ELECTRONIC COMPUTERS
AND THEIR
POSSIBLE APPLICATIONS

By N. C. POLLOCK

CHAIRMAN'S CONFERENCE

MAY, 1955

STEWARTS AND LLOYDS, LIMITED

ELECTRONIC COMPUTERS AND THEIR POSSIBLE APPLICATIONS

INTRODUCTION

The *Financial Times*, at the opening of a recent series of articles on electronic computers, stated that "more nonsense has been talked about electronic brains or computers than about golf or women". Being no expert in either of the latter, I cannot support or deny this assertion. Nevertheless, a steady stream of articles and comment is to be found in the national, local and technical press, and the expressions "electronic brains", "giant brains", "mechanical brains" have become popular, and have, I am sure, been encountered by most, if not all, of us here to-day. Additionally, names like ACE (Automatic Computing Engine), LEO (Lyons Electronic Office), UNIVAC and so on are probably familiar to some.

But these machines are neither figments from the latest science fiction, nor paper concepts on the drawing board. They are in being—and working. Their achievements have already been quite staggering and developments and improvements are going ahead extremely fast. Therefore some description of the composition, capabilities and applications—both present and future—of electronic computers may be of interest, and that is what this paper, in a brief way, sets out to give. In doing so, in the time allotted, there is bound to be much over-simplification and much which might upset the purist. For these shortcomings I apologise.

CONVENTIONAL EQUIPMENT AND THE BASIC CONCEPT OF CALCULATION

Many of the practical problems of science, business and war are essentially arithmetical. For example, scientific and economic conclusions may be drawn by subjecting a large volume of observed data to appropriate statistical treatment. The manipulation of figures is behind every cost, every accounting statement. Military plans are based on logistics involving numbers of men, tons of stores, measures of speed and distance and so on. The development of large engineering projects requires extensive calculations. Over the centuries, the invention of mechanical aids to calculation has been stimulated by the demands of business, navigation, engineering and, later, war. From the abacus, via Pascal, Leibniz and Thomas, to the desk calculators and adding machines of to-day.

These latter machines are commonplace and will be familiar to most of us. For simple calculations, they are reasonably fast and convenient in operation. Their speeds are low enough to permit continuous judgment by the operator.

However, they do not print the answer on a piece of paper. The advantage of a printed output is plain, and in the late nineteenth century developments designed to achieve it took place from two different bases. First, to give the simple adding machine a printing mechanism; second, to give the typewriter the facility to add. In other words, to add mechanical writing to mechanical adding. From these developments has emerged the modern keyboard accounting machine.

The remaining major invention prior to the electronic computer was the punched card method of doing accounting and statistical work. Punched card systems consist of a battery of machines, each of which is designed to perform a part only of the clerical work needed for the end product. For example, punches and verifiers to present the basic data in a form which the machines will accept (i.e. punched cards); sorters and collators to put the cards in a required sequence; multiplying punches to perform this arithmetical function; and tabulators to act as adding and printing machines.

Thus we have, roughly, three main classes of conventional modern calculator: the desk type (which doesn't print the answer but shows it in dials); keyboard accounting machines which add and print the answer; and punched cards which add and print and, in addition, operate on a standard medium capable of varied manipulation.

There are five basic steps common to every calculating operation—no matter how simple and no matter whether performed mentally or by a machine. These are:

(*a*) an input operation.
(*b*) a calculating or arithmetic operation.
(*c*) a storage function.
(*d*) a control function.
(*e*) an output operation.

Take a simple calculation such as 25 tons of scrap at £9 a ton. *Input* is achieved by writing down these two figures on a piece of paper—assuming that we are very elementary arithmeticians. The human brain then takes over the next three functions. First, an *arithmetical* function of multiplying 5 by 9. Second, as a *storage* unit to "hold" the "carry-overs"—such as the "4" of the "45" produced by multiplying 5 by 9. Thirdly, as a *control* unit in determining the sequence in which these steps must be done. Finally, when the answer is written down that is our *output*.

