Journal and Proceedings of the Institution of Agricultural Engineers

SUMMER
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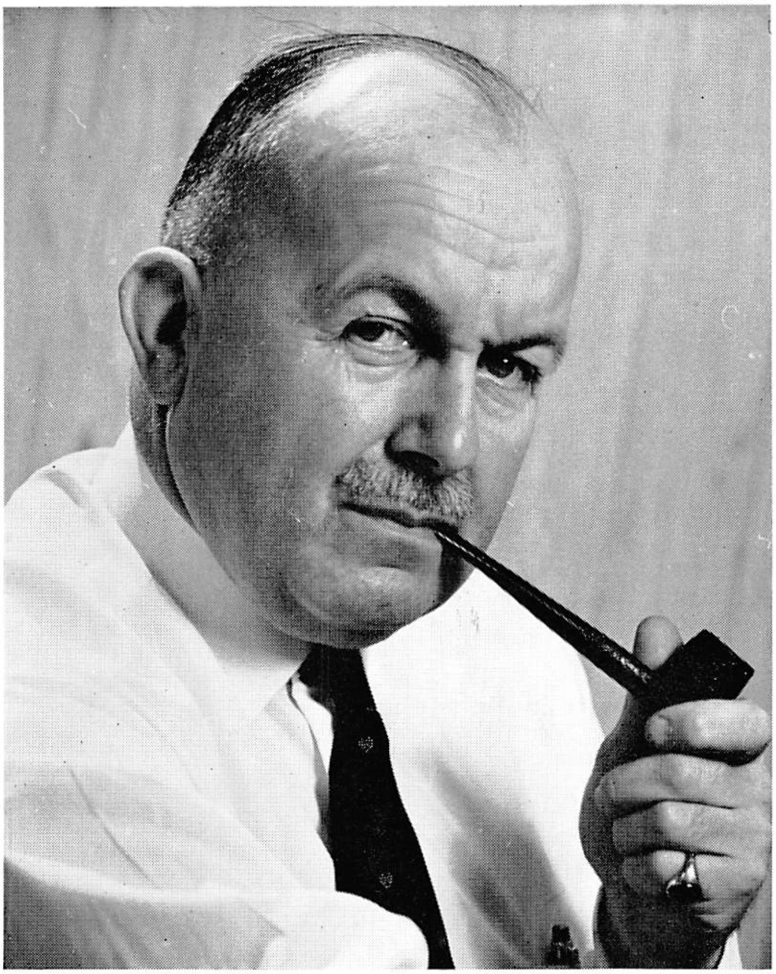
THE PRESIDENT



Mr H. C. George Henniker-Wright became the new President of the Institution on 15 May 1969.

An East Anglian born and bred, Mr Henniker-Wright comes from a family with strong farming associations. In 1934 he joined Fords as a student and has stayed with them ever since. Today he is Executive Engineer of the Ford Tractor Division at Basildon. He joined the Institution in 1945 and served on the Council in various capacities during the 'fifties and 'sixties. He has held office as Vice-President and, more recently, as Chairman of the Finance and General Purposes Committee.

Other bodies on which Mr Henniker-Wright serves include committees of the BSI and the AEA. He is a Member of the ASAE. Somehow, he finds time to follow his main hobbies, which are golf and gardening.

JOURNAL AND PROCEEDINGS OF THE INSTITUTION OF AGRICULTURAL ENGINEERS

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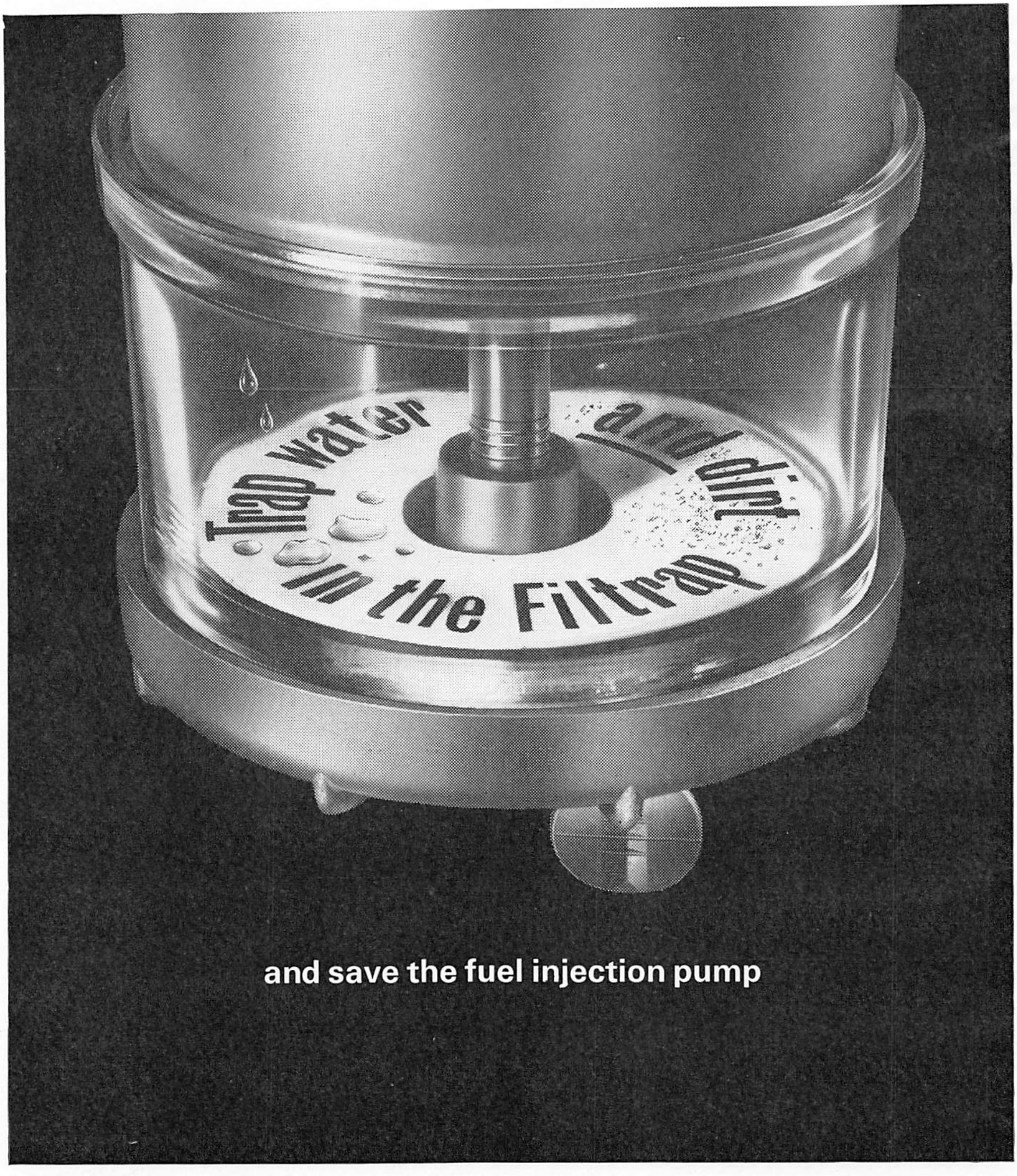

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INSTITUTION NOTES

Spring National Meeting

A large part of this *Journal* is devoted to the Proceedings of the Institution's Spring Meeting which took place at the National College of Agricultural Engineering, Silsoe, in March. Even so, space is insufficient to cope with the entire span of five papers and the lengthy discussions, not to mention the static displays and live demonstrations of hard and soft ware which contributed to the success of this marathon event.

This meeting was the second to be held under the general title 'The Application of Agricultural Engineering in Developing Countries'. The first one took place two years ago at the Institution's Spring 1967 Meeting at Reading University and dwelled mainly on the potentialities of mechanization in semi-arid and other conditions peculiar to tropical environments. The proceedings of that occasion appeared in the Summer/Autumn 1967 issue of the *Journal*. Its success led to the decision to hold a second meeting, the accent this time being on the development of agricultural resources.

Much valuable experience in this field has been made available through the medium of post-graduate research at the National College of Agricultural Engineering and this led to Dr P. C. J. Payne, College Principal, being appointed Programme Convenor. Thanks to his efforts, a uniquely interesting meeting resulted which was regarded by many as being no less applicable to developed countries than to under-developed terrains.

Annual Conference

A three-figure attendance and some lively discussion marked the success of the Institution's Annual Conference in London on 15 May. Thanks to the careful organization of the Programme Convenor, Mr F. S. Mitchell, of the National Institute of Agricultural Engineering, a well balanced coverage of the subject-theme 'Mechanization of Spaced Row Crops' was achieved. It included no less than five papers ranging from the initial requirement of the fresh vegetable market right through to harvesting and handling of the crop. Much of the material for this Conference was made available by NIAE, where a good deal of work in recent years has been devoted to this aspect of agricultural mechanization. It was therefore pleasing and appropriate to welcome the Director of NIAE, Mr C. J. Moss, who chaired the afternoon session.

Annual General Meeting

A full report appears elsewhere in this issue of the Institution's AGM held on 15 May in London. Mr Sherwen, having completed two active years as President, sounded a note of high optimism during the speech in which he moved the adoption of the Council Report. While recognizing that the Institution had to come to terms with the changing pattern of the engineering profession, he stoutly defended the Council's oft-repeated pledge to maintain the status of the agricultural engineer at all levels. Some criticism was voiced from the Meeting that Council had been reticent about how a closer association with the Council of Engineering Institutions was to be brought about, if the Institution was not to be a constituent member of CEI. To this, Mr Sherwen said negotiations concerning this would be continuing under the aegis of the incoming President and Council and he was sure that future policies would be framed on a basis of full consultation with all levels of the membership.

Annual Dinner

Mention has already been made in these Notes of the desire to draw into closer association with the Council of Engineering Institutions. This mood was echoed in the attendance and speeches at the Institution's Dinner in London on 15 May. The Guest of Honour was, indeed, to have been Sir Leonard Drucquer, C ENG, the CEI Chairman but, regrettably, he had been taken ill in South Africa. His place was taken by Sir Eric Mensforth, CBE, MA, HON D ENG, the Deputy Chairman, who, toasting the Institution, spoke warmly of its learned society activities and of the need to safeguard the interests of all those in the vertical engineering structure ranging from craftsmen to degree-level engineers.

Other distinguished guests included Dr D. F. Galloway, CBE, PHD, C ENG, FI MECH E, President of the Institution of Mechanical Engineers, together with senior spokesmen from the industrial, research and academic sectors. The Institution's new President, Mr H. C. G. Henniker-Wright, was in the Chair. He made an Address of Welcome and replied to the Toast of 'The Institution'. He also presented the Johnson Medal to Mr E. Torrance Smith, a Graduate member who had produced the most outstanding result in the 1968 examinations for the National Diploma in Agricultural Engineering.

COUNCIL 1969-70

President	H. C. G. Henniker-Wright, MEM ASAE, FI AGR E
Past Presidents on the Council	F. E. Rowland, C ENG, FIEE, MEM ASAE, FI AGR E D. R. Bomford, HON FI AGR E J. M. Chambers, C ENG, FI MECH E, HON FI AGR E C. A. Cameron Brown, B SC, MIEE, FI AGR E J. H. W. Wilder, OBE, BA, FI AGR E T. Sherwen, C ENG, FI MECH E, MSAE, FI AGR E
President-Elect	C. Culpin, OBE, MA, DIP AGR, FI AGR E
Vice-Presidents	J. V. Fox, ND AGR E, FI AGR E †J. A. C. Gibb, MA, M SC, MEM ASAE, FI AGR E A. C. Williams, FI AGR E
Honorary Treasurer ..	E. S. Bates, C ENG, FI MECH E, MEM ASAE, F INST PET, FI AGR E
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Members	R. E. Arnold, BA, MI AGR E T. W. M. Cook, MI AGR E J. H. Nicholls, MI AGR E J. D. Savage, C ENG, MI MECH E, AMIRTE, MI AGR E
Companion	E. N. Griffith, CBE, CI AGR E
Associates	J. A. Cole-Morgan, B SC, AI AGR E J. Monck, AI AGR E M. S. Searle, AI AGR E
Graduate	D. W. Jewett, B SC, M SC
Representative for Scotland	C. J. Swan, B SC, FI AGR E
Ex Officio	Chairman of the Examination Board in Agricultural Engineering Representatives of Branches

† Hon. Editor

Secretary	J. K. Bennett, FRSA, FCCS, MIOM

NEWSDESK

National College of Agricultural Engineering

Scarcely an issue of the *Journal* appears without something interesting to report about NCAE. Just when the I AGR E Spring Meeting was going on in England's Hall, there came latest news of the College's Post-graduate courses in Soil and Water Engineering. It was a happy coincidence that the Institution and the College were able simultaneously to channel information directed towards the development of agricultural resources in overseas countries—the Institution with its programme of papers on Planning and Executing the Development of Agricultural Resources, and the College with details of its courses on Soil Conservation, Irrigation and Land Resource Planning.

The College has always laid special emphasis on overseas problems and conditions. They believe that the need for agricultural development and increased food production in many parts of the world means in turn a need for increasing numbers of men trained in Agricultural Engineering. Their courses are designed to satisfy this demand, either by teaching recent graduates who wish to specialize, or by providing further training for men already employed in agricultural advisory or extension services.

Anybody who wants further information about these courses should get in touch with Mr N. W. Hudson at NCAE, Silsoe, Bedford.

Scholarships and Bursaries

The Institution is now receiving applications from Post-graduate NCAE students, with a view to selecting the one who might merit the award of the Dunlop Scholarship of £250. A number of £50 Bursaries will also be awarded to deserving candidates about to start on one of the courses at Essex Institute of Agriculture or the West of Scotland Agricultural College, leading to the ND AGR E.

Students who would like to know more about the above awards should lose no time in getting details and application forms from the Institution.

Metrication and You

As the change-over to metric units gains momentum, the Institution will be giving space in the *Journal* to news, data and opinion of special interest to agricultural engineers in their day-to-day activities. The Agricultural Engineers' Association held a full-day Conference on the subject at Silsoe on 3 June 1969, an event in which the Institution was glad to provide some collaboration. A Report of this should be out soon and I AGR E members will be informed of its availability.

The Production Engineering Research Association of Great Britain (PERA) has accumulated a fund of knowledge concerning technical and economic aspects of metrication and has acquired considerable experience of its implications for British Industry. During June, PERA ran the first open international conference on 'The Practical Application of SI Units' as a two-day event in Brussels. Those wishing to know about PERA's metrication proceedings and related work should write to Mr T. G. Williams at PERA, Melton Mowbray, Leicestershire.

CIGR VIIth International Congress

Asset Travel Ltd., a firm of specialists in sport and executive travel, have announced that they can offer high quality hotel and travel arrangements for British visitors to the CIGR Congress to be held in Baden-Baden, West Germany, on 2-6 October 1969. Special attention is being paid to the Congress Tours, and Asset say they will be pleased to offer arrangements either for the Congress only, or the Congress plus Excursions A, B or C mentioned in Congress Bulletin No. 2. It looks as though the inclusive arrangements offered by this travel firm should prove financially and organizationally beneficial, particularly to those who are willing to use Stuttgart as their point of arrival by air, in preference to Frankfurt.

Institution members who will be going to Baden-Baden and would like full details of these special facilities should write without delay, not to the Institution, but to the following:—

R. E. Phillips, Esq., General Manager,
Asset Travel Ltd.,
48 Maddox Street,
London W.1
Tel: 01-629 6567/8/9
Cables: Assetrad, London W.1.

More About BUPA

In a previous 'Newsdesk' we drew members' attention to the advantages of joining the I AGR E Group of the British United Provident Association. Existing Group members and others interested in joining should note that the Group has been transferred from Oxford to BUPA's Bristol Branch who will, in future deal with the settlement of members' claims. The Branch Manager is Mr G. Pienaar, and the address is as follows:—

The British United Provident Association,
Clerical, Medical Assurance House,
41-43 Baldwin Street,
Bristol, BS1 1RF
Telephone: Bristol 24583

THE INSTITUTION HAS TURNED A CORNER

. . . Theo Sherwen

'I sincerely believe the Institution has turned a corner, thanks to the careful husbandry of our finances during 1968, allied to some bold and imaginative forward planning for 1969 and subsequent years.' These were the words of the out-going President, Mr T. Sherwen, as he presented the Council's Report for 1968 at the Institution's Annual General Meeting in London on 15 May 1969.

He began his remarks with the reflection that this would be the last occasion on which, as President, he could present the Council Report. He said that during the two years that he had been President, the Council had probably borne a weightier responsibility than almost any previous Council in the Institution's history. The past year in particular had been one of great challenge and considerable worry.

Status for Agricultural Engineers

Securing a proper status for the agricultural engineer within the total context of professional engineering had continued to be the Council's deep concern. Useful negotiating links with the Council of Engineering Institutions had been developed, chiefly by way of a Joint Working Party with the Institution of Mechanical Engineers. One of the objectives was to find a means of conferring on suitably qualified and experienced agricultural engineers a status and title equivalent to that enjoyed by Chartered Engineers. The legal and constitutional barriers to registering I Agr E members in this category as Chartered Engineers were at present very great. This was a campaign to be kept up and a practical start had been made by reconstituting the I Agr E membership structure in such a way that if and when recognition were to be granted by CEI to enable individual members of non-chartered institutions to be registered as Chartered Engineers, it could be implemented with as little upheaval as possible.

The new Fellowship grade which had been introduced in January of this year, complied in every respect with the requirements of the Chartered Engineer and the Council was confident that the Fellowship grade would come to gain its own currency within the agricultural engineering industry and profession. The grade of Member had likewise been restyled so as to provide a natural career grade for the type of man who had long formed the bedrock of Institution membership; that is to say, the man qualified at around the level of the National Diploma in Agricultural Engineering. Council remained firmly pledged to maintain the status of the diploma-level engineer within the Institution's corporate structure and there was no intention whatever of departing from this basic philosophy.

The Council had been active in the negotiations currently taking place for conferring a national qualification and title upon diploma-level engineers. The Institution was strongly represented on the negotiating body for this purpose and during 1969 it should be possible to announce some progress towards the establishment of a national status which would be to the diploma-level engineer what chartered status already offered to the degree-level engineer.

Education

Mr Sherwen went on to deal with the Institution's work in the field of education, training and examinations. Helped by its Education Committee and the Examination Board in Agricultural Engineering, the Council had tried to ensure that the educational role was closely geared to the realities of the situation confronting the Institution. With the changes in national structure of technical education, stemming from the Pilkington Report, it required constant and concerted effort as an Institution to see that the education of the agricultural engineer, especially at diploma-level, was matched to the industrial requirements. Mr Sherwen said he believed that this was one of the Institution's most important tasks, and he desired to pay special tribute to the Education Committee under its Chairman, Dr P. C. J. Payne, and the Examination Board, under its Chairman, Mr J. A. C. Gibb, who had wrestled tirelessly with the extraordinary complexities of the changing education pattern.

Membership

Turning to the question of membership development, Mr Sherwen said he was delighted to be able to report very significant growth in the Institution's membership as a whole during 1968. The most encouraging feature was undoubtedly the fact that well over half the total intake of new membership had been in the Graduate and

Student grades. This signalled a bright prospect for the future, as regards both the Institution and the industry it served. In addition to its normal work of assessing applications for admission and transfer, the Membership Committee had had an enormous additional task in 1968 arising from the reframing of the membership regulations and a greatly accelerated flow of applications for transfer prior to the expiry of the old regulations. That Committee under its Chairman, Mr R. E. Arnold, had held nearly twice as many meetings as usual and during the last six months of 1968, had just about doubled its rate of work.

Meetings and Publications

As regards the programme of National Meetings, visits and social events, the Institution had had a successful year. Referring to the tour of Branches carried out by the Secretary and himself in the Spring, Mr Sherwen said he had been much impressed by the intense loyalty and affection for the Institution that had been manifested by Branch Officers and Committees throughout the country. This had been borne out fully by the success of Branch activities at which, on average, attendances throughout the UK had been up in 1968 compared with previous years.

In the field of publications, Mr Sherwen said he regarded it as an achievement that the Editor had managed to get so much technical literature into print in 1968 in the face of steeply-rising costs, coupled with the Institution's own financial problems. Although it had only proved possible to produce two issues of the *Journal* compared with the normal four, these had been much larger than usual and contained many innovations. The Yearbook had been published and a Diary had been introduced. At the close of the year the Council had been able to promise that in 1969 the Journal would be fully restored to its normal pattern of four issues per year.

Finance

Mr Sherwen said he sincerely believed the Institution had turned a corner, thanks to the careful husbandry of its finances during 1968, allied to some bold and imaginative forward planning for 1969 and subsequent years. He felt every confidence in the measures taken and he congratulated the Finance and General Purposes Committee, under its Chairman, Mr H. C. G. Henniker-Wright, and the Honorary Treasurer, Mr E. Atkinson, for their very conscientious and responsible conduct of the Institution's financial affairs.

The Council had been sorry to learn of the death of a number of Institution members during the year, including two distinguished Past Presidents, Mr D. P. Ransome and Mr W. J. Nolan. These two men had been very well known throughout the industry. They had earned their place in the Institution's history and would long be remembered for their contribution, especially during the Institution's pioneering years.

Mr Sherwen ended his remarks by thanking his Council colleagues for the immense support they had given him throughout his two-year term of office. He warmly thanked the Secretary and staff for their devoted and tireless assistance.

Following a formal motion to adopt the Council Report, several questions were answered by the President, particular interest being shown in the negotiations that might lead to a closer association with the Council of Engineering Institutions. In response to a suggestion that more information should be made available to the membership at large as to the basis on which these negotiations had been and would continue to be conducted, Mr Sherwen promised to ask the incoming President and Council to study this request and decide on suitable action.

On a majority show of hands, the Council Report was adopted.

Other business at the AGM included the presentation of the 1968 Accounts and Auditors' Report by the outgoing Honorary Treasurer, Mr E. Atkinson.

The new Council

Announcing the names of Office Holders and Council Members for 1969-70, the Secretary said a postal ballot had been conducted to select from two nominees, the person to fill the Graduate vacancy on Council. The result of the voting had been as follows:—

Davies, A. W. B.	—	50 votes
Jewett, D. W.	—	60 votes

and Mr Jewett had therefore been elected. The complete list of persons filling vacancies in 1969 would therefore be as follows:—

President	
H. C. G. Henniker-Wright (Fellow)	Executive Engineer, Ford Motor Company
President-Elect	
C. Culpin (Fellow)	Ministry of Agriculture Fisheries and Food (NAAS)
Past Presidents on Council	
F. E. Rowland (Fellow)	Retired
D. R. Bomford (Hon. Fellow)	Retired
J. M. Chambers (Fellow)	Retired
C. A. Cameron-Brown (Fellow)	Retired
T. Sherwen (Fellow)	Consulting Agricultural Engineer
J. H. W. Wilder (Fellow)	John Wilder (Engineering) Ltd.
Vice-President	
J. V. Fox (Member)	Managing Director, Bomford & Evershed Ltd.
Honorary Treasurer	
E. S. Bates (Fellow)	B.P. Trading Limited

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Branch Notes

NORTHERN BRANCH

The Branch successfully held its Second Annual Conference at the University of Newcastle-upon-Tyne in April 1969. Copies of the following papers presented at the Conference have been received:

1. 'Present Methods and Mechanisms for Slurry Disposal' by W. T. A. Rundle.
2. 'Effluent Disposal in Practice' by J. Moffitt.
3. 'The pollution of natural watercourses with particular reference to agriculture and the Rivers (Prevention of Pollution) Acts' by R. J. H. Dyson.
4. 'Design and cost of stock housing with particular reference to disposal of effluent both solid and liquid' by J. B. Weller.
5. 'The problems and prospects for farm waste disposal in the next decade' by J. R. Simpson.

Photocopies of these papers are available to members on request to the Institution Secretary, at the standard charge of 5/-d. per copy, post free in UK.

WEST MIDLANDS BRANCH

The Annual Dinner of the West Midlands Branch was held at the Regent Hotel, Leamington Spa, on 18 April.

For the first time in the history of the Branch, ladies were invited to this function, and were well in evidence among the 120 or so representatives of all facets of agricultural engineering who attended.

The principal speaker was Mr C. J. Chenevix-Trench, MBE, MA, County Education Officer for Warwickshire, who proposed the Toast to 'Agricultural Engineering and the West Midlands Branch of I AGR E'. He spoke of the importance of agricultural mechanization both at home and overseas for a country like Britain, which exports more tractors and farm machinery than any other country in the world, and the need for continuing co-operation between the Industrial Training Board for Engineering, the Institution, the Agricultural Machinery Industry and the relatively few Agricultural and Technical Colleges in the country who provide complete courses for agricultural engineering students from workshop floor to management level.

He pointed out that the Mid-Warwickshire College of Further Education was one of these—providing the full range of City and Guilds of London Institute Courses in agricultural engineering subjects not only for Warwickshire students but those from surrounding counties, in a specialized section of the Department of Engineering, with modern farm equipment and specialist staff.

Mr Chenevix-Trench stressed that education and training should go hand-in-hand and said that, despite a small minority who 'hit the headlines' he had great faith in the qualities of young people today.

Other speakers were Mr J. D. Elstone, OBE, FI AGR E, Assistant Managing Director of David Brown Tractors Ltd., Mr Theo Sherwen, C ENG, FI MECH E, MSAE, FI AGR E, (President of the Institution) and Mr P. T. Ward, FI AGR E, (Retiring Branch Chairman). Groups of Executives from Massey-Ferguson Ltd., and Bomford Bros. Ltd., attended and the Mid-Warwickshire College of Further Education was represented by its Principal, Mr H. M. Marklew, Head of Department of Engineering, Mr D. Waine and senior members of the Staff.

YORKSHIRE BRANCH

The Branch held an Open Meeting on 28 March at Leeds This meeting was preceded by the Branch Annual General Meeting.

The meeting was addressed by Mr D. Petty of the Forestry Commission who spoke on 'Mechanization of Timber Production' and pointed out that the Commission was celebrating its 50-Year Jubilee this year. Having outlined the origins and activities of the Commission, Mr Petty spoke about home-grown timber production—this being virtually entirely of softwood, which in itself has a bearing on the machinery used.

Timber production commences when the tree is felled either by man or naturally. The terrain used for forests is severe and usually of little other use. Thus a challenge exists in mechanizing production. The final cost of the product is fixed; thus economies must be made during production. Mechanization is one such economy as the annual increase in cost is only some one-third of the increase in cost of labour. Thus higher mechanization and declining labour are coping with an increasing volume of timber.

Mr Petty divided timber production into the three phases of felling, extraction and delivery. These he described in detail discussing the machinery utilized in each phase together with the problems which arose and how these had been tackled and/or solved, e.g. noise of chain saws.

Looking to the future, Mr Petty saw no likelihood of major changes though further development of existing forms of mechanization seem likely to continue. Hydrostatic transmissions were now undergoing tests and evaluation and seemed to offer encouragement for the future.

Following his talk, Mr Petty showed a film illustrating the use of the chain saw in modern forestry techniques.

Publications

The following books, papers and data have been received or noted by the Institution.

Ayub Agricultural Research Institute Annual Report 1966-67—compiled and edited by Mian Anwar Hussain of the Department of Agriculture, Government of West Pakistan.

A comprehensive 430 page report of the Ayub Agricultural Research Institute, Lyallpur, for the year 1966-67 which reflects a steady advance in scientific and practical studies on various problems being tackled by the respective specialists on various aspects of progressive agriculture.

The Countryside in 1970—News 6—published by The Countryside in 1970, 19 Belgrave Square, London SW1 and circulated to all member organizations and participants in the Countryside in 1970 Conference, 1965 and to those known to be interested in the subject at home and abroad.

Its purpose is to keep everyone in touch by giving a very broad picture of the many developments taking place in the various fields covered by the Conference.

Biannual Report of the Electrical Research Station, Shinfield Green, Reading—from University of Reading, Faculty of Agriculture.

The Electrical Research Association, which initiated this publication, circulates copies only to its members. All other distribution is by the University, to which any new requests or proposals for additions to their circulation should be sent.

16-19 An FE View—a Report produced by a joint working party of the Association of Technical Institutions, the Association of Teachers in Technical Institutions and the Association of Principals of Technical Institutions.

The subject is a very topical one, in view of the impending new Education Bill. The Working Party was set up in January 1968 to consider the education of the 16-19 age group, with special reference to the overlap between schools and colleges. Copies of the Report (price 1/- per copy) from ATTI, Hamilton House, Mabledon Place, London WC1.

The Origin of Sugar Beet Harvesting Systems in Western Europe and their Possible Future—by J. Jorritsma, Dutch Sugar Beet Institute.

The paper traces the history of the development of sugar beet harvest mechanization and discusses the many features to be considered in developing harvesting systems. A comparison is made of single, double and multi-row systems in relation to the climatic and other conditions in various European countries. A list of 16 references is appended.

An Introduction to the Physical Basis of Soil Water Phenomena—E. C. Childs, Published by John Wiley and Sons Ltd., 1969, price £6 per copy.

In this text Dr Childs gives an authoritative discussion of the physical properties of soil which are dependent upon the interactions between the soil and the soil water. The book is complete in itself, proceeding from the structure of soil minerals and water and the basic concepts of water retention and water movement, through to the advanced theories of infiltration and ground water flow. The main theories involving approximate and rigorous solutions are discussed and compared, and the reader is given a clear account of the advantages, disadvantages and limitations of each. To make the book of value to both agriculturalists and engineers, the detailed mathematical treatment has been removed from the main text and included in the form of Notes at the end of the relevant chapter; an understanding of the Notes is not essential for the general reader. Readers with Advanced Level GCE Mathematics should find little difficulty with most of the main text, but a great deal of effort, accompanied by outside reading will be required by many engineers, for a complete understanding of a number of the Notes.

Scientific Papers of the College of Agriculture, Krakow—A volume of seven papers printed in Polish with an English summary to each paper.

Tropical Rice Drying—Proceedings of a Seminar on the Principles and Practices of Artificial Heat Drying of Paddy held at the University of Malaya in May 1967.

This publication, edited by J. M. Beeny, M SC (AGR ENG), MI AGR E, gives local as well as general information about current and future techniques of harvesting, drying and storing of unhusked rice (Paddy).

There are fourteen pages prepared by research workers, senior Government Officers, commercial and technical personnel concerned with rice production equipment. Copies are available (price US $2.20) from Faculty of Agriculture, University of Malaya, Pantai Valley, Kuala Lumpur, Malaysia.

SYSTEMS ENGINEERING IN AGRICULTURE

At the Autumn National Meeting of the Institution in Reading on 26 September 1968, three papers were presented. They were 'An Outline of Systems Engineering' by Professor J. F. Coales, 'A Systems Approach to Farm Machinery Selection' by Professor D. R. Hunt, and 'A Systems Approach to Farm Machinery Selection' by Professor J. R. O'Callaghan. All three papers appeared in the Spring 1969 issue of the Journal (Volume 24, No. 1) and it is now possible to publish a summary of the Discussion Forum, rounding off the proceedings of the Autumn Meeting. The Chairman of the Forum was Mr K. E. Morgan, B SC, ND AGR E, MEM ASAE, FI AGR E, *of the University of Reading.*

Opening the discussion, MR IAN ARMSTRONG (Manager, Machine Systems Branch, Computer Dept., British Petroleum Ltd.) said that variables could be fairly easily measured in a steel plant or other intensive industrial organization, and mean data could be calculated. A data bank could then be established, on which systems analysis could be based. In agriculture, however, the factors were so much more variable that he thought compilation of data must be much more difficult.

PROFESSOR J. F. COALES agreed with Mr Armstrong, in that efficient control of biological systems depended on achieving control of the environment. But industrial systems were also very complex and approximations were often required. Even so, with data varying by $\pm 10\%$, a valuable degree of optimisation was obtainable.

DR D. R. HUNT said that he was confident that the system he had described was applicable to farming conditions of all kinds, although obviously the data he used in Central Illinois would not be applicable in the United Kingdom. Local conditions would also have special requirements—for example, in steeply-sloping areas—smaller rather than larger combines of the self-levelling type might be shown to be optimal.

