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JOURNAL and Proceedings of the INSTITUTION of AGRICULTURAL ENGINEERS

Volume 28 Autumn 1973 No 3

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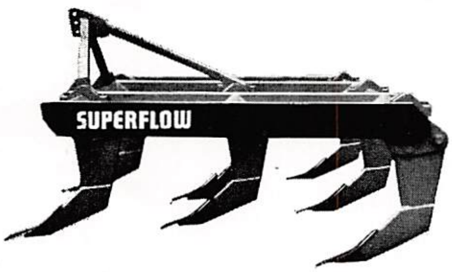

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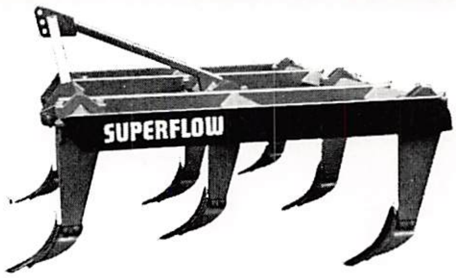

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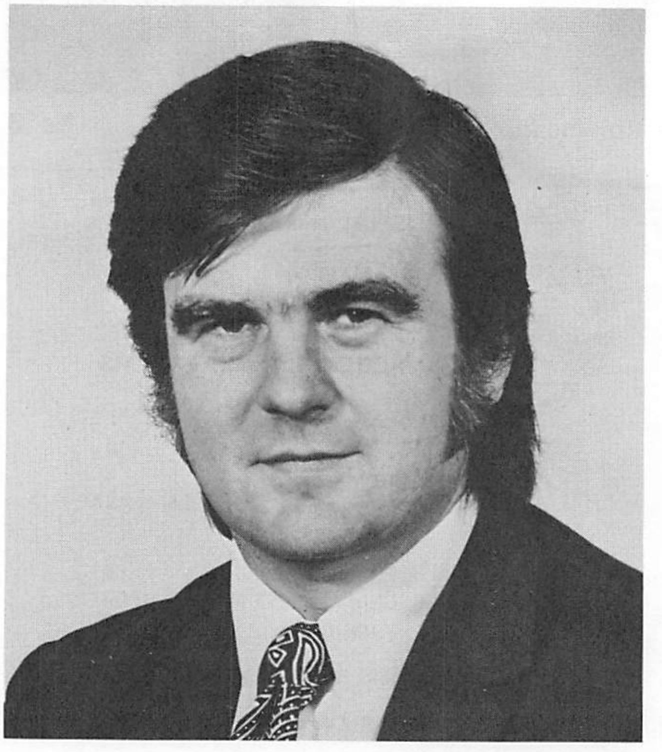
GUEST EDITORIAL

Institution Publications

by Brian May



SINCE my appointment as Honorary Editor and Chairman of the Editorial Panel in May 1972 a number of developments have taken place concerning publications. Most of these developments have been associated with Council's efforts to overcome the financial and administrative difficulties which have been identified in recent months. I should like to briefly report these developments, outline future publications policy and indicate ways in which members of the Institution can contribute to the future success of The AGRICULTURAL ENGINEER.

The Editorial Panel, which was formed originally in 1969 to select and edit material for inclusion in the *Journal*, gradually assumed increasing responsibility for administrative aspects of publications during 1972. At its meeting in January 1973 Council approved these arrangements formally which have been incorporated in the new organisational structure recently proposed by Council and accepted by members at the *AGM* in July 1973.

The Honorary Editor, assisted by the Editorial Panel now has executive responsibility for technical publication costs, budgeting, overall editorial policy and production arrangements. The Production and Advertisement Managers attend meetings of the Editorial Panel when selection of material for inclusion in The AGRICULTURAL ENGINEER is made and production details are agreed.

Several benefits are becoming apparent under these new arrangements. Recent issues of The AGRICULTURAL ENGINEER have been sent to members at the scheduled time. Subject only to freedom from industrial disputes it is confidently expected that this practice will continue. New printers have been appointed this summer which together with changes in print size and paper quality has enabled production costs for the *Journal* to be reduced by more than fifty per cent in less than one year. Confidence in the *Journal* as an advertising medium in the industry is increasing which represents an important means of reducing overall costs.

When formulating a policy for future issues of the *Journal* the Editorial Panel carefully considered a number of helpful comments and constructive criticisms received from the working party, branches and individual members. Taking account of the frequently expressed wish that the Institution should retain its professional identity, the Panel intend to continue with the present form and professional standard of the *Journal* during 1974. It is hoped that a wider range of material will be available for publication but this aim will be dependent upon the efforts of those prepared and able to present papers and articles for consideration by the Panel. To assist potential authors, the Panel has produced a guide to presentation of papers, copies of which are available from members of the Panel, the Secretariat and branch secretaries. Papers presented at national meetings are still likely to appear in future issues of the *Journal* but at least one issue each year will contain up to four papers on different topics together with short articles on the lines of this current issue.

An important feature of the new organisational structure is the increased participation by members in the management of the Institution's affairs. Members of the newly formed Executive Committee will be invited to contribute short articles describing their work for the Institution. In this way communications should be improved, wider interest encouraged and hopefully a plentiful supply of future office holders ensured!

Members will no doubt be wondering what happened to the Agricultural Engineers Manual which was announced in Volume 26 Number 3 and should have appeared 'towards the end of 1972'. There was certainly no lack of effort on the part of contributors. Some fifteen sheets have been written but as preparations for production advanced so the funds available for publications diminished. Since it was essential to maintain regular issues if the *Journal* was to remain viable this requirement took preference and the Manual was postponed. Council has subsequently advised that it may be desirable to extend the period of postponement in view of the initial cost and continuing expense of maintaining the sheets in an up-to-date form. The Editorial Panel has accepted this advice with some reluctance in view of the advanced state of the first issue of sheets. It may well be possible, however, to include some of this material in future issues of the *Journal*. On behalf of the Panel I should like to express our thanks for the support we have received from contributors.

Although the Membership Directory and Diary remain the responsibility of the Secretariate members may like to be reminded that a copy of the former is available free of charge upon application to the Secretariat and that there are no plans at present to re-introduce the Diary.

The Editorial Panel, Production and Advertisement Managers and I are looking forward to our work for 1974 with enthusiasm and optimism. We believe that technical publications will continue to contribute to the status and professional identity of both the Institution and its members. The extent to which we can succeed depends upon the continued support and interest of members. The Panel will welcome suggestions for future issues of the *Journal* and comments on the policy and plans outlined above. Appropriate correspondence on publications and other aspects of Institution affairs will be published in the *Journal*. Should you feel able to contribute an article to the *Journal* please obtain a copy of the notes for guidance to authors of papers. Branch secretaries are asked to consider the possibilities of publication when discussing with speakers their contributions to branch winter programmes and we are always pleased to receive their branch news for publication. I would like to thank those affiliated organisations who regularly advertise in our *Journal* and hope that their support will continue. To those who use this facility infrequently or perhaps not at all, I would like to say that the benefits are intended to be mutual and the Advertisement Manager will look forward to receiving your instructions!

The Corrosion of Aluminium Alloy Irrigation Pipe Exposed to Pig Slurry

by M. A. Moore

Summary

THE physical and electrochemical nature of the corrosion of aluminium alloy irrigation pipe exposed to pig slurry have been investigated. The exfoliation corrosion damage found can cause large increases in the fluid/wall friction, decrease pumping efficiency and lead to premature failure of the pipe. Metallurgical properties of the 'as manufactured' pipe, the presence of small amounts of copper in the slurry and bacterial action in the slurry contribute to the corrosion damage.

Various remedial treatments are discussed, including an extended ageing heat treatment which changes the metallurgical properties of the pipe and reduces exfoliation damage. The importance of the care of pipes during use is also discussed.

1 Introduction

The lightness, ease of fabrication and long life of aluminium alloys under normal atmospheric and water exposure have given rise to their widespread use in agriculture in recent years. Although the corrosion properties of aluminium and its alloys have been widely studied, very little information is available on their performance in agricultural environments, and in particular, exposed to animal urine and excreta.

Brace[1] has investigated 99.7 per cent A1 sheet, *NS*3, *NS*4, *NS*5, *NS*7, *HS*10, and *HS*15 (British Standard 1470) exposed to slurry from cattle, horses and pigs. Limited laboratory and *in situ* tests were made, and Brace concluded that horse urine and excreta were the most corrosive but that the alloys were little affected by exposure to pig urine and excreta. Huberty[2] has reported corrosion damage in aluminium alloy pipes used for water irrigation, especially when the pipes were also used to distribute fertilisers. Farmer and Porter[3] found that aluminium was little affected when in contact with wood in rural environments, except when preservatives containing copper were applied to the wood.

Awareness of the problem of corrosion in aluminium alloy irrigation pipes exposed to pig slurry is a result of a survey of the durability of farm machinery[4] carried out between 1966 and 1967. Although a reduction of service life by dissolution of the metal is a problem in the long term, the nature of the corrosion, called layer or exfoliation corrosion (fig 1 and 2), leads to drastic rises in fluid/wall friction and associated decrease in the efficiency of the pumping system.

This investigation was carried out to try to establish the causes of corrosion under exposure to pig slurry and possible means of reducing or changing the nature of the corrosion damage.

2 Properties of the Pipe

Aluminium alloy irrigation pipes are manufactured by extruding or drawing material in the 'as cast' condition. The majority of pipes are manufactured to British Standard 1474 *HE*9 or 1471 *HT*9, with the composition given in Table 1.

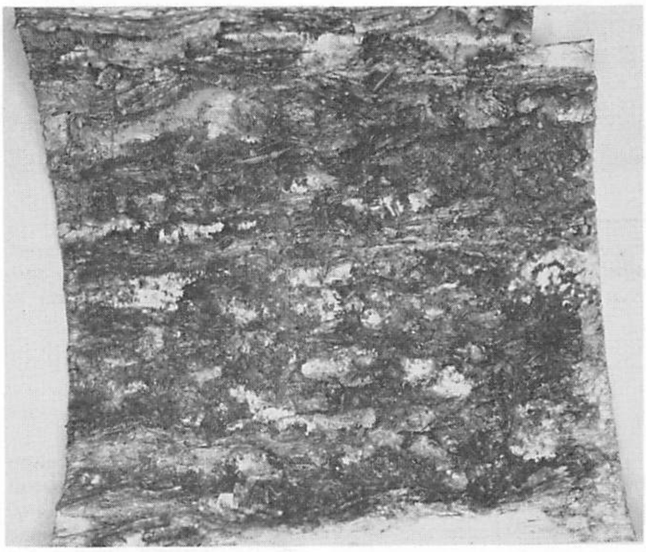


Fig 1 View of interior of the pipe showing extensive corrosion damage and trapped solids.

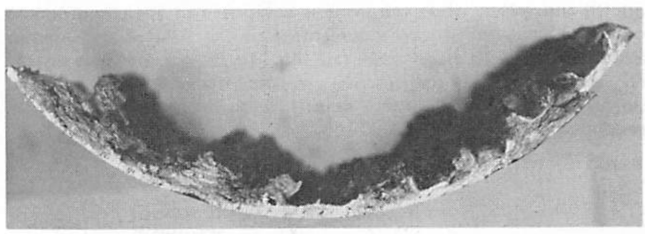


Fig 2 Cross section of the pipe wall showing the layers of corroded aluminium alloy separating from the interior surface.

Metallographic examination of a section through a typical pipe wall revealed a very distorted 'pancake' grain structure, elongated axially and circumferencially (fig 3). The alloy is basically single phase but contains small amounts of intermetallic constituents which are dispersed throughout the structure and along the grain boundaries. The following intermetallic inclusions are likely to be present in the alloy: Mg_2Si, $Mg_2Cu_2Al_5$, AlCuFeMn and AlFeMnSi and $Mg_3Zn_3Al_2$, in the form of globules, thin needles and 'Chinese Script' eutectic.

→ page 98

Table 1 Nominal Composition and Mechanical Properties of HE9 and HT9

Al per cent	*Cu* per cent	*Mg* per cent	*Si* per cent	*Fe* per cent	*Mn* per cent	*Zn* per cent	*Ti* per cent	*Tensile strength* tons/in²	*Elongation* per cent
R	0.1	0.4–0.9	0.3–0.7	0.6	0.3	0.1	0.3	7.0–10.0	15

**National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedford.*

→ *Direction of grain structure elongation.*
Fig 3 Polished and etched cross section of the 'as manufactured' pipe wall. The distorted 'pancake' grains are outlined by the dark etching grain boundaries and intermetallic compounds appear as black inclusions. Etchant: Keller's reagent. (Mag 250).

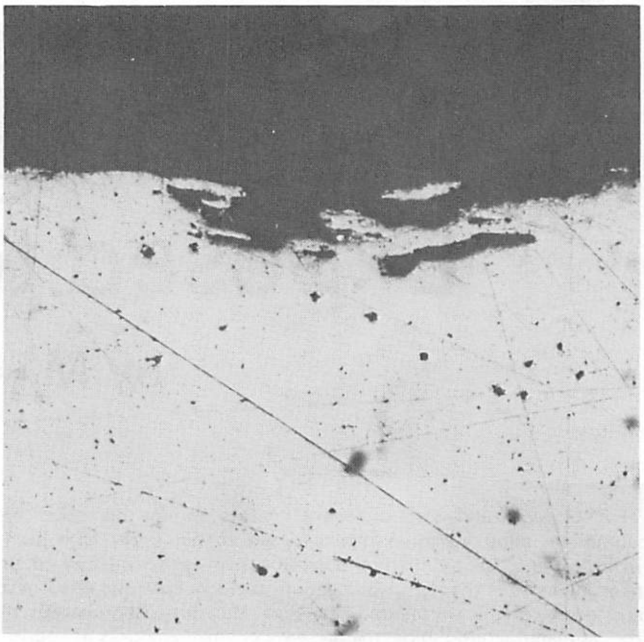


Fig 4 Polished section through the pipe wall showing pitting and damage at the interior surface (Mag 50).

3 Properties of the Pig Slurry

A comprehensive review of the properties of pig slurry is given by O'Callaghan *et al*[5]. Discussion in this report will be limited to those properties which may affect the corrosive nature of the slurry.

Both the chemical and microbiological nature of the slurry may vary widely according to diet, sex and breed of the pig, time of year and change brought about by pathological factors and bacterial action. Basically the faeces are composed of the undigested portion of the feed intake, bacteria from the digestive tract, digestive liquids and water, while the urine is composed of the end products of protein catabolism and a percentage of the mineral and vitamin additives of the feed and water (Fe, Zn, Mg, Ca, Cu, and vitamins *A*, *D*2, and *B*12). Bacterial activity can alter the composition of the slurry when it is stored, and Jones[6] has summarised the resultant products:

Aerobic action	– CO_2		
	H_2O		
	NO_3-,	NO_2-	(dissolved)
	$SO_4 2-$		(dissolved)
Anaerobic action	– CH_4		
	NH_3		
	H_2O		
	CO_2		
Facultative	– CH_4		

In general during storage the slurry becomes alkaline by microbiological ammonia production (max. pH 8.5–9) and, in the absence of oxygen, bacteria then actify the slurry (pH 6) and finally it reverts to about neutral.

4 General Observation and Consideration of the Corrosion Damage

The electrochemical properties of the corrosion cell have been investigated for the 'as manufactured' pipe and the same material after an extended ageing heat treatment. Full details of the test procedure, results and conclusions are given in an appendix to this text. It was found that the electrochemical properties of the pipe surface change during exposure and that the slurry in the vicinity of the pipe also changes. The heat treated pipe had a higher general metal removal rate than the 'as manufactured' pipe.

Microscopic examination of the surface and cross section of corroded pipe revealed qualitative information of the nature of the corrosion damage. The initial corrosion attack is in the form of localised pits (fig 4). Superficially the slurry is incapable of initiating corrosion damage, being neither highly acidic nor highly alkaline in nature, and it does not affect the stability of the oxide coating, which forms on the surface of all aluminium alloys and is responsible for their usual corrosion resistance. However, an important feature of the slurry is its mineral content, especially copper. Traces of copper (as little as 0.02 parts/million is sometimes necessary[7]), can be deposited on the aluminium alloy surface, creating minute electrolytic cells. With aluminium alloys points of weakness may occur in the oxide coating at the sites of intermetallic compounds, and the electrolytic cells caused by the copper result in the removal of metal from these points leading to pitting damage. The pitting damage is enhanced under stagnant or near stagnant conditions since local concentration differentials build up in the slurry giving a more favourable environment for metal removal. A more detailed discussion of this mechanism is given in the appendix.

Microbiological action in the slurry may also be effective in enhancing pitting damage. Miller[8] lists several ways that this may occur:

1. by the production of corrosive metabolic products (organic acids etc)
2. by the formation of differential aeration and concentration cells,
3. by the depolarisation of cathodic processes ie maintaining the cathodic potential
4. by the disruption of natural or other protective films, and
5. by the breakdown of corrosion inhibitors.

Although these mechanisms have been widely studied in connection with the corrosion of ferrous metals, very limited information is available on the bacterial corrosion of non-ferrous metals. Corrosion associated with bacterial action has been isolated in aluminium alloy fuel tanks[9] and it is accepted that similar mechanisms operate in other environments.

