

In order to illustrate some of these points a very brief description is offered of two applications which are currently in the design/development stage:

(a) A mobile weighbridge
(b) A psychrometric computer

Both of these applications are required to be battery powered: it follows then that low power consumption becomes a major design parameter — hence an interest in CMOS microprocessors. It has been pointed out that there are currently two choices: RCA 1802 *or* Intersil 6100. In terms of the technical design requirements both systems were equally suitable. The choice rested therefore on other considerations.

When producing a newly designed microprocessor based system the costs of producing the software (programs) is usually very much higher than the cost of hardware. In order to minimise this software cost it is usual to have a "development system" — an aid to program writing, correction, and execution on the given microprocessor. This development system requirement was the feature which distinguished the two systems above. The 6100 executes the same instruction set as the PDP-8/E minicomputer; since a PDP8 was available the programs could be written in PDP-8 assembler and after compilation loaded into the 6100. In the case of the 1802 a development system costing thousands of pounds would be necessary. The Intersil 6100 was chosen.

Mobile weighbridge

ADAS Northern Region – Mechanisation Section

Capacity	20 tonne
Layout	Three active pads; with dummy platforms and ramps which fold for transport. Loads measured by specially designed tension members.
Accuracy	± 1% of reading on level concrete with evenly distributed load.
Display	3½ digit LCD (1 in digits)
Operating Modes	Weigh Gross } up to 6 pads Tare Net } " " " " Zero " " " " Calibrate Store Individual pads " axles total, gross or net Print – V24 R5232 serial interface
Temperature	-5°C to +40°C
Humidity	up to 100% RH

Psychrometric computer

Object

To produce a portable battery-operated unit which would make measurements and by calculation produce the information available on the psychrometric chart.

Mode of Measurement

Measurement of wet and dry bulb temperatures using a hand-held unit.

Processing

To take the wet and dry bulb temperatures and to calculate Relative humidity, Mixing ratio, Moisture content, Specific enthalpy etc as per BS. 1339; 1965.

Accuracy

Temperature measurement: better than ± 0.3°C
Relative Humidity: better than ±2%RH

Although this unit has been designed as a stand-alone unit all the techniques used can be employed as the basis of a monitoring/control system in cereals and vegetable stores.

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Electronics and field machinery

J Palmer

Summary

THE silicon chip and the microprocessor are already starting far-ranging changes throughout industry and commerce. We can expect them to have some influence on the ways we use agricultural field machines too. This account examines some of the ways in which development may take place, considers some of the benefits which electronics could bring and draws attention to some constraints on the proliferation of electronics.

Introduction

THE objective in this paper is to crystal-gaze a little and to suggest lines along which applications of electronics to field machines may develop. Accordingly concentrated on digital electronics rather than analogue (because they are more adaptable) and systems rather than the vast range of possible electronic devices.

Components

The cost of electronic components has been falling at an increasing rate in real terms for the past 20 years. This has been partly because new components and manufacturing techniques have been developed but it is also because the demand for components has increased immensely as new applications have been invented. Nowadays the capital cost of a respectable mini-computer is comparable with the annual cost of a man. Soon, in all but the most elaborate systems, costs of electronics will be a minor part of total equipment cost.

The story is rather different in the case of mechanical components, including those with which information is sensed and the instructions of an electronics system carried out. Though the growth of new markets has brought reductions in price here too, the reductions have been far smaller because mechanical components are much less versatile. There are many electronic components which are equally well suited say for control of spacecraft or control of steel rolling mills but the mechanical parts of the corresponding sensors and actuators would be quite different. Thus mass production has far less influence on the costs of mechanical devices. It follows that there is a premium to designing systems in which mechanical data collection and mechanical actuation are relatively crude but electronic processing is elaborate. More generally, it may be more profitable to use very elaborate electronics rather than moderately complex mechanisms.

Possible systems

By way of an example of the potentialities of electronic components consider the design requirements of an electronic governor for a diesel engined tractor.

Like its mechanical counterpart this would be required to maintain the tractor engine speed at a value determined by the driver, irrespective of variations in load. It would need a speed sensor such as a switch mounted near the engine flywheel which delivered a pulse every time a starter ring tooth passed it. Thus the engine speed would be represented by the number of pulses per unit of time. The electronic controller would regularly subtract this number from a standard number set by the driver's manual control to give a difference which would represent engine speed error and from which the required change in fuel feed could be calculated. Such a digital controller would be more versatile than its mechanical counterpart: transferring a mechanical governor from one type of engine to another requires changes of physical components but a digital controller can be adapted merely by changing the numbers stored within it.

The versatility of the digital controller is one of its major attractions. Another is its speed. Even a modest digital controller could complete all the calculations required for the most complex diesel engine governors in less than a millisecond. However, the response of the tractor engine is so slow that we should not notice the difference if the controller adjusted speed only every ten milliseconds. Thus the digital controller could finish its work and idle for nine milliseconds out of every ten without spoiling the control of the engine. During the nine milliseconds when the controller was not required for this job there is no reason why it should not change the numbers with which it is working and regulate say the draught of an implement or its working depth or maybe apply power steering to the front wheels.

The ability of a digital processor to deal with several different inputs and outputs consecutively and so rapidly that each mechanism behaves as though it had exclusive use of the processor not only allows sharing of the cost of the processor between several mechanisms but is often a convenient way to compensate for the interactions that sometimes occur between different controlled factors. We know from experience that when we control tractor engine speed, implement depth and steering, alteration to the setting of any of these can change responses of the others. For example, if we alter the depth at which an implement runs this will certainly affect the power required from the engine and, with some implements, will call for steering corrections. It is relatively simple for a digital controller to be so arranged that the effects of change of one control device on the performance of others are themselves automatically controlled: if say the depth setting of an implement is increased the digital controller can be programmed to allow for this when next it turns to the governing of the tractor engine or the steering of the machine. Such an integrated control system would make the same kinds of changes in the degree of control as does the skilled and sensitive operator.

Integrated control systems can come close to replacing the skilled responses of the human brain. However the digital controller can perform work which is beyond the most skilled human operators. Purely for example consider that a tractor controller has been instructed to plough at not less than a certain depth and to complete the job within a certain amount of time at the minimum cost. Assume that there is a complex relationship between fuel consumption and the coarseness and frequency of adjustment in ploughing depth. The controller could be programmed to learn from experience how coarse and frequent it should make its depth adjustments. As time went by it would become more skilful at minimising cost. As the years went by it could learn what allowance should be made for seasonal effects. Such experience can be everlasting for it can be recorded by the controller so that it may be used in the future or handed on to its successors. The controller might even compare notes with the experience of other controllers so that the total volume of specialised logical information might be very large and the techniques automatically developed from it correspondingly refined.

To summarise conclusions so far, electronic devices and controls can be integrated into interdependent automatic systems centered on a digital controller. The controller can develop skills, remember them indefinitely and pass them on to its neighbours and successors. The principles of all these techniques have been proved in a variety of applications. The electronic components are probably already cheap enough for such processing to be feasible in any case they will be cheap enough in a few years time. All that we need is the information with which to design processes and programs and a clear appreciation of the

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road we wish to follow. However the acquisition of that design information will probably prove to be quite costly.

Practical experience

The path which real development must follow can be very different from the logical progression described above.

Controls Section at Scottish Institute of Agricultural Engineering has worked on electronic devices for potato harvesters and more recently for combine harvesters. First we developed an x-ray separator of potatoes from stones and soil clods. This equipment replaced the groups of workers carried by most harvesters to hand pick potatoes from rubbish of similar size. The separator was marketed in 1969 and has sold steadily from then until the present day. It sells because it satisfies an obvious need.

Once it had been accepted by the market we considered further ways in which electronics could be applied to the potato harvester. An obvious candidate was control of the forward speed of the harvester so that the separator was always optimally loaded despite variations in the population of potatoes, stones and clods from one part of the field to another. This could be done by making use of throughput data inherently present at the sensors of the x-ray separator. A second possibility was automatic control of cleaning mechanisms so that potatoes were agitated just sufficiently to remove the loose dirt, thus reducing potato damage. A third possibility was that of much subtler interpretation of data from sensors so that a more precise distinction could be made between large potatoes and small clods, in addition to differing responses from the segregating mechanism for large and small objects.

As in the tractor example above we could visualise a stage of proliferation of these control mechanisms where it would be cheaper to stop building them as separate mechanisms: instead a digital controller fed with information from x-ray sensors, agitation sensors, and so on would control separation, forward speed, agitation and segregating mechanism response successively. Accordingly we began work on the first of these mechanisms, an automatic throughput controller.