MR C. J. MOSS (Director, National Institute of Agricultural Engineering) pointed out that the environment could be easily controlled in glasshouse production.

The Chairman (MR K. E. MORGAN, University of Reading) said that some system of environmental control over extensive areas was also desirable.

Professor COALES said that the key factors in extensive agricultural production were sunshine and rainfall. If these inputs could be forecast with some degree of accuracy it was then possible to develop a suitable pattern of fertilizer and irrigation-water application, etc. Dynamic programming was a technique which could provide firm guidance, provided that the number of variables was not too great.

The CHAIRMAN added that machine-operator interactions should also be modelled into the system, and PROFESSOR J. R. O'CALLAGHAN commented that systems analysis very often emphasized the unreliability of accepted data.

MR ARMSTRONG suggested that machine pools might enable the overhead costs of machinery utilization to be spread, and MR PETER DUCK (Wiltshire) commented on the timeliness difficulties which could be associated with such co-operative use of machinery.

THE PRESIDENT (Mr T. Sherwen), referring to Fig. 1 in Dr Hunt's paper, asked why there was a pronounced dip in both curves showing the effect of untimely harvesting on the profitability of soya beans. Dr HUNT replied that this was due to changes in moisture content associated with a specific stage of maturity in the crop.

DR W. R. F. GOSLING (Consultant) said that no definition had yet been given of the systems engineer. What sort of person was he? Professor COALES said that the systems approach crossed into many disciplines. Although he felt a systems engineer should be temperamentally an engineer, and a 'doer of things', it was really more important to define clearly what the man was trying to do than to define the man. MR ARMSTRONG thought that a systems engineer should have both practical and theoretical engineering knowledge and the ability to describe existing patterns as well as the logical order of steps to be taken in developing systems further. PROFESSOR P. B. FELLGETT (University of Reading) added that the ability to design was also important. Systems engineers must be able to see the wood as well as the trees and be able to adopt optimization techniques.

MR D. W. I. BROOKE (University of Reading) asked how it was envisaged that the data banks previously referred to might be established. Professor COALES said that computers with large stores offered the most convenient location for such data and for routine programmes used in association with the data. Dr HUNT referred to a proposal that medical histories of whole populations could be held centrally in this way.

MR T. H. E. HARRISON (David Brown Tractors Ltd.) asked for information on the financial results of the

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THE INSTITUTION OF AGRICULTURAL ENGINEERS

To be held at
The University of Loughborough
THURSDAY 4 SEPTEMBER 1969

Autumn National Meeting 1969

ERGONOMICS IN AGRICULTURE

10.00 Assemble for Coffee

10.30 Introduction by President of the Institution of Agricultural Engineers

10.40 (Chairman of First Session—Mr H. C. G. Henniker-Wright, President of the Institution of Agricultural Engineers)

Paper 1 *Subject:* The application of techniques of physical and mental workload measurement to agricultural mechanization
Title: The Assessment of Workload in Agricultural Tasks
Author: DR R. W. TOMLINSON, Tractor and Machinery Performance Division, National Institute of Agricultural Engineering

11.15 **Paper 2** *Subject:* A study in optimization of combine-harvester operator's platform design, utilizing a laboratory simulation of the operator's task.
Title: Some Studies of Combine-Harvester Operation
Author: J. ZANDER, Landbouwhogeschool (Agricultural University), Wageningen, Holland

11.50 Discussion on the morning session

12.30 Luncheon
(Pictorial display of some ergonomics studies available for viewing during the luncheon period)

13.45 (Chairman of Second Session—Professor W. F. Floyd, Head of Department of Ergonomics and Cybernetics, Loughborough University of Technology)

Paper 3 *Subject:* The application of ergonomics to training of workers for the agricultural industry
Title: Ergonomics in the Development of Operational Skills
Authors: H. T. LOVEGROVE and D. J. EVANS, Agricultural, Horticultural and Forestry Industry Training Board.

14.20 **Paper 4** *Subject:* Investigations of the design of fruit grading equipment and its use
Title: The Human Operator and Quality Inspection of Horticultural Produce
Author: G. N. STEVENS, Crop Engineering Division, National Institute of Agricultural Engineering.

14.55 Discussion of the second session.

15.20 **Forum:** To discuss the present and future application of ergonomics to agricultural work and mechanization.
(Chairman—J. Matthews, Head of Tractor and Ergonomics Department, National Institute of Agricultural Engineering)

16.30 Tea and dispersal

TICKETS

	Non-Members	Members
Dinner (3 September)	18/-	18/-
Bed and Breakfast	35/-	35/-
Conference (4 September) including lunch and refreshments	60/-	50/-

EARLY APPLICATION FOR TICKETS IS ADVISABLE

Applications should be accompanied by remittance payable to 'The Institution of Agricultural Engineers', and addressed to the Liaison Officer at Penn Place, Rickmansworth, Hertfordshire, WD3 1RE

RESOURCE DEVELOPMENT PLANNING WITH SPECIAL REFERENCE TO INTEGRATED AGRICULTURAL FEASIBILITY STUDIES

by

D. V. CHAMBERS*

Presented at the Spring National Meeting of the Institution at Silsoe, Bedford, on 27 March 1969

Summary

Significant changes in sources and methods of finance for the development of agricultural enterprises have taken place during the past thirty years, the net effects of which have stimulated interest in resource planning and feasibility studies. An outline plan for a comprehensive integrated natural resources investigation is considered with special reference to the need to recognize the objectives, interactions and compatibility of each of the components which contribute to the overall picture. Since there may be more than one possible solution for the development of the resources of a particular area, it is necessary to consider a number of alternative methods for the achievement of a particular objective.

Where a project is dependent upon external finance it is inevitable that it will be subjected to an economic and financial appraisal. The treatment of benefits and costs and the implications of these as a yardstick to measure the attractiveness of one or more enterprises for investment is discussed. Finally a brief reference is made to some of the prerequisites and problems associated with project implementation.

Introduction

Whilst the need for resource planning, feasibility and pre-investment studies as a precursor to medium and large scale irrigation and agricultural development is now generally accepted in international circles, this has not always been the case. During the late nineteenth and early twentieth century a large number of successful agricultural enterprises were established without recourse to detailed studies of natural and physical resources, nor were economic and financial analyses, as we now understand them, undertaken. This situation may have been due to the fact that pioneer development, particularly in the under-developed countries was, in many instances, achieved through private enterprise in the form of private or limited liability companies. Presumably, the Directors of such companies were aware of some of the risks involved and the enterprises were evaluated as far as possible on empirical financial and commodity price criteria. No doubt a number of mistakes and miscalculations were made. However, by means of a process of trial and error and the application of the results of such research as was possible, a large proportion of plantation and estate enterprises survived and indeed proved extremely profitable. Examples of this type of development include the tea and coffee industries in East and Central Africa, rubber and oil palm in Malaya, sugar in the Caribbean, coconut and oil palm in the Far East and cotton and sisal in Africa.

During the past two or three decades there has been a radical change in the approach to investment in and development of agricultural enterprises, particularly where irrigation is concerned. This change can be attributed in some measure to the fact that investment now frequently emanates from both national and international development financing agencies, including The International Bank for Reconstruction & Development and its subsidiaries, The African and Asian Development Banks, as well as bilateral aid and loans. In essence, there has been a swing away from the number of enterprises financed and established by private enterprise having responsibility to a comparatively small number of shareholders, to the large international banking organizations or business groups commanding large financial resources which have responsibilities and obligations to exchequer departments or to the legislature where public funds are used for development.

It is apparent that policies followed by the majority of lending institutions dictate, in some measure, the form and procedures which require to be followed in the technical and economic appraisal of projects and to a lesser extent in resource planning.

Type of Resource

Before considering the factors likely to require investigation in the appraisal of project feasibility, it is appropriate to refer at the outset to basic physical resources which include soils, water, climate, forests and other vegetation, wild life and minerals. The latter is frequently overlooked during the formulation of agricultural plans. However, the prospects for agricultural development can be appreciably enhanced if they can be associated with or linked to mining or industrial development.

Many of the unexploited land resources are in countries which are less well developed, or which have only recently

*Hunting Technical Services Ltd

reached the stage of self determination and are dependent upon the development of resources for their economic growth. Frequently the contributory elements, for instance, capital, knowledge and experience have to be provided from sources outside the developing country. Both the countries themselves and the donor countries require to know the types of resources which occur, their extent and quality.

Land resources fall into two categories:

(a) *Physical:* including geology and geomorphology, soil, vegetation, climate and water. These resources of themselves are largely unchanging or only slowly. However, the influence of man and animals may greatly accelerate the changes, affecting in particular soil, vegetation and water.

(b) *Economic and Social:* By contrast these resources are not static. Trade conditions, monetary and fiscal policies, population levels and labour availability all exert variable influences on a country's non-physical assets.

The interaction which occurs between these two categories will vary according to the state of advancement of the country; in under-developed countries social and economic resources tend to affect land use to a lesser extent than in developed countries.

The comprehensive resource inventory enables classification systems to be used whereby the extent of each resource can be related to the others. This has led to the development of land classification systems in which extensive land areas exhibiting similarities of land form, soil and vegetation can be regarded as comparable units. Where land is already occupied, present land-use may be used as an alternative classification; in all probability land-use will be adapted to the environment and hence is capable of being used as a unit of measurement between environments.

Qualitative assessment or resource appraisal has led to the formulation of a land classification in which the potential productivity of an area is measured in terms of a specified use. This classification will vary according to use, for instance dry land farming or irrigation, pasture, forestry etc. Crop selection and management will, of course, influence the rating. A more detailed type of classification takes into consideration a number of relevant factors including economics, the rating being formulated in terms of 'repayment capacity', that is to say productivity resulting from the various inputs of development.

Ecological studies are complementary to land form studies and ideally such studies should involve the whole environment to include the ecology of land use; in the majority of cases, expediency and expense tend to curtail ecological surveys to specific aspects of a given environment. It is not proposed to consider in any detail the scope of ecology in the context of an integrated survey; however, it is of interest to note the aspects of such a survey which can contribute towards the build up of a natural resources picture:

(a) The identification and inventory of forest tree species.

(b) The assessment of range and grazing potential enabling a calculation of the livestock carrying capacity.

(c) The qualitative and quantitative assessment of the density of tree and bush growth in relation to the methods and costs of land clearing for development.

(d) The estimation of future erosion hazards and protective measures.

(e) An indication of present and past systems of agriculture.

(f) The correlation of vegetation and soil boundaries which is of considerable value in soil surveys, particularly where a recurring pattern is in evidence.

The time and effort involved in undertaking any one of the above studies on the ground is likely to be considerable. However, by making use of aerial photography in conjunction with appropriate field checks, it is possible to speed up a survey without detracting from the volume or quality of information provided. It is not proposed to discuss the value or limitation of aerial photography in resource appraisal other than to emphasize that good quality photography flown at the right time of the year and of appropriate scale is one of the most useful tools which the planner has at his disposal.

Types of Study

In carrying out a review of the land resources of a region it is necessary to present the basic physical and biological factors in such a way that, when evaluated in conjunction with social and economic factors, proper development will ensue. There are many methods by which the different resource factors can be investigated and although each factor has its own significance, it is the combined effect of all and the interactions between them which are important.

The study of a specific project in isolation can, in certain circumstances, result in inadequate or poor planning. In a situation where one or more resources is in short supply, it is necessary to ensure that existing or proposed projects which could make use of the available resources be examined and compared. In the case of capital, which is frequently the most scarce resource and subject to intense competition, it is essential that it be put to the best use. Single measures of improvement may upset the balance in such a way as to do more harm than good. Too often short-term gains are made at the expense of long term productivity, whereas changes or improvements should be introduced in what the planner believes to be in a logical order and in the right combinations.

In order to ensure that capital is used to the best advantage, it is frequently necessary to examine and collate information at the regional or national level. On the basis of this information, it should be possible to evaluate the merits and likely returns of a number of alternative projects or systems of development in terms of the available resources, thereby facilitating the selection of a project which is able to use them to the optimum.

It is, of course, possible to design a project which is in itself both technically and economically sound, yet by neglecting to relate it to the resources and conditions within a wider environment, the ultimate success or viability of the project may well be doomed.

Physical resource studies and investigations will, of course, vary in intensity and method ranging from a preliminary reconnaissance survey to establish the broad pattern of resources over a wide area, to a comprehensive and detailed study of a specific location or project.

The objectives of the study will determine the criteria to be used and the intensity of investigations required. In practice it is as well to allow for a degree of flexibility in planning, in order to accommodate unforeseen factors or circumstances arising during the course of the study.

A detailed discussion on the study of physical resources is inappropriate at this juncture; however the outline plan for a typical integrated resource and feasibility study (Fig. 1) gives some indication of the progressive stages which require to be examined. No two resource studies are identical. Therefore it is inevitable that there will be differences in approach and emphasis. However, by following through the stages suggested in Fig. 1 it is possible to make a worthwhile appraisal of an area or region.

Whilst the cost and time spent in undertaking pre-investment studies can be questioned, the necessity for a thorough study of the physical resources including man-power and the availability of agricultural inputs is essential. The consequences of pressing ahead with development without adequate and proper investigation may be extremely serious, as exemplified by the ill-fated groundnut scheme in what was formerly Tanganyika in the early 1950's. The scheme, which was designed to make good a shortfall in vegetable fats in the U.K. following the last war, failed to achieve effective production, yet cost the British tax payer some £25-30 million.[1]

Impact on National Objective

The planning of any one major project will inevitably result in interactions with other sectors of the economy; for this reason it is necessary to review the general whilst, at the same time, concentrating on the particular. The majority of both developed and under-developed countries have drawn up or are in the process of preparing national development plans, thus it follows that plans for development of any natural resources scheme should fall within the framework and time scale of the national plan, in order to ensure that there is a proper co-ordination and inter-relationship between the proposed scheme and the other sectors of the economy. Conversely where national plans require review or finalization, the study and inventory of resources can provide a very useful contribution to the overall plan. Where resource planning is ignored, there is a tendency towards imbalance between one sector and another resulting in a conflict for available resources, be they financial or physical.

Quality of Basic Information

Reliability and validity of the basic information is essential to effective feasibility studies, particularly since more sophisticated techniques have become available to the planner, including the use of linear programmes, mathematical models, automated picture analysis, infra-red scanning, etc. Inadequate understanding of the applications and capabilities of these various sophisticated techniques may lead the user into believing that the value of inaccurate data can be enhanced by their use. In fact, the results from a computer, for instance, are only as accurate as the data fed into it. This also applies to aerial photographs as much as factual or numerical data. The fact that the majority of developing countries suffer from a lack of readily available and reliable data tends to aggravate the problem, and the planner is frequently forced into the position of having to make assumptions based upon experience elsewhere.

Assuming that it is possible to quantify and evaluate the physical factors and constraints, the planner is faced with the need to appraise the human factor, which is the most difficult of all to predict. In essence great refinement in the techniques for assessing productivity on a purely physical basis may not be justified when considered against the background of the human factor. It is only when a high degree of management and skills can be assured that sophisticated techniques are justified.

There is a great temptation for the planner to wipe the slate clean and disregard existing systems of cultivation or techniques, which are in all probability primitive and apparently inefficient. Whilst it is accepted that many indigenous systems of crop and livestock production are lacking in terms of gross or net output, nevertheless, on closer examination it is often found that a particular system has been evolved through trial and error and it is more than likely that the system is generally attuned to the environment to the extent that it fits in with the traditional way of life and social values. With the introduction of modern innovations, including irrigation, increased intensity of cropping, mechanization etc., it is inevitable that such simple or primitive systems become overloaded to the point of being unable to cope. It is accepted that they should be superseded by patterns or systems designed for more efficient production, but experience has shown that the planner would be well advised to spend time in studying indigenous systems since it is quite likely that some of the basic principles are quite sound and may warrant serious consideration for inclusion in any new systems or refinements which it is proposed to introduce. The retention of even a few familiar practices may smooth the path of transition from primitive to progressive agriculture. Although these are very real problems, it should not be assumed that they are insurmountable; were this the case, then resource and project planning would be at a standstill.

Planning Procedures

It is, of course, necessary to set certain targets in order to be able to undertake an economic analysis of the benefits of a project. Such targets or objectives will include crop yields, labour inputs, and administrative and managerial capacity. In order to arrive at realistic targets for a

OUTLINE OF INTEGRATED NATURAL RESOURCES SURVEY

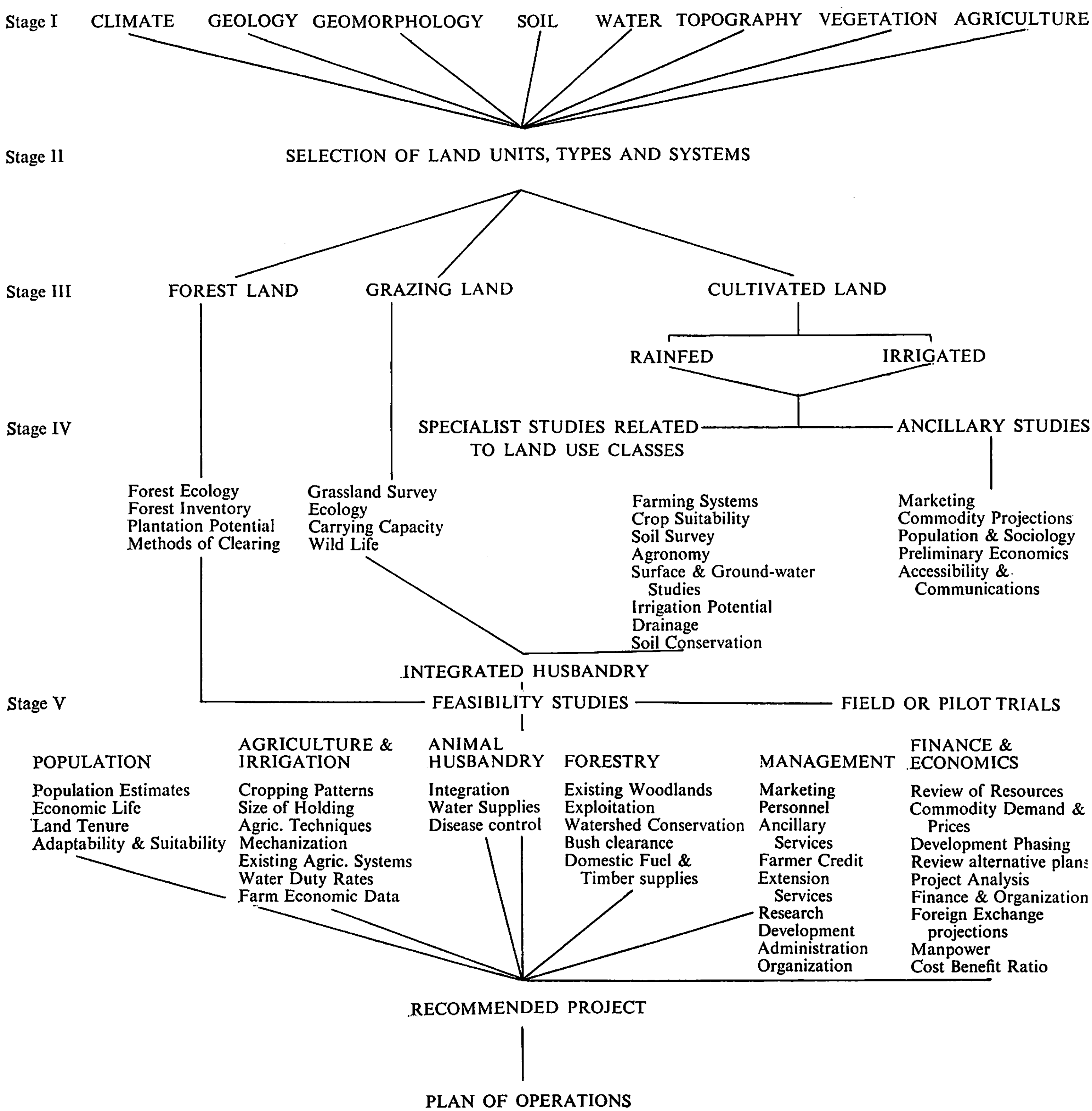


Figure 1

particular situation or environment, it is necessary to assess the potential target and 'discount' it by some formula based on the actual performance achieved elsewhere in the country or by analogy to similar conditions abroad.

The necessity for a realistic assessment of targets is not confined to the cultivator at farm level; on the contrary its application to the administrative and managerial sectors is equally important, particularly with regard to the cost of administrative efficiency and the rate of construction and development.[2] Similarly, consideration should be given to a country's political will to develop. Although the planner has no control over this factor, he can put forward feasible alternatives from which political authorities are able to select one or more suitable alternatives before the plan reaches an advanced stage. Recognition of the three basic elements discussed earlier —human potential, administrative capacity and political will to develop—in a project plan are likely to enhance its acceptance and ultimate viability.

In practice, technical methods and the scope of the financial and economic analysis will differ to some extent from one project to another depending upon local circumstances. Nevertheless, there exist certain principles which are common to all natural resource appraisals which are worthy of consideration. In the long run agricultural performance depends upon the compatibility of water, land, people and the availability of agricultural inputs, hence the feasibility and indeed viability of a particular project requires a careful consideration of the combined use of these resources. The supply and demand for water is of fundamental importance for without it agricultural development could not take place, particularly in the semi-arid zones. On the other hand, the omission of one or more of the factors involved could seriously hamper the success of the project and, in the extreme case, result in complete failure. The necessity to appraise all possible factors relevant to a specific set of circumstances cannot be over-emphasized.

The analysis of components of planning may be briefly summarized as follows:

(i) Definition of purpose or objective.
(ii) Identification of resources.
(iii) Selection of means.
(iv) Consideration of alternatives and selection of best option.
(v) Formulation of plans.

In practice the definition of purpose or objective will have been outlined by the instigator of the study or project at the national, or possibly lower level. Where a project arises as the result of a comprehensive regional resource study, it may be necessary for the planner to define the objectives of one or more schemes falling within the regional resource study.

The identification of resources available to the project constitutes one of the most important aspects of a feasibility study and is likely to prove time-consuming in the under-developed countries where essential data are not readily available.

The selection of the means of development embraces technical aspects, as well as the allocation of an agreed proportion of total available resources. The aim or purpose of the proposed development will, to some extent, determine the means by which such development will be achieved, for example, an irrigation scheme presupposes the supply of water in varying quantities at regular or specified intervals. At the technical level, the planner has to decide on the most effective and economical method of crop production involving flood, controlled furrow or overhead sprinkler irrigation systems. The selection of any one of the above systems will be influenced by the proportion and equality of available resources allocated to the particular project under consideration. Where water resources are limited, it is likely that an overhead sprinkler system will be adopted, this being more economical than either furrow or inundation systems. On the other hand, where land is in short supply, it is probable that greater emphasis will be given to cropping intensity in order to maximise returns to land.

Earlier reference was made to the need for the consideration of alternative proposals and plans in order to ensure that most favourable end-product from the technical and financial viewpoint. There is obviously a limit to the number of permutations and combinations which can be considered in the space of time likely to be available for a pre-investment study. It is evident that a balance must be struck between the time and expense involved and the number of alternatives which can be considered. The application of a linear programme computer model for the analysis of the variables greatly reduces the time required for the evaluation of alternatives, at the same time permitting a larger number of combinations to be examined.

Economic Appraisal

Economic appraisal of projects is most commonly carried out using discounted cash flow methods to produce benefit/cost ratios or internal rates of return to the project. The technique of discounted cash flow arises from the need to relate projected costs and projected benefits to a common time scale in view of the fact that they occur over different periods of time. Obviously £1 spent or earned now is of greater immediate value than £1 spent or earned in 10 years time. The difference in present value is determined by the rate of interest which could be applied to the £1 over the period in question. The D.C.F. approach discounts the cost and benefit streams back to year zero at differing rates of interest.[3] As costs are invariably incurred in the early stages of the project, before benefits accrue, the effect of discounting is to reduce the total value of costs by an amount less than the total value of the benefits. The higher the rate of discount the more this gap is closed. At any given rate of discount the relationship between total costs and total benefits may be expressed as a cost/benefit ratio. As long as benefits exceed costs, the project may be regarded as being feasible, provided the rate of discount used is not less than the rate of interest at which capital may reasonably be obtained from other sectors of the national economy or from external sources.

Running parallel to this, the internal rate of return to the project is that rate of discount at which total costs and total benefits are exactly equal, given a previously determined terminal date for the project. Alternative projects competing for scarce capital resources may this be compared according to an objective criterion, provided the assumptions governing the accrual of benefits to the two projects are thought to be consistent.

A hypothetical example of Discounted Cash Flow is given below:

Year	Actual Benefits (£)	Year	Actual Costs (£)
1	—	1	2,046
2	—	2	2,582
3	26	3	679
4	54	4	497
5	81	5-7	179 (each)
6	125	8-12	190 (each)
7	177	13	201
8	246	14	526
9	341	15-22	201 (each)
10	440	23	835
11	571	24	526
12	632	25-29	201 (each)
13	658	30	2,080
14	674	31-40	201 (each)
15	683		
16	694		
17-40	702 (each)		
Residual value	1,240		
Total	23,490	Total	16,082

When these two cash flows are discounted annually at 1, 2, 4, 6 and 8 per cent the following totals emerge:—

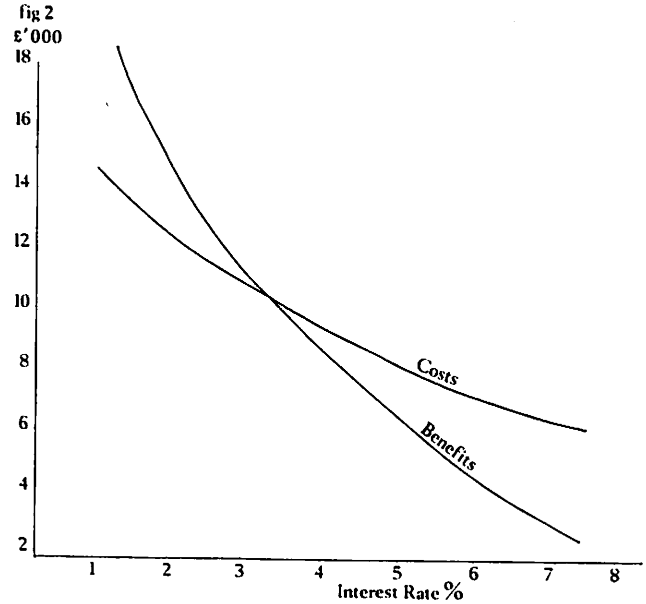
Discounted at:	Benefits	Costs	Benefit/Cost Ratio
Actual	23,490	16,082	1.46:1
+1%	18,291	13,813	1.32:1
+2%	12,833	11,403	1.13:1
+4%	9,035	9,538	0.94:1
+6%	5,865	7,931	0.74:1
+8%	3,917	6,855	0.57:1

The above totals for costs and benefits may be plotted on a graph. The point at which the two lines intersect indicates the internal rate of return to the project, namely 3.2 per cent (Fig. 2).

Although the economic and financial analysis constitutes an important yardstick for the appraisal of a project, the best economic solution may not necessarily prove to be the best overall solution, since it is not always possible to quantify and analyse all the technical and sociological constraints. There is a danger in endowing an economic analysis with an aura of accuracy which is not consistent with the accuracy or reliability of the basic data. It is at this stage that the planner requires to exercise his discretion and judgement and, above all, to demonstrate an understanding of all the components of the study including political, sociological, technical and economic limitations.

In formulating plans for development, it is essential to bear in mind at all stages of planning the following questions which are likely to arise when the project is being appraised by an investor:

fig 2



(i) Is the project technically and economically sound?

(ii) Have the physical and economic resources available been used to the best advantage?

(iii) Have sufficient alternatives bɔen considered and does the recommended project constitute the most favourable selection in terms of the returns to resources and inputs?

Organization and Management

There exists a misconception in some circles that the presentation of a feasibility report or master plan for resource exploitation constitutes the ultimate answer to development. This concept is, of course, erroneous for in the majority of cases there remain many problems to be overcome before full implementation can be accomplished. The acceptance of a proposal for financing by bankers or international lending agencies is often conditional upon reasonably stable political and economic conditions in the country concerned, in addition to the existence of adequate administrative and technical services in order that orderly development may ensue. In a number of newly independent and developing countries such facilities may be totally lacking or poorly organized, in which case the potential lender may require the employment of consultants or other organizations to undertake, organize or supervise development works and services. This may in itself create pressures within a Government, since national pride often demands that the implementation of a project shall be undertaken by local nations, albeit their capability to do so is open to question. Provided consultants or technical assistance organizations are able to gain the confidence of the executive agency, this problem can be overcome. For instance, the establishment of an expatriate advisory planning group comprising specialists in the more important disciplines (who outwardly have no executive powers, but who are able to monitor progress and, where necessary, advise on specific

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SPECIFIC APPLICATIONS OF AIR PHOTO-INTERPRETATION IN AGRICULTURAL DEVELOPMENT PLANNING

by

R. G. B. JONES, MI AGR E*

Presented at the Spring National Meeting of the Institution at Silsoe, Bedford on 27 March 1969

ABSTRACT

In countries where heavy seasonal downpours of rain are a characteristic of the climate, a pre-requirement to land use planning based on erosional hazards of use and the capacity of the soil to produce on a sustained economic basis is, ideally, either a detailed Soil or Land-Use Capability Classification Survey related to the major factors of soil depth, surface texture, permeability, degree of slope and existing erosion.

Aerial photographs can speed up the field investigations which are an essential part of these surveys, thereby substantially reducing costs, whilst in subsequent planning operations they can be used as specific aids in the design of conservation layouts, as well as for water resources assessment, erosion control and other purposes.

1. INTRODUCTION

In the tropics and sub-tropics, where heavy and prolonged downpours of rain are characteristic of the climate during the rainy season, the prevention and control of erosion can be achieved by biological and mechanical conservation measures which include:

1.1 The provision of adequate vegetative cover to encourage infiltration and protect the soil against wind, raindrop impact, and run-off.

1.2 The re-establishment of vegetation along water-courses by isolating them from livestock by means of fences also designed to form part of planned sub-divisional fences.

1.3 The maintenance and improvement of soil fertility by mulching, green manuring, fertilizers, and rotational systems of cropping and grazing management including the proper assessment of stocking density in relation to bush encroachment control.

1.4 The introduction of improved pasture species.

1.5 Selective methods of ploughing and cultivating with emphasis on the reduction of the speed of cultivating implements and of the number of workings to a minimum.

1.6 Structural measures such as terraces, ridges and bunds, stormwater drains and grassed waterways, and the reclamation of gullies.

*Land Resources Division, Directorate of Overseas Surveys

2. SOIL SURVEY AND LAND CLASSIFICATION

The foregoing measures can be applied most effectively if the land is used in accordance with land-use capabilities determined by topography, vegetation, soils and other natural features. A detailed soil survey or land-use capability classification—based on the major factors of soil depth, surface texture, permeability, degree of slope and existing erosion—is therefore very often an essential pre-requirement to any catchment re-assessment programme mounted to determine the changes in land-use practices required on eroded land, erosion hazard areas, and in the catchments as a whole (Soil Survey Staff U.S.D.A. 1951). Moverover, from an engineering standpoint, the land capability data provide essential information on the run-off and erosion characteristics of the different soils, a knowledge of which is helpful in deciding the design of control structures and what type of machinery is best suited for land clearing, road construction, and general agricultural operations.

2.1 Initial Stereoscopic Air Photo-Interpretation

Air photo-analysis and interpretation, if properly executed, not only play an important role in increasing the speed of mapping in the most expensive phase of soil survey and land classification—the fieldwork—but also result in better quality maps (Buringh 1954; Jones 1958, 1959). For this reason, when air photo cover is available, a thorough initial stereoscopic interpretation of the aerial photographs prior to field reconnaissance is one of the most important factors contributing to the accuracy of these surveys. Unfortunately, however, it still remains the greatest weakness because—in the author's experience, based on the training of more than 2,000 graduates—most field scientists only use a stereoscope for demarcating mountain land, tone and pattern at the expense of other more important information which can and should be defined stereoscopically.

