Journal and Proceedings of the Institution of Agricultural Engineers

DECEMBER
1965

Vol. 21 No. 4

JOURNAL AND PROCEEDINGS OF THE INSTITUTION OF AGRICULTURAL ENGINEERS

IN THIS ISSUE

Page

Published Quarterly
by the Institution of
Agricultural Engineers,
Penn Place,
Rickmansworth,
Herts

Telephone:
Rickmansworth 76328

Price:
Ten Shillings and Sixpence

VOLUME 21 **NUMBER 4** **DECEMBER 1965**

In Memoriam

Lieut.-Colonel Philip Johnson,

CBE, DSO, MI MECH E,
HON AMI AGR E

Foundation President of the Institution

Taken from the portrait by Russell Reeve, commissioned and presented by Lt.Col. Johnson's colleagues on the Institution Council in 1960

Colonel Johnson was Foundation President of The Institution of British Agricultural Engineers at its inception in 1938 and retained the Presidential office for nine years. He was elected an Honorary Member in 1947, by virtue of his distinguished contribution to agricultural engineering and science; it marked in addition the respect with which he was and will continue to be held by the Institution and its members. His career as an engineer began with a varied apprenticeship, including periods at the steel works in South Wales and at Maudslay Sons and Field. At this time he also attended the Durham College of Science, Newcastle-upon-Tyne. Subsequently, Col. Johnson went to India and thence to South Africa when war broke out there; in 1900 he worked for the Steam Road Transport Department. At the conclusion of the Boer War he remained in South Africa and was associated with the establishment of irrigation and pumping schemes. Col. Johnson returned to England in 1907 and joined John Fowler & Co. Ltd. of Leeds and later became their representative in India. During that phase, he travelled widely throughout the Far East and was engaged on a number of developments with cable ploughing tackle, a speciality of John Fowler & Co. at that time.

In 1915, Col. Johnson returned once more to England where he joined the Army and went to France with 'Tanks' in 1916. He was soon tranferred to Tank Corps HQ and at the conclusion of hostilities he was Assistant Chief Mechanical Engineer; for his work on tank design and development he was awarded the CBE and DSO. In 1919, at the request of the War Office, he formed the Department of Tank Design and Experiment and subsequently became Superintendent of Tank Design which post he held until 1923.

Thereafter, Col. Johnson's activities were entirely confined to the design, development and manufacture of track laying vehicles. He founded the firm of Roadless Traction Ltd. which under his guidance developed many novel designs including two completely original tracks known as the 'rubber jointed' and the 'driven girder' or 'DG' types.

The funeral of Col. Johnson took place quietly at Preston Crematorium on 11 November 1965, the Institution being represented by the President and other senior officers.

GUEST EDITORIAL

A TRIBUTE TO THE LATE LIEUT.-COLONEL PHILIP JOHNSON, CBE, DSO, MI MECH E, HON MI AGR E

by

A Past President of the Institution

It was a broad span from service in the South African War under Queen Victoria to being actively engaged in many parts of the World under her great-great-granddaughter, finding export markets for the products of his rare ingenuity. He never knew old age. In his late seventies and early eighties he might be met anywhere in the World from India to Brazil. Living to the end with a love for adventure, he approached his problems unfettered by any traditional prejudice. The Army's refusal to accept him on grounds of bad eyesight did not prevent Johnson from serving in South Africa. He had his own peculiar and often amusing solution for problems like that.

As an engineer he grew up in a steam age. After leaving South Africa and until the first World War he was working steam ploughing engines in India, moving long distances where there were no roads, crossing unbridged rivers and meeting many other hazards with native drivers. Unlike most of the steam engineers of his time he had no hidebound prejudice in favour of steam and in the first World War he took a leading part in the design and development of the first tanks. In spite of the opposition of many of the senior army staff and of the C-in-C himself, he and his small band of fellow workers went on to prove that they were right. His appointment after the war as Superintendent of Tank Design was a measure of his war achievement. But in 1923 the Cavalryman had the last word and the Department of Tank Design & Development which he had formed was closed. A terrible price was paid by a later generation of soldiers for that decision. Johnson with his knowledge of its folly must have suffered more than the loss of an appointment.

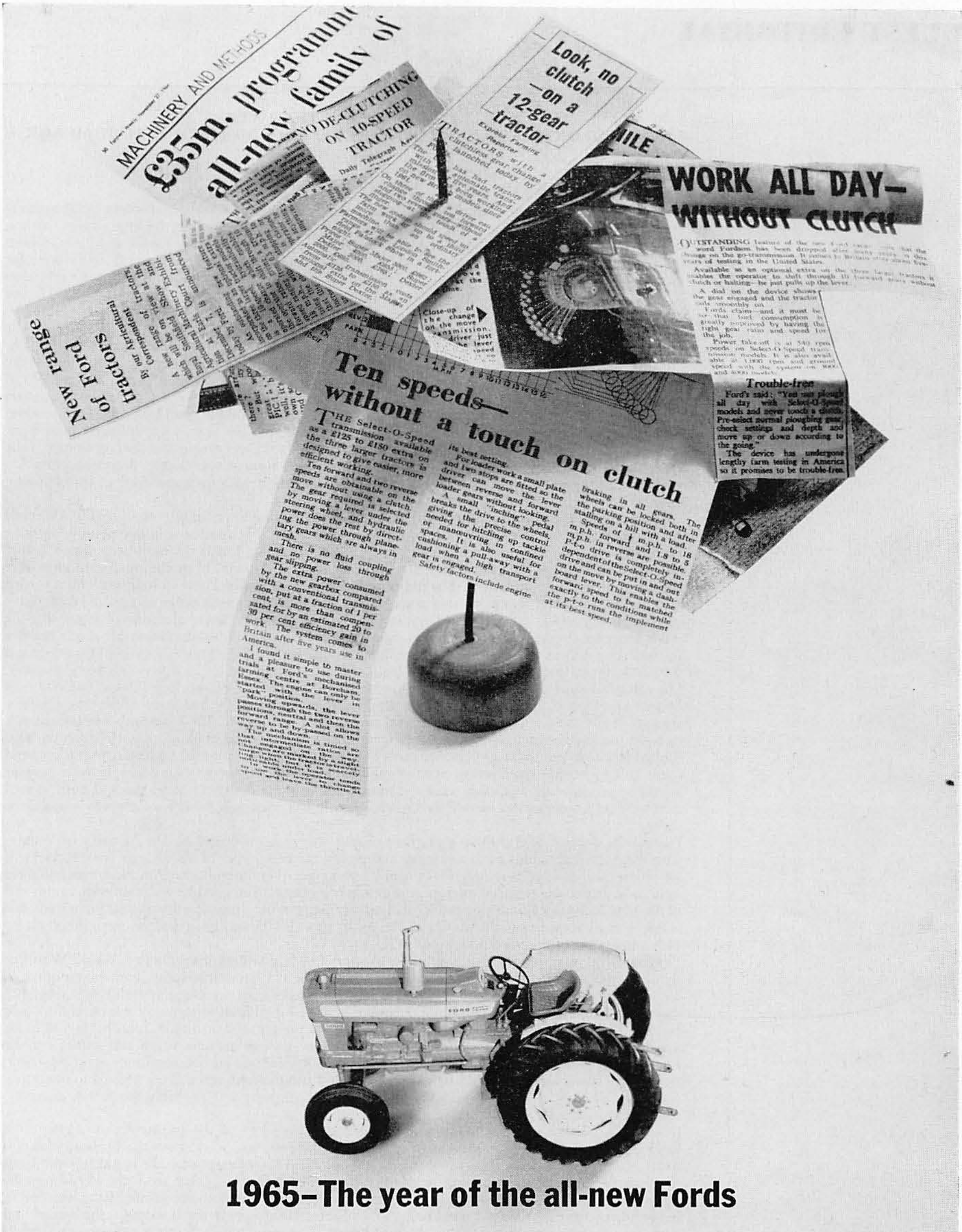
After this he founded the Company of which he was the driving force for the rest of his life. He could hardly have chosen a more difficult time for his venture. The short post-war honeymoon of farming prosperity was over. Ten years of desperate depression lay ahead. The farm tractor introduced during the war was regarded as a failure by the large majority of farmers. Even the small minority were conscious of its many limitations. The steam cable sets which Johnson knew so well were still regarded as the only practicable means of mechanical tillage. With his great experience of them he could have gone back to Fowlers whom he had represented in India. It must be assumed that he knew that the steam sets were doomed. If he did he was almost if not quite alone in his conclusion. He saw in crawler tractors the solution of the problems of soil tillage unsolved by the wheeled tractors of that time and with little but his knowledge of track design in his favour he founded his Roadless Traction Company. His capital resources were negligible by comparison with those of the Holt Organization in the States. The Holt Company, later the Caterpillar Tractor Company, had been developing Crawler tractors before the war and in advantageous circumstances during it. The Company was big enough to build tractors designed as crawler tractors with built in clutch and brake steering. Johnson with his limited resources had to buy wheeled tractors built to steer on their front wheels, build his tracks round them and overcome the steering problem as best he could. Although many people with crawler tractor experience still think his rubber jointed tracks a better design than the pin and bush jointed tracks the odds against him seemed overwhelming and it is remarkable that his Company was able to survive.

During the Second World War his factory output was commandeered by the Ministry of Supply. This did not prevent him from designing and producing prototypes of his 'Driven Girder' tracks. It was an original and brilliant design with many advantages over the orthodox American type but once again necessity to use wheeled tractors as prime movers put him at a disadvantage. In spite of this and of the hold of the big Companies on World markets many of the driven-girder tractors were sold both at home and overseas until the decline of the use of Crawler tractors in agriculture brought about by the competition of the pneumatic tyre.

Development work on pneumatic tyres for tractors had begun before the Second World War, but they only became widely adopted shortly after the end of it. Characteristically, Johnson was quick to see both their advantages and disadvantages. He had always been a perfectionist and was convinced that the pneumatic tyred tractor would only give of its best if all four wheels were driven. If this could be done economically he saw it as a better agricultural power unit than the Crawler. He was in his seventies and had spent most of his life designing, developing, manufacturing and selling crawler tractors, but he was not too old to abandon the work of a lifetime and become once again a pioneer, this time in the development of four wheel drives. In his eighties he was still not too old to develop a four wheeled drive with hydrostatic transmission. His company was probably the first to market a tractor combining these two features.

Johnson will claim a place in history as the founder President of the Institution of Agricultural Engineers. To measure his achievement as founder President, we, who know the Institution as it is today, may well look back to 1938 when, leading a small group of enthusiasts, he began to build from nothing. For nine struggling years he was President. But before he retired from the Presidency the future of the Institution was assured. Today it is recognised throughout the United Kingdom and in many other parts of the World as the body which has established professional status for the agricultural engineer. Its activities are increasing. Its local branches are growing in number and strength, and its qualifications are appreciated by both commercial and academic employers. We who are members are justly proud of our Institution and grateful to the small body of dedicated men who worked for years to create it. Sadly we salute the memory of the man who led them. Engineer, Soldier, man of wit and wisdom, courage and kindness, he was true to type of the bravest and best Victorians.

He leaves us with a legacy of pride and a debt of gratitude.



1965–The year of the all-new Fords

INSTITUTION NOTES

Publications

Members will by now have received the *Yearbook* 1965/66. It is the largest single publication to have been produced by the Institution and is the result of an exhaustive review of the role of the Yearbook as a handbook of the Institution in particular and, in great measure, of the agricultural engineering profession in general. The concluding words of an editorial article in the new Yearbook express the hope that the increase in size is matched by enhanced quality and utility. The Hon. Editor would welcome letters from members, stating their reactions to the content, presentation and style of the new edition.

Annual Conference

As announced in a previous issue of the *Journal*, the national Annual Conference of The Institution of Agricultural Engineers will be held in the Main Hall of The Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1 on Thursday 12 May 1966, commencing at 9.45 (for 10-15) a.m. The subject-theme of the day's proceedings will be Vegetable Harvesting and Handling. A great deal of work on this vital topic has been conducted at the National Institute of Agricultural Engineering at Silsoe and the I Agr E Conference provides a timely opportunity for information to be made public for the first time. Three of the speakers, Mr J. C. Hawkins, NDA, B SC(AGR), MI AGR E, Mr W. Boa, NDA, B SC(AGR), AMI AGR E, and Mr E. S. Devine, MA, B AGR (HORT), AM INST WS come from NIAE, whilst the fourth speaker, Mr A. J. Gane of the Pea Growers Research Association, will deal with the harvesting and handling of vegetables for processing.
Full details of the Conference programme, which incidentally will not cover potato handling and harvesting, will be circulated to all members in due course; early application for tickets will undoubtedly be advisable.

Annual General Meeting

Members are asked to make a preliminary note that the Annual General Meeting of the Institution of Agricultural Engineers will be held in the Main Hall of the Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1 on Thursday 12 May 1966 at 12 noon, immediately following the close of the morning session of the Annual Conference. Any corporate member, Companion, Associate, Graduate, Student, and accredited representative of Affiliated Organizations is free to attend the AGM; tickets are not required. Formal Notice and Agenda will be circulated in due course.

Annual Dinner

The Institution's Annual Dinner will be held in the Ballroom of St. Ermin's Hotel, Caxton Street, London SW1 on Thursday 12 May 1966 at 6.15 (for 7.0 p.m.). Full details will reach all members shortly.

Annual Subscriptions

A cordial reminder is offered that members' annual subscriptions become due on 1 January. Prompt payment is very greatly appreciated, as it helps the Institution to keep pace with its great many financial commitments.

Whitworth Foundation Awards

The Secretary of State for Education and Science offers for competition in 1966 a number of awards for projects of study or research in engineering or in the teaching of engineering. The awards may vary in length from 3 months to 2 years.
The award will normally be at the rate of £1,500 per annum, plus dependants' allowances as appropriate.
Candidates must have either

(*i*) A University degree in Engineering

or

(*ii*) A Diploma in Technology in Engineering

or

(*iii*) A HNC or HND in Engineering with at least two distinctions

or

(*iv*) A qualification approved by the Secretary of State as of equivalent standard.

The competition is open to candidates from any branch of engineering including teachers of engineering.
Particulars and application forms from the Department of Education and Science, F.E.I. (General), Curzon Street, London, W.1. The closing date for entries will be 31 January 1966.

