and Z coordinates. At this point it is extremely useful if the program does not reproduce 'hidden' lines, and by this means introduces opacity into what has been, up to now, a 'wire frame' model or representation.

The next desirable refinement is for 'curve smoothing'. A curved line is specified by only three points — both ends, and the point farthest away from the straight line between them. Of course, a complex curve (an 'S', for example) needs to be split up into its simple components in order for this procedure to work adequately, and it's important to have some simple way of indicating to the machine that the line in question is a curve that requires smoothing, and not just a straight angled line.

Next comes the ability to introduce light and shade into the drawing. First of all it is necessary to specify the position of the light source. The part of the drawn object that lies facing the source will then be highlighted, and progressive shading added to help define the object's shape.

movement. It is relatively easy to reduce movement to its individual components if we think of it as a problem in continuous solid geometry, even when the object represented is as complex as a human hand. The determining factor is the size and power of the computer that is being used. Bear in mind, however, that in order to produce a high-quality image, we will require a monitor capable of resolving something like 1,000 × 1,200 pixels. Each one of these pixels will require at least one eight-bit byte to hold the information that defines its colour and brightness. That means more than a megabyte per screen. Generation of high-quality moving pictures is therefore not possible on home computers. Indeed, professional animators use some of the largest and most powerful computers in the world, and their fees reflect this, being upwards of £1,000 per second of final film.

Magic Colouring Box
Until recently, the method of originating artwork for film and television stills and animated sequences followed closely that used for magazines — the design was executed on paper or transparent film, and then photographed. Quantel's Paint Box system, however, cuts out the use of paper completely, composing the artwork digitally within the computer and then recording it directly onto videotape
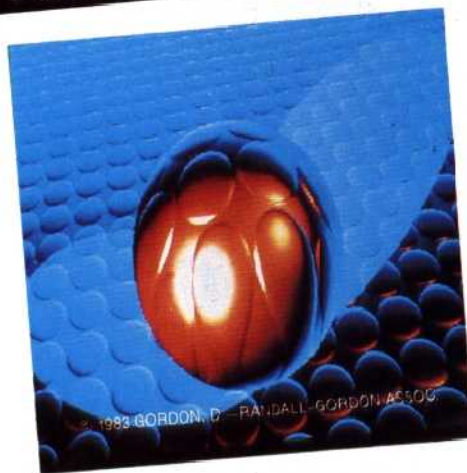
Sophisticated software will allow the use of more than one light source and cope with the reflection of light off one object onto another.

Along with shading goes the use of colour. Even the simplest of home computers now offers eight or perhaps 16 colours, but professional quality graphics computers generally allow at least 4,096. Some are limited simply by the number of binary digits in the computer's 'word'. If this is 24 bits for example, the computer has some 16.7 million colour options. The shading and colouring facilities are combined into one.

Let's now look at the problem of simulating

If we take as our starting point a simple object, like a cube, it is relatively easy to understand how we can cause it to move around the screen, tumbling, perhaps, as it goes. A cube can be defined by the coordinates of the eight corners alone, but exactly the same principle applies to more complex objects. The only difference is the amount of memory required to store all the coordinates and the processor power needed to be able to manipulate that information fast enough to generate 'real time' movement. In this application, like all others, there is the inevitable trade-off between quality and the amount of available space and power. The smaller the drawing unit one defines, the greater will be the