Journal and Proceedings of the Institution of Agricultural Engineers

WINTER
1969

Vol. 24 No. 4

THE INSTITUTION OF AGRICULTURAL ENGINEERS

Annual Conference 1970

To be held at
The Institution of Mechanical Engineers
1 BIRDCAGE WALK LONDON SW1
TUESDAY 12 MAY 1970

CULTIVATIONS

Current economic trends demand continual intensification of every aspect of crop production, not least among these being cultivations. Many radical techniques arising from the availability of greater tractor power and the development in chemical weed control make it difficult for the farmer to choose the best method for his particular situation.
The programme covers both the current research approach as well as a more applied look at some of the modern trends that are now under development.

Conference Convener:
N. J. BROWN, Rothamsted Experimental Station

09.30 Assemble for Coffee
10.00 Annual General Meeting of the Institution
11.00 Presidential Address
by H. C. G. HENNIKER-WRIGHT, President of the Institution
11.30 Conference opens—Chairman of First Session: H. C. G. HENNIKER-WRIGHT
11.35 **The Influences of Cultivations on Soil Properties**
by N. J. BROWN, Rothamsted Experimental Station
12.00 **The Effects of Traffic and Implements on Soil Compaction**
by B. D. SLOAN, Scottish Station, National Institute of Agricultural Engineering
12.30 Discussion of First Session Papers
13.00 Lunch Interval
14.15 Conference resumes—Chairman of Second Session: J. G. JENKINS, Childerley Estates Ltd.
14.20 **The Long Term Effects of Cultivations**
by J. R. MOFFATT, Rothamsted Experimental Station
14.45 **Current Cultivation Techniques**
by J. K. GRUNDY, National Agricultural Advisory Service
15.15 Discussion of First and Second Session Papers
16.30 Tea and Dispersal

Annual Dinner 1970

18.15 Reception
19.00 Dinner

To be held at
St Ermin's Hotel
CAXTON STREET
LONDON SW1
TUESDAY 12 MAY 1970

TICKETS	*Non-Members*	*Members (other than Students)*	*Student Members*
Conference (including lunch and refreshments ..	£8. 0. 0.	£5. 0. 0.	£2. 0. 0.
Dinner	£5. 10. 0.	£3. 10. 0.	£2. 0. 0.

EARLY APPLICATION FOR TICKETS IS ADVISABLE

Applications should be accompanied by remittance payable to 'I Agr E', and addressed to the Institution at Penn Place, Rickmansworth, Hertfordshire, WD3 1RE

JOURNAL AND PROCEEDINGS OF THE INSTITUTION OF AGRICULTURAL ENGINEERS

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VOLUME 24 **NUMBER 4** **WINTER 1969**

INSTITUTION NOTES

Credit Where Due

Government Ministers are not always renowned for acknowledging facts of life. So it is all the more pleasing when they do.

For example, it has long been a fact of life that a cordially informal but highly practical relationship exists between I Agr E and The Institution of Mechanical Engineers. As the two Institutions share a vital responsibility for promoting the ever-increasing application of Mechanical Engineering to agriculture and horticulture, collaboration between them is an essential and natural consequence of that joint responsibility. What is refreshingly new is to come across a senior spokesman of H.M. Government who not only discerns that such collaboration is good for British agriculture, but publicly encourages its furtherance. This happened at the I Mech E Annual Dinner in London on 13 November. The Guest of Honour was The Right Hon. Fred Peart, M.P., Lord President of the Council and one-time Minister of Agriculture in the present administration.

In his speech, Mr Peart dwelled at length on the importance of partnership between industry and technology, stressing the need for industry in the first place to attract well educated engineers and then to ensure that their talents and skills were fully utilized. He suggested this was a problem which should be pursued to its roots, possibly as far back as course structures in secondary school senior forms, taking early care to avoid over-specialization. Turning to the engineering profession, Mr Peart said that the need for close partnership had led to a growing realization that unity would be of benefit for all concerned. The proposals for the formation of a composite register under the umbrella of the Council of Engineering Institutions to cover the whole engineering community would, in his view, be a big step forward.

The reference to agriculture came towards the end of his speech when Mr Peart commented in nostalgic terms on his own active and lively interest in the farming industry. During his term as Minister of Agriculture he had been aware of the very close relations that existed between I Mech E and I Agr E and he hoped that these would become still closer. British agriculture, said Mr Peart, was in many ways the most mechanized in the world and the importance of mechanical engineering to the prosperity of the farming community could not be over-exaggerated.

Well said. On the strength of the above Mr Peart deserves to be wished a Happy New Year. The wish is well meant but unfortunately carries no guarantee!

Spring Fashion

The *Journal* is about to step into the 1970's with a touch of trendy gaiety. The Spring issue (Volume 25, No. 1) which will reach all members during April will have a very different appearance from anything that has gone before, including a new pictorial front cover and interior styling. A slightly larger page size will allow more space for features like '*Newsdesk*' and other newsy items that members seem to appreciate.

It need not be feared that the standard of technical content, which causes this publication to be sought after in most countries in the world, will be sacrificed for the sake of stylishness. The basic integrity of purpose of the *Journal* will still be jealously maintained, in the channelling of information and knowledge wherever agricultural engineering is applied and practised. One of the simple objectives is to make the printed word easier on the eye and if this results in valuable material being widely read, so much the better.

Viewpoint

One new feature to be introduced into the redesigned *Journal* will be a page of members' letters containing comment or opinion on any topic of special interest or concern to the agricultural engineering community. If you have a point of view which you think will provide food for thought, send it in.

Letters can be anything from 10 to 200 words in length. If we are overwhelmed by the response to this appeal, please don't be disappointed if your letter is not published. You can be sure that everything received will be carefully read. Mark your letter 'Viewpoint' and address it to the Hon. Editor, c/o the Institution. Letters intended for the Spring 1970 issue should arrive not later than 10 March 1970.

NEWSDESK

COLLABORATION ON COMPOSITE ENGINEERING REGISTER

In September 1969 a working party under the chairmanship of Sir Arnold Lindley was formed to implement a Board resolution of the Council of Engineering Institutions to establish an Authority for registration qualification and title in the engineering community.

On Monday 8th December CEI convened a meeting of representatives of organizations—including I Agr E—interested in collaborating with them in this and there has been a useful exchange of views. The two principal items discussed at the meeting were standards of qualification, and the structure of the Authority.

Standards proposed by SCNQT for technician engineers and engineering technicians were favourably received as a basis for resolving the requirements of bodies for entry to the new register.

CEI proposals for the structure of the new single Authority were considered in broad terms in which the three principal sections of the engineering community concerned, namely chartered engineers, technician engineers and engineering technicians, could subscribe to a common register set up through the medium of the Royal Charter of CEI.

It was agreed that a further working party consisting of representatives from CEI, SCNQT (the Standing Conference for National Qualification and Title), CSTI (Council of Science and Technology Institutes) and other interested bodies will be set up to develop proposals for the structure of the Authority so that it can be established as soon as possible.

Sir Leonard Drucquer, Chairman of CEI, who presided at the meeting said afterwards:

> 'This is a positive step forward and should ensure the all-important close collaboration between engineering institutions and societies. Fulfilment of the plans for composite registration arrangements, and the improved status that would result, should not only provide the better standing that so many technician engineers and technicians need and deserve, but considerable inducement for more young people to seek a career in engineering.'

More about Metrication

In an earlier *Newsdesk* (Volume 24, No. 2—Summer 1969) reference was made to the increasing momentum of the change-over process to metric units in agricultural engineering and allied industries.

A complete report is now available of the Agricultural Engineers Association Conference on Metrication held at Silsoe in 1969, an event in which the Institution was happy to provide some collaboration. Thanks to the courtesy of the AEA, we are able to reproduce in full in this issue of the *Journal*, the opening paper at that Conference—'Metrication' by Col. J. S. Vickers, British Standards Institution. Other papers in the programme were, in order of presentation, 'The Change-Over to the Metric System in the Steel Industry' by L. G. Dover of British Steel Corporation; 'Metrication and the Company with International Affiliations' by K. D. Craig, of International Harvester Company (Great Britain) Ltd., and 'Metric Components in Industry' by N. Fielders, Standard-Triumph Company Ltd. All papers were followed by questions and discussion, which feature in the Report together with an introductory address by the AEA President, Mr Trevor Knox.

Copies of the complete Proceedings are available directly from the AEA, price 25/- to AEA members (30/- to non-members).

What's On in Europe?

French Trade Exhibitions announce that the 41st International Agricultural Machinery Exhibition in Paris (10-15 March 1970) will feature the second INTERNATIONAL IDEAS MARKET. This scheme is designed to foster research in the field of farm mechanization and to sponsor the placing of patents. Full details can be obtained direct from French Trade Exhibitions, 24 Rutland Gate, London, S.W.7.

FIMA/70—The International Agricultural Machinery Show takes place at Zaragoza, Spain, on 4-12 April 1970. On 9-11 April, a Conference will be held on 'Mechanization of Viticulture and Wine Technology'. Complete details of these activities can be obtained from the FIMA/70 Press Office, Plaza Emperador Carlos, Zaragoza, Spain.

The Italian Society for the Advancement of Zootechnics announce that they will hold their 5th International Zootechny Symposium at the Milan International Trade Fair on 15-17 April 1970. The subject will be 'Biological, technological and socio-economic problems concerning housing and mechanization in the modern zootechny'. All enquiries should be addressed to the Society at Via Monte Ortigara 35, Milan, Italy.

OBITUARY

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

ATKINS, F. C. ..	..	Associate
GUNNING, P. R.	..	Graduate
PARKER, E. J. ..	..	Associate
WESTON, L. T...	..	Fellow

Publications

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

Selected Bibliography on Agricultural Engineering—by Mohammad Rafi, West Pakistan Agricultural University.

The bibliography presents under one cover information about books on agricultural engineering published in the English language during the period 1951-1968. It lists books on agricultural engineering, i.e. general reference dictionaries, yearbooks and directories ranging from general to particular fields of specialization.

Comparative Study of Wheel-type Tractors imported into West Pakistan—by Mohammad Rafi, West Pakistan Agricultural University.

A résumé of the different makes and types of tractor imported into West Pakistan.

Abstracts of Romanian Technical Literature—by Central Institute for Technical Documentation, Bucuresti.

This quarterly bulletin issued in English, French and Russian provides up-to-date abstracts of articles published in the Romanian periodicals.

Agricultural Land Development—E. D. Coles, Assoc Mem ASAE, MI Agr E, of S.A.S.A. Experimental Station, Natal, South Africa.

This paper, although not published, is available on loan to Institution members on request. The author's summary claims that in the past, agricultural land development has been conducted in a haphazard manner by a number of diverse disciplines and therefore it has become necessary to establish the role of the various disciplines concerned with the solution of land development problems—notably, the role of the agricultural engineer in land development. The role of each discipline in each category and the services provided by each of these disciplines has been indicated in the paper so that each service follows in logical order of application, from the largest project down to a simple farm plan.

Introduction of Cash Crops to Peasant Farming and their Processing—by R. J. M. Swynnerton, Agricultural Adviser, Commonwealth Development Corporation.

This paper was one of five presented at the I Agr E Spring National Meeting at Silsoe in March 1969 under the general heading 'Planning and Executing the Development of Agricultural Resources'. Although a large part of the proceedings of that meeting was published in the Summer 1969 issue of the *Journal*, space was unfortunately insufficient to accommodate Mr Swynnerton's paper. It is available on loan from the Institution or it can be purchased through the I Agr E Reprint Service. The paper gives details of some of the projects with which the Commonwealth Development Corporation has been associated such as rubber and oil palms settlements schemes in West Malaysia; Virginian flue-cured tobacco in Malawi and Zambia, the Vuvulane Irrigated Farms in Swaziland based on sugar cane and the Kenya Land Settlement Scheme where former European farms sub-divided into smallholdings carry productive dairy cattle and wool sheep, and grow sugar cane, tea, pyrethrum, hybrid maize and wheat.

BOOK REVIEW

Farm Machinery (8th Edition)

by C. Culpin (Crosby Lockwood & Son, London, 1969 (63/-)

It is always a pleasure to receive a new edition of Mr Culpin's standard book on Farm Machinery. The last edition was revised in 1963 and the opportunity has been taken to expand a number of sections. The most notable of these new features are chapters on Silage Making and Feeding, Equipment for Livestock Husbandry and Environment Control in Crop and Stock Buildings.

Illustrations and text have been updated throughout the volume, with the inevitable corollary that material on machines which are now of little economic importance in Britain, such as binders and threshers, is omitted.

As in previous editions, Mr Culpin has contrived to compress a very great deal of information into the pages of what has now become a pretty substantial volume. The result is a general guide to farm machinery which is of great value to agricultural engineers, farmers and students. Further reading on specific subjects is suggested in the references at the end of each chapter. Seven appendices on relevant engineering subjects provide a helpful background study for agricultural students and others who do not require a more detailed treatment of the topics concerned. A final appendix on definitions and useful data includes a list of British Standards applicable to farm tractors and machinery.

Mr Culpin refers to the forthcoming necessity for introducing metrication, but concludes that this exercise will be more appropriately undertaken in the 9th edition of the book, in due course. Meanwhile. the new 8th edition of 'Farm Machinery' is one that can be commended warmly to all agricultural engineers.