A world of difference

Most diesel tractors and combines are Perkins powered . . . and most farmers realise that the extra savings they get every day from Perkins add up to really significant amounts in year-round usage. What appear to be only small differences in actual fact make all the difference in the world. No wonder so many far-sighted farmers standardise with Perkins, not only in specialised farm machinery, but in trucks, vans and other equipment around the farm. For lower costs and substantially larger economies it pays to make sure it's a Perkins. Parts and service are readily available and a hand-picked distributor who specialises in Perkins is never more than a phone call away.

make sure it's a PERKINS

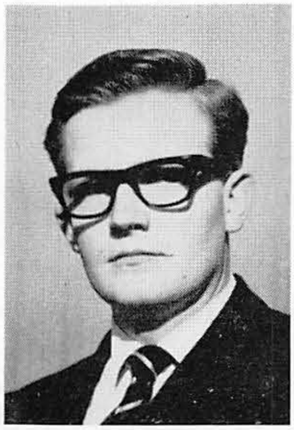
Perkins Engines Limited, Peterborough, England.

Scholarship Awards in Agricultural Engineering

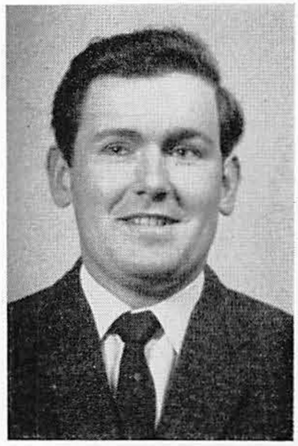
The Institution announces the award of the following Scholarships to full-time students of Agricultural Engineering during 1965/66

E. S. E. Southcombe

M. J. Hann



M. S. Keightley



P. O. Rushton

The DUNLOP Scholarship has been awarded to MR EDWARD S. E. SOUTHCOMBE, age 24. Mr Southcombe who attended Marlborough College from 1955-58 commenced his career in 1958 as a Student Apprentice at Blackburn Aircraft Limited. During his time with the company he obtained his Ordinary National Certificate and Higher National Diploma in Mechanical Engineering, and progressed to the position of Design Draughtsman. In preparation for his new career in agricultural engineering he is attending the National College of Agricultural Engineering, Silsoe, Bedford, for a one-year course in the design of farm machinery.

SHELL-MEX & B.P. Bursaries have been awarded to:—

(1) MR MICHAEL J. HANN, age 23. Mr Hann who attended Brymore School, Bridgwater from 1955-58, holds an Ordinary National Certificate in Chemistry for which he studied at Stroud District Technical College and the National Diploma in Agriculture which he obtained after a period of study at the Essex Institute of Agriculture. He returns to the Essex Institute of Agriculture following a period in farming to take the one-year course leading to the National Diploma in Agricultural Engineering.

(2) MR MARTIN S. KEIGHTLEY, age 21. Mr Keightley attended Stoneleigh West Technical School, from 1958-61 and after practical farming experience entered Harper Adams Agricultural College, Shropshire where he obtained the National Diploma in Agriculture. He continues his study by proceeding to the Essex Institute of Agriculture for the course leading to the National Diploma in Agricultural Engineering.

(3) MR PETER O. RUSHTON, age 21. Mr Rushton attended Cirencester Grammar School 1955-61, later continuing to the North West Wiltshire Area College of Further Education where he gained an Ordinary National Diploma and Higher National Certificate in Mechanical Engineering. While studying for his Higher National Certificate he was employed by Spencer Harris Limited of Cirencester and now proceeds to a course leading to the National Diploma in Agricultural Engineering at the West of Scotland Agricultural College, Glasgow.

THE INSTITUTION OF AGRICULTURAL ENGINEERS

Winter Session 1965-66

FRUIT HUSBANDRY

is the subject-theme of a National Open Meeting of the Institution to be held at:

WYE COLLEGE (University of London), nr ASHFORD, KENT

on

THURSDAY 24 MARCH 1966

PROGRAMME

10.00 Assemble for Coffee at Withersdane

10.30 PAPER I:
The Development of Specialised Machinery for Apple and Pear Production
by R. Hiller, of A. H. Hiller & Son Ltd

11.30 PAPER II:
The Relevance of Overseas Development in Fruit Husbandry
by F. A. Roach, National Fruit Adviser,
National Agricultural Advisory Service,
Ministry of Agricultre, Fisheries and Food

12.30 Luncheon Interval

14.00 PAPER III
A Designer's Approach to Fruit Husbandry
by J. B. Holt, M SC (AGR ENG), MIMH, AMI AGR E,
Harvesting and Handling Department,
The National Institute of Agricultural Engineering

15.00 PAPER IV:
Handling, Grading and Packaging of Fruit
by S. H. Brown, Chief Horticultural Adviser,
Ministry of Agriculture, Fisheries and Food

16.00 **General Discussion** of the four papers

16.30 Tea and Dispersal

TICKETS

Attendance at the Open Meeting is governed by ticket admission only. Tickets, at 18/- each, cover the following items:
Advance copies (approximately one week ahead) of full texts or synopses of papers (depending upon availability);
Attendance at morning and afternoon sessions;
Morning coffee and afternoon tea at Withersdane, and luncheon at the College Main Building;
Free car parking or, in the case of those travelling by train from London, free coach travel between Ashford Station and Withersdane, morning and afternoon.

EARLY APPLICATION FOR TICKETS IS VERY STRONGLY ADVISED. Applications should be accompanied by remittance payable to **'The Institution of Agricultural Engineers'**, to reach the Secretary not later than 14 March 1966.

NEWS FROM BRANCHES

Visit to Perkins Engines Ltd

A party of more than 40 members, led by the President of the Institution, Mr J. H. W. Wilder, BA, MI AGR E, and drawn from East Anglian, East Midlands, West Midlands and Yorkshire Branches as well as from south-east England, paid a visit to the Perkins organization at Peterborough on 17 November 1965.

On arrival, members received a warm welcome from Mr T. R. St. John-Browne, MI AGR E, General Service Manager, himself a Council member of the Institution and Vice-Chairman of the East Midlands Branch. During the morning, the visitors were shown two films, including 'The Royal in England', a filmed tribute to the Royal Agricultural Society of England and the Royal Show. After being most hospitably entertained to lunch, the party were taken by coach to the Eastfield Plant, proudly claimed by Perkins as being the biggest diesel engine factory in the world and producing up to one thousand units per day.

Altogether the visit was highly successful and enjoyable, the only regret being that with the necessity to limit the total attendance figure, many members could not be included who had applied. However, the Company indicated its willingness to receive a second visit and it is hoped to take advantage of this at a later date.

Northern Branch

The Branch Committee announce the following alterations to their Session Programme 1965-66 (originally published in the November 1965 issue of the *Journal*);

MONDAY 14 FEBRUARY (previously 7 February) at Holmwood, Calyton Road, *Newcastle-upon-Tyne* Discussion on **Minimum Cultivations,** led by W. E. Hughes, B SC, M SC, Grassland Officer, NAAS. at 7.0 p.m.

The **Annual General Meeting** of the Branch will be held on Monday 14 March 1966 (not 7 March as originally planned) at Holmwood, Clayton Road, *Newcastle-upon-Tyne* at 7.0 p.m.

Scottish Branch

The Branch Committee announces the following fixtures in its Session Programme 1965-66:

TUESDAY 18 JANUARY 1966—7.30 *p.m. in the Station Hotel, PERTH*

A Joint evening meeting with Perthshire Agricultural Discussion Society. Subject: **Chopped Hay Conservation and Feeding.** Speaker: G. Shepperson, Esq, B SC, MI AGR E of the NIAE, Wrest Park, Silsoe, Bedfordshire.

WEDNESDAY 26 JANUARY 1966—7.30 *p.m. in the West of Scotland Agricultural College, Auchincruive, AYR*

An open evening meeting of the Scottish Branch. Subject: **Machinery Testing and the Interpretation of Test Reports.** Speakers: W. J. West Esq, BA, MI AGR E (Director) G. Gilfillan, Esq, B SC, M SC, AMI MECH E (Principal Scientific Officer—Engineering Section) of the NIAE Scottish Station, Penicuik.

FEBRUARY—Two evening meetings are planned at which Mr John Palmer of the NIAE Scottish Station will give an address on the subject of **The NIAE Potato Harvester.** A separate circular will be issued giving full details at an early date.

WEDNESDAY 2 MARCH, 1966—*Scottish Branch Annual One-day Conference at Dunblane Hydro Hotel, Dunblane,* 10.0 *a.m, to* 4.30 *p.m.*

The theme of the conference is **The Provision of a Suitable Environment for Livestock Production.** The speakers and their subjects will be:

(*a*) Dr D. W. Sainsbury, University of Cambridge **General Environmental Requirements for Livestock**

(*b*) M. F. Tilley, Esq, ARIBA, National College of Agricultural Engineering, Bedfordshire. **Conservation of Heat within Farm Buildings**

(*c*) P. Wakeford, Esq, AMIEE, AMI AGR E, The Electricity Council, London. **The Control of Heating and Ventilation**

(*d*) Professor Olav Hjulstad, Head of Farm Building Department, Vollebek, Norway. **Current Developments in Controlled Environment for Farm Livestock in Norway**

Printed programmes for the Conference and application forms will be issued at the earliest opportunity.

THE ANNUAL GENERAL MEETING

The Scottish Branch Annual General Meeting will follow the above Conference.

THE 21ST ANNIVERSARY DINNER *of the Scottish Branch of the Institution*

The Scottish Branch celebrates its 'coming of age' this year and the Dinner will be held at 7.00 p.m. for 7.30 p.m. in the Dunblane Hotel Hydro on the evening of the Conference, i.e. 2 March, 1966.

The Chairman and Scottish Branch Committee look forward to your support of these functions and wish all members every good fortune during the coming year.

South Western Branch

A Branch Open Meeting was held on 11 November, 1965. The subject for this meeting, held in Exeter, was 'Education in Agricultural Engineering', when a Panel of speakers representing various aspects of the subject were invited to discuss a number of questions set by members of the Branch.

The Panel consisted of Miss J. P. Housley, (Secretary to the Examination Board of the Institution), Mr H. R. Jeffrey, (Past Chairman of the Devon Branch of the

NEWS FROM BRANCHES *(continued)*

A.M.T.D.A.), Dr P. C. J. Payne, Principal of the National College of Agricultural Engineering and Mr L. M. Tate, (Principal of Exeter Technical College).

Topics for discussion ranged from the opportunities for qualified agricultural engineers, to the availability of training for the apprentice employed by small firms in the Machinery Distributive Trade.

Miss Housley explained the composition and functions of the Industrial Training Boards formed under the Industrial Training Act, and the Panel considered the effects upon the Machinery Distributive Trade.

Amongst other topics discussed the need for more technicians in the Industry was stressed, along with the continuity of training at all levels of personnel: there was a gap between the mechanic in the workshop and the manufacturer which must be filled by the technician. One of the problems in the higher educational field was in persuading suitable men to enter agricultural engineering.

During the ensuing discussion when questions were invited from the floor of the meeting, the objects and the availability of the ND AGR E and Institution examinations were explained.

The **Annual General Meeting** of the Branch will be held on Friday 1 April 1966 (not 25 March as originally planned) at a venue to be announced in Exeter, at 6.30 p.m. followed by the ANNUAL DINNER.

As reported in the November 1965 issue of the *Journal*, the Johnson Medal was awarded to Stephen Bradford, a student of the Essex Institute of Agriculture, who was judged to be the outstanding candidate in the 1965 examination for the National Diploma in Agricultural Engineering. Mr Bradford is here seen receiving his award from a Vice-President of the Institution, of Agricultural Engineers, Mr C. Culpin, OBE, MA, MI AGR E, on the occasion of the Presentation Day of the Essex Institute.

Reproduced by kind permission of *Farmer and Stockbreeder Publications Ltd.*

Presidential Address

AN ANALYSIS OF CAREER OPPORTUNITIES FOR PROFESSIONAL AGRICULTURAL ENGINEERS

by

J. H. W. WILDER, BA, MI AGR E*

Presented at an Open Meeting of the Institution of Agricultural Engineers at Silsoe on 28 September 1965

Introduction

I have made a study of career opportunities for Professional Agricultural Engineers the subject for my Presidential Address because a principal function of our Institution is the promotion of training for Professional Agricultural Engineers. This gives us some responsibility that there shall be suitable employment for those who complete their training successfully. The Institution's *Journal* has already published an excellent lecture[1] on this subject given to an audience of schoolboys at the Royal Society of Arts in March 1959 and a paper[2] on the work of the National College of Agricultural Engineering presented to a meeting of the Institution in October 1962 which makes further references to careers. It is not my intention to duplicate these two memorable contributions to the Proceedings of our Institution, both of which were by Dr Payne, who succeeded in painting a picture of a vital and growing industry, full of opportunities for able men and rich in satisfaction as the result of making a real contribution to the welfare of mankind. For the sake of completeness, I will be making some references to these aspects of our industry but my real purpose is to look at careers from the point of view of the employer. Dr Payne was chiefly concerned firstly with arousing enthusiasm amongst school leavers with a view to encouraging them to enter our industry by taking training in agricultural engineering, and, secondly, with the training itself. It might be said that he was looking at this subject from the point of view of the producer whereas my point of view is that of the purchaser, the agricultural machinery manufacturers and dealers who offer the majority of the career opportunities for these trained men.

My choice of subject has been largely influenced by the *Farm Mechanization* conference[3] on Training and Careers in Agricultural Engineering which took place at the National College of Agricultural Engineering this spring. There was also a second event which influenced me. As an Institution, we are very proud of our achievements in ensuring that proper training is available for agricultural engineers. No President's address in 1965 would be complete without particular reference to the Graduation Ceremony of the National College which took place on 13 July and which marked the completion of its first three-year Associateship Course. The important part which our Institution played in persuading the Government of the day to establish the National College of Agricultural Engineering was acknowledged by the invitation to me, as President, to make the Address at the ceremony and present the awards. I said on that occasion that no duty which may fall to my lot during my Presidency would give me more satisfaction or be considered by the members of the Institution more worthwhile than the presentation of those awards. On the Institution's behalf, I also congratulated the Governing Body, the Principal and his Staff on two outstanding achievements, the first being the news that the Associateship had been designated comparable to a first degree and the second that all the Graduates wishing to obtain jobs in industry had been offered graduate apprenticeships, or the equivalent, many with leading agricultural engineering firms in this country. In fact, the demand was such that the Graduates had a certain amount of choice and I sensed satisfaction from all concerned with both the opportunities offered by the appointments obtained and their remuneration.