Tone and pattern are qualitative characteristics of photo-interpretation—as distinct from topographical elements which can be assessed quantitatively in terms of shape, size and site—and can be defined equally as well on an air photo mosaic, provided it is large enough in scale, as they can stereoscopically. Consequently, many field scientists feel it is a waste of time to carry out a proper stereoscopic interpretation of the aerial photographs and, instead, over-concentrate on tones and patterns at the expense of what really matters.

To overcome this weakness and to emphasize the important difference between topography, as a primary physical element of terrain, and the secondary and qualitative characteristics of tone and pattern, it is suggested that the following systematic sequence of photo-interpretation, which the author has contrived to design on convergence of evidence principles, will help to ensure that only definite, reliable and significant information is extracted stereoscopically—for this is the only information which has any scientific value.

2.1.1 *Method:*

2.1.1.1 Decide clearly the objectives of the particular exercise. The photo-interpretation should then be related to these objectives in terms of what and how much detail should be extracted stereoscopically. It is, for instance, obviously a waste of time to delineate information which is not required.

2.1.1.2 Study all available climatic, topographic, geologic, vegetation and soil maps and reports covering the area. If these are available it is wasteful not to make use of them as they yield valuable information which can substantially assist the initial photo-interpretation—and it is surprising how *often* they are ignored.

2.1.1.3 Assess the stereo-base of the instrument, if a mirror stereoscope is being used, and base-line the photographs by locating the principal points, transferring these stereoscopically to the adjacent photographs, and ruling in the flight lines.

2.1.1.4 Study the flight plan or photo index mosaic to determine the flight orientation of the photography. NOTE:—For photogeomorphological interpretation it is best to have the photograhy flown across the line of the main geomorphological boundaries whenever possible.

2.1.1.5 Mark the boundaries of the area on the field mosaics and study these to see what broad regional trends exist, separating any clearly visible land system boundaries with wax marking pencil.

2.1.1.6 Make a photo-laydown with the stereo-cover to decide which photographs to delineate. Mark these (alternates) with a cross in one corner and draw in the boundaries of the area on them to prevent doing any unnecessary annotation outside the boundary area during the subsequent photo-interpretation.

2.1.1.7 Stack the stereo-cover on the drawing hand side of the stereoscope with paper separators between each flight run. Orderliness of this nature is a great time-saver when a lot of photographs are involved.

2.1.1.8 From a stereoscopic study of a cross-section of the photographs, and bearing in mind any information derived from existing maps and reports, try and assess:—

2.1.1.8.1 The type of geomorphological formation.

2.1.1.8.2 The actual process (denudation or tectonic) responsible for it.

2.1.1.8.3 The stage of development classifiable in terms of the Cycle of Erosion as 'Youth', 'Maturity' or 'Old Age'. (Jones 1962).

Information of this sort can be a useful guide to the types of soil and soil profiles in the area to be reconnoitred.

2.1.1.9 Define terrain data methodically on each alternate photograph:—

2.1.1.9.1 One topic at a time.

2.1.1.9.2. From the known to the unknown.

2.1.1.9.3. From the general to the specific.

2.1.1.9.4 From small scale to large scale considerations.

These basic principles apply to all fields of air photo-interpretation and the information defined on each selected alternate photograph should be within the limits of vertical and horizontal match lines drawn parallel to the photo edges through the satellite principal points and approximately midway within the lateral overlaps between flight strips.

NOTE:—A 'match' line as defined by the U.S.D.A. Soil Survey Manual is 'an arbitrary line drawn in the overlap area of a photograph to serve as a boundary line for the mapping on the photograph to be matched to the same line drawn through identical points on the adjoining photograph'. In simpler terms it is merely a line drawn to ensure that information carried forward between each alternate photograph in the line of flight, and between successive flight strips, does in fact 'join up'.

2.1.1.10 Application of the 'Convergence of Evidence' principles mentioned in 2.1.1.9.1 to 2.1.1.9.4 above is reflected in the author's own recommended sequence of interpretation which is in the following three stages:—

2.1.1.10.1 *Stage I—Using the Stereoscope (Obligatory)*

2.1.1.10.1.1 *Delineate the full drainage pattern* This implies the demarcation of the whole drainage network with the centre lines of all minor depressions as well as streams carried almost up to the crest in each case. Subsequently, this proves extremely valuable in planning land protection and water disposal layouts.

Drainage is particularly important as it is not only related to the age of the river system and the geology but dictates almost all other factors in land-use planning—namely:—

2.1.1.10.1.1.1 Communications.

2.1.1.10.1.1.2 Arable land units and sizes.

2.1.1.10.1.1.3 Protection and water disposal pattern.

2.1.1.10.1.1.4 Watering points and water conservation potential.

2.1.1.10.1.1.5 Irrigation potential.

2.1.1.10.1.1.6 Siting of dams, cattle dipping tanks, houses, labour compounds and other farm buildings.

2.1.1.10.1.1.7 Fencing layouts.

2.1.1.10.1.1.8 The design of paddocking systems for maximum utilization of summer and winter grazing.

2.1.1.10.1.1.9 Beef policy (indirectly from 2.1.1.10.1.1.8)—besides being a reflection of the Geology, Parent Material and Soils.

The central line of all channels should be delineated, preferably in Blue chinagraph-type pencil as this colour is psychologically correct as an indicator for water.

NOTE:—In erosion surveys the cross sectional shape of eroded channels, which are visible under the stereoscope, can be an indicator of soil type e.g. V-shaped channels tend to form in clays, U-shaped channels in sands, and square-sided channels in contact soils.

2.1.1.10.1.2 *Outline all obvious non-arable rocky waste and mountain land*

It is suggested that Red chinagraph pencil be used for this as being psychologically appropriate to infer land which is non-arable in nature and where any attempt at cultivation would be dangerous.

NOTE:—Only obvious non-arable land will be able to be recognized stereoscopically. A proportion will remain unidentifiable and only capable of being picked up on field check.

2.1.1.10.1.3 *Mark in all relevant crest lines*

Except in the case of catchment boundary delineation this implies all crests *relevant to the correct siting of roads and mechanical conservation works.* Crests and drainage pattern together are fundamental to the interpretation of surface terrain configuration and field orientation. The demarcated crest lines are also a most useful navigational aid—especially in virgin areas—and in their capacity as potential roads are important because:—

2.1.1.10.1.3.1 Communications are an essential part of arable land protection.

2.1.1.10.1.3.2 They can be the over-riding factor in land selection on the basis of work study for full efficiency of field operations.

2.1.1.10.1.3.3 Crest-sited roads involve minimum care and maintenance as, in this position, they form the basis for properly designed water disposal layouts.

Brown chinagraph pencil is suggested for marking in crests—this colour being consistent with that of farm earth roads.

NOTE:—*All* relevant crests should be defined as only then is it possible to assess their relative merits in the overall communications plan. It is of no consequence if nothing appears to 'join-up' in the first instance.

2.1.1.10.1.4 *Demarcate all slope breaks along the margins of drainage depressions and within possible arable areas*

Slope should always be defined as a specific entity in the stereoscopic interpretation as failure to mark minor slope changes is an all too common fault despite the fact that slope is a primary topographical element. Slope length and gradient are associated with speed of run-off and degree of erosion and therefore of the utmost importance in land classification, many land classification systems being directly geared to slope in the first instance.

The first slope breaks to be marked should always be those bordering the drainage depressions (vleis, dambos, etc.) as, when these slope breaks exist, they nearly always form a reliable common boundary between the swamp areas and the possible arable land which remains, thereby making it easier to identify any other slope breaks *within* the possible arable areas.

The foregoing Stage I data define the skeleton of the landscape, and, as they consist of land factors only, they are not liable to change on field check provided only definite information has been delineated. This applies even where the field scientist is not familiar with the soils in the area being stereoscopically examined beside being basic to the proper design of roads and mechanical conservation works. For this reason, even if the Stage I data were the only information to be extracted under stereoscopic observation it would still be of great value.

2.1.1.10.2 *Stage II Without using the Stereoscope (or with confirmatory use only)*

Transfer all the information extracted in Stage I to the field mosaic and then record on the mosaic:—

2.1.1.10.2.1 *All apparent boundaries between swamp areas and possible arable land if not already defined on the basis of slope break in Stage I.*

2.1.1.10.2.2 *All areas suspected of having a wetness factor not critical enough to preclude them from 'dry land' cultivation*

2.1.1.10.2.3 *Place a question mark within all eroded areas and homogeneous tonal and vegetation differences provided they are clearly visible*

It is not recommended that a solid line be drawn between these differences as once such a line has been drawn there is a tendency for it to form a psychological barrier the interpreter is loath to change even on field check. In this connection it should be noted that the factors delineated in this second stage are often unreliable, by no means final, and quite liable to change on being field-checked.

2.1.1.10.3 *Stage III—Using the Stereoscope (Obligatory)*

2.1.1.10.3.1 *Select provisional soil profile examination pit sites unless an auger grid system of classification is being used*

This must be done stereoscopically as homogeneous areas based on slope changes (Fig. 3) have to be carefully examined to avoid transition zones which can yield atypical soils information.

2.1.1.10.3.2 *Wipe the stereo-cover clean and select all possible dam sites on the basis of stream gradient changes (Section* 3.4.4.1)

This exercise is deliberately left until last as reference needs to be made to the interfingering crest and stream patterns already transferred to the mosaic, these dictating the size of catchment areas.

NOTE:—The meaning of the term 'homogeneous area' needs clarification. As applied to air photo-interpretation for soil survey and land classification purposes it can be defined as:

'An area in which there are no *significant changes*, which can be outlined on aerial photographs as a result of the stereoscopic analysis or comparison of all differences or similarities in the landscape which result from differences in soil or vegetation conditions. It is therefore a recognizable photo-analytical unit'. (Figs. 1-2)

2.2. Second Stereoscopic Air Photo-Interpretation

After the soil profile examination pits have been studied in the field the relevant landscape and soils data can be written on the field mosaics next to the pit positions. A second stereoscopic examination of the area should then be undertaken.

Whereas the Initial Stereoscopic Interpretation was exploratory in nature the Second Stereoscopic Interpretation is partially confirmatory in that its object is the location of provisional mapping unit boundaries. In many respects, therefore, it is the more important of the two photo-interpretations.

Looking at the photographs a second time, after having been over the ground, all the more subtle differences in the air photo image can be appreciated so that the stereoscopic examination can then be directly related to specific differences in landscape and soil characteristics.

Adjacent soil pit information is compared and if the difference lies in land characteristics such as degree of erosion, slope, or wetness—the emphasis should be placed on landscape features. If, on the other hand, the difference is in profile characteristics—then the emphasis of the photo-interpretation should be placed on those features such as landform, tone and pattern, *which in the field reconnaissance* have been found to relate to those particular characteristics.

Thus *only* in the Second Stereoscopic Interpretation should any homogeneous areas of tone and pattern be taken *specifically* into account.

At this stage it is usually necessary to site additional pits on the photographs in conjunction with planned auger traverses designed to cross the mapping unit boundaries at right angles to establish their positions accurately.

The provisional mapping unit boundaries picked up during the Second Stereoscopic Interpretation must, therefore, still be confirmed on the ground by further field reconnaissance.

3. PLANNING

Subsequently, planning for optimum land use is based on the facts provided by the Soil or Land Classification Map considered in relation to the land user's inclinations and available capital resources. This approach is realistic in that it fulfils the broad objective of soil conservation:—

'The use of each acre of agricultural land within its capabilities and the treatment of each acre of agricultural land in accordance with its needs for protection and improvement'.

Here again stereoscopic pairs of aerial photographs, used in conjunction with air photo-mosaics, on to which the soils or land-use capability classification data have been annotated to produce photo-maps, are extremely helpful in designing an efficient sequence for the development of a plan. This stems from the fact that the aerial photograph and air photo-mosaic, despite the fact that they contain certain distortion errors, have the advantage of being pictorial representations of the ground, showing all detail in its proper place, and are not merely symbolic representations as maps really are despite their accuracy. Moreover, for explaining planning programmes to the public, the overall presentation of an annotated air photo-mosaic is more attractive and easier to understand by both peasant cultivators and sophisticated farmers alike.

The more specific advantages of using aerial photographs are apparent in the following planning approach sequence, applicable to the development of single farm units as well as to areas of land, which the author was associated with developing for conditions prevailing in Central Africa (Planning Staff, Federal Dept. of Conservation and Extension, Rhodesia, 1962):—

3.1 Planning Procedure

3.1.1. *Stage I—Extraction and Blocking-out of Basic Landforms*

On studying any land unit on a soils or land-use capability classification photo-map, in conjunction with the relevant stereo-cover, the following basic visible detail should be extracted and delimited as the first stage of planning:—

3.1.1.1 Watercourses (vleis, dambos, etc.)

3.1.1.2 Predominantly wet areas.

3.1.1.3 Rough, broken and steep terrain.

3.1.1.4 Land unsuitable for agricultural production.

When these areas have been defined, normally with coloured wax pencils which are very helpful in clarifying the different information, the resultant pattern shows the overall drainage pattern and type of topography in relation to the approximate possible arable/non arable ratio and its distribution.

3.1.2 *Stage II—Grouping of Broad Types of Arable or Grazing Areas*

Homogeneous areas of basically similar arable and grazing units can then be grouped together and outlined in terms of:—

3.1.2.1 Soils derived from similar parent materials or grazing areas having a similar homogeneous pattern.

3.1.2.2 Broken or scattered units of possible arable land or extensive areas of land which predominantly are possibly arable in nature.

3.1.2.3 Predominantly dry or well-watered areas.

3.1.2.4 Predominantly steep, undulating, or flat areas.

When these areas have been demarcated and studied in conjunction with Stage I a more detailed picture of the key physical factors relating to potential land-use emerges.

3.1.3 *Stage III—Demarcation of Potential Communications*

At this stage the potential communications dictated by

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Fig. 1

Single aerial photograph. An example of air photo-analysis showing stereoscopically demarcated homogeneous areas based on topography, erosion, anthill pattern and physiognomic vegetation differences.

Rhodesia middleveld. Photoscale 1/20,000

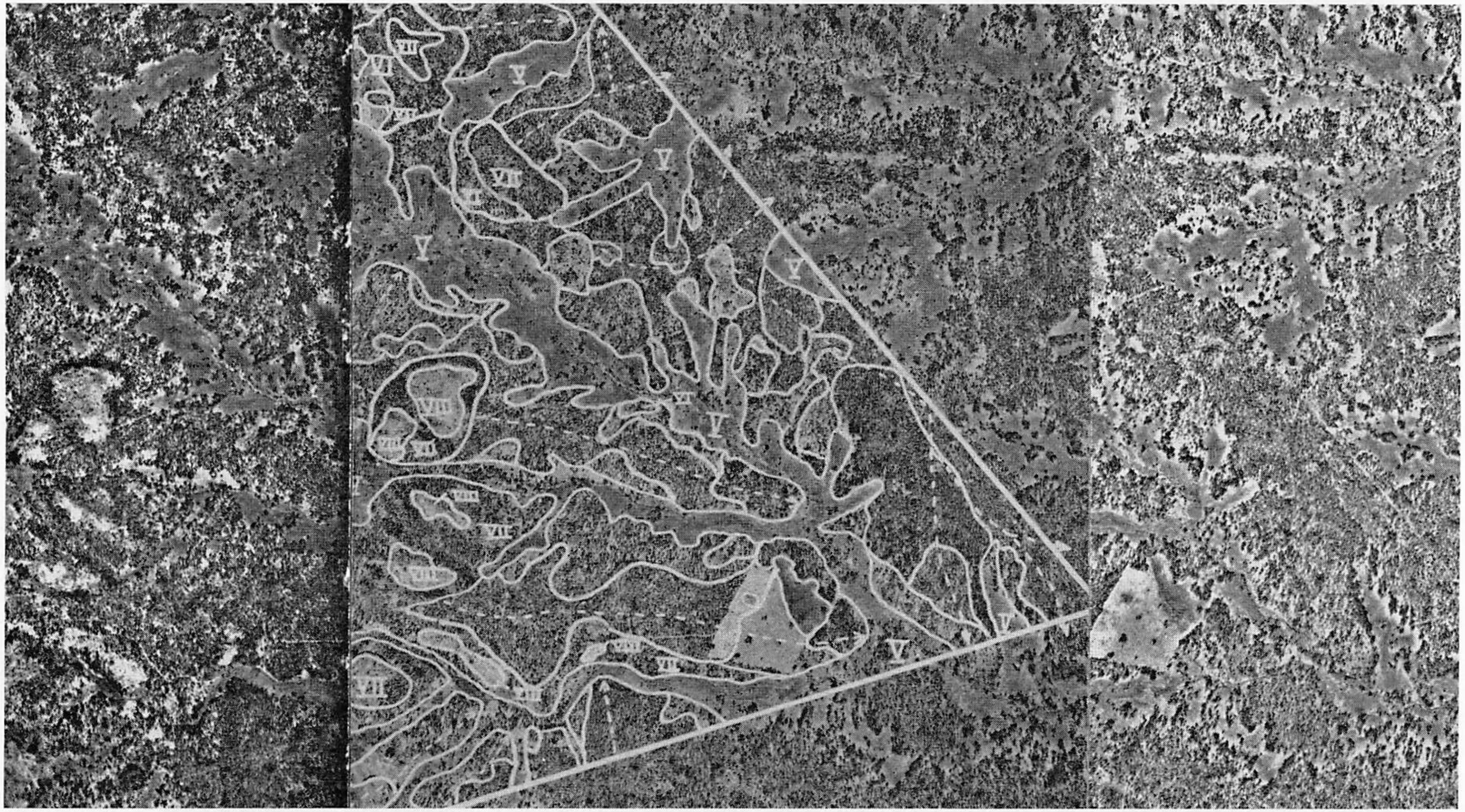

Fig. 2

Stereotriplet showing 'homogeneous areas' delineated on the basis of landform, vegetation stand, and grey-tone patterns related to wetness

Photoscale 1/20,000

Fig. 3

Stereogram showing a minor 'slope break' coinciding with a change in soil conditions.

Photoscale 1/20,000

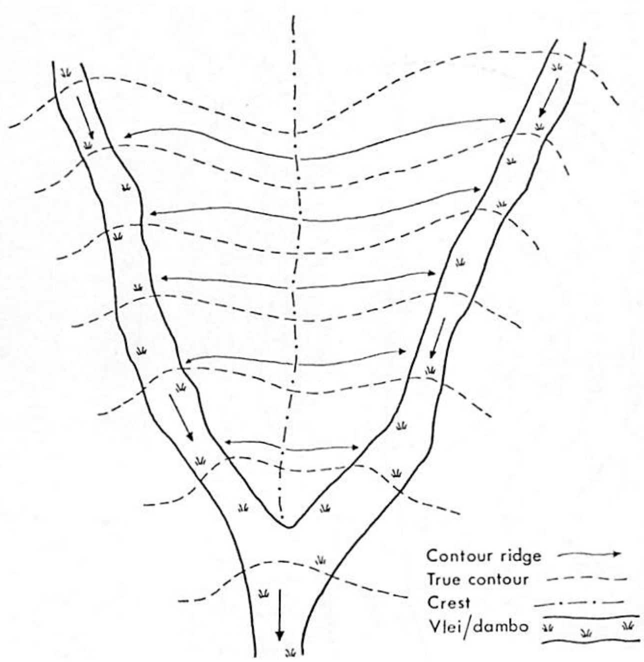

Fig. 4

THE SLOPING RIDGE

(Drainage Lines or Streams of approximately equal Floor Gradient)

This is the simplest layout in practice but becomes complicated when; (i) The ridge is too wide even for contour ridges spilling each way from the crest or; (ii) when the waterway on one or both sides has been encroached upon.

In the case of (i) extra waterways should be provided, if possible in natural depressions fingering from either one or both of the drainage depressions (vleis/dambos).

In the case of (ii) no protection of the land should be attempted until the waterways are established.

Where waterways are demarcated for establishment the markings should be of a permanent nature.

Best road access is provided by a crest road with laterals along the top of or immediately below the contour ridges when required.

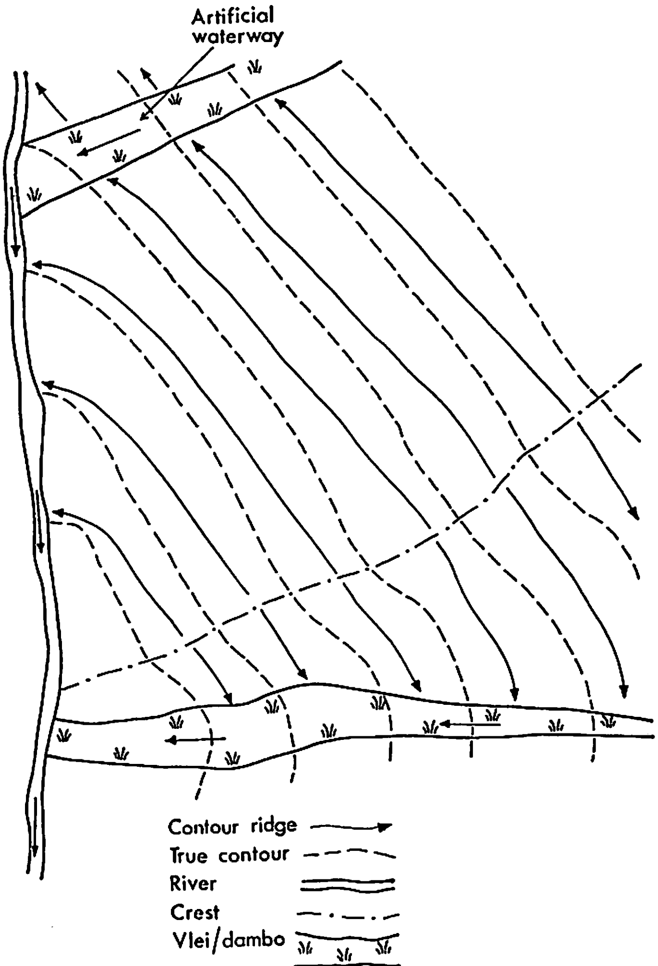

Fig. 5

Fig. 5

THE RIVERINE SLOPE

(Drainage Lines of Widely Differing Floor Gradient)

This layout often calls for an artificial waterway because the flat gradient of the river causes the contours to become too long. If such waterways are necessary they should be demarcated and established before protection is attempted.

Examples of this topography are frequently encountered along near-graded rivers and their larger tributaries.

Access roads can be provided down minor crests where contours split or down the side of a waterway when contours do not have to be crossed.

Fig. 6

THE DOME

This is not an easy layout because the whole dome usually cannot be seen from one point and if there is long grass or timber it becomes extremely difficult to visualise.

The permanent layout should only be attempted when the whole dome is opened up and completely clear.

The extension of a natural waterway to the top of the dome is the correct way of starting such a layout.

Waterways should be added as the circumference of the dome increases. Except at the top of the dome natural waterways usually occur and should not be cultivated.

Access roads can be provided without crossing contours if the contour split points are carefully sited.

Fig. 7

THE SADDLEBACK

The topography requiring this layout is quite common but it is seldom correctly protected.

The Y waterway limbs usually have to be artificial but are seldom needed on both sides of the saddleback.

The Y limbs have first to be established before efficient protection can be carried out.

Y limbs are not necessary when the domes are not higher than the V.I. being used on the contours.

This is the most difficult to recognise and the most awkward to protect. If a portion of such a feature is block-stumped and the rest is still under timber only temporary protection can be given.

Access roads need not cross contour ridges if the split points are carefully sited.

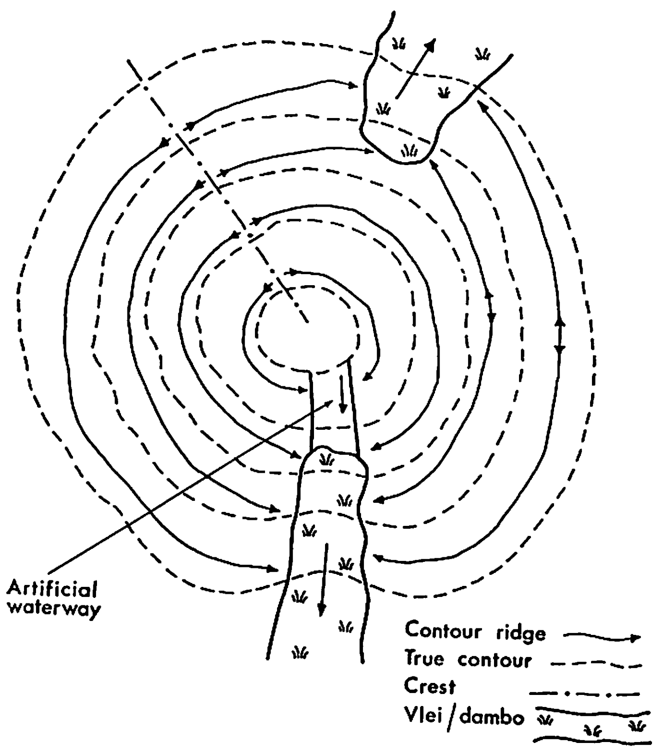

Fig. 6

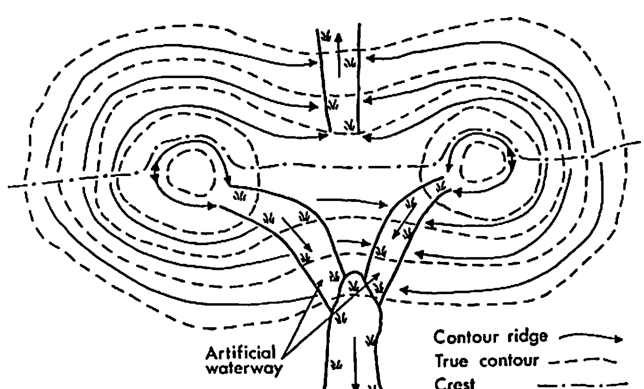

Fig. 7

Continued from page 58
the topography can be annotated. This skeleton pattern of communications will be found to bear a logical relationship to the two previous stages and will illustrate the accessibility of the various possible arable, non-arable and grazing land units.

3.1.4 *Stage IV—Sub-division into Natural Land Units*

This stage is closely associated with Stage II in that the grouping of the natural land units of similar type is critically re-examined to ensure that each unit is adequately served by the overall communications pattern and yet stands as an entity within itself.

3.1.5 *Stage V—Demarcation of individual arable lands, conservation layouts and basic fencing*

The ability of the stereo-image to reveal land contour makes it possible, after examining the stereo-cover, to design on the photomosaic a suitable protection layout for each land in keeping with its communications.

A conservationist, working in an area for any length of time, will soon learn to recognize the various micro-landforms lending themselves to properly designed conservation layouts. In Central Africa, for instance, which, geomorphologically, is composed of large uniform stretches of uplifted peneplane surfaces, there are four basic landforms, recognizable under the stereoscope, each of which demands individual treatment in layout design (Wiggill 1955). These are:—

3.1.5.1 The Sloping Ridge
3.1.5.2 The Riverine Slope
3.1.5.3 The Dome
3.1.5.4 The Saddleback.

In practice these features can occur each as a whole (Figs. 4-7), as part of a whole, or in combinations of the four (Fig. 8).

From stereoscopic examination it is also possible to calculate provisional earthwork quantities and costs of the total length of contour ridging required as well as the type of machinery needed for their construction.

Arable lands are blocked out to ensure that, wherever possible, each arable unit is homogeneous and can be sub-divided into equitable sub-units for rotational purposes. This exercise is best carried out for the whole of the area irrespective of immediate land-use requirements.

Having studied the blocked out arable units in the light of the four previous stages the skeletal fencing over the whole of the area will be apparent as it is closely dependent on all these factors. This fencing is then annotated.

All the demarcation, stereoscopic extraction and assessment of the land up to this stage has been dictated by physical terrain characteristics fundamental to any form of land-use practice regardless of individual human preferences. It is only now that the farmer's, rancher's, or land-user's inclinations are taken into account and it is the planner's function to fit these specifically-required enterprises where possible into those land units for which they are best suited and to design suitable rotations and management systems based on whatever capital resources are available to ensure that all these factors are integrated into a systematic, efficient and economic production unit.

3.2 Annotation of Land-use Plans

In the preliminary design stage the drawing of land-use plans is preferably made on stable transparent overlay, such as Permatrace, superimposed on the soils or land-use classification photo-map. In this way the soils and classification data, as well as the fundamental land characteristics, are clearly visible during the whole of the planning and drawing operation.

Again the liberal use of different coloured pencils makes for a ready appreciation of each significant aspect of the plan and standard symbols and as much detail as possible should be included on the draft overlay so that the plan can be easily understood without reference to any accompanying explanatory write-up.

3.3 Presentation of Plans

Final drawing is best done in black and white ink on further reproductions of the original base mosaics in the interests of clearer understanding on the part of the land-user.

This is most essential as the presentation of a land use-plan is undoubtedly one of the most important aspects of the whole planning exercise. A plan that is not well-presented, and therefore not clearly understood, is not likely to be accepted.

One of the greatest weaknesses in the presentation of plans is brought about by the fact that the planner, having a detailed knowledge of the aims and objectives of a plan and the intricate inter-relationships of the various aspects, tends to assume that what is clear to him is equally clear to the land-user. This does not necessarily follow and despite the plan having been designed in keeping with the user's inclinations it still has to be 'sold' to him—otherwise it stands little chance of being implemented.

A planner must ensure that he imparts his ideas clearly and concisely in a logical sequence similar to that used in its development—viz:—

3.3.1 A review of the overall objective.
3.3.2 An assessment of the factual situation of the area as found by the detailed classification.
3.3.3 The distribution and significance of the natural land units.
3.3.4 The detailed appreciation of each unit within the overall area.
3.3.5 The proposed land use pattern to be superimposed on each unit.
3.3.6 The natural relationships and inter-relationships of all aspects of the plan.

As previously mentioned, the presentation of the classification and planning data on photo-mosaics is a natural aid to ease of understanding by the land-user whilst the availability of the stereo-cover and a stereoscope during the explanation helps maintain his interest as well as assisting the presentation as a whole.

3.4 Types of Planning.

The foregoing planning approach can be employed in varying degrees of detail in:—

3.4.1 *Initial Development Planning*

This type of planning involves the maximum use of air photo-interpretation and the minimum amount of field checking and has as its principal objective that, in the absence of more detailed planning, initial development of

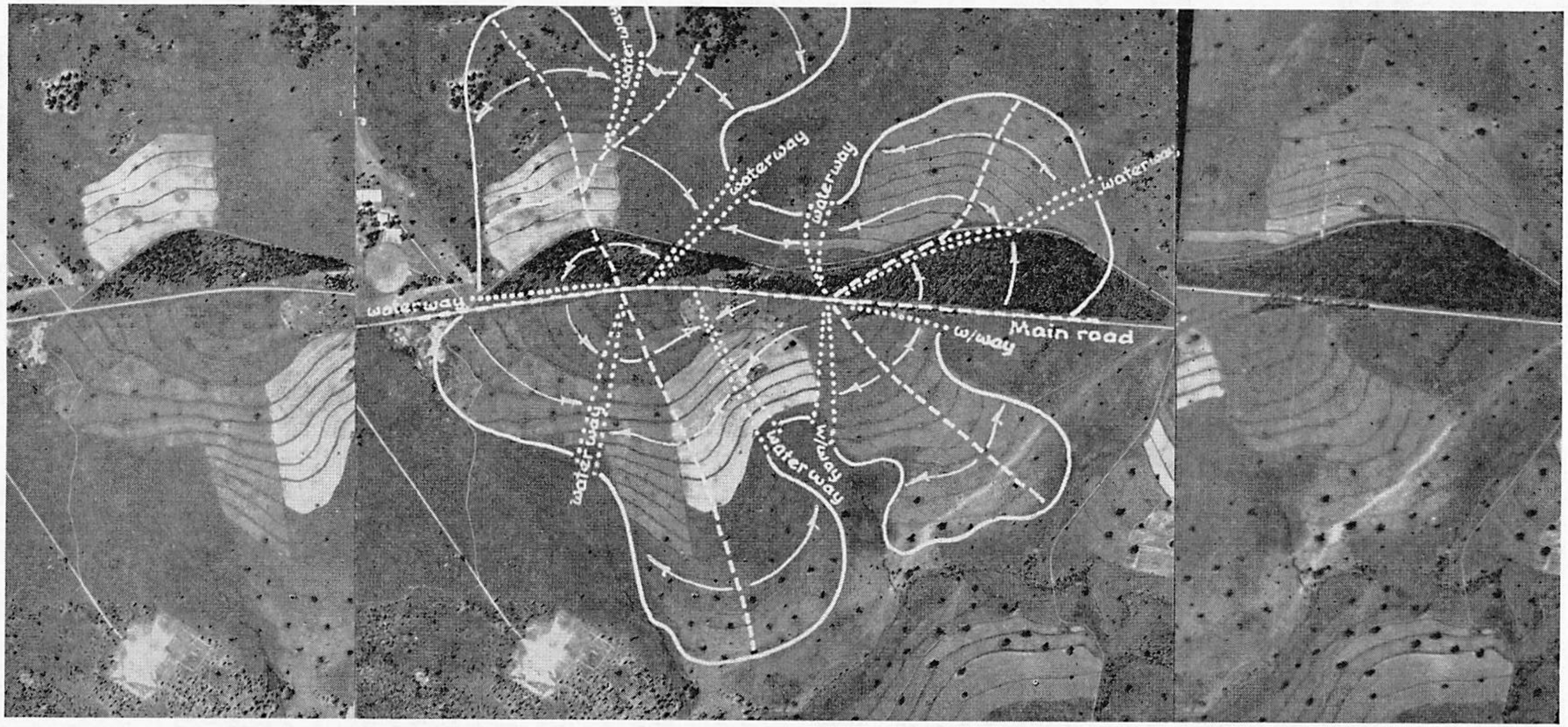

Fig. 8

Stereotriplet showing designed Conservation Layout in which the main characteristics of the Sloping Ridge, Dome & Saddleback are all recognizable.