By means of extensive field trials conducted over two seasons we determined the required control parameters. We then built adaptions which could easily be plugged in series with the x-ray separator's electronic component cards to tap sensor signals (fig 1) and arranged that the processed signals should drive a motor which adjusted the tractor governor (fig 2). We then tested the new control system on the farms of some x-ray harvester users and found that they were keen to possess it. Despite this the equipment has not been marketed, that is, so far the project has failed.

Our strategic error was that we had made an advance which was more than a marketing step. The x-ray harvester manufacturer could not commit himself to providing fittings and service for the large range of governors found on harvester tractors. Fortunately, we were able to simplify the equipment by using the signals intended to drive the motor to operate lights and audio signals instead — these told the driver whether he needed to increase or decrease speed. Of course such equipment can be fitted to any tractor so we had reduced the advance to a marketable step. The result is that a throughput monitor is likely to be on the market in the near future.

Perhaps some day a potato grower will want to have throughput controlled automatically instead of relying on interpretation by the tractor driver: if so, a governor control motor is already developed and waiting. However I suspect that this step will have to wait until tractors themselves are fitted with digitally controlled governors which can accept information from the digital controllers on their attached machines.

Our work on combine control is at an earlier stage. Again we can conceive of an integrated system which adjusts forward speed to maintain constant grain loss, automatic steering which follows the edge of the standing crop, automatic table height and automatic reel position and speed according to grain head height, and automatic control of fan settings. Perhaps these will come eventually and we shall have combines which adjust themselves from moment to moment to suit local conditions. However our immediate aim is to make a satisfactory forward speed controller, one which satisfies a real need and is marketable. We are still at the investigative stage where we can compare sensing and controlling techniques but even at this early stage we find it worthwhile to fit a digital processor to the combine (fig 3) not only to collect and juxtapose data but also to experiment with various forms of digital control.

Conclusions

Application of electronics to the field machine offers the operator relief from the simpler tasks which at present demand much of his time, tasks such as steering of a tractor or the picking of potatoes. It also offers to undertake highly complex tasks which for all practical purposes are at present beyond his capacity, such as adjusting forward speed of a combine for maximum throughput with acceptable losses. Electronics on field machines can free man for supervision of the middle range of rare events and for overall supervision. It can also offer a degree of automatic husbandry, as automatic mechanisms acquire more detailed knowledge of the characteristics of say individual fields, conducting automatically experiments which would be beyond the capacity of even the best of today's farmers. Yet advancement to these higher levels of electronic support must be a series of marketable steps.

Not all such steps need be in the agricultural market. For example it is possible that tractor electronics will eventually owe more to developments for the car and lorry market, spurred on by growing alarm over fuel supplies, than to specifically agricultural applications. Similarly development of space satellites which aid the navigation of nuclear submarines might bring world wide benefit by improving the precision with which automatic husbandry experiments are conducted. However it seems unlikely that there will be any such underpinning for the specialised field machines such as harvesters so strategies for development of integrated electronic systems for these will have to be carefully prepared.

Fig 1 An extension card which taps X-ray harvester sensor signals

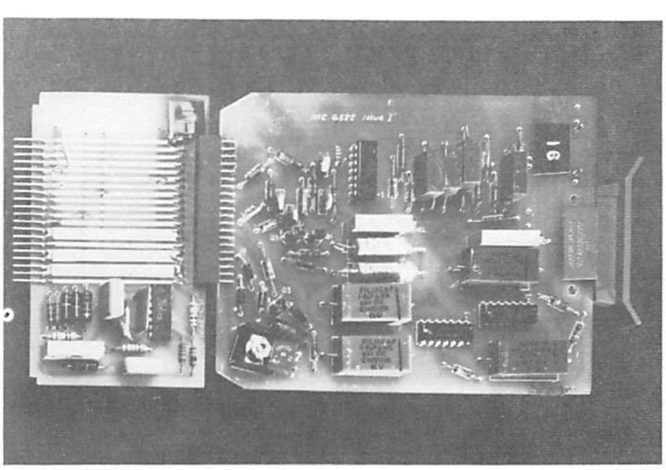
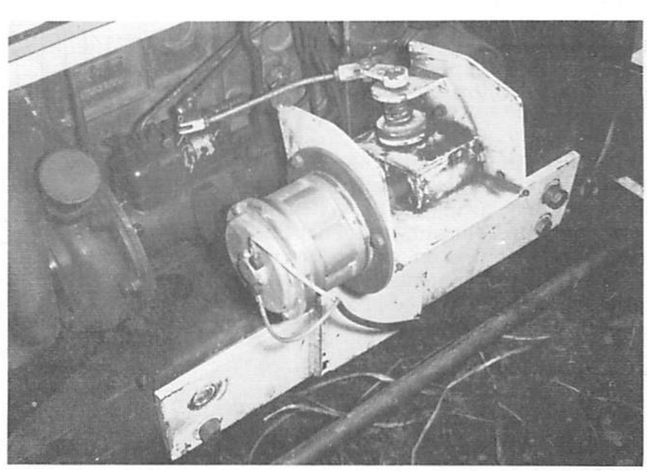


Fig 2 An actuator for controlling the setting of a tractor governor



A distributed microprocessor system for environmental monitoring and control in greenhouses

G S Weaving

Summary

A DISTRIBUTED processor monitoring and control system incorporating a host computer is described. Details of the system configuration, including the facilities for programming EPROM's are given and the software and programming languages are described.

The programme of research and development is outlined and possible commercial developments are discussed.

Introduction

THE control of heating by hot water and ventilating by hinged ventilators in greenhouses in the UK is usually based on commercial analogue controllers which provide proportional or proportional plus integral action control. On/off control of heating is also used together with proportional control of ventilation. Controls are not usually centralised and provision is rarely made for regular monitoring and recording of controller performance.

The control of other parameters, for example, carbon dioxide concentration, irrigation and pH and conductivity in hydroponic growing systems, require the installation of separate controllers often duplicating many of the functions of other controllers. (Weaving G S; Hughes M, 1979).

The use of computer control offers a flexibility in controlling the greenhouse environment that has not hitherto been possible with analogue controllers. Changes in the control functions may be achieved by software rather than hardware changes and control algorithms may be used that take more account of the meterological conditions or the condition of the plants growing in the greenhousė. (Udink ten Cate A J; Van de Vooren J, 1977). (Takakura T; Ohara G, 1976).

Because monitoring and control require only a small proportion of the computer time available, the system may also provide business management information. Taken together with improved environmental control the result could be improved productivity at a lower production cost.

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Work which began two years ago at NIAE on greenhouse controls has been centered around the installation of a computer based monitoring and control system that can provide not only facilities for research and development, but form the basis of a possible commercial system.

Because the size of holdings in the greenhouse industry varies from one or two 0.1 ha greenhouses to business enterprises having 20 or 25, 0.4 ha greenhouses it is important to ensure that a commercial controller is capable of being extended to suit the size of the enterprise. For this reason a system utilising a host minicomputer and distributed processes has been chosen and is shown in fig I.

System configuration

Host computer The NIAE greenhouse engineering research and development and control requirements fall into three categories:—

- The development of control algorithms:
- The monitoring and control of a number of greenhouses:
- The recording and processing of data from control and other experiments.

Having regard to these requirements a Texas Instruments FS 990/10 machine was chosen and is shown in fig 2. The computer is a 16-bit machine containing the TM9900 microprocessor (CPU). It has 64 k bytes of addressable error correcting memory, expandable up to 128 k bytes in a 13 slot chassis with