Our efforts to obtain proper training for agricultural engineers have been very successful and in addition to the present courses available, the University of Newcastle-upon-Tyne will offer an Honours Degree course in Agricultural Engineering from October 1966. The following questions arise. Will the number of qualified men exceed the demand? What is the demand for college-trained agricultural engineers? Mr Horsnail of the National College made the very relevant point at the conference[3] to which reference has already been made, that if we are to encourage bright young men into the Industry, we must try to establish a realistic aggregate figure for the annual demand. He stated that this annual demand is at least 100 and that in addition, there is a backlog to fill and, since employers are entitled to a fair selection of men to choose from, a few surplus to provide. Dr Payne in his paper[2] to this Institution on the work of the National College estimated that more than 300 qualified agricultural engineers go into American industry each year and on the basis of the relative populations of the two countries, said that we could easily absorb 100 men into the industry, even if agricultural engineering were no more important to the British economy than it is to the American, which in view of the volume of our exports would seem to be excessively pessimistic.

My paper at that Careers Conference[3] made a numerical assessment of the demand in the agricultural machinery manufacturing industry excluding tractors. Those who presented papers detailing the career opportunities in the tractor manufacturing industry and in the distributive trade were not so bold, nor so foolhardy as to make the equivalent numerical assessment of demand in their

* President of the Institution

particular spheres. This Careers Conference was so worthwhile and the information given in many of the papers was so interesting that there seems to me a need to try to complete the picture by attempting to provide an analysis of the demand for college-trained agricultural engineers. In the process of estimating this demand, there will also emerge an estimate of the total number of posts which could be filled by professional agricultural engineers and this figure is of great interest to the Institution as it will give an indication of its potential membership which will be helpful to its Council when planning for the future.

Justification of the need for analysis of demand

Let me hasten to explain that the method used in this Address for assessing the total demand for college-trained agricultural engineers is open to criticism both because the information on which the estimates are based is incomplete and because it depends on personal opinion as to how many qualified agricultural engineers are required by manufacturers and dealers of a given size. There are four reasons, however, why speculation of this kind has value.

Firstly, by recording an argued and, I hope, logical assessment, those who have access to the missing information might be goaded into correcting any wrong assumptions and thereby increase our knowledge. Secondly, by expressing an opinion as to the number of qualified agricultural engineers required in a given-sized firm, either manufacturer or dealer, it is to be hoped that others will give some thought to this question and express their opinions and this would enable a concensus of opinion to be formed. If many such firms gave consideration to this question, a third important result of value would be the possibility that these firms will formulate their own policies towards employing qualified agricultural engineers which is a big step towards actually deciding to employ such people themselves. Fourthly, an overall picture of our industry will emerge which, however incomplete, might be helpful to those concerned with training and to the students themselves.

One further point is worth mentioning. It is unlikely that a questionnaire to all the manufacturers and dealers asking them for their requirements for college-trained men would produce information of greater accuracy. The reason for this is that many manufacturers and dealers are relatively small firms and at the present time, the great majority of these small firms employ no academically qualified personnel at all. In any case, they could only justify employing three or four such people so that assuming a working life of 40 years, the demand would only be one every 10 to 13 years. These facts mean that most firms receiving such a questionnaire would have no immediate vacancy for qualified personnel and the chances are that they would reply that they have no need for such people, forgetting that they ought to point out that they probably will need to employ someone in the next 10 to 13 years. The obvious fact is, however, that 1,000 firms say, each requiring 1 person every 10 years or 1/10th person per year, create an average total demand for 100 men per year. At the Careers Conference, both a Staff Manager[4] of a large tractor manufacturer and a Director[5] of a relatively large dealer with several Depots stressed the growing need for graduates in their respective fields. Two quotations from the Staff Manager's paper[4] are worth repeating. 'The history of British industry during the nineteenth century and up to the outbreak of the second World War, was characterized by industrial leaders who had not had the advantages of any formal education, but who possessed all the necessary traits which their managerial positions warranted. However, with the emergence of large-scale industry founded on a strongly scientific basis, the existence of the "self-made man" in Company Board Rooms is rapidly vanishing, and industry is now looking hard at the universities and colleges of advanced technology to find his replacement.

'It is evident from recent articles in the Press, that various professional engineering bodies, such as the Institution of Mechanical Engineers and the Institution of Agricultural Engineers, are concerned that many senior executives and Directors are totally unqualified for corporate membership of such Institutions. This has led the Institutions to assume that the criteria used by them to judge the ability and potential of persons employed in industry, including those at senior levels, are not similar to the criteria applied by industry to itself.

'This is not so. The point is that it is only within the last 15 years that the need for the recruitment of qualified staff has been recognized; hence there is a scarcity of professional qualified engineers at managerial levels.'

Mr Crawford, from whose paper these quotations are taken, then went on to state that the number of hirings of graduates by his Company for all its operations, car, trucks and tractors were 14 in 1959 rising to 51 in 1963. Future plans are for a cumulative 10% increase culminating in a 1970 intake of 124 men, nine times the intake only 11 years earlier.

If a firm of this size has only recently appreciated the need for graduates, it is not surprising that the many small firms in the industry have not yet fully appreciated their own needs.

The Agricultural Machinery Manufacturing Industry (excluding Tractors)

Analysis of a recent A.E.A. membership list gives the following approximate information:

5 member firms make tractors only

7 member firms make tractors and machines and equipment to go with them

173 member firms make machinery, implements, garden tractors and agricultural equipment but not tractors

18 member firms specialize in marketing imported agricultural machinery

35 firms are associate members, making components such as tyres and materials such as

equipment, engines and so on, are also potential employers of college-trained agricultural engineers. To many of these firms, our industry must be substantial customers and it would seem to be important to them to keep in close touch so as to be aware of future trends affecting changes in requirements. Many of these suppliers operate a technical advisory service for their customers as does the Electricity Supply industry. 34 such firms are Associates of the Agricultural Engineers Association and there must be many other firms and organizations who could be included in this category. 88 exhibitors at the 1964 Smithfield Show supplied engineering components either to manufacturers or to farmers. It is most difficult to estimate the total potential for agricultural engineers in such firms as they differ so widely in the type of service offered. All that one can do is to make a guess of a total potential of 160 giving a demand of four a year and hope that someone with more knowledge will in due course provide more accurate information.

The estimated total demand compared with supply

The following table summarizes the estimates already discussed:

	Total number of posts which could be filled by Agricultural Engineers	*Estimated Annual Demand*
Tractor Manufacturers	600	15
Machinery Manufacturers	800	20
Machinery Distributors and Dealers	1,600	40
Teaching, Research, Advisory, Journalism	320	8
Associated manufacturers, Power supply industries etc.	160	4
TOTAL	3,480	87

This is 13 short of the minimum demand of 100 envisaged by Dr Payne and Mr Horsnail but is in fact not so different when one bears in mind that some trained in agricultural engineering will choose jobs outside the industry, some will go on to farms and, the biggest potential of all, many will find jobs overseas particularly in teaching and in advisory work.

The output of graduate agricultural engineers in 1968 is estimated as being about 7 receiving their MSC from Newcastle University, about 30 Associates from the National College, and about 50 successful ND AGR E and Institution examination candidates, which, by coincidence, is a total of about 87, equalling the estimated demand. In addition, about 20 graduates will be taking post-graduate certificates at the National College, many of whom will be from overseas but some of whom will be looking for jobs in the industry as will a few of those who obtain the M AGR SC degree at Reading University.

There are three interesting points that arise from these estimates. Firstly, the present estimated annual demand of 87, excluding overseas posts and employment outside the industry, is based on an assessment of jobs which could be held by qualified agricultural engineers. A high proportion of these jobs are not, at the present moment, held by qualified men and it is obvious that unqualified men will continue to obtain some of these posts. The eventual proportion of these jobs held by qualified men will entirely depend on the quality of the graduates offered and industry's experience of them. It was encouraging to note Mr Crawford's statement that one reason for the remarkable expansion of graduate recruitment in his Company was industry's successful experience with graduate trainees, referring of course in this case to graduates of all types. Agricultural engineering graduates are going to have to prove their worth if 87 a year are going to find employment in the industry.

Secondly, as an Institution we can take some pride in the part we have played in helping to create a situation in which it appears that industry's requirements have been approximately matched by the actual numbers being trained. Admittedly, it looks as if the numbers trained will be less than the demand by the numbers finding jobs overseas and jobs outside the industry but this is offset by the fact that not all the possible posts will in fact be obtained by trained men and by the many smaller firms in the industry hesitating, in my opinion, to employ such men until their worth has been proved. At this stage, therefore, I would have thought that it might be unwise to make any substantial increase in the numbers being trained over and above the present numbers until there has been a year or two's experience of the demand after the National College has reached its full output in 1968. I do not want to be misunderstood on this point. There is no doubt that we will be wanting increased numbers in years to come and that courses at other Universities will be needed. In the short term, however, it is better to have competition for the services of the existing numbers of trained men than create a situation at this stage in which it might be difficult for graduates to get the right sort of job which would result in a set-back to the recruitment of the best of the school leavers.

Thirdly, we can learn something about the potential corporate membership of this Institution and compare this with our actual membership as set out in the table below.

	Number of paid-up members in:		
	1955	1960	1965
(a) *Corporate Members*			
Members	194	236	215
Associate Members	443	585	694
Total Corporate Members	637	821	909
(*b*) *Non-Corporate Members*			
Companions	14	13	14
Associates	455	564	450
Graduates	59	113	225
Students	50	63	110
Total Membership	1,215	1,574	1,708

The estimated potential corporate and graduate membership of our Institution is 3,480 which is almost exactly three times our present corporate and graduate membership of 1,134 and since the rate of growth of this membership over the last 10 years has been about 43 per year, it will take many years for us to reach our potential membership unless we increase our rate of recruitment. It seems to me that we ought to be aiming for a corporate and graduate membership of 2,000 by 1975 which requires an average increase of 87 per year, double our present rate of growth but about the same as the annual production of graduates by 1968.

The future of the Industry

The analysis of the Industry given in this address has, in order to obtain a rough estimate of present demand, painted a rather static picture which could not be further from the truth. The value of wheel tractor production in 1958 was £84,000,000 and in 1963 £141,000,000, an increase in value of 68% in 5 years. Agricultural machinery production in 1958 was £53,000,000 rising to £61,000,000 in 1963, an increase of 15% in the same period. In 1963 over 8 out of every 10 tractors produced in this country were exported. This magnificent contribution to Britain's export effort must give the agricultural machinery manufacturers of this country a great opportunity because wherever there is power, it will be put to use by the farmers of the World to produce more food in a largely under-nourished World. British tractors all over the World require machines and equipment to enable them to do an increasing variety and quantity of work and we should be striving to supply a greater proportion of these machines. There is one other useful contribution which our agricultural machinery industry can make and that is to stem the growth, and even reduce the volume of imported machines, not through Government interference, but by offering better British made machines at the right price.

Given a period of comparative World peace, for a variety of reasons including the need for more food in the World and the drift of manpower from the land in industrial countries, the World turnover in agricultural machinery must surely be going to rise to a total which will make the present turnover seem small by comparison. In industrial countries, the trend will be towards more complex and highly developed machines requiring greater technical skill at all stages, in design and development, sales, installation and service. The ability of our industry to compete in the World will largely depend on the quality and judgement of ou selves, the professional agricultural engineers. Ultimately, it is we who create our own market for our own services. If we are of top quality, the demand will multiply and increase far beyond the estimates made in this address and this demand will be from other industries as well as our own. The most serious obstacle, in my view, is the old fashioned professional man's attitude to money-making as being something which one almost did not mention coupled with the businessman's bias against 'head-in-air' professional men. Profits are required to give the technologist adequate resources to develop the increasingly complex and therefore increasingly costly machines of the future and to provide an adequate reward for his effort and for the investment in his original training. The businessman is no longer going to be able to give the service required, particularly in the case of a machinery dealer, unless he is himself technically qualified or pays adequately for someone with such qualifications.

The Institution has a proud record in ensuring an adequate supply of trained agricultural engineers. Now we have a duty to ensure that the intake of students is of top quality, that the training is planned to produce men who are technically first class and who are able men of affairs, capable with further training of rising to the very top of any business. Another duty, as I see it, is to awaken the many smaller firms in our industry to their needs for qualified agricultural engineers if they are to continue to compete in the future, thereby helping to create the volume of demand which will encourage the best school leavers to join us.

As Dr Payne has said, ours is a growing industry, full of opportunities for able men and rich in satisfaction as the result of making a real contribution to the welfare of mankind. Because of its export potential, it can also make a substantial contribution to Britain's economic recovery. Surely for such an industry, only the best is good enough.