Pit formation and growth is followed by catastrophic attack along a preferred direction (fig 5). The preferred direction is the extrusion or drawing direction and attack is along the boundaries of the 'pancake' grains (see Section 2). This type of damage, called layer or exfoliation corrosion is well known[10,11] in aluminium alloys, and the mechanism has been widely studied[12]. In most aluminium alloys composition inconsistencies occur along the grain boundaries; in the form of discrete precipitates, depleted and enriched zones or continuous films. These inconsistencies represent

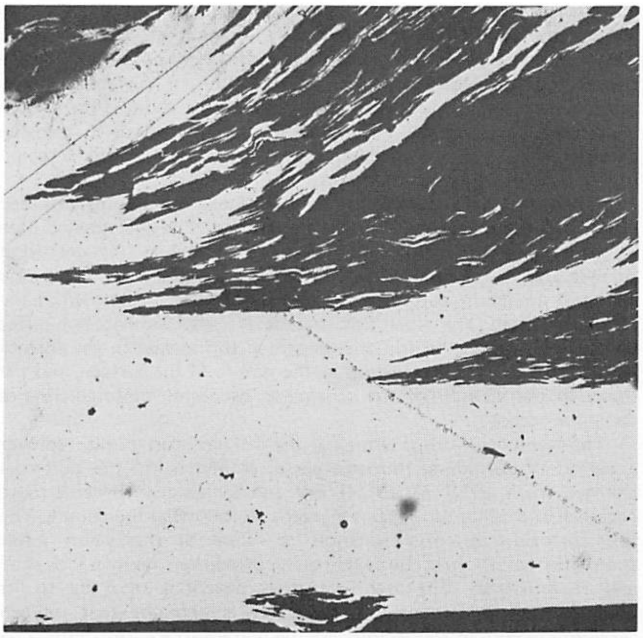


Fig 5 Polished section through the pipe wall showing the extent and depth of exfoliation damage at the interior surface. (Mag 200).

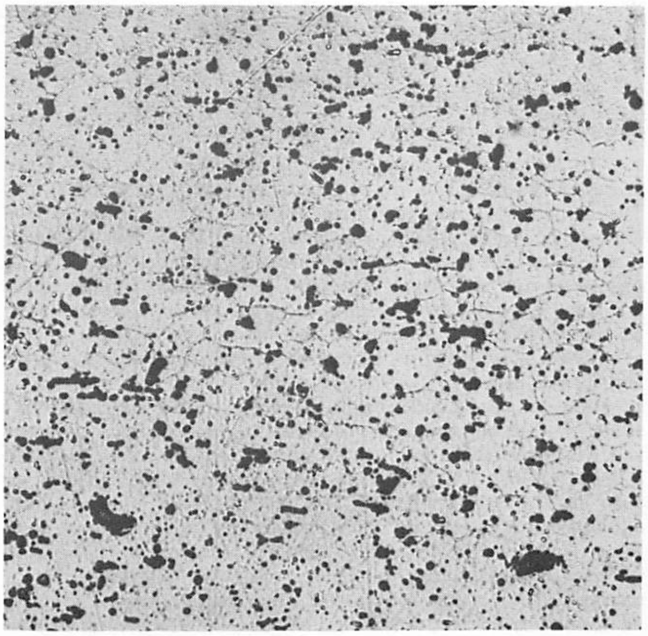


Fig 6 Polished and etched cross section of heat treated pipe wall. The equeaxed grain structure is faintly outlined by the darker grain boundaries and the sites of intermetallic compounds appear as black inclusions.

anodic or cathodic areas with respect to the bulk of the material and are potential sites for corrosion cells. Damage in the preferred direction, is aided by the large volume increase of the corrosion products which gives internal bursting stresses causing the uncorroded strata to be split apart. Local micro-residual stresses due to cold forming may also aid exfoliation.

5 Remedial Treatments

5.1 Production

The corrosion damage found in this investigation can be reduced by production treatment of the material. The aluminium alloy used for the pipes will pit, regardless of its condition (manufacturing and heat treatment), when exposed to pig slurry under the conditions defined in the previous section. Corrosion damage can be virtually eliminated if the surfaces exposed to slurry are given a protective coating. The most usual coating is pure aluminium, (99.5 per cent minimum purity), which has a tenacious oxide film. This process is obviously expensive and can hardly be justified for use in organic irrigation systems.

Some metal dissolution may be tolerated since the effect pitting alone has on the life of the pipe is small. By far the most serious problem is the exfoliation damage. Bell and Campbell[13] have shown that if the aluminium alloy is solution treated and then given an extended ageing treatment, the susceptibility to exfoliation corrosion is very much reduced. The extended ageing treatment has a two-fold effect; 1. it modifies the grain structure of cold formed material from 'pancake' to equeaxed grains, and 2. it modifies the type, morphology and distribution of intermetallic compounds. Effectively, the continuous paths for corrosion are eliminated. A section of pipe has been given an extended ageing treatment of one hour at 500°C, water quench, 24 hours at 180°C, and the resulting microstructure (fig 6) may be compared with that of the original pipe (fig 3). It must be emphasised that this treatment does not eliminate pitting damage and the results of the electrochemical tests indicate that dissolution of the heat treated material may even occur at a faster rate. The extent to which exfoliation damage is suppressed depends on the time at ageing temperature, and with low copper alloys very long treatments may be necessary to completely suppress it. A small loss of strength over conventional solution and precipitation treated material occurs with extended ageing but an increase over the 'as manufactured' material. A test for susceptibility to exfoliation corrosion is given by Romans[14].

5.2 Usage

In the study of the electrochemical properties of the corrosion cell (appendix) it was noted that corrosion damage could be virtually eliminated if a potential of about −1 volt was maintained between the pipe and some reference electrode. Unfortunately the current requirements at this potential are between 10 and 100 A/m^2. This method of protection, called cathodic protection, is therefore not very practical, especially when applied to long runs of pipe in the field, and the power requirements and cost of operation are high.

In Section 4 it was noted that pitting is more likely to occur when the slurry is stagnant or near stagnant and also in anaerobic environments (appendix). Therefore, long periods of exposure to stagnant slurry should be avoided and pipes should be washed after use to flush out any residual slurry.

6 Conclusions

1. The type of corrosion found in aluminium alloy irrigation pipes exposed to pig slurry can cause drastic increases in fluid/wall friction, decreasing pumping efficiency and leading to premature failure.
2. Breakdown of the protective oxide film is time dependent and occurs at a less negative potential than the free corrosion potential. There is a time dependent passivation reaction at the more negative potentials. (appendix)
3. The free corrosion potential becomes negative with time as oxygen depletion occurs near the metal surface. (appendix)
4. Corrosion is initiated at pits in the metal surface. The copper content of the slurry, weak oxide films over intermetallic compounds, relative movement of the slurry and metal surface, free dissolved oxygen and hydrogen oxidation by bacterial action affect pit formation. (appendix)
5. Catastrophic attack along the pancake grain boundaries follows pit formation, leading to exfoliation damage.
6. Susceptibility to exfoliation damage can be reduced by an extended ageing treatment although this may increase pit formation, and general dissolution of the metal.
7. Care of pipes during use and avoiding certain environments can help to reduce corrosion damage.

Acknowledgements

The author is indebted to Professor C. J. Moss, Director, National Institute of Agricultural Engineering, for permission to publish. Thanks are due to J. M. Sutcliffe of the Department of Metallurgy and K. A. Pollock of the Department of Agricultural Engineering, The University of Newcastle upon Tyne, for their co-operation throughout this investigation.

Appendix

Electrochemical Properties of the Corrosion Cell

The electrochemical properties of the aluminium alloy/slurry corrosion cell have been investigated by potentiostatic methods[15,16] The method involves monitoring the new current output of the cell while linearly scanning a potential range (−150°mV to 0 with reference to a standard calomel electrode of potential +280 mV), at various rates of scan (6 mV min^{-1} to 1200 mV min^{-1} in these tests). It must be made clear that the current/potential plots obtained, called polarisation curves, give the net current flowing at the aluminium alloy electrode, so that when the net current is zero the anodic and cathodic currents are equal. Since in a free corrosion situation the anodic and cathodic currents are equal the potential at which the net current is zero is called the free corrosion potential and is a measure of the driving force existing in the free corrosion cell. Also, in a free corrosion cell the electrode reactions are generally time dependent to varying degrees since they are controlled by chemical diffusion and ion activity. In order to study these electrode reactions it is necessary to make potential sweeps at different rates to isolate the various reactions. The faster rates of scan ensure that changes in the electrolyte (slurry) concentration are relatively small during the sweep, whereas the slower rates of scan are necessary to observe the more time dependent reactions such as the breakdown potential of protective oxide films.

Tests were carried out on specimens cut from an irrigation pipe, given a standard surface finish on 320 grit SiC paper. In addition to testing the 'as manufactured' material, several specimens were given an extended ageing heat treatment; one hour at 500°C. water quench, 24 hours at 180°C, (see Section 5.1). The slurry used varied in age from two days to several weeks with pH from 7.1 to 7.3. Repeatability of the tests was not very good, possibly due to variation in the slurry and difficulties encountered in effectively stirring it. Nevertheless, a general trend has been observed and typical polarisation curves are given in fig 7.

At the more negative potentials the net current flowing is predominantly cathodic with cathodic reactions occurring, and anodic reactions such as dissolution of the anode will be minimum. It will be noticed that with the slower runs this cathodic protection is maintained to higher potentials, probably due to a time dependent reaction eg film formation, which renders the aluminium alloy surface less susceptible to attack, and also the aluminium alloy surface becomes more cathodic during the testing period, a process known as passivation. As the potential becomes less negative the current becomes more potential dependent and rapidly becomes anodic in nature. This is followed by a region of relative anodic passivity where the current is fairly constant with potential. For the slower rate curves a region of fluctuating current follows representing the breakdown of the protective oxide film on the aluminium alloy surface. Finally as the potential tends to zero the aluminium alloy surface becomes more anodic representing a region of high rate metal removal.

The difference between the 'as manufactured' and heat treated pipe is more apparent in the first fast sweeps. The heat treated pipe is generally more anodic and will have a higher free corrosion current and metal removal rate. The curves at the slow sweep rate are very similar in nature, exhibiting oxide film breakdown at the same potential. The final fast sweeps are also similar but differ considerably from the initial sweeps due to increase in the surface area of the specimens, changes in the nature of the surface, and the slurry in the vicinity of the specimens becoming more alkaline as testing proceeds.

The free corrosion potential of the cell has been monitored over a period of 48 hours. Immediately after immersion the potential changed from −758 mV to 746 mV and then slowly became more negative to a value of −960 mV over the following four hours. The free corrosion potential remained constant at this value. After completion of the test the specimen electrode was removed, washed and re-immersed. The free corrosion potential returned to its original value of about −750 mV. It is thought that oxygen depletion occurs in the vicinity of the metal surface, restricting one of the cathodic reactions:

$$O_2 + 2H_2O + 4e^- = 4OH^-$$

and reducing the cathodic current. The net effect is shown schematically in fig 8. As the cathodic current is reduced the point of intersection of the anodic and cathodic curves (free corrosion potential ie zero net current) becomes more negative.

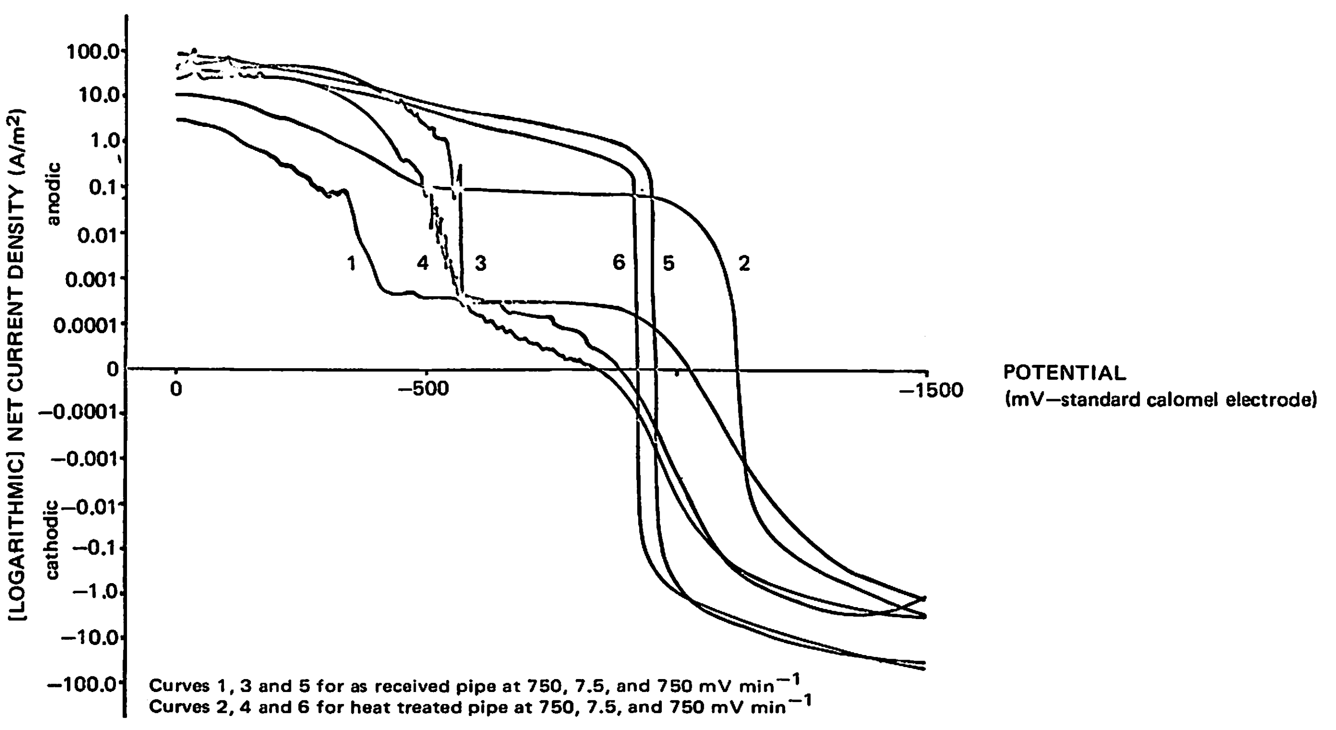
The Corrosion Mechanism

It was suggested in Section 4 that traces of copper can be deposited on the pipe surface creating minute electrolytic cells. Pitting will result at sites of weakness in the oxide film in the presence of an efficient cathodic depolariser so that the cell can operate at minimum energy requirements. In many electrolytes the cathodic depolariser is dissolved oxygen which removes electrons from the cathode by the reaction:

$$O_2 + 2H_2O + 4e^- = 4OH^-$$

However, in pig slurry the free dissolved oxygen is likely to be small because of the large amount of oxidisable organic matter

Fig 7 Net polarisation curves.



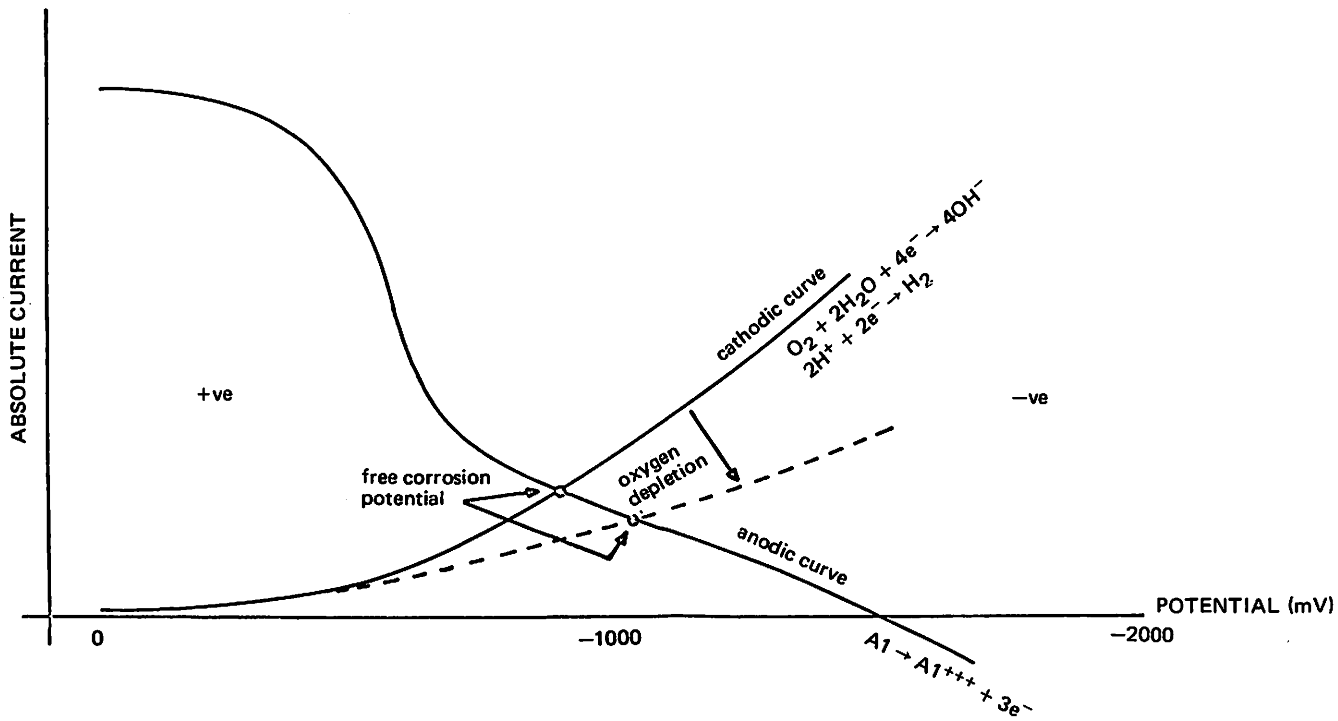


Fig 8 The effect of oxygen depletion on the free corrosion potential.

initially present (measured by the biological oxygen demand), and it has been noted that oxygen depletion may occur at the metal surface. Cathodic depolarisation can occur by the removal of atomic hydrogen from the cathode. Hydrogen is produced by the cathode reaction:

$$2H^+ + 2e^- = H_2$$

The hydrogen can be removed by bacterial oxidation and McDougall[17] gives various mechanisms:

$$H_2 + N_2O = N_2 + H_2O$$
$$6H_2 + 2NO_3- = N_2 + 6H_2O$$
$$4H + SO_4- = S^2- + 4H_2O$$
$$4H_2 + CO_2 = CH_4 + 2H_2O$$
$$4H_2 + CO_2 = CH_4 + 2H_2O$$
$$H_2 + S = H_2S$$

Some of the microbes responsible for these reactions are unable to grow in the presence of oxygen but are generally found in anaerobic environments, especially if the biological oxygen demand is high.