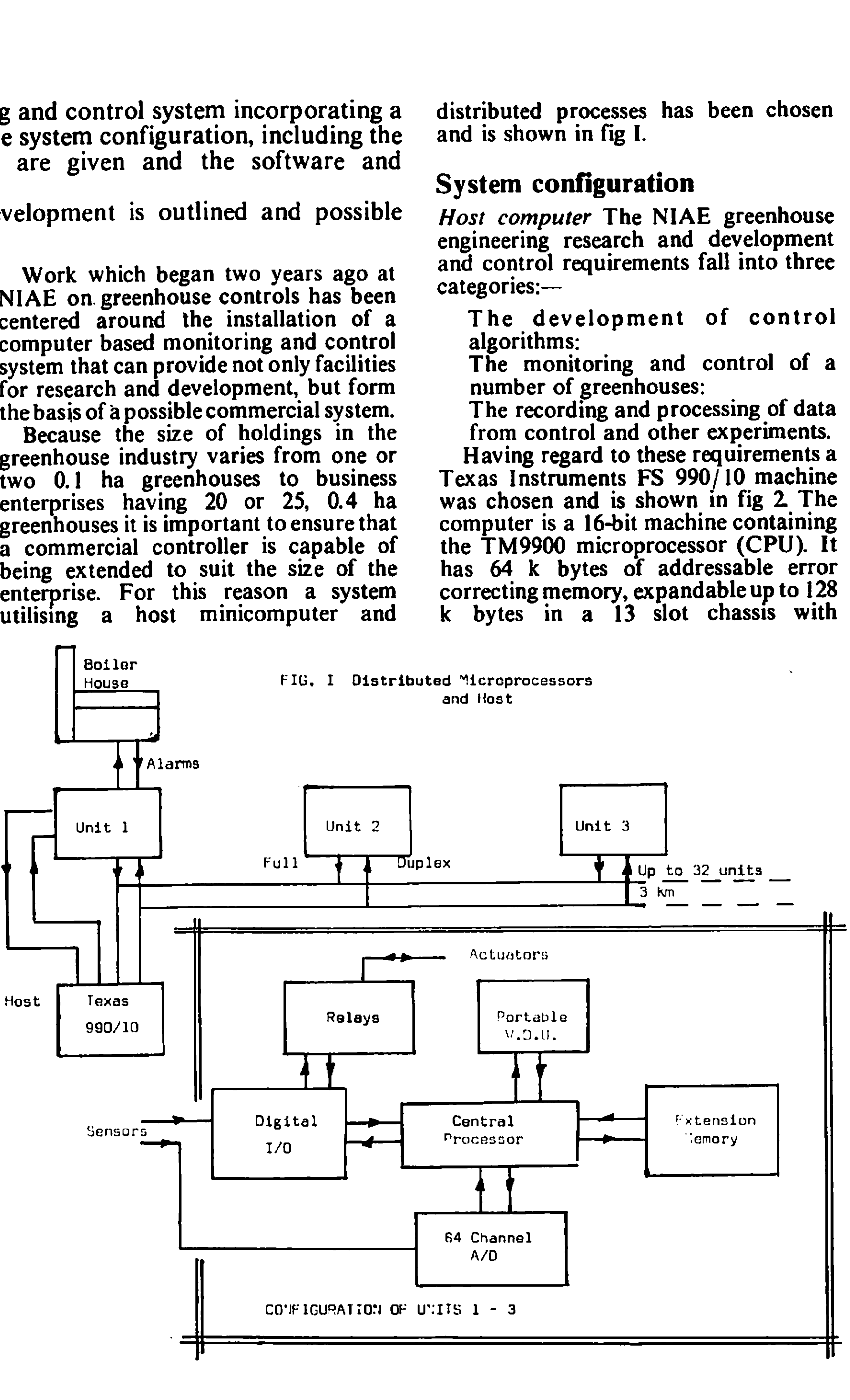
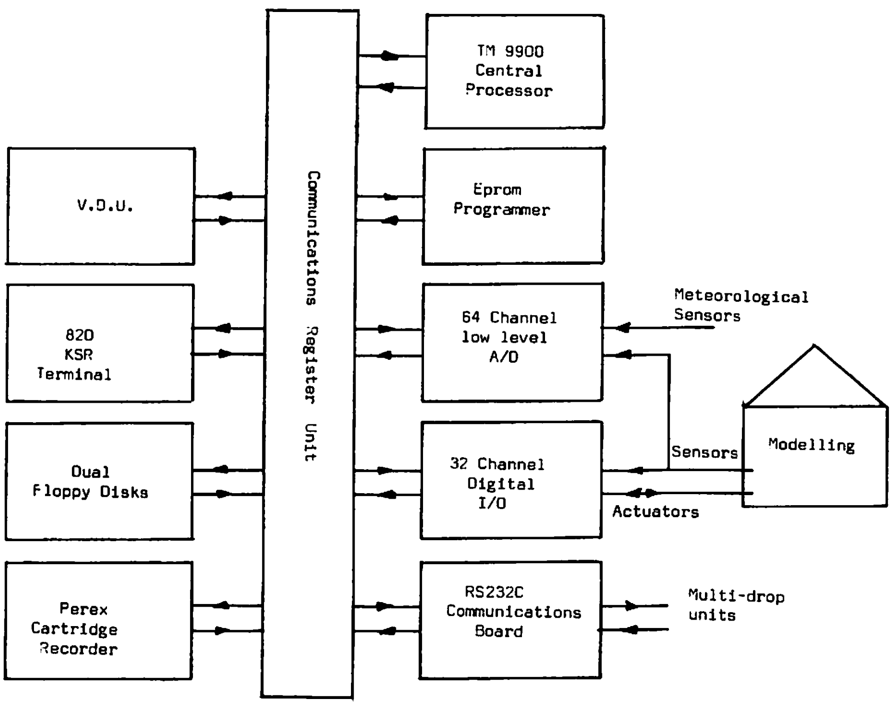


FIG. I Distributed Microprocessors and Host

FIG. 2 Texas FS990/10 Minicomputer



programmer panel and dual floppy disc drives. The dual floppy discs each have a capacity of 2048 k bytes. Two further disc drives may be added making a total disc capacity of 1024 k bytes. The communications register unit (CRU) serves as a general purpose serial input/output system for the computer, providing communications between the CPU and controllers for peripheral units. Provision is made for 16 interrupts, three of which are reserved for internal operations, whilst one is used for the real time clock.

A video display terminal (VDU) is used for operator entries and data display. Hard copy is provided by a Texas Instruments model 820, keyboard, send/receive terminal which may also be used as an extra terminal. A Perex Peridrive PD300 read/write cartridge recorder having a capacity of 1.8 m bytes is provided for mass data storage.

Communication with the distributed processors may be effected over distances of up to 3 km using a V24 RS232C terminal interface operating at speeds of up to 9600 baud. A PROM programmer unit is provided for programming linked object modules into EPROMS for insertion into the remote processor units. Analogue and digital sensor information is monitored by means of a Texas 32 channel digital input/output (I/O) board. Actuators are controlled by means of relays driven by the I/O board.

Distributed processors fig I also shows the configuration of the distributed processors. Each unit consists of a 16 bit processor, (Texas TM990/101M-2) having 8 k bytes of EPROM and 4 k bytes of RAM. Off board memory expansion is provided by a Texas TM990/201-42 memory expansion module having 16 k bytes of EPROM and 8 k bytes of RAM.

Analogue sensor information is monitored by means of an analog devices FT1-124IR 64-channel, +10mV, A/D converter. Digital sensors are monitored via a Texas TM990/310, 48 bit digital I/O board. Actuators, which are switched by solid state relays, Texas TM990/5MT12 series, are also controlled via the digital I/O board.

Software

The software consists of TX990/TXDS Terminal Executive Development System Software, TXDS FORTRAN IV and Configurable POWER BASIC.

The memory resident TX 990 operates in real time and is capable of controlling concurrent execution of multiple tasks in the FS990/10. Its main functions include task scheduling, interrupt handling, I/O servicing and processing standard system functions.

The TXDS is a floppy disc system which provides single user programme development capability in assembly language and FORTRAN IV. The TXDS FORTRAN IV allows the development of FORTRAN programs on 990 TXDS floppy disc software systems and includes the additional options of direct access I/O and debug.

Configurable POWER BASIC utilises the FS990/10 floppy disc based system for real time program development of control algorithms which may be configured into EPROMS for execution in the TM 990/101M remote processor board.

Remote communication may be either half or full duplex ie two wire or four wire. Although half duplex saves two wires, there are problems in determining protocol. For example, the host cannot send whilst it receives information from a unit; thus a faulty unit may cause the whole system to malfunction. For this reason it has been decided to use full duplex operation, the extra cost of cable being more than offset by the simpler software required.

Control programs

It is envisaged that the system will be used in three ways:—

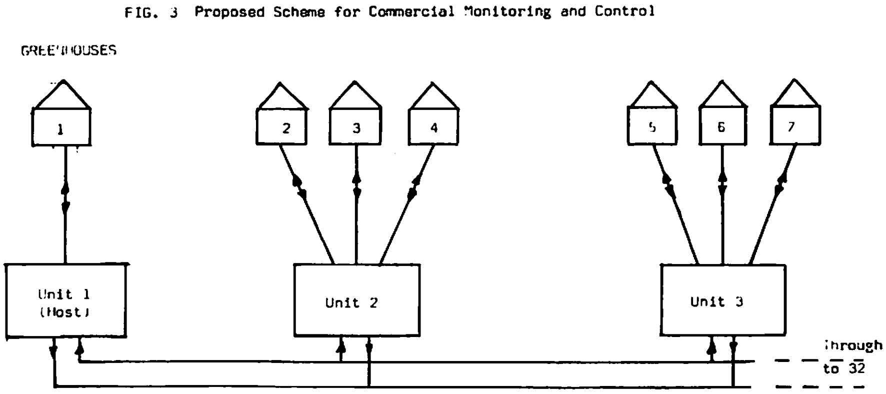
Development of control algorithms The host computer provides facilities for developing adaptive control algorithms written in FORTRAN IV. Adaptive control will take more account of the meteorological conditions which affect the greenhouse and tune the control algorithm to the prevailing conditions.