Photo Scale 1/20,000

virgin and newly opened areas and farms takes place in accordance with natural land features, and that a correct sequence of development and land selection is undertaken to ensure that the initial development will form a framework into which any future more detailed planning will fit with the minimum adjustment and expense.

In many instances these plans can be based entirely on air photo-interpretation to show on a photo-map:—

3.4.1.1 Watercourses (rivers, dambos, vleis, etc.)
3.4.1.2 Obvious non-arable mountain land.
3.4.1.3 Crest alignments.
3.4.1.4 Possible arable land.
3.4.1.5 Water disposal pattern.
3.4.1.6 Possible dam and weir sites.

3.4.2 *Farm Planning*

This is the other extreme from Initial Development Planning, the preliminary air photo-interpretation and land classification being in their most intensive and precise form. The maximum amount of information is extracted from the aerial photographs and the maximum amount of field checks are necessary. (Section 2).

The objectives are to provide the land-user with a sound design for future development based on long-term economic productivity in addition to a comprehensive understanding of his soils and their capabilities.

As previously described the results of farm planning are recorded on air photo-maps, the land use classification map showing the results of the survey and classification of information, whilst the farm plan map shows the recommended layouts and rotation practices for the farm.

3.4.3 *Regional and Catchment Planning*

These two types of planning are considered together as they can be coincidental—being essentially the same in overall approach.

A regional area, though frequently a catchment, is not necessarily so, often being dictated by political boundaries, area size and other considerations.

Regional planning usually has a set predetermined objective. It may, for instance, be that of ensuring that the natural farming system applicable to an area can be fully expressed on a conservation basis irrespective of farm boundaries—in which case homogeneous areas would probably be extracted from aerial photographs as a preliminary aid to subsequent soil and vegetation investigations.

In catchment planning, on the other hand, the intensity of investigation is dictated entirely by the planning objectives in each catchment. These may be:—

3.4.3.1 Erosion control by measures designed to eliminate erosion from all sources simultaneously in which case full farm planning at individual unit level would be required.

3.4.3.2 The siting and construction of dams for irrigation, silt detention, stock watering, water conservation to increase dry-season flow, or to detain and store peak discharges of flood water and release them at a rate not exceeding lower channel capacities.

3.4.3.3 The realignment of existing communications to conform more realistically with local conditions of topography and stream position.

3.4.3.4 Broad topographic appreciations and other measures.

With such a wide variation in the intensity of planning the degree and character of the air photo-interpretation will likewise vary in catchment planning from initial development planning to full farm planning level.

3.4.4 *Specialized applications of air photo-interpretation*

3.4.4.1 Dam Siting

A particularly important conservation engineering aspect of air photo-interpretation is the siting of dams for the purposes outlined in Section 3.4.3.2 relating to Catchment Planning.

Dam siting should also be considered in the overall context of resources appraisal where an essential aspect, particularly of First-Stage Reconnaissance Surveys, is an assessment of what resources exist that could be developed. In this connection an appreciation of the availability and potential availability of water in areas of inadequate rainfall is very often the first resource which has to be considered. (Robertson et al 1968).

Whilst the siting of large dams, such as those required for flood control, can be comparatively simple once the geology is known and local catchment flood history has been analysed, the site selection of small conservation dams is much more difficult as wall heights seldom exceed 20 feet.

Because of the unusual photo-interpretative problems posed by the size of these dams the following method of stereoscopically selecting the best possible site areas evolved by the author and his associates (Jones et al 1962; Jones 1964) is recommended:—

3.4.4.1.1 The boundaries of the area under consideration are marked on the stereo-cover and on a photo-reproduction of the aerial mosaic.

3.4.4.1.2 The drainage pattern and all crests are delineated stereoscopically on the stereo-pairs using wax marking pencil.

3.4.4.1.3 The data in 3.4.4.1.2 is transferred to the mosaic reproduction, the overall picture of stream and crest patterns giving a clear idea of the extent of catchment areas, this being a critical factor in cut-earth spillway design.

3.4.4.1.4 The drainage pattern is then erased from the stereo-cover leaving the stream channels clear for detailed stereoscopic observation.

3.4.4.1.5 Where the topography permits, all drainage lines having a bed gradient in excess of predetermined permissible percentages are discarded, as any steeper gradients will not result in sufficient throwback to give an economic capacity. This does not of course apply in areas of sharply fluctuating relief where only steep gradients exist and where dams may still be a vital necessity for water storage purposes.

Gradient assessment is primarily a matter of photo-field experience on the part of the interpreter. In this respect, however, stereogram photo-keys showing bed gradients of varying percentages are very useful as training aids (Fig. 9). At this stage of the interpretation, the interpreter carries out a stereoscopic reconnaissance of all the streams as well as of the terrain in their immediate vicinity, watching carefully for all physical phenomena of the land

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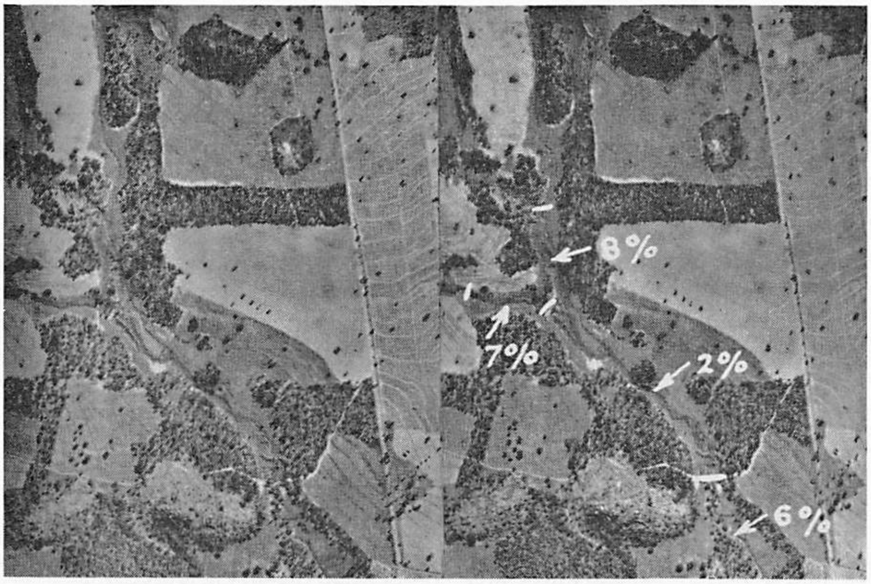

Fig. 9

Training Stereogram—Stream gradients.
Photo Scale 1/20,000

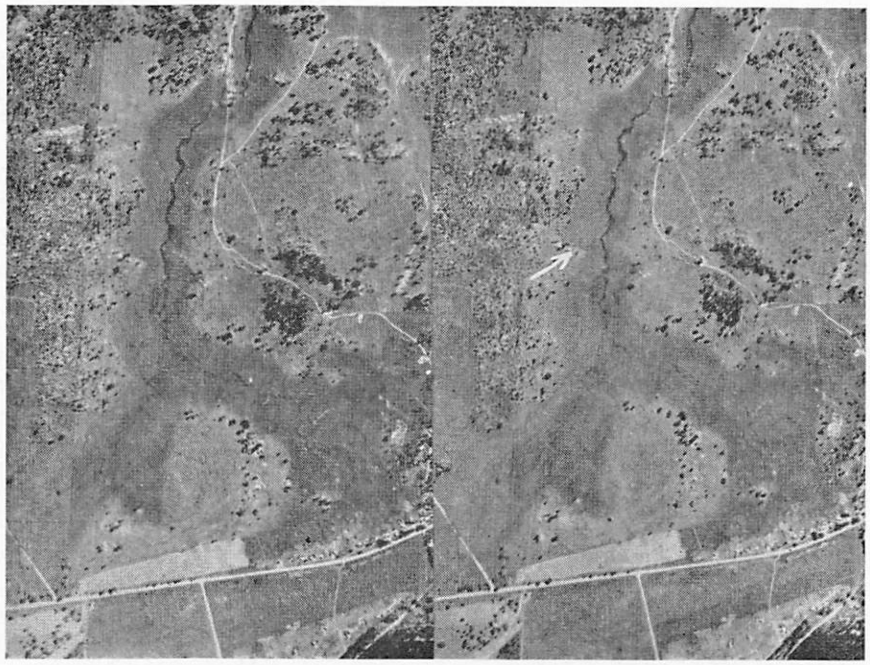

Fig. 10

Stereogram of Dam site. Note rock outcrop at arrowhead—ideal for 'keying in' dam wall.

Photo Scale 1/20,000

Fig. 11

Training Stereogram showing incorrectly sited existing dam and its correct siting position.

Photo Scale 1/20,000

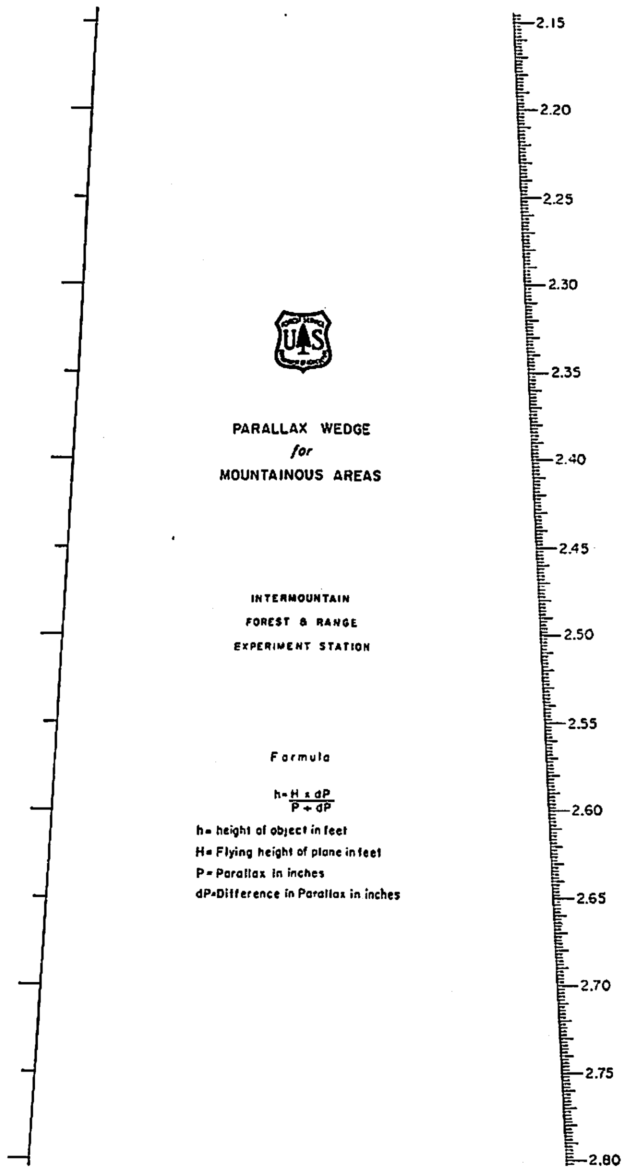

Fig. 12

Parallax Wedge—Actual Size

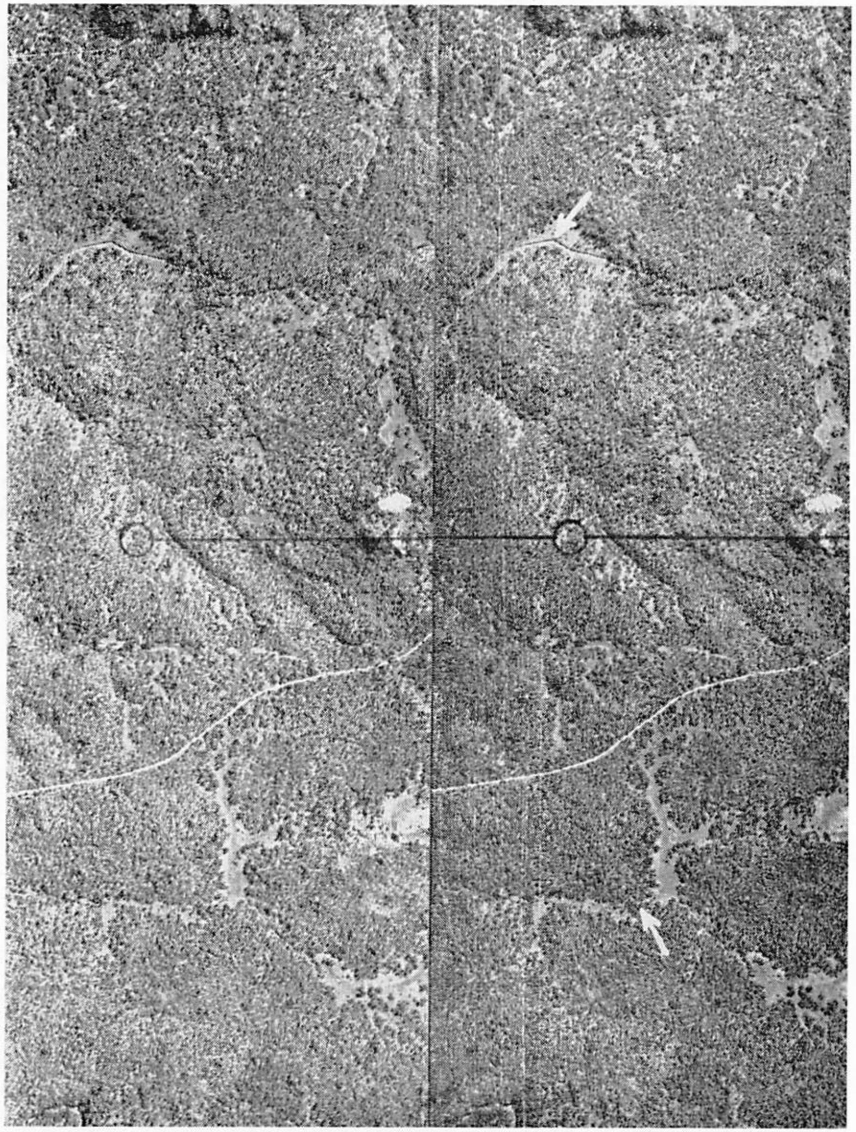

Fig. 13

Stereogram showing Dam sites on stream gradient changes, marked by arrowheads.

Photo Scale 1/20,000

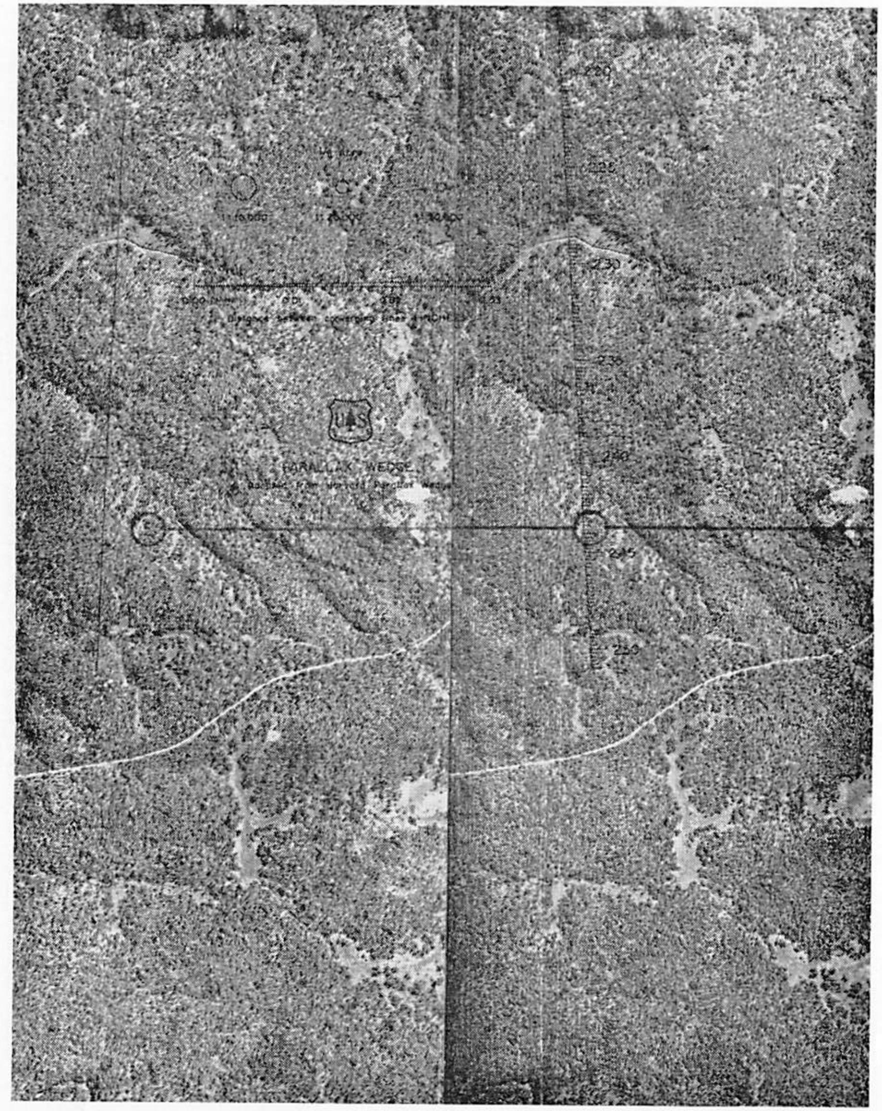

Fig. 14

Stereogram showing Parallax Wedge reading on true streambed of top dam site 2.288 in.

Photo Scale 1/20,000

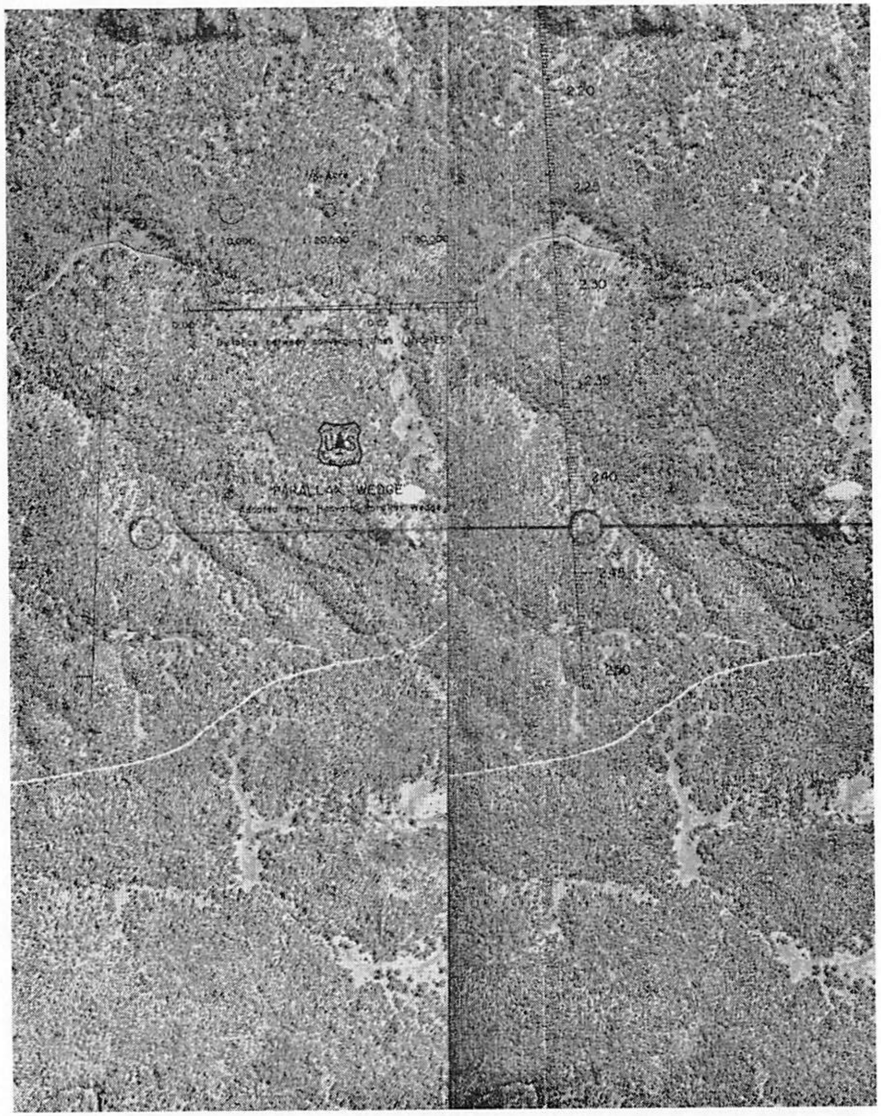

Fig. 15

Stereogram showing Parallax Wedge reading on left hand streambank of same site at Full Supply Level 2.282 in.

Photo Scale 1/20,000

N.B. Stream flowing from Right to Left.

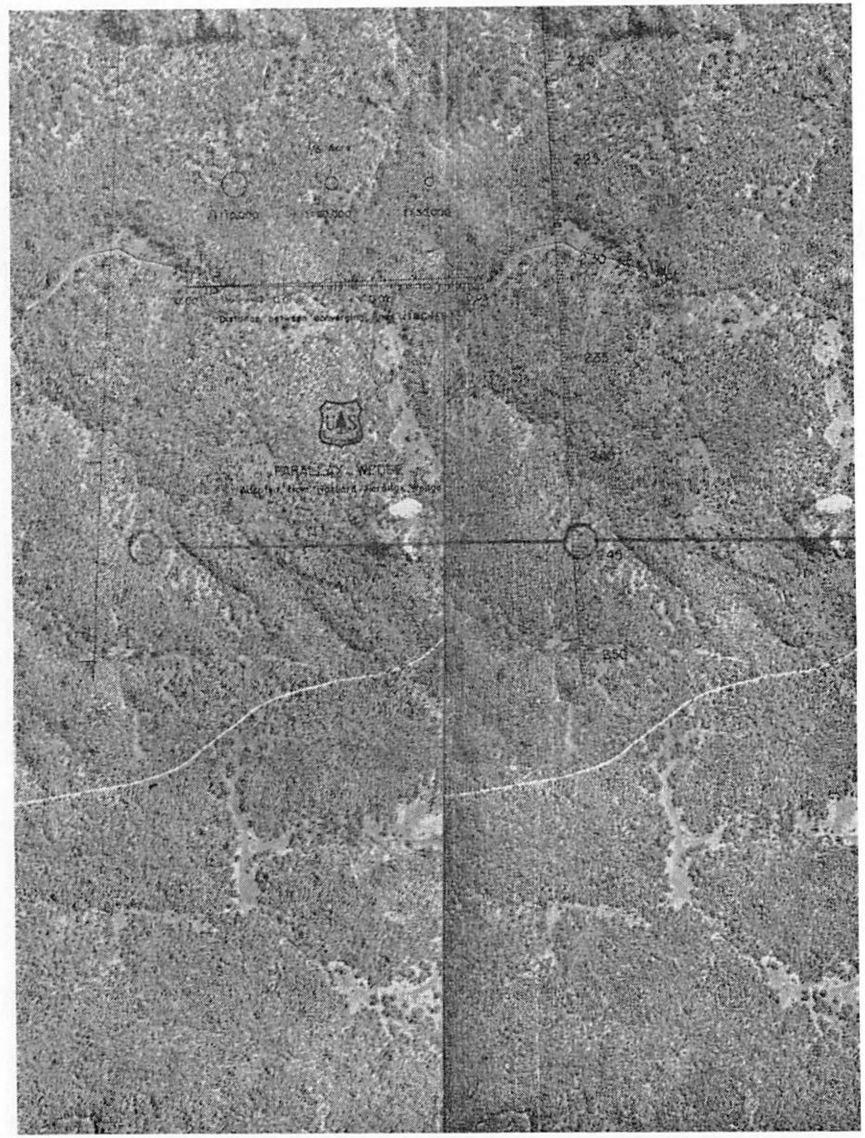

Fig. 16

Stereogram showing Parallax Wedge reading on right hand streambank at Full Supply Level 2.282 in.

Photo Scale 1/20,000

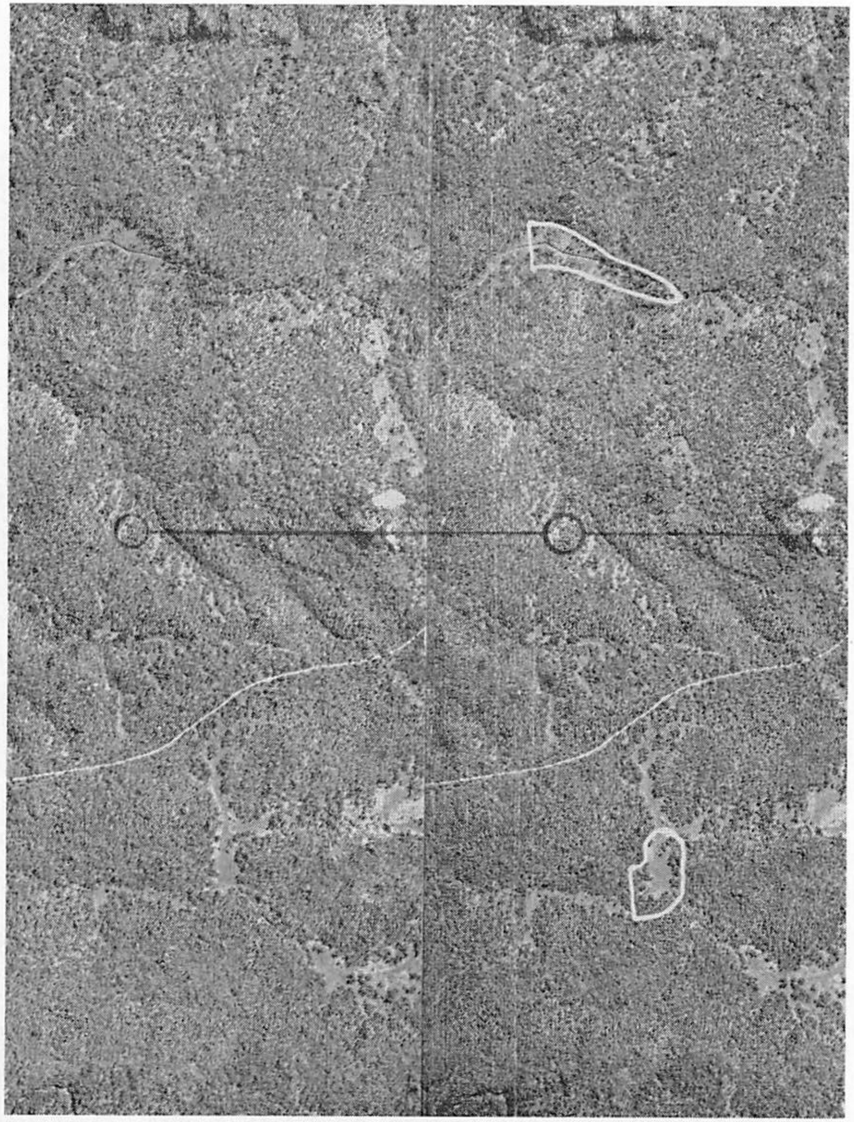

Fig. 17

Stereogram showing the same dam sites with Full Supply Levels stereoscopically form-lined.

Photo Scale 1/20,000

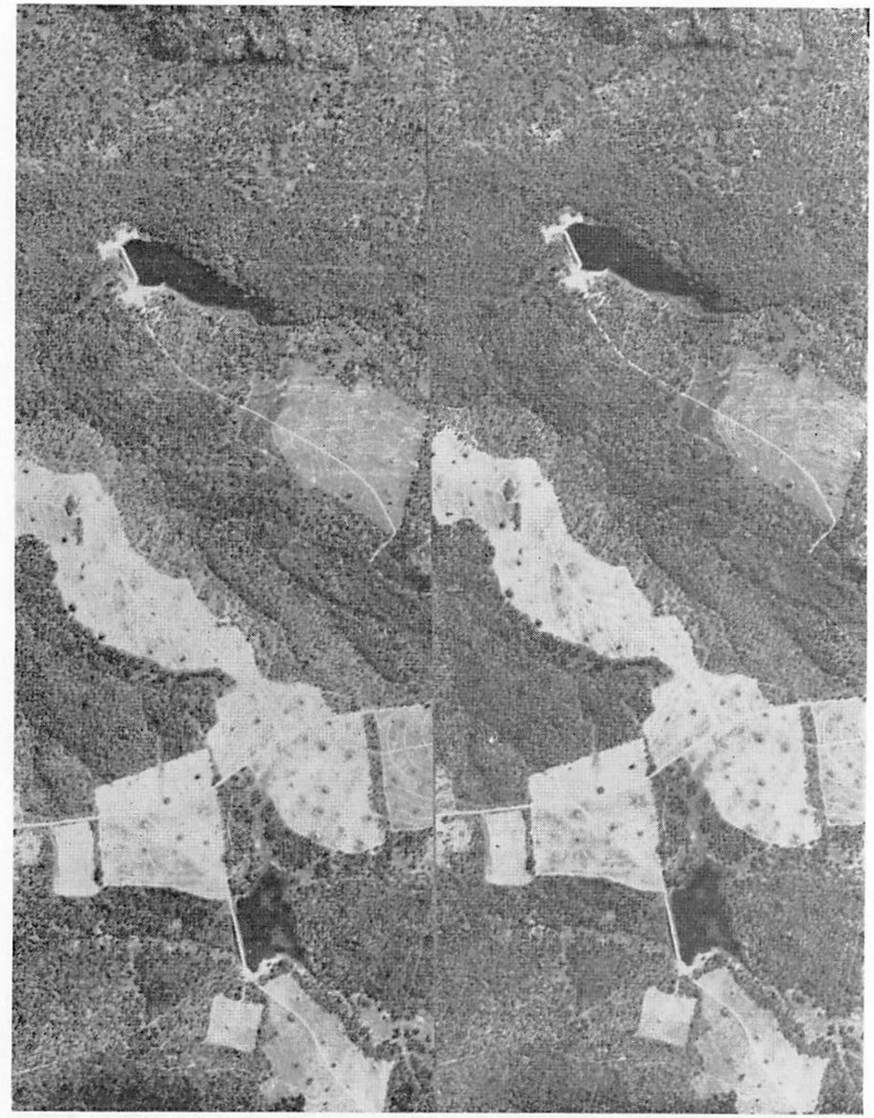

Fig. 18

Stereogram showing the same stream a few years later. The dams have been built and filled by the previous season's rains. The stereogram also shows opened-up tobacco fields with crest-sited access roads and contour ridges.