COMPUTERS AS COMPARED WITH CONVENTIONAL EQUIPMENT

The drawback to all conventional equipment is that its efficiency depends to a greater or lesser degree on the efficiency of the human operator. That is to say, one or more of these five basic functions are not being performed automatically but by the intervention of the human brain. On most conventional machines the *arithmetic* operation is usually automatic although often slow. The *input and output* can be partly or occasionally automatic. *Storage* is usually severely limited while automatic *control* either doesn't exist or is present only in a rudimentary form.

Electronic computers are the latest stage in the drive to get the maximum degree of automatic operation in each of these five functions and has been very largely achieved. A computer can be told to do the following:—

(*a*) carry out calculations *continuously* by referring to orders previously stored and applying those orders to the variable data being fed in.

(*b*) examine an intermediate result during calculation and select alternative programmes dependent on this result.

(*c*) check itself by doing a calculation a second time in a different way, and at the same time determine whether a sufficient degree of accuracy has been achieved.

(*d*) consult information previously stored within it and select appropriate items.

(*e*) reproduce final and subsidiary answers in a variety of forms dependent on the type of machine.

All this work is carried out at astonishing speeds and with great reliability. As examples of speed, LEO, the computer belonging to J. Lyons, the caterers, averages 1,000 calculations a second. Remington Rand's ERA1103 is reputed to have an adding speed of nearly 17,000 10-digit numbers a second, while prototype models have multiplying speeds in the order of 20 millionth's of a second each. Such figures border on the fantastic, but even the slower computers work at speeds hundreds and sometimes thousands of times faster than the swiftest desk calculator. It is this great speed, allied to the possibility of almost entirely eliminating human intervention in the process, that makes the prospect of electronic computers so attractive for clerical work.

I mentioned the power that a computer has of taking the results of its own operations to regulate and modify its future behaviour. It is this ability which has led to the machines being described as "thinking" machines. Now I dare say that it is just as wrong to suggest that computers can think as to suggest that they can't. In the sense that they can solve problems in the light of established criteria—such as the Ferranti Manchester Computer which can play an invincible game of noughts and crosses—then they *do* think. The same machine can also solve end problems at chess—but not very well: a good county player could solve them much more quickly. The Manchester Computer can also play a game of draughts—but in doing so it always assumes that its opponent will make the best of all the possible moves open to him. It cannot take advantage of unexpected and unprogrammed situations. And so in this sense, the machines cannot "think". In other words, the machine cannot think originally or intuitively, neither can it tell itself what to do except as a result of "feed-back". Nor can it cope with any situation which may arise beyond the precise orders originally given it. The tendency of the popular press to dwell dramatically on the parlour tricks of computers like playing chess, draughts, noughts and crosses, writing love letters and so on, has tended to obscure the prospects which they are offering to the practical world of science and business.

THE COMPOSITION OF AN ELECTRONIC DIGITAL COMPUTER

From what we have seen, a digital computer can be defined fairly specifically as "a device for performing a sequence of arithmetic or logical operations". I have now introduced a fresh word—digital. I have only done so because the description "digital computer" is often used in press articles. There are two main classes of calculating device—digital and analogue. A *digital* device, as the name suggest, is one which performs mathematical operations with numbers expressed in the form of digits, each of which has a distinct and separate value. Desk calculators, keyboard accounting machines and punched card equipment are all examples of digital machines. *Analogue* computers on the other hand convert numbers into physical qualities, such as lengths, voltages, angles of displacement, etc. Two common examples are slide rules and speedometers. For the purposes of this paper, however, I shall be dealing with digital machines only.

Perhaps it would be as well if I also disposed of the word "electronic". Quite simply, equipment so described operates by means of valves—or their equivalent. A radio or television set is a piece of electronic equipment. Conventional accounting and calculating machines work either by mechanical or by electro-mechanical components such as counter-wheels and relays. By substituting electronic tubes and circuits for these older devices, greater speed and improved consistency have been achieved.

The five features of any calculation to which I referred earlier will be found repeated, as components, in any electronic digital computer. All computers are alike in certain fundamental ways, although no two will be precisely alike and the basic components may be organised and the machines constructed in different ways, depending on their designers and purposes. In common, however, they will all have the five basic features. We should now consider each of these in turn.