Development of programmes for execution in distributed processors The host computer also provides the facility for the programme development, using Configurable POWER BASIC, necessary to allow the remote processors to operate independently of the host. The POWER BASIC package allows the user to enter the programme statements or commands necessary to examine, debug or run a programme. The POWER BASIC configurator may be executed to produce a smaller faster ROM/RAM partitioned interpreter which may be stored in ROM or EPROM and inserted in the TM 990/101 remote processor board.

Because the development of algorithms and programmes are carried out in different languages they cannot be run concurrently with control tasks. Thus control of units 1, 2 and 3 (fig I) will be assigned to their dedicated processors whilst the host is used for development or programming.

Greenhouse monitoring and control The system configuration of a mini-computer acting as host to a number of remote processors provides the flexibility needed for research and development. An alternative configuration shown in fig 3 can be arranged to form the basis of a monitoring and control system suitable for a commercial holding. Unit one

FIG. 3 Proposed Scheme for Commercial Monitoring and Control



assumes the role of host, supervising units two and three. Thus unit one provides centralised monitoring in addition to any control functions that it is called upon to perform.

Alternatively each unit may act independently but with the option of one to take over the role of another in the event of a failure. Where the monitoring and control requirements are simple the capability of a single unit may be sufficient to monitor and control a number of greenhouses. Thus in the case of a large area, say 10 ha, the number of units could be decreased, with a commensurate reduction in cost.

Business management With the provision of sufficient memory and bulk data storage the host computer or remote unit may also be used for routine business management or the development of economic models which can be used to optimise the greenhouse operation. Such a model would have a number of inputs and includes heat input and fuel cost, type of crop, growing regime, fertiliser and labour costs, transport costs, crop yield and market value and trends. From such a model the profitability of the greenhouse operation could be continuously updated and displayed.

Discussion

A distributed system of microprocessors offers a solution to the problem of centralised monitoring and control whilst at the same time retaining the flexibility needed to transfer control when a unit becomes faulty. Because the greenhouse industry offers only a limited market for computer controls it is important to minimise hardware and in particular, software costs by using standard products as far as possible. It is also desirable to ensure that any research or development results may be utilised in a commercial system with the minimum of software development costs. This is best achieved by adopting the same family of micro-processors and the same software language for both the research and commercial development.

The difficulty experienced in retaining staff trained to write software programmes and the high cost of buying specialist software services have been important factors in choosing computers that may be programmed in high level languages. (Bancroft J A, 1979). The use of FORTRAN IV and configurable POWER BASIC allows project staff who are not specialist programmers to use the computer, thus ensuring less interruption to the programme of work. The disadvantage of using high level languages is the reduction in the real time processing rate afforded by the use of assembler or machine codes. This is particularly important when data are sampled at high speed, say 500 samples/sec. In such circumstances, which do not often occur in processing greenhouse data, the problem can be solved by using assembler or machine code sub-routines.

However, with the continuing reduction in the cost of store an alternative solution is to increase the amount of store, thus reducing the amount of real time processing required.

The development of economic models offers a challenge for the future which may allow a grower to assess the profitability of a growing regime. With such information and a knowledge of the effect of lower temperatures on productivity it may be possible to make judgements regarding the advisability of continuing with particular air temperatures.

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Technological developments in the application of electronics to agriculture, including personal computing - the next five years

S W R Cox

Summary

AFTER a survey of present applications of electronics to agriculture and horticulture, technological developments likely to affect applications over the next five years are considered. New forms of transducers and other input devices are described, including simple opto-electronics and microwave sensors. The effects of developments in computer hardware, including the personal computer, are discussed in relation to on-line and off-line work. Then the prospects of cheaper output devices for on-line control are briefly reviewed. It is concluded that the next five years will bring steady expansion of computer-based monitoring and control in all sectors of agriculture and horticulture, backed by a widening network of installation and service agencies.

Introduction

AT the risk of repeating information in preceding papers a forecast of developments over the next five years calls for a prior summary of the present state of electronics in agriculture and horticulture. The balance of these papers reflects one obvious feature of the present scene, namely the extent to which electronics has penetrated the larger dairy farm, initially for measurement of milk yield and control of concentrate feeding but increasingly for collection and processing of data on herd and cow performance. The dairy parlour system thus embraces all three areas in which electronics can help farmers and growers to maximise the profitability of their enterprises, ie measurement, automatic control and the application of digital computer techniques to data analysis and forecasting. The only comparable developments so far are in monitoring and control of environment in heated glasshouses (another area of high capital investment) and in one commercial company's potato grading systems (Cowlin, 1978). Apart from these systems, present applications are more limited to scope. The use of electronic weighers for animals (large and small) is gathering pace, following pioneering work at NIAE (Turner and Filby, 1973) and electronic load cells are in use for trailer or feeder-wagon weighing, either free-standing in weigh pads or built-in.

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Monitoring instruments are now abundant on field machines and implements, providing the combine driver with information on work rate and grain losses and the tractor driver with a range of information on the tractor itself and on the performance of implements such as seed drills and sprayers. However, the most advanced application of electronics in the field is still the x-ray separator for the potato harvester, developed in the 1960's at SIAE. As far as other harvesting and post-harvesting operations are concerned the grain mositure meter is as widely used as ever; forage moisture meters are available commercially; grain drier control is well-established and conventional environmental control systems are fitted to a variety of crop stores. Simple environmental controls are available for livestock housing, too.

Most of the measurement transducers employed in these systems are of conventional industrial types — thermistors and electrical resistance thermometers strain-gauge load cells, magnetic pulse generators for digital measurement of shaft or wheel rotation and so on. Others have had to be specially developed for agricultural use — a costly process, sometimes requiring years of effort. The capacitance unit for grain mositure measurement is a good example of the latter type (Matthews, 1963).

The use of off-line data processing equipment on the farm or horticultural enterprise is not new — one glasshouse enterprise was employing a digital computer for stock control in the 1960's. However, the increasing availability of economic and technical information through Post Office and TV networks, coupled with program packages for analysis of data and forecasting via mathematical models, has created a lively interest in "the farm management computer". At the lower end of the market, personal computers now being imported into the UK are already being applied to management tasks by some farmers and growers.

Looking back over the past five years, no really novel applications of electronics to agriculture and horticulture have emerged. rather, there has been an increase of farmer interest and uptake, undoubtedly fostered by the growing evidence, available to all, of the power of microelectronics and of the microprocessor in particular. This, in turn, has encouraged more commercial interest in the provision of electronics equipment for agriculture and horticulture. Does this mean that technological change will be much more rapid over the next five years? Before an attempt is made to answer this question, it is necessary to look at those technological developments which may have a bearing on agriculture and horticulture between 1980 and 1985. These are considered in the next three sections.

Input devices

This paper is mainly concerned with on-line applications of electronics, therefore it seems logical to start with the new transducers and other input devices which should be available for monitoring and control systems on farms in the next five years.

First, a new and cheaper form of strain gauge was marketed in the UK during 1979. This employs vacuum deposition technology to produce a strain-sensitive film on the surface of the deformable element of a load cell, eliminating the conventional bonding of a wire or foil gauge to this surface — a slow process which requires manual skill and care for reliable results. At present these sputtered gauges are only available on cantilever elements designed for light loads but the development offers hope that the load cell, which has so many applications in agriculture, will become a mass-produced item, with consequent advantages in cost, supply and maintenance.

Next, optoelectronics is one of the main growth points in transducer technology at present, due largely to developments of the laser and the laser diode in particular, with their implications for communication of information by modulated light,-both in free air and via glass fibre glass cables. One main line of development of these sources is towards higher light output, for obvious reasons, but another, with interesting possibilities for agriculture, is the manufacturer's increasing ability to make them for operation at selected wavelengths in the visible and infrared regions. This brings in prospect equipment for spectro-photometric analysis at a much lower cost than existing equipment, with additional advantages of compactness and reliability. As always there is hope that agriculture will be able to employ devices made for a massive industrial market but at NIAE G E Bowman is already working with prototype devices which may lead to a new range of moisture meters for crops and soils.