J.A.C.G.

METRICATION

by

COL. J. S. VICKERS, B SC(ENG), MIAE, AMBIM*

This paper is reproduced by courtesy of the Agricultural Engineers Association Ltd. It is one of a series presented at the AEA Metrication Conference held at Silsoe on 3 June 1969 (see "Newsdesk" on page 156).

It would hardly be possible in the course of half an hour to cover all the aspects of this very important subject so I shall pick out what I consider to be the most important ones and leave you to bring up at question time particular matters of interest.

I believe it very important indeed that all concerned in this change should be very familiar with the reasons for making it. I think it is a human right to know why one is asked to do certain things and a change like this, on the face of it, is for a lot of people just a damned nuisance probably dreamed up by a lot of doctrinaire eggheads, and with no real, practical significance. This idea must be dispelled and the lowest form of company life is fully entitled to know why he is being asked to change his habits. Again, in the time available one can not do justice to the reason for this change but let us be clear that its underlying reason is to improve our export competitiveness. It is important to industry to be making things which are more readily describable to an overseas customer, more compatible with the environment in which he is going to use them, and so on. One sometimes hears the question asked that since exports are a minor part of our gross national product, why are we so worried about them? The economic adventures of the last few years tell their own story. It is true that exports amount to no more than about 15% of our gross national product but I think the best analogy I can give you is that they are a sort of 'servo-mechanism' for the whole of our economy. If they are right and if our balance of trade is right, then the economy prospers. If they are not then I do not need to elaborate on what happens—we are in the middle of it now. When the balance of payments is adverse, the pound falls, taxes rise, there is a credit squeeze and the standard of living goes down. We have even been brought to the stage where, as a matter of Government policy, we have brought in a thing called 'devaluation' to try and put our exports situation right. I think all too few of us recognize that for what it is—a negative, punitive device, which, in effect, says to us: 'Your standard of living is higher than anything you have earned and we will arbitrarily reduce it to something you can afford'. By contrast, to provide for our goods being more acceptable in the metric countries, who are our majority in export customers, is a constructive step. 90% of the world is already using the metric system and 60% of our exports are going to metric countries. In no time at all it will be true to say that the whole world will be using the metric system; here I very much include the North American Continent. It is worth explaining these simple facts to those who have to make this somewhat tiresome change and I think time spent in giving that information will ensure co-operation from those people whom we expect to help us in making it work.

What is the present country-wide position in regard to this change? As we all know the announcement was made by the President of the Board of Trade in May 1965 that the Government were disposed to encourage and support British Industry who had requested that the change be made. Let us be quite clear about this. This is an industry request and not a Government edict. The industry reckoned that they would be better off using the metric system than using their customary imperial system and the Government agreed. Since that time there has been a lot done at national level but all too little publicity has been given to it. I hope that situation will very shortly be rectified because the Metrication Board will regard as one of its major functions the dissemination of good information about metrication and publicity about what is going on at national level. It is vital that we should all know what the other chap is doing in this. We cannot afford to do it unilaterally. We have got to do this job in concert, because herein lies the secret of getting it done economically. We cannot afford to be out on a limb; we have to go with the tide, and the only way to do that is to know what the tide is doing.

In early 1966 as a result of the announcement, there was set up by the Ministry of Technology, a Standing Joint Committee on Metrication who were charged with implementing the Government's pledge to encourage and support industry in doing this, and that Committee energized various fields in the business of metrication. B.S.I. were represented on it and it was called a Joint Committee because it was joint as between Industry and Government. Industry was represented in the shape of the C.B.I. together with several industrialists. Various Government departments were represented and B.S.I. itself. They did, as I say, start energizing various people in work which could only be done at a national level. They combed through legislation to see what wanted doing there. They had a look at education; the educational system is now pretty well buttoned-up. There is a firm recommended plan for education at all levels to switch from imperial to metric systems. This switch will not be a cut-off so much as a change of emphasis and that change of emphasis has already started in many areas of education. It will certainly start in *all* areas in the academic year

*Chief Engineer, Planning Group, British Standards Institution

beginning this Autumn. The Standing Joint Committee also got on to the Ordnance Survey people to see what they could do and discovered that they (the Ordnance Survey) had already spent £80,000,000 of an allocation of £100,000,000 in re-surveying this country in the imperial system and they were a little aghast at the idea that they should now go back and do it in the metric system—a quite understandable reaction. But of course, as we know, most of their work is based on a kilometre grid and so far as the horizontal distances are concerned, there is no great problem. The maps can be produced in metric terms by photographic means, but it is not quite so easy to deal with contours in that way and if we want 50-metre contours or 25-metre contours or whatever it may be, the Ordnance Survey are going to have to do a certain amount of re-surveying. I think the general consensus of opinion is that the horizontal distances are the main concern, and the contours are something that one looks at on a map for guidance; if they are vital, one does one's own survey anyway.

In the whole of the two years of the existence of the Joint Committee, which still exists but has not met for some time, the very important problem in which we seemed to make no headway at all, was to induce the Board of Trade to act in respect of the retail sector of the country. We had great difficulty in persuading the Board of Trade that there was a link between manufacturing industry and retail trades. This reached such a pitch, that early last year the C.B.I. recommended that a Metrication Board be set up to co-ordinate this change throughout the entire economy. The idea was that there would be a Board analagous to the Decimal Currency Board, answerable to the Government, to see that this job really did permeate the whole of the national economy, because it is obviously absurd to imagine that manufacturing industry can, on the one hand, effect this change, and on the other hand, leave the rest of us in our every day commercial and social life with the imperial system. So the Metrication Board was proposed in July last year and the proposal was accepted by the Government. We now know that it has been set up and held its first meeting within the last few days. Its Chairman is Lord Ritchie Calder; the Vice-Chairman is Lord Bessborough and it has a permanent Civil Servant as a Director. It has a Secretary of the Civil Service and a group of Civil Servants to provide its permanent staff.

There is no doubt in my mind that the Board will give priority to getting the retail sector to catch up, because manufacturing industry is already in a position to start producing in metric terms next year. To many of us in the manufacturing world, the idea that for the retail sector we should continue to package our products in imperial terms, while packaging them in metric terms for our industrial colleagues, is just not on. This would create a duplication where none exists at the moment. So we are going to have items coming into the retail sector next year in metric terms and the sooner the retail sector realizes this the better. A perfect example of this is the construction industry which as you know, plans to start building in metric terms next year. The paint industry has appreciated that quantity surveyors will want to measure paint not in gallons or pounds but in litres or, conceivably, kilograms, and they have already arranged that from next year they will be marketing paint in 1, 2½, 5 and 10 litre cans for the construction industry. It is quite inconceivable to me that they would continue to supply pints, quarts and gallons for the retail sector.

At about the same time as the Standing Joint Committee was set up, my little Planning Group was set up in B.S.I. and we set out to plan B.S.I.'s role in this. Douglas Jay had said in his announcement that the basis for this change would be a series of Metric British Standards. As the Charter to do this job was to apply to the whole of British industry, one had to look at it pretty carefully, to decide where the priorities lay. As we saw it, British industry could really be split into three groups for the purpose of this sort of planning. The groups we selected were the manufacturers of engineering equipment who seemed to us to be the people who would be faced with a very complex task in making the change. As far as process industries were concerned, there were few who would not be the customers of the engineering equipment manufacturers. After all, the chemical manufacturer goes to an engineer for his pumps, tanks, pressure vessels, weighing devices, volume measuring devices, and so on. The textile manufacturer demands looms, and even the farmer now buys his horses from you gentlemen, doesn't he—in the shape of tractors! There are very few process industries that do not go to the engineering equipment manufacturer for their process plant. In his turn, the engineering equipment manufacturer looks to a whole series of supplying industries to supply him with the tools and components which he puts together to form his engineering equipment.

So we looked at it from the point of view of these three groups; the whole of the supplying industries, engineering equipment manufacturers, and the users of engineering equipment as process plant. I think that most people agreed with us that the man in the middle, the engineering equipment manufacturer, had the most complex task in making the change. Consequently, when we started thinking of which standards we had to put into metric terms first, we thought we had better ask him just what sort of time programme he was going to work on, because, given that he has got the most complex task, he must, to a certain extent, call the tune for the national economy's sake. Naturally, therefore, having set out to provide a set of metric British standards, we found ourselves investigating with industry what the timing of the change ought to be.

The architects plan to design in metric terms this year—they have already started, and their plans will broadly speaking be implemented on sites during next year. They reckon by the end of 1972 no new work will go on in the construction industry except in metric terms. In July 1968, we published the general engineering programme, again as the result of a very good consensus of opinion. At this point, let me correct a wrong national impression. It is often said that the construction industry are ahead—they are in planning, for very good reasons, but in implementation they are precisely in line with the rest of industry. The engineering programme began with planning and preparation in 1968, implementation being started in 1970, and to be substantially completed by 1975. Within the framework of this general programme we have in January this year, produced for the electrical engineering industry a programme which is entirely compatible with the general programme, but it gives a little more detail. In marine engineering, the programme is for preparation and planning this year, and a start on implementation next year.

Now, what is most important in all this is that none of these national programmes provide sufficiently detailed planning information for anybody. It is merely a national framework agreed by a very good consensus of the people concerned with implementing it to give a common ground and a common framework within which to carry out detailed planning. The Engineering Equipment Users Association have set everybody a wonderful example. Within their membership are the process industries who are the customers of the engineering equipment manufacturers. They produced a programme entirely compatible with the engineering programme, on which they would aim to accept metric equipment. The Engineering Equipment Users Association have not stopped there but have gone on to form a metrication committee in which all their members are analysing this programme, item by item, and giving as close forecasts as they can of the volume of metric equipment, by different natures, which they will be ordering from 1970 onwards. This information is collated to provide a really big bulk of factual information, by quantity and nature, of the sort of equipment they expect to buy next year (from 1970 onwards). They are then calling together committees of their suppliers, i.e. the engineering equipment manufacturers, who take the information provided by the metrication committee for the purpose of their own sound planning.

Now it is only by the exchange of good detailed information like this that we shall get this job done economically and I would recommend anybody to take a leaf out of E.E.U.A.'s book and start this process of customer/supplier liaison. I must repeat that the national programmes, grand though they may be for giving general indications of the economical programme which could be worked out, do not provide sufficiently detailed information for real planning on the part of the individual firm. Doubtless, some of you are members of a trade association and can do this through trade associations, which is grand. However, for those of you who are not, there is nothing to stop you doing this customer/supplier liaison on your own in order to get good information on which to plan, and it is vitally necessary that you should. Do be reassured that if you make enquiries with your suppliers and so on, you will not get a blank refusal or a blank ignorance of what you are talking about in metric terms. Over two years ago, I was in touch with a Coventry firm of machine tool manufacturers; their Purchasing Officer had circularized all their customary suppliers with a very simple letter drawing attention to the nature and volume of the items supplied and asking when the same sorts of things in metric sizes and qualities could be provided. They got a very good, satisfying reply. By this means of giving good advance information, one should be able to avoid any catastrophic rise in prices for metric articles.

As far as we ourselves are concerned in planning this individually, I would like to recommend to you what I have christened the 'doubting Thomas' technique. Do not assume that everything you have done is wrong, because we are going metric. Let me illustrate this in two particular ways. You will be concerned as manufacturers of engineering equipment with modifications to your machine tools. Please do not assume that every measuring device on every machine tool will require to be changed or modified. We must have the questioning technique of 'Here is a measuring device; do I use it?' It is surprising the numbers of times you get the answer, 'No, we never use that'. There is an indexing device on the feed screw on a lathe and it is amazing how many turners will admit that they never use it. Well, if they do not use it there is no reason to spend £60 or so on a dual metric/inch measuring device. Do let us make sure such items as this are needed before we put them in. How many people use the position-indicator on the saddle of a lathe? Precious few, and yet we find people quite blindly saying 'We had better get that converted'. The 'doubting Thomas' technique makes sure that everything you do to change your machinery's capabilities to metric standards is strictly necessary. The watch-word is that most machine tools have a production capability which is entirely dependent on what particular instrument the operator has in his hand. A great number of these machines have a perfect metric capability, given that the operator has a metric measuring device in his hand. Similarly, where training is concerned, all too many people are saying things like 'I have 400 shop floor personnel and 70 staff, I suppose we had better give the shop floor personnel a week each and the staff might want a fortnight to train them to use the metric system'. This is a frightfully wrong approach. Through the 'doubting Thomas' approach, begin by doubting that you need to give any training at all and then proceed to satisfy yourself whether you do. Ask each and every type of employee, the very simple question, 'What do you measure in the course of your work? Do you measure lengths, diameters, weights, volume, pressure, stress?' What in fact does the man measure? If he says he does nothing but linear measurements, then you do *not* teach him the intricacies of stresses and pressures—you would merely frustrate him. If he is a storeman who deals entirely with weights and capacities I doubt if he need bother with linear measurements. Establish the minimum needs in the way of new familiarization and see that he gets just that and that alone. As to how much training you give him, ask yourself what is the penalty for this man either making mistakes, or having his productivity impaired through lack of familiarity. According to the answer you get to that question, so do you give him either a great deal of training or precious little. The man on the mass-production line probably does not need any training at all because he does not know the size of anything he puts on anyway. On the other hand, when you come to the conclusion that this particular man does not need any training whatsoever, do not entirely ignore him. See that he is involved, and the way to involve him is to plaster the place with associability charts, and by that I do not mean conversion charts. Conversion charts which say 1 in.=25.4 millimetres are not worth the paper they are written on as far as his familiarization is concerned. Your designers and draughtsmen may need those things in time but the ordinary chap on the shop floor is much more interested in seeing a full-size football drawn for him labelled '220 millimetres in diameter' or a cricket ball '70 millimetres in diameter weighing 140 grammes'. This is the sort of thing required. Get him involved in that way. Do not leave him out entirely in the cold but do not spend a lot of training on a man who drives a fork-lift and never knows what is in it. Do ask questions all along the line. There is one important question on this matter of metrication that we are apt to neglect. Ask the man 'Are you by any chance familiar with the metric system?' and if he is a displaced person from Europe, it is quite conceivable that he is and that he grew up with it. Not only have you found someone who doesn't need training but have possibly also found a potential instructor.