REFERENCES

1. PAYNE, P. C. J., 'Agricultural Engineering as a Career', *Journal of I.Agr.E.* April, 1959.
2. PAYNE, P. C. J., 'The Work of the National College of Agricultural Engineering', *Journal of I.Agr.E.* October, 1962.
3. Conference on Training and Careers in Agricultural Engineering organised by *Farm Mechanization*—April, 1965.
4. CRAWFORD, H. C., Staff Manager, Ford Motor Co.—Paper to *Farm Mechanization* Careers Conference 1965.
5. FALCONER, A. W., Director, John Wallis Titt & Co.—Paper to *Farm Mechanization* Careers Conference 1965.
6. PARKER, L. A., Director of Marketing, Massey Ferguson (U.K.) Ltd, 'The Essential User—Manufacturer Link'—1965 *Power Farming Conference.*

FUTURE WORLD NEEDS OF MECHANICAL POWER IN AGRICULTURE*

by C. J. Moss, BSC, MI MECH E†

Extracts from a Paper presented at a meeting of the British Association for the Advancement of Science, Section M, Cambridge on 3 September 1965

In the world today there is a marked scarcity of food for a population estimated at about 3,000 million and there is much anxiety about the possibility of raising food production to an adequate level for present purposes, and an even greater anxiety about the problem of feeding the rapidly increasing world population. Such a situation has arisen before.[1] In the 1830s, when the population of this country was about one-third of what it is today, fears were expressed that the population was too high for potential food productivity. These fears were gradually dissipated as a result of changes in our agricultural methods, the introduction of fertilizers and the opening up of regions previously thought unsuitable for producing food but, in 1898, the problem was raised again at the meeting of the British Association in Bristol. On that occasion Sir William Crookes pointed out in his presidential address that the world's wheat eaters, then numbering 516 million and consuming 2.3 thousand million bushels per annum, would probably number 746 million in 1931 and would require 3.3 thousand million bushels; at that time it seemed impossible that such an increase could be achieved. This crisis was alleviated, however, by developments in plant breeding, which hardly existed as a science in Crookes' day, and which produced new varieties of crops enabling an extension of the area of cultivation into previously unproductive regions. Furthermore, the mechanization of agriculture started in this period and progress was such that at the beginning of the second world war it seemed that food production might even be able to overtake the increase in population.

Recently, however, it has begun to appear that the increase of world population is again outstripping that of food production. This time it seems clear that the long term solution is to set a limit to the population of the world but useful results in this direction will come slowly and in the meantime it is essential to reduce the world food shortage as far as possible by increasing production.

One way in which this can be done is by intensifying the mechanization of agriculture and eliminating primitive methods which make poor use of the available land. The process will range from the introduction of simple mechanical aids for primitive agriculture to the introduction of automation, both in the field and in the barn, in areas where the earlier stages of mechanization have already been successfully established. Another way is to cultivate more of the world's land surface; it always seems astonishing, indeed almost unbelievable, that only about 10% of the earth's land surface is cultivated and there is almost certainly scope for some further increases.[2] It is also possible that shortages may drive us to exploiting some hitherto less acceptable sources of food.

The population of the world is, at present, about 3,000 million and, of these, about 900 million inhabit the more highly developed countries. These more fortunate people enjoy an average intake of 3,060 calories per day with 90 grammes of protein (44 of animal origin) while the remaining 2,100 million take in 2,150 calories and only 58 grammes of protein (9 of animal origin).[3] Thus the average food intake of the more highly developed countries is nearly up to that required for a moderate level of activity while that of the remainder of the world is well below that for sedentary activity. The significant aspect of this is that the effort at present available for work is least in those parts of the world where most manual work has to be done.

World population trends have been studied by the United Nations and it has been predicted that the world population in the year 2000 will be 6,000 million[4, 5]; recent indications are that the population growth may be even larger. A more detailed examination of the figures shows that the more highly developed and adequately nourished countries mentioned are expected to increase to 150% of their present population while the undernourished countries of the Far East, the Near East, Africa and the greater part of Latin America are likely to rise to 250% of their present level.

The F.A.O. has set target levels to which nutrition in the less developed countries should be raised in order to give them a comparable diet to that of the more prosperous countries. Thus the hope is that minimum calorie levels should be raised to 2,400-2,500 per person per day and animal protein intake to 20 grammes per person per day. To achieve such targets and maintain the standards of the better-nourished countries means that the world's total food supplies will have to be approximately doubled by 1980 and trebled by the end of the century. Thus for a relatively small increase in the lower nutritional levels, there has to be an enormous increase in world food production. It has to be doubled in 15 years and trebled in 35 years. In many industries this would not seem in the least an alarming prospect but it must be seen in the context of only a 50% increase in food output in the last 20 years. Clearly, the agricultural industry has much to learn from other highly organized industries.

At present, practically all the world's food supplies are derived from the land although it only constitutes about 25% of the earth's surface. Only 10% of animal protein

---

* The Institution acknowledges the courtesy of the British Association in permitting reproduction of this paper.

† Director, The National Institute of Agricultural Engineering.

and not more than about 1% of the total food supplies come from water and it may be noted that the bulk of marine fishing takes place on continental shelves which form only about 10% of the available area, leaving vast areas of deep sea to be explored and perhaps exploited in the future.[2]

In the ten years from 1951-1961 the harvesting of fish from the seas approximately doubled and the weight of fish caught is now approximately 1½ times that for beef and veal production. The possibilities of further development are considerable; for example, the simple mechanization of fishing craft in India, Ceylon and similar countries has led to marked increases in yields. The increase in catches by mechanized fishing boats amounts to anything from double to ten times the catches of traditional craft in India and Ceylon. Unfortunately, however, it has not been possible to find any data on the power consumed in the fishing industry.

Agriculture in the more highly developed countries

The present power requirements for food production therefore depend almost entirely on the needs of agriculture and on farms these fall naturally into two sections, mobile power and stationary power. The main sources of power to the farmer are the internal combustion engine and electricity. In fact oil supplies practically all the mobile power for agriculture and some of the stationary power for heating, for processing products, and for motive power where electrical supplies are lacking. Electricity is almost exclusively used for fixed installations and is unlikely to be used extensively in any other way.

The F.A.O. Production Yearbook for 1963[6] gives the world totals of tractors as roughly 11½ millions for 1961 and 12 million for 1962 so that there are at present, presumably, about 13½ million. The same source shows 2¼ million combine harvesters in 1962 with a much slower rate of growth, perhaps 2½ million now. Less complete F.A.O. statistics[7] covering the 1950s show nearly 4 million trucks on farms and about 1½ million internal combustion engines and 4 million electric motors.

Assuming that the average tractor is 35 hp and works 1,500 hours per year at 50% full load and that corresponding figures for a combine are 50 hp, 200 hours and 75%; for a truck, 35 hp, 500 hours and 25%, and for other internal combustion engines, 2 hp, 200 hours and 50%, then if they consume fuel at 0.5 lb per b.h.p. hour, the total consumption for direct farming is now of the order of 85-95 million tons of petroleum products per year. These figures, which are clearly very rough estimates, suggest that tractors account for more than 90% of the total consumption of oil; this is perhaps convenient because the incompleteness of the statistics on combines, trucks and engines is probably of limited importance at this stage. To give some significance to this estimated consumption for agriculture of 85-95 million tons of oil per annum, the total consumption in the U.K. for 1964 has been quoted as 61 million tons.[8]

As far as electric motors are concerned, if we assume that the average motor is 1 hp, is used at 75% full load and has an efficiency of 75%, the total annual agricultural consumption is 600 million kilowatt hours. This may be compared with a world consumption of electrical energy which has been quoted as 2¼ million million kilowatt hours for 1960.[9] Thus, the present direct use of electricity for agriculture is negligible on a world scale.

F.A.O. statistics show that in the more highly developed countries there are nearly 6,000 million hectares of land of which about only one-ninth is cultivated, and two-ninths are pastures; the remainder is divided roughly equally between forests and 'unused' land; there were at work in 1961-1962 a little more than 11 million tractors in these countries and they produced about three-fifths of the world's food. In the less highly developed countries with a land area of just over 7,500 million hectares about one-tenth is cultivated and a little less than one-fifth is pasture, while forests occupy less than one-third, and nearly half is 'unused'; on an area of cultivated land slightly larger than in the developed countries an army of men work, and they are aided by only about one-fourteenth of the total number of tractors in use throughout the world, and produce only two-fifths of the total output of food for more than two-thirds of the total world population.

It will be obvious that the figures are not precise and it will be readily appreciated that demarcations are not always clear, for example between 'scrubby pastures' and 'thinly wooded forest land'. Furthermore, the 'unused' category contains large areas of land which are likely to be still unusable for agricultural purposes at the turn of the century. To look as far ahead as 2000 A.D. is difficult enough, but to try to look beyond that would surely be unwise! It appears from these figures that if the productivity of the land in less highly developed areas were brought up to the level of the more effectively cultivated ones, and if a further 2000 million hectares of unused land could be made equally fruitful, the result would be the trebling of food production which is so necessary. That is an indication of the problem facing mankind but the possibility of producing the food we need by increasing so much the area cultivated is open to serious doubt; probably a combination of increasing the area farmed and a more intensive use of present agricultural land will be the most likely outcome. It would certainly be overcautious to assume that the land in the more highly developed countries cannot produce much more food even though its output may seem high by Asian or African standards. However, production from a smaller area of land may only lead to small economies in power required compared with the same output from a larger area.

If our food shortages were to be overcome in this way then it seems likely that the increase in output would involve raising the tractor population of all this cultivated land to the general level that exists now in the more developed countries, that is, the world population of tractors should rise to about 55-60 million by the year 2000. This would suggest, incidentally, the need for a considerable increase in world tractor production which is now believed to be about 1.1 million per annum (about one-fifth of which are made in this country). Half of the new production presumably replaces old tractors since the world tractor population is only increased at about half a million per annum. It appears that there would be a need for an increase of about 45 million in 35 years in the numbers of tractors in use and if we were to meet targets for food production in this way the present level of tractor production would be inadequate. Another solution to the problem would be to use tractors more intensively. This may become possible if tractor operation can become 'automated' so that the farmer can set the operation in motion and then leave the tractor to continue without interruption for meal breaks, weather conditions or even perhaps for nightfall. Such a possibility is not unreasonable for large fields but its adoption would not lead to a reduction in demands for power.

If tractors, combines and trucks in the year 2000 are propelled by diesel engines as they are now, the fuel consumption would rise to about 400 million tons of petroleum per year. Statistics from the Petroleum Information Bureau[10] give the world oil consumption for 1963 as 1,300 million tons and various estimates have been made for the future. For example, predictions in a 1955 report of Political and Economic Planning[11] give upper and lower limits of 2,900 million and 8,100 million tons per annum in the year 2000 depending on the assumptions made for rate of growth, but whichever proves correct the needs of agriculture are likely to be important.

The use of electricity will naturally increase and its obvious convenience for driving fixed installations and for heating means that in such applications its growth will only be restricted by its cost and availability. It is a particularly suitable source of power for automatically controlled equipment, which is finding new applications in agriculture as elsewhere. The availability of electricity is particularly low in the more backward countries and it seems unlikely that it will play any great part in the urgent programmes to increase food production.

Agriculture in the less developed countries

That agriculture should develop on familiar Western lines with vast numbers of tractors, combine harvesters, etc., is naturally the way in which the mind of an engineer in Europe should at first turn. It is, however, extremely unlikely to be an accurate forecast of the future. It is incorrect because of the sociological factors which affect farming; for example, it is now known that in India there are 82 million farms between one-third and three acres in size. Doubtless the number of farms will diminish and their sizes will increase but it will be many decades before farming as we know it in Europe will be adopted in India and other vast areas of the world.

This, however, is still not the whole problem. Food for 70% of the population of the world is rice. In the monsoon areas of the world it is not possible to grow arable crops as we know them, and the staple diet is rice. In fact in 1962-3 approximately one-quarter of the world cereal crop of 1,000 million tons was rice.[5] Moreover in these parts of the world much of the work of the farmer has to be done knee deep in water, and so far little progress has been made in easing his arduous lot with mechanical aids. Here the problem is not 'how many tractors' or 'what sort of tractors' but rather can a simple wooden paddy transplanter be made cheaply enough for millions of small farmers to use and if suitable can it be made by the carpenters in the thousands of Asian villages? Unfortunately, mechanical power will be of little direct use in the rice fields for decades to come. This is important today but it must also be rembered that it is in the Asian countries that the greatest expansion in population is certain to occur, and where the problems of increasing the output of food will be most acute.

It is disappointing, perhaps, to a mechanical engineer, to find that his developments seem at present so largely irrelevant to such a large proportion of the population of the world but it is a challenge to him to seek other solutions to these stubborn problems. Fortunately, the agriculturalist has already pointed to the engineer some directions in which progress, perhaps very important progress, can be made. More than two-thirds of the population of the world depend on rice for food and in general they are the less well nourished part of mankind. It is therefore all the more appalling to learn that one-third of the rice crop harvested is wasted because of inadequate treatment and storage. To describe this as appalling is surely no overstatement, and it is clearly imperative that simple equipment for drying the rice etc. be evolved so as to prevent this loss of food.

It would not be appropriate to follow this subject further in this paper. It has been introduced so as to put the problems of mechanizing world agriculture in a proper perspective and to illustrate how different will be the needs for power in different parts of the world. At this stage, too, it is not profitable to try to assess quantitatively the needs for power which will emerge as methods are evolved to improve the proportion of rice used as food. Mention must be made, however, of one more aspect; yields from rice growing vary widely and in Japan outputs for a given area are more than three times as much as those in India. This is partly explained by the much more intensive use of fertilizers in Japan and the subject of power requirements for their manufacture is dealt with later.

Overall needs for power

It will now be readily appreciated that the estimates put forward earlier, which were based on meeting world food needs by Western style farming, are hopelessly in error. When so much of the population of the world lives in areas where climatic conditions make it impossible to grow wheat and barley with the help of the tractor and the combine it is necessary to look again at the forecasts for the number of them in use by the end of the century. It is believed that there is scope for some extension of the area cultivated at present, and there is little doubt that there is scope also for further mechanization of the area already cultivated. It is reasonable to predict, therefore, that there will be a steady increase in the numbers and perhaps in the powers of tractors, combine harvesters, trucks, etc. in use. In fact there may well be in advanced countries marked increases in power to reduce the costs of large scale materials handling. Perhaps, at present, insufficient attention is given to the very high cost of manpower employed in handling huge tonnages on the farms and it is probably not unreasonable to expect increased efforts to use mechanical power in the future. On British farms alone more than $1\frac{1}{2}$ million tons of fertilizers are 'handled' every year, and this at present makes heavy demands on expensive manpower.

