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(WITHOUT MUCH JARGON)

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ILLUSTRATING COMPUTERS

Colin Day read natural sciences at Cambridge, expecting to end up doing research in physics. Instead he found himself turned around and sent off to Vietnam to do three years of linguistic research and Bible translation. A three year Ph.D. course in general linguistics followed (in London), trying to sort out the grammar of a minor language of Vietnam. It was then that he discovered how computers can help reduce the drudgery of sifting through large quantities of information. A year or so in India and Nepal provided an opportunity to produce dictionaries by means of a computer in Bombay. Since 1967 he has been working in the Computer Centre at University College London, writing computer programs to handle letters and words rather than numbers.

Donald Alcock read engineering at Cambridge, then designed bridges in Africa and Canada. In 1957 he realised a computer could do bridge calculations quicker than he could, so went to an American university to learn how. He became an assistant professor of civil engineering but saw no future in teaching without a Ph.D. – and had not the wit or stamina at age thirty to go for one. Instead he joined Ferranti Limited and wrote engineering programs for antique computers (then shiny new) with names like Pegasus, Sirius and Atlas. Five years later he became founding partner of a technical computer consultancy – a firm that lasted fifteen years. He has now retired from the technical software business to see more of his family and write books and things.

PREFACE

This book is for those who want to know something about computers but have so far been put off by the jargon. The principles underlying computers are simple, however, and these we have tried to illustrate without assuming any previous knowledge of the subject.

Illustrating computers may be compared to sketching a building from a few essential vantage points. The sketches do not pick out every surface detail, nor do they illustrate the complete shape of the building, but they give a clear impression of it. The artist should not select unusual vantage points nor give a false sense of proportion by exaggerating perspective. The sketches in this book are intended to give a true impression for the layman to read. They are not for the computer expert – the already initiated – who would find deficiencies in our explanations and exceptions to our generalizations.

We wanted to give a bibliography for further reading but found it impossible to compile. It all depends which way the reader wants to go when finished with this book. The next step could be to visit a computer hobby shop – browse among books on the computer shelves of a book shop – subscribe to one of the glossy computer magazines – enroll on a course in computer science – seek an interview for a job with a computer company ...

Read this book first.

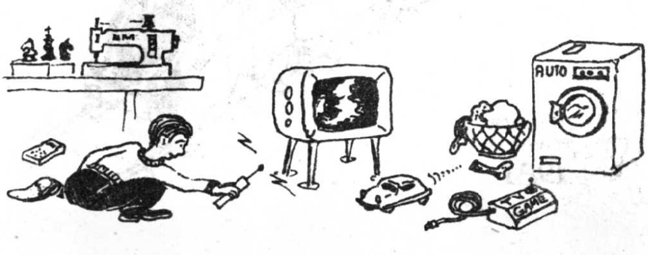
CONTENTS

1 WHY BOTHER ABOUT THEM?

(THE IMPORTANCE OF COMPUTERS)

Why bother about computers? Why not leave them to the elite who understand them?

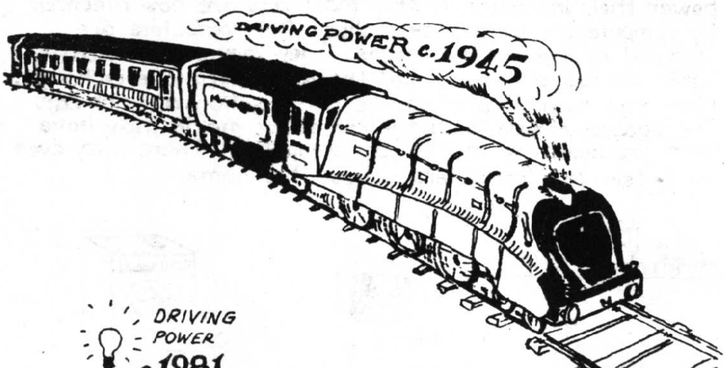
You cannot dismiss computers as easily as that. Their influence is spreading rapidly through our society. From supermarket checkout counters to the corridors of power their influence is felt. Most bills are now prepared by computers – so are wage slips. But computers are involved in less obvious areas. They may control traffic lights throughout town and the local telephone exchange. They may have controlled the construction of your car. The special effects in the latest space movie may have been produced by means of computers. There may even be a few tiny 'computers' about the home.



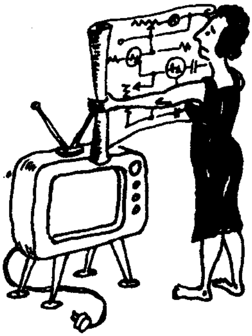
Why is it that computers are in such widespread use? This is mainly because of an enormous reduction in both the cost and the size of computers – coupled with their increasing power and flexibility. As a result the number of computers has increased and is increasing ever more rapidly.