Through the 'doubting Thomas' technique the questioning all along the line is 'What is the minimum I must do with my machine tools? What is the minimum I need do by way of training? What level of training is wanted, having regard to the consequences of the man not being familiar with the new system?' These are the sort of questions to ask and then, with the deepest respect to the educational establishments, do realize the limitations of formal education. Informal education can teach almost anybody the metric system in a morning, but it will remain for the man on the shop floor at his normal work to familiarize himself with it, get his productivity back to normal and his error-proneness down to a level that is reasonable. You cannot evade this responsibility. The familiarization part of his training is for the shop floor, and nowhere else, unless of course you are such an affluent firm that you can send your people away for a month to a technical college, and I doubt if you can. This of course is one of the many arguments in favour of the retail sector going along with industry. If you are busy trying to familiarize a man with metric working on the shop floor and then, in the evening, he reverts to the market place and the pub, and starts talking about pints and pounds all over again, his familiarization will be very much slowed down. We must have the retail sector marching along with industry for obvious national economy reasons.

I want to say a little about this system we are going to adopt which is called SI, the international system of units. We have decided to adopt this because the whole world has indicated its intention of doing the same. Although we are going to be ahead of the present metric countries for three or four years, we are going straight to this new system called SI instead of going through a current metric system and then making a change again in three or four years time. The only real difference that needs considering, in the sense of its being a difficulty, is the unit of force and those units associated with it.

Briefly, as a result of using the gravitational unit of force, i.e. the pound weight (or pound force if you were very erudite and knew what it meant), the aerodynamicist found himself in difficulties. He was presented with a unit of force which instead of being coherent and producing unit acceleration in unit mass, produced this thing called gravitational acceleration in unit mass, and this was an awkwardness as far as he was concerned. Consequently, against the background of using the gravitational unit of force like everybody else, he solved his problem by inventing a new unit of mass. He invented a thing called a 'slug' which was 'g' times the pound. Instead of taking these two irrational values to get a unit which was coherent within its own framework, SI said, 'No, let's go to the right units and apply the one which in the first instance produces unit acceleration in unit mass'. This is called the newton and, of course, from this unit of force stems the unit of energy the newton-metre, the unit of power and all the other complex units which derived from that. If we do not accept the newton then we wreck completely the coherence of the new system of units. Its coherence eliminates at a blow all the old conversion factors we have become so used to. There is no conversion factor in SI at all, because of its coherence. If you do a calculation you will not be bringing in your factor of 2240 to alter tons per square inch to pounds per square inch and you will not be bringing in 550 to alter horsepower to foot pounds per second. All these go by the board. Instead, you have a ridiculously easy system to use. The newton is worth using for its own sake and it has to be used anyway if we are going to maintain the coherence and therefore the value of the system called SI. It has been estimated, and I think conservatively, that calculations in SI will be six times shorter and six times faster than in imperial units and this is something we ought to go for. If they are six times shorter and faster, and I assure you they are, it follows they must also be six times less prone to error.

There are going to be practical problems in this and I only wish I had time to go through them all. I have spoken of training and machine tools and of this 'doubting Thomas' technique for discovering to your delighted surprise that you need not do as much as you had thought. The same sort of thing applies to small cutting tools. Over the years, we have acquired an extensive range of imperial cutting tools and it is highly probable that some of them are within the tolerances permissible in the metric sizes we want—this has been established from evidence obtained up and down the country. For example, Vickers Limited at Barrow in Furness, making their atomic submarines, have drawn up a very useful guide showing how their present imperial cutting tools can be used instead of the metric sizes specified, within normal tolerances. Here is a means of making the purchase of metric tools match the wastage of the imperial tools and you thereby acquire them at virtually no extra cost. All these sorts of devices have to be thought about and the more you think about them the more you will have the experience of discovering to your delight that the problem is by no means as formidable as it looks. ●

SOME ASPECTS OF AGRICULTURAL PROJECT PLANNING AND MANAGEMENT USING NETWORK ANALYSIS

by A. L. BALDWIN, C ENG, MI AGR E*

Applications within the Guyanese sugar industry are described. Specified date constraints were used on jobs involving a growing crop so that float values were realistic. Heavy field machinery requirements were estimated using rainfall records for a project area. Parallel heuristic methods were used for manpower resource allocation in a sugar factory project following a situation assessment using the network dual. A project management information system was described using sub-networks, sections of a MOST network and Gantt charting. The planning and scheduling described on all projects was done without using a computer.

SUMMARY

Network Analysis is a group of techniques which have been fairly recently developed. One of these techniques has been applied in the sugar industry in Guyana.

In a project involving the growing period of a crop, time controls in the form of 'specified date constraints' were introduced on certain jobs so that float values could be interpreted in the usual way. Estimating resources in terms of heavy field equipment can present a problem because of complications due to weather. An answer to this problem was worked out based on probability theory using past rainfall records and knowledge of the effect of various levels of rainfall on machinery operation.

In a project for major improvements to an estate raw sugar factory, resources in terms of numbers of fitters were allocated to jobs and the jobs scheduled using parallel heuristic methods. The dual of the original network was used for prior assessment of the situation.

If network planning is to be of value, the results must be used in project management. In one project this was undertaken using sub-networks and sections of a MOST network for planting and annual programmes respectively, and by the issue of short term programmes and progress reports in Gantt Chart form.

Electronic data processing was not considered necessary for the projects described, but may become economic for even small projects when the cost of using computers is reduced.

In the introduction of any new technique or system into an organization, some promotional and training work is considered necessary. This was undertaken in the cases described.

NETWORK SYSTEMS

Network Analysis is a programme planning and scheduling technique of fairly recent origin which is particularly suitable for large or complex projects. There have been several variants of it developed, but the system which has become most popular for general projects in Britain and the Commonwealth is the Critical Path Method (CPM) also known as Critical Path Scheduling (CPS). This is a job-oriented system in contrast to the other main division of the technique, known as PERT i.e. Programme Evaluation and Review Technique which is an event-oriented system and is perhaps more popular in North America. However, PERT and CPM have tended to converge so that there are now few important differences between them. PERT/COST has become popular and is a valuable control technique where cash flow and cost-time relationships are involved. Some other variants are PEP (Programme Evaluation Procedure), LESS (Least Cost Estimating and Scheduling) and SCANS (Scheduling and Control by Automatic Network Systems). These are all of the PERT variety. Another network system known as the Roy Method was developed independently of CPM and PERT in France.

The methods of drawing networks have been well reported elsewhere[1] for use in various construction, aerospace, marketing and defence projects. It was found that when applied to the actual growing period of a crop, a number of constraints were introduced, which complicated the normal method used.

The basic steps in Network Analysis are as follows:

1. Logical planning, that is sequencing the constituent jobs without considering any limitation in resources.
2. Estimating time and resource needs of each job, producing a schedule, analysing the network and finding out which jobs control project completion.
3. Re-allocating resources to revise and improve the schedule to meet definite managerial requirements, which may be to minimize labour or materials resources, provide the most economical use of capital e.g. major capital expenditure being required as late as possible, or to meet a particular completion date possibly under the threat of a penalty clause in a contract.

APPLICATION TO AN AGRICULTURAL PROJECT

The results of an investigation of the present Guyana Sugar Experiment Station indicated that a new station should be started and the present station at Sophia (founded 1919) run down. It was proposed that a different cultivation system from the present one should be operated, that the new station field area should be sited within one of the commercial estates, and that the experiment station control area, i.e. office, laboratory, glasshouse, hardening

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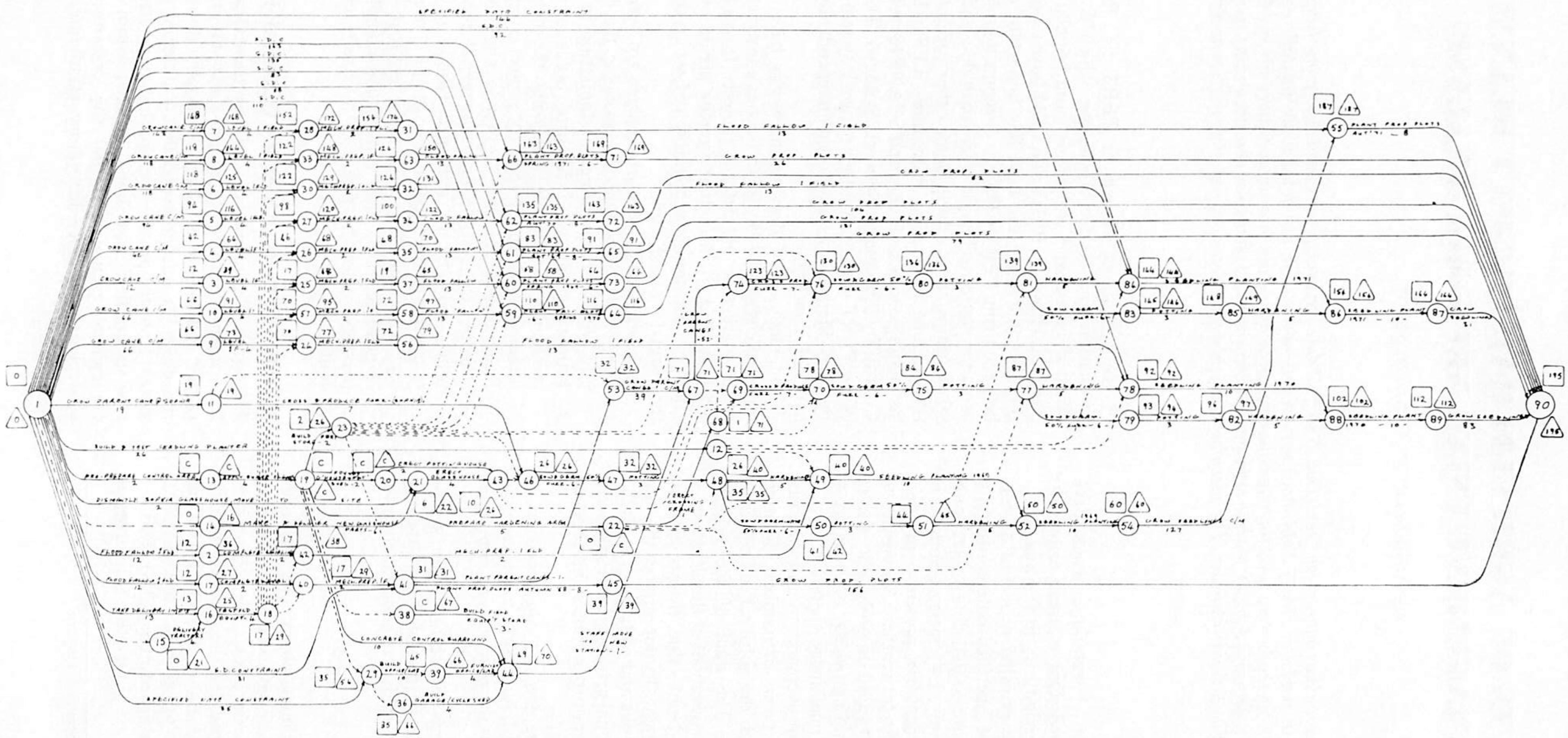

FIG. 1 Master Network for removal of Guyana Sugar Experimental Station

area etc. should be built within the security fence surrounding the factory-office complex for the estate concerned.

The cultivation system in use for commercial sugar production on estates in Guyana is based on cambered beds. The system intended for the new experiment station was a low single row ridge system somewhat similar to flattened Louisiana type bank, so that during the move to the new area, 130 acres of land i.e. the proposed area of the new station, would need to be levelled as part of the land conversion process.

It was considered essential that the experiment station should be removed with the minimum of disturbance to the breeding programme. However, it was also considered essential that the field area of the proposed station should be left in commercial cane until the latest possible date before being converted for experimental purposes. This was so that there would be little disturbance to the estate sugar production programme, and hence that losses due to the change would be minimised. For these reasons the inter-relationship between the various jobs involved in moving from Sophia, and providing facilities at the proposed new station were examined, and Network Analysis used for planning and controlling the project.

