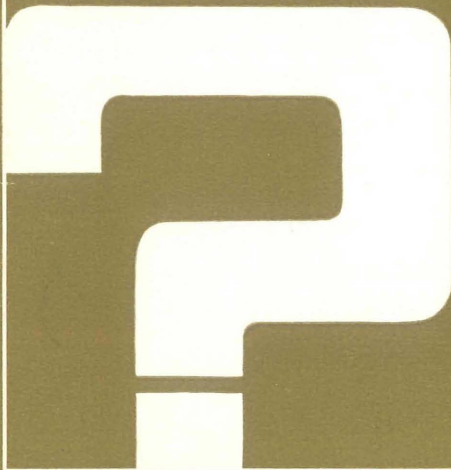# Elliott-Automation Computers Limited

Computer Concepts

Digital Computers

What they are

How they work

What they do

The arrival of the electronic computer has been hailed as the second industrial revolution. Already it is beginning to reach into every corner of commerce and industry and there are few who will eventually remain untouched by the profound and fundamental changes which this new era must bring.

To meet this challenge new methods of management will be required and new skills learned, while old habits are forgotten and the luxury of conventional thinking is discarded. There is a saying, "You cannot use yesterday's tools today and expect to be in business tomorrow". Yet to many the computer remains shrouded in mystery, an electronic wonder beyond the understanding of ordinary people.

Nothing could be farther from the truth. For although the electronic computer is a highly complex machine, its basic operating principles are essentially simple and well within the grasp of anyone capable of understanding the processes of logical thought.

It is not, of course, necessary to know how computers work to use them. This booklet is produced nevertheless in the belief that knowledge is the greatest enemy of suspicion and that change can best be achieved through understanding. It will not, on its own, turn you into a computer expert. But if it helps to clear away a little of the mystique so often associated with electronic computers, then its aim will have been fulfilled.

Elliott-Automation Computers Ltd

What is an Electronic Computer?

Computing devices are not, of course, new. In fact, even if one leaves out the abacus, calculating machines are still several hundred years old. In the past these have all been basically mechanical or electro-mechanical in operation, and although they have been developed to a high degree of sophistication, certain limitations are inherent in their mechanical construction.

Contrast this with a machine using electronic signals as the computing medium, moving at the speed of light yet precisely controlled by human instruction and entirely free from the limitations of conventional mechanics. Add to this the ability to store vast quantities of information and the facility, once instructed, to make logical decisions without further outside intervention. This is the digital computer, a machine which can be used to carry out complex operations which would normally require the application of human intelligence.

The Elliott 903 – *a modern desk size computer, low in initial cost, compact and easy to use, this system has opened up a new level of application within the smaller organisation and individual department.*

Today computers are making vital contributions in fields as diverse as agriculture and space research. They are a powerful tool for management, with an insatiable appetite for facts and figures and the ability to pinpoint critical trends and events in time for corrective action to be taken.

They are an indispensable aid to the engineer and scientist, releasing them from the burden of routine calculation to perform their true creative function. They enable work of such complexity to be undertaken that whole new fields of technology have been opened up.

In commerce, too, computers are taking over from time-honoured methods of data processing, which, however efficient in their day, now represent a bygone age.

And, of course, computers are at the heart of true automation, taking over full control of complex industrial systems, even complete factories.

Clearly, the computer is a device with enormous potential, the full implications of which are even now only beginning to be appreciated. Yet basically the computer is a machine which can add, subtract, multiply and divide. *It can do nothing more.*

Programming

Before any computer can be put to work it must be given a set of instructions known as a program. These instructions can be represented inside the computer, together with the data on which they operate, as a series of numbers. The purpose of the program is to break down a problem into relatively simple and logical steps which can be carried out by the computer. The way this is done can best be illustrated by means of a simple example:

PROBLEM: Convert a sum of money given in pence into £ s. d.

| divide total pence by 240 | ▶ | determine remainder | ▶ | divide remainder by 12 | ▶ | determine remainder | ▶ | write out £ s. d. |

Provided a problem can be broken down in this way it can be 'programmed' for solution by a computer. In practice, a skilled programmer can break down almost any problem into steps of this kind.

The task of programming has been greatly simplified in recent years by the introduction of 'user oriented' programming languages which enable programs to be written in a mixture of plain English and conventional mathematical notation. Thus, the problem previously considered, when

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written in an international computer language called ALGOL would look like this:

```
begin integer pounds, shillings, pence;
read pence;
pounds: =   pence div 240;
pence: =   pence − pounds × 240;
shillings: =   pence div 12;
pence: =   pence − shillings × 12;
print pounds, sameline, digits (4), shillings, pence
end;
```

Languages like this enable a far wider range of users direct access to the computer. Engineers, scientists, teachers and so on can easily write their own programs, or alternatively are able to discuss their problems with the programming expert in a mutually understood language.

Using languages of this kind, people with no previous computer experience at all are taught by the Elliott Educational Department to write their own programs in only three days. Details of these and other Elliott courses are given at the end of this booklet.

Binary Arithmetic

The electronic signals with which a computer works are generated within the machine itself. These could theoretically be put to work using the ordinary decimal numbering system which is universally used to carry out the calculations of everyday life. But for reasons which will become apparent later, there are important advantages to be gained by designing computers to work with a *binary* arithmetic system, and in order to look any further into the working of these machines it is necessary to know something about this system. There is nothing very difficult about it.

The conventional decimal system uses an 'alphabet' of ten different characters. The precise value of each character depends on the column in which it is placed, increasing by a factor of ten for each column it is displaced to the left, and vice versa. Thus, the figure 5 has a value of five in the 'units' column, fifty in the adjacent left-hand column and so on.

The binary system, on the other hand, uses only two symbols: 1 and 0. As in the decimal system the value of the symbol 1 depends on the column in which it is placed, but unlike the decimal 1 its value *doubles* for each column it is shifted to the left. The 0 is used simply as a convenient method of marking off empty columns and has no numerical value.

The way the system works can best be seen from the following table. The unit value of each column is indicated at the top.

decimal number				binary number										
10^3	10^2	10^1	10^0	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
			1	0	0	0	0	0	0	0	0	0	0	1
			2	0	0	0	0	0	0	0	0	0	1	0
			3	0	0	0	0	0	0	0	0	0	1	1
			4	0	0	0	0	0	0	0	0	1	0	0
			5	0	0	0	0	0	0	0	0	1	0	1
		1	0	0	0	0	0	0	0	0	1	0	1	0
	1	0	0	0	0	0	0	1	1	0	0	1	0	0
1	5	9	6	1	1	0	0	0	1	1	1	1	0	0

Arithmetic rules are basically the same for both binary and decimal systems. But in the binary system the most complicated step in addition or subtraction is to add or subtract one and one. This is discussed in greater detail elsewhere, when the arithmetic circuits of the computer are described. The important thing to note at this stage is that any number can be represented in the binary system using only two symbols. These can be simply represented in the computer by two voltage levels acting as signals to the various circuits involved.

binary number	representation							voltage level
	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
1	—	—	—	—	—	—	‾	+/0
10	—	—	—	—	—	‾	—	+/0
1010	—	—	—	‾	—	‾	—	+/0
1100100	‾	‾	—	—	‾	—	—	+/0

The Computer Input

The first step in putting a computer to work is to get the relevant data and instructions into the machine. There are several ways of doing this, each with particular advantages for certain areas of application.