Input unit

This provides an entry for the operating data on which the machine will work. The important point to bear in mind is that the machine will only accept information if it is presented to it in a particular physical form. The more common of these forms are:—

(*a*) punched cards.
(*b*) punched paper tape.
(*c*) magnetic tape.
(*d*) keyboard.

Punched cards are a well-established medium for storing information. This, together with their facility for being sorted before input, gives them an advantage over other forms—particularly in the early stages of computers when users are feeling their way. They are relatively slow, however—the general feeding speed being 150 cards a minute—and are bulky and somewhat wasteful in storage.

Punched tape is cheaper and faster than punched cards. If read by a photo-electric cell the speed is 200 characters a second. Original preparation is similar to punched cards—by a hand operated mechanical punch—although punched paper tape as a concurrent by-product of printing operations on accounting machines, electric typewriters and cash registers is now being produced in the U.S.A. Drawbacks are the problems of error-correction and the inherent disadvantage of having data stored in continuous form.

Magnetic tape. The prospects for this method are very good indeed. The tape is usually made of an acetate plastic coated with fine grains of iron and divided into channels. Any point on the tape can be given a positive or negative charge of electricity corresponding to the "hole" or "no hole" situation on a punched card or punched paper tape. The tape itself is fairly expensive and is only about to be produced as a working proposition in this country. Storage capacity, however, is large owing to the ability to crowd the charges closer together than is possible on paper tape. 1,000 ft. of 35 m/m tape could take about 360,000 words. The reading speeds are very fast—up to several thousand characters a second. In the U.S.A. Remington Rand have already developed typewriters which convert the typist's key stroke into a pattern of spots on the magnetic tape—either as an original entry or as a by-product.

Keyboard input is manual, and is so slow compared to other forms of input and to the calculating unit of the computer that it is not really suitable as a means of direct entry. However, the use of keyboard machines giving a printed page copy and with the additional facility for converting data into a medium capable of being read in a computer, must not be overlooked.

It will be seen that the computer is only able to accept information in a particular and stylised form. At present data reaching the electronic office has to be read and put into punched card or punched tape form by the manipulation of a keyboard. Some automatic device capable of "reading" type or handwritten documents and automatically transmitting the data to the computer is needed. And it may not be so far away. However, for some little time to come the preparation of data for the machine will occupy most of the staff needed to run an electronic office. It is true that this type of labour will be unskilled or semi-skilled, but it does mean that the computer equivalent of the punch and verifier operators in a punched card installation will be the last to be replaced by an automatic process. Computers are not, of course, necessarily confined to one type of input—indeed it is probable that multi-channel input is desirable in order to get the maximum benefits from all the different types.

Calculating unit

This does the arithmetic: adding, subtracting, multiplying and dividing. It usually consists of a number of electronic counters. Numbers are received in the form of electrical pulses which react on the counters in accordance with the orders previously given. For example, to multiply 2×3, 2 will go into one counter and 3 into another. Then 2 will be transferred into an accumulating counter 3 times so that 2×3 is, in effect, $2+2+2$ equals 6. In other words, multiplication is achieved by repeated addition and division by repeated subtraction. Checking the accuracy of the calculation is achieved by doing the sum the other way round (i.e. 3×2), using the same counters, or by repeating it using different ones. The results are compared and will only be accepted by the machine if both agree. Self-checking devices can be built in and be automatic, or can be programmed for specific jobs. Experience on LEO suggests that machine reliability may be higher than was originally thought and compares very favourably with other calculating methods. Therefore, built-in checks might be progressively dispensed with.

Storage

All computers possess some degree of internal storage. This is sometimes called the memory since it resembles the human brain in its ability to store and call on facts. This memory is in-built and therefore limited in capacity. A typical example is HEC4, the Hollerith Computer, with a magnetic drum storage of 1,024 locations, each capable of holding a "word" of 13 decimal digit numbers. LEO has twice this capacity. Other machines are much larger, with internal storage running into tens of thousands of locations. By and large, the following general principle applies: the larger the memory the longer the access time for any particular piece of information—and vice versa. This access time is important because the speed of the calculating unit is so fast that information should be available to it instantaneously.