TIME PLANNING

The estimation of job durations frequently presents something of a problem because people do not generally like to commit themselves on something for which they may be accountable later. It cannot be too strongly emphasized however that the estimates of duration should be realistic and not over optimistic and therefore unattainable, nor unduly pessimistic so that the overall project time and hence estimated cost is presented as an inflated picture at the planning stage.

Suppliers' salesmen can be misleading when durations are being estimated, and it is required to know the expected duration of a job such as 'place order and await delivery of equipment'. If the equipment has to be ordered from overseas and the delivery period has tended to vary greatly in the past, it is very tempting to the salesman to give the estimate which he thinks will secure the order. This can only be overcome by persistent enquiry and discussion to stress the need for realistic estimates.

In the experiment station project jobs such as planting seedlings could only be carried out at a certain time of the year for agronomic reasons. Cane could only be harvested under suitable weather conditions when the estate factory was grinding and similarly land can only be ploughed under reasonable weather conditions. These factors meant that the whole project in its entirety could not be moved forward or backward in time by anything less than steps of one year, or alternatively it could be completely revised and then moved in one-crop steps i.e. approximately six months at a time.

In drawing the network it was therefore necessary to calculate from past weather and cropping records when the land could be made available to the experiment station with the least disruption to the estate production plan. From this date the jobs on land levelling, mechanical preparation and flood fallow could be programmed in sequence using their estimated durations. Having prepared the land to receive the seedlings or setts there was again the problem that for best results agronomically, planting should be undertaken within a limited period each year. This problem was overcome on the network by using a 'Specified Date Constraint' to the start of each planting, in effect making planting dates 'Critical' but allowing float on preparatory work within the limits of land availability. The effect of these factors can be seen in the master network of the experiment station removal (Fig. 1).

TREATMENT OF FLOAT

In the analysis of the experiment station network, total, free, independent and interference float were calculated. Total float is spare time available along a path or section of a path through the network and if used up on one job is not available to subsequent jobs. The total float may be used up at the planning stage in resource allocation as discussed later in this paper. Free float is the spare time available for the completion of a job and its use does not affect subsequent jobs. This again can be used up during the project or at the planning stage in resource allocation.

Independent float is any float which remains to a job if all succeeding jobs begin as early as possible and all preceding jobs end as late as possible; if this is calculated as a negative number it is considered as equal to zero.

Interfering or interference float is the slack on the head event of the job and shows the difference between the total float and free float. In practice the calculation of interfering float can be used as a check on the calculation of total and free float, particularly if a computer is not being used.

From the experiment station network, the floats were calculated as follows:

Using Fig. 2 which shows two events and their connecting job, where e_1 and e_2 represent the earliest event times on the tail and head events respectively, l_1 and l_2 the latest event times similarly and d represents the estimated job duration, floats are calculated as follows:

Total float $= l_2 - e_1 - d$
Free float $= e_2 - e_1 - d$
Independent float $= e_2 - l_1 - d$
Interference float $= l_2 - e_2$

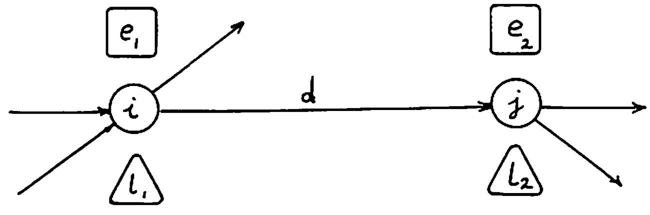

FIG. 2 Key to 'Float' calculations (see text)

In the agricultural project unless specified date constraints had been used, float values could have been calculated which would have given a completely mislead-

EVENT				START		FINISH		FLOAT (Weeks)				
Tail *i*	Head *j*	Job	Duration (Weeks)	Earliest Week No.	Latest Week No.	Earliest Week No.	Latest Week No.	Total	Free	Independent	Interference	Critical Job
39	44	Furnish Office and Lab.										
40	41	Mechanical preparation one field	2	17	29	19	31	12	12	0	0	
41	45	Plant prop. plots Aut. year one	8	31	31	39	39	0	0	0	0	*
41	53	Plant parent canes	1	31	31	32	32	0	0	0	0	*
42	49	Mechanical preparation one field	2	17	38	19	40	21	21	0	0	
43	46	Dummy	0	10	26	10	26	16	16	0	0	
43	70	Dummy	0	10	78	10	78	68	68	52	0	
43	76	Dummy	0	10	130	10	130	120	120	104	0	
44	67	Staff move to new station	1	49	70	50	71	21	21	0	0	
45	90	Grow prop. plots	156	39	39	195	195	0	0	0	0	*
46	47	Sow and germinate 50% fuzz	6	26	26	32	32	0	0	0	0	*
47	48	Potting	3	32	32	35	35	0	0	0	0	*
48	49	Hardening	5	35	35	40	40	0	0	0	0	*
48	50	Sow and germinate 50% fuzz	6	35	36	41	42	1	0	0	1	

Fig. 3. Section of Schedule for removal of Guyana Sugar Experiment Station

ing picture of the actual time available for various jobs. By introducing these specified date constraints this situation was prevented, so that all float values given are meaningful and are interpreted in the usual way.

The experiment station removal schedule derived from the master network of the project was issued showing a complete analysis including earliest and latest starting and finishing times for events, which jobs were critical and the values of the four types of float available for each job (Fig. 3).

RESOURCE REQUIREMENTS AND THE WEATHER

It is often suggested that weather conditions preclude accurate estimates of field machinery requirements. However, where a land conversion programme is being planned involving possibly several thousand acres, it is essential that something better than subjective judgement should be used in estimating requirements for heavy field plant such as high horse-power crawlers and draglines.

To help in solving this problem a method for estimating mobile field plant requirements was developed in which a 'model' of the situation was simulated.

In Guyana there are two harvesting periods per year and land becomes available as soon as the sugaı cane crop has been removed from it. The length of each cropping period and the dates of starting and finishing both Spring and Autumn crops were calculated for an estate as the mean of the ten years 1957 through 1966 (Table 1) as follows:

TABLE 1
Estate Cropping Periods—Summary

	Mean Starting Date	Mean Finishing Date	Number of Days
Spring Crop	10/2	28/5	107
Autumn Crop	13/8	28/12	137
Mean Total Cropping Days p.a.			244

For reasons of good agronomic practice it was decided that no working days for field equipment would be allowed for in December.

In estimating the number of days suitable for the operation of heavy field equipment, the concept of 'dry days' was used as suggested by Harboard[2]. A 'dry day' was considered as one on which it would be possible to operate field equipment and is dependent upon the preceding as well as upon the actual day's rainfall. Rainfall records were examined for every day in the sixteen-year period 1951 through 1966. Mean annual rainfall for this period was compared with that for the period from 1887 to the present and no significant difference was indicated. It was therefore concluded that the number of 'dry days' and their distribution could be fairly reliably estimated.

The definition of 'dry days' and 'wet days' was as follows:

Up to 0.25 in. considered a dry day
0.26 to 0.50 in. wet day, but with no drying days needed
0.51 to 1.00 in. wet day, with one drying day needed
1.01 to 1.50 in. wet day, two drying days needed
1.51 in. and over on one day, a wet day with three drying days needed.

A drying day was considered to be one with a rainfall of less than 0.20 in. Drying days could only be accumulated up to a total of three. For example, if rainfall of 2.76 in. 3.45 in. 4.51 in. and 0.51 in. fell on four consecutive days only three drying days would be needed before mechanical land preparation could be continued. The reason for this is that run off and drainage would account for the reduction of soil moisture to field capacity.

Soil type influences drying out, and maximum ground pressures which can be tolerated. Pegassy type soils can only be worked when fairly dry, sandy soils dry out quickly, and heavy clays can withstand much higher ground pressures than pegasse (a form of peat). None of these facts were taken into account over a large tract of land on an estate as overall they were considered to cancel each other out. These factors would of course be highly relevant on a smaller project where only a few acres were being considered.

The estimate of what constitutes a dry day is rather conservative since it assumes that all rain would fall during the sixteen hours working period. If however the rain fell at the start of the daily maintenance period, then the machines would possibly be able to get back into work for six to eight hours at the end of the twenty-four hour day.

The mean 'dry days' per month and the standard deviation were calculated for the estate, so that the number of days actually available for work could be estimated allowing whatever factor of safety was decided upon. In this case the 0.84 probability level was used i.e. mean less one standard deviation. This allowed a fairly high factor of safety.

From these data i.e. length of cropping periods allowing no land preparation in December, and number of dry days available for mechanical land preparation at the required probability level, the available working hours were calculated as shown in Table 2 allowing sixteen hours of actual work per day:

TABLE 2
Available Work Days and Hours (at 0.84p level)

	Spring Crop	*Autumn Crop*
Days	58	70
Hours	928	1120

The required total hours of land preparation to complete the job were estimated for past machine output data. For example, 16,000 hours required in the Autumn crop period, divided by the hours available (in this case 1,120 hours), gives the resource requirement. That is fifteen heavy crawler tractors and equipment, or seventeen allowing for miscellaneous downtime.

RESOURCE ALLOCATION

The problems of resource allocation are frequently the most difficult to solve when network analysis is being used for all but the simplest of projects. In the cases of planning major improvements for an estate raw sugar factory, it was required that the factory should be ready to grind cane between a year and eighteen months from the start of the project. A simplified version of the original network of the project showing job durations and estimated resource requirements i.e. number of fitters, is given in Fig. 4.

Company technical management decided that only fifteen fitters could be made available to the project. It was therefore required to know how these resources could be allocated to complete the project, and what effect this limit of fifteen fitters would have on the overall project duration.

Because the network (Fig. 4) was planar, it was possible to use its dual (Fig. 5) to determine the theoretical maximum manpower resource requirements in case it

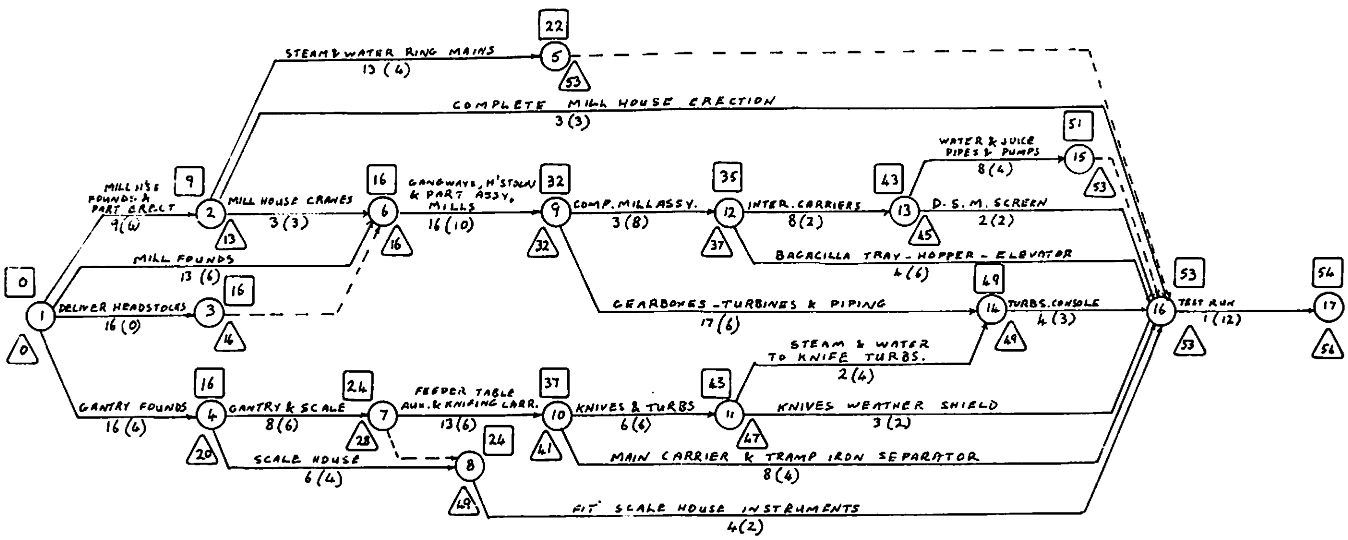

FIG. 4 Original Network of Estate Raw Sugar Factory Improvement Project

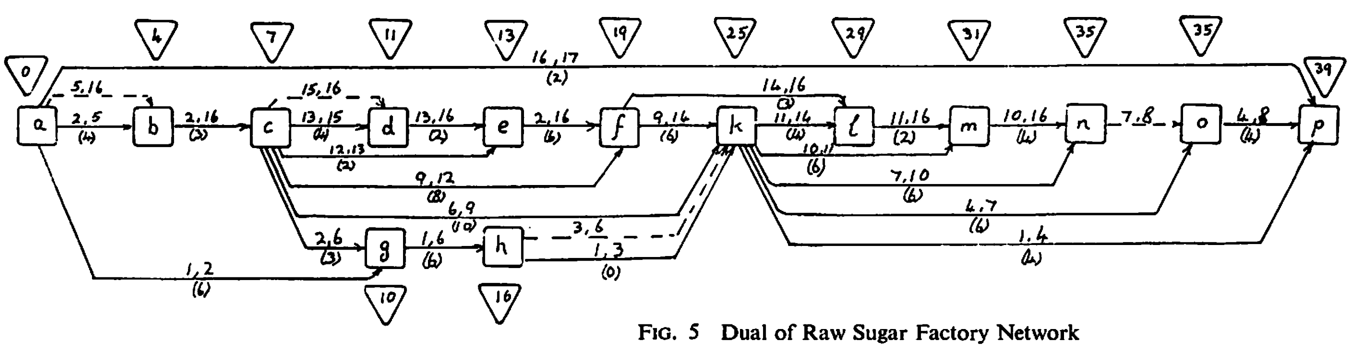

FIG. 5 Dual of Raw Sugar Factory Network

should be necessary due to delays to use up the free float on durations found in the analysis. This was done before reallocating available resources within the limits laid down. This method could not have been used for the experiment station project because being a non-planar network it has no dual.