The most direct method is by means of the control teleprinter (Fig. 1) with which most computers are equipped. This resembles an ordinary electric typewriter in appearance and is used in the same way. But in addition to the normal typewritten paper output, each time a key is pressed a pattern of coded electronic signals is generated and fed into the computer, representing the input information in the way previously described.
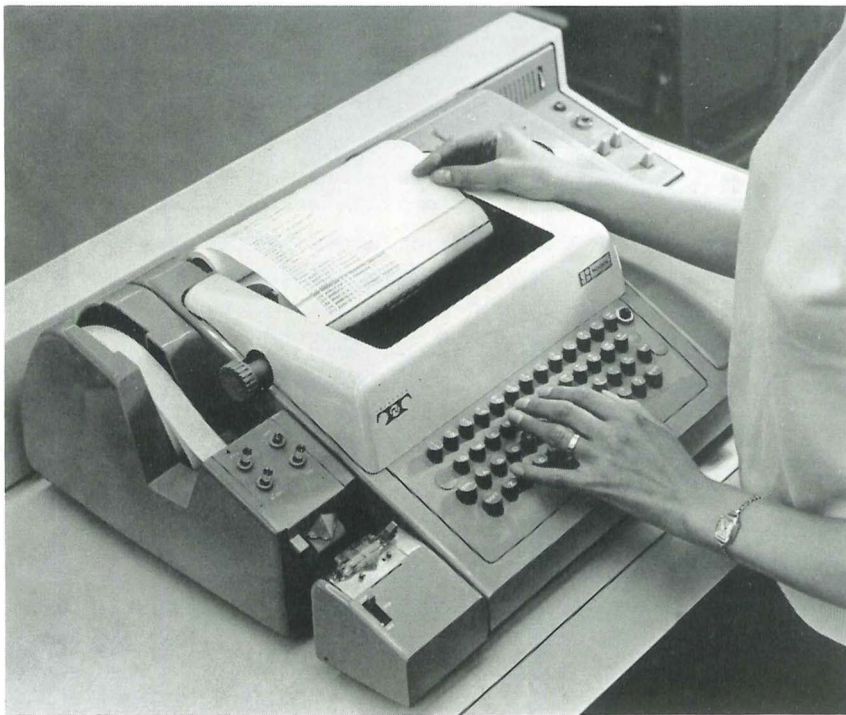
Fig. 1

Clearly the rate at which information can be input by this method is limited to conventional typing speeds which are far from sufficient to keep up with the enormous speed at which the computer can function. For this reason use of the control teleprinter is usually restricted to passing messages to the computer during a computation.

A faster method of input is by means of punched cards, similar to those which have been used for many years in commercial indexing systems

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(Fig. 2). By the operation of a keyboard, holes are punched in the card representing numbers (or letters) whose value depends on the position of the hole in the card. Using the binary system this presents no problem, the 1 and the 0 (the only characters used) being represented by a hole or no hole. Cards of this kind may be prepared in advance and kept until required. At this point they are loaded into a magazine and fed at high speed into a punched card reader (Fig. 3) which senses the pattern of the holes by optical or mechanical means and translates the information into a corresponding sequence of signals suitable for direct input to the computer. By this method information can be input to the computer at 400 to 1200 cards per minute.

Fig. 2

Fig. 3
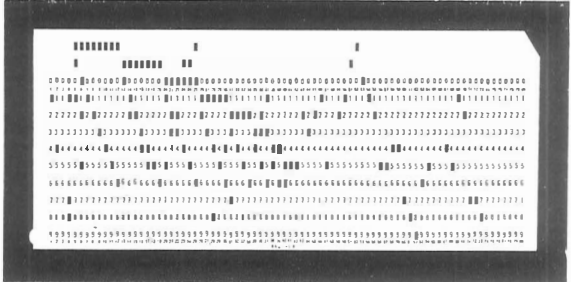
Punched card input is a commonly used method for commercial applications. There are several reasons for this choice. For one thing, punched card systems are often already in use when electronic data processing is first considered and the change-over can be made with minimum reorganisation. Secondly, in this kind of application it is often convenient to hold information on separate 'files' (cards), each perhaps relating to an individual customer-account or employee. The punched card system is an excellent method of achieving this and a further advantage is that it can be selectively updated without involving unaffected cards.
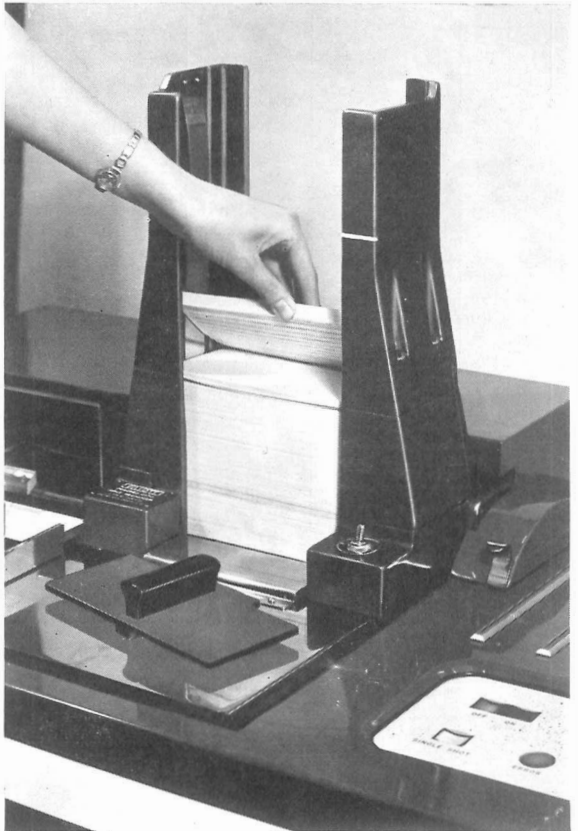
For scientific calculations the requirement is usually somewhat different. A single problem may involve a vast amount of data and a complex network of instructions which would have to be split up between a large number of punched cards.

For this reason a punched paper tape system of input is usually used for applications in the scientific field. The tape (Fig. 4) is prepared by the operation of a modified teleprinter.

As with the punched card, the information is coded by the positioning of the holes. When the tape has been prepared it is fed into a paper tape reader (Fig. 5) which optically reads the tape at up to 1,000 characters per second.
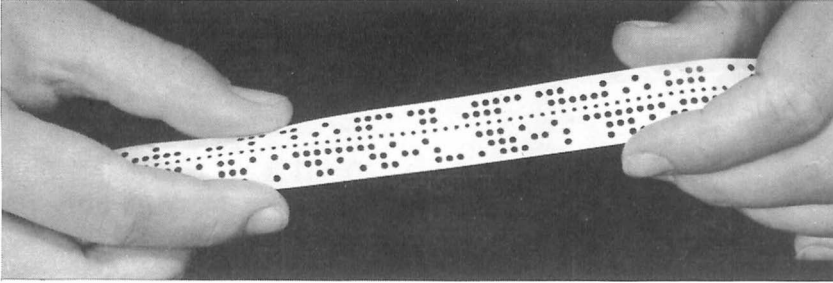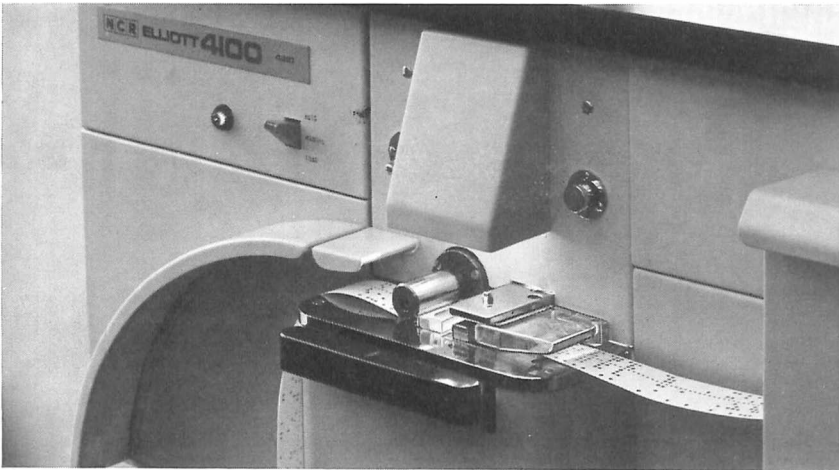