Recently the number of tractors in use in the world has been increasing at the rate of half a million per annum,[6] but it is difficult to judge whether this rate will increase or decrease; it is so much an economic problem that it would be rash for an engineer to make predictions. In the U.S.A. during the last decade the numbers of tractors has increased by only about 20% to about $4\frac{1}{2}$ millions, although the average horsepower of the tractors is believed also to have grown. In Europe the rate of increase from a very much lower starting number has been more sustained but the total in Europe without the U.S.S.R. is still less than in the U.S.A. Once again, however, there is evidence to support the belief that average horsepowers are still increasing. The total number of tractors in the U.S.S.R. in 1962 was believed to be less than one-third of that for the U.S.A., and in the remainder of the world this basic tool of farmers was comparatively thinly spread.[5] It seems therefore that in many parts of the world, but by no means in all parts, there is scope for steady increases in numbers and powers of the familiar four-wheeled tractor. It is also possible that a very much less sophisticated tractor may be evolved for the farmers of the less developed countries. For example, a single-wheel-drive machine of low power and with tiller steering is undergoing trial at present; it may be that many parts of such machines could actually be made in the developing engineering industries of, for example, some African countries, and this in turn would reduce their need for imports. However, if present trends continue, then by the end of the century there would be about 30 million tractors in use, with corresponding increases for other powered equipment and on this basis the consumption of oil would be of the order of 200 million tons per annum.

So far, this paper has considered only existing forms of power usage in agriculture and the extension of them, without any fundamental change, to fulfil an increased demand. The possibility of changes in the types of prime mover, the use of unusual forms of energy, changes in agricultural methods and in the sources of food that are tapped must also be discussed.

It has already been pointed out that electricity provides the ideal source of power for fixed installations and no significant changes in the design or performance of electrical equipment is to be expected that would influence its use in such applications. For mobile use in agriculture the diesel engine is not ideal. It is noisy and generates a great deal of vibration, its torque-speed characteristics make necessary a variable ratio transmission system, and its efficiency is not high, leading to the need for a cooling system. The great advantage that the reciprocating internal combustion engine has over possible competitors is that it has become established and its production and operating difficulties have been overcome. Developments are taking place in other forms of internal combustion engines but how far these developments are likely to come into general use in quantity-produced engines is not yet clear and it is always possible that in time some more revolutionary power plants such as gas turbines and fuel cells may yet overtake piston engines.

Gas turbines are free from vibration and are not necessarily noisy but their initial and operating costs are both high. Difficulties also arise in designing small gas turbines without loss of performance and the smaller sizes are at present larger than is required by most tractors. Fuel cells may become an efficient means of generating electrical energy but it is at present difficult to see their application in agriculture.

Sources not yet exploited for agriculture include nuclear power, tidal, solar and wind energy, and organic wastes.[12] The first two do not appear to have any specifically agricultural application but both may develop as general sources of electrical energy. The successful development of relativley small nuclear power units could make possible the provision of electrical supplies in remote areas where the transport of more conventional fuel might be uneconomic. However, the electrical needs of agriculture have already been seen to be low so that this would not be an important factor in increasing agricultural output and there are no signs yet that nuclear power units will ever provide the motive power for agricultural machines in any other way.

Solar and wind energy have the great disadvantages of discontinuity and diffuseness with the result that they are only suitable for very limited purposes and are unlikely to contribute much to the world's requirements for controllable supplies of energy. The use of organic wastes presents similar difficulties due to their wide dispersal and problems of collection for central processing, and worthwhile contributions of power from this source are hard to foresee apart from special local examples.

In considering changes in agricultural methods that may affect future power requirements, possibly the most obvious factor could be the widespread use of chemical weedkillers. Traditionally, weed control has been exercised through a wide range of tillage operations starting with the burial of old weed growth by ploughing at the end of the year and followed by lighter cultivation, leading to the sowing of the next crop, the growth of which is accompanied by hoeing to limit new weed growth. These operations account for a large part of the power used on farms, and it may be that the advent of modern weedkillers will reduce the need for these power consuming processes. It has to be remembered, though, that ploughing and later operations have other purposes as well as weed control and these include the breaking up of land surface where it has been compacted by the wheels of harvesting machinery and the provision of conditions suitable for the germination of seed, subsequent root development and the physical support of the growing crop. Thus, even though weed control may become a less important aspect of ploughing and cultivation, and in some circumstances these processes may be largely eliminated, it would be unwise to forecast that any very marked decrease in the power requirements of agriculture will follow from the increased use of chemical weed control. Another change which may influence the use of power in agriculture is the tendency, which will continue, for the average size of holdings to increase. In advanced countries the increased ability to mechanize may take the form of increased use of more powerful machinery, and thus lead to increased consumption. 'Factory farming', too, in so far as it leads to a more intensive production of food from a given acreage may lead to higher power requirements.

Other sources of food

Possibilities have been put forward of new sources of food, particularly of protein. A case has been argued since the 1940s for the direct extraction of leaf protein for human consumption because this would be less wasteful than feeding animals for subsequent eating. [13 14 15] and it has also been urged that plankton, particularly the larger, prawn-like krill [16 17], could be harvested and processed for feeding poultry and livestock if not for direct human consumption. The use has also been suggested of green algae which might produce 30-60 tons of dried weight of food per acre. Fish farming in rice fields, canals and irrigation reservoirs[18] has been proposed and there is the possibility that fish could be grown rapidly in the considerable quantity of cooling water that is warmed up in electricity generating stations. At present, approximately 56% of the energy of fuel used for electric power generation is lost in heating water, that is, in Great Britain at the present time, the equivalent of about 30 million tons of oil per year.[19] Unfortunately at this stage it is not possible to make useful forecasts of the power requirements of these unconventional methods of producing food but it is possible that they may add their quota to the total. There is, however, one process for producing a high quality protein which is already showing promise on a small scale; it involves a bacteriological fermentation using oil as a source of carbon. Out of ten parts of oil one part is consumed by the micro-organisms to yield protein and nine parts are dewaxed fuel. If good progress continues to be made then a new source of protein will in time become available to man but this will not have a marked effect on the overall problem in the next two decades. In the longer term it is possible that this or similar processes may reduce the demands for land and for power to produce the protein part of our diet, but it does not seem probable at the present that processes will be devised which will markedly alter the prospect very long before the end of this century.

Power for irrigation

A factor not yet mentioned is the steadily rising demand for power for irrigation. It is believed that by the end of the 19th century the area of land irrigated as a result of man's intervention had risen to about 40 million hectares and that this had increased threefold by the middle of the century. It seems probable that the area irrigated may double by the end of this century but this will still only be a very small proportion of the total land cultivated, and of this area perhaps one-fifth will involve the pumping of water. For this it is probable that a power requirement of the order of 3 million horsepower throughout the 20-25% of the year would be required and this would require the equivalent of only a million tons of oil per annum.

The manufacture of machines and fertilizers

So far, therefore, it seems clear that it is the direct use of the internal combustion engine to facilitate the cultivation of the land and the harvesting and handling of crops which dominates the subject. The other factors, some of which seem large when judged in isolation really add only a little to the overall demand for power. Now it is necessary to examine two other facets of the subject. To make the millions of tractors and other equipment we have shown to be essential, if the agricultural industry is to produce on the scale required, coal, fuel oil, electricity etc. are consumed by a very large number of engineering manufacturers and to make much more than a very rough estimate of the power required by them is difficult. At the risk of being seriously in error it is suggested that in this country the power consumed by agricultural machinery manufacturers would need the equivalent of something of the order of half a million tons of oil per annum. If this figure is roughly of the right order then throughout the world it is possible that the equivalent of about 5 million tons of oil per annum is used by manufacturers, and this must be compared with a consumption on the farms of the order of 90 million tons per annum. It would, of course, be possible to pursue this point further back into the manufacturing of raw materials for machinery etc., but that would really go further than is necessary at this stage to demonstrate that agriculture makes quite appreciable demands for power in the engineering industries as well as in the fields.

The final aspect to be considered in this paper is that of the manufacture of fertilizers. Their use on a large scale has already done much to increase the output of agriculture and it is almost certain that their consumption will continue to increase. The main demand for energy in fertilizer manufacture is in the synthesis of ammonia. It seems likely, too, that in the future ammonia will be produced in large, efficient plants, which will be heavy consumers of power. For example, to produce the nitrogenous fertilizers for this country the equivalent of 0.6 million tons of oil per annum is required. As we consume only about 4% of the world output of such fertilizers the extent of the world demand for energy of the industry will be appreciated. It is clearly of the order of 15-16 million tons per annum at present, for nitrogenous fertilizers alone;[20] a relatively small increase must be made for the other fertilizers and also for pesticides, herbicides, etc.

Forecasts made of the future production and consumption of fertilizers suggest a doubling in the next twenty years. Perhaps for the purposes of this paper it is not unreasonable to suppose that by the end of the century a trebled output of food will necessitate a trebled output of fertilizers. If that is so, then the power for their manufacture may well require the consumption of fuel equivalent to 50 million tons of oil per annum.

Conclusion

To discuss the future needs of the agricultural industry for power is a hazardous undertaking but an indication for the end of the century seems to be a tractor army of the order of 1,000 million horsepower which, with combine harvesters etc., will consume on the farm about 200 million tons of oil per annum. Chemical manufacturers may need the power derived from the consumption of 50 million tons of oil per annum to supply the farms with fertilizers etc. and engineering manufacturers the power from 15 million tons of oil to manufacture the tools of farming. A total of the order of 250-300 million tons of oil per annum or about 3-4% of the probable world output of oil is what may be necessary to feed a population of 6,000 millions by the end of the 20th century. The consumption of electricity on farms will increase but it seems probable that the greatest expenditure of power will be in tractors. They are likely to be based on oil consuming internal combustion engines and in the immediate future the well developed and well established diesel engine will maintain its dominant position. Later in the century it is possible that other forms of prime mover may become of commercial importance. Developments in agricultural techniques may reduce demands for power in ploughing and also reduce the number of times that a tractor crosses the land but, despite this the overall need is likely to be for very much more mechanical power to reduce dependence on man and animal power not only for the direct cultivation and harvesting operations but also for the varied other work of the farm.

However, in the monsoon areas of the world with a rapidly growing proportion of the population the picture will be quite different. The consumption of power, whether considered by acre or by man, will still be very markedly lower than elsewhere, and much of this power may be devoted to processing the rice crop to avoid the present disastrous loss of food. These areas will probably, however, be large indirect users of power in their agriculture because, following the example of Japan, their output of food will be increased by larger consumptions of fertilizer.

REFERENCES

1. RUSSELL, SIR E. JOHN, 'World Population and World Food Supplies', pp. 5-6, Allen & Unwin, 1954.
2. 'Possibilities of Increasing World Food Production', *F.A.O.*, Rome, 1963.
3. '6 Billions to Feed', pp. 11-14, pp. 35-41, *F.A.O.*, 1963
4. 'Third World Food Survey', pp. 70-71, *F.A.O.*, 1963.
5. 'Agriculture in the World Economy', pp. 15-25, *F.A.O.*, 1962.
6. 'Production Yearbook', p. 35, pp. 266-71, 274-75, *F.A.O.*, 1963.
7. 'Monthly Bulletin of Agricultural Economics and Statistics', p. 15, *F.A.O.*, November 1960.
8. DAVIES, J. E. H., 'The Competing Fuels, Oil,' p. 957, *Electrical Times*, London, 24.6.65.
9. GOLDING, E. W., 'Power Supplies', pp. 11-13, *The Overseas Development Institute*, London, W.1.
10. 'World Oil Statistics', p. 10, *Petroleum Information Bureau*, London, W.1., September 1964.
11. 'World Population and Resources', pp. 64-73, *Political and Economic Planning*, London, S.W.1.
12. GOLDING, E. W. 'Power Supplies', pp. 45-59, *The Overseas Development Institute*, London, W.1.
13. PIRIE, N. W., 'The Direct Use of Leaf Protein in Human Nutrition', pp. 45-48, *Chem. and Ind.* 24.1.42.
14. PIRIE, N. W. 'Large-Scale Production of Edible Protein from Fresh Leaves', pp. 173-81, *Report of the Rothamsted Experimental Station for* 1952.
15. PIRIE, N. W. 'The Efficient Use of Sunlight for Food Production', pp. 442-45, *Chem. and Ind.* 9.5.53.
16. HARDY, SIR ALISTER. 'New and Richer Marine Harvests Forecast', pp. 482-83, *New Scientist*, 20.2.64.
17. HARDY, SIR ALISTER. 'The Krill—An Ocean Harvest of the Future', pp. 41-43, *New Scientist*, 1.7.65.
18. BENDER, A. E. 'Protein Resources', pp. 270-74, *Researh Applied in Industry*, London, July 1960.
19. 'The Sub Tropical Waters of Britain', pp. 245-6, *J.I.E.E.*, June 1963.
20. 'Production Yearbook', pp. 259-67, *F.A.O.*, 1963.

ALTERNATIVE TILLAGE TECHNIQUES FOR THE DEVELOPING AGRICULTURE OF UGANDA

by

G. HILL, DIP AGR ENG, AI AGR E*

Summary

Compacted soils, matted roots and the presence of surface vegetation restrict the possibility of obtaining a seed bed in the shortest time and minimum number of operations. The demand for quicker and cheaper tillage has increased with the sharp rise in tractor population and the development of group farms based primarily on cotton growing.

It has been proved that versatile rotary slashers and rotary cultivators can deal with the main factors affecting basic tillage and that the use of these implements either singly or in succession prior to or in lieu of conventional tillage can reduce tractor time per acre by up to 40% and costs by a proportional margin.

Other advantages of the proposed tillage techniques are a reduction in the operator skill required and improved possibilities of timeliness of seed bed preparation and planting.

Consideration is also given to the choice of equipment and service requirements of it when used for these operations.

Introduction

Tractor tillage in Uganda peasant farming has, for the past two decades, been undertaken primarily by a Government Contract Hire Service. The operations were limited to initial tillage and seed bed preparation in virigin and previously cultivated land. Considerable experience had been gained over this period on the potential of tractor cultivations and a large measure of standardization of tillage equipment and practices was arrived at.[1]

In some areas where tractor cultivations proved to be successful, local farmers have tended to purchase their own tractors and to undertake work on neighbouring farms, thus taking over the work of the Government Hire Service. The number of privately owned tractors operated in this way is estimated at eighty. The benefits obtained from the work done by these tractors have, to both the owners and the farmers concerned, proved extremely variable, with the larger percentage of the tractors a doubtful economic proposition.[2]

Recently the Government, in an attempt to encourage group farming, has imported several hundred wheeled tractors for work on these proposed group farms, on which increased cotton production is to be the aim.