The memory is primarily used to store the instructions or orders to the machine—in other words a programme. It may also hold original data from the input until the calculating unit is ready to use it: constant information required during the programme, as well as intermediate and final results. In addition to the inherent memory capacity of the machine, storage can be external, e.g. data only occasionally required or which must be kept as a permanent record. Examples of this were mentioned when discussing the *input* feature, i.e. punched paper tape, punched cards, magnetic tape, etc.

Control Unit

This is a box of electronic tricks and is the unit which co-ordinates all the activities of the computer and enables a series of operations to be performed without human intervention. It will receive separate instructions from storage and will act on each successively until the programme is completed. It directs and controls movement within the computer—from input to store; from store to arithmetic unit and back again; and from store to output. Above all it ensures that the work is done in the correct sequence. It might be called the nervous system of the machine because without it the computer could not function.

Output unit

This is the last of the basic parts of the digital computer. It is responsible for presenting the answers. Very often we should like these answers to be readable—i.e. printed on a piece of paper—and so we can expect to find a direct printed output as one of the possible ways of revealing the answers to the problems put to the computer.

Unfortunately, however, the speed and adaptability of the computer itself is not matched in the printing. So far, the best that can be expected is a line-at-a-time printer (similar to a punched card tabulator) operating at about 100 to 120 60-character lines a minute, or an electric-typewriter working at about 600 characters a minute. Now although these speeds may sound high, they are pedestrian when compared with the computer speed and it seems to be the general concensus tha. the latter should be allowed to work as fast as it can.

Therefore, two courses are open. Firstly, to develop a high-speed printer or to couple a battery of, say, 8 electric typewriters to the computer itself. This has still the disadvantage of relative slowness, even though printers of up to 1,000 lines a minute are nearing production. Secondly, you can restrict output to the same type of media as the input, e.g. punched cards, punched tape, or magnetic tape or film, and then manually transfer the product on to one or more printing machines. Of these devices, magnetic tape once again offers the most attractive prospect. Speeds of thousands of characters a second of output are already being achieved. With such an intermediate output, a series of slow-speed printers could be used to present it in a readable form. It seems likely that, as with input, the ideal computer will have several output devices which can be used at will.

Programming

The essential requirement in using a computer is to tell it what to do. It must be led around by the hand, so to speak, and told every move to make. Fortunately, however, the machine needs only to be told once. But routines will have to be analysed and then presented to the machine in its own language. This is known as *programming* and it may be a long and detailed business on any one job. In fact, it will be apparent that the business of writing down the machine instruction and then presenting it to the machine in its own language could take longer than doing the actual operation by manual or other mechanised means. If this were the case, the computer would not be an economic proposition on non-repetitive jobs.

Programming consists of two separate operations:—

(*a*) to decide what has to be done and the sequence of it and (probably) to record this in flow chart form.

(*b*) to convert plain language to machine language—known as coding.

Coding techniques will vary with the type of machine, but can probably be taught in a few weeks by the equipment makers. Analysis of existing routines and the establishment of requirements cannot. They probably demand not only intimate knowledge of existing practices but the ability and authority to decide what is really needed. . However, it is probable that it doesn't matter greatly whether the existing system is good or bad—a detailed survey and critique for computer operation is essential. A high standard of programming will be required if the computer is to be used to its best advantage. For clerical work, mathematicians are probably *not* required—in fact, Lyons have recruited and trained their programmers from their own staff.

THE USES OF COMPUTERS

It is possible to classify digital computers by the three main uses to which they are being put:—

(*a*) scientific calculation.
(*b*) production-process control.
(*c*) business and accounting routines.

Scientific calculation was the initial demand which led to these machines being invented. All but one of the automatic calculators now operating in the U.K. were designed primarily for scientific work. The range of problems handled is immense. To quote a recent article by Professor F. C. Willams in the *Manchester Guardian* (he is referring to MADAM, the Manchester University Machine):

> "The problems may vary all the way from abstruse calculations concerned with the trajectories of meteors to the insides of the atom, to the routine engineering design of a turbine rotor".

And later he says:

> "All the necessary hydrodynamic calculations for the new St. Lawrence seaway were completed in a few months using a sister machine at Toronto. Steel framed buildings have been designed with considerable saving in material".