Fig. 4

Fig. 5

Computer memories

One of the computer's most powerful assets is its enormous speed of operation. A modern machine can complete an addition or subtraction in a few millionths of a second, and be instantly ready to proceed to the next stage of the calculation. Clearly, if information and instructions had to be fed in at each stage by human intervention, the process would be slowed to a degree which would make a nonsense of the whole concept of high-speed electronic computing. To avoid this difficulty, a method must be provided for the computer to store all the necessary instructions and information until required, when they must be instantly available to enable the problem to proceed to the next stage. This facility is provided by the computer's central memory, or store, which is normally accommodated in the central processor (Fig. 6) along with the arithmetic and control circuits.
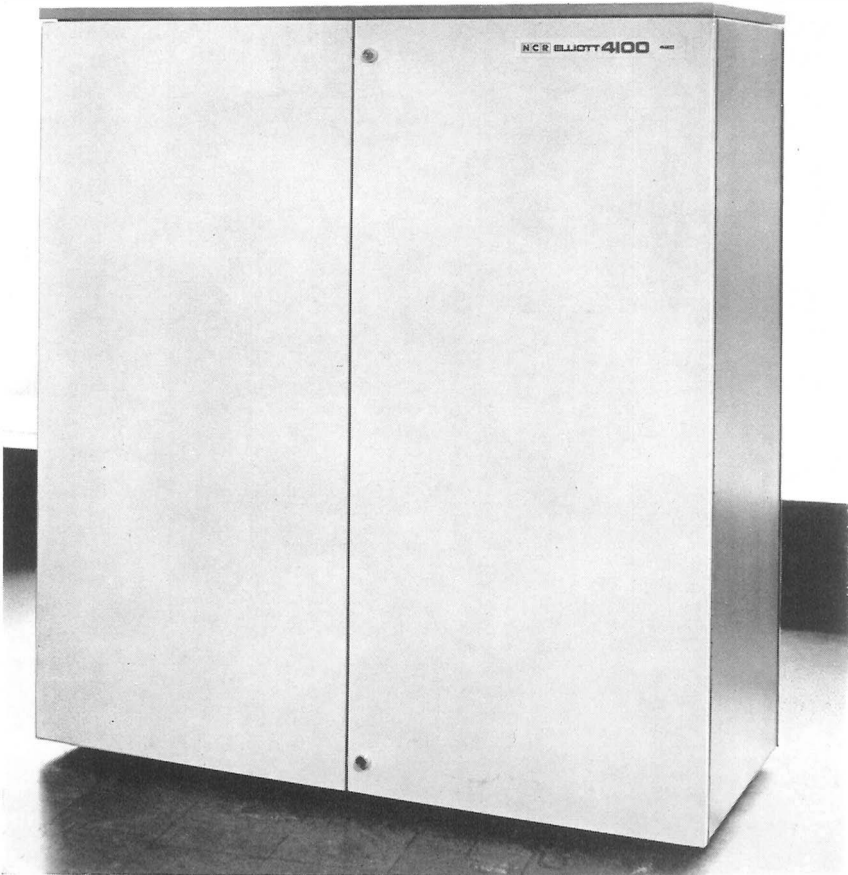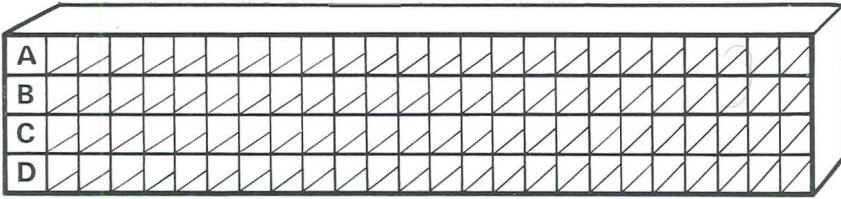

Fig. 6

Fig. 7

It is convenient to consider the store as a number of 'pigeon-holes' (Fig. 7), each with a separate address and with room to store a certain number of binary digits which together make up what is known as a computer WORD. In practice, the store would have many thousands of different locations each with its own unique address. Word lengths vary with different computers; in the Elliott 4100 system the word length is 24 binary digits (commonly called 'bits').
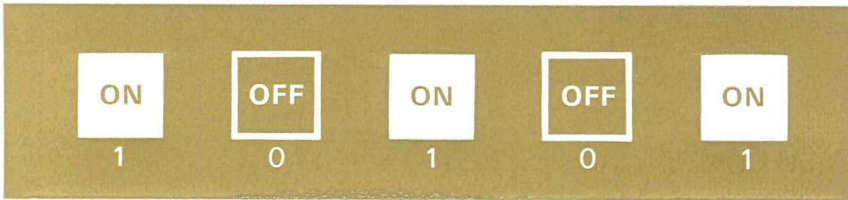

Fig. 8

Instructions and data input to the computer are directed into different locations. The contents of different locations can be selectively called out for use when required, as the program progresses. The time taken to retrieve information from the store is an important factor in determining the speed at which the computer can work. For this reason the central store is made to operate as fast as possible and is known as an immediate access store.

In practice immediate access stores take many forms. Thus, one may consist of a row of electronic switches, one for each digit (Fig. 8); ON represents 1, OFF represents 0. These switches contain no moving parts, of course, being controlled by changing voltages.
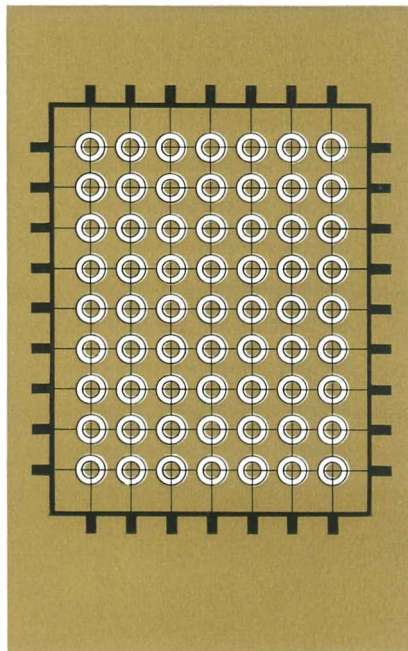

Fig. 9

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The most commonly used immediate access store in current practice is the ferrite core store. This uses a small ferrite ring (Fig. 9) with a diameter of only a few hundredths of an inch, to represent each bit. The ferrite rings are supported on a wire grid which enables each ring to be selectively magnetised in one of two directions by the passage of an electric current through the grid wires. Only if current passes coincidentally through *both* grid wires will the associated ring be affected. This property enables each ring to be selected according to its unique grid reference, or address. A third wire (not shown in diagram) running through all the rings in sequence, is used to sense the state of each ring.

To read the contents of a location a current is circulated through the grid and the magnetic polarity of each ferrite ring either remains the same or changes abruptly, according to its polarity at the time, i.e. whether it is in a 1 or 0 state. If there is a change in polarity the changing magnetic field induces a pulse in the output wire corresponding to a 1, while if there is no change, no pulse is induced indicating a 0.

The capacity of an immediate access store is often limited by cost and it frequently occurs that in dealing with work involving very large amounts of data there is not suffi-cient room to get it all into the store at once. In these circumstances sufficient information is put into the immediate access store to enable a particular stage of the calculation to be completed, while the remainder is placed in what is known as a back-ing or auxiliary store. When this data is needed it is called up by the computer and placed into the immediate access store, automatic-ally overwriting this in the process.