The first completely electronic calculator (not *quite* a computer) was developed at the University of Pennsylvania in 1945 and was called ENIAC. By 1950 there were in the world 15 computers completed or being built. Thirty years on, the Computer Users' Yearbook for 1980 lists a total of 26,872 computers in the United Kingdom and Eire alone. However, this figure is for medium to large installations; the number of small computers must be far greater. Including the smallest – the 'microcomputers' – the total for the whole world must run to many millions.

It is now possible to buy a microcomputer at about the same price as a black and white television receiver. Such a microcomputer does arithmetic twenty times faster than ENIAC did, it has a larger memory and is thousands of times more reliable. It consumes the same power as an electric light bulb, whereas ENIAC needed enough power to drive a locomotive. ENIAC took up 30,000 times the space and cost 10,000 times as much as today's microcomputer.

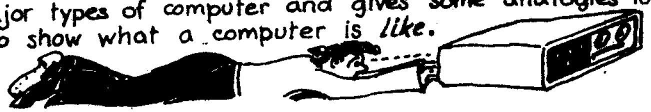


Because computers are rapidly getting cheaper and more easily available they are widely used, valued, respected – even feared. Computers work rapidly, tirelessly, obediently and (contrary to folklore) almost never make mistakes. They can do many things which have up to now been done by people. They can enable one person to do a task which used to take a dozen or more people (or would not be contemplated at all because of the labour involved). Some fear the widespread use of computers may cause more and more unemployment. There is all the more reason, therefore, for knowing what computers are like and what they can do. Only then may any potential threat be assessed objectively.



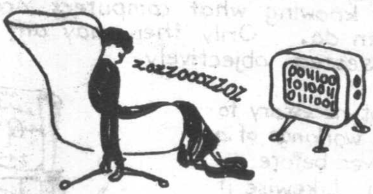
It is not necessary to understand the workings of a television receiver before switching it on. Likewise it is not necessary to know how a computer works in order to use one. This book explains the workings of a computer for two reasons: Firstly, people who may never have to operate a computer or write a computer program would nevertheless like to know how a bundle of electronic components can do what it is reported to do. Secondly, in order to appreciate the revolution these machines are causing it is as well to know something of how they are made and how they function. Only with this knowledge can one judge both the potential of computers and their limitations. Any mystery surrounding computers can be dispelled only by giving some explanation of the way they go about their work.

Computers are very different from everything else we know. It is hard to relate them to other things of which we have experience. Chapter 2 describes the major types of computer and gives some analogies to help show what a computer is *like*.



One aspect which makes computers unique is their ability to process information. That information is represented inside the computer using only the two numeric digits 0 and 1. This is not as limiting as it might seem. Chapter 3 shows how various types of information may be stored within a computer.

Instructions are also coded as 0's and 1's and stored in the computer's memory. Chapter 4 describes how such instructions are obeyed in sequence as a *program*.



It is hard to imagine how electronics can perform arithmetic such as adding two numbers. Chapter 5 provides a non-technical description of how this can be done.

The reduction in cost and size of computers has come about by the development of the *silicon chip* whose manufacture is revealed in Chapter 6.

If a computer is an 'electronic brain' it needs hands, eyes, ears and mouth to be able to respond. Chapter 7 reviews some of the devices that may be plugged into a computer as the equivalent of limbs to an animal.

If the instructions a computer has to obey are all strings of 0's and 1's one might suppose communication with the machine would be extremely difficult. As Chapter 8 shows, computers can be made to understand other languages besides their own.

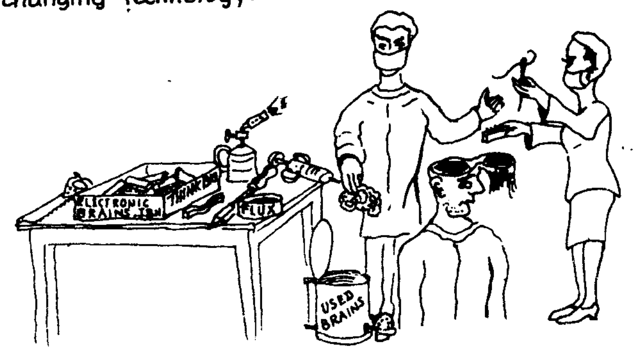
In order to give some idea of what it is like to write a program for a computer, Chapter 9 gives an example of a program written in one of the most common programming languages.

As computers have grown in size and complexity they have been given more responsibility for controlling their own work. The development of special programs called *operating systems* is sketched in Chapter 10.