Photo Scale 1/20,000

Continued from page 65

surface which indicate flatness of gradient. These include:

3.4.4.1.5.1 Areas of natural wetness such as swamps, sponges and reedbeds.

3.4.4.1.5.2 Meandering streams, ox-bows and cut-offs.

3.4.4.1.5.3 Silt bars in river bottoms.

3.4.4.1.5.4 Right-angled junctions of tributaries with main streams.

3.4.4.1.5.5 Wide contour terrace interval of nearby cultivated lands.

Additional factors which always have to be borne in mind and looked for are:

3.4.4.1.5.6 Stream junctions — for maximum storage.

3.4.4.1.5.7 Natural bottlenecks, e.g. where geological dykes cross streams.

3.4.4.1.5.8 Potential borrow areas—to facilitate building.

3.4.4.1.5.9 Rocky sites which may provide ideal erosion-free spillways or foundations for concrete construction (Fig. 10).

3.4.4.1.5.10 Rock bars on river bottoms which favour weir construction.

3.4.4.1.6 On the drainage lines not discarded in 3.4.4.1.5 all points where an increase in gradient occurs are marked. These, and/or the nearby upstream areas, are the logical places for dam construction, ground conditions permitting, as maximum throwback will be achieved (Fig. 11).

3.4.4.1.7 The pin-pointed sites and nearby areas are thoroughly scrutinized stereoscopically to assess spillway conditions, spillways with a return in excess of local permissible limits being generally undesirable because of the erosion hazard. This does not of course apply in rocky areas where sites may prove ideal for rock spills or for the construction of weirs.

3.4.4.1.8 Using a parallax wedge, approximate wall heights are measured and approximate wall volume quantities and water storage capacities calculated from relevant formulae.

3.4.4.1.9 All site areas where wall volume/capacity ratios are obviously uneconomic are discarded.

In very flat terrain, where changes in stream gradient may not always be apparent, site area selection is largely a matter of taking into account all those physical phenomena of the land surface enumerated in 3.4.4.1.5 as well as having an intuitive 'Eye for a Site' built up from photofield interpretative correlations. By following the procedure outlined, all possible areas where conservation dams can be sited are stereoscopically pin-pointed. Subsequent field examination might, however, prove some of these areas to be not feasible or uneconomic owing to factors not apparent on the photographs and it is stressed that aerial photographs are only a useful tool in the selection of conservation dam site areas. Gradient assessment and parallax measurements are limited in accuracy even for experienced interpreters as tree, bush, and grass canopy can seriously affect the interpretation of site conditions. Thus final site selection on the photographs is not possible, the interpretation being confined to the pin-pointing of the best possible site areas for field investigation and to the assessment of provisional wall volume quantities and water storage capacities with a view to determining economic feasibility of construction. In much the same way, therefore, as with air-photo analysis in its application to soil survey and land classification, the stereoscopic examination has been designed to economize on the amount of field control necessary and thereby reduce overheads in this the most expensive phase of the dam selection survey.

The estimation of approximate wall heights, earthwork volumes, and water storage capacities can be carried out with the aid of a parallax wedge (Fig. 12). When using this instrument for assessing approximate wall heights, the height measured in each case is that from the *true* stream bed to the proposed spillway level. As no measurement of the height of an *in situ* structure is involved, but merely the spatial assessment of the height of an imaginary water line, extreme accuracy is not possible, and the following procedure for using the wedge has been found to be the most practical:

3.4.4.1.10 The differential parallax value in feet corresponding to each of the smallest graduations on the wedge is calculated from the adjusted photo scale and the precise parallax formula

$$h = \frac{H \times dP}{P + dP}$$

where h = height of measured object in feet

H = height of aircraft above ground datum in feet

P = absolute stereoscopic parallax in inches

dP = parallax differences in inches.

On 1:20,000 scale photographs flown to within prescribed present day tolerances, the differential parallax value will be found to amount to approximately 5 feet per calibration.

3.4.4.1.11 The wedge is then oriented until a single calibration rests exactly on the stream bed within the stereo-image of the potential site area (Fig. 13-14).

3.4.4.1.12 The spatial position of the calibration corresponding to a difference of 15 feet (the maximum water depth of most conservation dams) is noted and the wedge shifted so that this calibration cuts each stream bank in turn, these points being marked on the photographs with a fine needle point (Fig. 15-16). As the walls of conservation dams seldom exceed 500 feet in length, this distance being equivalent to less than 0.4 inches on 1:20,000 scale photographs, anomalies in the differential parallax values caused by deformations of the stereo-model will be comparatively insignificant when the wedge is only moved over this short distance.

3.4.4.1.13 From the two points marked on the stream banks, the full supply level throwback is then form-lined stereoscopically by eye (Fig. 17-18). The parallax wedge is not used for this purpose as the tilts and model deformations present in varying degrees in all so-called vertical air photographs can cause appreciable errors in the differential parallaxes read between points more than about ½ inch apart on 1:20,000 scale photographs.

3.4.4.1.14 Approximate wall volume quantities and water storage capacities are then calculated in the usual way. For practical purposes of photo-measurement, the wall length measured along the crest is taken to be the same as the length of the water-line measured along the wall at full supply level, but to allow for actual ground differences between these two lengths caused by the freeboard a 10 per cent costing factor should be added to the wall volume quantities calculated from the parallax readings.

This dam siting procedure may form part of each of the different planning procedures mentioned or it may be undertaken as an entirely separate exercise for a specific purpose. The same technique of stereoscopically pinpointing sites on the basis of fluctuations in stream gradient and calculating their approximate wall volumes and storage capacities is now being used in France to site hillside reservoirs to meet the need for additional water supplies resulting from increasing farmer and tourist demands. (Corbet 1966).

3.4.4.2 *Erosion Assessment and Control*

On stereo-cover of 1.25,000 scale or larger it is quite easy to see whether erosion gullies are active or stabilized and to differentiate between those that can be repaired by simple hand methods and those that can only be repaired with the aid of heavy mechanical equipment. In addition, if the positions of individual gullies are plotted on gridded stable polyester overlays, and the total yardage of each type of gully obtained with magnifying distance measurers it is quite apparent where the erosion 'blackspots' are when the overlays are superimposed on photo-mosaic reproductions of the same scale. It is then a simple matter to allocate priorities for reclamation work. (Jones and Keech 1966).

3.4.4.3 Range Management

An important aspect of the erosion technique mentioned is the siting of conservation dams in the way previously described (Section 3.4.4.1).

The spacing of these dams is important. Wherever possible it is advisable to site them 2-2½ miles apart, practical experience having shown that cattle utilize grazing most efficiently when they do not have to walk more than 2,000 yards in any direction to obtain water.

Again, gridded polyester overlays with a 2½ square mile grid are useful—this grid interval acting as a check on the correct spacing of the dam sites and on where additional cattle dipping tanks might be needed.

Besides improving the grazing 'spread' such a dam-siting exercise helps to arrest the movement of sediment and gives better distribution of water supplies leading to increased irrigation potential and an improvement in human and animal carrying capacities. It also helps indirectly to control erosion by reducing the risk of gullied cattle tracks, excessive overgrazing and the trampling characteristic of too heavily used watering points—whilst encouraging the local inhabitants of an area to take a hand in any needed gully repair work themselves.

In areas which have obviously been subjected to heavy overgrazing over long periods of time a stereoscopic study of old and new air photo-cover, if it exists, can be extremely useful in helping to assess the amount of bush encroachment which has taken place in the time interval between the successive air photo missions (Figs. 19-20).

In surveys for the planning of pastoral utilization the same general principles as used for planning in cropping areas are called on. The vegetation is surveyed and the field mapping unit is an area of homogeneous vegetation type visible on the aerial photograph as a physiognomic photoanalytical unit. The vegetative and floristic characteristics of the area can then be coded together with physical soil characteristics to give an overall indication of the site condition so helping to arrive at an intelligent estimation of the carrying capacity as a basis for planning.

Owing to the rapid changes which are possible in vegetation when it is being used, and the difficulties of translating utilization characteristics from one area to another, attempts to design specific vegetation use—capability classifications have not proved successful. The most generally satisfactory scales of aerial photographs and air photo mosaics used for field mapping and final mapping in ranching areas is 1:20,000 to 1:25,000.

4. CONCLUSION

4.1 Standard operational procedure

It has been shown in this discussion that stereoscopic pairs of aerial photographs, used in conjunction with air photo-mosaic reproductions, are most useful aids to agricultural development planning, the standard operational procedure for terrain investigations at all levels assuming the following more or less uniform pattern:—

4.1.1 Study of all available maps, geologic and agronomic references.

4.1.2 Initial stereoscopic study of aerial photographs.

4.1.3 Selective field reconnaissance after 'on the spot' consultations with local staff.

4.1.4 Selective field sampling and provisional control of air photo boundaries.

4.1.5 Laboratory testing and summary of data.

4.1.6. More detailed stereoscopic study of aerial photographs and mapping.

4.1.7 Selective field checking and detailed control of air photo boundaries.

4.1.8 Transfer of controlled air photo boundaries to base maps.

4.1.9 Preparation of reports and tables and reproduction of maps.

From the foregoing it can be seen that the use of the aerial photograph does not preclude the necessity for field investigation. It does however enable areas to be investigated much more quickly and accurately, which is very significant as the field work can account for more than 50% of the total costs of a survey.

4.2 Methods of extracting data and rates of working

Depending on the size of the area under investigation information can be extracted from the stereo-cover either run by run according to the Flight Plan or Photo Index

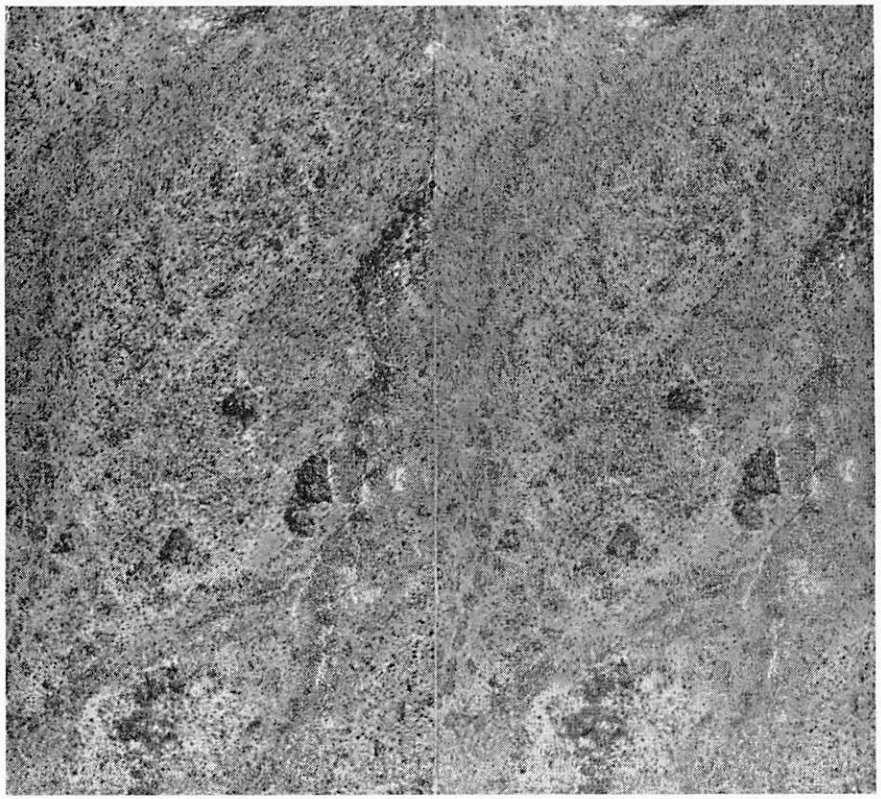

Fig. 19 (1950)

Fig 20 (1955)

Bush Encroachment Evaluation—Matabeleland—Rhodesia Lowveld

Stereograms demonstrating value of examining aerial photography of different dates covering the same area.

Photo Scale 1/20,000

Mosaic—this is the fastest method and for this reason the more usual—or alternatively, in the case of large areas, it can be extracted by landscapes. This is a slower method of working but a more detailed interpretation usually results.

The rate of working varies with the photographic scale and amount of information called for. For detailed surveys, such as those required for planning down to farm unit level, 15,000—25,000 acres per day can be stereoscopically analyzed and defined on 1:25,000 scale aerial photographs—viz. about 5 complete photographs per day on the basis of demarcations being carried out within match lines drawn parallel to the photo edges through the transferred principal points and approximately mid way within the lateral overlaps between flight strips.

Stereoscopic air photo-interpretation is very exacting, if done properly, and imposes a certain amount of mental strain. For this reason it should be done, whenever possible, in the morning when the mind is clearest and the judgement sharpest. In the author's experience the rate of interpretation is always appreciably faster in the morning than in the afternoon, when interpretative efficiency also falls off sharply.

A whole morning's work of about 5 hours should be allowed for the initial stereoscopic interpretation of a 2,000 acre farm unit and transfer of the photo-analytical data to a field mosaic in the manner explained in Section 2.

Many field scientists claim they cannot afford the time to do a proper initial stereoscopic examination little realizing that by neglecting to do so they are more likely making extra work for themselves. No time at all is saved by going straight on to the ground—this practice, more often than not, resulting in less accurate field survey.

They also fail to appreciate that much of the value of a careful initial stereoscopic air photo-interpretation lies in the preliminary stereoscopic appraisal of the terrain *regardless* of whether any physical information is defined on the photographs or not as it is this stereoscopic *examination* which enables the scientist to make an appreciation of the type of terrain in which he will be working and so plan his access routes and sequence of field examinations accordingly.

4.3 Common Weaknesses

The most common weaknesses in the forms of photo-interpretation described are:—

4.3.1 Failure to align successive stereo pairs of photographs with the photo air base and instrument base in coincidence and at the correct separation distance. This results in incorrect orientation, a deformed stereo-image, eye-strain and inability to see stereoscopically using magnifying binoculars.

4.3.2 Failure to demarcate information within match lines. This results in duplication of detail in the overlap areas of the photographs in the line of flight and between flight strips and so wastes time.

4.3.3 Insufficient use of magnifying binoculars. The mirror stereoscope's accommodation lenses are non-magnifying and should be used for the scanning of terrain on an area basis. For accurate delineation of the data required for agricultural development planning binocular attachments of 3 to 4 power magnification must be used.

4.3.4 Lack of appreciation of the effects of photo-distortions and mosaic errors especially in regard to accurate scale determination and planimetry. It is necessary to guard against the tendency to regard the aerial photograph and uncontrolled air photo-mosaic as accurate maps and to realize that they have limitations as well as advantages in this respect.

4.3.5 Failure to bear in mind the vertical exaggeration of the stereo-image.

Many field scientists, inexperienced in using aerial photographs throw what is possible arable land into a non-arable class on the basis of vertically-exaggerated slopes. This is another argument in favour of using magnifying binoculars which reduce the vertical exaggeration by an amount approximately equal to the binocular power.

Dam sites, slope breaks and crests need initial identification with the accommodation lenses only—for *maximum* vertical exaggeration effect—but subsequent delineation under binocular observation in the interests of accuracy.

4.3.6 Inadequate and unsystematic extraction of physical terrain data, especially minor slope breaks in possible arable and opened arable areas, and too great a tendency to define photo-analytical boundaries on the basis of photo-tones and 'patterning' rather than on more reliable land factors.

4.4 Philosophy of Interpretation

As the aerial photograph is a pictorial representation of the ground, on which all detail is shown in its correct relative position, the general approach to interpretation should be that if there is failure to obtain the basic terrain information required by stereoscopic air photo study then this is not so much the fault of the photographs but of the person using them who has simply not progressed sufficiently, or completed enough research or selective field checking, to obtain the maximum amount of data, which is *reasonably* extractable, from the stereo-image.

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SOME CONSIDERATIONS BASED UPON OPERATING EXPERIENCE WHICH AFFECT THE AGRICULTURAL ENGINEERING ASPECTS OF THE DEVELOPMENT OF MODERN SUGAR CANE ENTERPRISES

by

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Presented at the Spring National Meeting of the Institution at Silsoe, Bedford, on 27 *March* 1969

Summary

Some of the principal considerations which influence the development of sugar cane enterprises are discussed. They have been selected as having a particular bearing on agricultural engineering—the influence of climate, the nature of land surface and soils, and the requirements of an increasingly mechanized agriculture. Reference is made to their impact on the layout of sugar cane land, the use of irrigation and the development of cultivation and harvesting machines; the discussion is illustrated by examples drawn from a wide international field.

Agricultural Engineering in Sugar Cane Production

The production problems of sugar cane depend heavily for their resolution on human, agronomic or engineering considerations and these are, to a degree, interrelated. However, the difficulties in which existing enterprises find themselves or which face new ones, increasingly require the successful application of engineering. The tropical and subtropical world is strewn with sugar enterprises in various degrees of difficulty and new enterprises present a variety of engineering problems. In recent years these have been added to as a result of advances in agronomy, (e.g. in weed control, in pest control, in irrigation, in nutrition control) because of changes in social conditions, (e.g. an increasing and more general unwillingness to do manual work or the physical lack of labour) and by changes in the costs of agricultural inputs compared with the price of sugar cane. Today nearly all new sugar cane areas are being laid out in the so called 'developing countries', in many of which the agronomic and engineering problems are often made more difficult by the limited choice of site dictated by the absence of alternative ones, or by political considerations. By contrast, Cuba, where the planned rationalization and redistribution of the world's largest sugar industry is in its early stages, is favoured by conditions of land, climate, an authoritarian government, a lack of labour and an economy of scale—all of which should make the exercise both in design and in practice an agricultural engineer's paradise. Formerly sugar cane enterprises grew, and flourished or died, principally as a result of their own efforts. By today a situation has developed where a small number of large international companies, principally two British and two American, operating sugar interests in several countries under a very wide variety of conditions and backed by their own research organizations, contract to help existing enterprises, or to carry out the research and pilot exerises which lead to these companies laying out new industries including their complete operation and management, and the training of new staffs. It is against a general background and the experience of such a company that the observations which follow are made.

The considerations which affect the development of a new sugar cane area or the extension or the improvement of an old one, and which have repercussions of considerable engineering significance are—climate, more especially rainfall and evaporation, physiography and soil types, hydrology, agricultural practices, the nature of harvesting and the requirements of cane transport.

Agricultural engineering plays a dominant role in:

(a) the detailed design and installation of drainage and/or irrigation systems,
(b) the layout of fields,
(c) the design and use of agricultural machinery necessary to cultivate the crop,
(d) the design and use of harvesting machinery, and
(e) the design and operation of the transport system and its equipment.

Today agricultural engineers are becoming, increasingly, key personnel in sugar cane agriculture.

Climate

Rainfall and evaporation determine whether irrigation is

*Bookers Agricultural Holdings Ltd.

essential or whether it should be used in a supplementary role, the drainage load, the time available for mechanized cultivation, and the timing and the duration of harvests. In many new areas paucity of meteorological data is a major handicap, especially since economic projections require a quantitative base related to probability. To project the economics of irrigation upon rainfall data only is extremely unsatisfactory, for if land is cheap it may well be more economic to farm extensively than intensively, as would appear to be the case in an area of Africa receiving an average annual rainfall of 45 in. To date the extensive use of land has been one reason for the strength of Cuban competition even though large areas receive less than 45 in. of annual rainfall. At the other extreme it can be economic in parts of the W. Indies to irrigate sugar cane receiving 80 in. to 100 in. of rain per annum supplementarily during the drier months because of the high value of land and its scarcity. In this instance, the faster and earlier replanting of fields and the quicker get away of ratoon stubble account for from one half to one ton of extra sugar per acre—up to about £17 per acre directly from supplementary irrigation excluding the factory profits from the extra sugar at marginal costs of extraction depending on the price of sugar assumed.

Levels of yield are key data in any development exercise. The risks inherent in predicting yields from rainfall data are obvious. Provided temperatures are not seriously limiting, e.g. due to extremes of latitude or elevation, yields in tons of sugar cane per acre equal about one half the annual rainfall may be expected—a very rough rule, see Table 1.

TABLE 1

Some relationships between average annual rainfall [ins.] and the yield per acre of sugar cane in the absence of irrigation

Area	*Rainfall (in.)*	*Yield tons of cane/ac*
Antigua	45	23
Barbados......	45-70	22-40
Parts of St Kitts.....	65	35
Jamaica	55-90	30-40

Numerous, largely unsuccessful, attempts have been made to try to relate cane yields to rainfalls for specific cane areas—usually using annual rainfalls, or rainfalls during selected periods of the year—in order to predict the response to irrigation. This is to be expected, since the available moisture 'deficit' in the soil is the factor which limits growth. In certain circumstances, e.g. St Kitts and parts of Jamaica, it proved possible to relate cane yield on a plantation scale quantitatively to the 'deficit' of available water accumulated during the growth of the crop. Use was made of the relationship between the development of the cane leaf canopy and the age of the crop from its planting or harvesting (in the case of ratoons)—i.e. f $(=E_t/E_o)$—and arbitrary assumptions relating to soil available water storage capacity and run-off characteristics, all fed into regression analyses to obtain the highest regression coefficient. Resultant regressions, accurate at 1000:1, confirmed the experimentally derived relationship obtained in Hawaii viz., that generally the elimination of one inch of 'deficit' produces about one ton of extra sugar cane/acre. A more precise relationship was found to be:—

'the yield in tons cane per acre $(y)=48.4-0.20x-0.0124x^2$ where x is the accumulated "deficit" in inches'.

An extension of the method using existing rain gauge data established the relationship between response to water and locality, as well as the probability of the effects, from which it proved possible to evaluate the economics of irrigation. In areas where 'deficits' cannot be adequately related to the long term yields of sugar cane and where temperatures are limiting over periods of the year, as for example, at high elevations in parts of E. Africa, a rough approximation of response to water can be obtained by using the derived mean ratio of tons of cane per acre to computed total 'deficit' during the growth cycle. The value is substantially less than the values obtained nearer sea level.

Rainfall, by determining the duration of harvest determines the capital requirements of harvesting and transport operations as well as the capital invested in the factory—all critical factors affecting the overall economics of sugar production. Rarely are harvests shorter than four months; five to seven months are common, and in some favoured areas such as e.g. Peru, Hawaii and parts of E. Africa, harvests can extend from nine to twelve months. The continuity of harvesting once commenced in important—another function of rainfall. Where two harvest periods are possible, as in Guyana, the disadvantages of the interruption are compensated in part by the greater flexibility of crop size possible by resort to the trick of bringing forward the reaping of cane from one crop to the previous one.

The variety of acceptable rainfall patterns is very wide indeed. Figure 1 illustrates the mean monthly rainfalls of the sugar areas of Ghana, Cuba, Eastern Jamaica, Kenya and Guyana. The Peruvian sugar industry with a desert climate and only a negligible rainfall represents the extreme and allows of uninterrupted all year harvesting.

Probability diagrams illustrate the other differences which arise when constancy of rainfall patterns becomes important. Rainfall probability curves for an area of St Kitts and Guyana are illustrated in Figure 2. Differences in rainfalls and their probabilities assume their greatest importance in harvesting, especially when the mechanization of harvesting operations has to be contemplated. Conversion from hand operations to the greater use of machines requires not only a substantial capital investment in the transport system but also in factory capacity, and both increase with shorter and more interrupted harvests. It is therefore important that the effects of rainfall variability be forecast well in advance of any changes in harvesting procedures becoming necessary. The method to be used relies upon the relationship between accumulated 'deficit' and the bearing strength and shear strength of the main soil types. Such considerations appear to have been sadly ignored in the case of certain African sugar cane areas stituated on Black Cotton soils, for which transport systems and harvesting schedules have been very badly designed. At the other

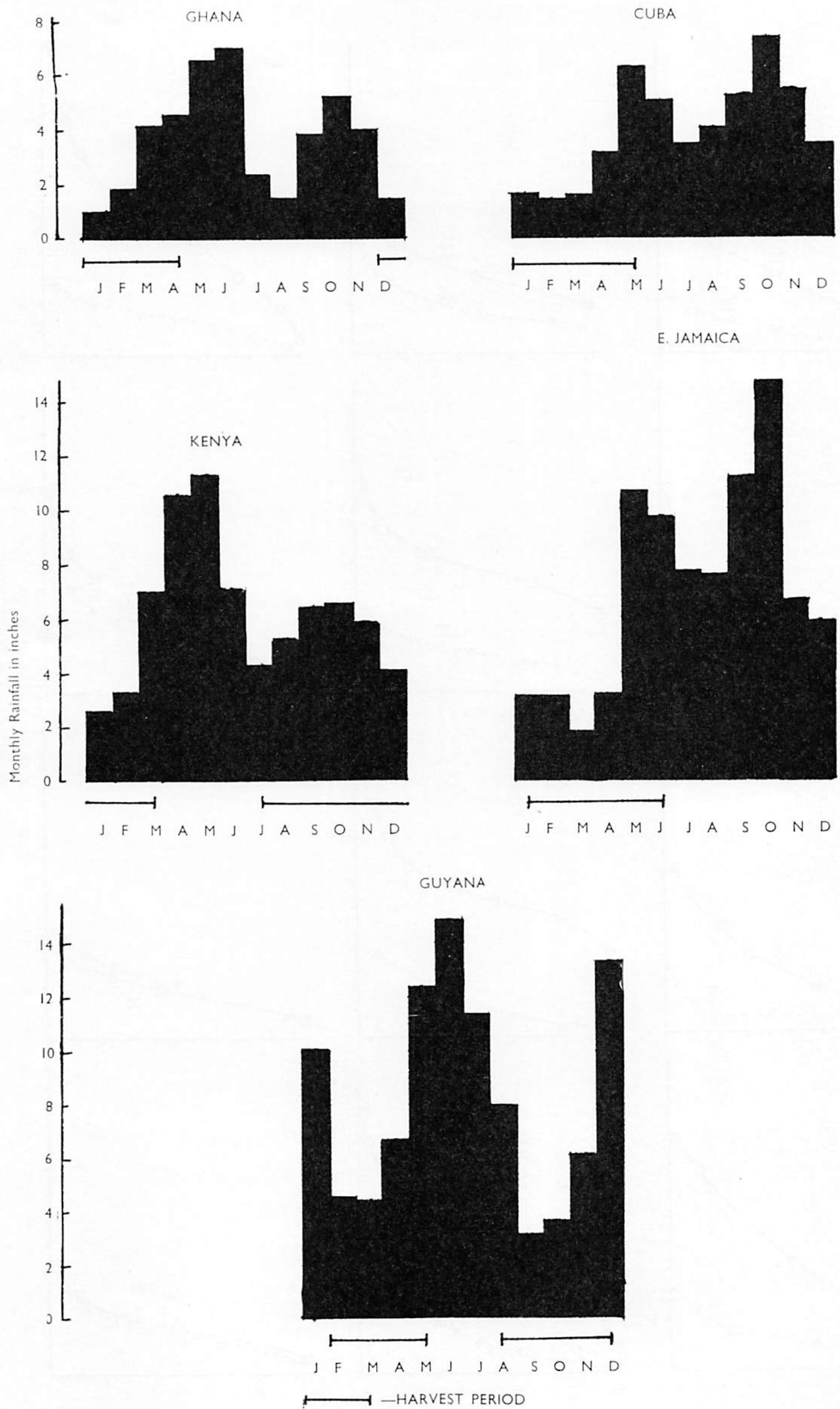
GHANA
CUBA
E. JAMAICA
KENYA
GUYANA
Monthly Rainfall in inches
0
2
4
6
8
10
12
14
J F M A M J J A S O N D
—HARVEST PERIOD

Figure 1

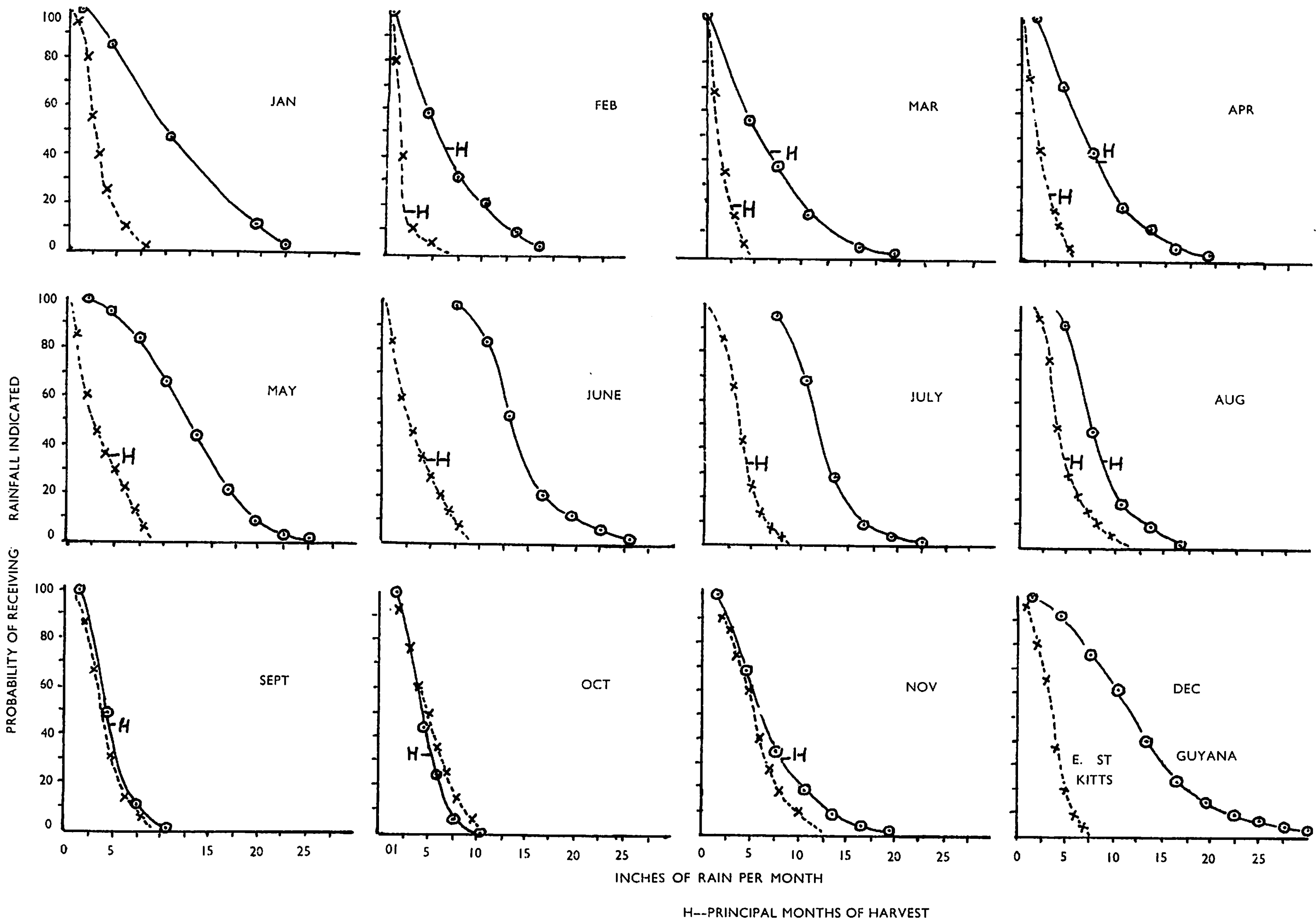
PROBABILITY OF RECEIVING RAINFALL INDICATED
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
H
E. ST KITTS
GUYANA
INCHES OF RAIN PER MONTH
H--PRINCIPAL MONTHS OF HARVEST

Figure 2

extreme, the mechanized harvesting methods hurriedly adopted in Hawaii, often under unfavourable weather conditions, were only possible because of the extremely favourable physical properties of their deep red latosoils.

The problem of land and plantation layout

The topography, hydrology and soils conditions to be coped with in sugar enterprises are extremely varied. The problems they cause are difficult enough where new sugar cane areas are laid out, but doubly so when existing layouts or enterprises have to be adapted to changed circumstances of operation—particularly to increased mechanization. In laying out new areas or extending old ones, detailed soil and topographic maps are requested, the latter with vertical increment contours every five feet unless the area is very flat and/or is likely to be furrow irrigated, when an accurate topographic survey based upon hundred feet intersections becomes necessary. Were choice free and the long view taken, land with slopes in excess of five per cent and certainly ten per cent would be avoided because of the limitations of existing harvesting machines.