Whilst the opportunities for economic utilization of tractors are considerably enhanced when large units are mechanized, as is envisaged on the group farms, the need to reduce cultivation cost to an absolute minimum is essential to ensure a reasonable return to the farmer whose cotton crop will give him a gross return of 300-500 Shs. per acre. The 4-6 acres of cotton will constitute two thirds of his arable acreage.

* Development Officer (Agricultural Engineering), Makerere University College.

Tillage based on the disc plough

A considerable range of tillage implements was tried in the initial years of the Contract Hire Service and the disc plough, in spite of its recognized shortcomings, was adopted generally. The reasons for its choice were based more on the limitations of the alternative implements then available than on the perfection obtainable by the use of the disc plough as a basic tillage implement. The mouldboard plough, for instance, proved to require too high a degree of operator skill, particularly in the typical conditions in which relatively tall vegetation and dense surface trash could generally be expected. The disc plough, on the other hand would roll over the trash and keep working, although many subsequent operations were required before a suitable seed bed could be achieved. Disc ploughing in matted, tough grass or heavy trash in medium to heavy soils produced poor results which frequently required three or more operations to produce a seed bed, at a total cost of up to 150 Shs. per acre.

Chisel ploughs and heavy duty tillers were unable, as could be expected, to work in the heavy trash encountered. Even under conditions where the surface trash had been removed or burned the chisel plough was effective only in limited areas with dry soil conditions, but the type of implement and tractor power then available were unable to work to the required depth.

Rotary cultivators were, initially, unsatisfactory particularly because of the high rotor speed and the low forward speed required for the tractors of the early 1950's to operate a 50 in. machine. This resulted almost invariably in pulverization of the soil, as was found in Kenya.[3] In addition, the machines were not sufficiently robust and as a result caused grave misgivings regarding the value of rotary cultivators, which have persisted.

Alternative tillage techniques

As has been outlined earlier, a re-examination of tillage techniques became imperative with the introduction of large numbers of tractors on to group farms.

The higher horse power tractors available, the perfection of the rotary grass cutter and great improvements to rotary cultivators enabling greater scope for these types of power take-off driven implements suggested a line for further examination with a prospect of solving some of the problems.

Preliminary observations suggested three major factors were responsible for multiple tillage operations, namely, dense surface vegetation soil conditions and in these conditions the inability to utilize available tractor power with conventional drawn equipment.

It was clear that any simplification and cheapening of operations would be feasible only if the machines could operate effectively despite these limiting factors.

Preliminary trials with a rotary grass slasher (Fig. 1), showed that this type of machine could deal with virtually any quantity of surface vegetation, giving an output of 0.4 to 0.6 acres per hour when travelling at a forward speed of 1 to 1.5 mile/h.

Fig. 1
Slashing in elephant grass up to 12ft in height

The cost of such a preliminary operation is estimated at 15 to 17 Shs. per hour. The vegetation after being lacerated in this way was, furthermore, found to be in a suitable state for incorporation into the soil by subsequent tillage operations.

It also became evident that modern rotary cultivators with variable rotor speeds, of robust design, held considerable potential in dealing with land otherwise unsuitable for conventional basic tillage implements. It was established, in particular, that many of the objectionable features of the rotary cultivator, notably that of tending to pulverize the soil, had largely been overcome in modern machines.[4]

A combination of the two machines proved to be very effective for direct preparation of a seed bed, or where deeper cultivations were necessary *as preliminaries to conventional cultivation methods*. This latter point is of paramount importance, in so far as rotary cultivation as a preliminary operation could destroy vegetative trash and growth as well as the surface compaction of the soil or root-mat and greatly facilitate conventional ploughing ensuring complete burial and incorporation of vegetation. Above all, it could eliminate or reduce considerably the usual subsequent operations in seed bed preparation.

Numerous trials have suggested a clear procedure for the optimum use of the machines, as follows:

Rotary cultivation as the only operation

This machine has proved to be most valuable in preparing a seed bed in one operation in conditions of medium to low vegetation and trash, where the depth of cultivation is not critical (Fig. 2). The rate of work is, as can be expected, affected by the intensity of surface vegetation. Whilst a rate of 0.8 ac/h can be expected in light conditions, this may be reduced to half in extreme conditions. The cost of this operation could thus vary between 25 Shs. and 48 Shs. per acre.

Grass slashing followed by rotary cultivation

Whilst the upper limit of surface vegetation with which the rotary cultivator can cope effectively in one operation is remarkably impressive (Fig. 3), in more extreme conditions a pre-slashing operation becomes necessary (Figs. 4 and 5). In very severe conditions a second rotary cultivation some 3-4 weeks after the first tillage operation may be carried out with advantage.

Preliminary rotary cultivation could be expected to cost up to 50 Shs. per acre and secondary operations with this machine would rarely exceed 25 Shs. per acre. Thus, in extreme conditions requiring two rotary cultivations after a slashing operation, an overall cost as follows could be expected:

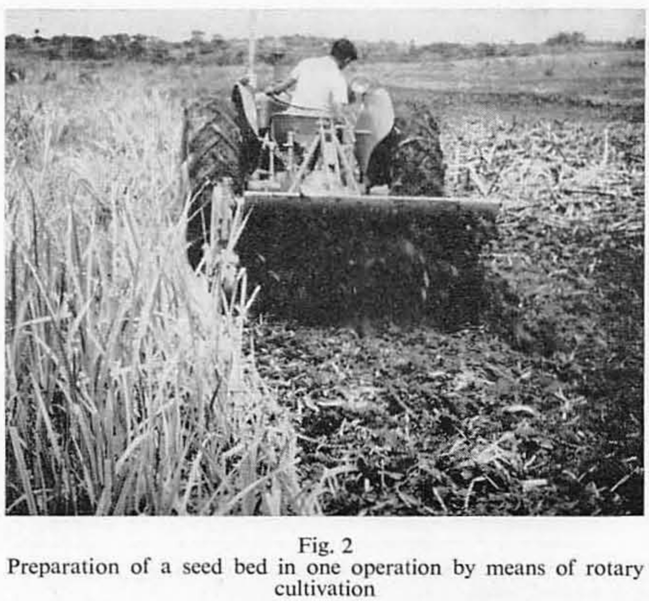


Fig. 2
Preparation of a seed bed in one operation by means of rotary cultivation

35-40 hp tractors employed in Uganda with 3-disc ploughs are expected to work at a rate of 0.3—0.4 ac/h for initial ploughing and 0.5—0.6 ac/h for second ploughing. Thus, in difficult old grassland where two ploughings and two harrowings are necessary, comparable to trial M.12 (Table II), pre-rotary cultivation reduced tractor hour requirements and, on estimated tractor costings, proved considerably cheaper.

Tractor and implement requirements

Throughout the preliminary trials, variations in tractor and implement performance were noted and the following conclusions arrived at:

(*a*) *Tractor*. For work with power take-off implements in these difficult conditions, a low forward speed and high p.t.o. hp at rated speed are required, i.e. approximately 1 mile/h in low gear and 75% or more of the total available power.

It was found when comparing two tractors of similar p.t.o. hp at rated speed but with different forward speeds, that the maximum depth obtainable with a rotary cultivator was approximately inversely proportional to the speed. i.e.

Tractor A with 50 rotary cultivator at 1.2 mile/h max. depth 6 inches
„ B „ 50 „ „ „ 1.5 „ „ „ 4.5 „

After trying several types and makes of tractors with different widths of rotary cultivators, the following formula was arrived at as a reliable guide to power requirements for rotary cultivation in average to difficult conditions:

$$\frac{\text{WIDTH (IN.)} \times \text{DEPTH(IN.)} \times \text{MILE/H AT RATED P.T.O. SPEED}}{10} = \text{P.T.O. HP REQUIRED AT RATED SPEED}$$

TABLE II

Plot B3/2 1 acre

1st Ploughing (Disc)	2.28 h	@ 17.50 =	39.90
1st Harrowing „	1.82 „	@ 15.00 =	27.30
2nd Ploughing „	1.84 „	@ 16.00 =	29.40
2nd Harrowing „	1.14 „	@ 14.00 =	15.96
Total hours	=7.08	Cost =	112.56 Shs.

35-40 hp Tractor
3 Disc Plough
5 ft 6 in. Offset Harrow

Plot B3/3 1 acre

Rotavation	2.62 h	@ 20.50 =	53.40
M/B Ploughing	1.54 „	@ 17.50 =	26.95
Disc Harrowing	1.06 „	@ 14.00 =	15.84
Total hours	=5.22	Cost =	96.19 Shs.

35-40 hp Tractor
50 in. Rotavator
2F 12 in. M/B Plough
5 ft 6 in. Offset Harrow

Plot B3/4 1 acre

Rotavation	1.72 h	@ 22.00 =	37.84
M/B Ploughing	1.22 „	@ 18.50 =	22.57
Disc Harrowing	0.87 „	@ 15.00 =	12.75
Total hours	=3.81	Cost =	73.16 Shs.

58 hp Tractor
60 in. Rotavator
3F 10 in. M/B Plough
5 ft 6 in. Offset Harrow

Two 40 hp and one 58 hp tractors were tried and resulted in the choice of the 58 hp tractor and a 60 in. cultivator as being the most suitable, as illustrated in Table III.

TABLE III

Tractor	*Engine rev/min at 540 p.t.o*	*Speed 1st gear*	*Depth required*	*Width of rotavator*	*Power required*	*Max. p.t.o. hp available at 540 rev/min*
A	1,750	1.20	5-6 in.	50	30-36	36
B	2,000	1.42	5-6 in.	50	35.5-42.5	36
C	1,750	1.20	5-6 in.	60	36-43	46

Tractor C had power in hand and a 20% greater width of tillage. Tractor B obviously possessed too high a forward speed in 1st gear and could not cultivate at the required depth. Power requirement figures are approximate and power available figures do not take into account altitude losses. However, it can be seen that tractors and rotavators need to be carefully matched to ensure efficient operation and maximum effect.

Live p.t.o. and hydraulics are very desirable as tractors without them require considerably longer to restart when obstructions are encountered, which is found to happen frequently and shows a marked effect on output.

No difficulty was experienced in obtaining suitable ploughing and cultivating speeds, i.e .2½—4 mile/h, on any of the tractors tried.

(*b*) *Rotary cultivators*. Robust construction is of prime importance as stones, stumps and roots are often encountered. A variable rotor speed allows the tilth to be varied to suit requirements and the soil and vegetation conditions prevailing. Speeds giving 3.4-4.3 cuts per foot are most commonly used and only in wet clay soils where blockage of the rotor occurs is it necessary to use higher speeds giving 5 cuts per foot. At

$$\left.\begin{array}{l}\text{1.2 mile/h: 125 rotor rev/min} = \text{3.4 cuts per foot} \\ \text{150 „ „} = \text{4.3 „ „ „} \\ \text{175 „ „} = \text{5 „ „ „}\end{array}\right\} \text{using a 3 bladed rotor}$$

As can be expected, fuel consumption, power requirement and blade wear rise sharply when rotor speeds are increased.

It was found that the rotary cultivators were the only cultivation implements which could utilize the full power available from the tractors tried, as they were not dependent on wheel adhesion for optimum performance. In deep trash or lush vegetation, wheel spin restricted performance with conventional tillage implements.

(*c*) *Slashers and rotary cutters.* Robustness is again a pre-requisite for this implement. High peripheral blade speeds were found preferable, i.e. 12,000-15,000 ft/min thus allowing greater flexibility of forward speed with a clean cut in light conditions and adequate laceration in heavy growths. Variable-sized discharge outlets were found to assist in varying the degree of laceration and power requirements to suit conditions, but if these were not available, adjustment of the top link length partially fulfilled this requirement. In very tough grass the mulched grass was discharged into the uncut grass and was thus taken through the slasher again and further shredded.

(*d*) *Ploughs: Mouldboard and Disc.* Both require large under-beam and share-to-share or disc-to-disc clearances. Disc ploughs with variable disc angles worked best over a wide variety of conditions. In deep trash, mouldboard ploughs with large-diameter coulters worked best, as with small coulters set at the required depth, it was the coulter stems and brackets which trashed first.

(*e*) *Servicing and Spare Parts.* One hour's servicing time to ten hours of work proved to be adequate for tractors with ploughs, harrows and slashers, whilst the necessity to check and tighten blade bolts on rotary cultivators when working in stony or stumpy conditions demanded a further 30 minutes in servicing. When working in tall grass particular attention must be paid to radiator grilles and air cleaner gauzes, as elephant grass hairs and grass seeds restrict the air flow. Other than this, manufacturers' recommendations should be adhered to.

Selected spare parts to approximately 10% of the capital cost of the equipment were found to be desirable when operating a tractor away from base.

ACKNOWLEDGEMENTS

The author is indebted to the Faculty of Agriculture and numerous manufacturers and their agents for assistance rendered during the course of these trials.

REFERENCES

1. 1958 Symposium. Mech. Cultivation. Uganda. *Gov. Print.* Entebbe.
2. Olwoc. Interim Report. *Agric. Eng. Div. Fac. Agric.* Makeree.
3. PERIERA & JONES. *Emp. J. Exp. Agric.* 1954 22(88) 323.
4. BOSHOFF & HILL. *E. A. Agric. Mach. Specialist Committee.* 1964.

OBITUARY

The Council records with deep regret the death of the following members:

Mr C. B. Chartres	Honorary Member (*Past President*)
Mr B. Farrar	Associate Member
Lt.-Col. P. Johnson	Honorary Member (*Foundation President*)
Mr T. F. Ringer	Associate Member
Mr P. J. Venables	Associate Member
Mr A. C. Whitlock	Member
Mr C. S. Wright	Member

The fact that the above list includes the names of two Past Presidents lends emphasis to the loss suffered by the Institution and indeed by the industry. A special obituary notice and Guest Editorial tribute to Lt.-Col. P. Johnson are to be found on pages 142 of this issue of the Journal.