The backing store does not neces-sarily need the very high-speed access of the central store but is often required to store very large amounts of data indeed. It also enables information to be stored per-manently, an important requirement. One form of backing store which has been successfully used for many kinds of application is the magnetic drum (Fig. 10); this con-
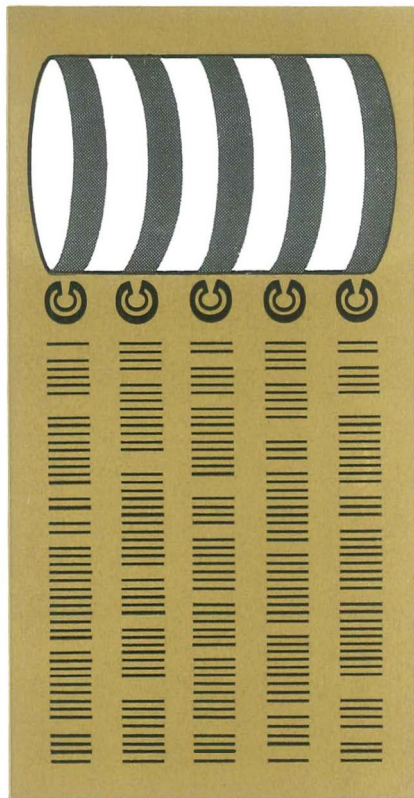
sists of a cylinder rotating at high speed. The surface is coated with magnetic oxide on to which the information is recorded in a manner similar to that of a normal tape recording. A magnetic spot represents a 1, no magnetic spot a 0. Each spot is recorded in a precise position on the drum. When needed, the recorded data is selectively read by means of read-write heads. A typical magnetic drum has an access time measured in a few thousandths of a second, depending on the speed of rotation.

A more commonly used form of the magnetic drum in current practice is the magnetic disc which can be changed like a gramophone record to allow reference to a different store of information. The Elliott Random Access Magnetic Disc Unit which uses this technique can store over 1 million characters on a single disc. Information is read or written either by the recording mechanism being swung into position like a gramophone arm, or by a number of read/write mechanisms being available, any one of which can be lowered to commence work. Essentially the selection of the area to be read or written is at the random selection of the user; this technique therefore comes under the broad heading of random access storage.

Using the same principle, magnetic recording tape can be used as a

Fig. 11

Fig. 12

backing store. A bank of magnetic tape units is shown in Fig. 11. Tape is wound from one reel to the other, passing under read-write heads in the process. It can store millions of characters on a single reel of tape, which may be several thousand feet in length. Data is thus recorded serially, and access time is relatively slow since the tape has to be wound on until the relevant data passes under the reading heads. In practice this is not usually of critical importance since the data can be arranged sequentially on the tape and called into the main store by the program before it is required.

One big advantage of tape stores is that the store can be 'cleared' without erasing the stored data simply by changing the reel of tape. A device which combines this facility *and* the random access facility of the magnetic drum is shown in Fig. 12. Known as CRAM (Card Random Access Memory) the device uses a file of 256 'cards' rather like stiff magnetic tape, each of which can be selectively called up by the computer. At this point the card is drawn on to a rotating drum and held in place by suction. When the card is no longer required it is automatically returned to the file. All 256 'cards' can be changed in a few seconds as shown in the photograph.

The Arithmetic Unit

In this section it is not intended to go into the electronics of the computer, but simply to look at the logic of its operation.

All mathematical problems capable of solution can be solved using the basic arithmetic steps of addition, subtraction, division and multiplication. Often, of course, the process can be speeded up by employing more advanced mathematical techniques but since the computer can work at extremely high speeds it can operate efficiently with basic arithmetic alone.

Indeed, since subtraction can be achieved by complement addition (which is explained elsewhere), and division and multiplication by a series of successive subtractions or additions, the computer can carry out all its mathematical work with just an adding facility alone. It is at this point that the basic simplicity of the electronic computer becomes apparent for, bearing in mind that the computer normally works in binary arithmetic, it can function effectively without ever performing a more complicated task than adding $1 + 1$.

Before looking at the way a computer circuit can be made to carry out the process of addition, consider first the requirements of such a circuit by means of the following simple example:

$$
\begin{array}{r}
1\ 0\ 1\ 1\ 0\ 1\ 1\ 1\ 0\ 1 \\
+\ 1\ 0\ 1\ 1\ 0\ 1\ 0\ 1\ 0\ 1 \\
\hline
1\ 0\ 1\ 1\ 0\ 1\ 1\ 0\ 0\ 1\ 0
\end{array}
$$

The binary figures are simply added up column by column and the possibilities involved can be summed up by the following simple rules:

1.
2. $0 + 1 = 1$
3. $1 + 1 = 0$ and carry 1 (to next digit position)
4. $1 + 1 + 1$ (carried) $= 1$ and carry 1

All these requirements can be met by applying the numbers to be processed to a network of electronic *gates*.

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One type of gate is shown diagram-
matically in Fig. 13. It is a two-input
OR gate which has the property of
producing an output signal in the
presence of an input signal on one
input or the other, but not in the
simultaneous presence of both. By
the convention already explained,
these signals represent the figure 1,
and from the diagram it can be seen
that the use of a single gate of this
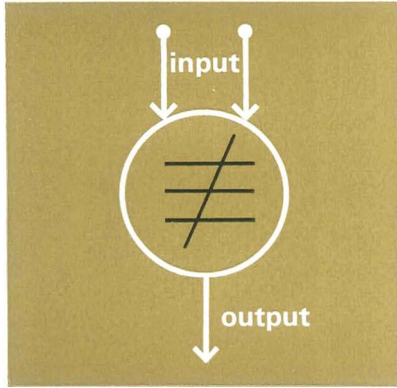kind gives the results:

Fig. 13

$$1 + 0 = 1; \ 0 + 0 = 0; \ 1 + 1 = 0$$

which satisfies conditions 1 and 2 but not 3 or 4.
However, if the gate just described is used in conjunction with a second
type of circuit known as a two-input AND gate, this overall network
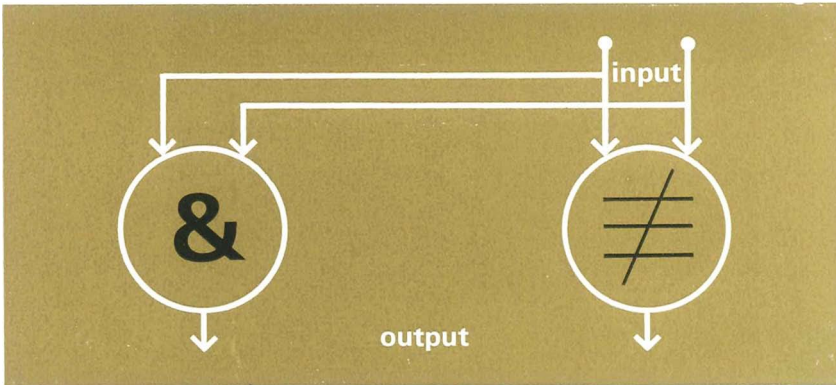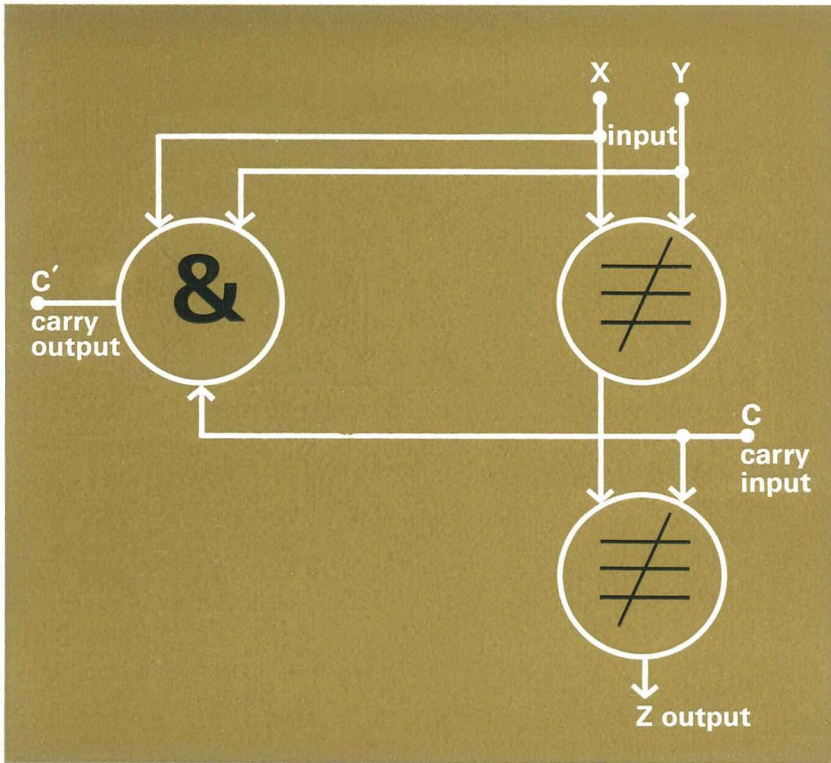(Fig. 14) can be made to satisfy condition 3.