Machines have also been used for weather forecasting where speed is invaluable. A recent paper given to the American Society of Mechanical Engineers described the economic use of a computer for the solution of pipe expansion and stress problems. This, plainly, is an application which may be close to certain of our own requirements.

There are many other examples—so many, in fact, that the Manchester Computer is operated 24 hours a day, 7 days a week. Now, as a generalisation, it is a characteristic of scientific work that much calculation is performed on relatively little data. In other words, input and output problems don't loom large—in distinct contrast to clerical applications.

Process control of production work is another possible application for computers. Remote control servo mechanisms have been developed to replace the manual control of machine tools and experiments have been made using a digital computer to control these servo mechanisms. In other words, it seems possible to *programme* on a computer the *shape* of the finished product. Obviously, much hard work and study will be needed before automation to this degree can be accepted as a matter of course.

Thirdly, the use of computers for *business and accounting routines* is one which offers the biggest field of all. According to the 1951 census there are $2\frac{1}{10}$ million clerical workers in the U.K. This figure represented a 67% increase in this classification since the 1931 census. The *Economist*, commenting on these figures referred to "this monstrous growth of clerks and typists". In Stewarts and Lloyds, the following approximate figures may be of interest:—

Clerical Staff

	Men	*Women*
MAIN OFFICES		
Glasgow	250	250
Birmingham	250	250
London Area	40	100
WORKS		
Scottish Group	300	200
Birmingham Area	300	200
Corby Area (incl. Bilston)	500	350
South Wales	200	100
	1,840	1,450

These figures exclude Stanton, Victaulic and Oxfordshire. Over the last five years the numbers have been rising until, as you can see, the total is about 3,300—or, in money, over £$1\frac{1}{2}$ million annually in salaries alone.

The features and characteristics of clerical work differ significantly from scientific calculation. Unlike the latter, clerical work usually involves a relatively small amount of calculation on each piece of data, but the quantity of input data is very large. So is the output—which also has usually to be presented in a particular printed form. It will be remembered that these were the two points at which computers tend to be the weakest. Clerical work is not only characterised by the large input and output requirements compared with the calculating volume, but also by the general need to perform work to a tight schedule. This again is a difference from scientific calculation. A payroll routine is, of course, the classic example. Here the consequences of failure would be serious rather than inconvenient. Therefore, the degree of machine dependability (as distinct from reliability or accuracy) must be higher. Alternatively, enough reserve time must be in hand on the computer to cope with the expected down time.

But computation is *not* the sole problem in clerical work. Doing arithmetic is obviously a very important operation but there are others. For example, the selection of a particular item of information. Before posting an invoice total to a customer's personal ledger account, that particular account has to be found among a large group of customers. Next is the problem of sorting information. On a payroll job, two main documents may be needed to prepare the gross wage for a batch of employees. One document may be the individual clock card showing time, and the other a bonus statement. It is plainly desirable to sort the clock cards into the same sequence of names as the bonus statement. This example also serves to illustrate the need for comparing items. After sorting, each clock number has to be checked to see that it agrees with the next one on the bonus statement. Finally, not only have the results of clerical operations to be arranged in the form suitable for subsequent action or for the convenience of customers, but much information has to be stored for long periods—either for reference or for repetition of the procedure at some future date.

Ideally, all these facilities should be provided by an automatic calculator. Usually, the arithmetic capabilities are more than adequate and the rapid development of magnetic tape or film is about to provide a reasonably cheap and fast method of external storage and reference. All computers have the facility to sort, select and check but that facility is restricted by the capacity of the internal storage. On HEC4, the Hollerith Computer, this storage is severely limited. On Elliott's 403, it is 16 times as large. A great deal will depend on the particular problem being considered.

Summing up, I think it can be fairly said that although individual problems may be difficult to solve and individual computers limited in application, there is no fundamental reason why clerical work should not be done by a suitable and reliable automatic calculator. If these machines do not belie their early promise, their possibilities are immense, but I think it might be said here that their use in any large company is not necessarily a revolutionary step. As you know, Stewarts and Lloyds were among the very early users of Hollerith for a specific accounting job: similarly we were among the first to employ a country-wide network of private telephone and teleprinter lines. Each of these services in their own way implied a forward-looking attitude on the part of management. I suggest that employing a computer may be little more revolutionary than these. It is largely a matter of degree—a big jump but not necessarily a revolutionary one. Obviously there must be a sufficient field of work and this is one aspect I should like to touch on for a moment.