Mr C. B. Chartres, much of whose career was spent with C. P. Parsons & Co Ltd, was a distinguished engineer who was decorated for his services during the war when he was Chairman of a Ministry of Agriculture Committee dealing with the supply of farm machinery. His qualities of incisiveness, drive and enthusiasm were of great value when he became a member of the Institution, for this was at a time when men of his distinction were greatly needed to advance the Institution in its formative years. His whole-hearted support in Council and his work as President (1949-51) remain on record as an outstanding contribution to the Institution's growing effectiveness and prestige at that time. Acknowledgement of his work was made in 1953 when he was elected an Honorary Member.

The death of Mr A. Carleton Whitlock will be noted with particularly deep regret by those who remember his valuable service as a Council Member of the Institution between 1960 and 1962. At the time of his death he was a member of the Governing Body of the National Institute of Agricultural Engineering. His entire career had been devoted to his family business, Whitlock Bros. Ltd, of which he was Chairman and Managing Director. He was able over the years to include among his many distinctions service as a Council Member of the Royal Agricultural Society of England and President of the Agricultural Machinery and Tractor Dealers Association.

THE IMPROVEMENT OF SMALL RICE MILLS IN BRITISH GUIANA

by

V. P. CHUNG M SC (AGR ENG), B SC(MECH ENG), AMI AGR E*

With the exception of the two large government central rice mills at Anna Regina and Burma the majority of the rice mills in British Guiana consists of a steeping tank with facilities for steaming, drying floor, a mill comprising one or more rice hullers and home made sieves for grading the finished rice. These mills are either of the Engleberg or Lewis Grant Planter's Mill type and the output from each mill is on the average between 700 lb and 900 lb of cleaned rice from paddy per hour. Power is supplied by a diesel engine which on the average has a rating of 18 hp at 1,000 rev/min per huller. Steam for parboiling is obtained from boilers of varying types and ages. However, each boiler must be examined yearly to ensure that it is in a workable condition.

The paddy sown in British Guiana is mainly of three types viz. No. 79, a medium long grain paddy, D110, a long grain paddy and barley grain paddy which is a short grain mixture of paddy. However, in most areas paddy is sown as a mixture of the above paddies. The mixture generally contains red grained paddies which are considered very undesirable as the grades of milled rice are affected by the proportion of red rice they contain.

Storage facilities at these mills consist of storage bonds constructed with wooden framing and galvanized outer sheeting. Some of the bonds have reinforced concrete floors, but generally most of the bonds have floors made from wooden beams and wooden planking. Paddy is delivered to the mills in bags which are stacked in tiers of up to twenty bags high and are stored in this manner ready for milling. There is naturally some deterioration due to insect infestation during storage, but since most of the paddy delivered to the mills is milled out rapidly—paddy is not usually kept from one crop to the next—damage and loss from this quarter is not as extensive as would be expected. Replacement of these bonds by bonds bettter equipped to handle the storage of the paddy crop is considered too costly an item for the miller to bear immediately and it is considered more feasible in the first instance to improve the rice mill machinery itself so as to obtain:

(1) Improved milling efficiency.
(2) Reduced losses of by-products.

Procedure

At the time of a recent investigation, there were 216 small rice mills in British Guiana. Two areas which contained 61 rice mills were selected and a complete survey of the rice milling equipment was carried out in these areas. These areas were considered representative of all the rice milling areas in British Guiana.

It was discovered that of the 61 mills listed in these areas 54 were in actual operation—50 of these were of the huller-polisher planter's type mill and the remaining four were of multi-stage construction. In the case of the huller-polisher combination mill, most of the millers had discarded the polisher and were using the huller alone for both shelling the paddy and whitening the rice; and it was observed that this method of milling resulted in an increased throughput, although there was a greater percentage of broken rice. The larger percentage of broken rice obtained did not appreciably affect the rice grades. The market is fairly tolerant to broken rice and only brewers' rice affects the grading appreciably. Rice obtained from the huller-polisher combination mills carried a distinct brownish coloration, and the throughput from these mills was not as high as that from the hullers alone. The coloration of the grains was attributed to the use of poorly cleaned paddy, containing large pieces of earth, together with the fact that most millers did not clean the polisher at regular intervals.

The multi-stage mills visited were not of uniform make or construction, and were either Lewis Grant—'Grantex', Shule or Satake mills. These mills consisted of the following—paddy pre-cleaner, paddy sheller, paddy separator, one or two whitening cones or rolls, and a rice grader.

Both types of mill installations were observed very closely and the results obtained were noted.

Results

For parboiled rice the returns from the huller type mills were of the following order:

Paddy input per hour	1,160 lb
Rice output per hour	720 ,,

Closer examination showed that about 45 lb of this 720 lb represents fine broken grain. Computed on a percentage basis, therefore, the returns were as follows:

Milled rice including broken	58.22%
Fine broken rice (brewers' rice) ..	3.88%
Total recovery of edible rice	62.10%
Husks with bran and invisible milling losses	37.90%

For parboiled rice the returns from the multi-stage mills were of the following order:

Paddy input per hour	2,100 lb
Rice output per hour, including broken	1,350 ,,
Fine broken rice (brewers' rice) ..	52 ,,
Bran per hour	216-250 ,,

* Agricultural Engineer, Department of Agriculture, British Guiana.

Reduced to a percentage basis the results were therefore as follows:

Milled rice including broken rice ..	64.28%
Fine broken rice (brewers' rice) ..	2.47%
Total recovery of edible rice	66.75%
Bran and rice polishing	10-12%
Husk with bran and invisible milling shrinkage	21.25%-23.25%

Having considered the results obtained from the mills examined and the condition of harvested paddy delivered to these mills and after a careful study of the results, the following recommendations were made for small multi-stage rice mills which would be erected in future (see diagram 1).

This mill would consist of: Paddy cleaner with magnetic separator, paddy grader, paddy sheller, paddy separator, second or return paddy sheller, three milling breaks, rice polisher and rice separator or grader. This mill it was considered had the minimum essentials to enable the miller to obtain the greatest returns from the paddy delivered to the mill and would be able to handle both parboiled and white rice. Experience showed that for parboiled rice, the three milling breaks should be divided into one huller and two milling cones, while for white rice the huller should be by-passed and the rice milled in the remaining two cones alone—milling white rice through a huller resulted in excessive breakage of the grain.

With the exception of the paddy grader a mill containing all the other stages was set up, and for parboiled rice the results obtained from this mill were as follows:

Paddy input per hour	2,610 lb
Rice ouput per hour including broken rice	1,728 „
Fine broken rice per hour	72 „
Bran and rice polishing per hour ..	286 „

Converted to a percentage basis therefore we have:

Milled rice including broken rice ..	66.21%
Fine broken rice (brewers' rice) ..	2.76%
Total recovery of edible rice	68.97%
Bran and rice polishings..	11.00%
Husks with bran and invisible milling losses	20.03%

No figures were taken throughout this investigation for white rice milling, but it was observed that the milling cones appeared to handle white rice much more efficiently.

Summary

From the results of this investigation it is definite that a greater milling efficiency can be obtained from the erection of small multi-stage mills. The multi-stage mill erected according to the mill recommended showed an increased milling efficiency over those already existing and the results obtained from this mill are probably the best that can be secured until a more uniform type of paddy is planted throughout the country and delivered to the mills.

The inclusion of the polisher in the multi-stage mill has resulted in an improvement in the appearance of the finished rice.

The adoption of small multi-stage mills will not only enable millers to collect and use the by-products of milling, but also result in an increase in the percentage of edible rice recovered. The greater efficiency gained will help to pay for the initial increased cost of setting up these mills, but further studies of the economics of operating these mills may be necessary before this can be shown conclusively. The indications, however, are very encouraging at the present time.

REFERENCES

F.A.O. Development Paper No. 27 'Equipment for the processing of Rice prepared by P. Aten, A. D. Fannet and Luther R. Ray

F.A.O. Illustrated Glossary of Rice Processing machines by L. Borosio and F. Garibold.

Rice D. H. Crist.

Memo on Small Rice Mills in British Guiana by L. P. Grant.