Fig 14

The AND gate produces an output only in the simultaneous presence of a
signal on both input wires. In Fig. 14 the output of the AND gate
represents the carry pulse in condition 3. The OR gate functions in the
same way as in Fig. 13. In this new arrangement, it can be seen that:

$$0 + 0 = 0$$
$$0 + 1 = 1$$
$$1 + 1 = 0 \text{ and carry } 1$$

Fig. 15

X **Y**

input

C′
carry
output

&

C
carry
input

Z output

Fig. 16

It now only remains for condition 4 to be satisfied. The signal carried from the previous digit position is, in fact, introduced into the addition by adding it to the output from the OR gate in Fig. 14. Clearly the possibilities which now have to be considered at this point in the circuit correspond once again to conditions 1, 2 and 3. So to cope with them a further OR gate is used which acts in exactly the same way as that previously described. This is shown in Fig. 15. At the same time the AND gate is given an additional input to accommodate the carry signal from the adjacent digit position, and in this form it produces an output for

X	Y	C	C′	Z
0	0	0	0	0
1	0	0	0	1
0	1	0	0	1
1	1	0	1	0
1	0	1	1	0
0	1	1	1	0
0	0	1	0	1
1	1	1	1	1

any two or more inputs. Although this network may look relatively complex, it is, in fact, a simple matter to follow through the behaviour of each gate under the various possible input conditions and to build up a 'truth' table, as shown in Fig. 16.

There is a complete adding circuit of this kind for each binary digit, the total number depending on the length of the computer word. They are inter-connected as shown in Fig. 17.
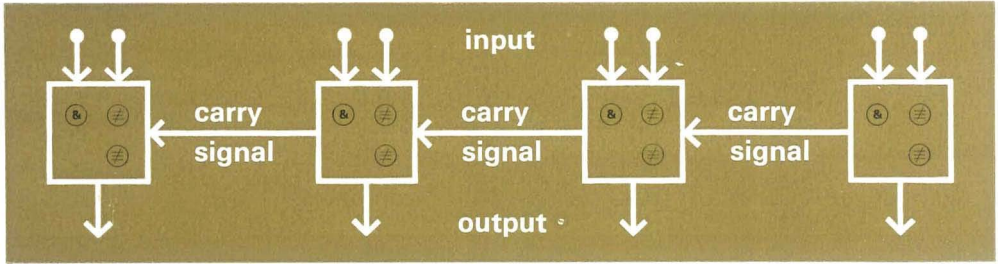
Subtraction

It can easily be shown that the subtraction of a number is the same as the addition of its complement. The complement of the number is obtained by subtracting it from zero. Thus, to find the complement of 1:

$$
\begin{array}{r}
0\ 0\ 0\ 0 \\
-\ 0\ 0\ 0\ 1 \\
\hline
9\ 9\ 9\ 9
\end{array}
$$

To put this rule to the test, consider the following example:

$$
\begin{array}{r}
1\ 6\ 4\ 9 \\
+\ 9\ 9\ 9\ 9 \\
\hline
1\ |\ 1\ 6\ 4\ 8
\end{array}
\qquad \text{is equivalent to} \qquad
\begin{array}{r}
1\ 6\ 4\ 9 \\
-\ 0\ 0\ 0\ 1 \\
\hline
1\ 6\ 4\ 8
\end{array}
$$

The computer, of course, works with binary numbers, but the same rule applies. Thus the complement of 0010110100 is 1101001100.

If these two numbers are compared digit by digit from the right hand end it can be seen that they are the same up to and including the first 1; thereafter a 1 in the number becomes a 0 in the complement and vice versa In fact, this applies generally to binary complements.

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Now, if *every* 0 and 1 are reversed in a binary number the result is known as a digital complement as distinct from the true complement. Digital complements can readily be produced in the computer.

These can be converted to true complements simply by adding 1 and a little consideration will show that this is a general rule. So subtraction can be carried out by *adding* the digital complement $+1$.

Multiplication and Division

In current practice special circuits are provided for multiplication and division to achieve the greatest possible operating speed. The computer is then said to have full hardware arithmetic facilities. However, this is not essential for, as already mentioned, these processes can be carried out by a series of successive additions or subtractions, and instructions can be given for this to take place in the computer program. It is not, therefore, necessary to examine multiplying and dividing circuits to understand how these operations are carried out. In any case the operation of these circuits is very similar to those already discussed.

Output devices

When all the necessary calculations have been carried out the results are placed in the computer's main store. At this stage, the program instructs the computer to output the required information.

There are a number of different ways in which this can be done. Often these are simply the reverse of certain input procedures. Thus, the control teleprinter can be used to type the output automatically, but this method is comparatively slow and can become a bottleneck in many applications. A faster method is to feed the computer output into a tape punch which records the results on punched paper tape identical to that used for input purposes. The output tape can be converted into legible type-matter by feeding it into a teleprinter. Several machines can be used simultaneously, if necessary, to cope with the output of a single computer system. Punched card techniques can be used in a similar manner, in conjunction with a card reader. The cards so produced can be kept if required and subsequently used for input purposes.

When a great deal of printed output is involved, a high speed line-printer can be used (Fig. 18). This prints a whole line of type-matter at

Fig. 18

a time at up to 1250 lines per minute. A line-printer is usually found in commercial installations and can be used to print customer invoices, stock records, pay slips and so on, at very high speed.

Often it is useful to have results presented in the form of a graph or diagram and in this case the computer can be connected to the Elliott Graphical Display which traces the image with a spot of light on the face of a cathode ray tube (Fig. 19). This device is especially useful in presenting dynamic information in 'real-time', i.e. as events actually occur. It can also be used as a combined input-output system in conjunction with a device known as a light pen, and in this combination it is a powerful aid to the design engineer. The computer can, for example, display on the screen an engineering drawing. Using the light pen the design engineer can then mark suggested amendments or additions on to the screen. The computer will then not only execute the required alterations but will also, if required, automatically analyse the implications of them.

The digital plotter can also provide a graphic output (Fig. 20). Both pen and paper move to trace out the relevant diagram or graph. A selection of plotter outputs which show the flexibility of this machine are shown in Fig. 21.

