Four Years of Automatic Office Work

by T. R. Thompson

Summary: In this paper, read to The British Computer Society, in London, on 19 May 1958, the author, who has been concerned with the *LEO* project since it was first conceived, surveys four years' experience of doing office work on an electronic computer, some of the applications of the machine, the difficulties of using a computer at full capacity and some of the problems that are still waiting to be solved.

1 GENERAL SURVEY

If I had been giving a paper to your Society four years ago my aim would have been to convince you that to do office work by means of an automatic computer was a practical proposition. Now this is taken for granted. So today I shall try, in the time available, to offer you a picture of what it means in practice to use a computer in this way. First I will try to give you a broad picture, covering as many aspects of this question as possible. In this review I shall normally be referring to *LEO I*, since it is this computer which has been in regular operation for over four years. You should bear in mind, however, that LEO I was started in 1949 as an experimental machine when there was little experience of computer design to guide us. Whatever we are achieving with this computer can be, and is being, surpassed by our prototype *LEO II* and its production models.

(*a*) *The loading of the computer*

Normally we run the LEO I computer on a two-shift basis with a switched-on time of about 100 hours per week, of which about 85 are assigned to productive work, leaving 12 hours for routine testing and preventative maintenance, and three hours for program trials; but we have, for certain periods, loaded the computer much more heavily than this. Something over a year ago for a period of 7 months, when we had to do a very large urgent job for the British Transport Commission, we had the computer switched on constantly for 24 hours a day for all 7 days of the week.

(*b*) *Efficiency and reliability of the computer*

Not all the time assigned to productive work can be productive. First there must be inconsistencies in data which necessitate the computer stopping so that the operator can decide how best to proceed. There will also from time to time be stoppages due to a computer fault, and there must also be lost time in changing over from one job to the next. In practice we do not normally expect to load the computer to the extent of more than 75 to 80% of the time allocated to productive work.

The most important requirement of doing office work by computer is to be sure of getting the results at the scheduled time. That we have been able to satisfy this requirement will be clear when I say that, over the four years or so we have been doing payrolls, every one of them has always been completed in good time.

As experience has been gained in preventative maintenance and fault diagnosis, the incidence of faults has lessened, and the extent of the delay when one does occur has been progressively reduced. The result is that we can now with safety heavily load our computer with office work that has to be done to a tight schedule, with a small proportion of mathematical and other work to be done as convenient. To be able to do this we need always to have an engineer on duty in case a fault occurs. For day shifts he has an assistant. The training of all our engineers on how to maintain a computer has been carried out entirely within the LEO organization, and normally it takes about 12 months to do this.

(*c*) *Accuracy of results*

Since LEO I commenced working it has produced hundreds of millions of result numbers of one kind or another. We cannot say that it has invariably produced the right answer because occasionally we do have queries on results and have to re-run a part of the job. But, whenever we compare LEO answers with those produced by previous or parallel calculations done by orthodox means, we find the LEO answers far more accurate, and we can say with confidence that the errors produced are of a very much lower order than those which occur when other methods are used.

I should explain that the checks we make on the results produced are mainly by means of the program, and not to any extent by means of circuitry within the computer.

(*d*) *Operating the computer*

Under ideal circumstances, where the computer is doing only a few long jobs, LEO can be run by one operator. In general, however, we find it necessary to have two, so that one can be available for

(i) directing the assembly of data;
(ii) scrutinising and disposing of results;
(iii) covering for meal breaks, etc.

This is particularly necessary in view of the great variety of jobs we handle. Moreover, because we are constantly training new operators for further installations we have, in fact, usually had three operators on each shift.

These operators are not programmers, though they have received basic training in programming. They are ordinary intelligent young men without previous specialized experience. They have become quite useful on the computer within about three or four months after starting. An experienced operator is capable of dealing with well over a hundred jobs and may be called upon to deal with about half that number in a single week.