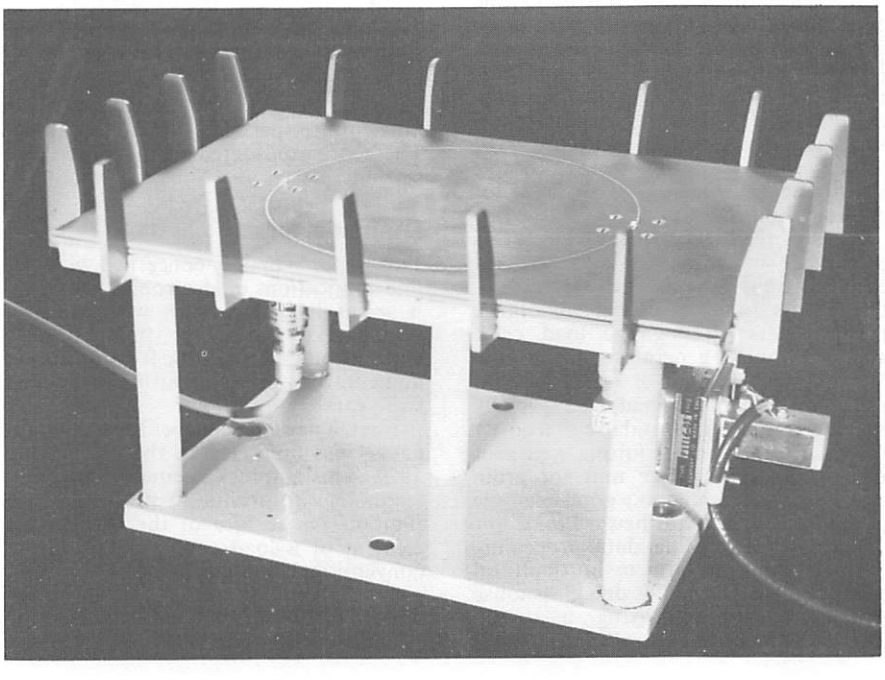
In another part of the electromagnetic spectrum — the microwave region — bulk measurement of moisture content is possible by application of stripline technique. This has been applied to determination of moisture in fish meal, at the Torry Research Station (Kent, 1972, 1973) and at NIAE. Bowman is also exploiting the technique for forage (fig 1). The measured quantity is the output signal from the stripline, which depends on the absorption characteristic of the material in proximity to the stripline at the microwave frequency. Working at 10 GHz, Bowman has found good correlation between the moisture content of forage (compressed to uniform bulk density) and the output signal. The inexpensive Gunn diode, operating from a low voltage supply, provides a convenient source of microwave power, while straightforward printed-circuit techniques are used to produce the stripline element. Similarly, the signal detection circuit requires no expensive components. In all respects the method shows promise for application in the next few years.

It seems likely, therefore, that the designer of moisture measuring equipment will soon have a choice of sensors, any of which may be the most suitable for a particular application. For example, spectral reflectance in the infrared region may provide the best available localised measurement of soil moisture for control of seed depth during planting. Other areas where benefit may be expected from new moisture sensors are the control of additives for forage preservation and the control of improved grain drying techniques (Nellist, 1976).

Reverting to the new generation of optoelectronic devices, these will extend the degree of automation in grading of produce. In fact, the potato grading system referred to earlier now incorporates automatic, non-contacting size grading, based on image analysis. The next step will be the introduction of optical quality assessment.

In the field of environmental measurements NIAE aims to establish the design of a set of sensors, suitable for long-term, unattended operation in livestock buildings and other "difficult" environments. In the case of humidity measurement, which has always created problems, joint work with a manufacturer has produced a sensor which may prove highly reliable over a wide range of humidities (Cove and Chawner, 1978). Recently, too, specialised integrated circuits have been designed for anemometry (Matino, 1979) and for measurement of the concentration of particular elements or compounds in gases and liquids. The areas for application of these new devices include monitoring of animal environment, NFT solutions and, possibly, milk (for detection of mastitis).

Fig 1 Circular microwave stripline assembly for forage moisture measurement with Gunn diode generator (right) and detector (left). The forage sample is compressed by an upper, metal plate (not shown). Courtesy N.I.A.E.



Implantable coding devices for animals could be available in the next five years. The technology is available: the need is to establish the specification required and the size of the resulting market.

Human inputs will still be needed, even in so-called automatic systems. It is just possible that voice operated units may supplement the conventional keyboard before long.

One recent development which may find application for off-line data processing deserves mention here, too. The hand-held portable data terminals now available, employing CMOS technology, provide a very useful means of collecting and storing data in the field. They are also designed to transmit and receive data via an ordinary telephone line, to and from a variety of computers. The cost of these units lies between £500 and £1000 at present, depending on the facilities provided, but an expanding market should bring cost reductions.

Data processing

This section is concerned with the hardware and the associated software required for digital processing of input data from manual and transducer inputs.

Beginning with computing hardware, in general the trend towards faster operation, lower power requirement and lower cost will continue. Also, the next five years will certainly bring forth chips with increasing capability. Many of the simplest measurement and control jobs will then require only the built-in memory on a single microprocessor chip. Where larger amounts of memory are required the magnetic bubble memory will be competing with established bulk storage devices. Like magnetic tape and floppy disc, it provides non-volatile memory and it has the advantage that it does not require a mechanical drive.

Communications links will also develop. The two-wire data highway is already available, making it straightforward to link many monitoring and control points (each with its local processor, possibly) to a central processor and data bank. This offers a valuable facility for the glasshouse or livestock building complex, for example. It will also become easier to link an on-farm data processing installation to external sources of information accessible through the Post Office network. It is to be hoped, too, that communications between electronics equipment on tractors and on implements will be rationalised before long, as a first step in the integration of monitoring and control of the tractor/implement combination.

There is much debate, inevitably, on the relative future roles of the general-purpose minicomputer, the special-purpose package based on distributed microprocessors and personal computers, in the context of on-line monitoring and control. The safest forecast is that all of these systems will be adopted in agriculture and horticulture, according to circumstances. The NIAE is following all three lines. A specialist hardware/software team, armed with the necessary development equipment, is completing a dairy-parlour management and control system which employs specially designed hardware, based on distributed microprocessors and a resident software package, programmed in low-level language (Burgess and Street, 1976). The software development cost has been enormous but the system has been designed for simplicity as far as the worker in the dairy parlour is concerned. On the other hand, improved control of glasshouse environment is being sought through the application of a standard commercial mini-computer (Weaving, 1980), programmed in BASIC or FORTRAN, which offers the facility for on-site adaptation, for those users who can take advantage of it.

Thirdly, a personal computer (an 8k Commodore PET with cassette tape) has been linked to strain gauge transducers, via its standard 8-bit input/output port. The transducers are, in effect, perches placed in a broiler house, which provide a sample weight of the birds, for daily checks on liveweight gain (fig 2). From this information the PET produces a histogram of the measured weights at the end of each day, together with their mean and standard deviation. There has been ready commercial interest in this development because it provides the manager with a clear picture of the birds weight and weightrange, which has a financially important bearing on his marketing decisions.

With the growth of distribution centres, nationwide, the personal computer therefore provides a readily available means for the farmer or grower to adopt simple on-line data logging and processing, adaptable to local needs by anyone who is prepared to gain some competence in the BASIC language (not a difficult task). Starting from the mimimum configuration, at about £500, a system can be expanded into a moderately powerful minicomputer as the owner's interest and requirements expand. The input/output port also provides the opportunity to build the computer into an automatic control loop, in which case the use of the VDU to monitor the state of the controlled process and to prompt the operator would be an attractive feature of the system.

Output devices

Standard computer output peripherals — VDUs, printers and floppy disc (disks) have become less expensive in recent years and colour graphics are becoming more common. This process is likely to continue. In the context of on-line control, however, the need is for cheaper control elements, to match cheaper transducers and electronics. In agricultural and horticultural applications there are distinct possibilities of such developments through greater use of on-off devices. At least one manufacturer of proportioning electrohydraulic control valves is experimenting with parallel, on-off solenoid valves for digital control. These could be less prone to blockage by impurities in the oil.

Parallel on-off control of fans is an essential part of the NIAE ventilation system for animal houses (Randall, 1977). It may be, too, that flexible, digital control of machine milking will emerge as a commercial possibility. Apart from developments of this type, the greater use of low voltage electric motor drives is to be expected.