Fig. 19

This list of output devices is by no means exhaustive, and the range of different techniques available is constantly growing. It is sufficient, however, to illustrate that computer systems can be tailored to meet a very wide range of applications in many different fields.
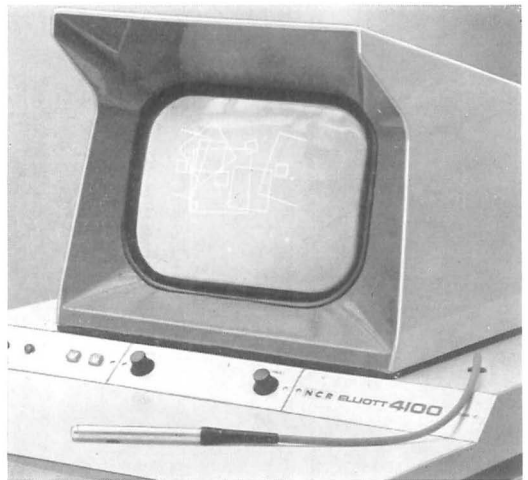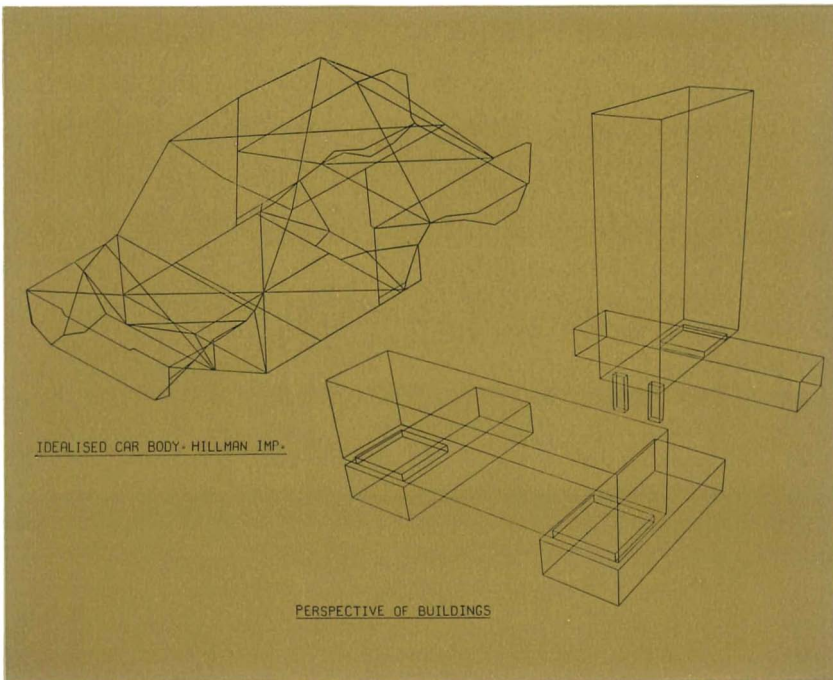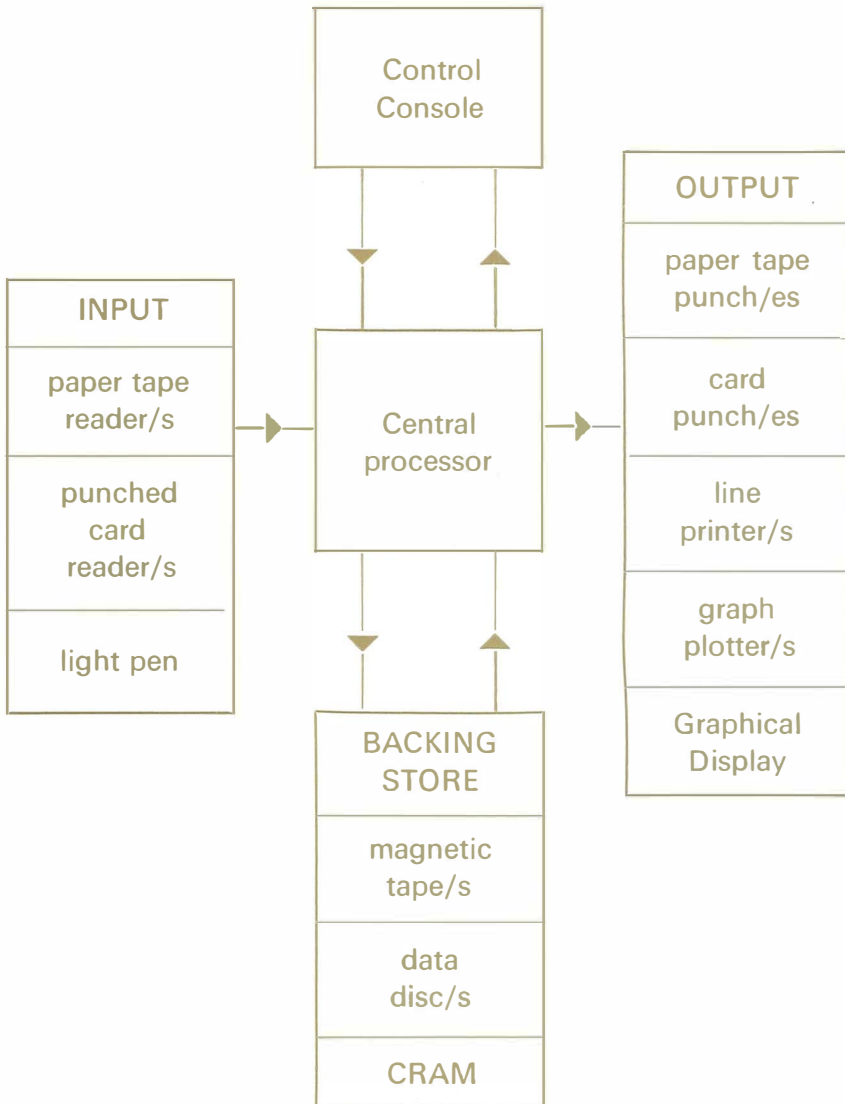
Fig. 20

Fig. 21
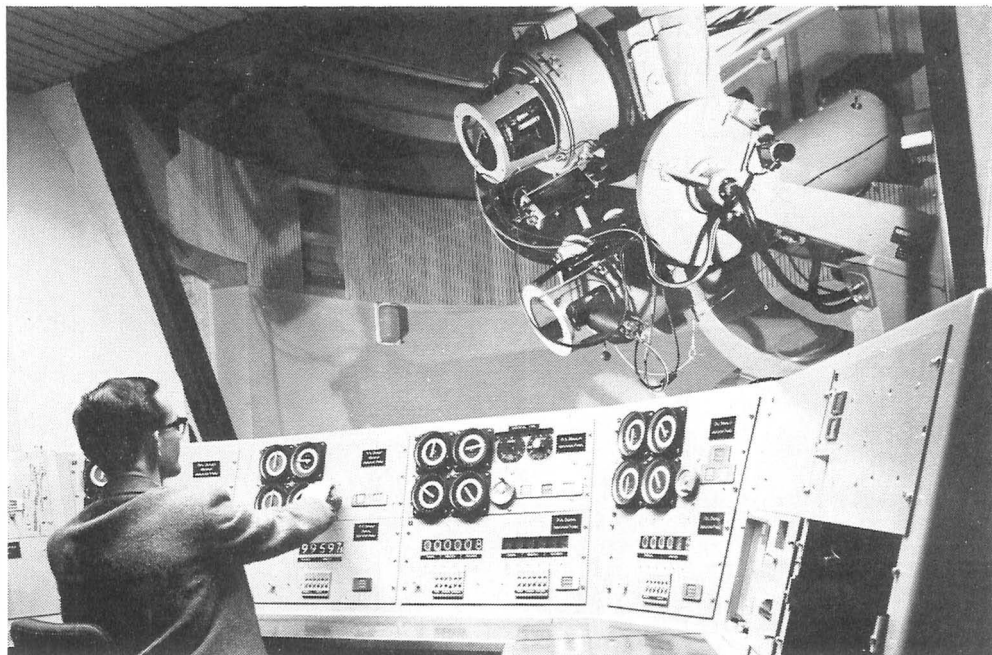
IDEALISED CAR BODY · HILLMAN IMP ·