Once a pit has formed under stagnant or near stagnant conditions local concentration differentials build up and a passive-active cell is created. The surrounding oxide coated material is passive while the pit is active and dissolution of the anodic pit takes place. Metal ions from the anode can concentrate in the slurry until their concentration is high enough for the formation of metal hydroxide. The metal hydroxide precipitates out as a hemispherical membrane covering the original pit. Normally oxygen migrates to the anode giving anodic polarisation which limits the removal of further metal. However, the hydroxide membrane screens the pit from available oxygen so that it remains anodic and dissolution continues. Even in the absence of the hydroxide membrane anodic polarisation may not occur since it has been pointed out that the dissolved oxygen available in the slurry is likely to be small, and in view of the nature of the slurry oxygen depletion at the metal surface may be continually maintained. It can be seen that conditions for attack are very favourable in the vicinity of the pipe surface.

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Low-cost Self-steering Devices for Out-of-furrow Ploughing

by D. J. Hilton* and A. A. W. Chestney*

Abstract

THE two devices described have been developed for the purpose of steering the tractor at a set distance from the furrow wall when used for ploughing with the tractor wheels up on the land. They each employ a mechanical follower skid which moves in contact with the previous furrow wall and senses any displacement error. In one case the error signal is transferred by a simple mechanical linkage to the tractor's drag link to produce the necessary steering correction, making use of the tractor's in-built power assistance. In the case of the tractor with hydrostatic steering it operates an hydraulic valve which is connected to the steering ram. When ploughing, the self-steering devices have been shown to be capable of reproducing a straight furrow and of coping satisfactorily with obstructions and normal breaks in the furrow wall. Very gradual curves in the furrow path are reproduced, while waves of short wavelength tend to be eradicated on one or two passes of the plough.

1 Introduction

1.1 General

Increasing interest is being shown in out-of-furrow ploughing (or ploughing 'up on the land') ie with all four tractor wheels out of the furrow, for a number of reasons. One is the concern which is felt about soil compaction and smearing of the furrow bottom with the use of heavier tractors and large ploughs. This particular problem has been high-lighted by the Agricultural Advisory Council's Report *Modern Farming and the Soil*[1]. A second is that very wide section tyres or tandem wheels may be used. Finally, ploughing up on the land may also result in reduced tyre wear and damage on flinty soil.

The decision to plough with the tractor wheels out of the furrow can lead, however, to problems of tractor steering. When ploughing conventionally, with two of the tractor wheels firmly located in the furrow, any tendency for the tractor to slide laterally is resisted by reaction forces at the furrow wall, while the operator's steering task is minimal, and can generally be performed by feel rather than by sight. When ploughing with the tractor out of the furrow, the steering task can demand the operator's full concentration which makes it difficult to monitor the plough and after a few hours can lead to considerable fatigue, resulting in reduction of work quality and output. The development of the self-steering devices described in this paper was carried out for the purpose of alleviating this fatigue and also to enable this type of ploughing to be performed at night-time without the necessity for powerful lighting. As with most other mechanical furrow-follower systems, the objective is to obtain automatic control only while the implement is in work: when the headland is reached, the operator is responsible for retracting the follower and turning the tractor round to bring it again into work.

2 General Description of Equipment

2.1 Tractor with Power-assisted Steering

A general view is shown in fig 1. and the sketch in fig 2 shows the principle of the device. A cross-beam attached to the tractor carries a pivoted follower arm which projects slightly forward of the tractor and parallel to the furrow. The follower is held firmly

Fig 1 General view of device fitted to tractor with power-assisted steering.

against the furrow wall by a rubber torsion spring embodied in the pivot while a coil spring provides an additional force vertically downward. The follower arm is also hinged to allow it to be raised and lowered into and out of work, the operation being performed by a hydraulic ram powered by the tractor's auxiliary hydraulics. When the follower arm is lowered into work, jaws on the arm engage a relay lever which is pivoted on the same axis as the arm itself. The relay lever is connected mechanically by means of a transverse rod and bell-cranks to the tractor's steering system and thereby transfers lateral motion of the skid to a fore-and-aft motion of the tractor's drag link. When in work, however, the linkage is capable of being

Fig 3 General view of device fitted to tractor with hydrostatic steering.

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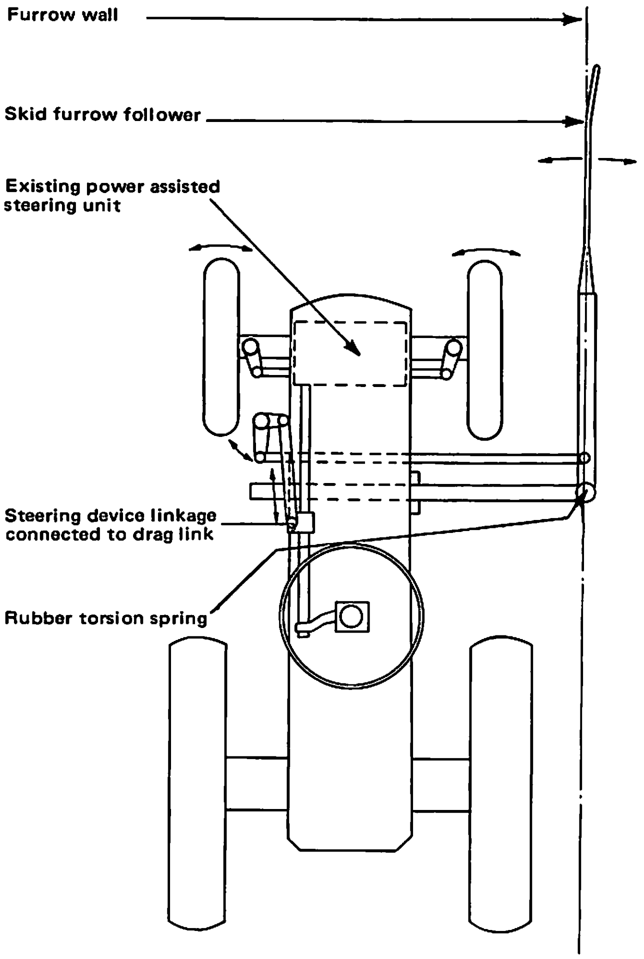


Fig 2 Sketch showing self-steering principle on tractor having power-assisted steering.

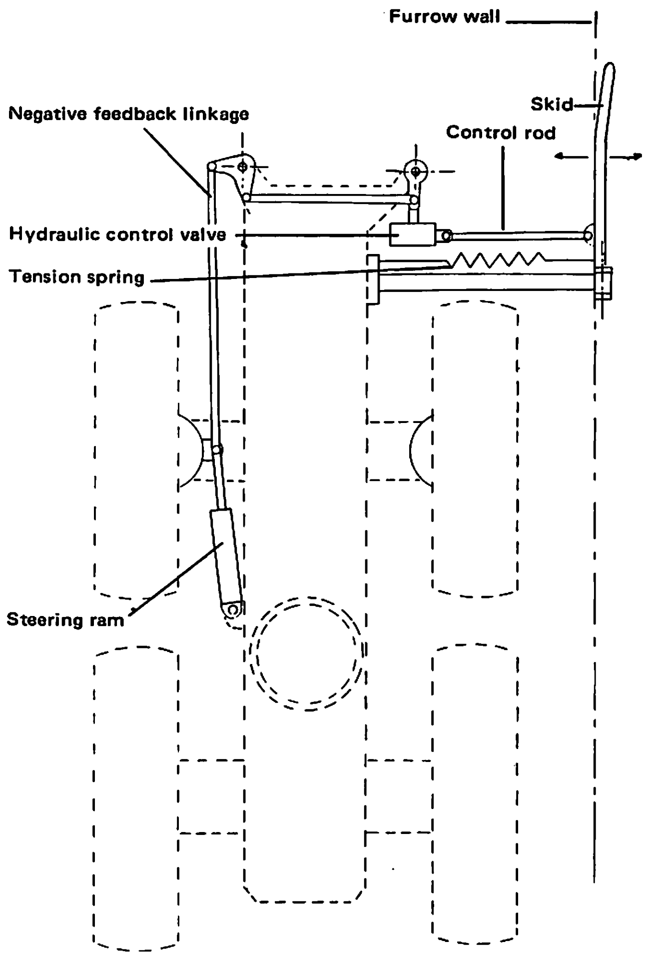


Fig 4 Sketch showing principle of device fitted to tractor with hydrostatic steering.

over-ridden if necessary by pulling hard on the steering wheel. Operating the hydraulic ram raises the follower arm out of work, thus disengaging the relay lever, and the pre-load force of the torsion spring is taken up by a stop which keeps the arm in the straight ahead position. The tractor can then be steered normally although the relay lever continues to move with the drag link. Provision is made for adjustment of the distance between tractor and furrow wall by releasing the clamps and sliding the main support beam to the desired position. Both assembly and adjustment can be carried out by one man.

2.2 Tractor with Hydrostatic Steering

A general view of this device is shown in fig 3 and the principle of operation is illustrated in fig 4. This time the mechanism supporting the furrow following skid consists of a folding frame linkage attached to the side mounting pad of the tractor just forward of the front wheels. A hydraulic ram lifts the whole assembly into and out of work, and in work the skid is held down under the weight of the assembly while being held against the furrow wall by a tension spring. Deviation of the tractor from the desired path causes lateral motion of the skid in relation to the tractor and this is made to operate an open-centre hydraulic control valve. The valve, which uses oil from the steering pump supply, then operates the tractor's steering ram to achieve the required correction. The body of the valve is itself mounted on a linkage which moves as soon as this steering correction takes place and effectively cancels the original signal, this being essential for stability.

While the steering is being performed automatically, the tractor's own steering pump must be isolated, and for this reason a two-way valve is situated in the driver's cab for changing over from one mode of steering to another.

2.3 Off-setting the Plough

In order to plough with wheels up on the land, a special on-the-land plough can be used or alternatively, as in these experiments, a conventional plough may be used in conjunction with a special frame to offset the plough from the normal position by the desired amount.

3 Performance

3.1 Control System Performance

The ability of the device to reproduce a straight furrow depended on three groups of factors, namely:

(i) those relating to the device as a closed loop control system
(ii) those relating to the tractor/plough kinematics
(iii) those relating to the ground conditions at furrow depth and at the surface.

Since each self-steering device constitutes a control system, it was necessary to determine the optimum gain factor (ie ratio of wheel angle change to follower movement) in order to achieve the best compromise between response and stability. Too high a ratio led to the system becoming unstable at high working speeds while too low a ratio led to the tractor's position not being controlled quite so accurately. Stability tests were carried out over a wide range of speeds. At the lower speeds these were performed both when ploughing and without the plough fitted, but the plough was of necessity removed for all tests at the higher speeds.

In the case of the device fitted to the tractor with power-assisted steering the optimum gain factor was found to be 0.058° of wheel angle/mm of follower movement. (1.47°/in). This corresponded to a ratio of follower movement to drag link movement of 8.6:1. With the above gain factor, the steering system was stable up to 17½ km/h (11 mile/h) with the tractor on its own. Experiments at the lower speeds also suggested that the system was even more stable when actually ploughing. This indicated that there was ample stability margin at speeds well beyond present-day speeds of ploughing or any envisaged for the foreseeable future.

In the case of the device fitted to the tractor with hydrostatic steering the overall gain factor was determined by the linkage to the valve spool and also by the feedback linkage. Both of these quantities were varied in the stability tests and the optimum condition found to correspond to a negative feedback ratio of 1.1:1 and a ratio of follower movement to valve spool movement of 4:1. This gave an overall gain factor of 0.049°/mm (1.24°/in) of follower movement. At this setting the steering system was stable up to 10 km/h (6.3 mile/h) without the plough fitted and again evidence was that the margin of stability was even greater when ploughing.

3.2 Ability to Attenuate Waves in the Furrow Path

At these settings the control system on each tractor was capable of keeping the front wheels of the tractor within 30 or 40 mm of the desired path under normal conditions. Such deviations at the front can easily be tolerated, since the resultant deviations in the path of the tractor's rear wheels are in any case much less, because of the natural tendency of the tractor's rear wheels to trail behind the front and thereby reduce the wave amplitude. Likewise in turn the plough, though mounted, to a certain extent trails the tractor's rear wheels. The outcome is that only a fraction of the deviation of the front of the tractor is reflected in the line of the furrow being cut. In practice this means that any waves that exist in the furrow tend to be smoothed out. To prove this point, tests were carried out along a furrow into which waves had been deliberately introduced. A furrow was marked out which had one whole wave of 32 m wavelength (amplitude 1 m), followed by a straight section, then four whole waves of 8 m wavelength (200 mm amplitude) and finally a further straight section. Successive passes were made at a ploughing speed of 3.6 km/h (2.3 mile/h). In the case of each steering system, the 8 m waves were almost eradicated on the first pass, but the longer wavelength was attenuated much more gradually as might be expected. The rate of attenuation of the 32 m wave was in fact approximately 11 per cent on each pass for a 3-furrow plough or 14 per cent per pass for a 4-furrow plough. After eight or ten passes the furrow became virtually straight.

3.3 Ability to Hold a Straight Furrow

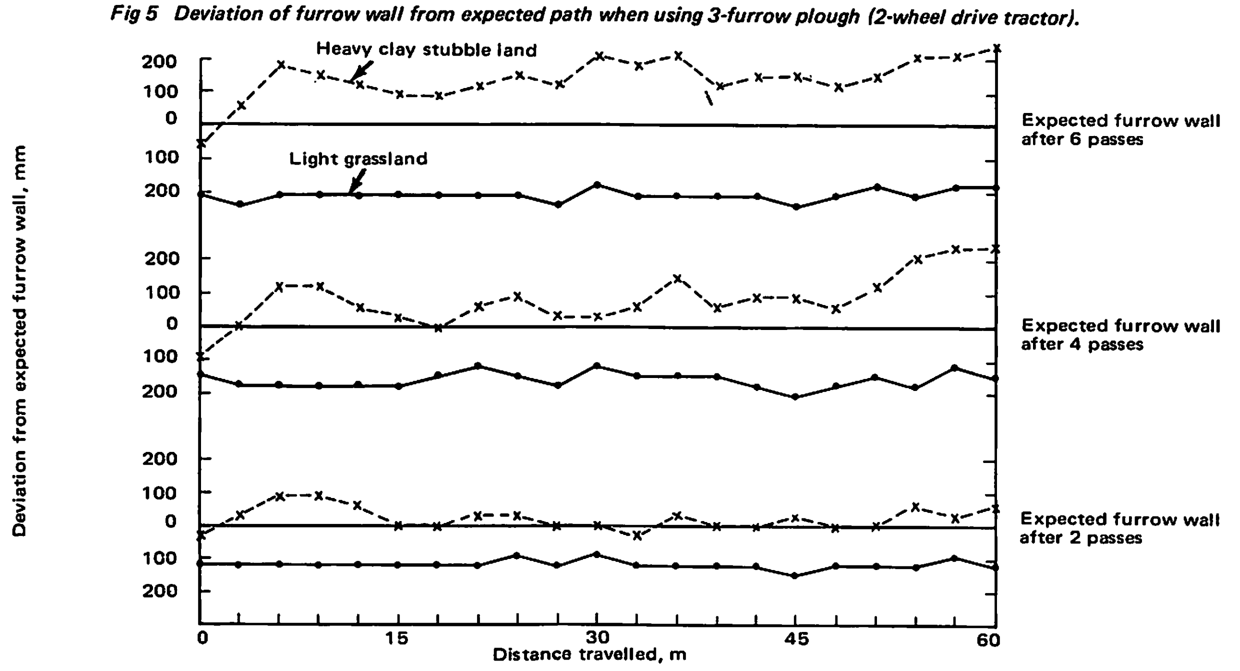
While the tractor/plough kinematics produced a general tendency to smooth out bends and waves in the furrow, changing ground conditions could on the other hand tend to introduce a certain amount of deviation from a straight path. This occurred when a change in soil or surface condition affected the balance between the plough draught forces and the lateral reaction forces at the wheel/ground contact area. Deviations caused in this manner were in the main not excessive and the furrow tended to be straightened out again in subsequent passes.

Under the majority of soil conditions no special measures were found necessary, except that a tensioning link was introduced between the rear of the plough and the left hand side of the offsetting frame to make the structure more rigid and reduce flexing

under load. With such an arrangement, ploughing tests were carried out on both light grassland and heavy clay stubble, with an initially straight furrow and measurements of furrow deviation were taken at intervals of 3 m over a total distance of 60 m after two, four and six passes with the plough. The 60 m run formed part of a much longer furrow so that end effects were minimised. Results of these tests for the two-wheel drive tractor fitted with 3-furrow plough are summarised in fig 5. As a general observation, it can be seen that on the heavy clay stubble land, the first furrow width was greater than the expected value while on the light grassland it was less. The mean first furrow width appeared to depend on the type and condition of the soil and on the moisture content both in the soil and on the surface. As might be expected, it was necessary to adjust the plough and the position of the tractor relative to the furrow wall to suit prevailing conditions. On the light grassland, which represented favourable conditions with low draught, the furrow was maintained within a 60 mm band over the whole length, as shown in fig 5. It is observed that the amount by which the furrow falls short after two passes is proportionately greater than after four and six passes but this could possibly be explained by the drying conditions prevailing at the time. This result after two passes still represents a mean deviation of only 6 per cent of the nominal width of 1.8 m. On the heavy clay stubble the deviation from the straight is clearly greater, though still not very important from a practical point of view. Apart from a single point at the beginning of the run, corresponding to a wet patch in the field, the furrow is contained within a band of 150 mm throughout the whole length even after six passes, with the mean deviation not exceeding 3 per cent per pass. It is apparent from observing the line of the furrow that sometimes deviations can persist over several passes of the plough. It is thought that this is a reflection of varying soil and/or surface conditions between one end of the furrow and the other. The ground used for this test did in fact contain compacted areas and was crossed by wheel tracks from very heavy machinery, thus presenting a greater degree of variability than is normally encountered in practical farming.