The dual was drawn in stages as follows:

(a) Each of the meshes of the network were labelled with nodes.
(b) Each mesh node was connected so that one connection cut each job arrow; there were then the same number of connections as jobs on the original network.
(c) Directions were assigned to connections.
(d) The dual of the network i.e. mesh nodes and connections, was then re-drawn and each of the resource arrows labelled with the corresponding job and its resource requirement from the original network. The dual (Fig. 5) showed the length of the critical path of resources to be thirty nine fitters. From the dual the resource float was calculated by the same method as that by which the free float was calculated from the original network. This emphasized the uneven demand on resources.

Parallel heuristic scheduling of the workof the available fifteen fitters was carried out as shown in Fig. 6. Because of limitations on resources it is often necessary to extend overall project duration. For this reason this technique is also known by the alternative term 'extrusion method' of resource allocation.

On the left of Fig. 6 is shown the analysis of the original network, i and j being tail and head events for the jobs, D being duration, TF is total float, R for resource i.e. manpower requirement, and ES being earliest starting week number for each job. The line for 'Contract Duration' shows 54 weeks as originally planned on the network (Fig. 4).

Under week 0, any of the four jobs (1,2), (1,3), (1,4) or (1,6) could start. The Job (1,3) with no total float was critical so that this was entered first, but since 'deliver headstocks' had no resource requirements it did not affect the manning. The procedure was to sort jobs according to lowest float, so that job (1,6) was entered to be followed by either job (1,2) or job (1,4) if resources permitted. Job (1,6) needed six fitters so that nine fitters were available for job (1,2) and job (1,4), the latter needed four fitters, the former six fitters. Therefore unless the work could be replanned one of these two jobs would have to be delayed. It was agreed that job (1,2) which was 'prepare mill house foundations and part erect mill house' and for which the originally estimated duration was nine weeks for six fitters, could be done by four fitters but would then take fourteen weeks. From this modification it was thus possible to schedule the start of both job (1,4) and job (1,2), but there would be one fitter to spare. The block diagram in the lower half of Fig. 6 reflects this situation.

From the original network the three jobs beginning with event 2 could have started at week 9, so their total floats were entered in the column under week 9 showing that these jobs were then in a queue waiting to start. However, due to rescheduling, jobs beginning with event 2 could not start until week 14 even if resources were available, which was not so. In week 9, job (2,6) had four weeks total float, i.e. it would become critical by week 13 and by week 14 when the replanned event 2 occurred, job (2,6) would have one week of negative float. This could mean that the overall project time would be extended by one week unless this job was re-examined. It was decided that more men could be put on to this job (2,6), which was 'install mill house cranes' and so the manning was increased to five men and the estimated duration reduced to two weeks. Thus the delay of one week, due to one week of negative float, was eliminated.

In week 14, job (2,5) or job (2,16) could be started, again sorting according to least float the job (2,5) was selected to start by which time its total float would have reduced to twenty six weeks.

From the original schedule the jobs which could start in week 16 if resources were available were the dummy job (3,6) and jobs (4,7), (4,8) and (6,9). Event 6 would have already been completed so the dummy job (3,6) was ticked under the column for week 16, showing its completion. The job (6,9) which was critical would be started in week 16, which together with job (2,5) would use up all resources except one fitter. This meant that job (4,7) which in week 16 had four weeks of total float had to be delayed until week 27, when it would have seven weeks negative float. The net effect was that the overall project duration or contract duration was extended by seven weeks so that at week 27 the total float on job (4,7) was increased to nil and floats on all other jobs not yet scheduled had to be increased by seven weeks. This situation is shown by the break in the schedule and the new contract duration figure of sixty one weeks. This procedure was continued until it was again necessary to increase contract duration at week 48 due to negative float on job (9,12).

Using this parallel heuristic method of resource allocation it was possible to schedule the major improvements to the sugar factory within the resource limits of fifteen fitters, with a contract duration of sixty eight weeks which was within the limits laid down of twelve to eighteen months. The resource histogram derived from the rescheduling is shown in Fig. 7.

For project management purposes a Gantt Chart and revised network diagram were derived from Fig. 6.

PROJECT MANAGEMENT

If the planning work is to be of value, the project must be managed according to the schedule planned. The greatest problem in practice seems to be to convince people that jobs must be started on time and progressed according to the schedule. This is not an easy problem to solve if project management has previously been carried out by 'hunch' methods. It is in any case a human problem and its solution is outside the scope of this paper.

It is important to set up an information system for project management which will set out at predetermined time intervals which jobs have to be started and when they should be started, and will also report progress on jobs and show any deviations from the plan requiring corrective action.

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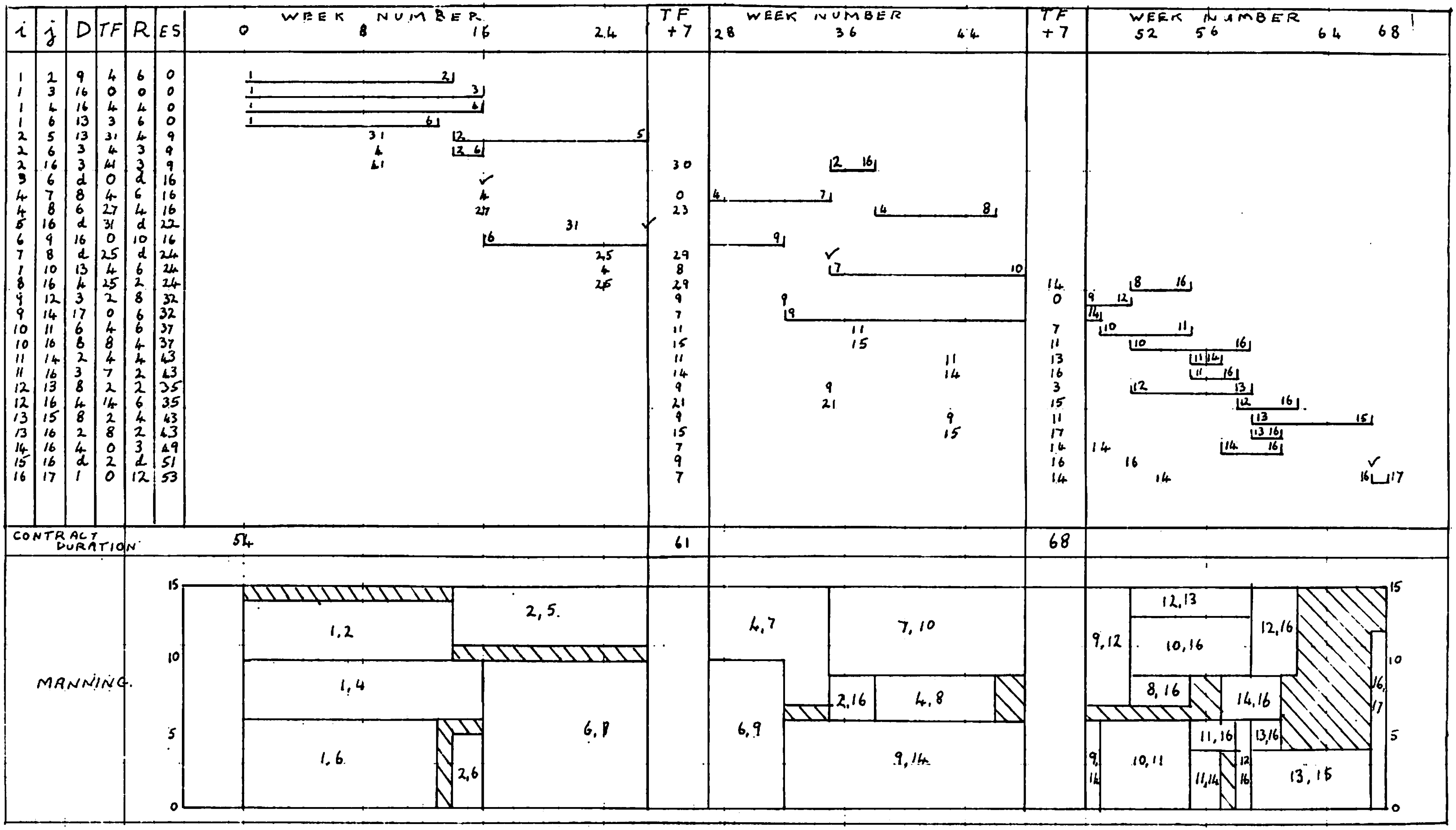