The uses to which computers have been applied are so varied and numerous that Chapter 11 can give only a few examples to indicate areas in which computers are making their presence felt.

Although it is true that microcomputers differ from large machines in terms of size and cost (rather than any fundamental way of working) they are becoming so cheap and small that they may be used in ways never contemplated for their bigger cousins. Chapter 12 has therefore been specially devoted to 'micros'.

Everyone would like to know what lies ahead. The authors claim no prophetic foresight. In Chapter 13 we indicate some possible developments of this rapidly changing technology.

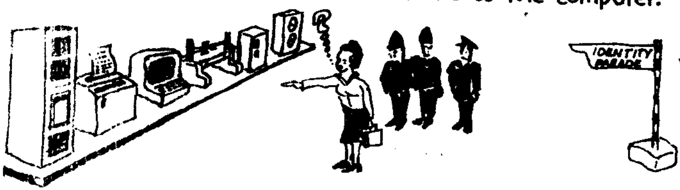


2 WHAT ARE THEY LIKE ?

(OVERALL CHARACTERISTICS)

The problem faced by most people when hearing about computers is to get a rough idea of *what they are like*. When we encounter a new machine we try to relate it to things we already know, giving it a place within our knowledge of the world. The difficulty with computers is that they are so different from everything else. In one sense they are like nothing else on Earth.

The physical appearance of computers is little or no help towards understanding them. Computers are mostly boxes with nothing much appearing to happen to them. When confronted with several boxes and other bits and pieces it's puzzling to know which one *is* the computer.



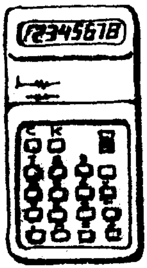
Seeing several computers is even more bewildering because they can look so different. Some fill a large room with their various boxes. Others may be desk-sized and perhaps desk-shaped. (This is roughly the kind called a *mini-computer*.) Yet other devices are the size of a typewriter. (These are commonly termed *microcomputers* or just *micros*.) So the physical appearance is not much help to people wanting to know what a computer is like.

The computer has been described as an 'electronic brain', but this can be misleading. Both the computer and the human brain can store information in a memory and process that information (by arithmetic for instance). But the way they do these things appears to be very different. A computer memorizes and recalls information almost instantaneously whereas the brain may take a number of repetitions to memorize. Recalling something may be agonizing for a human and may take several minutes. On the other hand...

Recognizing distorted letters

..., is a simple and rapid task for the brain compared with a computer.

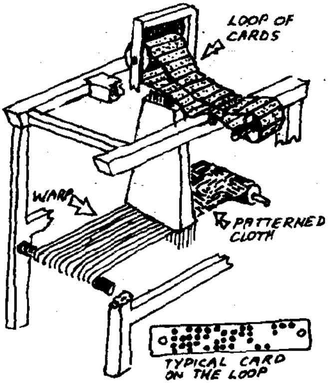
Perhaps the closest piece of equipment to a computer is a calculator. Indeed some calculators are so sophisticated they might be classed as computers. Silicon chips are used in their manufacture (as described in Chapter 6). Numbers may be fed in and stored. Arithmetic may be performed on those numbers. The result may be displayed. All these things are true of both computers and calculators.



Even this analogy is inadequate. A computer is not confined to processing numbers. It can also handle letters, words and diagrams. But even more important, a computer does not have to wait for a human being to tap keys before doing each arithmetical (or other) operation.

There are various classes of computer not described in this book. The type described here is technically known as a *general purpose digital computer* and is the most common kind. Some explanation is needed for the terms *general purpose* and *digital*.

A musical box which only plays 'Pop goes the weasel' is a special-purpose device. When you are in the mood for hearing 'Pop goes the weasel' this musical box comes into its own; otherwise it is not much use. If, on the other hand, it is the kind of musical box where you can replace the spiked cylinder to make it play other tunes it becomes a more general-purpose device.

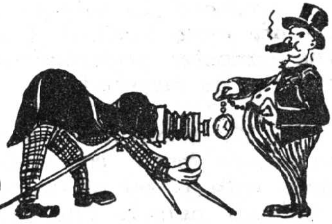


An ordinary loom is special-purpose. It can weave cloth only in the usual under-and-over kind of way. A Jacquard loom is different. It has a loop of cards with holes punched in them. Each card in turn comes against a set of needles. Wherever there is a hole in the card a needle falls through – and this causes a corresponding thread of the warp to be lifted. The pattern of holes in the loop of cards thus determines the pattern on the emerging cloth. A Jacquard loom is therefore general-purpose.