Results of the tests for the 4-wheel drive tractor fitted with 4-furrow plough are summarised in fig 6. It can be seen as a general observation that on the heavy land the width of cut was very close to the expected value whereas on the light land it was greater. Again the mean value for the first furrow width appeared to depend upon the type and condition of the soil and moisture content both in the soil and on the surface. In this case the moisture content at the soil surface was much greater on the light land than on the heavy clay soil. For the runs on the light land the furrow is contained within a band of 210 mm throughout the whole length even after six passes,

Fig 5 Deviation of furrow wall from expected path when using 3-furrow plough (2-wheel drive tractor).



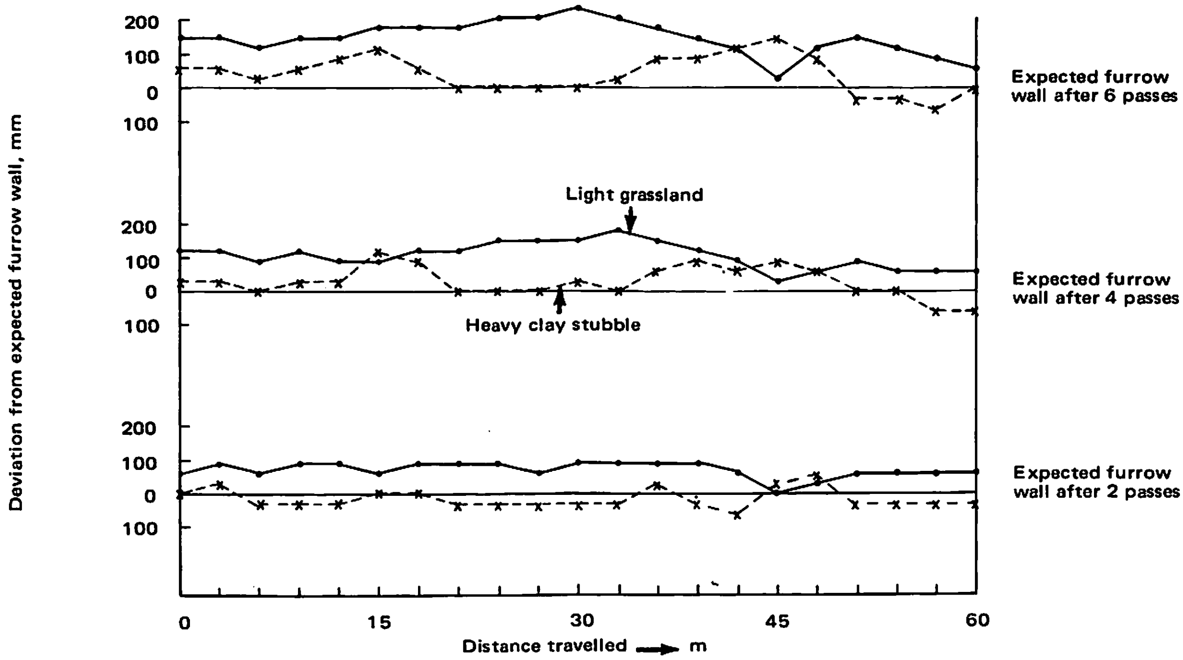


Fig 6 Deviation from expected furrow wall when using a 4-furrow plough (4-wheel drive tractor).

with a mean deviation of approximately 2 per cent per pass. The furrow is also contained within a band of 210 mm after six passes on the heavy land and here the mean deviation is approximately 1 per cent per pass.

3.4 Performance on Sloping Land

Both tractors were used to plough across sloping land with a gradient of up to one in eight. The attitude of the tractor and plough was affected by the slope, which caused a change in the mean first furrow width. When travelling above the ploughed land, the width was reduced by between 125 mm and 175 mm, and when travelling below the ploughed land it was increased by between 25 mm and 75 mm. The ability to reproduce a straight furrow was, however, not impaired by the slope provided that the gradient did not change appreciably across the slope. On a slope of constant gradient, this could be allowed for simply by setting the follower to the appropriate position to compensate. A problem was presented when changing direction across a slope, in that alternate follower settings were necessary if equal first furrow widths were to be maintained in both directions. This therefore pointed to the possible need for the provision of a trimming adjuster which could be operated from the cab.

4 Limitations with On-the-land Ploughing

The self-steering devices described here have been developed to provide an operator aid for such instances where out-of-furrow ploughing is considered practicable and advantageous. Precisely under what conditions the practice of out-of-furrow ploughing is practicable or impracticable is not easy to define. Ploughing with the tractor wheels out of the furrow could be said to suffer from two possible disadvantages. Firstly, the surface texture and moisture conditions may be such as to provide a poorer tractive surface than the furrow bottom. Secondly, if the number of furrows pulled are few, the relative offset of the draught force from the tractor's centre line will be considerable and may cause the tractor to yaw or crab sideways, owing to the fact that the rear wheels no longer have the furrow to provide a firm location. In the author's experience the unploughed land can provide an equally good tractive surface as the furrow bottom with the exception of the following conditions:

(i) during or immediately after rain
(ii) during a thaw after frost
(iii) when the surface consists of very dry, hard crumbs to a depth of more than 50 mm (2 in).

Any tendency that the tractor may have to yaw or to crab sideways is determined by the magnitude and degree of offset of the draught force, and by the ability of the tractor wheels to sustain side reaction forces[2]. The typical lines of action of the longitudinal draught force component for ploughs having various numbers of 14 in furrows is shown in fig 7. It can be seen that with a small number of furrows this force component is considerably offset and

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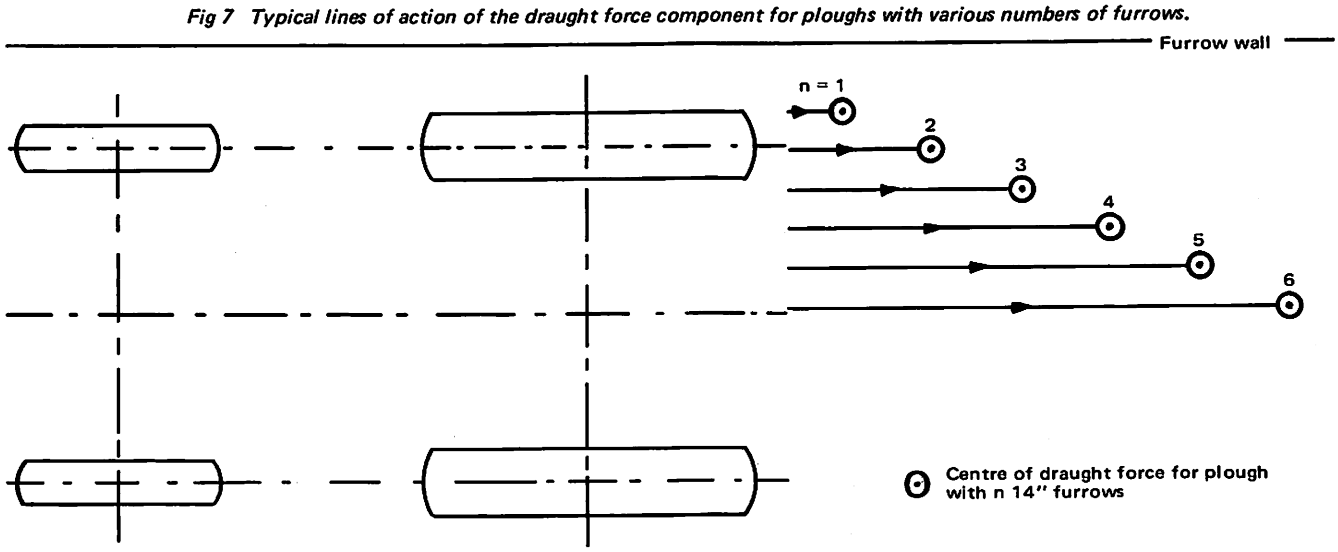
Fig 7 Typical lines of action of the draught force component for ploughs with various numbers of furrows.



The Control of Environment in Livestock Buildings

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IN any commercial situation three economic indicators exist:

a. the capital input required; to obtain
b. the output desired; and
c. the time required to transform this input into an output.

In the diagram below the livestock building is considered from this point of view.

INPUTS	taken from	OUTPUTS	give	PROFITS
animals		animal product		all in good
food		gain		TIME
labour		manure	=	if not then
equipment		other wastes		LOSS
fuel and power		(heat, CO_2, etc)		
land				

It is important to note that a building is assumed. This is the result of five trends in costs which can be identified as follows.

a. The increasing price of land makes sure that this commodity is used to its best advantage in producing animals. Data[1] suggests that average agricultural land prices are rising at about £17/ha a (£7/acre a). The necessity of fitting as many animals as possible into a minimum space has forced the development of techniques to achieve this — hence a building.
b. Figures published this year[2] give the following data:

Year	*Index of average work cost for manual tasks**
1968 (1st quarter)	124.9
1969 (1st quarter)	131.3
1970 (1st quarter)	140.7
1971	159.4
1972	178.3

*1963 = 100

This increasing price of labour has made it necessary for each man to look after more animals — hence the building.

c. Projected food price rises[3] between 1969–70 and 1977–78 taking into account the projected *EEC* price changes, and reduction of *UK* subsidies, assuming 5 per cent inflation and a constant parity of sterling of £1 = 2.40 *EEC* units of account. Feed grain price increases of 30 per cent to 60 per cent are expected. These appear to have been exceeded already due to the 'floating' of sterling currency and harvest failures in the *USSR* and South America.
This increasing price of feed ingredients has made closer control over the environment of animals essential, since it is only by such control that transformation of food into meat can be efficiently carried out:— hence a building.
d. The increasing scarcity of labour willing to work under filthy and often dangerous conditions is forcing farmers to consider the satisfaction of their staff more closely. This trend is reflected in data[4] which indicates that the total number of accidents incurred by agricultural workers is tending to decline.
e. The growing interest of the public in conservation, environmental pollution and animal welfare, coupled with the encroachment of suburbia into the countryside[5] is increasingly forcing the farmer to consider the social results of his policies, in order to prevent and forestall any adverse reactions.

Since these five economic forces have a major influence on any livestock enterprise, they are a necessary background to a discussion of environmental control. Bearing this in mind, it is now possible to define the livestock environment, and the means man uses to control it.

There is much confusion over the definition of 'environment'. To the farmer 'environment' is often synonymous with 'climate'. However, this is not the correct meaning of the word[6]. Possibly the most meaningful and comprehensive definition (for the farmers'

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it is not until six furrows are fitted that the line of action passes close to the centre line of the tractor's rear axle. (This compares with three furrows in the case of a plough which is not offset.) However, if fewer than six furrows are being ploughed the offset draught causes a greater proportion of the weight transfer to be taken by the furrow side wheel. This in turn increases the tractive force from that side, thereby producing a restoring moment which provides some compensation. The remainder of the moment then necessary to maintain equilibrium is under normal circumstances provided by lateral reaction at the tractor wheels. The amount of lateral reaction that wheels can provide depends not only on the wheel load, but is also affected by the amount of wheelslip which is taking place. Additional lateral reaction may, however, be obtained by attaching a wheel to the plough which locates against the furrow wall. Alternatively for stabilisation the plough can be fitted with a non-pivoting disc which runs in the soil, provided that this does not present undue penetration problems.

Practical experience gained in ploughing with different numbers of furrows suggested that with four furrows or more, the offset draught force did not present any great difficulty. Where it was necessary to drop to two furrows under very heavy conditions, ploughing out of the furrow appeared to be impractical. With three furrows the situation appeared to be marginal. The tractor tended to pull satisfactorily at low values of wheelslip, but when the draught was sufficient to produce 20–30 per cent wheelslip this sometimes caused the tractor to crab and yaw. This tendency was greater in the case of the two-wheel drive tractor, resulting occasionally in the front wheels sliding into the furrow. To ameliorate the situation some experiments were performed with a disc fitted to the rear of the plough and this did in fact improve matters provided that penetration was not a problem. With the 4-wheel drive tractor there appeared to be less tendency to yaw in such marginal cases.

It is apparent, therefore, that out-of-furrow ploughing is more suited to larger tractors capable of pulling four furrows or more.

5 Conclusions

Both devices described have been shown to be capable of satisfactorily steering the tractor when ploughing out of furrow under all conditions except those under which it would be difficult in any case to steer manually. The steering control can operate at speeds well beyond normal ploughing speeds and the follower holds the furrow wall despite the normal occurrence of short gaps in the wall or occasional obstruction by clods and stones. For working across slopes, it is considered that the variations which can occur in first furrow width could be eliminated by providing the operator with some means of trimming adjustment.

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Acknowledgements

Thanks are expressed to J. Butler for his assistance with the experimental work.

purposes) is 'all those factors influencing animals which are not genetic in origin'. This rather vague definition is the one adopted here. In considering such a broad field some kind of classification is necessary, and the following is suggested as being both practically and scientifically useful.

ANIMAL ENVIRONMENT

Physical (Climatic)	*Physical (Nutritional)*	*Biological*
Includes such factors as: heat, light, sound, dusts, gases, aerosols etc.	The eaten environment: energy, proteins, fibre water, vitamins, minerals etc.	Behavioural effects of other animals, of the same or different species. Disease organisms etc.

Each of these environmental factors has an optimum value for a given livestock enterprise in given market conditions. Hence for general market situations generalised optima, associated with an error term, or an economic limit, can be determined. This point is important, and will be referred to in later discussion.

It is obviously a mammoth task to keep an accurate and extensive control on each aspect of the environment of a livestock building. Yet this is what the farmer is setting out to achieve. In order to judge the merits of particular methods of achieving this aim some discussion of control theory is apposite.

Control equipment undertakes three distinct actions,[7,8,9,13] which may be carried out by separate parts of the control gear, but are usually integral parts of the same machine. The first action is one of monitoring or sensing the actual environmental condition. This signal is then compared with the desired environmental condition, or a derivative of this value, before being converted into a form which activates a method of adjusting the actual environmental condition towards the desired value.

This is shown diagrammatically below.

The cycle of sensing, comparing and adjusting, is repeated at intervals, depending upon the accuracy required. This basic control cycle is fundamental to any control function, whether this be control over ventilation, over an enzyme system within the animal, or over the provision of a particular diet.

However, the control of actions can be of differing sophistication. They may involve manual stages or be completely automatic. They may have a discontinuous action (for example, simple two-position control), or they may be continuously variable (eg proportional control). Devices to protect the controlled equipment from excessive demand by the acuator may also be installed.

Thus, in addition to the mammoth task of knowing what he wants to achieve from environmental control, the farmer has the unenviable task of deciding how to achieve these requirements.

Nevertheless, for any given livestock system two questions require elucidation:

1. Is control necessary over a given environmental factor?
2. If control is necessary, what kind of control is most suited to the enterprise?

Because of the large number of environmental parameters, livestock housing systems must be designed to eliminate the need for controlling equipment or labour. This can be achieved by designing the system to work between the established environmental limits referred to above. Failing this, a simple but automatic control circuit should be installed. But such systems must:

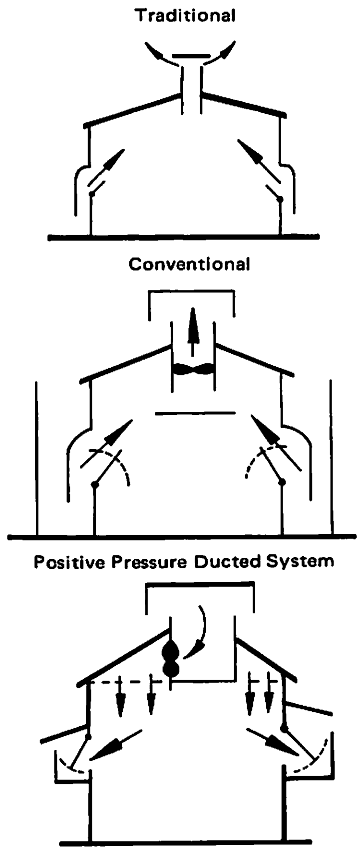
a. achieve control over one factor without limitation on possible benefits of a different factor: for example, a draught free ventilation system could be achieved by lowering ventilation rate to such an extent that overheating occurred;
b. be economically viable: the control system must achieve an economic, not a physiological optimum.

The basic argument, that control facilities should be 'designed out' of livestock buildings by fixing extreme limits of variation within those economically acceptable, has but one flaw; namely that the economically acceptable limits may narrow, thus jeopardising the financial viability of the unit. However, it has already been shown that the major economic trends are well established, and can therefore be anticipated at the design stage.

In order to exemplify this theoretical discussion, three aspects of the animal environment, and alternative control solutions are considered below:

(1) THE CONTROL OF ENVIRONMENTAL TEMPERATURE AND AIR DISTRIBUTION IN ANIMAL HOUSES

There are a number of differing ventilation systems[10]. Three only are mentioned here.