ECONOMICS OF COMPUTERS APPLIED TO CLERICAL WORK

There is only one digital computer in the U.K. which was built for, and is largely confined to, clerical work. That is LEO, the Lyons electronic office, built by J. Lyons & Co. of Cadby Hall. LEO also does scientific work at £75 per machine hour if you wish it. According to its makers, LEO is now an out of date machine. Its cost was high—somewhere between £100,000 and £150,000. The new LEO will sell at about £65,000. But this is a high priced computer compared with other equipment now, or about to be, available in this country. The list which has been issued shows the prospective range of equipment. As you can see, prices range from below £10,000 up to £65,000.

There are two essential pre-requisites for clerical work to be suitable for automatic calculators:—

(*a*) the basic information must be capable of pre-determination (i.e. *ad hoc* judgments and decisions are eliminated or insignificant).

(*b*) there must be an adequate volume of work:—

(*i*) on any particular procedure. That is, the procedure should be recurrent, otherwise programming costs outweigh the machine advantages.

(*ii*) at any particular time. It would not be worth while feeding the programme if the amount to be done was small. This implies the accumulation of data and feeding it to the machine in batches.

If we assume that the capital cost of any computer had to be recovered in, say, 3 years, then on an installation costing £25,000 we should need to make a clerical saving of about £10,000 per year—or roughly 20/25 clerks. On a LEO the saving might have to be in the order of 60 to 70 clerks. Savings of this magnitude imply a pretty substantial clerical centre or the centralisation of scattered functions. However, if we are prepared to recover over a longer period or *to use the machine to provide information which was not otherwise obtainable*, then the number of clerks displaced could be less.

At first I was rather of the opinion that savings on the smaller machines (if we can talk so flippantly about £20,000 or so) were likely to be marginal. However, Plessey (No. 7 on the list) whose payroll at Ilford is roughly of the same order as Corby and whose existing methods resemble ours, reckon to save 35 to 40 clerks on preparing it—using a computer which will eventually market at about £10,000 to £15,000. This means a recovery of capital cost in roughly one year—and the computer only being used two days a week. Such savings, if realised, are quite obviously anything but marginal. Probably on any large size computer, shift work would have to be regarded as sensible—although it doesn't necessarily follow that it would be an uneconomic proposition if worked on single shift only.

In considering the economics, the emphasis has been placed on clerical work because it is a permanent commitment and one which absorbs a large number of staff at a continually rising cost. Furthermore, clerks are a scarce commodity. It can also be argued that there is a moral as well as a financial need to transfer routine, semi-skilled clerical work on to fully automatic machines. In addition, we must not overlook the use of a computer for statistical information not previously available because of the costs of production.

THE EFFECTS ON STAFF

In any large office there is a great deal of clerical work which is repetitive and semi-skilled. Where this work is being done to *further* the procedure (e.g. extending an invoice as distinct from punching a card from it), then it is in this field that computers will make the greatest savings. As has already been suggested, the *preparation* of the data will be a continuing commitment until such time as common language machines can be installed at points of original entry. The planners and programmers will, of course, be an extra commitment. Such work will probably introduce a type of clerical worker who does not now exist in precisely this form. Data-processing workers will undoubtedly be reduced, but printing output and reference demands will still call for clerks. Above all, if the machines are to be used to provide additional information for management control, interpretation of the figures will be needed.

It seems possible, therefore, that if there is a reasonably extensive use of computers we may find:—

(*a*) that a number of clerks will have more extensive and more skilful jobs —assuming that programmers and interpreters of machine results are to be drawn from existing staff.

(*b*) data-preparation and presentation will continue to employ a number of workers similar to the punched card and keyboard operators of to-day. This requirement may only be temporary depending on the speed of technical development.

(*c*) the desk calculator machine operator as well as the routine clerk who only exercises limited judgment will be superseded by the machine.