FIG. 6 Resource Allocation Planning using Extrusion

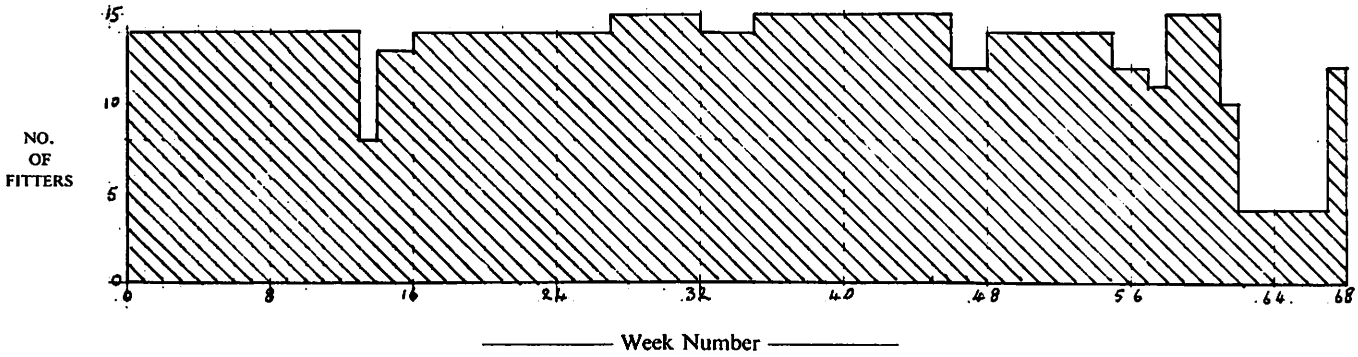

FIG. 7 Resource Histogram — Raw Sugar Factory Improvement

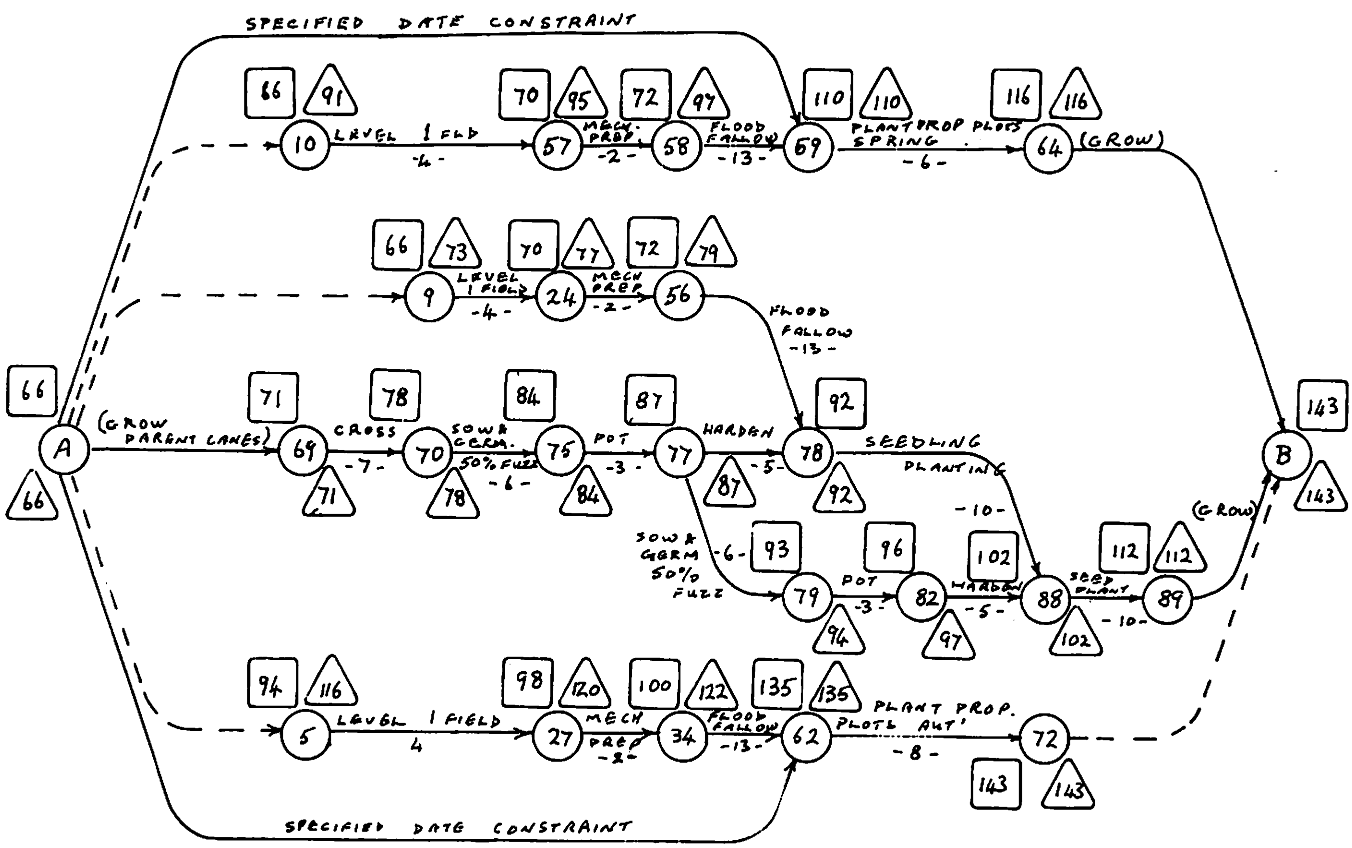

FIG. 8 Experimental Station Sub-network — 1 year's planting

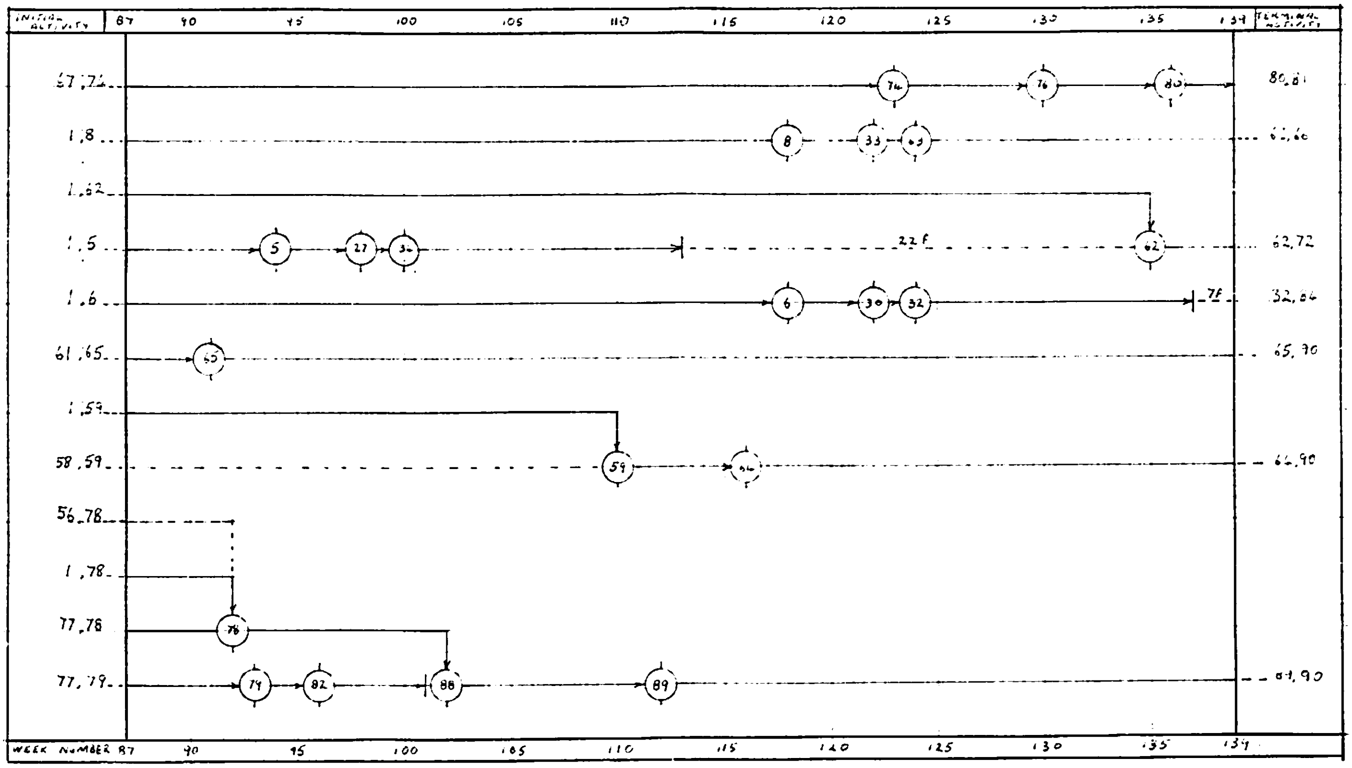

FIG. 9 Section of M.O.S.T. Network for Year 3

EVENTS i	j	ACTIVITY	DURATION	START EARLIEST	START LATEST	CRITICAL ACTIVITY	SUB-CRITICAL ACTIVITY	IN PROGRESS	TOTAL FLOAT	FREE FLOAT
1	2	FLOOD FALLOW 1 FIELD	12	0	24			✓	24	0
2	42	COMPLETE LAND LEVEL, 1 FIELD	2	12	36				24	3
1	17	FLOOD FALLOW 1 FIELD	12	0	13			✓	15	0
17	40	COMPLETE LAND LEVEL 1 FIELD	2	12	27				15	3
3	25	LEVEL 1 FIELD	4	12	40				28	1
1	16	TAKE DELIVERY IMPLEMENTS	13	0	12			✓	12	0
15	16	[illegible]AKE DELIVERY TRACTORS	4	0	21			✓	21	9
16	18	ASSEMBLE & TEST TOOLBAR IMPLEMENTS	4	13	25				12	0
1	12	BUILD SEEDLING PLANTER	26	0	14				14	0
1	21	DISMANTLE & MOVE GLASSHOUSE	2	0	20				20	4
19	23	BUILD FERTILISER STORE	2	0	24				24	0
20	43	ERECT POTTING HOUSE	2	0	[illegible]			✓	24	8
22	68	ERECT CROSSING FRAME	1	0	70				70	0
38	44	BUILD FIELD EQUIP'T STORE	3	0	67			✓	67	46
19	44	CONCRETE CONTROL SURROUND	10	0	60			✓	60	39
14	21	MAKE NEW GLASSHOUSE PARTS	6	0	16			✓	16	0
21	43	ERECT GLASSHOUSE	4	6	22				16	0

FIG. 10 Guyana Sugar Experimental Station
Three month work programme issued 'Week 4'

Continued from page 168

In the sugar experiment station project this is being done as follows. The master network is updated (Fig. 1) and the use of c shows which jobs have been completed at each updating.

All jobs relating to one annual planting programme are shown in a sub-network (Fig. 8). The period covered by each sub-network overlaps more than one year, and shows all preparatory work leading to the planting of seedling plots in Spring, and propagation plots planted in both Spring and Autumn. The isolation of the work in this manner simplifies the task of line management.

Each calendar-year work programme is issued as a section of a MOST network (i.e. Management Operational System Technique). This is a time scaled network (Fig. 9) and shows all jobs which are scheduled for a single calendar year but which may lead to plantings in different years.

Short term project management information is provided by a work programme which is in the form of a Gantt Chart issued each month (Fig. 10). The work programme shows which jobs were scheduled for the previous month and for the succeeding three months from the date of issue. It also shows the state of the situation as at the date of issue.

In all of the cases mentioned, planning, scheduling and updating are being done manually. There are a number of arguments for and against computers and the decision as to whether use of a computer is justified hinges on the answer to several questions among which are the following:

(a) How often is updating required? If very frequently then a computer can become almost essential.
(b) Is the company making extensive use of networks? If it is then the use of the computer on quite small projects may be justified, especially if the company has its own computer.
(c) How large is the network in question? It has been suggested that the break-even point for manual and electronic methods is between one hundred and fifty jobs and two hundred jobs, depending upon the answers to questions (a) and (b) above. Networks of several thousand jobs would be almost impossible without the assistance of a computer.

Package deal computer software for all the usual network systems is now readily available, so it is anticipated that as companies make fuller use of computers and cost is thus reduced, then computers will be economic for even very small network systems.

INSTALLATION OF NETWORK ANALYSIS

The installation of any 'new' technique into an organization requires a certain degree of promotional work and the idea has to be sold. This applies as much to installing network analysis as to any other technique.

The way in which this was undertaken in Bookers was to discuss at Board level the application of Network Analysis and the shortcomings of other planning techniques, and then by means of the two films 'Critical Path' produced by Richard Costain and 'Critical Path in Use' produced by the British Information Services, to give a basic appreciation of the workings of Network Analysis. Short appreciation seminars were also run for executives concerned at all levels with the projects discussed.

CONCLUSIONS

Network Analysis is of great value for project planning and management within most industries. Agriculture, which the author considers to be somewhat akin in its type of problems to civil engineering, forestry and heavy chemical industry, is a field in which Network Analysis should find ready application. There are certain problems associated with a growing crop and dependence on external conditions, but every industry has its own problems and these particular ones can be overcome as has been indicated.

The main benefit to be derived from the use of Network Analysis is that it identifies trouble spots well in advance through the logical pre-planning necessary. From this, alternative methods of organization of the work may be suggested which help to reduce cost. In particular, management attention is directed to those sections of the project which are, or are likely to be in trouble.

Network Analysis is therefore a system which merits the full attention of agricultural engineers and the agricultural industry.

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THE DEVELOPMENT OF A FERTILIZER SPREADING UNIT FOR OPERATION ON POOR GROUND

by

N. DEVERIA, C ENG, MI MECH E, MI AGR E*

Land Conditions

Although Northern Ireland was at one time a well-wooded country it is now, in common with most of the British Isles, among those with the lowest percentage of afforested land in Western Europe. It is however part of the policy of the Government of Northern Ireland to establish and re-establish forests and forest based industries as part of the national economy and the execution of this policy is part of the functions of the Ministry of Agriculture for Northern Ireland which has set up a special division for this purpose. The Ministry is therefore, to some degree, responsible for the Land Use policy on the ground which it owns and has laid down that only land which is unsuitable for agricultural purposes should be used for afforestation.

The land which is acquired for this purpose is marginal and sub-marginal land lying between the 500 and the 1,200 foot contours and comprising either rock or boulder-clay with a peat overlay ranging in depth from 6 in. to 30 ft. Much of this ground is of blanket bog of very low fertility consisting of water-logged peat with a ground vegetation which ranges from molinia grass in the better areas through cotton grass to deer grass where the fertility is at its lowest. Heather (Culluna valgaris) is a dominant plant species growing rankly in the drier areas but becoming stunted where the water table is near the surface. Polythrycum and Sphagnum mosses are also present, the latter growing strongly particularly in the wet areas where it forms mats several inches thick. The topography is not uniform but rolling, the round hills being fissured by drains running in various directions with depressions and flats of water-logged peat, many of which are overgrown ponds with several feet thickness of peat overlaying the water surface.

Former Methods

The usual method of dealing with ground of this type is to drain the planting areas by cutting surface drains using heavy ploughs pulled by specially designed Crawler tractors. These tractors have long and wide tracks and have a static ground pressure of approximately 2 lb per square inch which enables them to operate over the soft ground conditions, but in the very soft areas even these machines will sink through the surface and become bogged and this causes considerable difficulty and expense in extricating the machines from the peat and in the subsequent overhauls which are then necessary. Between the surface drains, shallower plough scores are made which turn out ribbons of peat approximately 9 in. thick into which the young trees are planted. The planting technique adopted is to cut out circular plugs of peat from the strip of turf turned out by the ploughs at the correct planting distance, usually 6 ft spacing between plants, using a semi-circular spade of a suitable diameter. Into the holes thus made is put first 2 oz of fertilizer and then the small plants are put into the hole, the roots being spread out to avoid 'bunching'. The plug of peat removed by the spade is then replaced and packed down tightly by the heel of the planter.

This then was the method of applying fertilizer to the young trees which was in use in this Division for the past 10 to 12 years, but while this appeared to be theoretically sound the results produced, particularly in the wetter peat areas, were not those expected, in that, after a short growing period the young trees invariably went into 'check'—a state of suspended animation in which the growth rates were so low as to be infinitesimal—while the trees lost colour and showed indications of lack of fertilizer, although the planting techniques had provided what was considered to be sufficient fertilizer for at least the first few years of the plant's life.

Fertilizer Distribution

In 1961 a field investigation was carried out on a typical area of checked plantation and the investigation has shown that, in fact, the tree did not make use of the fertilizer placed in the planting hole and that the tree roots tended to grow away from this, spreading on or just below the surface of the peat in all directions often to a length many times greater than the height of the tree itself. Several instances were found of stunted trees with these long spreading roots which had the ball of fertilizer—now a hard cake—still adhering to some of the hair roots at the base of the plant. It was obvious from these investigations that the technique of placing the fertilizer in the hole at the time of planting was not the best method to ensure the availability of the fertilizer for tree growth.

