COMPUTERS IN THE CLASSROOM

by **D. M. TAUB,** M.Sc., F.B.C.S., C.Eng., F.I.E.E.

Many schools are taking the first steps to bring education in the operation and use of computers into curricula. In order to teach the principles of computing to children, a special type of demonstration machine is necessary, and such a machine has been developed and used in several UK schools.

THE USE OF computers is now growing at such a rate that before long anyone claiming to be educated will need to know something of how computers work and how to use them. Many teachers already recognise this and are taking the first steps to bring them into the school curriculum. Various methods are being tried, depending on the interests of the teacher and on the facilities he has available.

One approach, for example, is to include a study of computer logic circuits and storage devices in the physics course. This approach gives children an understanding of how the basic components of a computer work, but it does not tell them how these components are organised into a complete machine. To cover this topic at such a fine level of detail would take more time than could reasonably be allowed.

Another approach, becoming quite popular at the moment, concentrates on how computers are used rather than on how they work. Children are taught to write mathematical programs in one of the problem-oriented computer languages such as ALGOL or FORTRAN, and the programs are then sent away to be processed by some nearby machine, perhaps at a local-authority or university installation. Writing programs in this way is a valuable discipline, but it does not teach a child anything about the computer itself. He can still look on it as a mysterious 'black box'.

A more practical disadvantage is the time taken—often two or three days—between sending a program away and receiving the results. Usually this procedure will have to be followed several times before all the faults have been corrected, and the succession of delays can easily make a child lose interest.

In a sense, the two approaches outlined above represent opposite extremes; the first one concentrates on the details of the machine, while the second looks on it simply as a means of getting results. Neither of them considers the structure of the machine or how it is organised.

Perhaps the soundest approach lies midway between the two. The computer can be initially presented as a simple assembly of store, input and output devices, arithmetic and control units. The child can be taught how instructions are initially placed in the store, how they are sent one at a time to the control unit, and how the various processes and movements of data take place as the instructions are carried out.

Several teachers have already introduced this idea of structure by means of a 'live' model. Five children sit round a table. In front of one is a set of pigeonholes rather like a postal sorting frame, which represents the store. A second child with a desk calculator represents the arithmetic unit, and the third and fourth act as the input and output devices, respectively. The fifth child represents the control unit. He has in front of him a pack of cards on which are written the detailed steps needed to control the machine. He reads out these cards one after another, and the other children carry out the required action.

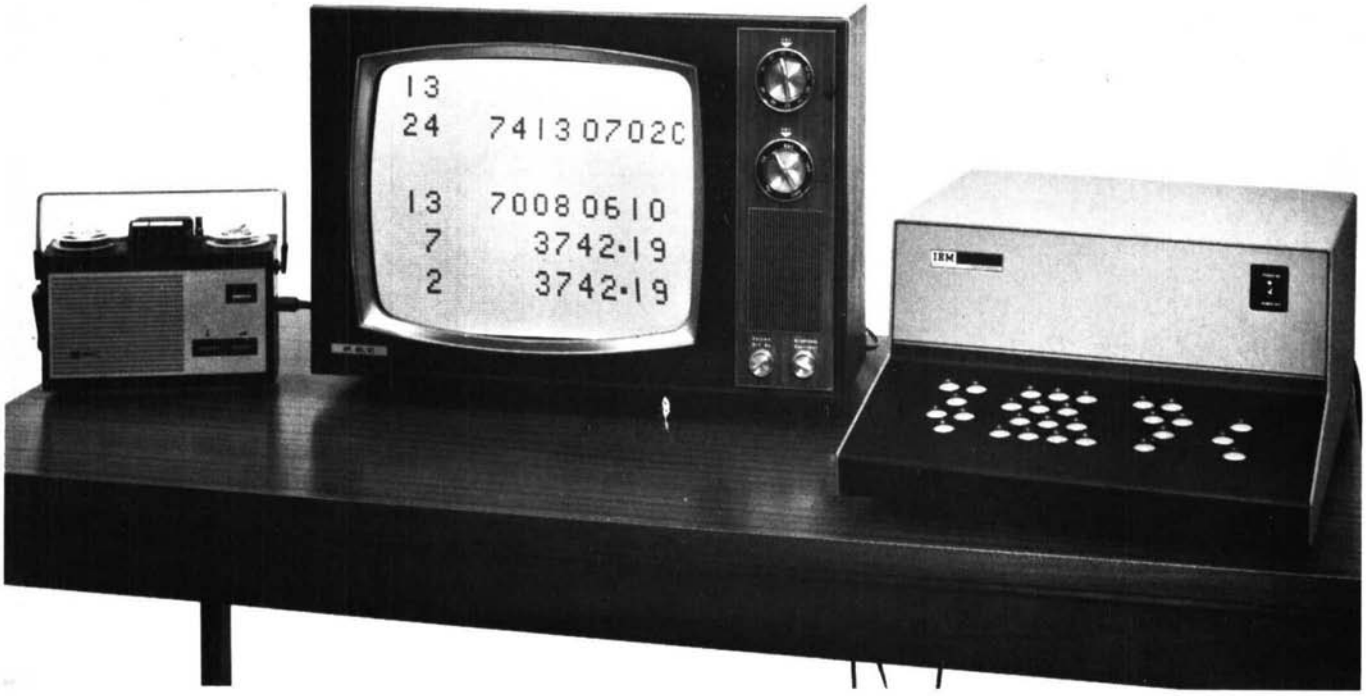
This 'computer game', as it is sometimes called, is a useful teaching aid, particularly at the elementary level, but to make further progress one needs a real machine, and one in which all the details of the action can be clearly followed.