PERSPECTIVE OF BUILDINGS

The Complete Data Processing System

Having described the various component parts which go to make up a computer installation, all that remains is to put them together to form a complete system as shown below.

```
                    ┌─────────────┐
                    │   Control   │
                    │   Console   │
                    └─────────────┘
                           │ ▲                    ┌─────────────────┐
                           ▼ │                    │     OUTPUT      │
                                                  ├─────────────────┤
┌─────────────┐     ┌─────────────┐               │   paper tape    │
│    INPUT     │     │             │               │    punch/es     │
├─────────────┤     │             │               ├─────────────────┤
│  paper tape  │ ──▶ │   Central   │ ──▶           │      card       │
│   reader/s   │     │  processor  │               │    punch/es     │
├─────────────┤     │             │               ├─────────────────┤
│   punched    │     │             │               │      line       │
│     card     │     └─────────────┘               │    printer/s    │
│   reader/s   │           │ ▲                     ├─────────────────┤
├─────────────┤           ▼ │                     │     graph       │
│  light pen   │                                  │    plotter/s    │
└─────────────┘     ┌─────────────┐               ├─────────────────┤
                    │   BACKING   │               │   Graphical     │
                    │    STORE    │               │    Display      │
                    ├─────────────┤               └─────────────────┘
                    │  magnetic   │
                    │   tape/s    │
                    ├─────────────┤
                    │    data     │
                    │   disc/s    │
                    ├─────────────┤
                    │    CRAM     │
                    └─────────────┘
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Three giant telescopes at the Royal Observatory, Edinburgh, are to be controlled by an NCR Elliott 4100 computer. When the scheme is fully implemented, the computer will decide whether the sky is clear, tell the telescopes which stars to observe, organise the taking of photographs and analyse the resulting data.


At the Westminster School, London, pupils use the 903 computer during a visit of the Elliott Mobile Computer Classroom. The classroom, which holds ten pupils, is available for hire by local education authorities and schools.
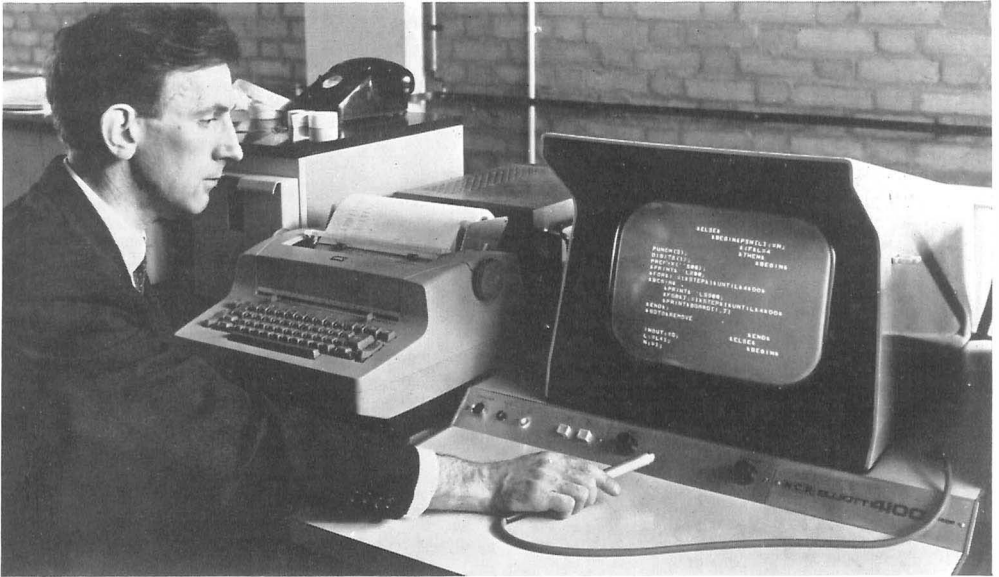
Using an NCR Elliott 4100 Computer with a graphical display and light pen equipment. The National Physical Laboratory is developing methods to aid the computer programmer by allowing programs to be written, tested and edited on-line to the computer.