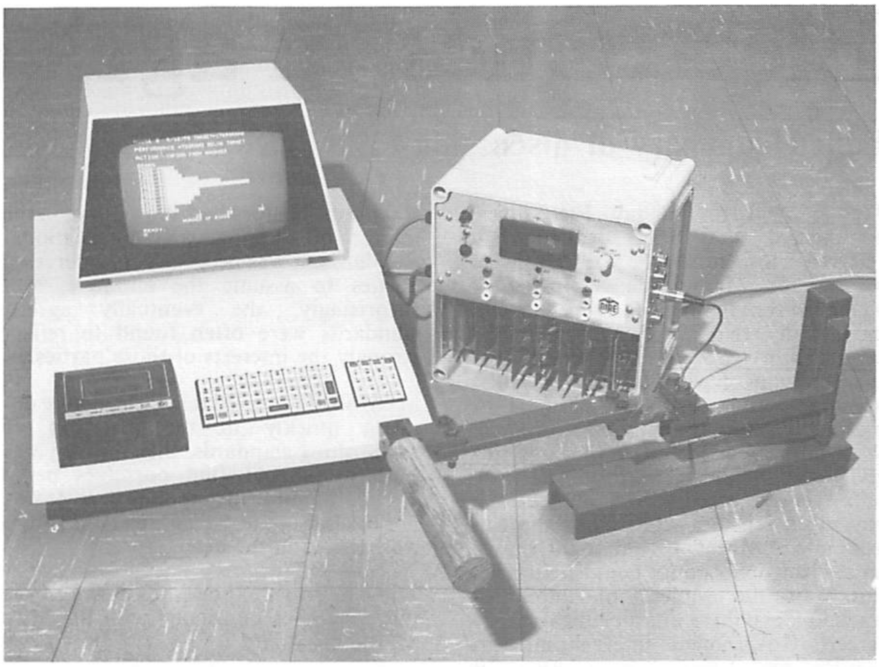


Fig 2 Personal computer applied to monitoring of broiler weights
Foreground – strain gauged perch
Background – signal conditioning unit

Conclusion

The foregoing brief survey is consistent with steady change over the next five years, rather than any dramatic expansion of the applications of electronics to agriculture and horticulture. New and cheaper tranducers will widen the range of measuring equipment available for monitoring and control of field operations. In static installations digital computers — micros and minis, including the personal computers — will find increasing application, on and off-line, for data processing and control. Some will communicate to outside sources of information. In the field, we can expect closer integration of tractor and implement electronics through increased use of microprocessors.

There is unlikely to be a shortage of manufacturers of the new equipment. Some of these will undoubtedly be responsible for installation and servicing of their own equipment. There are welcome signs, however, that dealers will be taking an increasing interest in this important aspect (Cox, 1979).

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Electronics in agriculture

Edited summary of discussion

Mr J Moffitt (Hunday Electronics) commented that the speakers had referred to automatic retrieval of information. Many firms were using the well-tried NIAE system (to which he felt, incidentally, that insufficient credit had been given) but it was time that everybody involved — farmers as well as manufacturers — evolved a national, or preferably international, coding system. With this, a single number allocated to a given cow, would relate to her national milk records, breed society number and any other schemes with which she was associated. Mr Moffitt thought that a large electronics house could undertake this. On the subject of implanted transponders, there was an ethical smoke screen. Government intervention was required and it was no excuse that, for example, small herds of a hillside in Wales would not use the scheme. Two million dairy cows in herds greater than 100 certainly would.

Mr Grant (ADAS speaker) said that he could not comment on MAFF policy but thought that

a) the ethical problem was more imagined than real and asked in turn for advice on technical problems of implantation

b) the main problem at present was finance and wondered if an organisation such as the Milk Marketing Board would be appropriate to handle this side of the matter — the Board was known to be interested in a central recording scheme.

Mr Hollis (Fullwood, speaker) said that the idea voiced by Mr Moffitt had been put forward in the Netherlands in 1976 as an international suggestion but had not been pursued. Proliferation of technology involved many commercial companies and new types of transponder are coming forward from Europe. The difficulties of standardisation had to be overcome.

Mr A B Turner (Alfa Laval, speaker) thought that farmers looked towards manufacturers for a lead in standardisation. Mr Brooke (Reading University), speaker, referred to the Los Alamos system in the United States which was claimed to be operable from horseback with a ray gun! Mr Moffitt replied that this was not relevant to the United Kingdom and was too expensive in any case. As a farmer he thought that £20 for a transponder was too expensive — it should be possible to make one for about £1.

Mr S W R Cox (NIAE, speaker) commented that the NIAE transponder could be struck to implantable size. In the matter of international approval, one way ahead would be for manufacturers to co-operate and advance proposals for standards. History had shown that, in the matter of national and international standards, it was necessary for interested parties to assume the initiative. Not surprisingly, the eventually agreed standards were often found to reflect strongly the interests of those parties.

Mr Moffitt observed that if steps were not taken quickly in the direction of establishing standards, then in five years time we should find ourselves being obliged to import from elsewhere. It was not too late at the present time but action was needed in the near future.

The Chairman expressed a desire to see this discussion continued with the Milk Marketing Board.

Mr H G Stirling (NRDC) considered that the lead in these matters should come from research stations since they were in the best position to pool expertise from among state and commercial interests. Mr Hollis considered that the small number of transponders required (10,000 — 20,000) was likely to be the major difficulty in arriving at low cost units. Mr Moffitt suggested that a proposal should be put to one of the major electronics companies, such a proposal being underwritten by the government. If such action were taken, he felt that the £1 transponder would be readily attainable.

Dr D J White (MAFF) was unable to comment, at short notice, on a subject which must be a matter of policy. He observed that a national identity scheme seemed to be necessary before transponders could be manufactured in sufficient numbers, with the appopriate specifications, to be economic. He supported the idea that manufacturers be encouraged to take the initiative.

Mr J Shipman (ATB) asked for a brief outline on the current situation regarding the detection of oestrus and mastitis.

Mr A Turner replied that, though there was a strong relationship between oestrus and temperature, milk yield, food consumption etc, these factors were all influenced by other factors in turn. The lack of 100% certainty in the results of an electronic detection device was as counterproductive as the present methods. He reminded the audience that other methods were known (eg by the bull) and could still be used.

Mr Hollis referred to promising work conducted in the Netherlands where the temperature of the milk at the cluster had been monitored. This worked had also lapsed owing to the unpredictable influence of outside factors. He referred to work carried out by the MMB measuring excessive cow movement during oestrus with a pedometer. Once reliable input signals had been identified, electronic systems could accept the data.

Mr Mundy (Bridgetts EHF, speaker) said that despite previous arguments, existing methods of detection of oestrus and mastitis at least had the effect of focusing attention of the cowman on individual cows. This was particularly significant when different operators milked morning and evening. Mr Grant observed that subclinical mastitis could be diagnosed by electrical conductivity of the milk. He wondered if this was of use since it was not clear what action could be taken. The consequences of erroneous information — eg over-use of antibiotics — were serious. The main needs he felt were the recording of events and the automatic diagnosis of *clinical* mastitis.

Mr A M Stirling (ADAS) asked if any special precautions were needed to control humidity or moisture within the parlour to protect electronic equipment. Mr Hindmarsh replied that equipment must be designed to fit in with traditional and existing procedures in parlours — appropriate precautions must be taken in packaging of electronics. There was a negligible problem from the generation of internal heat with modern electronic devices.

Mr E Buck (ADAS) queried whether the accuracy of records at present being obtained electronically was sufficient. He cited figures quoted by Mr Mundy (97% true identification and +30 kg bodyweight) and wondered if a better degree of accuracy could be expected in the future.

Mr J Barringer (MC Computers) drew attention to schemes which his company had operated for several years, ie.

1. A service agreement. For a percentage cost of the system the user can call out an engineer on guaranteed response or, without pre-payment can call out an engineer on availability basis.
2. Module replacement — but the user must be prepared to pay for the cost of this service in terms of replacement cards.

Mr I Johnson (ODA), referring to his work in remote countries and the cost of replacement parts there, felt that the price of spares should be reviewed. At present this was far too high and he considered that development cost should be included in the cost of the original article whilst spare parts should be supplied at nearer their actual cost.

Mr F Murray (Simplex) asked about the future of the "stand alone" computer on dairy farms. Mr Brooke replied that DAISY is a stand-alone device. A central machine would have been more expensive at the time when his work was started. The situation may now have changed. There was a feeling, however, that a £5000 to £6000 barrier existed to purchase of stand-alone machines. Mr Grant observed that personal computers could be used for a variety of purposes including salaries and other managerial matters.