(*e*) *Data preparation*

Much of the data is fed to LEO in the form of punched paper tape, so the transcription of current data from the initial record forms is an important preparatory step. At the moment we have about a dozen staff using Creed perforators to transcribe data for both LEO I and LEO II, and another dozen checking the tapes by means of the LEO comparators. Most of these are secondary school girls, all under the age of 18. They were recruited immediately they left school and have been trained by us. Some of the earlier ones have graduated to other jobs in the LEO organisation: two or three have become either Group Leader or scrutineer on the Data Preparation Section; one with a better education has become a computer operator, another a junior programmer.

The present load of work handled is about 2 million characters a week. Under normal pressure the perforator operator or checker can deal with 7,500 characters an hour.

Because of the independent checking device the standard of accuracy is high, but this can only be maintained by careful training. We also find it necessary to take great care in form design so that these junior staff can follow very precise rules of procedure, because there is always the danger that both transcriber and checker may misinterpret the information on the data form.

(*f*) *Economics of running a computer*

The question as to whether a computer can pay for itself is a matter that would-be users are naturally concerned about. In the U.S.A. the view has often been expressed that a computer can only pay for itself if incidental advantages are taken into consideration. We do not share this view and I am told that some users in the U.S.A. now agree with us. Provided there is a sufficient load of work for the computer there should be no doubt about it, and we know of many organizations in this country which have single jobs that could occupy a large computer for the whole of a single shift.

LEO I, which as I have said could never be expected to be as effective as later production machines, is certainly paying for itself, and LEO II is just beginning to do so now that the load of work is reaching reasonable proportions.

When a computer starts work it cannot be expected to pay for itself at once, because, even if there are to be only a limited number of jobs on a computer and all are ready when the computer is installed, it does take time to build up the load, mainly because of the time taken to prepare the records for transfer from the old system.

(*g*) *Experience gained from running a computer on office work*

The use of computers on office work has naturally taught us a great deal about the many aspects of this problem. I have only time to make the barest mention of some of them, yet each aspect really deserves a paper to itself.

(i) In organizing office jobs for a computer we have found that the essence of the problem is in stating it properly and in organizing the data carefully so as to minimize the computer operation time. One important factor in making the plan is to make provision for the occurrence of errors in the data and mistakes in operation, which in practice inevitably occur.

(ii) We have found that we can train coders so that, given the job plan, they can quickly prepare the coded program, incorporating adequate checks without over-burdening the program. We have perforce also had to devise means of doing program trials on the computer in the shortest possible time.

(iii) The technique of designing data forms, so that data can initially be recorded more correctly and then accurately transcribed to paper tape, is an important question about which we have learnt a great deal. Having drafted a form we try it out to see what mistakes are made in both recording and transcribing before we finally put it into use.

(iv) Experience of different kinds of operational mistakes have indicated what precautions are needed. These precautions always seem very obvious afterwards. For example, where more than one program can be used with a particular kind of data, we now introduce a program check to make sure the operator cannot use the wrong program.

(v) From experience of deterioration of components, we have been able to plan our preventative maintenance with a view to checking in each respect as often as is necessary, and no more.

(vi) In fault diagnosis, we have realized what might have been deduced by analogy with medical diagnosis: namely, that one must start with a knowledge of all the different things that may go wrong and the symptoms each give rise to, and then, in the case of any given fault, deduce the root cause by a process of elimination.

(vii) From experience of what goes wrong, predominantly valve deterioration, we have, in some cases, been able to introduce improved units into LEO I to make it less liable to faults and, of course, we have been able to use this experience in designing LEO II.

(viii) In some respects experience has shown us that additional facilities can be provided to make the computer more useful for doing office work but, by and large, we have found the LEO I facilities to be adequate.

2 APPLICATIONS

Our policy in deciding what work to give to LEO has been to make our experience as diverse as possible, though naturally this aim has been upset to some extent

by circumstances. In the early days from 1951, before we were ready to do any large mass of office work, we took on many mathematical jobs, and we have throughout continued to do any job that we have been asked to do. It is very convenient to fit these jobs in at the times of the week when the load of office work is not so great.