The results of this investigation suggested that there would be greater availability of fertilizer to the plants if it could be distributed over the area in which the plant roots were likely to spread and the obvious way of achieving this was by broadcasting the fertilizer. It was decided to adopt this method on an experimental basis but it was considered that to spread the total amount of fertilizer normally applied by the earlier method over the whole area would result in there being insufficient available in the immediate vicinity of the roots at the time of planting to give the necessary 'boost' which enables the plants to

* United Nations Food & Agriculture Organization.

respond to their new rooting medium. To overcome this it was decided that the quantity of fertilizer to be broadcast should be doubled over the quantity which would have been used by the acre in the earlier planting technique. This posed the problem of how to transport large quantities of powdered fertilizer from the nearest road point across difficult country and to spread it uniformly at the rate of approximately 4 cwts per acre at a reasonable cost. Broadcasting by hand had been carried out on small pilot experiments before but the cost of this was quite prohibitive and no guarantee of uniformity could be obtained by this method while, of course, it did not overcome the difficulty of transporting the material from the road to the planting area. This latter difficulty had been met in the past and various methods had been tried to overcome it, including the use of light agricultural tractors and trailers on the drier ground, animal transport and—in the final stage on wet ground—'packing' by man-power with the workers carrying out the 1 cwt bag on their backs to the spreading area. Difficulties were experienced with all these methods with the cost of the transport rising progressively as the capacity of the carrying medium fell.

Soft-Land Transport Equipment

To overcome this type of transport difficulty a machine had recently been purchased for general duties over ground of this type and this had proved itself capable of carrying a load of up to 2 tons over all types of terrain and capable of crossing even the softest ground without danger of becoming bogged. This machine had already been used to carry out loads of fertilizer to planting areas and had cut the cost of this operation to one-twentieth of that by the previous methods. The machine is the Bombardier Muskeg Tractor, a tracked vehicle of Canadian manufacture which, when laden, has a static ground pressure of only 1 lb per square inch and, more importantly, which by virtue of a special flexible track suspension system and weight distribution can maintain the dynamic ground pressure to within the same limits. This appeared to be a machine ideally suited for the spreading of the fertilizer over the planting areas if it could be fitted with a suitable broadcasting medium but the tractor unfortunately was fitted with neither hydraulics nor a power take-off and it appeared at that time to be no simple method of adapting any of the current models of spinner/broadcasters then available.

Consideration was then given to the possibility of putting such a sipnner/broadcaster on to one of the Crawler tractors used to pull the draining ploughs but while such machines could fairly easily have been fitted with the necessary three point linkage and hydraulics, the lack of carrying capacity made them unsuitable for this work and in addition, their very low forward speed would have made it impossible to restrict the distribution rate to the low figure required.

Trailed Fertilizer Distributor

Attention was then directed to the possibility of using a trailed type fertilizer distributor of the kind used for broadcasting lime in agricultural operations. Such machines are normally mounted on wheels and pulled by conventional agricultural tractors and it was obvious that considerable modification would be required before such a machine could be adapted for the broadcasting of powdered fertilizer over the typical planting areas. One such difficulty was to achieve the correct distributional rate since these large lime-spreaders are designed for putting out large quantities of material per acre whereas it was required in this case that it should distribute a comparatively small quantity per acre. This difficulty was partially overcome by deciding to use the Muskeg Tractor as a towing unit since this machine not only had excellent cross-country performance but could also maintain a very high speed, approximately double that which could be obtained from the Crawler tractors. The final decision then was to purchase the spreading unit of a commercial lime-spreader without the under-carriage and to mount this on a special tracked trailer also manufactured by the Bombardier Company specifically for use with the Muskeg Tractor. This trailer had light articulated tracks of the same design and construction of those on the Muskeg and was designed to carry a load of approximately 2 tons. The lime-spreader was mounted on the trailer chassis in such a way that it could be easily removed leaving the trailer with a suitable removable floor in position available for other types of load carrying. Modifications were then made to the driving speeds of the chain conveyor which carried the fertilizer to the vertical spinners at the rear of the spreader to reduce the speed of flow without reducing the speed of the spreading fans and so obtain a further reduction in the spreading rate to give the 4 cwt per acre required. The final problem to be overcome was that of driving the spreader and this was done by fitting a 6 b.h.p. diesel engine on the forward frame of the spreader itself and taking a drive by V-belts from the output shaft of this engine clutch to the input shaft of the spreader drive, using a suitable reduction to maintain the correct speed. The engine was fitted with a variable speed governor and a toggle clutch and the control of these was effected from the cab of the tractor by means of flexible cables for the throttle control and a rope system to the clutch lever. A swivel-type drawbar was fitted to the tractor to give free articulation between the tractor and the trailer unit in all planes and a type of coach roof canopy was fitted over the hopper of the spreader to prevent the ingress of water since the material to be spread set hard when it became wet.

Performance of Trailed Spreader

The weight of the spreader unit complete with engine, etc. was approximately 20 cwt and since the maximum load of the Muskeg Trailer was 2 tons the amount of fertilizer carried in the spreader was limited also to 20 cwt and a reserve of 2 tons of fertilizer in bags was carried on the platform on each side of the Muskeg Tractor. This gave a total fertilizer load of 3 tons sufficient for 15 acres before a return to the road was made to replenish the supply.

It was obvious that this method of fertilizing would not be suitable on ground which had already been drained and ploughed since not only would it be impossible to place the fertilizer in the rooting zone beneath the upturned plough spoil but the machine would be unable to negotiate the broken ground at anything like the speed necessary for good distribution. Accordingly, the ground preparation procedure was changed and it was decided to broadcast the fertilizer in advance of the draining and ploughing for planting. There was some concern that much of the fertilizer would be lost in the moisture content of the peat which would flow off the area during draining but since the fertilizer is only slightly soluble it was considered that this loss would be small.

This machine combination worked very satisfactorily from the silvicultural point of view, distributing the fertilizer uniformly at the required rate over the planting areas. Some trouble was experienced due to uncontrolled scatter in high winds but this was corrected to some degree by fitting flexible shields to the guide wings of the spinner to extend the affected area which these covered. The daily output of the machines depended on a number of variables, such as the distance of the planting area from the road, type of terrain, whether hard or soft, and the degree of slope of the planting area, and it is therefore difficult to give typical figures for its performance but for spreading over an area of fairly uniform and fairly dry ground 30 acres of planting ground were fertilized in one day at a spreading cost of approximately 17/- per acre while on another site approximately the same distance from the road but where the ground was soft the machine delivered and spread fertilizer over 20 acres in the same time at a cost of 20/- per acre.

Trailed Distributor Limitations

However, although the required results were obtained with this combination of the Bombardier Muskeg Tractor towing the lime spreader there were aspects of the operation which were unsatisfactory from the operational point of view. It was obvious from the beginning that the combined weight of the spreader and its fertilizer was imposing a load on the tracks of the trailer which was much in excess of 1 lb/in^2 and even on comparatively dry areas there was appreciable sinkage of the trailer tracks which resulted in a considerable increase in the drawbar pull required to operate this combination. The towing vehicle had to work in first gear to obtain this pull while at the same time operating at full engine throttle to reach the forward speed required. This resulted in severe over-heating of the engine and led eventually to bearing failure. Furthermore, the tracks of the trailer were too short to enable them to bridge the natural drains which intersected the planting areas so that the machine frequently became stuck in crossing these and this resulted often in considerable interruption of the work. However, interruptions of a more serious nature occurred when the combination was working over ground with very soft patches since, while these were not always obvious to the operator and the Tractor could cross them without difficulty, the more heavily loaded tracks of the trailer could not, and very often the trailer sank into these soft patches, on occasions turning over on its side as it slipped into the slough. This then required the digging out of the fertilizer in the container and the bringing up of equipment to haul the machine clear followed by an extensive visit to the workshops for washing out and cleansing of the spreading mechanism and the driving power unit. It follows therefore that while the costs of spreading given above were applicable in those areas where the machine could work on the rates quoted, there were many areas where these figures were not obtainable due to unsuitable working conditions. The increased costs resulting from such operational mishaps were, however, not charged against the work of the individual forests concerned, but were made as a charge against the operating costs of the Tractor and resulted, over two seasons while this work was being carried out, in a significant increase in the operating costs per hour for this machine. This, in retrospect, appears to have been an unjustifiable method of solving such costs since it reflected on the machine charges which were not due to any defect in the machine itself but rather to the operating conditions. However a still worse effect of these operations was the increased incidence of track failures on the Tractor. The tracks on this machine each consist of three continuous bands of rubber reinforced with steel and nylon across which steel cross-links are bolted and when one of these bands breaks it has to be replaced. This, while being a fairly simple operation, does involve not only the cost of the new track band but also that of removing and refitting a considerable number of bolts and nuts. Failures of the track bands had occurred in the past at infrequent intervals, but during the period when the Tractor was used to pull the loaded trailer these failures became frequent and resulted in a considerable increase in the lost time of the machine.

The operating costs of this machine, therefore, rose sharply during the periods it was being used with the spreader for broadcasting fertilizer but the overall savings in establishment costs of the plantations were so great that there was considerable demand for this machine in all parts of the Division. However, this Muskeg Tractor had been purchased for use in one particular area for cross-country transport, fire protection and supervisory duties and its absence from its home forest on this spreading work resulted in considerable interruption of the programme of work there and it was therefore decided to return this machine to its home forest and to purchase a new machine purely for the distribution of fertilizer. At the same time information was received from the suppliers of the Muskeg Tractors giving details on the handling of the tractor and on the use of the tracked trailer in conjunction with it and it was obvious from this latter information that the conditions under which we were using this Tractor and trailer were very much at variance with the recommendations of the manufacturer. When all the above factors were taken into account it became obvious that the new Muskeg must, if possible, be made able to transport and spread the fertilizer without the use of a trailed implement of any kind.

A Mounted Distributor

A new type of fertilizer spinner/broadcaster was marketed about that time and this was driven by an hydraulic motor and therefore required no power take-off or shafts for its operation. This broadcaster was designed either for mounting on a three-point linkage of the conventional agricultural tractor or for fitting on to a trailer and it was decided that this equipment would be the most suitable for use with the Muskeg.

The use of such a broadcaster with the Muskeg would obviously require the fitting of hydraulics to the tractor and some consideration was given, initially, to the fitting of a complete agricultural hydraulic system including a three-point linkage. It was found that this could only be supplied by the manufacturers of agricultural tractors and since their systems were incorporated in the construction of their machines and in the lubricating oil supply of the tractor units they could not be adapted for fitting to the Muskeg Tractor. Furthermore, while the high speed cross-country performance of the Muskeg was of benefit for its primary purposes as a means of transport and also for broadcasting fertilizer over large areas, it was not at all suitable for other operations for which a tractor might be used and therefore was of little benefit in equipping a Muskeg with conventional agricultural tractor linkage. This decision greatly facilitated the design of the hydraulic installation since this was therefore required only to supply the motor of the spinner/broadcaster.

The Muskeg was ordered with a large radiator suitable for tropical conditions and an oil cooler to overcome difficulties which had been experienced due to overheating and an extension was fitted to the front end of the engine crank shaft. To this extension was fitted an hydraulic pump driven through a flexible coupling and a suitable hydraulic tank was mounted above this pump and behind the radiator and engine oil cooler with a full flow filter fitted on the return to the tank. In view of the extremely corrosive nature of the fertilizer and the probability that the tractor would be operating surrounded by clouds of this material, particular care was taken to ensure that no fertilizer could get into the hydraulic tank. The control valve was a simple two-way valve and was mounted on the side of the hydraulic tank with a remote control to the operator's cab, this valve being located in the 'on' position by a detent. (The general arrangement of the fitting of this spinner/broadcaster with the associated hydraulic equipment is shown on figs. 1 and 2). Since the rate of application of the fertilizer depended on the speed of the hydraulic motor of the broadcaster and the forward speed of the Tractor a hand throttle was fitted and marked to set the correct engine speed to give the distribution rate required.