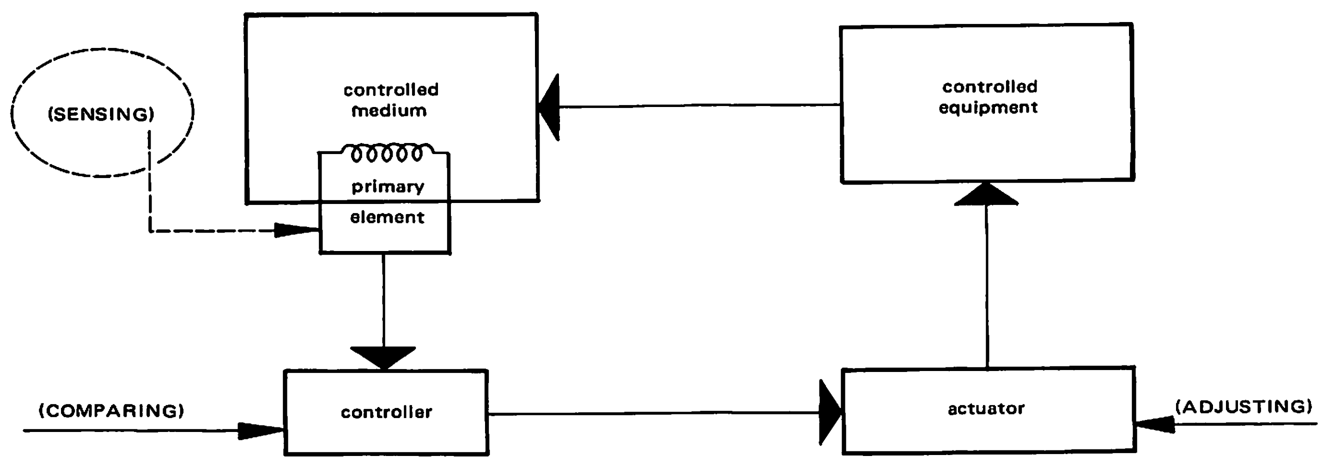


Wind interference meant that inside house temperature varied directly as ambient. Air distribution was controlled manually by adjusting the louvres on the side walls.

The traditional housing system developed to the installation of fans, and control gear varying fan speed and inlet size automatically and continuously, providing very sophisticated control over house temperature and air distribution.

Designed from first principles this system has no control over air speed, but the variation in air speed and distribution is reduced to acceptable limits by the large duct surface area (which is constant). However, it is still necessary to control temperature through ventilation rate. This is done by simple thermostatic control over the fans. The fan pressure is used to open valves in the outlets which close under wind pressure and their own weight.

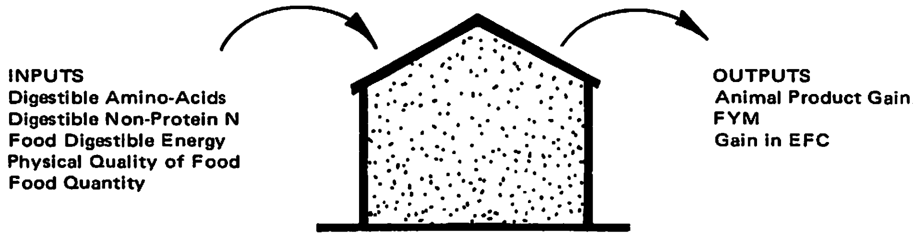
Both the latter systems can be made to provide control over air distribution and temperature within the required limits[11,12]. However, the former has a large number of complex control elements, whereas the latter need only have three. The farmer is therefore better able to understand and operate Positive Pressure ducted



systems than a more conventional system, and the system itself is inherently more reliable.

(2) THE CONTROL OF PROTEIN

This example of control of the nutritional environment shows that even today control methods in this sector are very naive.



Generally speaking the nutritionist reduces the variation in each of the input factors so that the food delivered to the farm provides a fixed protein quality and quantity. Thus the only controls the farmer has are:

i. to vary manually and discontinuously the quantity of food fed to stock: in *ad lib* feeding systems this control is not available;

ii. to alter the food specification manually and discontinuously, by contacting his feed supplier.

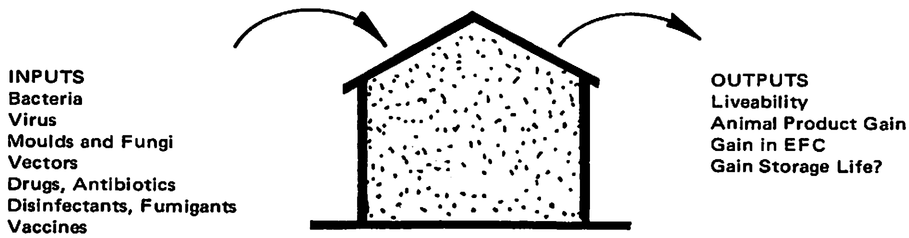
Neither of these methods is very helpful since they are not automatic, nor are they particularly fine controls. Thus it is difficult to gear-up to given production levels, especially when it is necessary to treat individuals within a flock or herd separately.

In such circumstances two approaches are possible:

i. the feeding system is programmed so that food changes are made relatively automatically and continuously (for example, dietary protein can be decreased gradually through the life of a broiler flock if the total quantity of food the flock has already eaten is known);

ii. a dietary formulation can be made which will suffice for all of the stock under consideration: that is the system does not have a control, but variation is reduced to an acceptable level (for example, the *ad lib* feeding of laying hens).

(3) THE CONTROL OF INTERACTIONS BETWEEN ANIMALS AND SPECIES OF DISEASE ORGANISMS



Here the quantity of organisms entering the building can be reduced by filtering incoming air, making sure that food and bedding is sterile, restricting personnel access and following an 'all in/all out' stocking policy. Once the ingress of pathogenic organisms has been reduced to acceptably low levels, it should then be possible to pursue the normal manual discontinuous control over the use of drugs, vaccines etc for which there should be a reduced demand. (For example, coccidiosis can be reduced in the broiler chicken, as *Salmonella* species infections in the pig and calf.)

Obviously it is impossible to cover each area of the environment in this discussion, therefore the basic trends in control design have been highlighted. Two trends are evident:

i. to replace manual by automatic control;

ii. to reduce the variation in outputs resulting from parts of the environment which are costly to control by more thoughtful design of the livestock building so that the necessity for control is reduced or eliminated.

In the past not enough thought has been given to what livestock buildings ought to achieve. Vast sums of money have been spent on lost production and curative measures instead. There is a large and increasing body of evidence to show that a further small investment in thoughtful building design could prevent most of this lost production and reduce the cost of curative measures. Can we afford not to consider it?

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[13] Coales (Ed) Theory of Control Systems; using discrete information, Butterworth 1968

The AGRICULTURAL ENGINEER

The next issue of The AGRICULTURAL ENGINEER will carry reports of the papers read at The *IAgrE* meeting at Silsoe on 27 September. Orders for advertising support should be forwarded now.

Fluid Power on the Farm

A JOINT discussion meeting was held at the National College of Agricultural Engineering, Silsoe, by the Fluid Power Transmission Group and the Eastern Branch of the Institution of Mechanical Engineers and the Institution of Agricultural Engineers. To set the scene for the subsequent discussion three brief papers were presented, summaries of which are given below.

F. M. Inns, Senior Tutor of the National College of Agricultural Engineering, spoke on the evolution of fluid power in agriculture.

The Farm Tractor

THE use of hydraulics on the modern farm tractor, like so many other of its features, is the consequence of the foresight and ingenuity of the late Harry Ferguson. The original Ferguson hydraulic system was designed for an intermittent power output as required for implement lift and control and, for many other purposes, power was limited. The first applications external to the tractor of the available hydraulic power were to intermittent use of hydraulic jacks to operate tipping trailers and front-end loaders.

Current tractor models are fitted with pumps giving a maximum power output in use of about 0.20 of the installed engine power which is itself roughly proportional to tractor weight and maximum implement lift capacity. The installed power is provided mainly for the normal implement lift function and this function is in many respects incompatible with the provision of external power, since higher flow rates lead to problems of instability in the depth control of implements. This has led in some instances to the provision of separate pumps for implement lift and control and for external service connections. A closed centre system in conjunction with a variable delivery pump is used on some larger tractors.

Farm Machines

Hydraulic power from the tractor may be used on farm machines in a number of ways.

(a) **intermittent operational functions.** These functions are usually provided by hydraulic rams. The tipping trailer and front-end loader were the first pieces of equipment in this category; bale handling devices which accumulate and stack bales are also extensively used

(b) **continuous operational functions.** The operational function may be a continuous one, such as providing the drive to a spinning disc fertiliser distributor. Three limitations may be noted on the further application of continuous hydraulic drives to equipment used in conjunction with the tractor. Firstly tractor installed power is limited, severely restricting the range of machines which can be driven using the installed hydraulic power. The second limitation arises from the variation in flow from the pumps fitted to different tractor models, resulting in variation of the driven speed of equipment unless motor capacity is matched to the oil flow from the particular tractor model. Finally cost and convention favour the mechanical power take-off unless the drive line is particularly tortuous or the cost of providing adequate guards is particularly high

(c) **intermittent control functions.** Hydraulic power is frequently applied to the control of farm equipment, including depth control and transport of the implement, angling of multi-gang disc implements, changing the direction of reversible ploughs, levelling and depth control of potato harvesters and drainage machines. The speed of these functions is not so critical as in the case of continuously driven equipment and some mis-matching of flow rates may be tolerated

(d) **continuous control function.** The tractor hydraulic system is sometimes used to provide a continuous control function to farm machines, an example being the automatic regulation of the working depth of the share on a potato harvester.

Self Propelled Farm Machines

In addition to machines making use of the tractor hydraulic system a wide variety of large specialist self propelled machines such as combine harvesters and pea viners exist, many of which use hydraulic power for various control functions and some of which are also equipped with hydrostatic ground drive transmissions.

Industrial Equipment

The versatility of the modern farm tractor has led to its use, often in modified form, in a number of off-farm situations, such as in constructional work where it may be employed in bulldozing, loading and excavation using rear mounted digger attachments. Ground drive transmission is frequently by hydrokinetic torque converter, this being particularly well adapted to loader work with its need for maximum thrust at zero speed and frequent reversals of direction. Another extensive application is with local authorities for roadside verge trimming.

Fixed Equipment

Electric motors are the most widely used prime movers for fixed equipment on the farm, although fluid power has been applied to various items of fixed equipment such as hammer mills, auger elevators and cubing and pelleting machines. Pneumatic power is of course extensively used for milking machines and in milk handling systems.

The Future for Fluid Power on the Farm

(i) Separate hydraulic systems should be provided for the implement lift and control function and for operation of services external to the tractor. Provision of a separate oil supply is desirable.

(ii) Provision should be made on the tractor engine block or transmission housing for the attachment of a hydraulic pump, with a drive from the engine adequate to provide up to 25 kW at 3000 rev/min.

(iii) External service pump flow rates should be standardised, perhaps to two flow rates of, say 0.75 and 1.50 litre/s.

(iv) Agreement should be reached on the working pressure. A standard relief valve pressure of 20 MN/m^2 (3000 lbf/in^2) is suggested.

(v) Standard motor capacities should be specified to achieve standard speeds of say 150, 300, 600 and 1200 rev/min. Motor mounting plates and shaft dimensions should be standardised.

(vi) Standardisation should be reached on a quick release self-sealing coupling.

W. P. Billington, Design Engineer of the National Institute of Agricultural Engineering, spoke of his experience in the design and development of hydrostatic transmissions applied to specialised agricultural research and testing equipment.

THE generally accepted advantages of hydraulic transmissions — simplicity, ruggedness, versatility and infinitely variable speed control — make their application particularly suitable to this type of equipment. Two recent applications of hydraulic drives on very different machinery will be considered and from this practical experience brief comments will be made on transmissions for tractors and other field equipment.

Rotary Extrusion Press

The *NIAE* rotary extrusion press was built to provide experimental facilities to investigate the relationship between the power input and the output of packaged forage crop over a wide range of crop types, maturities and moisture levels. The effect on product quality of varying press speed, crop moisture content and feed rate can also be established. The decision to use a high speed hydrostatic transmission was influenced by four major factors:

1. The wide range of output speed and torque required ie 0–400 rev/min with 13 500 Nm (10 000 lbf/ft) available at 30 rev/min.
2. The operational convenience of a steplessly variable speed transmission.

3. The need for easy rotation of the final drive unit between vertical and horizontal.
4. The requirement for either the die or the rollers to be rotated.

The range of output speed and torque capacities was chosen to encompass that of all existing machines of similar size. A number of alternative prime mover and transmission combinations were considered, including electric and diesel motors with a multi-speed mechanical gearbox final drive and also a low speed high torque hydraulic motor. The transmission finally selected consists of Lucas *PM*3000 axial piston pump and motor units delivering power from a diesel engine to a two stage dual speed chain reduction box with the coaxial die and rollers crankshaft forming the final output shafts.

Single Wheel Tester Mk II

The single wheel tester was constructed for a study of the effects of size, ply rating, inflation pressure, vertical load and ground conditions on the tractive performance and rolling resistance of agricultural tyres. The tester is based on a four wheel drive forward control tractor, modified to provide two independent hydrostatic transmissions of the axial piston type. One transmission drives the tractor in place of the standard gearbox while the other can supply up to 52 kW (70 hp) to the test wheel. The tractor transmission uses the Lucas *T*100 integrated transmission unit in place of the standard gearbox. The test wheel transmission consists of Lucas *PM*1000 pump and motor units. In operation, the initial speed and direction of both transmissions is set by the driver in the front cab and the test operator in the rear can then vary the speed of both transmissions down to zero by means of two independent controls. Positive tractive force with wheel slip can be produced by running the test wheel faster than the tractor or a negative tractive force with wheel skid can be produced by running the test wheel slower than the tractor. To date the tester has been used to investigate the effect of ply rating on tyre performance to determine whether future experiments would have to take account of this, and work has also been done to measure the performance of a range of tyres on a number of different soil conditions in order to provide traction design data.

Tractor and Implement Transmissions

Although hydrostatic drives for wheels were being considered at the beginning of this century, practical applications in agricultural tractors began in 1950 at the *NIAE*. Low speed motor developments, the construction and field study of a tractor incorporating wheel motors, and research into aspects of design and performance of hydrostatic transmissions were continued for ten years or so. Motors based on *NIAE* design have been manufactured commercially and have been extensively used in constructional machinery and cranes, but not for agricultural tractors (other than experimental prototypes).

The present application of hydrostatic transmissions to farm tractors on a commercial basis has generally been restricted to high speed 'gearbox replacement' units, which in the *UK* are represented by the Dowty 'Taurodyne' and until recently the Lucas *T*100 units. A recent example of a tractor employing low speed, high torque motors to drive wheels directly is the 30 kW (40 hp) log skidder tractor developed by the Forestry Commission, which uses ball piston motors manufactured by Carron under licence from the National Engineering Laboratories. On this tractor, a four-wheel hydrostatic drive has been combined with chassis steering to provide a highly versatile and manoeuvrable vehicle. Another application is the use of a hydrostatic drive to the front wheels of a vehicle converted to four wheel drive (John Deere). As far as implements are concerned the main application of hydrostatic transmission has been on the combine and some forage harvesters.

The integrated hydrostatic transmission units, used as a direct replacement for a conventional gearbox, entail minimum vehicle modification, but because this type of transmission replaces so little of the mechanical drive line, it seems almost inevitable that the hydrostatic feature must cost more. The alternative to the high speed system is the low speed high torque radial piston wheel motor. Two or four wheel drive can be equally well incorporated; the engine and chassis do not have to be laid out for directly coupled gear trains or drive shafts and, where motors are within the rims, the maximum amount of space is available for the increasing number of tractor components such as hydraulic pumps, lifts, cab, mounted loaders etc. The disadvantages are the size and weight of motors, the additional high pressure plumbing required and, perhaps most important, the large capacity pumps needed to generate the high oil flows required.

General

Over the past few years hydraulic transmissions have been steadily developed, improved and simplified, and complete systems are now ready for general use. There has been a steady increase in the use of hydraulics for auxilliary power, but hydrostatic transmissions have made slow progress with regard to being adopted for traction. Perhaps in the discussion some possible reasons for this may emerge, but general acceptance of hydrostatics will probably depend on direct comparison of cost with the conventional mechanical drive.

E. G. Morley, Research and Development Manager of Plessey Hydraulics Limited, spoke on the problems of the hydraulic equipment manufacturer.

Why Fluid Power?

MECHANISATION of agriculture developed in an attempt to replace the diminishing availability of human skills on the land, to improve the speed and efficiency of farming operations, and to overcome the problem of operator fatigue. Conventional mechanical transmission of power was used in the early stages, fluid power being introduced by Harry Ferguson in the 1930s. Since then the use of fluid power has increased due to its flexibility in operation, the high power to weight ratio of hydraulic units and the ease with which it can be integrated with other power systems and signalling devices.

The Present Situation

The modern tractor may have a hydraulic system providing power for:

(a) draught and position control of the lift arms
(b) power brakes
(c) power steering (power assisted or hydrostatic)
(d) hydraulically operated pto clutch
(e) hydraulically operated front loader
(f) facility for the hydraulic operation of ancilliary equipment
(g) hydrostatic drive
(h) four wheel hydraulic drive.

The International Harvester 1066 hydrostatic tractor is one of the most advanced tractors on the market at the present time in its use of fluid power for the operation of various working functions. The circuit diagram of the system will indicate its sophistication and this in turn the amount of technological expertise that must go into the design and development of such a system.

It will be obvious that in order for such systems to work correctly and reliably, they must incorporate high performance high reliability components having an 'acceptable life'.

Take the agricultural tractor as an example, to explore possible operating parameters. It may have to operate in any crop-producing area of the world. This affects:

(a) operating temperature (ambients between -20°C to $+40^\circ$C)
(b) dusty and arid air conditions
(c) vastly differing work cycles
(d) differing operator know-how (operational maltreatment)
(e) from normal to complete lack of on-farm maintenance
(f) from normal to virtually complete lack of dealer maintenance expertise.

Consider the above six points. It will be apparent that operating oil temperatures in the transmission and hydraulic circuit could well vary between -20°C and $+100^\circ$C and more under certain operating conditions. It is difficult to maintain cleanliness of the oil. The differing work cycles coupled with variation in operator know-how make it extremely difficult for the machine manufacturer to decide what sort of work test cycle and life should be aimed at during the vehicle development. The last two points really demand an excessive safety factor against use with dirty, contaminated or aerated oil.

Because of these problems it is virtually impossible for the machine manufacturer to present to the component supplier a realistic specification against which to work. So he has two viable choices open to him.