SUMMING UP

In conclusion, actual experience in the U.K. of applying digital automatic calculators to clerical work is limited. But such work as has been done by J. Lyons & Co. (i.e. payroll for 10,000 workers and the provisioning of tea shops in London area), as well as authenticated information from the U.S.A., points unmistakably to the conclusion that clerical work *can* be effectively dealt with by such equipment.

In a large manufacturing organisation like our own, there may be a demand for scientific calculation which, although not sufficiently in itself to justify the purchase of a computer, might profitably employ one bought primarily for clerical work. In this connection, it might be considered desirable to buy time on one of the existing scientific computers as a means of finding out what features might be needed and to test whether the type of scientific calculation we have can effectively be dealt with.

Savings in staff, or alternatively, the ability to provide information which was previously not obtainable for management, are *likely* to be substantial. Furthermore, the deterioration so prevalent in clerical routines not primarily automatic may largely be avoided.

Precise information of requirements and a thorough analysis of existing practices, will be essential preparatory steps to computer operation. It will also be vital to ensure that basic information which is to be fed to the machine is accurate and timely, and more attention may have to be paid to ensuring that this is so.

There may have to be a change in attitude by the users of information. If the best use is to be made of automatic calculators, emphasis on control by exception will be needed. It is pointless using a computer as a high-cost printer—it can be programmed to point to the exceptional item while ignoring (from the output point of view) run-of-the-mill routine results.

Possible applications for a computer might be a large payroll, sales accounting and analysis, stock control, invoicing, and even works programming and machine loading. However, it should be borne in mind that the purchase of a large computer might inevitably lead to a concentration of functions and all that that implies.

Finally, consideration of equipment like this from the technical and methods viewpoint must go hand in hand with a consideration of the effect that it will have on the type of staff now being employed or which may have to be recruited.

APPENDIX "A"

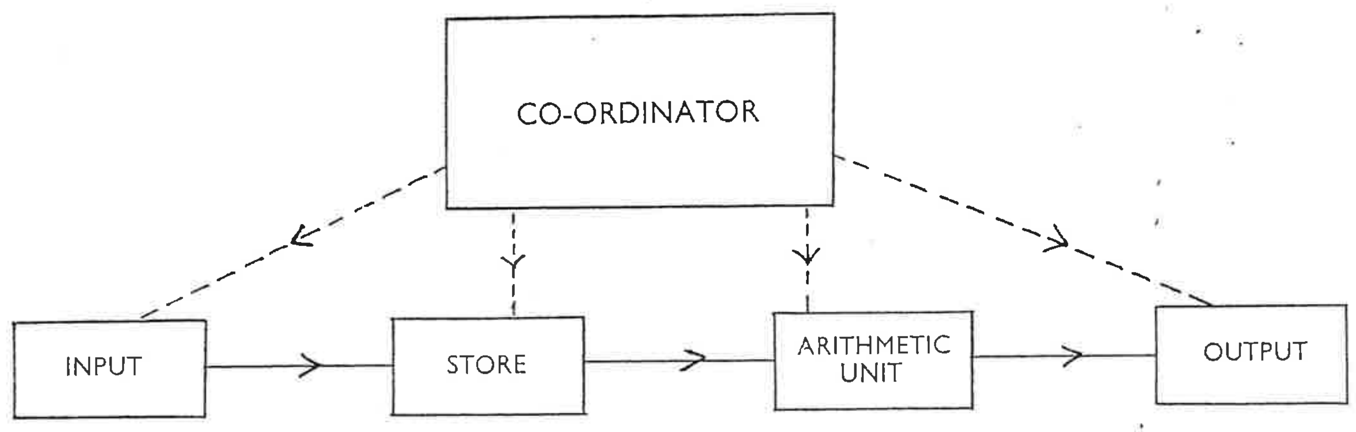
SIMPLIFIED STATEMENT OF ELECTRONIC DIGITAL COMPUTER AVAILABLE, OR LIKELY TO BE AVAILABLE SHORTLY, IN THE U.K.