If such a machine were available, it would have other uses besides teaching children about computer organisation and programming. Mathematics teachers could use it as a class demonstration device, enabling them to cover various topics which tend to be ignored today because they call for too much computation. Examples are successive approximation, summation of convergent series and numerical integration.

During the past few years, a machine of the type suggested above has been developed. Several models have been built, and have been used experimentally in various schools around the United Kingdom.

Design features

The design of the machine presented an interesting challenge. It had to be inexpensive, which meant leaving out all the features of a general-purpose machine that are not strictly necessary in a school environment. But the machine also needed a number of features that a general-purpose computer tends to lack; in particular, it had to be very easy to use, and the display had to be so clear that even an unsophisticated user would have no difficulty in following what the machine was doing. In other words, it had to be more than just a cut-down version of a general-purpose computer.



Classroom computer developed at IBM United Kingdom Laboratories Ltd., Hursley, Hants.

There were two main ways of keeping the cost down: one was to restrict the capacity of the store, and the other was to use the simplest possible input and output arrangements. The capacity of the store was set at 1760 decimal digits, which is only about one fifth of that of a small general-purpose machine. This store may seem to be too small to be of much use, but a remarkable variety of programs can be contained within it. For the main input device, the machine uses a keyboard—but not the usual kind with mechanical contacts. A capacitive touch keyboard was specially developed, working on the same principle as the keys found in some modern lift installations. The aim was to avoid mechanical contacts wherever possible in the interests of reliability.

For display and output, the machine uses a perfectly normal television receiver, which has a number of very attractive features:

- Potential users will already have one, giving a great saving in cost.
- When the set needs attention, it can be arranged locally without calling in a computer-maintenance engineer.
- The size of screen makes it ideal for class demonstration work.

Another unusual input/output device is an ordinary domestic tape recorder. Programs can be recorded on the tape, and when they are needed again the tape is played back directly into the computer. This method of reloading the program is much quicker than entering it again on the keyboard.

The tape recorder is very useful when a class of children is taking turns at using the machine. When a child finds that his program will not run properly and needs some time to find out what is wrong, he records the program on tape, leaving the machine free for use by another child. When he has decided what changes need to be made, he reloads the program and makes the necessary changes from the keyboard. Another way in which teachers find the tape recorder useful is for building up libraries of demonstration programs.

As mentioned earlier, a computer for schoolchildren needs certain features that are not found in general-purpose machines. It has to be simple to use, and should handle and display data in a form that is familiar to the child. The machine was therefore made to work in decimal rather than in binary notation, and to display numbers with the conventional decimal point instead of showing the significant digits and exponent separately. Also, negative numbers are represented in 'sign-and-modulus' form rather than as complements.

The display is probably the most important feature of the machine. Its main purpose is to show what is taking place when a program is run in slow motion. The operator can make the machine stop on completion of each instruction or at certain stages in the processing of an instruction, and the television set will automatically display the contents of all registers and storage locations relevant at that time. The illustration, for example, shows the display on completion of a 'branch' instruction.

In general, addresses are shown on the left of the screen and their contents on the right. The instruction, 74130702, appears on the second line down, and the number 24 to its left is the address in the store from which it was read. This instruction calls for the contents of addresses 7 and 2 to be compared, and, if they are equal, for the machine to take its next instruction from address 13. The three addresses referred to in the instruction, together with their contents, are shown on the lower three lines, and the letter C immediately to the right of the instruction itself indicates that the instruction has been completed. The number 13 in the top left-hand corner is the address from which the next instruction will be taken. Had the contents of addresses 7 and 2 not been equal, the number appearing there would have been 25; i.e. the machine would take its next instruction from the next address in sequence.

Another point that was given special attention in the design of the machine was its suitability for teaching. One must accept that a computer is a complicated device, and if a child is to understand its complexities they must be presented to him in easy stages. The machine was therefore designed so that the more advanced features such as indirect addressing and subroutine linkage could be hidden until a child is ready for them.

A final requirement—a very practical one—was that the machine should be robust. It has to be able to withstand the rough treatment that schoolchildren are likely to give it, and the frequent moves from classroom to classroom and from school to school.

Six of these computers have been in use for several months, in schools of various types and among children of widely differing abilities. The project is an experiment, and there are no plans for commercial production, but even at this early stage it is encouraging to see the enthusiasm with which children have taken to these computers and the skill they show in using them.

Details of the computor described in this article can be found in the reference, TAUB, D. M., OWEN, C. E. and DAY, B. P.: 'Experimental computor for schools', *Proc. IEE*, 1970, 117, pp. 303–312.