Computing By Analogy

Analogue computers, used for controlling machines and processes, react directly to changes in the real world without the need to translate information into digital form

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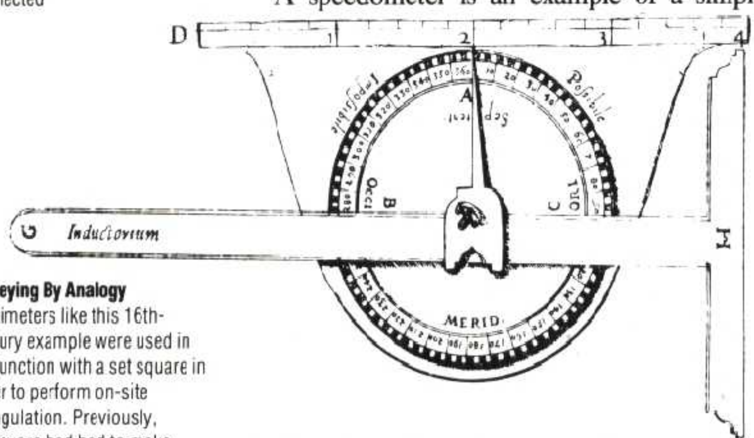
A Patchboard
Analogue computers do not use languages such as BASIC. They are 'programmed' by wiring together various electrical components. The components are attached to the back of a circuit board. On the front are plugs and sockets that allow selected components to be connected

There are two quite different families of computers, and so far we have been looking only at one of them: the digital computer, so named because all the instructions in a program and all the data are represented using binary 'digits'. The other, older family comprises analogue computers.

A speedometer is an example of a simple, dedicated, 'analogue' computer; the name derives from the 'analogous' behaviour of the speed of the car to the position of the needle on the dial, the former being directly proportional to the latter. Modern analogue computers can perform many tasks and are based on the type of electrical components that are commonly found in domestic appliances — transistors, capacitors, resistors and magnetic inductances. Early on in the development of electronics it was discovered that the behaviour of electrical components resembled that of mechanical devices. For example, electrical engineers discovered that the oscillations of electric current that can result when a magnetic inductance and a capacitor are connected together closely mimic the oscillations of a weight hanging on a spring. In fact, the mathematical description of both systems was identical — the basis for 'computing by analogy'.



Surveying By Analogy
Planimeters like this 16th-century example were used in conjunction with a set square in order to perform on-site triangulation. Previously, surveyors had had to make measurements and then do mathematical calculations in order to determine the length of the remote side of their triangle, but this simple analogue instrument made their work considerably easier and more accurate. Similarly-named instruments are still in use today, for measuring the area of irregular planes such as animal hides

Some analogue devices look very similar to the systems they model — for example, the model of an aeroplane used in a wind tunnel experiment is an exact copy, scaled down, of the airframe. Other models appear very different. A 'model' of a real life situation may be just a list of mathematical formulae, or it may be an electrical circuit that mimics the flow of water over a weir, for example.

Calculating machines that use analogue principles first showed their importance with the invention of the slide rule in 1630 by William Oughtred. Numbers were arranged on two rules in such a way (they were logarithmically spaced) that the movement of one alongside the other is equivalent to multiplication, and the answer can simply be read off the scale.

At the end of the 19th century Lord Kelvin designed an ingenious hand-cranked mechanical device that could be used to calculate the high and low tides at a port throughout the year.

Then in 1930 an electromechanical machine was built in America that could solve general differential equations (the type of equation that crops up in almost any mathematical representation of the real world), rather than the specific set of differential equations that Kelvin had succeeded in solving. It was invented by Vannevar Bush and called a differential analyser.

Early Analogue Computers

The first fully electronic analogue computers came into operation in 1947 just after the first digital computers were born. We have seen how digital computers do arithmetical calculations using a combination of logical gates (see page 68). The analogue computer can perform mathematical calculations simply by utilising the nature of electricity. If there is, say, an electric current of five amps flowing in one wire and a current of four amps flowing in another and the two wires are joined together to merge into a single wire, then the current in the new wire will be nine amps — the sum of the two currents. So the