ELECTRONIC COMPUTERS

AT AWRE ALDERMASTON

The I.B.M. 7030 STRETCH COMPUTER

A. E. Glennie

describes

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Educated at Aberdeen Grammar School and Edinburgh University where he graduated as an M.A. with 1st Class in Mathematics and natural Philosophy, Mr. Glennie first became interested in electronic computers in 1949. Since then he has worked with them in laboratories at Cambridge and Manchester Universities and at the Carnegie Institute of Technology in Pittsburg U.S.A. He came to Aldermaston in 1955.

ELECTRONIC Computers are a development of the last two decades. Although the concepts of automatic computing machines had been discovered more than a century ago, it was not until the techniques of electronics had been perfected that useful electronic computers could be constructed. Ten years ago, there were scarcely more than a dozen in use; now there are several thousand in the world, and the number is increasing very rapidly; in fact the production of computers has become an industry.

This very rapid growth has taken place because electronic computers satisfy a very real need. Just as the steam engine, the internal combustion engine, and the electric motor have replaced muscle power so can the electronic computer replace human labour in accounting and much of the other paperwork which is a feature of the modern world. They make it possible to do many things which would be impossibly expensive and slow by unassisted human labour, and were fostered to satisfy such a need in scientific research. The very first electronic computer was built, during the war, to calculate the trajectories of shells, in order to give range tables in gunnery-a very tedious business if done “by hand.”

The scientific calculations now done by electronic computers are usually not difficult for the trained mathematician but are so lengthy that few were willing to put up with the tedium; only a very few actually enjoyed this kind of work. To give an example, I was engaged, more than ten years ago in one calculation which took more than six months to complete. This was only one of a series of similar calculations which were required. Obviously the time involved prevented us from doing many; and now the fastest of modern electronic computers could do this job in a few minutes. Clearly when a computer does as much in an hour as a man could do in a lifetime, we can do much which was formerly impossible.

It may come as a surprise that calculations of this scale are undertaken. The reasons for making them are usually a matter of hard cash. Many modern industries are mainly based on scientific technology, on physics, and chemistry, and the design of the product or the process to produce the product is often understood quite well in theory-in a theory that can be expressed mathematically. Thus it is often possible to make a great deal of the design by mathematical prediction rather than by rule of thumb, and it is often much cheaper, especially when the design is very costly and a theory is available. In some cases, design can only be made mathematically.

Those organisations that possess electronic computers make such heavy use of them. that one suspects that this is another application of Parkinson’s Law-that work expands to fill the time available. Since electronic computers do not require holidays or sleep, the time available is 24 hours a day, seven days a week and usually most of this time is used. But then computers are very expensive and should not be idle.

There are two sorts of computer-analogue and digital computers respectively. We are concerned with digital computers, so called because they work with digital numbers which are numbers expressed by digits or figures. Decimal numbers, pounds, shillings and pence, and Roman numerals are all examples of digital numbers in different notations. Computers generally use binary numbers where the digits 0 and 1 only are used. The system works like the decimal system except that a carry is made into the next column when the sum of two digits is greater than 1. (In the decimal system a carry occurs if the sum of two digits is greater than 9). The system of binary numbers is preferred because of the simplicity of addition, subtraction, multiplication and division with it. For example the multiplication table is very simple 0 x 0=0, 0 x 1 =0; 1 x 1=1. This simplifies the construction of the computers very considerably. The following table shows how some numbers are represented in words, the decimal system and the binary system.

zero	0	0
one	1	1
two	2	10
three	3	11
four	4	100
thirteen	13	1101

An electronic computer has three main parts which are, a storage system, an arithmetic unit and a control system. The storage system (or store) is used to hold the numbers in the calculation and also to hold a set of rules by which the calculation is made. In most modern computers small rings of a magnetic material (a ferrite) are used to store the digits of numbers. They do this by their state of magnetism. The digit “1” is stored when the ring is magnetised round the ring in one direction: the digit “0” is stored by the ring being magnetised in the opposite direction. The digits are “read” or "written" by means of electric currents in wires which pass through the ring. A large computer may use more than a million of these rings, which are no more than a quarter of an inch in diameter. The wiring of the rings and the electronic circuits to which they are connected are so arranged that the set of digits forming a number can be got from the store all at once. The big computer at Aldermaston uses a number length with 36 binary digits and its store can contain more than 32,000 such numbers.

The store can be likened to a set of "pigeon holes" each of which contains one number and the particular "pigeon hole" is identified by a number called its address. When another part of the computer requires a number from the store, the address of the required number is sent to the store which then sends back a copy of the number stored in this address. The number is also retained in the store. Numbers may also be sent to the store to be remembered there, where they remain until altered or until the computer is switched off. The store works pretty quickly, taking two millionths of a second to issue or receive one number. It handles one number at a time.

Numbers are sent to and from the arithmetic unit where they may be added to, subtracted from, multiplied by or divided into a number already in the arithmetic unit. These arithmetical operations occur one at a time, one after another under the direction of the control unit which is obeying a set of rules which are also kept in the store. These rules are coded so that they may be stored as if they were numbers. Normally they are stored in neighbouring addresses and are "obeyed" in order. Such a set of rules is called a programme, an example of which might be:

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100    CLEAR
101    ADD      1023
102    ADD       567
103    STORE     901
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In this snatch of programming, the first column shows the store address in which the rule (or instruction) is stored. The instruction itself consists of a code specifying what operation (e.g. addition, subtraction, etc.), is to be performed and on what number. The number is specified by giving its address. The above programme, then, has 4 steps: it first clears out the arithmetic unit so that on the second step the number in address 1023 may be added to zero in the arithmetic unit. The third step then adds the number from address 567, after which the fourth step causes the result to be stored in address 901. Note that the instructions say where the numbers are to be found. Thus the second instruction does not cause the number 1023 to be added, but the number stored in the address 1023, whatever that number might be.

Normally, a computer obeys instructions from consecutive addresses as in the example but it must also be able to change to another sequence of instructions. This change from one sequence of instructions to another is called transfer of control and may be conditional, e.g., depending on whether a number is positive or negative. By such conditional transfers of control, the computer can be programmed to make different calculations according to the results it has already obtained. Such instructions allow the computer to make decisions.

The ability that a computer has of making decisions is supplemented by its ability to change its rules as the calculation progresses. This capability comes from the fact that the instructions themselves can be treated as numbers and modified by arithmetic. All this is possible because the instructions are coded as numbers and are stored as if they were numbers. This simple but fundamentally important idea of using the same storage system both for numbers and for instructions enables the programme to have rules for changing its rules and even rules for changing these rules and so on. The first electronic computer was built before this simple trick was applied, but every subsequent large electronic computer used it. This ability of the programme to modify itself is as fundamental, simple and important in this field as was the invention of the wheel in transport. As with the wheel it is not known exactly who devised it.

To complete the picture of the electronic computer, one must mention the printing devices required to print results and the input devices (such as punched card readers, paper tape readers, etc.) by which numbers and instructions are fed into the computer. Their action is controlled by instructions stored within the computer. Also of increasing importance is the use of magnetic tape recording. Many computers now are coupled to magnetic tape units and can record on and read from magnetic tape under control of computer instructions. By this means the amount of data under the control of the computer can be increased manyfold.

If you are interested in working with computers write for further details to:—

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