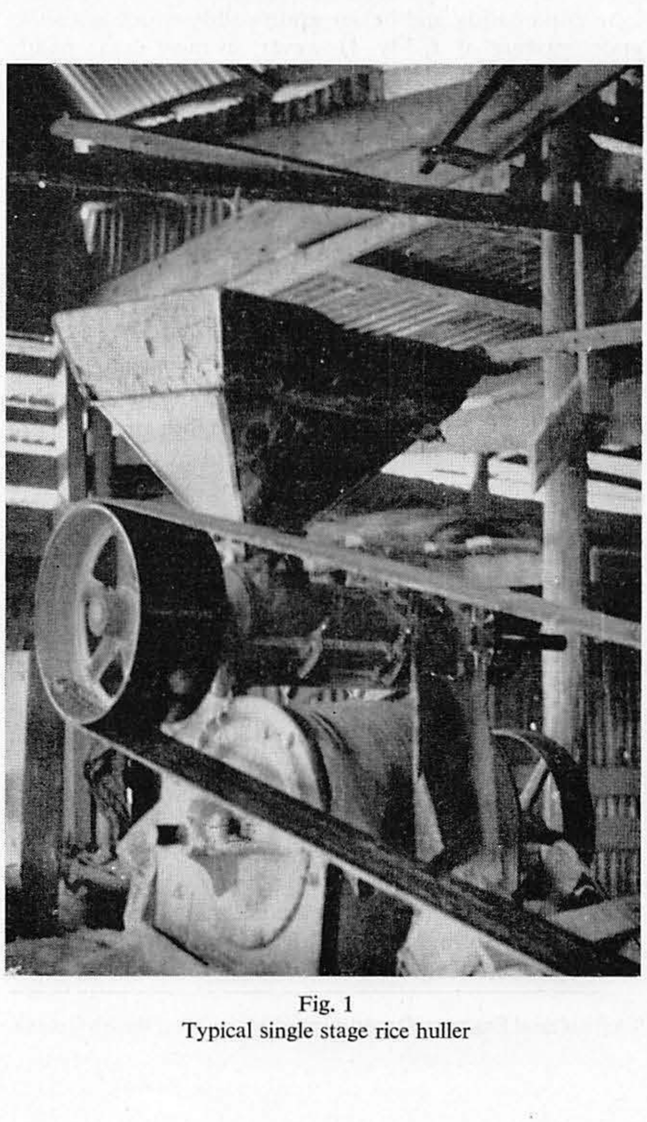


Fig. 1
Typical single stage rice huller

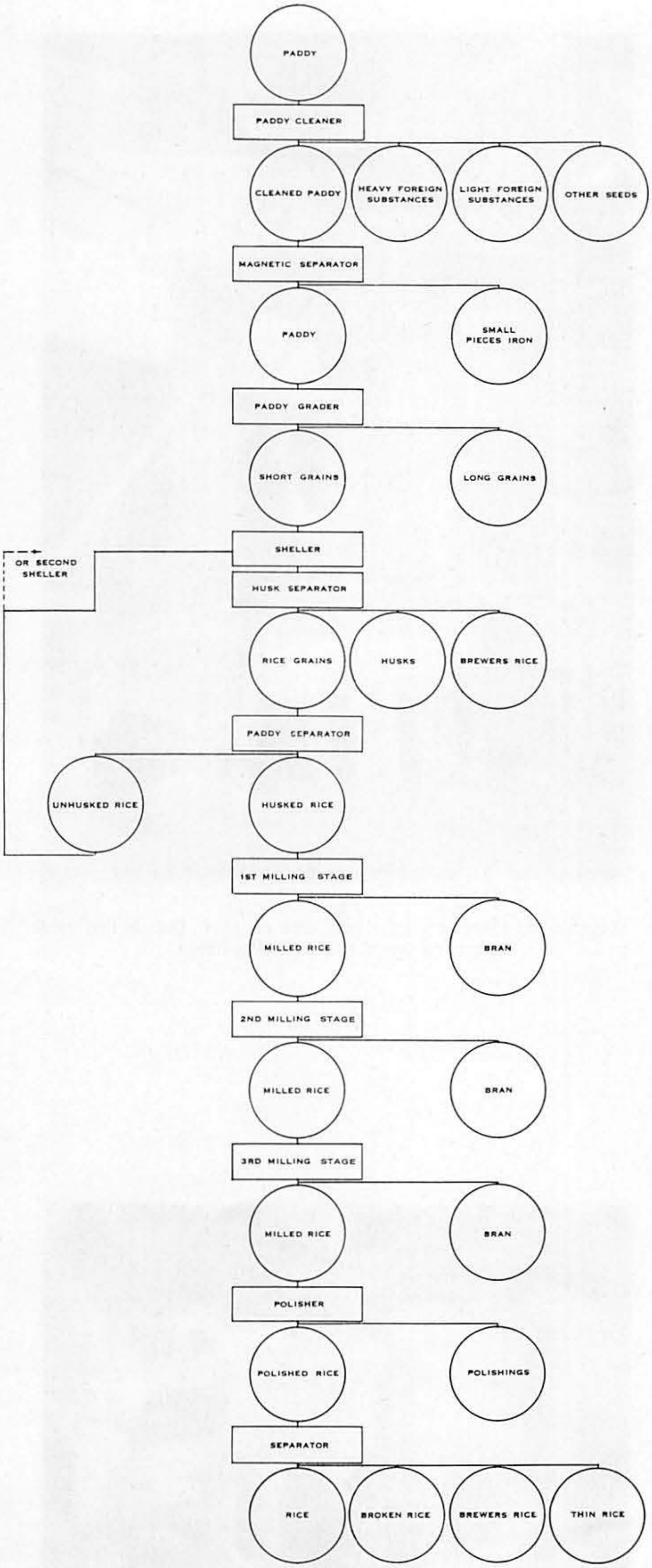


Diagram 1

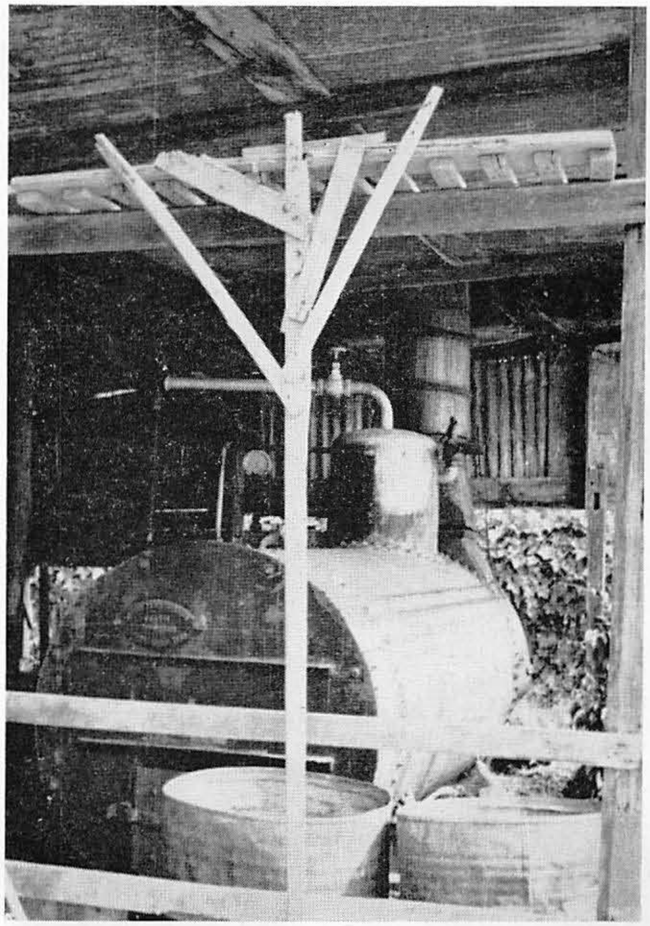


Fig. 2
Typical boiler installation at a small rice mill

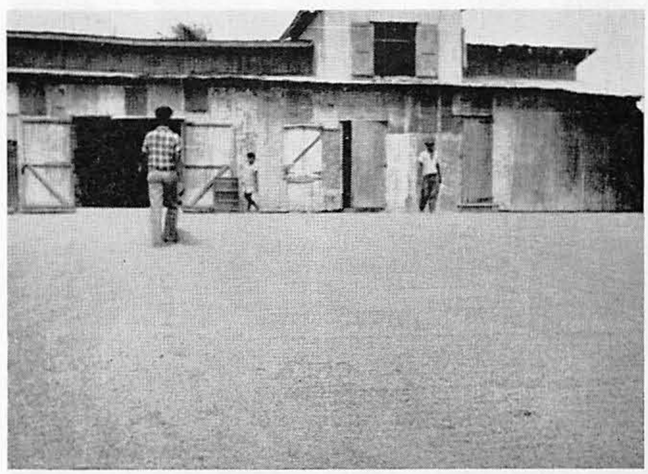


Fig. 3
Typical paddy bond and drying floor. Note men at work turning paddy on floor by foot for more even drying by sun

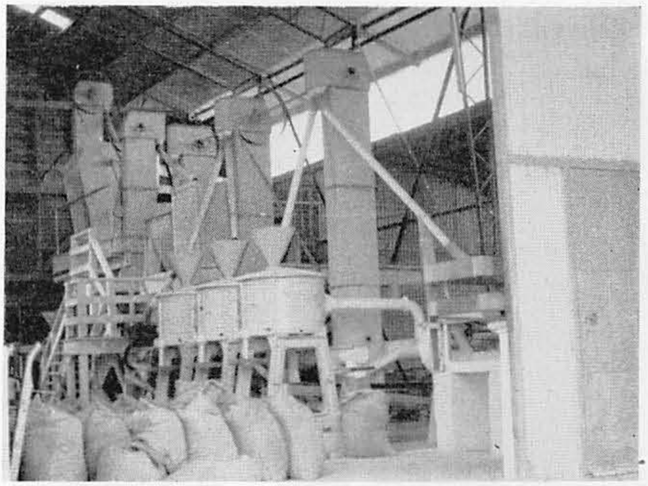


Fig. 4
Multi-stage rice mill built according to writer's recommendation

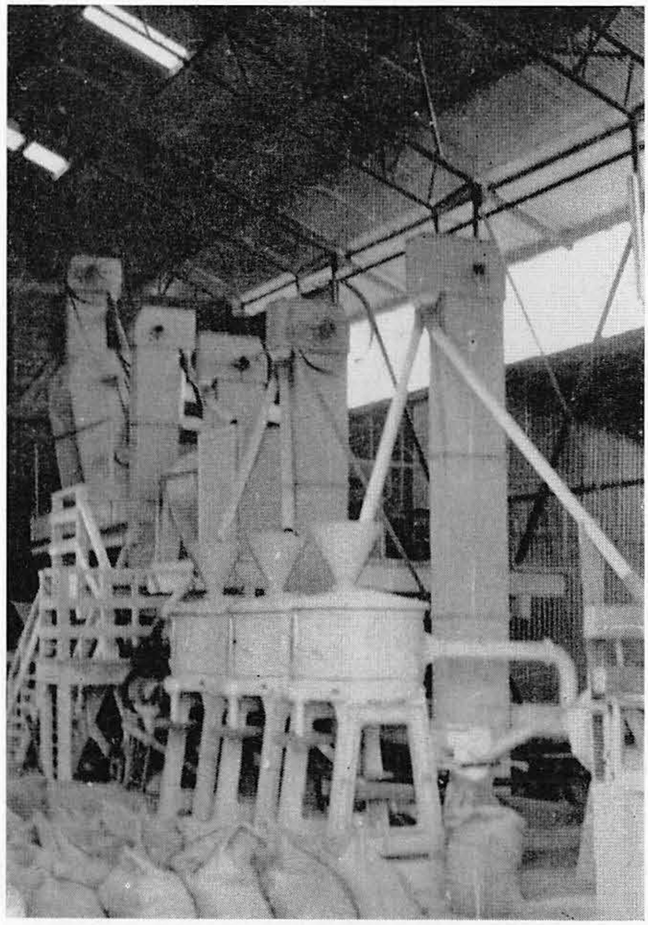


Fig. 6
Foreground: three milling stages and polisher. One huller, two milling cones, one polishing cone

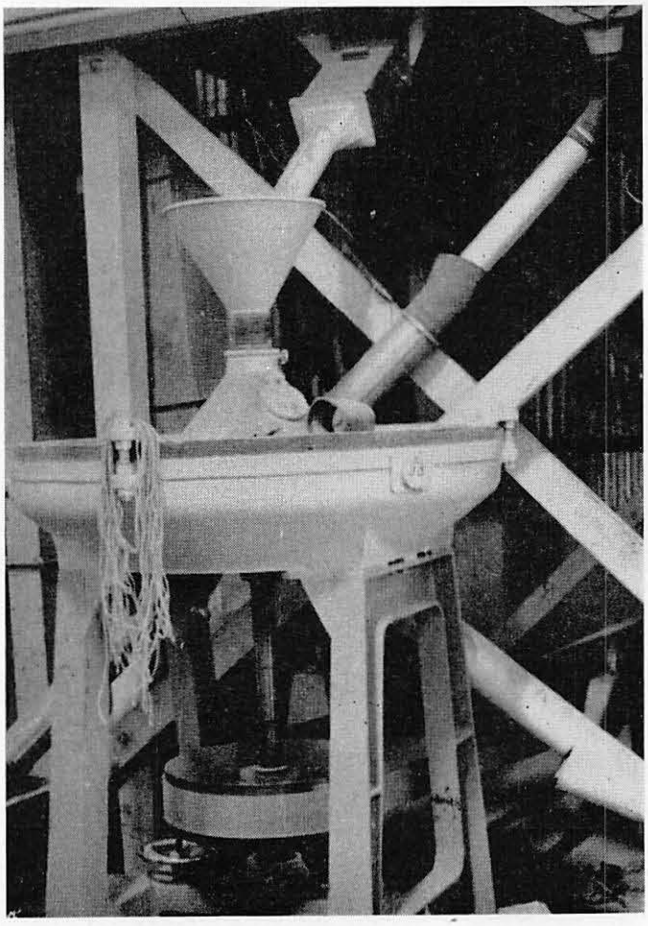


Fig. 5
Sheller

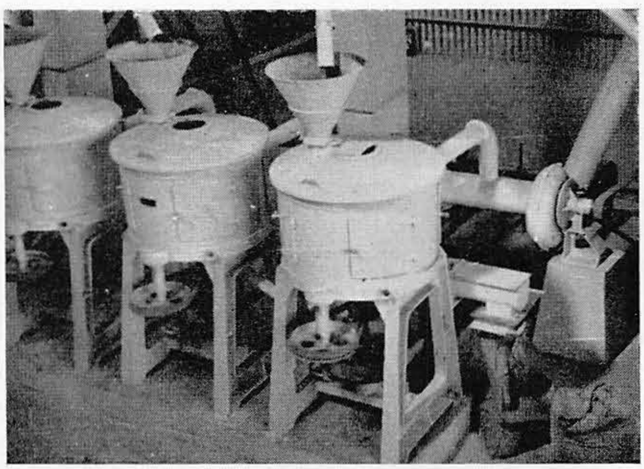
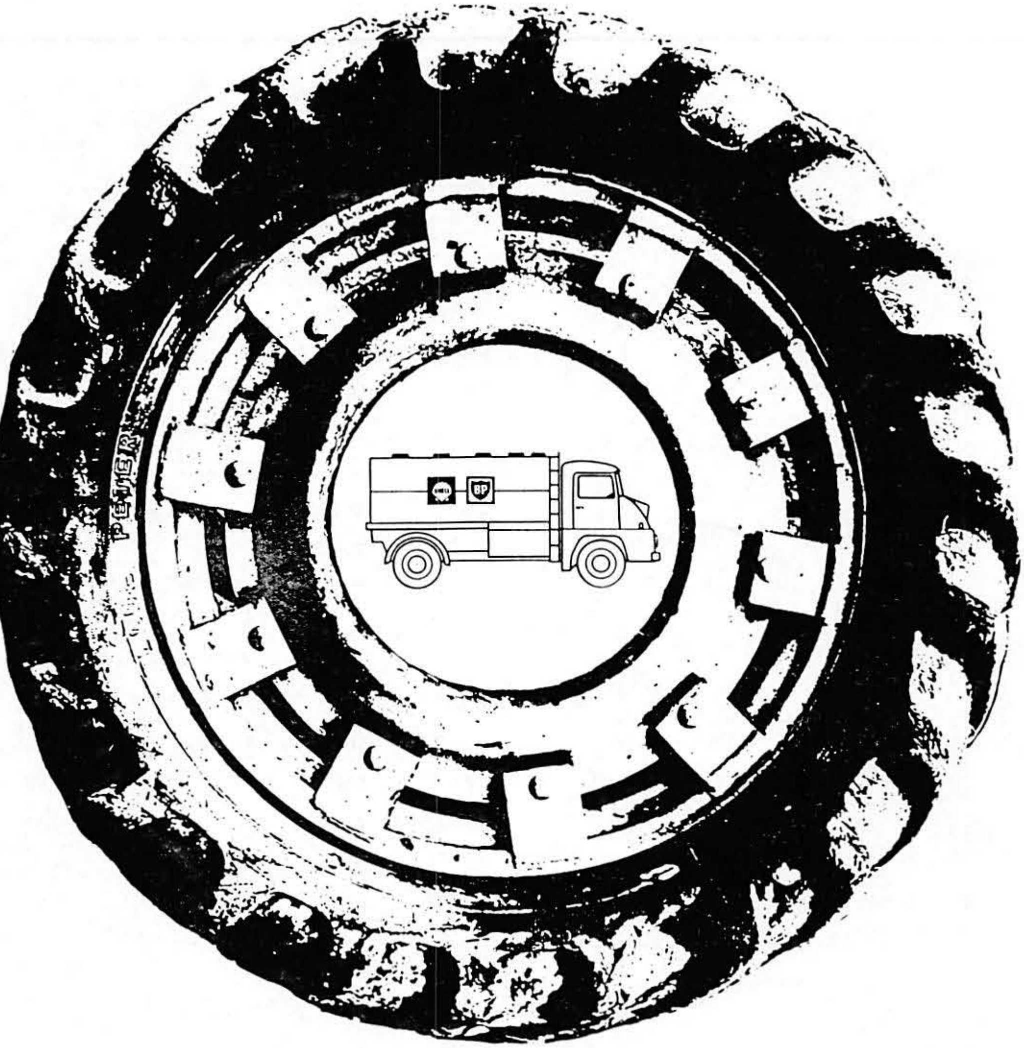


Fig. 7
Another view showing two milling cones and one polishing cone

Abbreviations and Symbols used in the Journal

a	year
A or amp	ampere
ac	acre
a.c.	alternating current
atm	atmosphere
b.h.p.	brake horse-power
bu	bushel
Btu	British Thermal Unit
cal	calorie
c.g.	centre of gravity
C.G.S.	centimetre gramme second
cm	centimetre
c/s	cycles per second
cwt	hundredweight
d	day
dB	decibel
D.B.	drawbar
d.c.	direct current
°C, °F, °R	degree Celsius, Fahrenheit, Rankine
deg	degree (temperature interval)
dia	diameter
doz	dozen
e.m.f.	electromotive force
ft	foot
ft^2	square foot (similarly for centimetre etc.)
ft lb	foot-pound
G.	gauge
g	gramme
gal	gallon
gr	grain
h	hour
ha	hectare
Hg	mercury (pressure)
hp	horse-power
h	hour
in.	inch
in^2	square inch
i.d.	inside diameter
kWh	kilowatt hour
l	litre
lb	pound
lm	lumen
m	metre
max.	maximum (adjective)
m.c.	moisture content
m.e.p.	mean effective pressure
mile/h	miles per hour
mill.	million
min	minute
min.	minimum (adjective)
o.d.	outside diameter
o.h.v.	overhead valve
oz	ounce
Ω	ohm
pt	pint
p.t.o.	power take-off
qt	quart
r	röntgen
r.h.	relative humidity
rev	revolutions
s	second
s.v.	side valve
S.W.G.	standard wire gauge
t	ton
V	volt
v.m.d.	volume mean diameter
W	watt
W.G.	water gauge
wt	weight
yd	yard
$>$	greater than
$\ngtr$	not greater than
$<$	less than
$\nless$	not less than
$\propto$	proportional to
$\sim$	of the order of
° ′ ″	degree, minute, second (of angles)

The above abbreviations and symbols are based mainly on B.S. 1991 (Part 1), 1954



Printed by Eaton Press Ltd., Liverpool