For J. Lyons & Company Limited we are doing a number of office jobs, but we have also been anxious to interest other organizations in the possibility of doing their office work by computer. Consequently we have taken on a number of service jobs, and we are also doing customers' jobs prior to their being taken over by the customer's own computer. In fact, to a great extent we have found it necessary to give priority to customers other than Lyons. For instance, after 1956 when Ford Motor Company Limited were anxious we should take over their payroll as quickly as possible, we did so in preference to Lyons so that, for the last year or so, we have been doing the payroll for *more* of their employees than of Lyons.

(*a*) *Payroll applications*

We have, in fact, done more work on payroll than on any other type of application. This has occurred for three reasons. The first is that our earliest investigation, starting in 1947, was on the payroll procedure and it became our first experimental job on LEO I in 1951.

The second reason is that the high productivity of the computer on payroll work is easily demonstrated. On many payrolls one can deal with about 40 employees a minute, or over 2,000 an hour. Between Friday evening and Tuesday evening we currently deal with the complete payroll for over 40,000 people employed by six different organizations, as well as other regular daily and weekly jobs.

The third reason is that, of all the office jobs, the payroll has been most rationalized over the last 15 years. With the advent of *P.A.Y.E.* it became almost essential to have a systematic procedure, so that during and immediately after the war a great deal of time was spent by office managers and methods specialists in introducing improved payroll procedures. In doing this the payroll requirements were rationalized to a considerable extent so that, when the time came for considering the payroll as a job for a computer, it was relatively clear what the computer would have to do.

I must not, however, give the impression that to put a payroll on to a computer is an easy matter; it is not. The amount of detail to be considered is very large and the number of exceptional circumstances to be dealt with is beyond belief except by someone who has been concerned with a payroll application. Moreover, the rationalization I spoke of has only been carried to a certain point. The methods of keeping the records for time worked and other pay entitlements differ very much from one organization to another, often for no obvious reason. Ideas differ also on what should appear on an employee's pay slip, and the way the information should appear on the pay slip is very much a matter of taste.

There are many other ways in which payroll applications differ from one another. One of these, which sometimes has an important bearing on the computer running time, is the extent to which the wage cost has to be analysed under different headings. Because of all the detail that has to be considered, it takes much longer—usually at least 6 months—to establish the precise requirements of the payroll than it does to do the coding and trials for the program.

Once the trials of the program are complete, however, the transfer of the job to the computer is relatively painless. There are, naturally, a few teething troubles, but these are exceptional, and in all cases payroll jobs have gone into normal operation after no more than two or three weeks' parallel running.

The payroll application is in our experience quite an economical one. It also has other incidental advantages, particularly in regard to the short period of time that need elapse between the availability of data and the completion of the pay slips. One advantage at Bank Holiday times is that the amount of overtime working is limited to very few people.

(*b*) *Other office procedures common to many organizations*

I should next like to refer to other types of application that are common to many organizations: sales invoicing, stores control, production control, and cost accounting. These applications are closely related to one another, but in orthodox offices are often carried out in different parts of the office.

The problem of determining precise requirements for this kind of job is a very much greater one than for the payroll, as the amount of rationalization previously carried out has proved to be very small. Consequently it usually takes anything from one to two years before coding can start on a job of this sort. Moreover, our experience has been that, once the job is being done by the computer, Management becomes alive to possibilities that could be provided by the computer system, and asks for changes which involve substantial recoding.

Our policy now, therefore, is to start the job in a limited degree, and to expand only when the job has been running for some time and has been fully accepted.

We are doing a number of jobs of this type, all different from one another, for instance:

(*a*) an invoicing job for the orders taken by travellers;
(*b*) a stores control job for the chests of tea that are to be blended;
(*c*) a cost accounting job, dealing with the standard costs of goods from production to distribution.

Any name I give to these jobs is, however, quite misleading because the aim in doing office jobs by computer is to combine as many different procedures as possible into the one job, and this is true of each of the jobs I have mentioned. Often the most important aspect of the job is not the routine aspect by which the job comes to be named, but some other. In the case of the stock control job for the chests of tea, the control of the stocks as such is quite a routine matter, but the incidental work of

preparing statements of quantities and prices of tea under different categories for the buyers and blenders is a much more important aspect.