The plantation unit is the field. Formerly, field sizes were determined by topography where this was limiting (it also determined field shape), by the small size of plantations (many of which have since either disappeared or have been amalgamated), and the necessity to manage fields as entities, by having to haul animal drawn loads of cane to access road (headlands or 'intervals') and by the need to isolate and confine accidental or deliberate cane fires. In this way fields of about ten acres became the practice except where topography intervened. Today, the principal considerations are becoming increasingly the efficient use of machines for cultivation and the likely requirements of a highly mechanized harvesting operation. Fire control remains but is now greatly facilitated by the use, planned or in an emergency, of motorized graders or bulldozers. The dimension of a field, parallel with the direction of cane rows is influenced by such factors as the length of run of irrigation water if furrow applied, the ease with which residual furrow water can be discharged completely into field drains using the minimum of land forming, the fall of the land and, in areas where rain interferes with harvest, by the number of passes of loaded carts down the same infield track in relation to the risk of rutting and the damage to cane cultivation which this can cause. The dimension in this direction tends to be between 200 and 350 yards; the flatter the land, the drier the harvest and the more physically stable the soils, the longer this dimension can be. More and more, where topography permits, fields are being consolidated into blocks managed agronomically as a unit, in such a way that cane rows in successive fields align accurately and thus permit of long runs both of cultivation equipment, aircraft and mechanized harvesters. Today, twenty and thirty acre fields are becoming commonplace and under favourable circumstances without irrigation, 100 acre and larger fields are being used. The largest fields are usually found where cane yields are light, say below about 25 tons can per acre, but Hawaii is a notable exception. Steeply rolling or hilly land, of which there is much in the former British West Indies and in South Africa, causes special problems of field layout, the dominant consideration being the gradient and distance apart of access roads, the disposal of road and soil run-off and, when reaping becomes mechanized, the direction of cane rows. The difficulties are immeasurably increased where such areas have heavy clay soils and uncertain harvest weather as in parts of the West Indies. Much of this land will not accommodate mechanized reaping but can be harvested by manual cane cutting and mechanized cane loading.

Mechanized cultivation and harvesting operations are favoured by rectangular field shapes and straight and parallel cane rows so that as land becomes increasingly undulating the conflict increases between the demands of surface irrigation, or surface drainage or soil conservation and the ease of accommodating mechanized operations. Greater use is being made of terrace drains designed in such a way as to be integral with between-field access roads, but generally the reconciliation of conservation practices with the demands of mechanized sugar operations leaves much to be desired over large areas of the sugar world. The stringent requirements of furrow irrigation on rolling land have been met in the highly mechanized Hawaiian industry, but this has been aided by very favourable soil physical properties, a biennial cane harvest, an elaborate system of repairing damage to cultivation brought about by harvesting and, significantly, by a most highly trained field staff at all levels.

Guyana

Many sugar industries and some developing ones are in areas where the combination of regional drainage, soils and rainfall combine to present special, and difficult, development problems; the Guyana industry is probably the world's most difficult. The area is an alluvial coastal plain just above high tide or just below it, with a mean annual rainfall of ninety-nine inches (see figures 1 and 2), a universally high water table and extremely heavy montmorillonitic clays, the lowest areas (about one third of the area in cane) being generally nearest the shore line and highly saline. Most of the land is backed by huge freshwater swamps which act as irrigation reservoirs at very low heads, and whose seawards edges of highly acid tropical peat have been incorporated to varying degrees into the cane producing areas. Creeks and rivers have cut through the clays and peats and given rise to slightly more elevated, free draining, less clayey and more fertile levee soils. The lower lying land is protected by sea and river dykes, through which drains discharge by gates controlled in accordance with the state of the tide or through pumping stations. In each case the drainage system must cater for surge capacity; On the higher areas drainage is direct by gravity. The omnipresence of water and the complete absence of road materials as well as the very level nature of the land have caused the evolution of layout illustrated in figure 3. The whole system caters for the control of water table depths, the maximum shedding of rainfall to relieve the highly impermeable soils of their internal drainage load, the control of soil salinities, crude flood irrigation procedures, the deliberate flooding of fields as a fallowing procedure, water transport of all cane (which requires a canal system at a higher level than the drainage canal system surrounding the fields on three sides leaving the fourth side for the drainage canal) and the controlled recycling of drainage water (subject to limitations imposed by salinity) for irrigation purposes. Because of the disposal of spoil from the canals and drains, each field is saucer shaped, being bounded by an inclined 'dam-bed' which is cultivated but cannot be flood fallowed or flood irrigated. The fields proper are laid out in beds of varying cambers, separated by open drains. The beds are 5.5, 11.0, or 16.5 yards wide (centre to centre of drains) the narrowest beds being favoured on the more saline areas and the widest on the freer draining more elevated soils. Two rows of cane run the length of the narrowest beds; elsewhere most frequently the rows run across the beds. With the heavy incidence of rain, drainage water accumulates in the system to the point where the sloping sides of the beds and sometimes whole beds, are flooded. Experience has indicated that to manage this land the system has to be capable of discharging 2 in. of rain in 24 hours. The Drainage Factor is a very high one; a factor of 1 in. has proved adequate in other pump-drained areas which suffer heavy precipitation in the west season, e.g. in the Niger valley and in the Western area of Jamaica. The Guyana system requires a high degree of engineering design and skill, in the layout and operation of the hydrology of the plantations. Increased mechanization of agricultural operations may require a radical redesign of the system, more particularly the method of managing the soils and the infield layout, and perhaps the rationalization of field sizes also.

St Kitts

In other sugar cane areas difficulties of a different kind have been inherited which require a considerable degree of rationalization and all that this implies, such as the amalgamation of production units, changed layouts, perhaps the retirement of marginal land, and the more effective use of machines and technical and managerial personnel. The industry in St Kitts is a case in point. The plantations are very small and, because much of the land occupies the highly gullied slopes of a small island central volcanic massif, many fields are small and most irregular in shape. Much of this cultivated land lies on a series of narrow, radial spurs down which roads, through being old and badly engineered, have become sunken. The future success of sugar cane in this industry depends, to the extent that ownership will permit, on redesigning the physical and management structure of the industry to give unit areas of land composed of far fewer and larger fields which can be managed by unit tractor teams of cultivation and harvesting equipment. Sociological considerations require a delicate balance between manual operations and the use of machines. The total size of the industry requires that manual operations, particularly at harvesting, be kept for as long as possible on those areas on which the use of machines will prove limited because of the slope or smallness of the fields which cannot be amalgamated.

Queensland

The sugar cane industry of Barbados suffers from some of the same physical and traditional difficulties but to a much lesser degree. The Queensland industry, even more highly fragmented, presents an interesting contrast. It was developed as a series of family farms, as distinct from being plantation based, whose average area in sugar cane is about 80 acres. The relatively light, free draining soils and reasonably level lands, coupled with a high degree of inventiveness and mechanical skill on the part of the farmers, have enabled the maximum use to be made of light wheeled tractors. Contract harvesting has permitted the rapid mechanization of harvesting, now in many areas total. The contrast between these industries illustrates the importance of tradition, the nature of the land resources and the mechanical skill of the peoples involved. The contrast is even greater by comparison with some of the newer sugar enterprises of Africa.

Africa

Instances exist where sociological conditions have imposed extreme constraints upon the rational development of sugar cane areas such as a sugar scheme developed for settlers in one area of East Africa. Here each settler owns seven and a half acres of land in cane, divided into two and a half acre units, these being in three fields of 'n' units each, and the fields being in plant cane, first and second ratoons respectively. All is so laid out that cane transport at harvest from the units furthest from the headland has to pass over the unit adjoining the headland, often resulting in severe cultivation damage to this unit. The system also requires the separate farming and harvesting of the cane of each unit, even though the harvesting of a field is carried out by a gang of settlers. Such schemes need to be designed in the first instance paying due regard to the requirements of any mechanized operations and particularly to the requirements of orderly cane harvesting. If sociological factors and the requirements for orderly development and management of the area in cane cannot be adequately reconciled before the area is developed, it is probably best to think of some other enterprise. The heavier the soils and the less well defined the rainfall pattern the less can layout be compromised.

Some infield considerations including irrigation

Since the war the mechanical means of earth moving have been greatly improved and are now extensively used in sugar cane agriculture for land forming. The practice is important if surface methods of irrigation and surface drainage are to be made efficient. In many pre-war and older systems of irrigation used for sugar cane, irrigation ditches were cut across cane rows at frequent intervals,

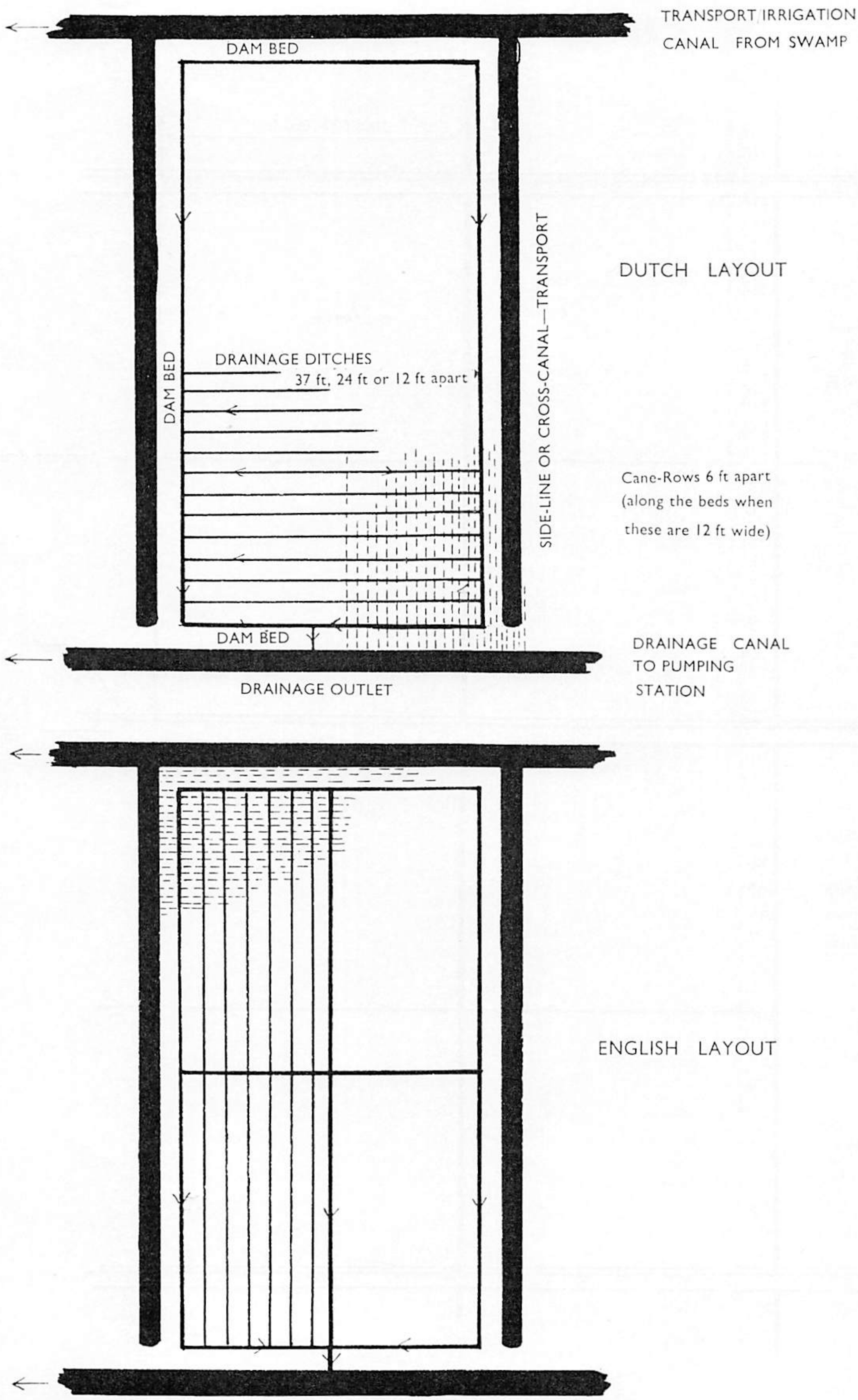
TRANSPORT IRRIGATION CANAL FROM SWAMP
DAM BED
DUTCH LAYOUT
DRAINAGE DITCHES
37 ft, 24 ft or 12 ft apart
DAM BED
SIDE-LINE OR CROSS-CANAL—TRANSPORT
Cane-Rows 6 ft apart (along the beds when these are 12 ft wide)
DAM BED
DRAINAGE CANAL TO PUMPING STATION
DRAINAGE OUTLET
ENGLISH LAYOUT

Figure 3

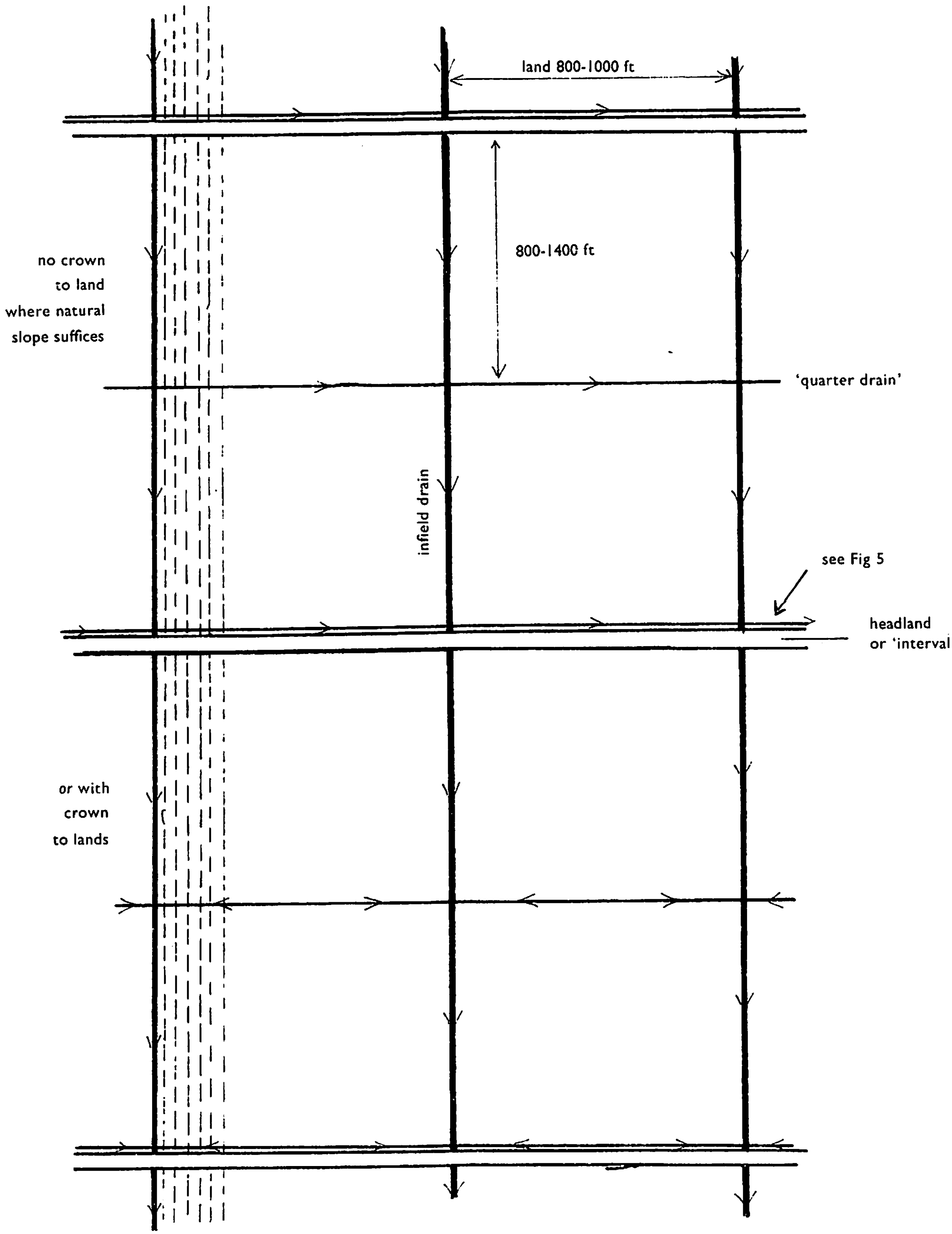
land 800-1000 ft
800-1400 ft
no crown
to land
where natural
slope suffices
'quarter drain'
infield drain
see Fig 5
headland
or 'interval'
or with
crown
to lands

Figure 4

e.g. at eleven yards or 22 yards in order to cope with non-uniformity of land surface. When infield drains were also necessary, the layout became complex and offered much inconvenience to inter-row cultivation and infield transport at harvest. The system also did not lend itself to the easy working of water by irrigators. By redesigning field layouts, by precision grading and smoothing (planing) of field surfaces and by choosing furrow directions so as to achieve desirable furrow slopes (e.g. less than 0.3% on medium and heavy textured soils), uninterrupted furrows running for the lengths of the fields are made possible, the output of an irrigator has been doubled or trebled, and the effective duty of water also nearly doubled, and cultivation, infield transport and mechanized harvesting operations greatly facilitated. On heavy soils a degree of land forming, even if only in the direction of cane rows, is extremely important in order to make sure that all surface water drains away completely after rain. None must remain as slight ponds in furrow bottoms, otherwise cane growth becomes non-uniform and infield transport and tractors rut and stick at harvest. The practice is particularly important on Black Cotton Soils. The degree and precision with which land forming is practised for surface drainage increase in importance as land surfaces become more flat. On the sugar cane lands of Louisiana the system illustrated diagramatically in figure 4 represents the ultimate model sought.

Drainage

In disposing of infield drainage water it has been the practice in some countries to lead this into open drains running along the headland or 'interval' at the lowest side of the field. Until recently, these drains have been too steep sided to be negotiated by machines and consequently have interfered with cultivation. They required bridging or padding (temporary filling with logs or earth) to enable transport vehicles and tractors to cross. Traffic concentrated at temporary drain crossings and caused excessive damage to the cultivation, with resultant loss of yield and extra expense. The use of flat, triangular or trapezoidal, shallow ditches, to engineered design sections is increasing—a typical section would be as in figure 5. The cane rows are continued down into the ditch and the other slope becomes integral with the headland or 'interval'. The system allows of either long runs for machines through several aligned fields, or for turning equipment on the 'intervals' without damaging the cultivation.

Damp ditch bottoms may make it increasingly important to use 4-wd tractors. These ditches must ultimately discharge into natural water courses if near by, or otherwise into open drains running parallel with the cane rows and passing through the 'intervals' or headlands in culverts. Depending on the rainfall, open drains in ten acre fields can be cut along the sides of the field. In fields which are very long at right angles to the cane rows, it will be necessary to cut the open drains parallel with the cane rows, so that they become infield drains. Under near flat conditions, the ultimate layout of drains should be the result of an hydraulic analysis—very large fields requiring not only parallel 'infield' drains but also 'quarter' drains cut across the cane rows, but no deeper than the furrows between the rows, to lead water into the infield drains. To aid flow in the 'quarter' drains, it is sometimes necessary to give the lands between two infield drains enough 'crown' to obtain slopes of up to 0.3%. Apart from catering for run-off, infield ditches and their depth and frequency take on an added significance if also required for subsoil water control and for soil leaching purposes. In sugar cane agriculture the drains are usually open drains. The incidence of tile drains is low but mole drains are being used increasingly in heavy clay soils and in peats.

Irrigation

The use of land forming can be overdone. Engineers should be careful to consult soil specialists if the practice is to be extensively used. In recent years sugar areas have been laid out with too much geometric perfection—two areas especially come to mind, both surface irrigated. Soil scraping has exposed infertile subsoils and overlaid surface soils of limited fertility with much less fertile soil. In one area, despite this, such a rigid, rectangular layout of canals and drains has been used that it is impossible to change furrow directions in order to relate furrow runs and slopes to the infiltration characteristics of the soils. Soil boundaries have been ignored, so that sandy soils and clay soils have been included in the same fields in much of the area, thus rendering impossible the proper

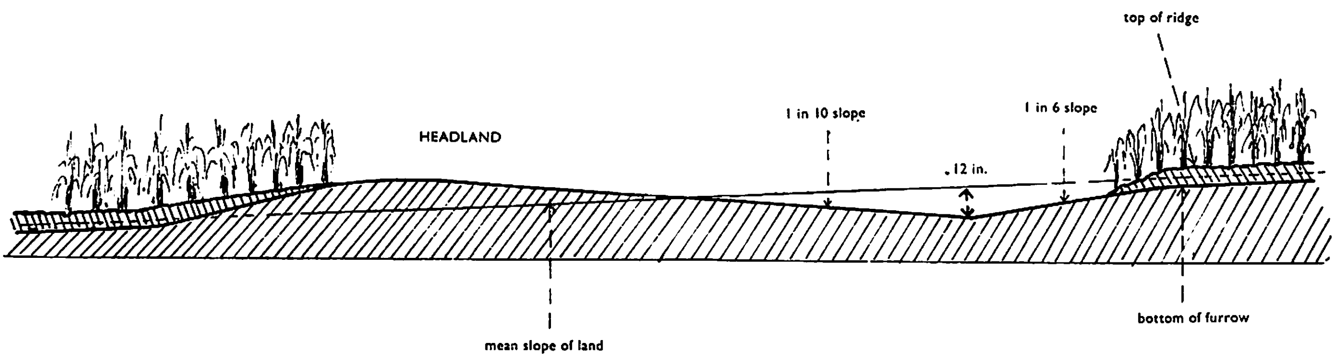

Figure 5

physical handling of either soil—their drainage, cultivation, and surface irrigation have suffered. The answer should have been to have designed field boundaries to conform more closely to soil boundaries; to have used a very modest degree of land forming on the soils of low permeabilities and to have used sprinkler irrigation instead of surface distribution. Perforce, in many areas the sandy soils are now overridged and suffer from an inadequate irrigation especially in the early stages of plant growth, and the heavier soils are insufficiently ridged and suffer from water logging in the rainy season. Despite a ruinous degree of land forming in many fields, furrow slopes are still so excessive that the ridges are not wetted adequately and furrow stops have to be used to terrace the water.

A further price paid for rigid, geometric designs is the inadequate elevation of the irrigation water in channels or ditches with respect to the cane furrows being served, which renders impossible the use of automatic irrigation devices such as plastic syphons. It is remarkable how widespread this limitation is, but only fair to add that in some instances it has been the result of development without adequate prior surveying, and engineering advice. As recently as 1964 a substantial irrigation extension was visited which was being installed not only without any engineering advice but also without even levels having been taken! The same area today is being redesigned and laid out anew using professional skills—but at much avoidable expense. The combination of bad engineering and its induced water management difficulties are often the main cause of low irrigation efficiencies and low irrigator productivity. This is particularly true where night watering is practised. There is no better way of drawing attention to the waste and imperfections of the irrigation than by installing recording drain gauges at strategic points in the drainage system. An irrigation distribution system should permit of fields being cultivated, and dried out prior to harvest, either in sequence or in blocks—a requirement which is missing in many plantations. The worst arrangement is to have an irrigation canal conveying water through a field which is drying out prior to harvest. Canal distribution losses are generally a straightforward matter of the cost of the water lost against the cost of lining canals. But where water supplies are limiting, lining canals becomes the price at which more water is bought and in certain instances it can become of great significance, e.g. in reducing the load on an aquifer which is becoming increasingly saline, as in the case recently with many of the aquifers in Jamaica. It also has indirect benefits such as the increased canal flow so necessary in many instances for increased output per irrigator and increased infield irrigation efficiency.

Sprinkler Systems

The design of sprinkler systems is outside the scope of this paper. The higher capital outlay and operating charges are generally justified in terms of water savings and/or because of difficult land surfaces. Where soil surfaces are flat and the soils heavy textured it is often overlooked that infield efficiencies which match those of sprinkler systems can be attained by furrow distribution at a fraction of the cost. However, in some countries with no tradition of surface irrigation the difficulty of getting surface irrigation well practised may favour the installation of sprinkler systems. This is especially true of parts of Africa. Sprinkler systems, by eliminating distribution ditches also facilitate the mechanization of cultivation and harvesting, a consideration which is becoming increasingly important. Completely automatic sprinkler systems are entering sugar cane agriculture in special circumstances, e.g. where labour costs are extremely high, and/or where soils are excessively gravelly and free draining. An area of gravelly soils in south Puerto Rico which would otherwise be growing tufted scrub separated by bare soil produces 60 tons of cane per annum as a result of very frequent, automated sprinkler irrigation. The piping is completely buried, each riser permanently inserted, applying 0.22 in. gross per hour for two hours (at an assumed 75% efficiency) during the period six p.m. to eight a.m., when wind speeds average five m.p.h. The sprinkler risers are on p.v.c. laterals buried by machine, the operation of each lateral being sequenced by an electric impulse to the valves sited at the junctions with the mains. Control is by means of a Paso Seco type American pan which rises with the cane canopy and 'f' values are taken as varying from 0.60, rising to 1.0 as the canopy covers over. At peak demand the risers operate five to six nights per week. The only human function is that of scheduling the time clock to the evaporation, but even this can be automated. The installed cost in 1963 was U.S. $450 per acre, of which $300 was for equipment. The annual cost of irrigation including the cost of water and all operating and depreciation charges worked out at $65-$70 per acre. To purchase irrigated land capable of producing 60 tons of sugar cane per annum for $450 per acre is very cheap, when sugar sells at over £50 per ton, as also is the cost of a year's irrigation at $65-$70 per acre to produce nearly seven tons of sugar. The system is of particular interest to other very dry, gravelly areas such as the dry area of St Kitts where the soils are very coarse textured and irrigation water is in short supply. Such soils require large root systems which can only be developed by wetting the soil to depth and keeping it so by frequent light waterings.

Mechanized equipment for cultivation

When developing new areas or modifying old ones the massing of a balanced tractor and implement fleet, either with or without the contract hire of some equipment requires careful consideration. The composition of the fleet is determined principally by the soils and the cultivation operations. Provided the soils are light enough, all agricultural operations can be undertaken by 65 to 90 hp two wheeled drive tractors, although four wheeled drive tractors are often used. Indeed 90 hp tractors can be used to handle quite heavy soils provided they are at the correct moisture content—such tractors are being so used in Louisiana. The Australian industry is based almost exclusively upon the use of intermediate-powered wheeled tractors. However, in large scale plantation sugar cane agriculture, heavy crawler type tractors are used almost exclusively for land preparation—usually 120-300 hp types drawing three-pronged, toolbar mounted or tandem mounted road rippers for subsoiling, and offset type 36 in. disc ploughs or harrows for initial soil cultivation. With the advent of vibrating subsoilers the power required to draw these particular implements has been reduced by about 40% and heavy, vibrating type subsoilers are now being drawn by 90 hp 2-wd tractors. Where land forming is necessary earth scrapers, bulldozers or motor graders are used, depending on the quantity of earth to be moved and the distance. The final surface uniformity is obtained by the use of a land plane, either of the hopper or of the scraper blade type (the original 'land plane').

Because of the heavy maintenance of crawler equipment, there is already a well developed trend to move into heavy, wheeled tractors, e.g. of the MSR types, or the International 4100. Both crawler tractors of the 65 hp size and wheeled tractors (65-90 or 100 hp) are used for furrowing. Mouldboard furrowing bodies are normally used for light soils but are also too often used for heavy textured soils. Unless the soil preparation has been good and soil moisture conditions are optimum, furrowing bodies are better replaced by disc gangs on the heavier soils, in which case the faster moving wheeled tractors are preferable. For furrowing and inter row cultivation generally, it is better to use the cheaper, higher speed wheeled tractors and, except for structurally weak soils, to use disc gangs because of their extra cultivation or soil preparation effects. Sixty-five horse power tractors will usually handle two rows at a time whilst at 90 hp unit can cope with three rows. For accurate work it is important that each pair of discs or disc gangs forming a ridge should float independently and toolbar mountings need to be designed accordingly.

Planting Techniques

In Hawaii planting machines have been developed on D7 and D8, or their equivalents, crawler tractors which open four furrows simultaneously, drop the cane pieces, place solid fertilizer, usually superphosphate, spread other fertilizers and cover the cane pieces. In some instances they apply pressure to the soil of the planted cane rows as well. At the other extreme cane pieces are dropped by hand into the furrows from moving cane carts or are dropped by hand from baskets carried by bearers--the degree of mechanization is principally a matter of labour supply and costs, complicated in some areas by sociological considerations and government policy.

Depending upon the soil texture and the requirements of harvesting procedures, sugar cane is either planted in furrows and maintained thereafter in furrows (e.g. on irrigated free draining deep soils, as in Hawaii) or planted in slight furrows and thereafter brought to a flat culture (e.g. on the light soils of Australia) or planted in banks or ridges of varying height, and usually maintained in even higher ridges. The last method should always be used when surface drainage or internal soil drainage have to be reckoned with and, except for special areas, is the universal method on medium and heavy soils over which tractor drawn equipment has to pass during harvest. On some of the freer draining soils, cane is planted in furrows but maintained in slight ridges for harvesting reasons or because of irrigation. Whether furrow irrigation is practised or not, ridge heights and spacing need to be very uniform and furrow bottoms clean and free of fallen debris so that they drain completely. A variety of implements is used, but discs and disc gangs (18-24 in. diameter) are fast becoming very general except for furrow maintained cane or cane grown on a flat culture, where inclined pegged wheels dragged over the furrow sides or tined cultivators are used.

In passing it is worth mentioning the complication caused by soil salinity; where soil drainage permits, furrow culture should be used since surface accumulation of salts takes place in the ridges and irrigation water has its maximum leaching efficiency in the furrows. Unfortunately, many saline areas are on heavy soils where there can be no alternative to ridge culture, but the planting position should be as low as possible in the ridge, whilst still above the furrow levels, and ridges should be as low as surface and internal drainage permit. The optimum can only be determined by a study of the distribution of roots and salinity within a section of the soil. It is in these situations that sprinkler irrigation may have special merit, and especially if a saline water table is a complication, e.g. as in parts of Iran.

Inter Row Cultivations

Inter row cultivation, as the plant cane gets older, requires the use of high clearance tractors and tool bars, clearances of from 20-30 in. being required. The necessity for such tractors can be reduced or eliminated by the use of long-acting residual weedicides, and tractor use in ratoons may not generally be necessary. Inter row cultivation in ratoons is only necessary where furrow shapes have to be improved for irrigation or drainage (run-off), where ridges have been eroded in the course of age, where the cultivation has been damaged by difficult harvesting conditions or where stool sizes and shapes have become too irregular to permit of efficient mechanized harvesting. If cane trash (leaf debris, principally from the previous crop) has not been burnt at harvest, inter row cultivation cannot be carried out efficiently, especially earthing-up operations. The first cultivation in ratoons on medium and heavy land is usually chiselling by tines, preceded by rolling disc coulters to define the edges of cane stools; and thereafter an earthing using disc gangs.

The general principle to be followed in inter row cultivation is to make a tractor carry out as many operations as possible simultaneously. Some tractors which are used for inter row cultivation also spray weed control chemicals on the newly cultivated soil; others may spread or inject fertilizers whilst inter row cultivating, etc. Because of the high stool mortality in Hawaiian cane fields as a result of harvesting methods, machines have been evolved (based upon D6 and similar chassis) which, under hydraulic or pneumatic control, open a furrow where a gap exists, drop the cane pieces, and then cover them over, the whole mechanism being lifted and put out of action where the gap ceases. Such machines are examples of the extremes to which mechanization has been taken. Experience suggests the following are typical machine outputs over very wide areas where sugar cane is cultivated.