Mr Turkington (ICI) estimated that the market for microcomputers on UK dairy farms in the next three to four years was between 2000 and 3000.

Mr W James (Ryecotewood College) thought that we were now at an ideal moment for manufacturers to write to all colleges telling them of the qualifications which they would expect for students leaving colleges over the next few years. The Chairman agreed and suggested that, in this respect, the Institution of Agricultural Engineers could perhaps adopt a liaison role.

Mr Mundy said that a certain amount of natural variation in cow weight was to be expected and that the ±30 kg chosen was designed to eliminate "nonsense weights". It was a developmental figure adopted at present and would be altered if required. Mr Hindmarsh observed that the only reliable method of checking body weight at present was by the weekly average. Spot checks were of no use.

Mr R Morrison (ESCA) noted that the electronics were all related to parlour operations and asked about extending these to deal with the feeding of silage. Could speakers expand on expected cost benefits? Mr Mundy, whilst well aware of the significance of costings, felt that insufficient evidence was available for firm conclusions at present. He therefore welcomed the information which was to be expected in the future from Bridgetts EHF. Mr Turner felt that the cost effectiveness at present was perhaps most encouraging from the feed monitoring aspect, quoting the case of a Devon farmer whose milk yields had shown significant increase but whose use of protein concentrate had been reduced at the same time (with an attendant reduction of ketosis).

Mr Turkington (ICI) asked Mr Weaving about the cost of software. In reply, Mr Weaving said that the average production by one programmer was ten lines per day costing £150. He confirmed that the language used in his own control system was BASIC. Mr Brooke pointed out that the DAISY programme cost £80,000 to write.

Mr K Pollock (BBC) asked Mr Cox for comments on the suggestions which had arisen from Mr Palmer's paper relating to the measurement of ploughing depth and its integration with speed, cost of operation, and potential optimisation from season to season. Mr Cox felt that at present it was too hopeful to base measurement and control systems on yearly variations of conditions. For such facilities he would look more than five years ahead. In particular there was a need for a mathematical model of the influence of weather conditions. Mr McCarthy (University of Newcastle) agreed that the solution to the implement control problem was unlikely to arise within five years. The development of transducers was a limitation as was our limited knowledge of agricultural processes.

Dr B D Witney (ESCA) regretted Mr Palmer's absence but wished to take issue on the matter of electronic control of potato harvesters. The use of a grain monitor on a combine harvester was justified if linked to speed control since it reduced losses and maximised output but in potato harvesting the use of a sensor to monitor throughput actually induced damage. A simple system whereby web and forward speed were interlinked was available, which reduced damage but it had not been taken up so far by manufacturers. Dr Witney went on to ask how reliability of equipment was ensured and whose duty it was to repair it when it broke down. He felt that simpler systems which were more readily understood by the farmers might be more attractive and more reliable. Mr Turner confirmed that care in the design stage, thorough proving in the development stage and appropriate education of installers, operators, servicemen and owners were all essential. Military experience should be drawn upon regarding levels of reliability and ease of servicing of equipment.

Mr J Hutnell (SCATS) complained at the lack of information from manufacturers and the paucity of service backup material particularly in the form of handbooks. Manufacturers were more prepared to provide expensive callout service visits than to issue service manuals. Mr R Sadler (Simplex) recognised the problem and stated that his company would be prepared to train staff of dealers. However, the response had not been great and, in the meantime, it seemed reasonable for the manufacturer to retain the responsibility for repairs. One difficulty was that dealers did not always have men who were suitable or available for training. Mr M Hulme (East Devon College of F E) stated that EDCFE was in the process of setting up a course in close liaison with manufacturers and dealers, specifically to train technicians to service this type of equipment.

I Agr E National Conferences 1980-1981

1980 Autumn	Agricultural machinery manufacture in developing countries	Tuesday 14 October 1980, National College of Agricultural Engineering Silsoe, (South East Midlands Branch).
1981 Spring	Engineering in horticulture	Tuesday 17 March 1981. Wye College, Ashford (London/ Kent Branch).
1981 Annual	Engineering for beef production	Tuesday 12 May 1981. National Agricultural Centre. Stoneleigh.
1981 Autumn	Engineering for intensive vegetable crop production	Tuesday 13 October 1981, (North Western Branch).

Registration forms will be sent to members as they become available.

Enquiries to:

Mrs Edwina J Holden, Conference Secretary,
The Institution of Agricultural Engineers,
West End Road, Silsoe, Bedford MK45 4DU.

Potato grading and inspection

D C McRae

Introduction

MOST of the present methods of grading and inspection have been in use for a very long time. The current types of grader are really refined versions of machines developed up to 30 years ago. Likewise, inspection tables have altered little over the years. We are now moving into a period of rapid change in the equipment to carry out both operations. In the area of seed production, where competition from other European seed growing areas is increasing, future markets both here and abroad for Scottish seed will depend very much on the quality of the product.

Sizing

At present potatoes are sized by shaking them with various degrees of violence through a square mesh, either on a fixed riddle or a moving screen. There are relatively small numbers of other graders based on the rotating spool principle but these are not within the scope of this paper.

The action of shaking the crop through a riddle or screen is usually accomplished with little damage, but can sometimes be very damaging particularly at low temperatures. Tests at SIAE in 1965-66 (Test reports 499 and 528) showed that when operated correctly, at throughputs of under 7 tonnes/h, a continuous chain screen grader caused less than 10% scuffing and no severe damage, whilst at 3.5 t/h throughput a reciprocating sieve caused less than 60% scuffing. However, in a PMB investigation at Sutton Bridge (1972) 8% severe damage attributable to a screen mesh grader was recorded. In recent investigations damage exceeding 40% severe has been observed on grading lines mainly due to drops and trapping in cold conditions.

Apart from the risk of damage associated with grading, are there any other problems and are the present methods of sizing satisfactory?

Sizing for the seed grades should preferably be compatible with sizing for other requirements such as retail and processing outlets. What are the requirements of the seed buyer? Most buyers look for uniformity which means in the case of round varieties, that the diameter falls within specified limits. In the case of ovals and long ovals, grading is based on the minor or major axis, depending on the shape. Since the length is not directly assessed by the square mesh riddle size, the buyer who has to be content with a sample ranging widely in length and also in weight. A large length variation can reduce the precision of popular belt fed planters which depend for accurate spacing on assembling potatoes in contiguous arrangement prior to planting.

According to Allen (1978) the most useful basic characteristics of plant density are stems/ha and weight of seed/ha. Ware and seed growers can adjust the weight of seed/ha by changing spatial arrangment and by selecting the appropriate seed size but the latter is less than satisfactory.

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Shape of potatoes

Though potato shape can be expressed in a number of ways which cover many varieties (Huaman *et al*, 1977) the following shape approximations would seem useful:—

1. Sphere — potatoes of this shape will pass through a square mesh of appropriate size whatever the orientation.
2. A prolate spheriod which is round in cross section, oval in the plane of the longest section, eg rugby ball shape, or
   An oblate spheroid which is oval in short section — doughnut shape. These shapes will pass through a square mesh if correctly orientated.
3. Ellipsoid — this is oval both on long axis and in cross section, eg a slightly flattened rugby ball. Potatoes of this shape can pass through when aligned on the diagonal of a square mesh and it is probably the most common shape for a potato, for example Maris Piper is an ellipsoid with a ratio of major to minor axis of approximately 1.25:1.

The volume of each of these shapes can be expressed by the following simple formulae —

1. Sphere Volume = $0.524\ \text{diameter}^3$
2. Spheroid Volume = $0.524\,a^2b$ (prolate)
   $0.524\,ab^2$ (oblate)
   where a = diameter
   b = length
3. Ellipsoid Volume = $0.524\,abc$
   where a and c are minor and major axes and b is length.

In the case of the first two shapes there is a rapid increase in volume (approx weight) with a small change in diameter. Thus in grading spherical potatoes through a square mesh, there is likely to be a big increase in weight for a small change in riddle size. The relationship between volume and linear dimensions of spheres and spheroids is shown in fig 1.

For an ellipsoid (fig 2) there is an almost linear change in volume with respect to length, double the length and the volume doubles. Double the "length" of a spherical potato and the volume and the weight goes up *8 times*.

According to Kolchin (1975) if tubers are sorted by weight, the scatter of linear dimensions is smaller than the scatter of weights when sorting by linear dimensions. It would, therefore, seem advantageous to sort tubers by weight or volume, rather than by linear dimensions. Houstoun (1957) showed that volume assessment by projection of the profile in three planes gave a 4-12% error in weight.