No.	*Company*	*Name of Equipment*	*Approximate Price*	*Type*	*Remarks*
1	Brit. Tab. Machine (Hollerith)	HEC 4	£25,000	Clerical	First machine going to Morgan Crucible autumn this year. Others on order.
2	Elliott Bros. (Lewisham).	1. 402	£25,000	Scientific	Several in use.
		2. 403	—	Scientific	First going to Australia this year.
		3. 405	£30,000	Universal	Available middle of 1956.
3	English Electric.	DEUCE	£50,000	Universal	First model recently produced.
4	Ferranti	PEGASUS	£35,000	Universal	Prototype ready in July, 1955.
5	I.B.M.	1. 626	£1,400 a year (say £7,000 capital cost).	Clerical	Development from a mechanical calculator. In use at Goodyear Tyre and Coventry Corpn.
		2. 604	£3,000 a year (say £15,000 capital cost).	Clerical	Only one in use; Nielsen's of Oxford (Market Research). *Note*: I.B.M. have a wide range so far only available in U.S.A.
6	J. Lyons & Co. (LEO Computers)	LEO	£65,000	Universal	Prototype of LEO II functioning this year.
7	Plessey Co. (Ilford).	PEP	£10/15,000	Clerical	Being built for Plessey's own payroll. Operating in July/August 55. Will be subsequently marketed.
8	Powers-Samas	PCC	£13/15,000	Clerical	First model to be on show April/May 1955. Stated to be 60 on order (including Steel Company of Wales).

NOTE: In addition to the above Companies, BURROUGHS, NATIONAL CASH REGISTER CO. and REMINGTON-RAND are in the field but their equipment is, so far, only available in U.S.A. Other companies like UNDERWOOD and E.M.I. are "interested", but actual equipment seems to be a long way off.

APPENDIX "B"

DIAGRAMMATIC REPRESENTATION OF A COMPUTER

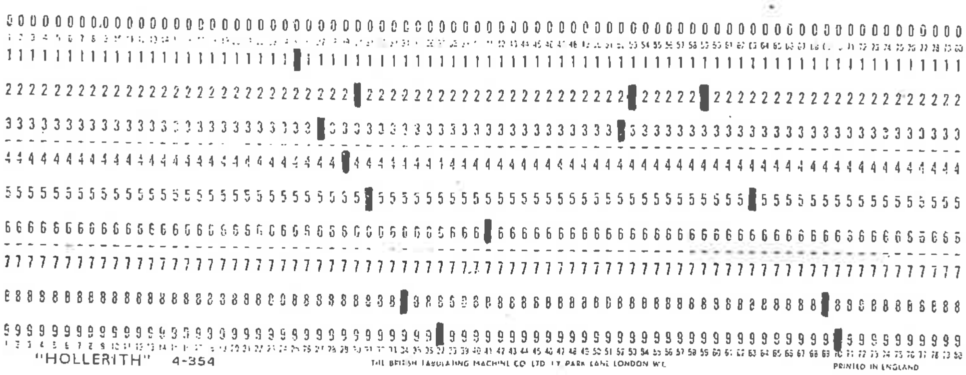


APPENDIX "C"

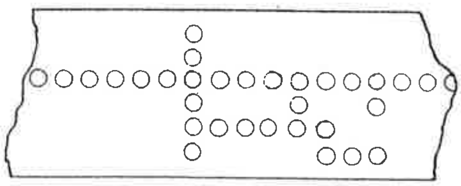
THE INPUT FUNCTION

SOLUTION TO THE PROBLEM OF TURNING TYPEWRITTEN OR MANUSCRIPT DATA INTO A FORM ACCEPTABLE TO THE COMPUTER

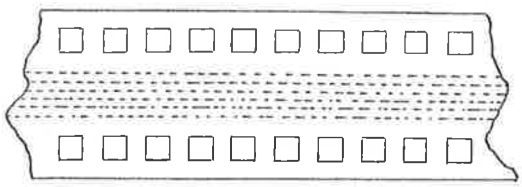
PUNCHED CARDS



PUNCHED PAPER TAPE



MAGNETIC TAPE



KEYBOARD

AS ON A TYPEWRITER OR KEYBOARD ACCOUNTING MACHINE

SIMILAR MEDIA CAN BE USED FOR OUTPUT