The mounting of the spinner/broadcaster to the tractor presented some special problems since, when the broadcaster was mounted at the correct distributing height on the Tractor it was found that there was a considerable reduction of the ground clearance below the broadcaster and it was obvious that when operating over very rough ground there would be considerable danger of damage being done to this part of the implement. To prevent this, a heavy skid-plate was fitted to the framework of the

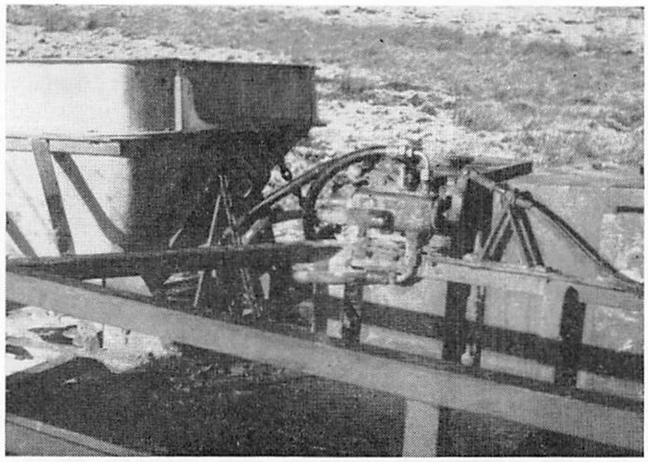

Figure 1
View of Muskeg Tractor showing the positioning of spinner broadcaster and the hydraulic central gear

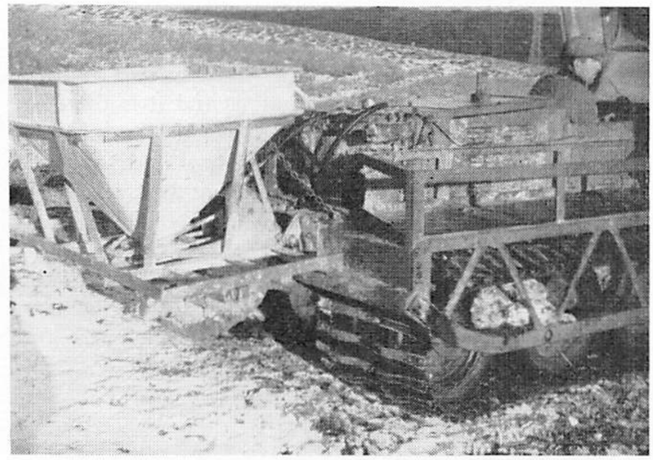

Figure 2
Rear view of Muskeg Tractor with spinner/broadcaster in position. The overhanging mounting can clearly be seen

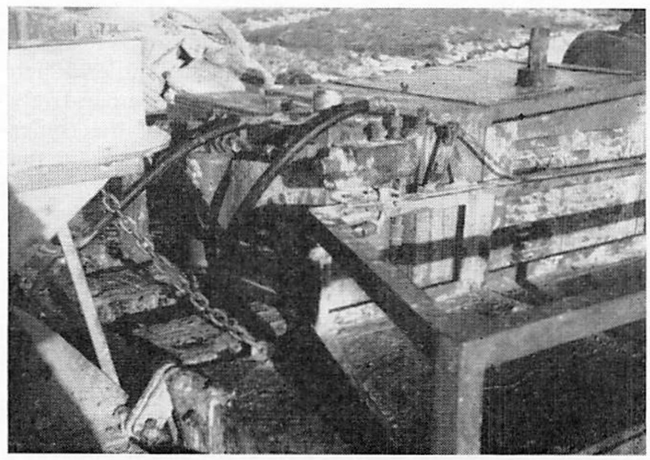

Figure 3
Muskeg Tractor with spinner/broadcaster showing the mounting links which allowed vertical movement of the equipment in relation to the tractor

broadcaster extending below the hydraulic motor which was the most vulnerable part of the equipment. The framework was then allowed to pivot from mounting brackets and two hinged check bars were fitted from the rear of the tractor through special brackets on the framework of the broadcaster. Rebound springs were also fitted to these pivot bars so that should the lower end of the broadcaster strike any obstruction it could pivot on the tractor and fall back into its workings position without shock after the obstruction has been passed. (See figs. 3 and 4).

Performance of Mounted Distributor

In operation, the Muskeg Tractor was loaded at the nearest road point and carried 15 to 20 bags of fertilizer in racks along each side and 7 cwts in the hopper of the broadcaster mounted at the rear. With this load it could traverse most kinds of terrain negotiating both steep and soft ground with considerable ease and could spread fertilizer at the rate of approximately 15 to 20 cwts per hour depending on the distance from the road to the planting area and the uniformity or otherwise of the terrain. The operating costs of this new tractor was rather higher than that for the earlier machine and there had been several wage increases affecting the labour costs in this operation, but the costs of transporting the fertilizer from the nearest road point and spreading it over the planting area using this machine were approximately 13/- to 15/- per acre. The machine could operate at a much higher speed than with the trailed spreader and much less time was lost due to bogging or sticking, while the redesign of the cooling system plus the inclusion of the engine oil cooler greatly reduced the engine working temperature.

Fig. 5 shows this machine in its loaded condition and in operation and it will be noted that there is still a problem of 'drift' from the use of this very fine powdered material and this led to some difficulty in ensuring correct distribution.

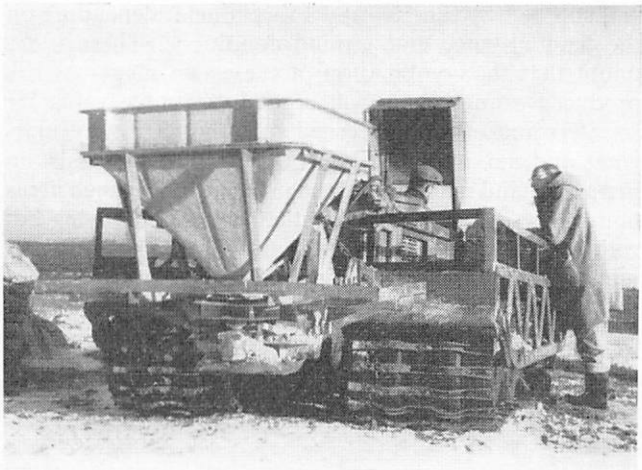

Figure 4
Rear view of spinner/broadcaster mounted on Muskeg Tractor. The heavy skid plate designed to protect the hydraulic motor and spinner can be seen

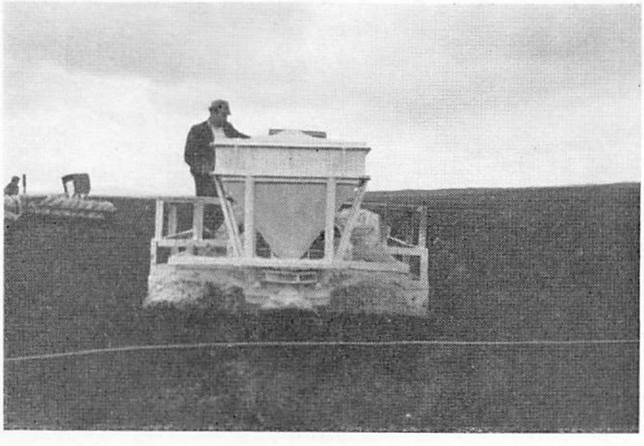

Figure 5
Muskeg Tractor with spinner/broadcaster ready to commence work. The hopper is filled with fertilizer and a further supply is carried in bags on the tractor

A Pneumatic Distributor

However, as with all technology, the rate of development is continually accelerating and even as this article was being written the possibilities of broadcasting of fertilizer were being further explored. This was brought about by the chance discovery that a machine had been developed in Finland for the broadcasting of fertilizer in standing forests where this technique is being developed to increase the rate of growth. As mentioned earlier, there are large areas of plantations in Northern Ireland in which the trees are in 'check' or growing very slowly and it was considered that this Finnish machine might be used to fertilize these areas and so increase the growth rate.

A demonstration of this machine—the Metsa-Viska Blower—showed that it would blow powdered fertilizer up to 2 chains in still air and that this could be done through standing forests or over newly planted areas with equal facility. These trials were carried out with the Metsa-Viska Blower mounted on the three-point linkage of a 4-wheeled drive tractor, the blower being powered from the tractor p.t.o. While these trials showed the suitability of the Blower for these fertilizing operations, it also showed that a wheeled tractor was not a suitable vehicle for carrying it during this work. The ground was not only soft but also intersected by deep drains and the wheeled machine soon ran into trouble in these. A further disadvantage was that the tractor had no carrying capacity and frequent returns to the road had to be made to re-fill the hopper of the fertilizer spreader.

The obvious answers to these latter difficulties was to fit the Metsa-Viska Blower to the Muskeg Tractor, especially as this machine was rather too successful in its pre-planting fertilizing operations in that it could complete the broadcasting for a whole year's planting programme—approximately 5,000 acres—in about three months and thereafter had little work to do. However, the problem of drive had to be overcome, as the hydrostatic transmission used with the spinner/broadcaster for pre-planting distribution of fertilizer developed only 3 b.h.p.

whereas the drive requirements of the Metsa-Viska was 20 b.h.p. Furthermore, the input shaft speed of the Metsa-Viska was only 650 rev/min which, unless major changes in the drive arrangements of the Blower were made, required a considerable speed reduction between the driving motor and the shaft. Fortunatly, a standard unit was available which, with some modification, allowed this to be done fairly cheaply and after considerable head-scratching the Metsa-Viska Blower was mounted to the Bombardier Muskeg Tractor with the Blower mounted to overhang the rear of the tractor and the hydraulic tank, control valve, pipe arrangements, etc., neatly gathered around the radiator end of the engine, (see figs. 6 and 7).

Figure 6
Muskeg Tractor with air blast type of distributor. Note hydraulic tank, pipes and control gear and overhang of distributor

This combination was then set to work and performed the spreading function most satisfactorily but there was no doubt that the handling characteristics of the tractor were changed and that its soft ground performance was impaired to a considerable degree. Fortunately, the representatives of the Rolba Corporation, who are the distributors of the Muskeg Tractor in Europe, were present at the trial runs of this machine combination and they were able to point out the main causes of this loss of performance. By hind-sight these were obvious since the arrangement of the additional equipment all at the rear of the Muskeg had completely upset the weight distribution, overloading the rear of the tractor and upsetting the steering and track loading. The effect of this can be seen in plate 12 which shows the excessive 'nose-up' position of the tractor when working on soft ground.

Once more to the workshops where the equipment was stripped off and re-positioned. To ensure better balance, two hydraulic tanks were fitted, one on each side of the machine at the front of the track guards and batteries were also removed from the rear and re-fitted to the front of the machine. This allowed the Metsa-Viska Blower to be re-positioned on the Muskeg so that it is now carried directly on the frame of the tractor with a very small overhang.

Performance of Blower Distributor

Now this machine is in action broadcasting fertilizer for our current pre-planting operations, after which it will be more or less continuously employed on the fertilizing of 'checked' and other slow growing areas. It is, as yet, too early to state the actual costs of this operation but on the operating costs of these machines over several years and with present wage rates and outputs, it would appear that the costs of transporting the fertilizer from the nearest road point and broadcasting it over the area to be treated will still be between 10/- and 15/- per acre, depending on the haul distance and ground conditions. There is no doubt that the combination of these two machines has produced a unit which will be of inestimable value for foresters and others concerned with the fertility of marginal and sub-marginal land and that it will assist in increasing and maintaining the productivity of such areas not only at a lower cost than that of aerial spraying but without the considerable amount of organization and preparation which aerial broadcasting requires.

Figure 7
Muskeg Tractor with air blast distributor at rest. The bags of fertilizer at front tend to stabilize the weight distribution

ELECTIONS AND TRANSFERS

Approved by Council at its meeting on 16 *October* 1969

ADMISSIONS

Member		Green, T. L.	Durham
	Overseas	Makanjoula, G. A.	Nigeria
	Overseas	Muchiri, G.	Kenya
Associate		Banwell, M. G.	Kent
		Chave, B. J.	Wilts
		Cooper, F.	Yorks
		Fryett, R. J.	Herts
	Overseas	Graham, M. W.	Nigeria
		Higgs, P. J.	Norfolk
		Hirons, R.	Yorks
	Overseas	Kemble-Taylor, J.	Ethiopia
		Landels, D. G.	Scotland
		Marshall, C.	Devon
		Murray, G.	Scotland
		Nance, K. H.	Kent
		Sutherland, I. J.	Scotland
		Williams, R.	Northumberland
		Zalichi, D. E.	Surrey
Graduate		Jones, I. C.	Montgomeryshire
Student		Thompstone, R. G.	Beds

TRANSFERS

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		Hinds, Miss C.	Worcs
		Muldowney, A. J.	Northampton
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		Martin, S.	Devon
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Graduate		Adams, G.	Som
		Allan, A. M.	Sussex
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Abbreviations and Symbols used in the Journal

a	year
A or amp	ampere
ac	acre
a.c.	alternating current
atm	atmosphere
b.h.p.	brake horse-power
bu	bushel
Btu	British Thermal Unit
cal	calorie
c.g.	centre of gravity
C.G.S.	centimetre gramme second
cm	centimetre
c/s	cycles per second
cwt	hundredweight
d	day
dB	decibel
D.B.	drawbar
d.c.	direct current
°C, °F, °R	degree Celsius, Fahrenheit, Rankine
deg	degree (temperature interval)
dia	diameter
doz	dozen
e.m.f.	electromotive force
ft	foot
ft^2	square foot (similarly for centimetre etc.)
ft lb	foot-pound
G.	gauge
g	gramme
gal	gallon
gr	grain
h	hour
ha	hectare
Hg	mercury (pressure)
hp	horse-power
h	hour
in.	inch
in^2	square inch
i.d.	inside diameter
kWh	kilowatt hour

l	litre
lb	pound
lm	lumen
m	metre
max.	maximum (adjective)
m.c.	moisture content
m.e.p.	mean effective pressure
mile/h	miles per hour
mill.	million
min	minute
min.	minimum (adjective)
o.d.	outside diameter
o.h.v.	overhead valve
oz	ounce
Ω	ohm
pt	pint
p.t.o.	power take-off
qt	quart
r	röntgen
r.h.	relative humidity
rev	revolutions
s	second
s.v.	side valve
S.W.G.	standard wire gauge
t	ton
V	volt
v.m.d.	volume mean diameter
W	watt
W.G.	water gauge
wt	weight
yd	yard
$>$	greater than
$\ngtr$	not greater than
$<$	less than
$\nless$	not less than
$\propto$	proportional to
$\sim$	of the order of
° ′ ″	degree, minute, second (of angles)

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