1. To decide upon operating parameters of steady state and transient pressure, oil temperatures, running speeds etc

based on his own controlled field work, and to draw up a component performance specification around these including some form of life target.

2. To take the above characteristics and factor them up in an attempt to cater for all the unknowns listed earlier. When this is done usually a foreshortened life is stipulated and the test is considered as an accelerated test.

Both specifications have limitations because certain operational assumptions have to be made in both cases. There is also the problem of shifting goal posts, for instance when the machine was designed the hydraulic system had to be capable of lifting a maximum load of *x* kg, but after the machine had been in production, say for twelve months somebody produces a larger plough or some other implement and the machine cannot operate it effectively.

There are many other instances where operational conditions are changed which result in:

(a) at the worse a large number of field failures and intensive redevelopment to uprate components within the existing envelope, because it is a costly business to make extensive tooling changes to a tractor manufacturing line

(b) failures which can be tracked down and eventually pinpointed to some factor which can be rectified without major component re-design. Even so, during the time of the trouble the tractor manufacturer and component manufacturer has lost face and prestige.

I suppose that on the face of it the accelerated test would have some advantage in such circumstances. But here we may be over-designing a component, particularly from the fatigue aspect, if the operating stress level under accelerated test conditions is approaching the upswing point on the *S-N* curve.

Summarising, the problem is:

1. the need cannot be precisely defined
2. the design specification is predicated against, under or over severe requirements
3. field service may not be adequate to meet present day needs.

The third point is open to question, but the increasing complexity and sophistication of the operational systems on tractors demands some thought on the publication of a simple series of checks to pick up impending problems before they become really serious.

Future Trends

The trend in hydraulic system pressure has not been a gradual increase over the past twenty years, but rather increases in steps of approximately 2.0–3.5 MN/m^2 (300–500 lbf/in^2) from about 10 MN/m^2 (1500 lbf/in^2) to 20 MN/m^2 (3000 lbf/in^2). The important thing to note here is that the actual physical size of tractor lift pumps has only increased slightly with the doubling of the pressure for the same displacement. At the moment there seems to be no great urgency to increase the pressures in tractor systems, but rather to obtain more reliability, and utilise engine power more efficiently.

Reliability of farm machinery is of prime importance and quality control has become a very important function from the design through the manufacturing and marketing stages of hydraulic components. With the ever-increasing severity of operating requirements this will become even more important.

More efficient utilisation of power is very desirable and although at the moment there seems to be no great urgency to increase pressure levels in agricultural machinery systems above the 20 MN/m^2 level, there appears to be a need to increase pump flow, and hence hydraulic power. The hydraulic pumps already fitted into tractors and other equipment have operating efficiencies well above 90 per cent, so there is not a lot of saving to be made here.

The normal open centre system with a fixed displacement pump already has off-loading, so one can only reduce the power loss by reducing the off-load circuit pressure drop.

I feel that the next step will be closed centre systems with variable displacement pumps. With such systems one gets a more efficient power utilisation and faster response. On the other side of the coin they become more expensive.

Machines such as combine harvesters lend themselves readily to the incorporation of various closed loop systems, to improve their overall operating efficiency. The lack of human skill on the land now makes it necessary to attempt to replace some of this by electronic, electromechanical and hydraulic sensing and control devices, and this, in fact, is being done. The main problem here is not only technical but there are, of course, considerable commercial overtones.

There are naturally many other points which could have been brought into this discussion but time does not permit it. But I would like to mention one point which is of extreme importance to the component manufacturer, and that is noise. Another more general point I would like to make concerns the importance of ergonomics in agricultural machinery which, when we are searching for the elusive one or two per cent increase in overall efficiency of operation, becomes an essential consideration.

Research and Development Work at the National College of Agricultural Engineering

A LARGE proportion of the research and development work carried out at the National College of Agricultural Engineering is in the form of small student projects which form part of the *BSc* Honours Degree, a one year Master's Degree and a nine month postgraduate certificate. This is supplemented by research higher degree projects, and work carried out by individual members of staff. Some of the main areas within which work is in progress are summarised below.

Work is in progress to achieve better implement depth control than is possible with present draught control systems whilst still benefitting from almost complete weight transfer and weight addition. Two approaches have been taken, one based on horizontal force sensing through three strain gauged attachment pins on the tractor with their output signal controlling the raise and lower valve in the hydraulic system. The alternative approach through a sensitive depth wheel system was first made using a mechanical linkage between the wheel and the draught control lever but this was superseded by an electronic system linked directly to the hydraulic control valve. Built into the electronic system is an override device which responds to excessive wheel slip by tending to lift the implement.

Raindrop splash and soil erosion studies are continuing through instrumented field plots to study the severity of soil erosion on certain British soil types particularly those on the Greensand. The erosion of roadside embankments is a serious problem, particularly in the tropics, and a joint project with the Road and Transport Research Laboratory is in progress investigating the erodibility of Kenya soils. Related to this is some basic work on the effect of slope on soil loss and on soil loss from ridges. The determination of the infiltration rate of soil for sprinkler irrigation design is always difficult and an attempt is being made to apply some of the soil erosion splash results in this field. Soils are subjected in the laboratory to storms of similar energy levels to those encountered under sprinkler irrigation and infiltration rates measured. As part of this work an acoustic energy transducer has been constructed to measure the energy delivery rate of a storm.

As part of the College's involvement in overseas agriculture, effort has been put into the development of an efficient low-cost power unit which could be locally produced. In co-operation with Makerere University, Uganda, a small four wheeled tractor has been developed together with the necessary implements but this suffers like all small tractors from a poor tractive performance.

A way around this problem is to use the engine power through a winch and this approach is receiving most attention at the moment. Improvements in the design of animal drawn equipment in the form of seed drills and cultivation implements have been made, with help from members of the Intermediate Technology Development Group, Agricultural Project Unit, located on the site. Systems analysis has been used to investigate the mechanical harvesting of rice and sugar cane transport.

The effect of vegetation and bends on the flow in a small watercourse was examined in conjunction with the local river authority, prior to developing the rivers in this area of Milton Keynes new town. Other hydraulic projects are in the development of simple energy dissipating drop structures for irrigation channels, investigation of the hydraulics of overland flow and preliminary work on the pumping of slurries.

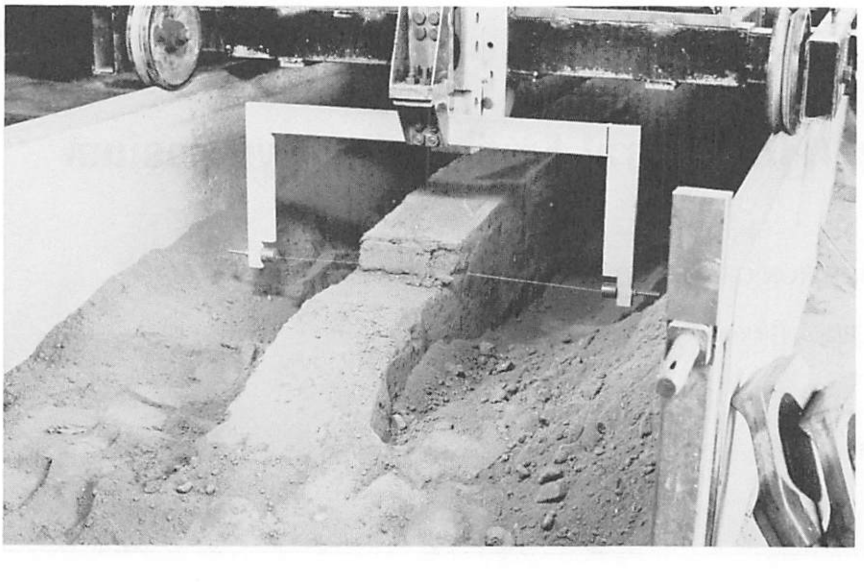
A number of projects in progress are concerned with tropical crops including the dehusking of rice, maize shelling, groundnut decortication and the separation of palm kernels and shells. In addition to the actual operation, ergonomic aspects of the machines are being investigated. Rice transplanting is being investigated on the basis of a two stage process to overcome the difficulties of machine separation of the rice plants. The rice plants are hand separated and spaced beforehand between two belts and the 'cartridges' of belt + plants are mounted on the transplanter for the planting stage.

In the soil mechanics/cultivations field, methods of raising spring soil temperatures for germination are being investigated. The midslope position on the south side of a ridge has been found to be advantageous and any net gain is being assessed using crops of maize, soya bean and haricot bean. Soil failure patterns and the forces acting on very narrow tines have been investigated with the aid of funds from Calor Agriculture with the aim of developing the designs of anhydrous ammonia applicators and other implements.

In this age of itinerant satellites, aeroplanes and balloons, aerial photography is facilitated, with great benefits to the planning process. Land resource planners are investigating the uses of remote sensing to identify further agricultural crop characteristics and phenomena from photographs.

Natural ventilation of buildings, mainly for livestock production, is being investigated with a view to the provision of design data concerning the construction and position of buildings. These studies include the identification and examination of factors influencing pressure distribution around buildings and their effect on ventilation systems. Spacing and thickness of slatted walls and the development of a portable environment monitor are also included in this programme.

Gordon Spoor



A study of the forces of soil cutting being conducted under the controlled conditions of the Soil Implement Research Laboratory.

Research and Development Work at the University of Newcastle upon Tyne

RESEARCH and development work in the Department of Agricultural Engineering of the University of Newcastle upon Tyne during the past year has been based in six major areas and a brief account of each is given here. Further details may be obtained from the Department directly.

In soil/machine mechanics theories which relate machine performance to soil properties over the full range of applications from earthmoving machines through tractors and cultivation equipment to the plant root itself are being revised and further developed. A major part of the past year has been concerned with the analysis of the effects of vibratory mechanisms on the soil. A self-propelled tunnelling mole has been developed.

Further studies of the dynamics of engineering systems, with particular reference to the tractor/implement combination, have continued and are finding application in the design of a tractor mounted spray boom and the prediction of tractor field performance. Techniques and equipment for data collection from machines operating under field conditions have been developed and used to measure forces and movement in a tractor/plough combination with pure draught sensing and also in a tractor lift rod.

The design section has achieved success with its tractor mounted tree extractor, which is now in commercial production. Design is an important part of the undergraduate degree course in the department and students work in groups on projects, often in co-operation with an outside commercial sponsor.

The success or failure of a farming business or even an individual enterprise is often determined by the ease and success with which the various sections can be integrated. These interactions are quantitatively studied under the title of 'systems analysis'. Grass drying and silage system studies have been completed and a start has been made on the systems analysis and model synthesis of biological systems. Simulation models of key operations in sugar beet production and in the growth of the wheat plant have been completed.

Field measurements of an experimental implement control mechanism being recorded on magnetic tape for later computer analysis.

Drying has remained the major interest of the crop conservation section. A mathematical model of the drying process has been developed and validated by experimental laboratory and field measurements for barley and for ryegrass. Certain thermodynamic properties of paddy rice and maize have been measured in the laboratory for use in these simulation models. New designs of high temperature driers for cereals and grass have been further developed on a commercial scale. Control systems for low temperature bulk driers for cereals have been designed and are being tested under farm conditions. These drying systems operate at greater risk but can achieve drying without using vast quantities of energy derived from fossil fuels. The control philosophy is based on the analysis of weather records and acceptable losses of dry matter. The dry matter loss occuring in wilted ryegrass has been measured and shown to be moisture content and temperature dependent with temperature the more important factor if moulding does not take place.

A major constraint on the size of animal production units is the necessary disposal of the waste products. A variety of treatment techniques has been investigated and compared with the traditional land spreading. Measurements of waste quality and quantity from pigs under test and under commercial conditions have been made in support of a simulation of aerobic treatment processes aimed at producing a clear effluent and solid sludge. Whilst land spreading will undoubtedly remain the most attractive technique for many livestock producers even this may lead to pollution and a computer simulation model has been used to predict safe limits for spreading rates on agricultural land. The model is being validated in experiments at several sites by sampling drainage water from the site for quantity and quality after various rates of land spreading of slurry.

D. J. Greig

The

AGRICULTURAL ENGINEER

The winter issue of the Journal, to be published on 7 December, will carry the papers read at the Institution of Agricultural Engineers Autumn Meeting to be held at the NCAE, Silsoe on 27 September 1973. 'Irrigation for Agriculture and Horticulture in the 70's'.

Research in Agricultural Engineering at the University of Reading

Research by Students

READING UNIVERSITY offers options in agricultural engineering and agricultural building in the final year of the *BSc* Honours Degree course in Agriculture and at postgraduate level offers one-year and two-year taught Masters' degrees. Facilities are also available for research programmes leading to the degrees of *MPhil* and *PhD*, demanding periods of study of not less than two and three years respectively. While research higher degrees are normally undertaken by internal candidates, arrangements can sometimes be made for suitable members of the staffs of other appropriate bodies or affiliated research institutes, and occasionally of similar organisations overseas, to register for Reading *MPhil* or *PhD* degrees.

At any one time the greatest amount of student research activity is normally at the less advanced levels, in connection with Final Year Honours projects and taught Masters' degree dissertations. Because of the specialised nature and high capital cost of the necessary research equipment, in most cases the more fundamental studies tend to be carried out at research institutes, such as the National Institute of Agricultural Engineering, rather than in the University itself.

Staff Research

As in most universities, work by members of academic staff tends to follow their special interests, subject to the inevitable constraints of time and funds. The University is also fortunate in having had handed over to it, in 1968, responsibility for the continuation of work initiated by the Electrical Research Association at its former field station at Shinfield, and four of the agriculturally-oriented members of the old field station staff now work in the Agricultural Engineering and Building Section of the Department of Agriculture.

Research Topics

The effect of the provisions and circumstances mentioned is to produce a continuing basic core of research topics, while allowing individual students a very large measure of freedom to investigate particular topics on a much wider basis, subject only to overriding considerations of feasibility.

The core topics are as follows:

Thermodynamics

In collaboration with the Department of Applied Physical Sciences, several projects are in hand. These include: the Stirling engine as a development project with particular relevance to possible future shortages of fossil fuels and to the reduction of atmospheric pollution, heat pipes as a device for rapid thermal transfer, and some related developments in furnace design.

Instrumentation

The Section has for many years been concerned with the development of automatic control systems for agricultural tractors. Funds for this project have come to an end for the time being, but the staff involved are now working on related projects of a non-agricultural kind, in collaboration with the Transport and Road Research Laboratory. It is to be hoped that in due course it may again be possible to continue the work with tractors, no doubt benefitting from the *TRRL* experience.

The development of instruments, recording and data logging techniques, hardware and software also forms an important part of the work of the Section.

Livestock Environment

The engineering aspects of environmental control are being investigated particularly in connection with pigs and poultry. A comprehensive research unit for work on the effect of elevated temperatures for laying hens is operated in collaboration with the poultry research unit, and another installation for work on the effects of gas concentrations on pigs and other animals of similar size has just been completed.

The building division of the Section is engaged on design and layout studies of many kinds in connection with livestock and other buildings.

Waste Disposal

Substantial grants from the Agricultural Research Council have enabled work to be undertaken under two main headings. These are the evaluation of the performance of a floating aerator as a means of controlling smell in the treatment of manure from dairy cows, and a study on a high-rate filtration tower treating poultry waste. A solids/liquid separator developed in collaboration with University staff is used in both projects.

A further project on the refinement of liquid effluents is about to start, with support from the Ministry of Agriculture, Fisheries and Food.

Student Projects

A selection of recent studies includes:

The possibilities of pallets as a means of handling materials on farms (*MSc*).
Problems affecting the layout of slaughterhouses (*MSc*).
The tractive and drawbar performance of high-power wheeled farm tractors.
Some aspects of tractor and implement design for high-speed operation.
Mechanised solid/liquid separation of animal slurries.
Automation of sprinkler irrigation.
Minimum cultivation and direct drilling techniques.
Developments in potato harvesting.
Some ergonomic aspects of tractor operation.
A study of agricultural contracting.
Mechanisation for quality baled hay.
An investigation into fire in farm buildings.
The contamination of livestock houses by noxious gases and odours.
Low cost plastics clad climatic shelters.
Some aspects of young calf housing.

J. A. C. Gibb

Reading University treatment plant for cow slurry: floating aerator.

ADMISSIONS AND TRANSFERS

THE following candidates have been admitted to the Institution or transferred from one grade to another.

ADMISSIONS

MEMBER

Akparanta, S. E.
Edwards, P.
Nagarajah, K.
Wan, K. Y.

GENERAL ASSOCIATE

Carpenter, T.
Desmond, P.
Harvey, J. L.
Houlden, R. E.
Hussain, N. M. M.
Jaggard, P. G.
Jenkin, L.
Mentel, K. M.
Newman, F. D.
Nketiah, A. K.
Pile, W. B.
Riley, V. W.
Roberts, B. D.
Salter, A. J.
Skelton, P. F.
Wayne, R.

TECHNICIAN ASSOCIATE

Bruce, G.
Davis, J. R.
Shelbourne, K. H.
Walton, W. R.

GRADUATE

Hannhah, J. J. H.
Laws, S. H.
Norman, P. J.
Rashid-Nooh, A. B.

STUDENT

Jupp, D.
Perera, D. A. L. P.
Sidgwick, G. N. B.
Spratt, D. H. C.

TRANSFERS

FELLOW

Hill, P. R.

MEMBER

Hann, M. J.
Hutchings, I. J.

GRADUATE

Nwankwo, J. O.
Schiele, M. A.

AROUND THE BRANCHES

Scottish Branch

A ONE-DAY conference on grass conservation was held at the Dunblane Hydro Hotel on 28 February 1973. The morning session was chaired by Mr J. B. Cameron, of Balbuthie, and papers were given on Forage Harvesting by Mr D. Walker, managing director of John Deere Ltd, and on Modern Haymaking Techniques by Mr G. Shepperson, of *NIAE*. The afternoon session was chaired by Mr John Forbes, farms director, Moray Estates. Papers were given by Mr W. A. S. Wyllie of Eastwoods on Grass Drying, and by Mr J. N. Jones, Haddo Estates, on the Practical Economic Aspects of Grass Conservation.