Humphreys and Glasgow, Consulting Engineers, use their 4100 system on a wide range of design work in the chemical engineering field. It also enables the company to take advantage of the most modern computer-based management techniques.

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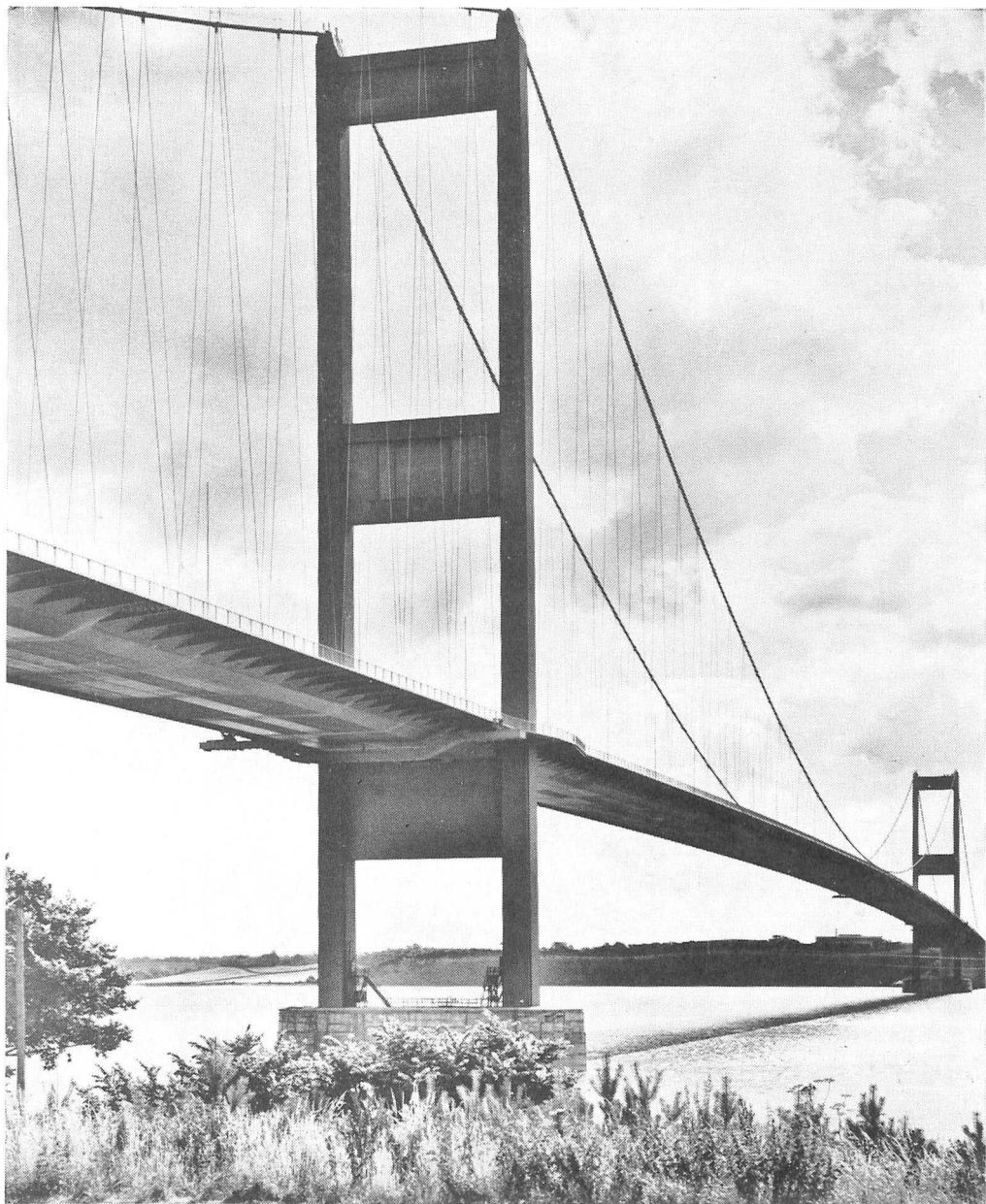
The Severn Bridge is equipped with the first computer-based toll system in Europe. The system, based on an Elliott ARCH 1000, has to record for each of ten channels the tolls paid by vehicles using the bridge. The charges levied vary according to the class of vehicle and the number of axles. In all there are seventeen classifications to be recorded for each of the ten lanes.

Far infra-red spectroscopy is an important technique for the investigation of a wide variety of chemical and physical problems. One of the most effective spectroscopic techniques in this region uses a Michelson interferometer in combination with a digital computer. The National Physical Laboratory has constructed this completely new design of interferomer which is connected on-line to an Elliott 903 computer.
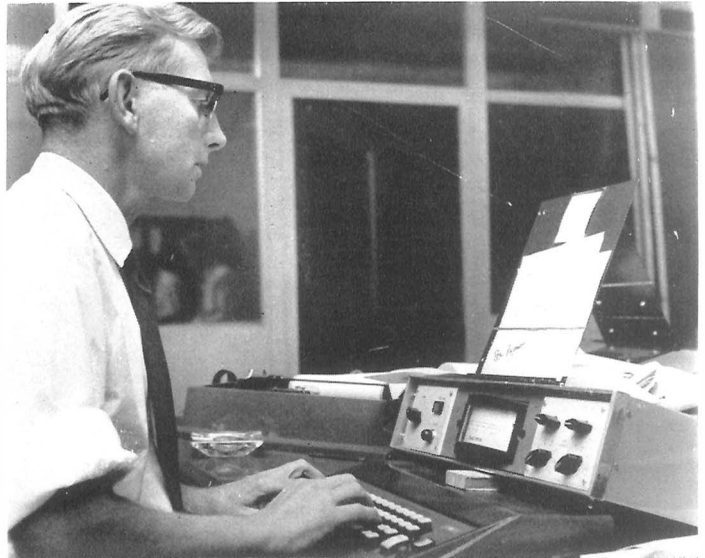
Published by the Thompson Organisation, the Reading Evening Post uses revolutionary new production methods including computer controlled typesetting. The Elliott-Thompson computer set system which carries out the work is based on Elliott 803 computer.
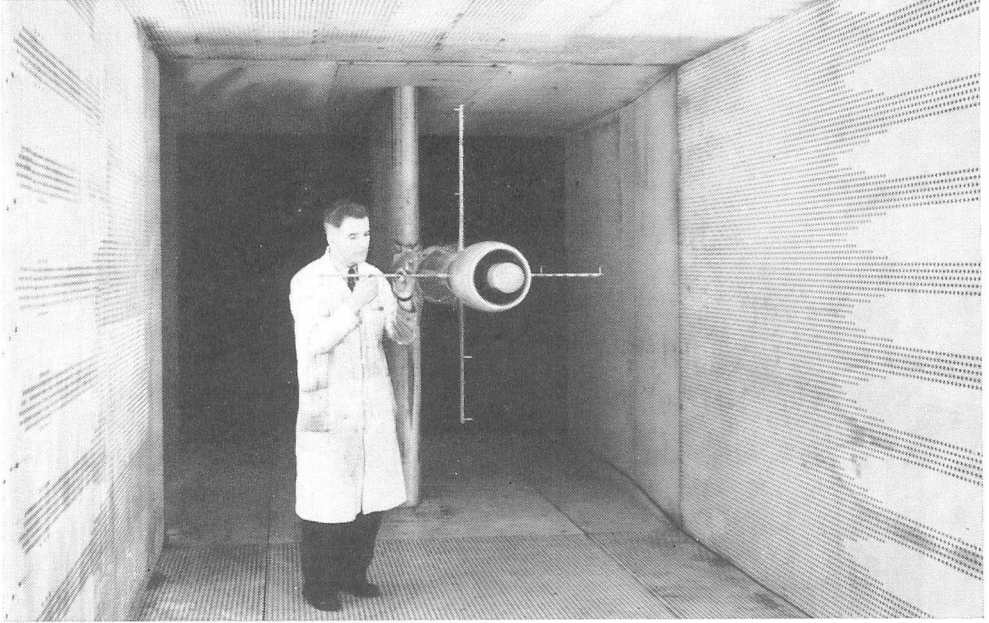
At the Bedford laboratories of the Aircraft Research Association, research is carried out into high speed flight at up to six times the speed of sound. These experiments are carried out in wind tunnels, tests often being continued over several days. The mass of complex data resulting from these tests is processed by an NCR Elliott 4100 data processing system.
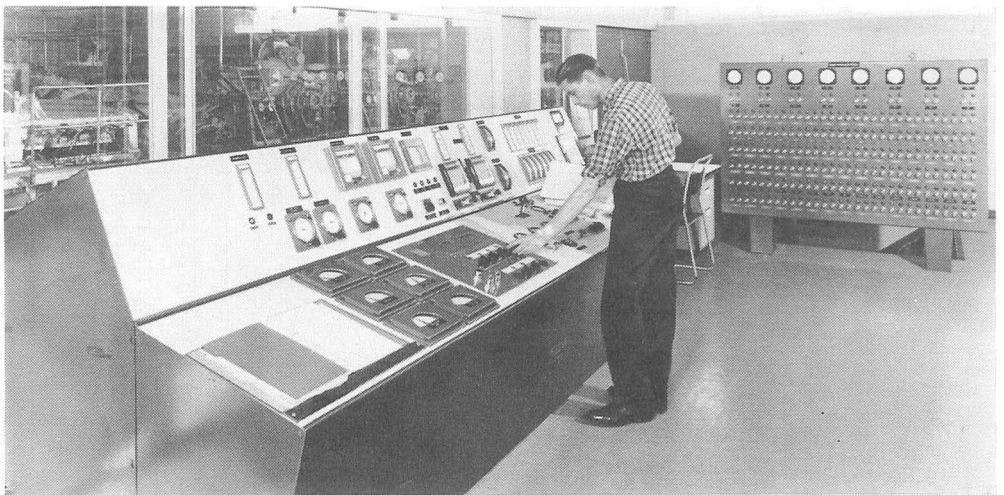
Paper has been made at Wolvercote Mill since the seventeenth century. Today it operates the world's first completely automatic computer control system in a paper mill. The system, which was supplied by Elliott Automation, affords a five per cent increase in output, and the whole cost of the project is expected to be recovered in the first two years.

Elliott Educational Courses

Elliott-Automation Computers Limited in conjunction with NCR provide a wide range of educational courses.
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Computer Appreciation courses for executives wishing to acquire a general knowledge of electronic data processing. These are designed for people knowing little or nothing about computers.

Programming courses. Both NCR and Elliott run courses designed to cover the particular requirements of commercial and scientific users.

Operators Training Courses. Available for users of NCR Elliott data processing systems, these cover all procedures for their efficient use.
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