Since Lyons is such a diverse business (or collection of businesses), the jobs differ widely from one another and are, in some respects, not typical of the jobs required by large organizations of a more homogeneous kind. We have, however, satisfactorily dealt with the stores records for a public utility, and we are currently keeping the records for replenishing and controlling the van stocks of a large organisation. Furthermore we have in an advanced state of preparation several applications for other organizations—invoicing, utility billing, stores control, production control—which are more typical and on a larger scale. All appear to be economical and will also provide information to Management not previously available.

(*c*) *Other office procedures peculiar to J. Lyons & Co. Ltd.*

LEO is carrying out several office procedures for Lyons that are rather specialized in character. A very important one, which has been much publicised, concerns the orders placed by London teashops on Cadby Hall factories. The main part of the job has to be done every afternoon and takes about $1\frac{1}{2}$ hours. Its interest outside Lyons lies in the fact that it illustrates most of the advantages of using a computer for office work. Apart from the fact that it saves about 40 clerks, it has helped the business in various ways.

(i) It has simplified operations in both the teashop and the Cadby Hall despatch department, and the paperwork generally throughout all departments involved.
(ii) It enables the last-minute needs of the teashops to be given effect up to a very short time before the assembly of the goods begins.
(iii) At week-ends and Bank Holidays fewer staff have to work at inconvenient times.
(iv) Information can be made available to Management which it would have been very uneconomical to provide previously.

(*d*) *Pension fund and insurance jobs*

Another class of office procedure on which we are working is that involving pension fund and insurance schemes. These are service jobs for insurance companies and private organizations. The runs seldom take longer than a quarter of an hour but, at short notice, the computer is able to do a job that would extend over many weeks if done by orthodox means. This type of work is, of course, very suitable for a computer since a large number of calculations have to be made on the data fed in.

(*e*) *Market research and other statistical analyses*

Another type of work which is particularly suitable for computers is statistical analysis. We do a number of service jobs of this kind for a number of different organizations, varying from large public utilities to market research organizations. Again, besides the advantage of economy, there is the speed of completion which enables the tabulated information to be available more quickly.

(*f*) *Other types of work*

Apart from the types of work already mentioned, we have done a number of jobs, large and small, and varying from the very mathematical to the very simple. One of these jobs was the calculation of shortest working distances from each station on the British Railways to every other station, involving many hundreds of computer hours; another job was the calculation of a ready reckoner for an investment company.

This has shown us how great is the range of jobs that can, in the right circumstances, be done usefully on a computer.

3 THE DIFFICULTIES THAT HAVE MOST BESET US

Undoubtedly the experience gained in using a computer for office work can best be brought out by listing the difficulties which have caused us most trouble.

(*a*) *Rationalizing the requirements*

To my mind the biggest single obstacle to putting a job on to a computer is that of finding out precisely what the job is required to do. The difficulties are:

(i) In large organizations no *one* person knows all the ramifications of a procedure which involves many departments.
(ii) Many of the supposed requirements arise from the conservatism of staff at all levels, or worse still from emotional prejudice arising from experiences of the past which are now irrelevant.
(iii) There is seldom a person in the organization who is in a position to make comprehensive decisions.
(iv) There are not many members of an organization who have the mental capacity to grasp the whole concept of an involved procedure and to rationalize the many facets of it.

(*b*) *Limitations of the equipment*

As is to be expected, the equipment up to the moment in operational use is not ideal for its purpose. This, no doubt, will continue to be the case for many years yet and, as experience is gained, more and more facilities will be demanded by the user. In a new field such as ours this is inevitable, but only by using what is available at any time can experience be gained to show what improvements are required. From our experience we have found a need for better facilities in a number of directions, in all of which much development work has already been expended and with which you will all be familiar. As a result of this work, equipment is now being produced which can be used in conjunction with later LEOs.

This includes:

(i) Ways of reading data in its initial form so that it can be fed to a computer without being transcribed.
(ii) A computer store which will hold available large volumes of information with a very short access time at relatively low cost.
(iii) A means of holding large volumes of carried-

forward information which can be recorded and read at high speeds.