The Conference was attended by nearly 300 delegates for a fee of £3 (inc. midday meal) to non-Institution members. Net profit to the Branch was nearly £250. These funds will finance the current winter programme of the Branch, and the Weir Shield. This shield is awarded annually to the company which has identured the most successful Craft Apprentice in Scotland in the C. and G. 015 course. The apprentice receives tools or appropriate memento to the value of £10. The award has been named after Mr Jim Weir in recognition of his many years of valuable service as Branch hon. secretary and latterly as chairman. Mr Weir will be presenting the first annual award at the 1974 Branch Conference.

West Midlands

A PARTY of some 100 members and their families, were the guests of Major and The Honourable Mrs B. A. F. Hervy-Bathurst at their Eastnor Castle estate on 12 May.

The party was welcomed by Major Hervy-Bathurst and the afternoon's itinerary explained.

The first item of very unusual interest was a demonstration of hole-blasting — starting with a bang in more ways than one! This technique using a wine bottle container was developed by Major Bathurst to overcome problems of putting gateposts etc into rock. (Such is the drilling power of the device that thick steel plate can be penetrated successfully.)

Moving across the hill, ears somewhat dulled, bracken and scrub clearance machinery was explained by our host. The problems of obtaining adequately designed equipment for such work were highlighted and the main practical requirements outlined.

Following on from the earlier explosive drilling demonstration was a display of tree stumps removal using 'farm materials' explosive? Such was the success of this display that a large bole was deposited some distance away — adding transport to extraction!

On the lower slopes, the area *ADAS* drainage officer showed the scheme under way for piped drainage integrated with a new lake

The 1972/73 Scottish Branch Committee taken at the recent conference on grass conservation at Dunblane. From left to right, back row: Messrs Brian Witney, Peter Tong, Jim Weir, Bob Storie. Middle row: Messrs Sandy Scott, Campbell Pearson, Jim Pascal, Hamish Shiach, John Armstrong. Front row: Messrs Bill Davidson (vice-chairman), John Palmer, Bob Hart (chairman), Bill Godley and Charles Swan.

The plate with a hole in it following a demonstration of hole blasting.

project for salmon breeding. A continental drainage machine was shown at work and many practical discussions ensued.

Major Hervy-Bathurst then gave a lucid and fascinating talk on conservation and recreation/environmental aspects of estate and countryside management. The relationship of the farmer, forester, planners and general public, one to another, in using and developing the 'face of the country' came to the fore in the many interested questions.

At the forestry yard, the engineers of the party discussed equipment for handling and maintenance of forestry areas and timber products. During question time, the extent to which the ravages of the grey squirrel presented the forester with severe limitations as to planting policies, and the effects of 'elm' and other diseases of our principal tree species, gave everyone very serious food for thought.

BRANCH PROGRAMMES

East Anglian Branch

Hon. Secretary J. B. Mott *MIAgrE*
County Hall, Norwich (tel: Norwich 22288 ext 5076).

September
28 Tractor Development, by J. M. G. Layton (Ford Motor Co Ltd), The Scole Inn, Diss, Norfolk, 20 15 h.

November
21 Conference on Mechanical Livestock Feeding, Norfolk School of Agriculture, 10 20–16 30 h. Speakers: G. Newman (Rotary Hoes Group), J. B. Finney (*ADAS*), G. Shepperson (*NIAE*), P. Clough (*NIRD*), R. H. M. Robinson (farmer), D. Chalmers (*ADAS*), C. J. V. Baskerville (*ADAS*), H. W. Whitton (farmer).

1974
March
1 Dinner Dance, Kings Head, Diss, Norfolk, 19 00 for 19 30 h.

April
5 Annual General Meeting, Scole Inn, Diss, Norfolk, 19 30 h. Followed by What of Tomorrow's Mechanisation? by R. A. den Engelse (East Anglian Real Property Co Ltd).

East Midlands Branch

Hon. Secretary R. D. S. Barber *MSc(Agric) NDAgrE FIAgrE*
Kesteven Agricultural College, Caythorpe, nr Grantham, Lincs (tel: Fulbeck 521).

October
9 Effluent Towers, by R. Balls and A. Hacking (*ADAS*), 14 30–16 30 h. Paper and visit to the installations at Shardlow Hall, Derby.

25 Feed Preparation Equipment, by P. Wakefield (The Electricity Council) and a speaker from Farmhand Ltd, Nottinghamshire College of Agriculture, Brackenhurst, Southwell, Notts, 19 30 h.

November
21 Annual Conference – Minimum Cultivations, Kesteven Agricultural College, Caythorpe Court, Grantham, Lincs, 10 00–16 00 h. Papers: Non-Ploughing for Cereals, by R. Bee (Farm Director, Drayton Experimental Husbandry Farm), Seed Sowing of Cereals, by J. B. Page (*ADAS*, Wolverhampton), Chemical Treatments, by J. S. Gunn (*ADAS*, Shardlow), A Farmer's View of Cultivations, by J. J. Rainthorpe (Welton, Lincoln).

1974
January
24 The Operation of a Potato Co-operative Group, by M. J. Hill (Vale of Trent Produce Ltd), Lindsey College of Agriculture, Riseholme, Lincoln, 19 30 h.

February
12 Hydrostatic Transmission Systems, by International Harvester Co Ltd, Brooksby Agricultural College, Brooksby, Melton Mowbray, Leics, 19 30 h.

March
5 Aerial Spraying, paper and visit to Aerial Spraying Co, Boston Aerodrome, Lincs, 15 15 h.

April
4 Annual General Meeting and Dinner.

North Western Branch

Hon. Secretary F. J. Heathcote *AIAgrE*
'Longmede', Church Fold, Off Chapel Lane, Coppull, nr Chorley, Lancs (tel: Preston 59333).

September
20 Dairy Engineering, speaker to be announced.

October
25 Crop Conservation Conference. Speakers and venue to be announced.

November
22 Glasshouse Heating and Boiler Plant, by M. B. Smith (*ADAS, NIAE*, Wrest Park, Silsoe), Becconsall Hotel, Hesketh Bank, nr Preston, Lancs, 19 30 h.

1974
January
24 Electronic Circuits, by John Tyblewski, Lancashire County College of Agriculture, Myerscough Hall, Bilsborrow, nr Preston, Lancs, 19 30 h.

February
21 Applied Electronics in Agriculture and Horticulture, by Ron Frampton (Wright Rain Ltd), Lancashire County College of Agriculture, Myerscough Hall, Bilsborrow, nr Preston, Lancs, 19 30 h.

March
21 Annual General Meeting, 18 30 h, and Dinner, 20 00 h, Royal Oak Hotel, Market Street, Chorley, Lancs.

May
23 Visit to Reid Paper Mill, Wigan, Lancs, 19 30 h.

The AGRICULTURAL ENGINEER

The copy date for Editorial matter and advertisements for the Winter issue of The AGRICULTURAL ENGINEER is 7 October 1973.

Northern Branch

Hon. Secretary K. A. Pollock *MSc(AgrEng) MIAgrE*
Dept of Agricultural Engineering, The University, Newcastle upon Tyne NE1 7RU (tel: Newcastle upon Tyne 28511).

October
3 The Development of Rotary Milking Parlours, by Miss Thesca Thomas (*ADAS* Newcastle), Northumberland College of Agriculture, Kirkley Hall, Ponteland, 19 30 h.

November
7 Finance for Farm Machinery: The Present Position, by Duncan Torrance (*ADAS* Alnwick), Northumberland College of Agriculture, 19 30 h.

December
12 Silage: Horizontal or Vertical, by Gordon Newman (Howard Harvestore), Northumberland College of Agriculture, 19 30 h.

1974
January
9 The Big Bale: The Future for Haymaking? by Peter Redman (*ADAS* Liaison Unit *NAIE*), School of Agriculture, Newcastle University, 19 30 h.

February
6 Hydrostatic Power Transmission, by Donald Firth (National Engineering Laboratory, East Kilbride), School of Agriculture, Newcastle University, 19 30 h.

March
6 Recent Developments in Drainage, by Brian Trafford (*ADAS* Drainage Experiment Station), Northumberland College of Agriculture, 19 30 h.
20 Annual General Meeting, Northumberland College of Agriculture, 19 30 h.

Scottish Branch

Hon. Secretary J. A. Pascall *NDA MIAgrE*
'Donmaree', Springhill Road, Peebles (tel: Peebles 20161).

October
11 Day Visit to Peepy Farm, Stocksfield, (Mr J. E. Moffitt), Steading and Vintage Tractor Collection. Details and booking form to be circulated.
24 Fertiliser Distribution and Handling (solid and liquid), by D. H. W. Thompson (*CSC*) and C. J. Campbell (Chafers), Engineering Dept, *NOSCA*, Craibstone, 19 30 h.
31 Repeat of Fertiliser Talk, Elmwood College, Cupar, Fife, 19 30 h.

November
20 Livestock Mechanisation, by J. Stewart (*NOSCA*), *WOSAC*, Auchincruive, Ayr, 14 00 h.
20 Repeat of Livestock Mechanisation Talk, Ernespie House Hotel, Castle Douglas, 19 30 h.
21 Repeat of Livestock Mechanisation Talk, Silver Bell, Lanark, 19 30 h.

1974
January
23 Cultivations for Cereal Crops; panel includes D. Hill (*SAI*), D. MacIntyre (*NIAESS*), J. Macfarlane (Kames E. Mains), 19 30 h.

February
27 Annual One-Day Conference – Mechanisation of Potato Crop; session chairmen; J. E. Rennie (chairman *PMB*), Lt Col J. B. Swan (Ld Lt Berwickshire); speakers; D. McRae (*NIAESS*), F. E. Shotton (*ADAS*), A. G. Norrie (farmer), W. J. Whitsed (manufacturer). Presentation of Weir Shield and Prize by J. Weir. Annual General Meeting, 17 00 h, followed by social evening and buffet supper, 19 00 h.

South East Midlands Branch

Hon. Secretary G. Spoor *BSC(Agric) MSc(AgrEng) MIAgrE*
National College of Agricultural Engineering, Silsoe, Bedford MK45 4DT (tel: Silsoe 60428).

October
22 Labour and Machine Costs, by J. S. Nix (School of Rural Economics and Related Studies, Wye College, Ashford, Kent), *NCAE*, Silsoe, 19 30 h.

October/
November Social evening; to be arranged.

November
19 Design for Safety in Farm Machinery, by I. Abbott and A. Cooper (Royal Society for the Prevention of Accidents, Purley, Surrey), Village College, Bassingbourn, Royston, Herts, 19 30 h.

1974
January
21 Machinery Requirements of the Continental European Farmer During the Next Five Years, by Comte Louis de Lauriston (farmer and Executive Director of Federation of Land-owning Farmers, France), *NCAE*, 19 30 h.

February
11 Machinery Investment: A Banker's View, by A. J. Deaville (Farming Representative's Dept, Barclays Bank Ltd, London), *NCAE*, 19 30 h.

March
4 Annual General Meeting. Development of Agricultural Mechanisation in Chile, by D. H. Sutton (Overseas Dept) and D. W. Smith (Tractor and Ergonomics Dept, *NIAE*), *NCAE*, 19 30 h.

South Eastern Branch

Hon. Secretary K. A. McLean *NDA CDA CDAE NDAgrE MIAgrE*
Ministry of Agriculture, Fisheries and Food, Beeches Road, Chelmsford, Essex (tel: Chelmsford 532011).

October
16 Labour and Machinery Costs, Past, Present and Future, by J. S. Nix, Writtle College of Agriculture, 19 30 h. (To be held in conjunction with *FMA*).

Institution of Agricultural Engineers

AUTUMN MEETING 1973

'IRRIGATION FOR AGRICULTURE AND HORTICULTURE IN THE 70's'

The meeting will be held on Thursday 27 September 1973 at the National College of Agricultural Engineering, Silsoe, Bedford. The papers presented, and the discussions on them, will examine trends and possibilities for the future in the farming and engineering aspects of irrigation.

In addition to considering United Kingdom practice, there will be component parts on equivalent practice overseas. During the course of the one day meeting irrigation equipment manufacturers and contractors will display hardware and techniques for irrigation purposes.

The programme, details below, starts at 10 15 and closes formally at 16 15 but College premises will remain open for those who wish to make further examinations of equipment and projects.

10 15 Reception and coffee

10 45 The President of the Institution introduces the theme of the meeting and the Chairman of the sessions.

Morning Session

Chairman: E. A. G. Johnson CBE CEng FICE FIWE (Consultant, Sir M. Macdonald & Partners)

10 50 Paper 1
'The irrigation policy, practice and economics of two companies farming in Essex and Suffolk' by Major J. A. Comyn MBE FCIS (a director of Lord Rayleigh's Farms Inc. and of Strutt and Parker [Farms] Ltd)

11 15 Paper 2
'Water for Irrigation' by R. Huntingdon BSc MICE FIWE FIPHE (Water Conservation Engineer, Essex River Authority)

11 40 Discussion on Papers 1 and 2, opened by C. N. Prickett MICE AMICE (Deputy Chief Engineer, drainage & W.S. arm, *ADAS, MAFF*)

12 30 Luncheon
During the luncheon interval there will be opportunities to visit irrigation equipment manufacturer's demonstrations

Afternoon Session

Chairman: Dr H. L. Penman OBE PhD FinstP FRS (Head of Physics Dept, Rothamsted)

14 00 Paper 3
'The evolution and evaluation of irrigation practices in Britain' by W. B. J. Withers BSc MICE (Senior Lecturer, National College of Agricultural Engineering)

14 20 Paper 4
'Trends in irrigation development overseas' by P. H. Stern MA FICE MIWE (Water development consultant to the Intermediate Technology Development Group)

14 40 Discussion on papers 3 and 4, opened by E. J. Winter MS MSc (Scientific Liaison Officer, National Vegetable Research Station)

15 20 Paper 5
'Equipment available for use in agriculture and horticulture in the United Kingdom' by J. Ingram NDH (Deputy Director, Luddington Experimental Horticultural Station)

15 45 Discussion on paper 5, opened by W. T. A. Rundle and Dr A. Iveny PhD (respectively Managing Director, and Head of Research and Development section of Wright Rain Ltd)

16 15 Tea and dispersal

November
7 — Manmade Meats: The Development of Synthetic Food, by Mr McMichael (Food Pilot Plant Section, *RHM* Research Ltd), Writtle College of Agriculture, 19 30 h.

December
5 — Maintaining Soil Permeability to Secure Effective Drainage, by B. D. Trafford (Field Drainage Experimental Unit, Cambridge), Writtle College of Agriculture, 19 30 h. (To be held in conjunction with *ADAS*).

1974
January
14 — Mechanisation Aspects of Forage Conservation, by G. Shepperson, County Hotel, Chelmsford, 19 30 h. (In conjunction with Essex Grassland Society).

February
6 — The *NIAE* After 50 Years, by T. C. D. Manby, Writtle College of Agriculture, 19 30 h.

March
6 — Programme to be arranged.

South Western Branch

Hon. Secretary J. Pritchard *AIAgrE*
Hillside, South Brentor, Tavistock, Devon (tel: Mary Tavy 216).

October
10 — Potato Harvesting Machinery, speaker to be confirmed, The Lord Elliott, Liskeard, Cornwall.

November
8 — Modern Development in Milking Machinery, speaker to be confirmed, Seal Hayne Agricultural College, Newton Abbot, Devon.

1974
January
10 — Development of the Combine Harvester, by J. Blackmore (Service and Sales Promotion Manager, Ransomes Sims and Jefferies Ltd), provisionally at the Exeter College.

February
14 — The Application of External Hydraulic Power, speaker to be confirmed, *SWEB* Training Centre, Taunton.

March
14 — Maize Production and Harvesting Machinery, speaker to be confirmed, Bicton Agricultural College.

West Midlands Branch

Hon. Secretary M. J. Bowyer *CEng MIMechE MIAgrE*
9 Lyng Close, Mount Nod, Coventry CV5 7JZ (tel: Coventry 73331).

September
24 — Loss Control, by J. C. Shakespeare (Perkins Engines Ltd), the Massey-Ferguson Training Centre, Stareton, nr Kenilworth, 19 30 h.

October
29 — Forum — Implications of the Larger Tractors. Panel: I. Rutherford (*ADAS* Liaison Unit, *NIAE*), D. R. F. Tapp (County Commercial Cars Ltd), S. D. Bond (Velcourt Ltd), Warwickshire College of Agriculture, Moreton Morrell, Warwickshire, 19 30 h.

November
26 — Recent Developments in Forage Machinery, by W. E. Klinner (*NIAE*), *ADAS* Unit, *NAC*, Stoneleigh, 19 30 h.

December
12 — Development of Tractors and Agricultural Machinery, by T. C. D. Manby (*NIAE*), Grosvenor Room, Hotel Leofric, Coventry, 19 30 h. (Joint meeting with the Automobile Division of the Institution of Mechanical Engineers).

1974
January
7 — Use of Unconventional Power Sources, by K. E. Morgan (University of Reading), Mid-Warwickshire College of Further Education, Warwick New Road, Leamington Spa, 19 30 h.

February
4 — Recent Developments in Fodder Conservation, by H. Paterson (Electricity Council, Millbank, London), Farm-Electric Centre, *NAC*, Stoneleigh, 19 30 h.

March
4 — Annual General Meeting, followed by New Protein Foods, by J. Watson (Courtaulds Ltd, Coventry), Massey-Ferguson Training Centre, 18 45 h.

April
5 — Dinner/dance, Manor House Hotel, Leamington Spa, 19 30 h.

Western Branch

Hon. Secretary H. Catling *NDAgrE MIAgrE*
Royal Agricultural College, Cirencester, Glos (tel: Cirencester 2531).