Operation	*Tractor*	*Output (acres/hour)*
subsoil ripping (3 tines)	D8, D7 or equivalent	1
ploughing (disc—36 in.)	,,	1
harrowing—(disc)	D6, ,,	2
furrowing	65 to 75 hp wheeled	1-2
inter row cultivation	,,	2
fertilizing and earthing	,,	2
earthing and chemical spraying	,,	2

In selecting an equipment fleet a strong tendency exists to plan for a uniform work programme each year—especially a replanting programme—and therefore much cultivation is attempted when weather and soil conditions are unfavourable. The quality of replanting operations significantly affects levels of yield and the duration of ratooning and is an investment. The fleet must therefore have an adequate reserve capacity related to the probability of getting acceptable soil conditions, for the area handled each year must vary with the weather. The nature of operations must also change with later replanting; cane must be planted in higher ridges, less use made of earthing and its weeding effects and more reliance placed on residual weedicides. It is quite surprising to find the extent to which machines are not used for sixteen or more hours per day. In many areas, even of uncertain weather, machines are still only used for about eight hours per day and for less than seven days a week.

Harvesting

Harvesting is generally arranged so that a balance is struck between areas nearest and furthest from the factory in order to keep all the harvesting equipment fully stretched. Where hand cutting and hand loading are practised, two systems of loading exist. Cane is cut and stacked in orderly heaps between uprights, and these bundles are winched up over the rear of trailers by trailer- or tractor-mounted winches or over the sides of trailers by special winch-tractors pulling across the trailers. The loads so handled vary from two to ten tons. This method is popular in S. Africa and is particularly useful in many other areas for small settlers who are prepared to cut and pile their own cane. The system makes the maximum use of infield transport vehicles and tractors where a high manual work content is unavoidable or is being insisted upon for sociological or political reasons.

Alternatively, the cane can be thrown by the cutters into heaps large enough to constitute a cart load (three to eight tons) and empty carts are then 'spotted' besides the cane heaps and loaded by hand. Two-wheel drive tractors of 65 and 75 hp are usually adequate to handle the lighter loads but 4-wd 60 to 75 hp tractors or intermediate sized crawler tractors (65 hp) are used for the heavier loads, depending on the clearance necessary and the steepness of the terrain. Because of its much less efficient use of equipment, the cart 'spotting' method is not favoured for new cane areas, especially where the management of a sugar plantation contracts to transport the cane of settlement schemes or small farmers. The most inefficient use of equipment seen was an instance where 75 hp tractors were permanently coupled to six ton payload carts loaded by hand.

Loading

Mechanical loaders are designed to operate with the cane stalks from four to six rows laid parallel and across the direction of the cane rows in a continuous windrow, or laid as discrete piles in a discontinuous windrow. The windrowing is done mechanically by harvesting machines, or manually. Continuous windrows require the cane to be pushed into heaps by tractor mounted pilers, so that a hydraulically controlled grab mounted on a boom on the same tractor can load the piled cane into carts which travel alongside. The piling operation and the curved locus of the points of the grab cause earth to be incorporated to varying degrees with the loaded cane, especially after bad burns* in wet conditions. The equipment can be mounted on standard wheeled or crawler tractors or made as special two wheeled or four wheeled drive machines. The special machines are generally preferable, unless loading is to be carried out on very steep land, e.g. on slopes of up to forty per cent, when the loader needs to be mounted on a crawler tractor.

Whilst the loaders described travel down each windrow, others have been designed with booms operating at up to thirty feet radius—machines which can load from three windrows at a single pass. Where the axis of the loaded cane need to be across the receiving vehicle, as on the infield light railway bogies used extensively in Queensland, hydraulically controlled rotating grabs are a necessity. If the inclusion of 'earth' presents few factory difficulties, e.g. on the peats of Florida, loaders are used which travel down the windrows feeding the cane between fingers which pass under it and a feeding scroll which passes over it, onto an elevating conveyor discharging into a trailer travelling alongside. These loaders also chop the stalks in 20 in. lengths.

The key to efficient harvesting operations is to have the correct equipment and the ability to organize. In Louisi-

* Sugar cane fields are commonly, although not universally, set fire to before being cut out in order to burn all the dead leaf material.

ana mechanized loaders are capable of sustained loading rates of 50+ tons cane per hour and often reach 80 tons/h for short periods; yet in other countries, the same machines average about fifteen and twenty tons per hour and in one country the maximum rate is as low as ten tons per hour! The principal causes of low outputs are shortage of empty vehicles alongside the loaders because of hold ups at the unloading or transloading stations, the use of too small or otherwise inappropriate transport vehicles and time lost because vehicles become stuck in the field in wet conditions. Even the time in coupling and uncoupling vehicles can be a significant factor where road trains are formed. The extremes of low productivity are usually also associated with undisciplined or disorganized cutting and windrowing procedures, in situations where standards of management are low or where the ability to insist on standards is limited because of social or other customs—in some instances rendered even more difficult by unenlightened union leadership.

Mechanized Harvesting

Because of lack of labour, the unpopularity of cutting cane or the high wage rates necessary to retain cane cutters, harvesting is being increasingly mechanized. The machines have been developed, largely by practical farmers or operators in the first instance, but later improved upon by engineers. At present the Americans are putting much effort into engineering the development of the basic principles involved, including studies of minimum horse power requirements; the advent of hydraulic motors has greatly facilitated the transmission of power to the moving parts. A detailed discussion of the design of these machines is beyond the scope of this paper.

Broadly two kinds of machine have been developed depending on cane yields, stalk straightness and degree of lodging and matting. In straight upright cane, or cane where stalks have not lodged to the point of matting, i.e. where fingers or other devices can still raise stalks into a near vertical position, machines of Australian or Louisiana design predominate. The stalks are lifted, severed at ground level usually by counter-rotating disc knives, the green upper part of the stalk is decapitated by an adjustable high speed knife, and the stalks laid parallel (and across the rows) in continuous windrows, up to six rows going into a windrow, or in piles in a discontinuous windrow.Alternatively, the stalks are chopped into 18-24 in. lengths, sometimes subjected to a varying degree of winnowing and deposited into cage-type netted vehicles positioned alongside.

The upper limit of yield per acre at which these machines can operate is about 36-40 tons cane/acre, but the limit may be considerably lower if specially selected, straight stalked varieties are not grown, or where sugar cane has lodged because of wind or soil conditions. Above 36-40 tons per acre, or less in some instances, 'mat' type harvesters must be used. Such machines deliberately knock any standing cane flat, isolate a 'mat' or 'swath' by a vertically cutting arrangement, and discharge the 'mat' either back on to the near edge of the uncut cane so that by a number of passes a large windrow of tangled cane is formed. In passing through the machine the 'mat' is chopped into 18-24 in. pieces by passing between chopping rollers, chopping scrolls, chopping rotary disc blades or rotating reciprocating 'hayknife' type blades. The chopped material is then discharged into suitable vehicles. Either type of harvesting machine may deliver the cane into windrows on the ground, or as chopped pieces direct into infield transport vehicles. It is claimed by many that if cane has to be lifted off the ground by grabs, especially in wet weather, it will contain unacceptably large amounts of mineral matter, which causes heavy factory wear and process complications.

In Australia where the mills buy nearly all their cane supply, the penalizing deductions for dirt in cane are causing chopper type harvesters to be increasingly popular with the farmer, but with the added complication of a much increased biochemical destruction of sucrose in the chopped cane piece. This loss, being a function of time, greatly increases the importance of a speedy, uninterrupted delivery system. Because grab-loaded cane has an increased dirt tare, the use of grabs has to balanced against the capital and operational costs and sugar losses of cane cleaning and/or in washing plants. The answer lies partly in a well-prepared and maintained ridge and furrow system of culture, in laying cane in piles rather than in continuous windrows, and in using grabs whose points have a horizontal locus in the last stage of closing. By these means dirt in cane can be kept to acceptable limits except under very wet conditions.

If possible cane is burnt prior to being harvested mechanically but much hand harvested cane is also burnt. Wet harvests or heavy dews therefore give rise to heavy adulteration with leaf material, both dead and green. Apart from increasing the sheer bulk of material handled, this leads to further cleaning and disposal problems as well as to complications in the basis of cane purchase—but these are another subject. Because of the almost universally decreasing quality of manual harvesting, the same problems arise to a lesser degree here also. To chop cane or not also affects transport—bent, twisted, procumbent stalks pack less densely than chopped ones. The density of packing mechanically loaded cane can vary between about 14 and 20 lb/ft^3, depending on the straightness of the stalks, whilst chopped cane averages 16-17 lb/ft^3. Instances are known where carts carrying only six tons of heavily lodged plant cane can carry ten tons of straight ratoon cane.

The weights of harvesting machines increase in 'mat' cane harvesters and flotation in these machines is a problem, except under dry conditions. They are nevertheless being made to operate successfully under the very limiting conditions of peat soils, e.g. in Florida, by using tracks. Except in Hawaii, wheeled models are almost standard for mineral soils. The upper weight of erect cane harvesters is six to eight tons, whereas the large Hawaiian machines go up to between eleven and fifteen tons. Output is highest for straight cane harvesters, which can operate at 30-40 tons/h of cane, compared with about 20-25 tons/h for 'mat' types. Much depends upon the quality of land form, uniformity of rows, straightness of cane, and length of row runs. Windrowing machines enable cane to be loaded mechanically at 40-60 tons/h, resulting in much better use of transport equipment. Land slope determines the use of harvesters and ten to thirteen per cent is probably the very upper limit with existing machines.

Transport Systems

Cane transport systems are as old as the industry itself and yet in many areas leave much to be desired. Railway systems, broad and narrow gauges, were once very general, infield transport being by ox cart or portable railway track. Railway systems only survive today in special circumstances—e.g. in South Africa, Santa Domingo, Florida, Queensland, Fiji and Cuba—for very long haulage distances, such as thirty or forty miles or more, or where the absence of a highly developed competitive public road system is a factor. Generally the modern trend is towards long distance road transport and a network of transloading stations, and/or infield transport vehicles running direct to the factories. The quality of roads and the nature of road regulations influence the nature of long distance vehicles. Where these permit, semi-trailer units carrying up to thirty to fifty tons are becoming common, or similar loads split between a truck and trailer. Some recent remarkable exceptions occur such as the use of Leyland 200 hp Hippo tractors to draw a semi-trailer and trailer of only thirteen tons combined capacity in East Africa.

Infield vehicles vary from ancient oxen drawn carts of about two tons capacity and mule or horse drays, through four wheeled goose necked carts of three to five tons capacity, three ton to ten ton two wheeled trailers, side-dumping Florida waggons of four tons capacity (limited because of the bearing strength of wet peat), to five to twenty ton four wheeled motor trucks, thirty-six ton payload four wheel driven, goose necked steering vehicles, or tractor drawn semi-trailers of similar sizes using 250 to 300 hp engines. With most sizes, recently installed anachronisms seem to exist such as the lightly built, two tons capacity hydraulically, side-dumping carts of Polish origin used in Ghana and the goose-necked, four wheeled drive units on a Sudan plantation using a 300 hp Cat. 619-power unit and a total net tare of twenty-two tons to carry a payload of nine tons!

For all infield units flotation and traction are vital, unless soils have very stable structures such as in Hawaii but even here difficulties can arise. As a generalization, the track width of wheels should fit accurately into the furrows. Instances are known where tracks have been used to allow the vehicles to travel on the ridges in furrow maintained fields. Where infield traction is to be supplied by wheeled tractors, especially by two wheel drive varieties, the principle of weight transfer becomes vital but is often overlooked, e.g. in the use of the goose-necked four wheeled carts so ubiquitous in the West Indies. Standby crawler tractors infield or the use of crawler units for all the infield haulage, and changing to wheeled types for hauling to the factory, are then necessitated. Because of this, and the 'spotting' of carts for hand loading, the practice of forming road trains grew up and has persisted into the era of cane loaders. The maximum radius for running infield vehicles direct to factories will vary slightly from place to place, but generally the distance is about 7-8 miles. Beyond this it is better to use transloading stations and long distance road vehicles. Where mechanical loaders are used it is probably best to have two or three trailers permanently coupled, to travel and be loaded as a unit, and better still for the units to be permanently attached to their tractor, making provision for weight transfer. The key to an efficient transport system is a quick turn around in the field and at the factory or transloading stations.

The system of transloading or of unloading cane is changing. Formerly (and still in wide use) loads were lifted by lock-sling chains, usually three or four per load, and if stacked, the bundles can be left in their chains. The method is relatively slow and annual chain replacements are costly. The modern trend is to hang a chain net or wire ropes in the vehicle and to roll the cane out over the side, either direct into long distance vehicles, into the factory cane carrier, or into a storage space from which it is retrieved by overhead travelling grabs, gantry or tower-crane mounted grabs, by walking cranes or by tractors fitted with front end grabs or push rakes.

Enterprise Development

In developing a new enterprise, or in changing or extending an existing one, the ultimate form must reflect most of the matters discussed and others of an agronomic and managerial nature, including repair and maintenance facilities to match the degree of mechanization practised. The latter is extremely important in isolated areas far from manufacturing countries. When laying plans it is becoming increasingly important to anticipate changes in supply or cost of labour. In general it will be wise to adopt estate and area layouts and cultivation practices which will permit the orderly introduction of machines as and when they become necessary, bearing particularly in mind that in most instances some prior research, development and training are necessary. A well developed system of land management will require ridges and furrows uniformly spaced at 5.5 or 6.0 feet apart, the periodic control of stool width and alignment, the efficient removal of surface water, fields of an adequate size, the proper design, placement and maintenance of headlands and the evolution of an efficient harvesting, transport and cane handling system. The matters discussed have nearly all been of a physical nature, but the quality of the management team itself will always remain something for which there is no substitute. This quality, more than any other will determine the degree to which layouts and equipment are optimized in the course of experience and what is obtained from the capital invested.

Spring National Open Meeting 1969 – Discussion

Introducing the morning session of the meeting, the Chairman, Mr P. C. Chambers, (Director, Land Resources Division, Directorate of Overseas Surveys) said the subject of these proceedings was the planning and execution of the development of agricultural resources. This made no specific mention of overseas countries or developing countries but the choice of speakers and the character of the audience suggested that this would provide the background to a lot of these discussions. Although this was where the main emphasis might lie, it should not be thought that interest in this subject was confined to the developing countries in the tropics and sub-tropics. Australia and Canada were among countries actively interested in this work. The United States of America, having produced much of the original framework for land capability classification, was currently doing more with the use of remote sensors. In Europe, the Dutch and the French had similar activities in progress and here in Britain it was pleasing to see the increasing use of air photography and aerial surveys of the more rugged parts of Britain. This form of development was taking place in all countries and was basic information for development generally, regardless of the degree of sophistication and knowledge within a particular country. As a particular area increased in sophistication and knowledge, the need for this sort of activity did not decrease but rather intensified. Additional activity in an area, such as industrialization and urbanization, merely provided additional facets to be studied within the field of the use of natural resources.

Summarizing the different types of survey and appraisal exercise within the range from the general to the particular, Mr Chambers said the first line of attack was the broad regional reconnaissance survey, to give a framework on which additional information could be hung. The air photograph had made an enormous difference to the ease and speed with which this could be established. From that would emerge an indication of the areas most worthy of further attention and giving most promise of developmental value. Semi-detailed surveys could follow and at that level, project identification would emerge. The more detailed survey would thereafter be needed, leading on to feasibility study and the development plan which would be required for the government of the country and in order to assist the acquisition of external financial aid. The use of air photos in relation to these activities varied according to the density of work required. They had a part to play at all levels but in the wider reconnaissance survey more of the work was based on air photo interpretation and checking in the field, whereas the emphasis was more on field work as the picture became more detailed.

Inter-action, integration and correlation were all very important aspects of this work. With regard to integration, Mr D. Chambers had indicated in his paper that the economist and sociologist came in at the more detailed feasibility study stage of the exercise but it was important that there should at least be communication with people concerned in the relevant discipline at the earlier stages so that the information collected could be in a form that would be of value to them when their turn came later on. A pleasing recent development was that the agricultural field had become attractive to the economist, partly as a result of agriculture having gained prestige in the developing world through activities in Kenya and elsewhere. Mr Chambers said he was not quite so sure about the sociologist, who had tended in some cases to be more concerned with crocodile-worship or fertility rites rather than with the relationship between cropping and labour requirements, and the social pattern of the village. In any case, it was important that all concerned—the agriculturalist, the engineer, the vegetation man, the climatologist, and water development people were all concerned in this sort of appraisal and planning exercises. Another important aspect of communication was the need to make this work comprehensible to the client. The different methods and technologies being adopted were becoming increasingly difficult for the people in the overseas countries concerned to understand.

This was where a place like Silsoe had a part to play, particularly at post-graduate level and, having post-graduate students from overseas who could pursue their own discipline in their post-graduate activities, they could help in this matter of fostering understanding when they returned. On the question of land capability classification and terminology, it was a major problem to get agreement on some degree of uniformity and mutual understandability on land classification. Another point was that those engaged in these activities were becoming increasingly conscious of the need for quantitative work, using adequate sampling techniques. Computer programmes for various forms of assessment could be and were being increasingly developed. Finally, one of the most important aspects of communication in all directions lay in gatherings of this nature, which should undoubtedly play a significant part.

Papers were then presented by Mr D. V. Chambers of Hunting Technical Services Ltd. and Mr R. G. B. Jones of the Land Resources Division, Directorate of Overseas Surveys.

Opening the discussion, Mr N. W. Hudson (National College of Agricultural Engineering) asked whether Mr R. G. B. Jones would comment about the alternative use of colour photography compared with black-and-white. It was known that there were problems over the probable increased cost of colour photography and he believed also that there had been some problems at the initial stages in the reproducibility of colour tones. Mr Hudson said he believed that a comparative survey had been conducted by the Land Resources Division and wondered whether Mr Jones could give any information about this.

Mr Jones replied that his experience of using colour photography had been confined to a statistical land use survey in Malawi to supplement the agro-ecological survey of that country. It had been carried out using 1:40,000 scale colour prints. The reasons for using colour in the first instance had been experimental because it had not been used before for this purpose in the Division. Secondly, it had been thought that colour photography would give much greater accuracy in identification of various forms of land use. Trouble had been encountered in some instances in discerning the differences between medium term fallow land—on which a certain amount of bush regrowth had taken place and perennial-type crops like mature cassava. They looked very similar on black-and-white photographs and it had been thought that colour would be particularly helpful in identifying the difference between them. Moreover, the contractors for the photography had indicated that, given a large area of land to be photographed, the overall cost of the colour photography would be more or less the same as for panchromatic photography, and they had also included a free set of colour prints in the photographic contract. Consequently, there had been increased interest in the use of colour photography, but there had since been some further thoughts about it. Opinions now tended to be considerably more qualified, as a result of the Malawi point identification exercise and subsequent experimentation carried out in the Land Resources Division. Investigations had been conducted into the comparative advantages of black-and-white and colour for specialized land resource purposes. Pairs of photographs covering different parts of Kenya, Malawi and Fiji had been chosen which had been covered simultaneously by black-and-white, colour and false-colour photography. Each set of photographs was then examined by selected members of the scientific staff of the Division, all of whom were very experienced in the use of aerial photographs. They were asked to demarcate boundaries between different areas of vegetation, soil and land use—identifying the vegetation on the basis of physiognomic type, and certain categories of land use in terms of some thirty different categories on a schedule supplied to them. The results which emerged showed, firstly, that there were no advantages at all for land form identification using colour. This merely served to confirm what was already well known. The second, and more interesting point, was that no advantage was obtained by using colour in the case of vegetation and soil boundaries. In fact, in the case of vegetation very slightly fewer boundaries were defined on the colour prints than on the black-and-white. In the case of soil boundaries, very slightly more—about two per cent—were defined, so it was hardly worthwhile at all. These results were obtained from very experienced soil scientists, and applied to both visible and inferred boundaries. Parallax measurements to estimate height compared with known heights on the ground were slightly less accurate on the colour than they were on the black-and-white. When identifying land use and trying to find the difference between bare ground and sparse herbaceous fallow, then either true colour or false colour gave, as with soil boundaries, only marginally better results. Mr Jones said that many interpreters, himself included, were troubled by the unfamiliarity of false colour and one had to be cautious in the use of this medium which had been originally evolved for camouflage detection purposes during the war. Admittedly, it had uses in very specific instances, such as disease detection in crops and forests. However, Mr Jones said he found it unrealistic to look at vegetation which was scarlet in colour, fallow ground that was pale blue, at grass that was pale pink and ploughed land that was dark green. He said that this was merely his personal opinion and some people might think that the results were clearer that way. Colour photographs were poorer in terms of textural and resolution value and the drawback of lack of uniformity of colour rendering between successive flight strips and photo missions still existed. Mr Jones instanced one particular photograph, showing a soil catena in Malawi which had been processed several times and which, on each occasion, had resulted in quite different colour rendering—so much so that, from a distance, the casual observer might think they were entirely different prints. Another difficulty was that very often the colour itself was incorrect; this would be acceptable if it were only consistent, which, unfortunately, it was not. Because of the problem of lack of uniformity between successive renderings, Mr Jones felt that logetronically printed black-and-white panchromatic photographs—printed that is to say with electronic printers so that one achieved perfectly uniform grey-tone values—would very often provide the best answer for certain types of photo interpretation. The cost of repetitive sets of colour prints too was extremely high. Although one might obtain a free set of prints included with the contract, if one wanted further sets, which one very often did, it became extremely expensive as initial prints cost several pounds each as opposed to a few shillings for black-and-white photographs. Mr Jones said that he personally found it easier to identify moist soils and to decide soil boundaries and land use on the colour photographs. In land use identification in particular, although only very slightly more accurate, he had obtained speedier and more decisive results with colour. One could, however, achieve the same results on the black-and-white but with not quite the same ease. Summarizing, Mr Jones said that despite the shortcomings of colour photography, he was still very much a 'pro-colour' man in the interests of being progressive. It was after all the natural medium and hardly anybody nowadays thought of taking black-and-white snapshots. Once the processing anomalies that now existed had been ironed out the extra dimension that colour photographs could give would be invaluable.

Mr T. Sherwen (Consultant Agricultural Engineer) said that, arising from the previous question, he would like to ask Mr R. G. B. Jones if infra-red photography had been tried and whether there would be any advantages in trying to identify soil types with the use of infra-red photography.

Mr Jones replied that he had had little experience with the use of infra-red, but that it was useful in determining the identification and assessment of wet areas. He also mentioned that he had had very little experience of using Infra-Red Ektachrome—that is to say, false colour photographs.

Mr P. Chambers (Chairman) said the question of timing was important in the matter of colour photography. In many countries the colour photography benefits had been in showing up disease effects, fertilizer limitations, moist areas or vegetation distribution, by showing up particular plants in flower or some early flush with red tinges. Photography was governed by the actual time at which one could see the ground to take the photograph at all. This was a problem that needed mentioning, for there was many an anxious moment when the people on the project were waiting for new photography to be flown in, say, British Honduras, and the flight plan came in with the message 'still no success over the mission area'. It was the timing factor that was tremendously important.

Mr R. G. B. Jones was asked by Mr D. V. Chambers for his view on the advantages of preparing a black-and-white positive from the negative and in this way achieving the best of both worlds. The questioner said he believed the quality of black-and-white from a colour negative was good and in fact might well be better than an actual black-and-white shot. Mr Jones said that some black-and-white positives prepared from the Malawi colour photography had been of excellent quality. They were, in his view, almost as good as they would have been had they been processed from panchromatic photo-negatives.

Mr W. Clark (Binnie & Partners) commented that infra-red photography was useful in conditions of cloud cover and he added that he believed the infra-red technique was being used for the siting of the sea-level canal in Panama.

Mr V. C. Robertson (Hunting Technical Services Ltd.) said that the only experience he had had of the direct application of infra-red photography had been in Malawi some thirteen years previously. Two sets of photography had in fact been taken—one in panchromatic and one in infra-red, and both had been available for the soil survey being undertaken at that time. The main advantage with infra-red in those particular circumstances had first of all been that the boundaries of wet and dry soils could be very clearly designated. The different types of reed and other marsh vegetation were also quite clearly distinguishable in tone on the infra-red and not on the black-and-white panchromatic. Moreover, for actual field work in the swamp, they were of great advantage but this was rather a specialized use. Mr Robertson believed there would be quite a lot of specialized applications in future, utilizing false colour or infra-red colour for disease indentification in crops. He had recently come across a case in California where it was being used in a legal action in connection with prune growers who were suffering from spray in neighbouring rice areas. The trees were dying but could not be seen to be dying 'in the flesh'. However, they could be spotted as dying by means of infra-red colour photography.

Mr W. I. C. Crowe said he wished to bring the subject of photography nearer home by asking for guidance from Mr R. G. B. Jones as to whether he considered aerial photography could be used to advantage in wet, low-lying spring activities and the like in England, bearing in mind that so much information was already available from the excellent Ordnance Survey maps, ranging from 1 in. and less up to 25 in. and more. The point of particular interest was that infra-red photography clearly defined the difference between wet and dry ground.

Mr Jones replied that he thought photographs could still be useful, it being essential to consider them as complementary to maps. He would never advocate throwing maps 'out the window', especially when the maps were good. The context in which he had been speaking in his paper was mainly an overseas one where in many cases mapping services were in early stages of development and one could not always get reliable maps. However, where they existed, maps should by all means be used but he would always use photographs as well, because of the fact that they provided a pictorial representation of the ground and not merely a symbolic one. It was nevertheless important to realize that the air photograph, although a very useful tool, did have certain limitations. Many people tended to regard them as accurate maps, which was all wrong because they did contain distortion errors and failure to realize this could lead to serious errors in measurement.

Mr T. F. Shaxson (Malawi) said he wished to ask Mr D. V. Chambers a question arising from his paper. Mr Chambers had illustrated processes which had to be gone through before the final feasibility report could be produced. In view of the fact that a vast number of decisions had to be taken all down the line, it would be interesting to know whether the computer had been used as a decision assisting machine in this work. The sheer number of possible combinations which could be fed into a feasibility study was so daunting that there was surely a risk of a lot of useful possibilities being arbitrarily rejected.

Mr Chambers replied that computers had been used on at least two of these studies. In one instance the cropping pattern had been selected empirically and the computer linear programme was utilized to check that the assumptions made were in fact correct. Mr Chambers said he believed there was a greater extension of this on a river basin study. One could have mathematical models now that brought in any number of permutations and combinations but one of the problems was the collection of data to feed into the computer. It would give an answer only as good as the information that was fed into it and this could be time-consuming. The authority responsible for the organization of the project had to decide in terms of time and money what was warranted and whether in fact one had to do it by hand. With this type of planning, Mr Chambers said he thought there was a certain art to it and that it was ninety per cent common sense—a way of thinking and of going through things logically.

At the commencement of the afternoon's session, the Chair was taken by Mr V. C. Robertson, (Director and General Manager, Hunting Technical Services Ltd.). He said that the two papers to be given during the afternoon contrasted markedly with those already presented. The morning's papers had been mainly concerned with the assessment of the potential in natural resources. The final two papers at these proceedings would be rather more concerned with the realization of that potential. Mr Robertson said he wished to say a few words about the contrast between problems of development in sparsely populated and densely settled areas; this was a big problem and he would have to simplify drastically.

One might start with the generalization that, at least in the planning stages, the main concern when looking at sparsely settled or unsettled areas was probably with the natural resources that existed there. On the other hand, in the densely settled areas the main problem might be the human factor. This was a gross over-simplification because the two things—natural resources and the human factor—interlocked. In the present state of the world it was not unreasonable to suppose that if one encountered a problem involving development of an area that was either not populated or, at best, only very sparsely settled, there was something wrong with it—not wrong with the land itself but there was some obstacle to development which had so far not been tackled. Water was an obvious factor and if one looked at most of Australia, which was very sparsely settled, the critical lack in Australia as a continent was water. There were areas elsewhere in the world where the reverse was the case. One could have too much water and then one had to think of flood control, for example, before one could even think of development. This was the sort of problem which, under fairly primitive systems of agriculture and settlement, simply had not been able to be tackled. There was an opportunity now in advanced technology for dealing with the more difficult areas which remained undeveloped and this argued for more use of the kind of techniques that were described in the earlier papers of this meeting, not only in assessing what was actually there but because in most cases development implied really radical changes in the environment, such as irrigation or drainage or the felling of rain forest and planting of crops in its place. A full appreciation of the present situation was extremely important in predicting what would happen when one changed it. That was the approach as far as natural resources were concerned in new areas or areas that were hardly settled at all.

In densely settled areas, natural resources had still to be considered carefully but they were not perhaps of such primary importance as in entirely new areas. In a number of densely settled areas where improved development was being planned often the situation was that the areas may have originally been good but had been damaged or otherwise altered by human occupation over a long period. This could readily be observed in some of the older established irrigation areas of the world; much of Iraq, for example, or West Pakistan, where long-continued irrigation without drainage had presented the countries with very serious problems indeed. In Iraq, it had probably gone much further than in many other places, large areas having become completely useless chiefly as a result of irrigation without drainage, salinisation and—in Iraq particularly—a curious loss of soil structure whose causes were not fully understood as yet but which seemed in extreme cases to be almost irreversible. This was an example of continued occupation which had in fact rendered the original resource almost useless. In West Pakistan, the situation had not yet deteriorated to that extent and the nature of the soils were probably such that it would never do so, but there were very large areas that were now suffering from major problems of soil salinity or water-logging or both, which required measures that were beyond the scope of the farmer to cope with. In dealing with unoccupied land and settled land, respectively, there were two quite different situations to be dealt with. The techniques available were very considerable and one could make assessments of the natural resources and their potential in a way that had not been available only a few years previously. Mr Robertson suggested that in fact this sort of resource had possibly not been available to the authors of the two papers this afternoon when they were doing the work which they described in their papers. However, it was necessary to proceed beyond the stage of assessing the actual physical potential in trying to project what in fact the realization of that potential would be. It was relatively easy to say that a particular environment could grow a given amount of a particular crop but what in fact would it grow when farmers were actually trying to grow it? This was not necessarily quite the same thing. The importance of the kind of work described in the afternoon's papers would be the description of the kind of inputs that were necessary in order to realize the full potential; and this work had a feed-back into planning because in planning a project and trying to assess its cost and benefits so that somebody could decide whether it was a viable project in which to invest, one had to attempt a realistic assessment of the potential production. The human and social factors must be built in and one drew on the kind of experience of schemes such as those described in the afternoon's papers in order to make that realistic prediction. In a new area, one was faced with the problem of how to develop it from the human point of view.

Was it to be dealt with on a commercial estate basis? Were people to be settled on small holdings? Or should there be an attempt at a complex of both? The answers to these questions might in fact offer quite different returns on investment. There was therefore an economic argument and there was also a social argument and the two had to be fitted together in some way. In West Malaysia, for example, there were a considerable number of potential settlers who could be brought in to develop new areas. In East Malaysia, where there was a much larger amount of available land, very few people could be brought in. In theory, one might transfer settlers from West Malaysia to East Malaysia—as was being done to some extent—but there were important ethnic differences and transfer was not easy. In the Sudan, where there were large areas open to development, it was extremely difficult to find a continuing source of settlers at all.

There were strong arguments there for developing, if the crops were suitable, a commercial-type enterprise using a large degree of mechanization, but the current political climate was not really in favour of that kind of development. These were the kind of problems that came up when one was trying to decide the right thing to do. In settled areas there were even more complex problems. In the Indian sub-continent, for example, the bulk of the agriculture was based on very small farm units which were almost certainly not the right size for the sort of productive agriculture to be desired. Most of it had been based on subsistence and if intensification of production was to be considered, changing people from subsistence to a cash outlook, then this size of farm was almost certainly not the right size of unit. In theory, consolidation into bigger units was the answer but this presented the question as to what was to be done with the people who were dispossessed. During the course of a recent World Bank study in West Pakistan, consultants estimated that even if the present farm population was maintained at its present level, which was almost certainly too high for efficiency, it would be necessary to find 100,000,000 new jobs outside agriculture by the year 2000 A.D. This was the size of the problem and it was a horrifying thought to have to try and find a solution to it. The same sort of difficulty came up when one was considering the introduction of new techniques, such as mechanization. Here again, was it the right thing to attempt to introduce techniques which were efficient but which used much less labour? In those circumstances it might well not be.

Mr Robertson said that his own Organization's recommendations for mechanization in West Pakistan had been very limited, aimed primarily at easing the bottlenecks at harvest and in land preparation. This had attracted criticism for being too conservative in this respect but one was still faced with the real social problem as to what one did with people who were dispossessed. These were important and difficult problems to assess, and in making realistic forecasts of what benefits could be obtained from a certain kind of investment, one had to try and bring these factors in. One was forced to draw as much as possible on past experience from other projects, and indeed this was no easy task because of the comparatively few projects that had been monitored in relation to the original forecasts. It constituted a big gap in planning.