In the examples of a musical box and a loom the machine is general purpose if you can change the set of instructions (the spiked cylinder or loop of cards). Computers are general purpose if one can change the set of instructions – the *program*. Computers have shown themselves to be so useful simply because programs can be written to do such different things. The question, 'Can a computer do it?' is almost exactly the same as asking, 'Can you write a program to do it?'

General-purpose computers would not be able to do anything unless people had written programs for them. The clever things computers do (such as correctly calculating a mid-course correction for a spacecraft) are the result of programs written by people called *programmers*. The foolish things computers do (such as paying salaries of a million pounds or sending out electricity bills for zero amounts) have the same origin.

Digital is the opposite of *analogue*. Watches can be digital (with, say, a liquid crystal display) or analogue (with hands sweeping round). The difference is that a digital watch shows the time as a series of digits, and the number of possible times it can show is limited. The time shown varies from, say, 3:45:07 to 3:45:08 without visibly going through intermediate forms. On an analogue watch the time is infinitely variable. If you were to take photographs of the dial you would find it impossible to get two shots exactly alike unless the watch had stopped.



There are analogue computers that represent information (numbers) by means of continuously varying voltages. However, almost all computers are similar to the digital watch in the sense that they represent information as a series of digits. At each position on the face of a digital watch there is a limited number of digits that can be displayed. This is at the most the ten digits 0 to 9. Numbers written using these ten digits are called *decimal numbers*. These are the numbers familiar to everyone.

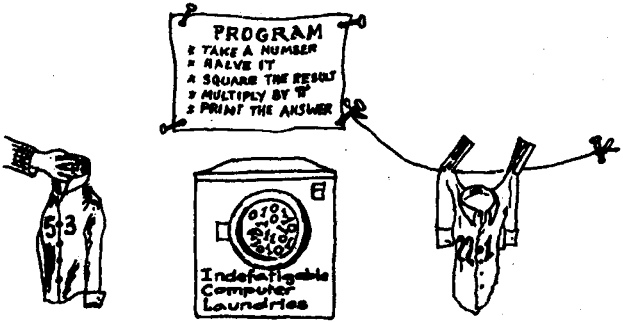
Digital computers almost without exception do not use decimal numbers for their internal working. Instead they use only the two digits 0 and 1. Numbers written using only these two digits are called *binary numbers*.

The reason for digital computers using the binary system is that it is the simplest way to store and process information. The distinction between a 0 and a 1 may be represented by a switch that is either on or off, part of a circuit that is conducting or not conducting, a wire that has a positive or zero voltage, a piece of iron magnetized one way or the other and so on. Cards for a Jacquard loom may be considered to be coded in binary because the important point is whether, at a particular place on a card, there is or is not a hole. When there are only two possibilities each can be represented very simply.

Such a rudimentary system does not limit the information that can be stored in a computer. As the next chapter shows, it is possible to represent decimal numbers, letters or words quite easily as binary numbers.

Although the computer finds it easiest to work in binary the people who use computers are not expected to use binary numbers. Information fed into a computer —or produced as output — may be in forms with which we are more familiar (for example decimal numbers). The computer performs the translation to and from binary as required.

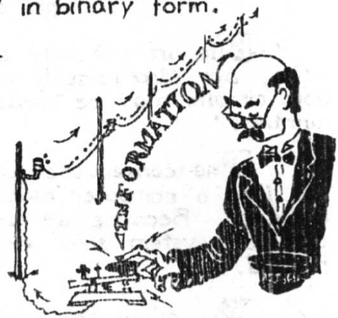
To summarize: a computer takes information in binary form, processes the information in accordance with a set of instructions called a program, and produces output. The processing includes arithmetic, copying information from one place to another, and performing comparisons. By carrying out a large number of tiny operations the overall effect is achieved.



3 WHAT IS INSIDE THEM ?

(REPRESENTATION OF INFORMATION)

If you open up a computer you see a mass of wires, circuit boards and electronic components. This chapter does not deal with the circuitry, however, but with the *information* inside the computer. In the last chapter it was said that information is stored and processed using the binary system. The data which computers are required to process are rarely in the form of 1's and 0's to begin with. The data may consist of names and addresses, amounts of money owing, numbers of parts ordered and so on. If the computer is to handle such information it must be *coded* in binary form.



A code is not just something used by secret agents. Coding may be used to change information into a more manageable form. For example in the early days of the telegraph, words were transmitted by means of the code devised by Samuel Morse.

Information may be coded in a variety of ways but the result is not always easy to process. It would be possible, for example, to take the score of a Beethoven symphony, describe each note in words, then transmit the words to instrumentalists using the Semaphore code. The information is there, but the orchestra might find it difficult to process.