(iv) Printers which will print information direct from the computer at moderate speeds—300 to 500 lines per minute.

(v) Improved devices for feeding paper to printers so that good and consistent registration can be obtained.

I would like to stress, however, that many jobs, properly organized, can be done without these improvements. One must also bear in mind that the improved equipment adds to the capital cost.

(*c*) *More dependable components*

Automatic computers are made up of a very large number of components—electronic, electrical, electromechanical, and mechanical. The consistently faultless performance of a computer depends on each one of these components continuing to function correctly. Careful design can permit a considerable tolerance in the behaviour of any component and allow for limited deterioration over a period of time. But, if this deterioration takes place too quickly, the problem of preventative maintenance is much more difficult and the occurrence of a fault during operation more likely.

As I have said, the component most subject to deterioration is the valve. A few valves in a given batch may last for over 10,000 hours, but some will usually fail in the first 1,000 hours. The more quickly valves fail the greater the likelihood of failure during operation and the greater the problem of preventative maintenance.

Makers are working hard to provide valves with a consistently long life, but it is difficult to know what success they have achieved until a long period has elapsed.

Another important factor of reliability is in respect of mechanical components. Equipment which feeds data to the computer and records its results has to work very fast and is, therefore, subject to considerable wear. Experience has shown a need for an improved standard of durability and increased margins of tolerance in design.

The introduction of improved facilities often involves the use of new electronic components or new mechanical equipment. Since no one knows in advance how reliable these are going to prove over a long period, there is always the hazard that unreliable components may for a time hamper effective utilization.

(*d*) *Accuracy of data to be fed to a computer*

Another problem is that data is unlikely to be 100% accurate. In ordinary office work, the clerk dealing with it is expected to scrutinize the data and, where it is patently wrong, to prevent it going through the clerical process.

A computer can be programmed to apply the same scrutiny to the extent that anyone can foresee possible kinds of error. When the program does detect the error, the computer either stops for the operator to see how he should proceed, or it prints a query slip for a query clerk to deal with afterwards. But in any case the error is a nuisance and, if many occur, smooth operation is impeded and the computer's effectiveness reduced.

A great deal of trouble needs to be taken, therefore, to keep the initial recording of data to a high standard. Apart from mere accuracy there is always the danger of ambiguity which might lead both the operator who transcribes it and the checker to make the same mistake. An ambiguity may arise either through one numeral appearing as another or, more insidiously, through an item appearing to be in one place on a form when it is meant to be in another.

The high standard required is achieved by the design of simple, convenient, well set-out data forms, and by careful instruction of the people who are to record the data.

4 THE HUMAN ASPECTS OF A COMPUTER INSTALLATION

No statement on the operation of an automatic office could be complete without some reference to the human aspects.

(*a*) *Redundant staff*

First let me dispose of the question of the people whose jobs are taken over by the computer. Potentially this is a very dangerous problem but, by taking care, we seem to have avoided any trouble. At a time when it is difficult to find enough clerks and when young people are less inclined to become clerks, there can clearly be no problem of finding work for the displaced clerks. Nevertheless there is a real danger of the clerks as a whole feeling insecure and some leaving in consequence.

Before we started building LEO I, we told the clerks publicly what we were going to do and reassured them. This was satisfactory until the demonstration of an experimental job in 1951. At that time, despite new assurances, some undoubtedly wondered what was going to happen, but when operation started in earnest and the staff saw that we were carrying out our published policy their fears were soon submerged in pride of what we were doing. The result has been that as jobs have been transferred to LEO, the staff whose tasks were disappearing could not have been more co-operative.

As far as Lyons is concerned, therefore, we are not troubled by this question and, as far as we are aware, our customers also are not meeting any trouble. Reports from the U.S.A. give the same impression.

(*b*) *Getting the right personnel*

The next question is that of obtaining suitable staff. In a time of full employment it is difficult to obtain staff for any kind of post, and for the kind of specialized posts that we have to fill in operating computers, it is bound to be doubly difficult. Whenever possible we take existing employees and train them, but there are only a limited number of suitable people and many of these cannot conveniently be released.