Extension and management represented a very critical field indeed—the marrying of research to extension and to management in implementing project plans and in helping farmers to change to new crops and new techniques. Sociologists have a part to play which they had not yet played fully enough. There was a tendency to export extension on a Western kind of model and one might well be dealing with a farmer of a completely different kind from those for which the extension service in Britain and America was designed. It is in this respect that the sociologist had a role to play. To take Pakistan as an example, in some parts of the rural areas the social structure was still quite rigid. There was a kind of clan system and members of the clan did what the Leader said and would not do what anybody else said. If the extension worker had not sufficient status to be able to talk to the clan chief, he would get nowhere. As the average extension worker was a man who came out of school after a year and was given a bicycle if he was lucky, he could not talk to the right people and extension could not make an impact. There was therefore a tremendous amount of work to be done on designing the right kind of extension service for the different circumstances.

The two afternoon papers were then presented by Mr R. F. Innes of Bookers Agricultural Holdings Ltd., and Mr T. S. Jones, of the Commonwealth Development Corporation. (Mr Jones presented the paper 'Introduction of Cash Crops to Peasant Farming and their Processing' on behalf of Mr R. Swynnerton, Agricultural Adviser, Commonwealth Development Corporation, due to Mr Swynnerton's unavoidable absence.)

Following this a discussion took place.

Mr J. Low (Massey-Ferguson Limited) said he would like to identify certain priority areas which he considered were very well described in a recent address by the President of the World Bank. This made reference to the gap between rich countries and poor and said that certain studies indicated that the population explosion, rather more than any other factor, had held back the advancement of the poor, widening the already dangerous gulf between the poor and the rich. This had to be taken into account when planning and furthermore these economic studies showed that this drag of excessive population growth was quite independent of the density of population. This needed emphasizing in view of the fact that many policy-makers in the developing countries attached only minor importance to reducing population growth. It was a false claim that some countries needed more population to fill the land and accelerate their economic growth. There were no vacant lands equipped with roads, schools, houses and the tools of agriculture or industrial employment. Concerning the need for a variety of educational activities, the World Bank Report had mentioned that the aim would be to provide assistance where it could contribute most to the economic development. This would mean emphasis on educational planning, the starting point for the whole process of educational improvement. It would mean assistance in particular for teacher-training at all levels from primary to university; it would mean expansion of support to a variety of other educational activities, including the training of managers, entrepreneurs and, of course, agriculturalists.

The sector of the greatest improvment as identified by the World Bank—that of agriculture—had for too long been a step-child of development. In the past, investment in agricultural improvement had produced but a modest yield. The traditional seeds and plants did better with irrigation and fertilization but the increase in yield had not been dramatic. Research over the past twenty years had resulted in a break-through in the production of new strains of wheat and rice and other plants, which could multiply yields by three to five times. However, these new strains were particularly sensitive to the input of water and fertilizer. Badly managed, they would produce little more than the traditional plants but with correct management, they would give the peasant an unprecedented crop. Mr Low said he believed these extracts from the World Bank Report were of tremendous importance in planning.

In considering the subject of this conference, it was in order to ask 'What about implementation?' Execution was one thing; successful implementation was another. The papers read had outlined modern techniques of land resource planning and had highlighted the two contrasting developments; namely, the estate size and the peasant holding level, respectively. However, it was difficult for those who had had field experience in this area to decide what was an ideal investment mix. Was it, as some economists suggested for tropical agriculture, a mix of something like a 6:1 ratio? Was it in dry-land farming, with something like 3:1? What was the average, if one might even use the term 'average'? Mr Low said that in the field of agriculture he would place human endeavour as a prime factor, allied of course to the management necessary to make the most of that endeavour. It was this factor which co-ordinated, improved, compromised and tried until success was achieved or failure acknowledged. What were the factors influencing human endeavour which could breathe a spark of life into a project? Sound planning could identify the development areas and the resources necessary—the execution and successful implementation could however be bedevilled by the human reaction. Resistance to change could be a formidable obstacle—and interpretation of intent could so often be misconstrued.

Machinery manufacturers had their problems. The stigma of being considered manufacturing-orientated could be avoided if there was a viable service back-up to the product. However good the planning, if the sales technique was a blunt weapon and the recommended applications were wide of the target, the result would fall far short of expectations.

The need or want of farm mechanization was basically governed by the following factors:—

(a) That unless there was an increase of the absolute product, there could be no case for mechanization;
(b) That unless there was a production bottleneck incapable of solution by man or animal, there was no case for mechanization;
(c) That unless there was an input requirement incapable of economic solution by man or animal, there was no case for mechanization.

Frequently, social and/or economic factors were allowed to obscure the main objective. If one considered Kenya (with an economy suffering the problems of unemployment) it could be said that any mechanization intent must be governed by the consequent effects, if any, of labour displacement, and restricted accordingly. It could also be said however 'First establish your viable farming unit and then decide just how far one can go in meeting the social problems, by dilution of the full mechanical approach'. Partial mechanization of a system had well known pitfalls. For the longer term, how was one to avoid the dangers of fragmentation which, if uncontrolled, could nullify any earlier achievement? There were of course many other factors which could arise during discussion. Mr Low concluded by briefly referring to another major problem—how to make machinery available to users having limited capital resources and training. The establishment of machinery pools operated through the medium of any one or all of the following groups might meet the need:—

- Co-operative societies
- Private syndicates
- Private contractors—farm based
- Private contractors—non-farm based
- Quasi government bodies
- Government bodies.

How, asked Mr Low, could the motivation at grass-root levels be encouraged? How important was it and to what degree should the experience of the social scientist, the agricultural economist, and the agricultural engineer, be drawn upon at all levels?

MR G. BATEMAN (Intermediate Technology Development Group Ltd.) said that rather than try and reply directly to the previous speaker, he wanted to introduce the idea of 'intermediate technology' and describe its basic philosophy. The whole idea of intermediate technology was to introduce to a particular development situation the intermediate or the appropriate technology that would fit into their situation. It was no good giving 65 hp tractors to a community group of peasant farmers. Quite clearly, such a system would not work. Even if you trained them to drive the tractors then you would have the problem of what happened when something went wrong, and so on. The idea of intermediate technology was to take the development business a step at a time. If one considered for a moment the way in which Britain had developed, it had not suddenly come from the middle-ages to the twentieth century—it had taken a step at a time. One might say to this 'This is no good in the case of the developing countries, because time is against the step-at-a-time procedure and a developing country cannot afford to take things easily'. Mr Bateman said he agreed that one could not take things easily, but if one attempted to run a fast sprint before being able even to walk, we would, he felt sure, fall flat on our faces and never get anywhere.

A typical example of the application of intermediate technology related to the use of oxen in Malawi. The situation there was that the peasant farmers' method of transport was by the women carrying loads on their heads. Obviously, transport had to be improved if those peasant farmers were to start increasing their crop production and getting their crops away to market. The next step from carrying loads on their heads was some sort of cart, but ox-carts in Malawi cost £70 imported from Salisbury, Rhodesia. Not only did the peasant farmer not have the £70 but even if he had, this would produce a strain on the foreign exchange situation. So an extension worker in the area had developed a system by which ox-carts were built by the villagers. This worker, who was a missionary, started by getting local carpenters to build ox-carts at his mission station, making use of local timber and the rear wheels and back axles of old cars. The situation had eventually developed to the point that carpenters from all over Malawi were being brought in, two at a time, to attend the short training course of two weeks and they were given at the end of that time a kit of parts, consisting of simply all the metal parts—the nuts, bolts, wheels and axle—necessary for them to make an ox-cart. They would then go back to their village and make the wooden parts of the cart and assemble the whole thing. They would sell it for about £35, the cost of the kit being about £20. Having sold their first cart, they would then buy their second kit. The investment of that particular carpenter had been just £20 for his first kit. The important point was that those carts when they were sold cost £35, just half what imported carts from Rhodesia would have cost. So at once, a local industry had been created, a local person had been employed in making the carts and foreign exchange was conserved by reason of not importing carts from elsewhere. The peasant farmers who could not afford £70 but could afford £35 had got their ox-cart. This, said Mr Bateman, was one typical example of intermediate technology working in the field.

MR A. G. CHADBORN (Wolverhampton Technical Teachers' College) commented that it should not be necessary immediately to increase production in absolute terms. The most important resource, in the long-term, was the human resource. One of the main problems that had been spoken of was the conservatism of local peasant farmers. The major difficulty appeared to be that their system of agriculture had no appeal for the young men; the bright young men went off to the cities. If one could attract these young men back into agriculture by some means, one would have a number of forward-looking people who could accommodate change very rapidly. One way to encourage these people into agriculture would be to provide them with some gadgetry, some form of mechanization that would appeal to them and make them feel modern young men. Even if it did not increase production in the short term, it would in the long term because one would have active young men back in farming.

MR CHAMBERS (Chairman) said he was somewhat appalled at the suggestion of gadgetry. He thought something basic and solid on the ground was needed and that what was not appreciated was that in order to break through the conservatism, something massively worthwhile had to be produced. First and foremost, if a man was accustomed to producing enough for his family, probably with the women doing most of the work, that man had to be very sure of a return if he was going to be put at risk by investing money in fertlizers and the like. Mr Chambers said that there were two aspects in the modern agricultural field overseas as he saw it. One was that in which governments were trying to secure aid from outside sources. The project approach was really the only one that could lend itself to this kind of activity. But side by side with that, both within Ministries, Departments and those who were servicing, and within farming, there was the overall improvement that had got to continue; the stock-taking, natural resources development and the like, on a continuing pattern. Certain projects had made a big mark, without any doubt, but if one examined them closely, one would find that other aspects of the farming community had in fact suffered.

The sort of thing that happened was that large projects got off the ground only if the very best staff, which were limited in number, were made available and in consequence the best staff were collected for a project. Some projects could also lead to the overall marketing economy of the country being put to a certain amount of peril because the repayment of funds to the World Bank or other external source was geared to a certain price on which returns could be met. It was necessary to establish a definite balance between the overall improvement as against the project.

With regard to the point about encouraging young men, Kenya was a typical case where originally the young people, seeing what farming involved, had had only one idea, which was to get off the land. In far too many places the object of farming was to be able to get out of farming, make enough money from it to set up a shop or get away to the town. But when things like native-grown coffee got moving, the prestige factor changed and the young men started coming back. One found government servants actually wanting to leave, to go and take up farming. This is how it happened in Kenya but it had to be soundly based, extension-wise and finance-wise. If it depended only on gadgetry, the last state of the city would be worst than the first.

MR T. S. JONES (Commonwealth Development Corporation) said he did not entirely agree with Mr Chadborn's contention. His own experience was similar to that of Mr Chambers in that when he had last visited the Kenya small-holders scheme, there had, in fact, been a very large number of young men who did not wish to leave. On the part of the scheme closest to Nairobi, which was admittedly a rather extreme case, the farmers had fifteen or twenty acres each and some of them were making £400-£500 per year profit by growing vegetables and selling them in the town; they were in fact making more than the equivalent white-collar workers. On other parts of the same scheme, particularly where the Kikuyu were concerned, they being basically a very active and hard-working people, some of them were found to be making profits far more than the £120 which had been budgeted for their small-holdings. In a few cases profits of £300-£400 had been made in the second year after starting, and within three years a few had even taken over adjacent farms. Some did better than others, as was to be expected taking into account human nature, but it was clear that a lot of the young men could see that there was money to be made on such schemes and in a more interesting way, what is more, than just pushing a pen.

Mr Chambers said that the question of resistance to change was important and was where the sociologist came into the picture. At certain times, in the development pattern, one in fact might be doing a disservice to the brighter individual by encouraging him to work to a level which did not conform to the norm. Jealousies could be aroused amongst his fellows and produce most unfortunate reactions. It was in these respects that local knowledge was vital, and this could not be handled remotely from Britain or elsewhere. This kind of problem could only be handled by the people who were in daily touch with the farmer and land. It was one of the joys of this work that people of the right kind were being developed within overseas departments and government services and it was only by working with them that help could be given.

Mr H. R. Lancaster (Unilever Limited (Plantations Group)) said it had been interesting to hear from Mr T. S. Jones of the success of some of the schemes in Kenya and one might marry this with the success of the schemes that were under way in Malaya at the moment. In view of the nightmare described by the Chairman of the morning session concerning the population explosion and the amount of under-developed land, it was particularly unfortunate that some of the success in Kenya and Malaya could not be found in the equatorial rain-forest belt of West Africa where, unfortunately, young men were leaving the land. There was little to attract them and indeed the government of the countries in which they lived seemed far more occupied in promulgating most complicated labour codes far in advance of the development of the country, which made life particularly difficult for anyone trying to develop an agricultural venture in those countries. There had even been cases of plantation companies having to grow commodities to sell them in the countries themselves because the peasants had not been able to match up to the need. It was a particularly strange case of man's inhumanity to man, or of man's unawareness of his own needs. In this world of human suffering, there was indeed a place for the agricultural engineer in these parts and the hope was that more would be seen of him.

Mr H. Watson (British Agricultural Export Council) suggested that extension should be seen as a matter of priority. Extension personnel were highly important in the areas in which they worked and they were the intermediate key to development in many cases. Was it not feasible, as a matter of priority, to give these people a real incentive to return to their extension work after they had been trained? In Libya, FAO trained extension people and then after two weeks of training they merely wanted to sit in an office in Tripoli or Benghazi, order tea and tell somebody else what to do. If these men had an adequate incentive to go back and carry on—and perhaps the same thing might apply on the management side through extension—the situation might make sense.

Mr Robertson (Chairman) commented that this difficulty of people not wanting to go on with extension work was fairly widespread. He thought it partly related to the status of agriculture as such, which he believed was improving but in general it was not the thing to go for, especially in a community which lived off the land. The individual then probably wanted to do something that he considered better, probably in an office. There was some reason to hope that this situation was changing with agriculture being given a more adequate status in many countries today. The level of remuneration and indeed training of extension workers was frequently extremely low, so that in fact it did not offer an attractive career prospect. These were real problems and to those concerned with feasibility studies, both in extension and management, it affected the way a project would be implemented, following a decision on investment. One normally tried to assess this need and produce both a management structure and a requirement for extension in a feasibility appraisal. One tried to keep up, in effect, an output of propaganda on the importance of these things but it took a lot of time to become operational; it was not operationally widespread enough yet.

Mr T. S. Jones said that in countries where the educational facilities were short, the danger was that if one operated a training scheme for extension workers, they became better educated and therefore better equipped to take jobs which were vacant for anyone who was educated at all. He had, on a number of occasions, come across training schemes which had failed as they had resulted in those trained quickly leaving their new posts for other jobs. On another aspect of this matter, in his experience the best extension workers, generally speaking, were born, not made. Extension workers could be trained but they had to have a feeling for people; one could not make just anyone into a good extension worker. Part of the solution to the problem therefore lay in selecting the right people, but this did not necessarily always mean taking the 'bright boy'. Often one did much better with a steady person whose interest lay in this type of work and who wished to work with people and improve their lot.

Mr H. G. Stirling (West of Scotland Agricultural College) said he wished to say a few words on intermediate technology. One of the problems which had only been touched on rather lightly in the discussion was after-sales service. Mr Stirling said he had spent some days on a Middle Eastern desert farm owned by a man educated and trained in Britain. This farmer had purchased a combine-harvester which subsequently broke down; it had cost the farmer about £200 for a mechanic to be flown from Teheran to change a cylinder head gasket. The farmer had since sold his combine and was now cutting his crop with a method some 2,000 years old, namely by scythe. He would not buy another combine because it was more economic to cut by hand. Mr Stirling thought that until after-sales servicing had been made economically feasible, mechanization had got to be introduced at an intermediate level.

Mr A. B. Lees (Retired) said that it was immaterial what the price was if the goods or services could not earn their keep. As to the cost of service, one could not 'bicycle' out into the desert whether to repair a combine or sharpen a sickle at less than cost. Mr Lees said that the saddest thing in his twenty years' export experience related to Africa; the number of tractors taken every year (excluding South Africa) had been between 5,000 and 6,000 in 1956/57; it had remained exactly the same in 1966/67. A great deal of support from the United States and other countries had been poured into Africa during those ten years, and in only two did the population growth and food production growth match up. The small balance in favour of food production in those two years had only been about one or two per cent. This, said Mr Lees, was really rather terrible. He suggested that a very important need in many of the underdeveloped areas was the ability to break the ground ahead of the rains, with quite small tractors. It was amazing that, with the talent existing in agricultural engineering, some sort of supersonic vibration of ordinary share points could not be operated behind a tractor of not more than 20 hp, to get the grain or seeds of some kind into the soil ready for the rain when it did come.

Mr F. E. Rowland (Retired) said that he agreed with the previously expressed need for agricultural engineers. It should be realized also that agricultural engineers or anyone doing extension service needed something additional to technology, namely, the ability to train people in character which was often more important than training them in technology. Conferences such as this very frequently, if not always, came back to this point. Mr Rowland said he had been interested in what Mr T. S. Jones had said about the best extension workers being born and needing to have a feeling for people. This was very important if one was to get the best out of these schemes.

Mr D. F. Howson (NIAE) said he could not understand why it had to be intermediate technology versus advanced technology because surely the world was a big enough place for both. One might be considering on the one hand a little village in Kenya and on the other hand the Gezira Board Scheme, and so on. Why could not agricultural engineers work together instead of bringing up these odd little arguments which really did not help the problem? Mr Howson said another point that had interested him had been the question of farmers in underdeveloped countries having to go over the same lengthy ground that had already been gone over in Britain over the centuries. Mr Howson questioned whether it was really necessary that this should happen and drew a parallel between his own training which had resulted in his becoming a recognized engineer before he had ever seen a computer. Nowadays, on the other hand, a student shook hands with a computer almost on his first day and therefore did not have the same worries about the new techniques involved. The crux of the matter appeared to be in identifying the problems and this was perhaps the difficult thing to do.

Mr T. S. Jones said he agreed fully with Mr Howson and believed it was a matter of circumstance. If one had the necessary financial and technical backing it was possible to move faster, although there was room for both intermediate and advanced technology. There were particular situations however in which one could not have the intermediate position at all; for example, one could only manufacture tea nowadays by making it in a modern factory and it was no use manufacturing it in the way it was done in a simple factory fifty years ago. In such cases, obviously one had to be prepared to move directly to the most modern techniques and produce a product that could be sold in competition with other peoples'. However, there were other circumstances, particularly in the example given earlier regarding transport, where any improvement was much better than no transport or head-loading, but one did not necessarily need to use 5-ton lorries. The conflict between intermediate and advanced technology did not exist as often as was sometimes supposed.

Mr T. F. Shaxson (Malawi) said he would like to comment on the position of the agricultural engineer who would be coming from the National College of Agricultural Engineering and what his role might be in the situation where there was no place perhaps for large scale mechanization. He might think it not worth considering, but it was heartening to discover that the curriculum of the College produced men who had an appreciation of a lot else besides gudgeon pins, piston rings and the rest of it. Mr Shaxson said that in the days when he was at college agricultural engineering was the shapes of cutterbars and that kind of thing which was useful if you were going into a dealership in the UK but no use at all if you were going out to the tropics. In Malawi which, in the south was extremely densely populated, the thought that the population might double by the year 2000 was positively frightening. A man with an appreciation of the techniques of planning described during this conference and an appreciation and an understanding of the engineering aspects of land development could help. At a recent meeting of the British Soil Science Society a paper had been presented by a member of the Road Research Laboratory. He had stressed the point that in agricultural surveys it was essential that other data in addition to agricultural data be collected. Mr Shaxson said he could himself in no way presume to write information which would be of use to a road engineer but a man who had been trained at NCAE perhaps would be able to feed this data in. The agricultural engineer coming into the tropics should be able to see the implications of what was going on. It was important that he should know how to plan and that the planning went sufficiently far ahead so that one did not make the most terrible mistakes in short-term planning, and find that in ten years time the whole thing had to be done over again. He looked forward to the time when people trained in this way would be able to help out, not only as agriculturalists but as engineers who could contribute in other fields as well as agriculture.

Mr B. Wilkinson (Soil Science Dept. NAAS) said that the title of this conference remained just as applicable to Great Britain as it did to developing countries. The problem existed all the time, no matter where one was. Every country was at a different stage of requirement and this was something that was going to remain so virtually as long as *homo sapiens* was on this planet. It was going to be a requirement of every sort of society and only differed in the amount of information required. The techniques which had been discussed such as air photographs and land capability classification would still be applicable, whatever level of agricultural society one was dealing with.

Dr Payne said he would like to ask Dr Osman, who was in the audience, from the University of Khartoum, if he would comment on the motivations and attitudes of his students to extension work in his country. Dr Payne said he believed this was a piece of information terribly lacking in Great Britain and to which all too often one tended to invent false solutions.

Dr M. S. Osman (University of Khartoum) said that many people had the impression that Africa was all one country, rather like England or Wales, whereas the variation in climate, vegetation and peoples was vast indeed. When one talked about an under-developed country, it was necessary to be rather specific because a lot of the things that may be applicable to one country were not applicable to another. For example, in the Sudan, there were now about 100,000,000 acres still to be developed, all suitable for irrigation and all suitable for cropping. In this situation, what was to be done? The Sudan was faced with a sparse population, only about 14,000,000 people, less than the population of London, in an area of 1,000,000 square miles, about the size of Europe. So there had to be mechanization on a large scale and the aim had to be for the most modern equipment one could get, and not intermediate technology. Dr Osman said that when talking with many people about mechanization they appeared to think that with under-developed countries one had to start with mechanizing the ox by providing simple implements and then adding attachments and then in fifty years time one would get a small tractor. In his opinion, this was completely wrong. One should go for the most modern tractors and equipment one could think of and train people to use it. During visits in Britain, Dr Osman said that he had been told by farmers that the tractor was complicated, and this in a country which was far from being an under-developed one; rather was it an over-developed one, and yet the farmer thought his tractor was complicated. So it came back to the matter of training.

Turning to the question of extension, Dr Osman said that a course in extension of only two weeks had been mentioned and yet on the other hand, extension was becoming a study in its own right. In America one could obtain a degree in extension. One could get a post-graduate and master's degree in extension. It might take ten years to become a qualified extensionist. At the same time, one could arrange an extension programme for a week and then tell the fellow to go and do extension work. Dr Osman thought that basically an extensionist should first understand the discipline he was going to give extension in. If an agricultural engineer was going to advise people on machinery then the extensionist must be a person who had done a lot of work with agricultural machinery. In the Sudan, it was thought that extension would play a great role in the development of agriculture and that was why the University was currently in the process of introducing extension as a discipline in its own right in the Faculty of Agriculture. It would be a department, just like the other major departments in the Faculty. It would be possible for students to receive under-graduate as well as post-graduate training in extension. The Sudan would also have a national extension service within the Ministry (rather like NAAS in Britain) but it was unlikely that it would be as detailed as the American system where, if one was a horticulturalist then one would have extension in horticulture. In the Sudan there would be an all-round extensionist and then if more advice was required there would be subject-matter specialists to give advice later and in greater detail on a particular topic. It was hoped to produce these schemes in the Sudan within the next three to four years.

Mr N. M. Garrard (Overseas Liaison Unit, Silsoe) wondered just how far one could go with mechanization in developing countries. Thinking in terms of complete mechanization from land preparation right through to harvest, was there any point in working out the size of the units? Should one take mechanization up to the land preparation stage and then complement it with animal-drawn equipment for the farmer to get on with his own planting and weeding?

Mr Robertson thought it was extremely difficult to generalize on this subject. With such a great divergence in environmental conditions there was no one formula that could be applied to solve this problem. Nevertheless, there were certain problems that did arise, and one of the biggest was the problem of primary tillage and breaking the ground before the rains came, or pre-irrigation. One should have the maximum amount of effort in the whole farming operation confined to this one section. Whether in fact subsequent cultivation would be by animals would depend on whether the land was available in any case on which to keep a buffalo or an ox. In densely populated areas, this area would become less and less.

Mr T. S. Jones commented that the key problem for many small farmers in the tropics was the bottleneck in cultivation which arose at the time of planting. With nearly every annual crop there was a loss of twenty or thirty per cent in yield if it was planted three or four weeks later than the optimum date. Cotton in Nigeria was a good example where this had been shown time and time again. In growing food and cash crops the bottleneck arose, in the timely land cultivation and planting of both to get good yields, as the two were in competition and initial mechanization requirements arose in solving this problem. How far mechanization could go after that was largely a matter of economics, but it was for initial land cultivations and preparation that mechanization was most urgently needed on a wide scale.

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NOTE—I wish to express my particular appreciation of the very considerable amount of work done personally by Mr J. K. Bennett, the Institution Secretary, in transcribing this long and valuable discussion from the tapes on which it was recorded.

J. A. C. Gibb
Honorary Editor

ANNUAL GENERAL MEETING

—*from page 43*

Fellows

T. C. D. Manby	National Insitute of Agricultural Engineering
P. T. Ward	Rubery Owen & Co. Limited

Members

J. H. Nicholls	David Brown Tractors Limited
J. D. Savage	B.P. Trading Limited

Companion

E. Griffith	Rotary Hoes Limited

Associates

J. Monck	Farmer

Graduate

D. W. Jewett	Seale Hayne Agricultural College

A list of the full Council 1969-70 appears on page 40 of this *Journal*.

The AGM concluded with Mr Sherwen presenting a Certificate of Honorary Fellowship to Mr J. M. Chambers, C ENG, FI MECH E, who had been thus honoured by Council in January, in acknowledgement of his outstanding contribution to the agricultural engineering industry and his distinguished service to the Institution.

Immediately following the formal closure of the AGM, Mr Sherwen commended to members, the new President, Mr H. C. G. Henniker-Wright, MEM ASAE, FI AGR E, and vested him with the Badge of Office. Mr Henniker-Wright thanked Mr Sherwen for his valuable endeavours as President from 1967 to 1969. For his own part, he would do his utmost to uphold the high standard of his predecessors.

RESOURCE DEVELOPMENT PLANNING WITH SPECIAL REFERENCE TO INTEGRATED AGRICULTURAL FEASIBILITY STUDIES

by D. V. Chambers —*from page 54*

aspects of the agreed development programme), has been shown to achieve considerable success. In addition, such planning groups are able to undertake on-the-job training of counterpart personnel so that local nationals can assume increasing responsibility, with gradual phasing out of the expatriates.

In conclusion, the writer would venture to suggest that resource planning and integrated feasibility studies constitute an essential feature not only for the orderly development of agriculture, but for other industries as well. Whilst this paper has been principally concerned with various aspects of resource planning in the more newly developing countries, it would appear that there is also a need for the application of similar studies in the more highly developed countries including Great Britain. Current demands on agricultural land for industry, housing, recreation and water reservoirs is ever-increasing and gives cause for concern. Moreover, the lack of up-to-date land capability maps would appear to preclude the adoption of a rational approach to proper land use as suggested in this paper. It is, however, encouraging to note that a start has been made on the preparation of land quality maps which will indicate cropping potential, but it still remains to be seen whether those responsible for future development will recognize the importance of agricultural land of which only about half an acre of crops and grass per person is available for food production in England and Wales.[4]

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AUTUMN NATIONAL MEETING 1968 (DISCUSSION)

—*from page 47*

systems approach. In reply, Professor Coales said that one must distinguish between the cost of modelling and that of on-line optimization. The cost of modelling was likely to be very large, but once it was done it would be of fairly general application. In the Park Gate steel mills, computers were used to match the measured lengths of individual billets to the orders in hand, making substantial economies in minimizing scrap.

Dr Hunt said that his farm machinery selection programme required one man-hour of time to insert the data, plus £2-worth of computer time to run—the cost was therefore very small when the initial programme had been compiled. Professor O'Callaghan said that the Newcastle programme had taken 18 months to produce, but required only 2 minutes of computer time to run. It gave a whole range of management information which could be of immediate value. He felt it was essential to establish a bank for agricultural engineering and management data as soon as possible.

Concluding the discussion and the Conference, the President said that he felt sure that Systems Engineering would not only prove applicable to the scientific mechanization of farming, but also that it could offer to the engineering designer a valuable means of rationalizing design and procedures, to be added to those qualities of instinct and feeling for design which were his basic qualities.

ELECTIONS AND TRANSFERS

Approved by Council at its meeting on 17 *April* 1969

ADMISSIONS

Fellow	*Overseas*	Hearnshaw, J. J.	Kenya
	Overseas	Scicluna-Spiteri, A. S.	Malta, G.C.
Member	*Overseas*	Len Swe Chooi	Malaysia
		Cooper, D. J.	Staffs
		Straughen, G. C.	Wilts
		Neal, M. S.	Yorks
		Washbourne, J. F.	Lincs
		Westrope, J. H.	Scotland
Associate		Bayley, J. J.	Sussex
		Bowley, A. K.	Wilts
		Chapman, R. M. D.	Norfolk
		Corbishley, R. H.	Warwicks
		Gledhill, C.	Yorks
	Overseas	Kassam, S. A.	Tanzania
		McMullin, T. D.	Northampton
		Osborne, W. M.	Mon
	Overseas	Page, R. A.	Rhodesia
	Overseas	Parameswaran, K.	Ceylon
	Overseas	Penrice, P. J.	Ceylon
		Pound, J. P.	Wilts.
		Russell, J. H.	Yorks
		Sears, B. L.	Derbys
	Overseas	Tuck, N. G.	Uganda
		Sykes, A.	Cornwall
		Wickington, H. C.	Sussex
	Overseas	Woo, M. C.	Hong Kong
Graduate		Alcock, R.	Scotland
		Brix, P.	Staffs
		Counsell, G.	Cornwall
	Overseas	Khoo, D. C. P.	Malaysia
Student		Aldis, C. A.	Hants
		Allan, A. M.	Sussex
		Barnard, R. J.	Essex
		Beswick, R. G. B.	Beds
		Davies, G. R.	Beds
		Ford, J. E.	Beds
		Gibson, R. F.	Beds
		Henry, G. P. C.	London
		Jones, R. H.	Beds
		Key, A. R.	Beds
		Moffat, J. C.	Beds
		Morrison, R. R.	Newcastle-upon-Tyne
		Pepper, A. T.	Beds
		Stacey, K. L.	Berks
		Steele, P. E.	Beds
		Trevarthen, R. H.	Cornwall

ELECTIONS AND TRANSFERS (*continued*)

TRANSFERS

Grade		Name	Location
Honorary Fellow		Chambers, J. M.	Warwicks
Fellow	*Overseas*	Aboaba, F. O.	USA
		Bunting, J. F.	Lincoln
		Charlton, J. U.	Yorks
		Codrington, C. de B.	Bucks
		Falconer, A. W.	Wilts
		Gibson, J.	Staffs
		Lee, R. H. D. F.	Herts
		Maughan, J.	Yorks
		Neale, A. H.	Cambridge
	Overseas	Wilson, W. A. W.	N. Nigeria
Member		Wingate-Hill, R.	Cambridge
	Overseas	Baker, C. J.	New Zealand
		Barnes, M. M.	Berks
	Overseas	Beeny, J. M.	Kuala Lumpur
	Overseas	Downes, J. R.	Holland
		Ellam, D. F.	Berks
	Overseas	Green, L.	Rhodesia
		Harding, J. S.	Bucks
		Laird, T. R.	Orkney
		Lamin, W. H.	Nottingham
		McLaren, E. A.	Worcs
		McNaught, J. B.	Warwicks
		Mitchell, D. G.	Warwicks
	Overseas	Onafeko, O.	Nigeria
		Pritchard, L. A. G.	Brecknocks
		Roberts, R. J.	Sussex
		Snape, A. E.	Cambs
	Overseas	White, C. G.	Ceylon
Companion		Potter, S. L.	Warwicks
Associate		Eddison, H. P.	Yorks
		Lyford-Smith, A.	Worcs
Graduate	*Overseas*	Hollick, M. F. G.	Western Australia
		Keevil, G. R.	Wilts
		Turner, P. T. D.	Oxon

OBITUARY

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

Gates, G. R. G.	Fellow
Gothard, H. A. S.	Fellow
MacKenzie, P.	Fellow

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