October
17 — The Future for Agricultural Engineering Businesses, by Ben Burgess (Ben Burgess & Co), Lackham College of Agriculture, Lacock, Chippenham, Wilts, 19 30 h.

November
21 — Slurry Treatment and Disposal, by G. F. Shattock, The Royal Agricultural College, Cirencester, Glos, 19 30 h.

1974
February
13 — Annual General Meeting, 18 30 h, to be followed at 19 45 h by Winter Forage Feeding, by Gordon Newman (Howard Harvestore Ltd), Bath Arms, Warminster, Wilts.
16 — Visit to see Tower Silo and Auto Feeding Installations.

March
13 — Electronics in Agriculture, by J. A. Brown (*RDS* [Agricultural] Ltd), Bath Arms, Warminster, 19 30 h.

Wrekin Branch

Hon. Secretary J. Sarsfield *MIAgrE*
Staffordshire College of Agriculture, Rodbaston, Penkridge, Stafford (tel: Penkridge 2209).

October
8 — The Mechanised Vegetable, by J. S. Robertson (*ADAS*, Cambridge), Staffordshire College of Agriculture, Rodbaston, Penkridge, 19 30 h.

November
6 — Farmers Lung — How the Agricultural Engineer Can Help, by speakers from the medical profession and fodder conservation industries, University College of Wales, Aberystwyth, 20 00 h.
12 — Problems in Crop Protection from Above and Below, by R. C. Amsden (Fisons Ltd, Chesterford Park), Harper Adams College, Edgemond, Newport, 19 30 h.

December
10 — The Hydraulic Transmission of Power, by H. W. Norton (Technical Director, F. W. McConnel Ltd), Shrewsbury Technical College, London Road, Shrewsbury, 19 30 h.

1974
January
14 — The Manufacture of High Grade Service Tools, by A. H. Faulkner (Snap-on Tools Corporation Ltd), Wolverhampton Technical Teachers College, Compton Road West, Wolverhampton, 19 30 h.

February 11	Visit to *ATV* Studios, Birmingham, 19 30 h.
March 11	Annual General Meeting, 19 00 h, to be followed at 20 00 h by *Farm Contractor:* The Birth of a New Journal, by A. Collier, Harper Adams College.
March/April	Branch Dinner to be arranged.

Yorkshire Branch

Hon. Secretary	J. R. Ashley-Smith *MSc(AgricEng)* 57 Acre Lane, Meltham, Huddersfield HD7 3DH (tel: Meltham 850361).
September 13	The Combine Harvester: Present and Future, by W. S. Riddick (New Holland), Holmfield House, Wakefield, 19 30 h.
October 18	Distribution of Granular Insecticides and Fertilisers, by Horstine Farmery, Horstine Farmery Ltd, North Newbald, 19 30 h.
November 15	Cultivations without the Plough, by Brian Finney (*ADAS*), Askham Bryan College, 19 30 h.
1974 January 10	Is the Farm a Safe Place? by Jim Whitaker (*MAFF*), Holmfield House, Wakefield, 19 30 h.
February 14	Farm Transport and Bulk Handling, by J. U. Charlton (Consultant), Askham Bryan College, 19 30 h.
March 14	President's Address and Annual General Meeting, Griffin Hotel, Leeds, 19 30 h.
April 2	Recent Developments in Agricultural Crawler Tractors, by H. F. W. Flatters (Marshall-Fowler), Griffin Hotel, Leeds, 19 30 h. (Joint meeting with the *NE* Centre, Automobile Div. *IMechE*).

BRITISH STANDARDS

Technical Manuals

ADVICE for those who prepare operating instructions and maintenance manuals is given in a new *BSI* publication *BS* 4884 *Technical manuals*, Part 1 *Content.*

Technical manuals range from instructions supplied with a domestic appliance and written for the housewife, to elaborate handbooks, written for the trained technician. The standard lists nine categories of information likely to be needed for the most comprehensive manual: Purpose, operating information, technical description, preparation for use (including transit and storage), maintenance instructions, maintenance schedules, parts lists, modification instructions and disposal instructions. It then describes the information that should be given in each category. *BS* 4884 therefore provides a means of checking that all the necessary information has been given, though some manuals will require only some of the categories.

The second Part of this standard will deal with the presentation of technical manuals.

BS 4884: Part 1 may be obtained from BSI Sales Branch, 101 Pentonville Road, London N1 9ND, price 90p.

INSTITUTION NEWS AND NOTES

Institution Secretary

THE President, Mr Ian Gibb, speaking at the Annual General Meeting of the Institution of 3 July 1973, announced the impending retirement of Mr H. N. Weavers from the post of Secretary. Mr Weavers is due to retire on 30 June 1974 but for health reasons will be working part-time, mainly from his home from 1 January 1974.

Accordingly it will be necessary for the Council to appoint a new full-time Secretary prior to Mr Weavers' retirement, and an Appointments Committee has been formed under the chairmanship of the President-elect, Mr John Fox.

The new Institution Secretary will be based in the new Secretariat which is to be set up at Silsoe on 1 January 1974 and the Appointments Committee will begin its work towards the end of September.

Any Institution member who might be interested in applying for the appointment is invited to write in confidence to:

The Chairman, Appointments Committee, Institution of Agricultural Engineers, Penn Place, Rickmansworth, Herts WD3 1RE.

NATIONAL COLLEGE OF AGRICULTURAL ENGINEERING

Commemoration Day

THE annual Commemoration Day of the National College of Agricultural Engineering was held at the College on 10 July, and the principal guest was Sir Alan Wilson *FRS*. The Agricultural Engineers Association was represented by Mr J. H. H. Wilder, a past president of the Institution of Agricultural Engineers, and now President of the *AEA*, and the President-elect of the Institution of Agricultural Engineers Mr J. V. Fox represented the Institution.

Reporting on the year's work at the *NCAE* Professor Peter Payne said he had submitted to *CNAA* new proposals for first degrees based on a modular structure which will provide a wider choice of syllabus to enable the individual to exploit his talents and interests, and that if accepted will be operative from October 1974.

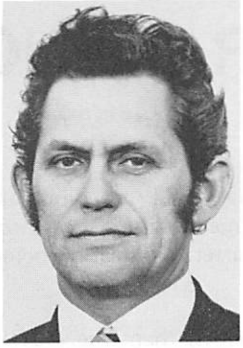
Referring to College staff he said the most important event had been the retirement of Group Captain Kenneth Crick, the Registrar. He was the first member of the staff to be appointed and much of what the *NCAE* had become, both physically and spiritually was his work; he would not be forgotten at Silsoe in this generation.

Activity was increasing in research and consultancy and secondment and the main limitation was staff time not opportunities.

In research the College had new contracts with *ODA* on the development of a low cost power source for developing countries and with National Environmental Research Council on soil erosion in Britain.

In consultancy the College was a third member of a consortium planning to build an agricultural college in Kano State, Nigeria.

On secondment Mr N. W. Hudson, Head of Field Engineering, had returned from two years at the Asian Institute of Technology in Bangkok. Mr Vincent Austin was to become manager of an *ILO/FAO* project in Nigeria.



Vincent Austin

The number of graduates joining *UK* commercial organisations was up once again. This year the College had almost three times as many vacancies notified as it had graduates.

Mr J. P. Neat (31) was awarded a first class honours *BSc* in agricultural engineering in 1972 and joined Ransomes Sims & Jefferies Ltd as a test and development engineer in the same year, received the Skefko Trophy for the best final year student of Engineering Design, and the Davies Cup for the undergraduate with the best appreciation of agriculture.

Mr J. Roberts received the Hunting Cup for the best final year student of Field Engineering.

The new Registrar and Clerk to the Governors at the National College since May 1973 is Squadron Leader Colin King, who is 40 years of age and was in the *RAF* from 1954–1973.

John P. Neat

If you make irrigation equipment and wish to have your products advertised in the Winter 1973 issue turn to page 122.

INSTITUTION OF AGRICULTURAL ENGINEERS

Penn Place Rickmansworth Herts

APPOINTMENTS REGISTER

This service is available to members who wish to learn of vacancies in specific branches of agricultural engineering and the related services; it is also designed to assist organisations and employers to bring any such vacancies to the attention of persons who have a direct interest. It will operate in the following way:

MEMBERS

Broad areas of interest have been categorised and identified by a letter as shown below:

A. Design/Manufacture
B. Administration
C. Technical representation for manufacturer
D. Technical representation for distributor
E. Service for manufacturer
F. Service for distributor
G. Farmbuilding
H. Field Engineering
I. Education
J. Advisory

OTHERS

New categories will be included as and when it proves necessary.

NB: Members may wish to include details of qualifications and any other information which, it is felt, could help in ensuring that suitable information is forwarded; but this is optional. Any information will be treated as confidential.

Members wishing to use the scheme should write to:

J. Turner, Ryecotewood College, Thame, Oxon (Tel. 2501) indicating the types of vacancy on which they would like information and enclosing some stamped addressed envelopes up to ten in number, suitable for A4 or foolscap size papers.

As vacancies are notified, Mr Turner will arrange for photocopies of particulars to be forwarded to members who have expressed interest in the particular type of post involved.

This service will continue and the penultimate stamped addressed envelope, returned to the member, will contain a reminder that the supply of s.a.e's is almost exhausted. If the member wishes to continue the service, more s.a.e's should be sent. Particulars of vacancies will continue to be sent until either the supply of s.a.e's is exhausted or the member writes asking that the service be discontinued.

ORGANISATIONS/EMPLOYERS

Details of vacancies should be sent to:

J. Turner, Rycotewood College, Thame, Oxon (Tel. 2501) in a form suitable for copying by the thermal photocopying process. Copies of information will be sent to members who have expressed an interest in the type of work in question.

There will be no charge to either party for the service.

Take an ADVERTISEMENT in

The AGRICULTURAL ENGINEER

The AGRICULTURAL ENGINEER, which is the Journal and Proceedings of the Institution of Agricultural Engineers, is read by professional agricultural engineers, manufacturers, research workers and others interested in the industry. Circulation is over 2,500 copies every quarter, publication being 7 March, 7 June, 7 September, 7 December.

If you sell machines, equipment, instruments and services, then The AGRICULTURAL ENGINEER is the medium for advertising whatever it is you have for sale.

If you require managerial staff, research workers, tutorial staff or other professionals, then the classified section is your medium.

Display advertisement rates

Space	*Type area*	*Price*
Whole page (left-hand)	10 in X 7 in	£40 ROP £44 facing matter
Half-page (left-hand)	$4\frac{7}{8}$ X 7 in 10 in X $3\frac{3}{8}$in	£25 ROP £28 facing matter
Quarter-page (left-hand)	$4\frac{7}{8}$ in X $3\frac{3}{8}$in $2\frac{3}{8}$ in X 7 in	£18 ROP £20 facing matter
Front cover	$8\frac{3}{4}$in X $8\frac{3}{8}$in	£100 full colour £70 black and one colour
Back cover	10 in X 7 in	£50
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Colour		Ordinary rate plus £15 per additional colour per page or part page
Inserts	Random insertion	£15 per 1,000 2,700 required
Discounts	A series discount of 10% is allowed on gross rates when four consecutive display advertisements appear in the Journal A 10% gross commission is allowed to recognised advertising agents	
Copy date	8 weeks preceding publication	

Classified advertisements

Small semi-display advertisements	£3 per single column inch or part thereof
Small advertisements	3p per word (minimum of 75p)
Box numbers	25p extra

Advertisement Manager — Linda Palmer, PO Box 10, Rickmansworth, Herts. WD3 1SJ
Telephone: Rickmansworth 78877

Classified Advertisements

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DEVON EDUCATION COMMITTEE
EAST DEVON COLLEGE OF FURTHER EDUCATION, TIVERTON

LECTURER I

Required at East Devon College of Further Education a qualified Agricultural Engineering lecturer for September, 1973, or as soon as possible thereafter. The person appointed will join an enthusiastic team of staff and will be expected to teach agricultural engineering theory and practice in a wide range of courses.

Salary: £1660–£2685.

Further details and application forms from:
The Senior Administrative Officer,
East Devon College of Further Education,
Bolham Road, Tiverton, Devon, EX16 6SB.
Telephone: 4247/9.

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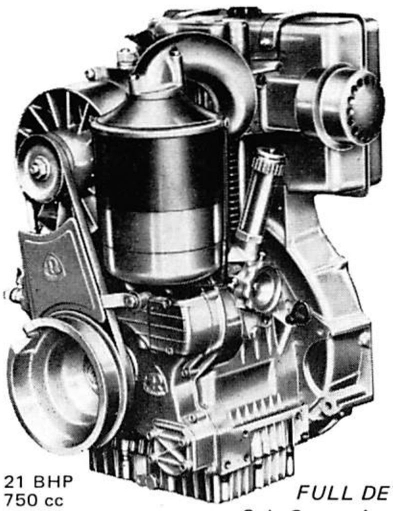

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The Diploma course also enables you to take appropriate City & Guilds examinations in preparation for further study and to qualify for the national qualifications for technician engineers and technicians now being established.

Entry is by way of a Probationary Term; there are eight entry dates per year.

It is possible to combine automobile engineering or management with the agricultural engineering course and shorter courses are offered to meet students individual requirements.

THE COLLEGE OF AERONAUTICAL AND AUTOMOBILE ENGINEERING

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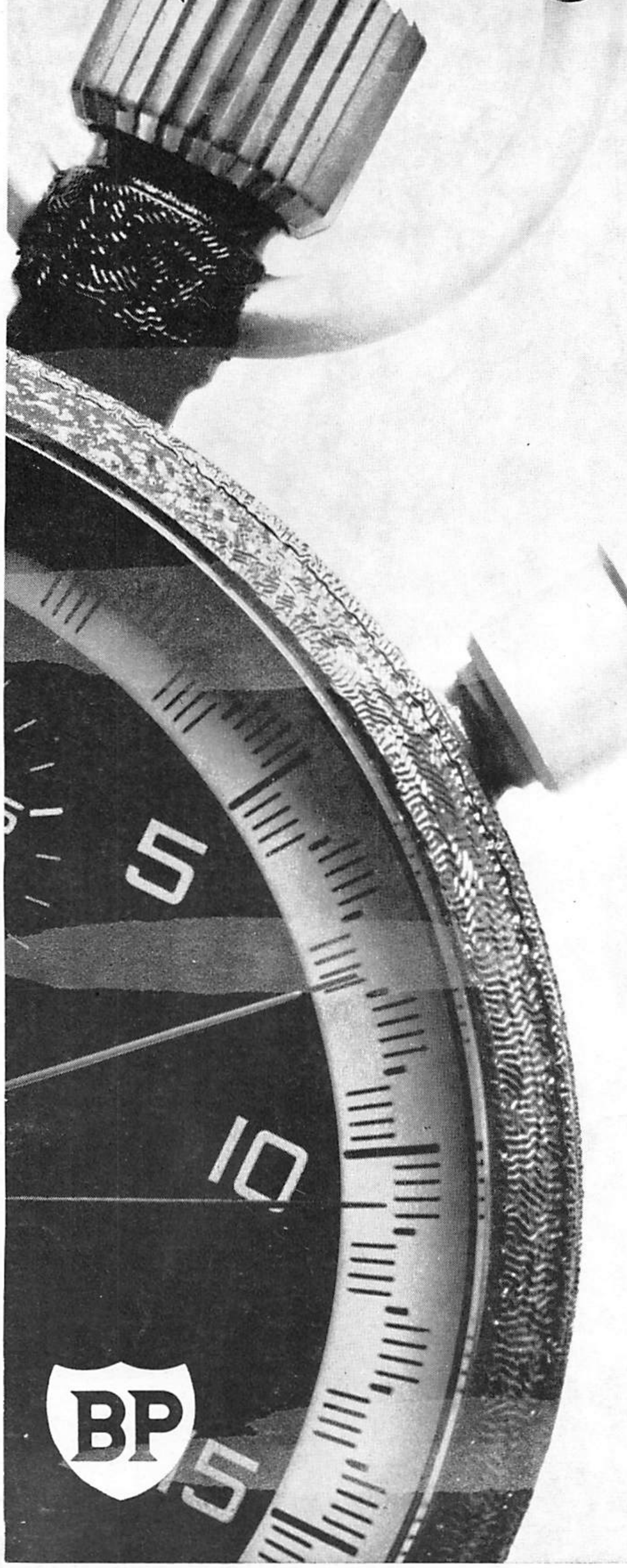
BP announce the time saver
New BP Super TOU



Few farm people have time to waste. Especially on lubrication. BP now save you time and trouble with a newly-formulated multi-purpose farm oil. New BP Super TOU covers all these farm requirements...

For all farm engines

including tractor engines with a Series 3 requirement. New, high performance engines need an oil which minimises carbon deposits. BP Super TOU, based on new lubricants technology, keeps pistons clean. Wear is reduced and power output maintained.

For oil-immersed disc brakes

No more need to worry about special wet brake additives. New BP Super TOU lubricates wet brake transmissions and contains a friction modifier to alleviate squawk.

For transmissions

on tractors, combines, planters, harvesters, balers, conveyors, elevators, etc. New BP Super TOU is a high load-carrying oil which offers maximum resistance to wear. (Exceptions: IH and John Deere tractor transmissions; all semi-automatic transmissions; Land Rover axles; some other machinery. See BP Farm Lubricants User's Guide.)

For hydraulics

Use new BP Super TOU for hydraulic systems combined with tractor transmissions and others, including combines. This new oil keeps hydraulics efficient and responsive. It also fights corrosion – especially important on machines in store such as combines. Rust-vulnerable components such as servo valves and control mechanisms are effectively protected by new BP Super TOU.

New BP Super TOU saves you time by simplifying lubrication. And keeps down machine down-time because it more than meets the protection demands of modern, high performance farm machines. If you have a mixed fleet including modern machines, you must have new BP Super TOU. For older machines, regular BP TOU is still available. Contact your BP Farm Service distributor or your agricultural traders.

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