We have tried to avoid the mistake on the one hand of taking any possible person and on the other of insisting on nobody but the best. For those posts that involve prolonged training we have devised tests to ensure that a person is suitable before starting the training. This has certainly saved us from engaging unsuitable people, but it has made the engagement problem more difficult.

(*c*) *Computer operators*

Next I should like to consider the people who actually operate the computer. They are responsible for carrying out a complicated process with little to see except the results produced, though they are, of course, familiar with the program the computer is following. They work at high pressure for long periods and when a fault on the computer develops they are thwarted for the time being. They have to work on shifts, on some Saturdays, and sometimes at night, on Sundays and on Bank Holidays.

Despite this job being so unusual, specialized, and arduous we have a most zealous and competent group of operators who do whatever the job demands. Not one has ever thrown in his hand or asked to be relieved of the job, and as time passes their keenness is not diminished.

(*d*) *Data preparation operators*

The work of those who transcribe the data is very repetitive and we feared it might become boring. Yet we have had no difficulty with them on this account. They seem to remain keen and interested and the work is carried out smoothly and well.

(*e*) *Program coders and planners*

Turning now to the program coders and planners we are concerned with a job of utmost interest and stimulation and, not surprisingly, those who do the job enjoy it thoroughly. They work to the needs of the job rather than to set hours, sometimes doing trials on the computer during the evening or at week-ends.

(*f*) *Maintenance engineers*

Some of the trickiest human problems arise with the maintenance engineers. These are electronic engineers and, as everyone is aware, they are in very great demand in a rapidly expanding industry. In order to maintain an electronic computer it is necessary for the engineer to be experienced, not only in the basic matters of electronics but also in the way the computer works. This involves first of all the logical functioning of the computer, which is a very involved conception, and secondly the design of the electronic circuits that carry out the functions. What is more, the engineer must have the power to talk the same language as the operators and programmers.

This means that the engineer must be very able mentally, and he must undergo a considerable period of training, both theoretical and practical. He must be ready to co-operate with the operators and, furthermore, he is asked to work shifts which involve working early, late at nights, at week-ends, and on Bank Holidays, as the needs of the work load demand.

This is not an altogether pleasing proposition to an engineer, especially when he is married. It would not be surprising, therefore, if our maintenance engineers did not so readily adapt themselves to the demands made by a heavily loaded computer. The fact that they have done so in practice demonstrates that the right type of man does rally to the needs of the job, however arduous.

5 CONCLUSION

Briefly, to sum up our experiences, we can say that we have shown that office work can be done by an automatic computer and that, for many types of job at least, it is worth while using one. We have learnt the nature of the difficulties of using a computer at full stretch and have overcome some of them. Most important, perhaps, we have some idea of the problems that are still waiting to be solved.

SUMMARY OF DISCUSSION

The following points were made during the discussion which followed the presentation of the above paper to the British Computer Society in London on 19 May 1958.

Mr. A. J. Bray (*Turquand Youngs & Company*):

1. What reorganization of clerical methods took place before the programs for computer input proper commenced?
2. How far have Management been willing to accept the integration of data and the change in the presentation and form of statements at which they have looked in the past?

Mr. J. D. Croston (*Kodak Limited*):

3. In view of the unreliability of data in the original documents used for preparing the input data for a computer, what types of check does Mr. Thompson consider that it was essential to include in the input checking program?
4. I was also most interested to hear that the speaker considered that, in applying computers to the clerical operations of sections other than payroll, in which procedures were likely to be less clearly defined, it might be desirable to tackle only part of the operations in the first place to gain experience, as it was likely that the requirements would change as a result of the output obtainable. In this connection I should like to know, in terms of lengths of time taken by the computer, what was the smallest job for which it had proved worth while to write a program.
5. The selection of the most suitable part of an organization for the first application of a computer is also of considerable interest. Has it been found better to consider a horizontal or a vertical section through the organization chart, and is it better to consider similar operations in a number of different sections, or the interlinking of the clerical operations in interdependent sections using common data but having different functions?