Since length is likely to be linearly related to weight, especially in long varieties, it would seem in some circumstances to offer a less variable dimension for sorting them either minor or major axis. If length grading were practised, however, certain checks would be necessary; for instance, in changing from one variety to another an alteration in the length bands would be required.

The present situation

At present one British company is developing a fully commercial length grader and has demonstrated a production model. At SIAE work is well advanced on a weight grader designed to produce five weight grades for the whole crop.

In addition to offering a better range of grades with flexibility in setting weight or length bands, by their gentler action and reduced number of drops, electronic graders are less likely to spread soft diseased potatoes over the grading surfaces, in comparison with conventional machines. Electronically graded potatoes could meet with some resistance from both home and overseas buyers, but their greater uniformity is likely to outweigh most objections.

Potato inspection

After grading, potatoes for the ware or seed market require final inspection and a proportion of sub-standard potatoes must now be removed so that the sample conforms to the PMB ware standard, or the Seed Potato Regulations. In order to control quality, repeated sampling at the bagging point is necessary to assess and maintain a standard but this practice is uncommon. In the last year during investigations in grading installations SIAE staff found 28-53% severe damage in bags destined for the ware market.

Inspection is usually carried out on roller tables, or on a flat conveyor belt with a cord stretched across it to encourage potatoes to roll. A roller table should be kept clear of soil, which if allowed to harden can do a lot of damage.

Malcolm and De Garmo (1953) in USA and PMB (1972-73) at Sutton Bridge, have drawn the following interesting conclusions with regard to the important factors in efficient inspection:—

1. The speed of translation of rollers should be steplessly adjustable.
2. The number of potatoes inspected/minute seems to matter more than the defect level. In USA 250-300/min/operator (1.5-1.8 t/h) was found to be suitable, corresponding to 1.44 t/h medium throughput in the PMB tests. Quite commonly a throughput of 1 t/h operator is used in grading plants and 0.5 t/h for very highest quality markets.

3. In USA a conveyor speed of 6-9 m/min gave good results, in PMB tests 5 m/min with closer (76 mm) roller spacing appeared to be best.
4. A rotational speed for the rollers of 4.5 rev/300 mm movement is suggested (USA results) but the tests by PMB did not show any marked effect of roller rotational speed. At SIAE 1.5-2 revs/300 min travel was found sufficient if erratic movement of long potatoes was to be avoided. At present it is uncommon to have any control of roller rational speed.
5. According to the USA tests there appears to be a 3% loss in efficiency with each additional type of defect being searched for.
6. A lighting intensity of 150 lux is suggested as being suitable for a typical roller table (USA figure).
7. With one operator, grading efficiency can be low 35-59% (PMB) at about 1.5 t/h throughput though in USA up to 80% efficiency was noted. With two operators standing opposite each other 69-82% was achieved in PMB tests. Each operator sees damage on the ends of potatoes hidden from the other operator.
8. In USA workers preferred front to side presentation.
9. "Belt sickness" with operators was found in USA to occur at high belt speeds (35 m/min) but the problem has also been reported in Scotland at much lower speeds than this. Lowering speed does improve scanning efficiency.

New inspection aids

Two electronic inspection aids are now being developed commercially. One of these is an indirect viewing system in which the operator "touches" damaged potatoes viewed on a colour TV screen with a light pen. This is now available and has the claimed advantage of allowing the operator to work in a cleaner more pleasant environment. It also minimises hand movements which is really the principal gain with electronic inspection aids. The other is the SIAE system which offers direct viewing of the material in 4 channels at throughputs of about 2.5 t/hour/operator. The operator touches objects to be later rejected with a hand-held wand. There is a gain in efficiency over hand operation especially above 15% damage levels. There are gains through better enjoyment of the work and in one farm trial this was reflected when output was at least doubled at no loss in efficiency from a relatively low working rate of 1 t/hour/operator.

Inspection aids can suffer due to transfer of potatoes from one roller to another after sensing an inevitable, occurrence when translating rollers rotate.

If as seems likely, very much improved quality inspection will become necessary, the future use of inspection aids especially for large grading stations seems assured. In addition to the development of manually assisted inspection aids equipment is now being tested at SIAE to carry out non-destructive external and internal examination for a range of diseases and internal bruising.

Conclusions

1. A re-appraisal of what sizing is really for and whether the traditional square mesh size standard is the most appropriate for modern farming, industrial and retail needs is urgently needed. In the face of the challenge of electronics, a revision of UK and European standards may now require consideration.
2. Length, volume and weight are all measures which could have a place in graders of the future.
3. Inspection is likely to become more stringent and electronic aids for both external and non-destructive internal examination of potatoes are becoming available.
4. In addition to evolving electronic devices for low damage grading and inspection, a more painstaking approach to layout and design of mechanical parts of graders will be essential to eliminate serious damage at this final stage in potato handling.

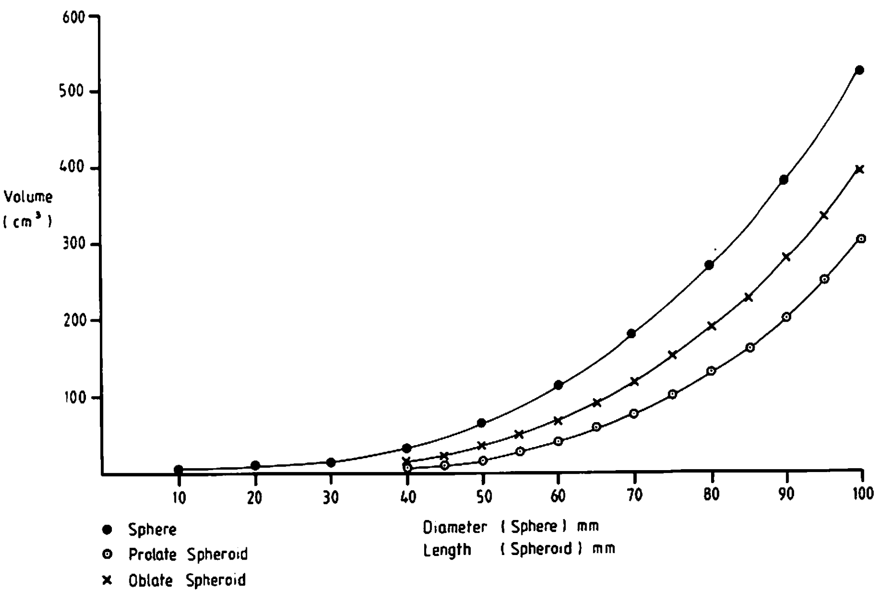
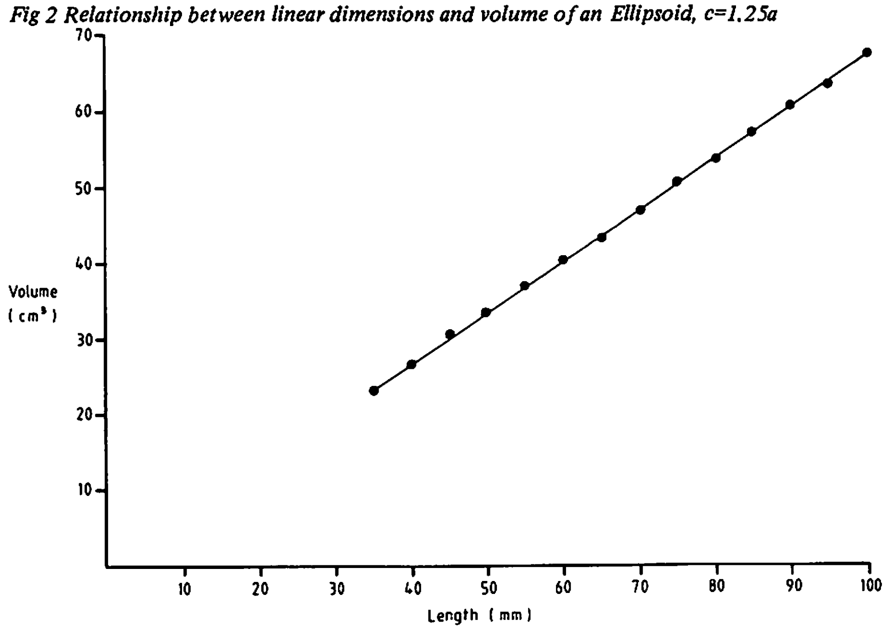


Fig 1 Relationship between linear dimensions and volume of sphere and spheroids

Fig 2 Relationship between linear dimensions and volume of an Ellipsoid, c=1.25a



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