Mr. C. R. Merton (*National Research Development Corporation*):

6. Does the speaker think it possible that the operating procedures developed by his team were designed in part to overcome the limitations of LEO I, so that they were not necessarily applicable to other computer installations? I have in mind the larger computers on which it might be uneconomic for the

computer to wait for operator intervention, when, for instance, a discrepancy in data is detected by the machine.

Mr. E. C. Clear Hill (*The De Havilland Aircraft Company Limited*):

7. I have been very interested to hear of Mr. Thompson's experience of the accuracy of input data used in business applications—there are two aspects of accuracy involved, that of the raw data itself and that with which it is transcribed into a form acceptable to the computer.

   In this connection the speaker has rightly placed emphasis on the importance of good form design which quite clearly made for an overall improvement. I would therefore be very interested to hear of Mr. Thompson's experience and views on the effect on overall data accuracy of introducing peripheral equipment for the direct recording of basic data in a form acceptable to the computer.

The following contribution was received in writing after the lecture:

Miss B. K. Bubb (*Kodak Limited*):

8. To what extent is it found necessary to amend programs after they have been fully developed, because of changes in the required calculations as a result of changes in external circumstances (e.g. production process changes)? How much time does this occupy?

The author (*in reply*) has provided the following answers to the above questions:

1. We always plan the reorganization of the whole clerical procedure at the same time as we plan the computer program. The plans are tried out and put into experimental operation while the program is being prepared and tried, so that the reorganization can be complete when the program is operational.
2. Management usually accept in principle the idea of integration of data and changes in presentation. Nevertheless, as one might expect, they are always conservative when it comes to detail, so that some compromise usually has to be made.
3. The type of check must depend on the nature of the data. Sometimes it is possible to check by means of a control total, but usually only limited checks can be made, such as checking the size of certain items and relationship of one item to another.
4. The size of the job which it is worth while putting on a computer must depend on how often it is repeated. In general a job repeated about once a week is not worth while if it involves less than 10 minutes of computer time. There are, however, some jobs where the length of time of computer running varies. We do pension scheme jobs which may vary from an hour or so to less than a minute. Nevertheless, it is worth while doing the smaller runs because they can be completed so much more quickly than by orthodox means and, in any case, once the program is available, it is worth while using it for smaller ones as well as the larger ones.
5. It is usually desirable to select the work to put on the computer by both a horizontal and a vertical split, where this can conveniently be done. The horizontal split is an advantage, because it limits the volume of work to be reorganized in the first place until the job is proved to meet the true requirements; expansion horizontally can then take place as convenient.

   The vertical split is sometimes an advantage because it limits the extent of the reorganization throughout the business. It is, however, most important that the main plan should cover the whole of the office procedure and not merely the vertical section that is first put on the computer, so that when the other sections are put on the computer, no significant reprogramming of the first part will be necessary. I should perhaps stress that no vertical split should be contemplated where the whole procedure can be carried out by a single program.
6. Operating procedures must always be developed on the assumption that data errors will occur, and it is clearly unsatisfactory to press on with a clerical job with wrong data. With some of the larger computers, special data-vetting programs are often used to check the data prior to starting on the main program. This itself uses computer time, but it can conceivably be less than would be incurred by stoppages during the main program. We ourselves do edit data in special cases, but usually it does not pay us. The policy in this will depend on the computer used, the frequency and nature of the errors to be expected, and the time likely to be taken by the operator in deciding how to proceed when an error occurs.
7. I have no direct experience of using data prepared by peripheral equipment in a form immediately acceptable to the computer. So far we have not found a case where it has been economic to use special equipment for preparing data in this form, though we are planning to do so in the future.
8. A change in external circumstances which was not anticipated when the program was prepared must necessitate an amendment to the program. In payrolls this has not occurred more than about once a year, and it never affects more than a small part of the program. Other jobs have not involved amendments more frequently than this. The average amount of time to maintain a program would not amount to more than a week-or-so's work per annum, and only a very small percentage of our programmers' time is spent in amending programs once they have been fully established.