Not only computing — also art

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It will come as no surprise to regular readers of these columns that I have something of an obsession with geometry. I developed this interest when I was a student in the 1940s and 1950s but, except at the purely practical level of technical drawing, my enthusiasm rarely seemed to be shared by others. Good texts on geometry were hard to come by and, in the eyes of many academics, the subject seemed to be dead or dying. Currently, I am glad to say, this fascinating discipline is enjoying a resurgence.

This new flowering has been fostered by three post-1960 books which should be on every would-be geometer's bookshelves: March and Steadman's *The Geometry of Environment,* Coxeter's *Introduction to Geometry,* and Grünbaum and Shephard's *Tilings and Patterns.* All three of these are currently available in paperback.

Whilst browsing through the three texts can be both interesting and profitable, it has to be said that none of them are particularly easy to read. The *Introduction*, in particular, requires very careful attention if the arguments are to be properly followed. Coxeter deals with what could be called 'conventional' geometry. He starts with triangles, passes through affine and projective geometry, goes on to differential geometry and topology, finally ending up with close packing of spheres. This does not mean, however, that one new thing necessarily follows another in a conventional arrangement. There are often unusual changes to the order you might expect to be introduced to items. All the way through there are answered exercises which test the reader's ingenuity and understanding. There is probably little about the subject that isn't touched upon in some interesting way in this seminal work.

Grünbaum and Shephard cover two-dimensional patterns. There is no shortage of sources for this subject — the authors list about 600 of them. One of the problems for me with the literature on regular patterns that can be made with tiles is the magical, mystical level of much of it. From some of their remarks in the text, Grünbaum and Shephard seem to share my dislike and they successfully avoid it. But, early on in the book, they mention in passing something surprising that, to my mind, might help to account for the apparent lack of British or American interest in geometry in the 1940s. They have a paper on tiling, printed in Germany during the Second World War, and marked 'Top Secret'! Could it be that the Establishment, which has always displayed an unhealthy obsession with secrecy, still hides important yet classified contributions to pattern making by some of the many mathematicians, including Türing, which it employed during the war?

The text is essential reading for anyone who wishes to develop an understanding of patterns which fill the plane. It is an endless source of ideas for tilings — some groups of which I had never seen before. It would make an ideal undergraduate or even postgraduate introduction to 2-D patterns (and thence to other geometries) either as part of a course in mathematics or one in computer graphics. In the running of MA Computer Graphics courses for artists and designers, I have been surprised how readily they take to the maths involved, but I fear the book is too difficult for those who are not already fairly skilled in mathematical thinking. The authors are at pains to establish a rigorous nomenclature and classification system for tiling; this makes the text highly technical. They are generous in their praise of the contribution to the subject by non-mathematicians, particularly artists and architects, although they are concerned about the number of errors that occur in their writings. Happily, though, they do not seem to share the somewhat elitist view of Coxeter quoting Hardy: *"A mathematician, like a painter or a poet, is a maker of patterns. If his patterns are more permanent than theirs, it is because they are made with ideas."* Art, too, is made of ideas.

Let the force be with you

In the October 1989 issue I showed some solid modelling pictures. Solid modelling, of course, uses conventional 3-D geometry at its foundation and its techniques greatly simplify the description of all sorts of items. But, after all I have said in these columns about its supremacy, it might come as something of a shock to learn that quite complex objects can be described to computers without the use of geometry at all! Furth-

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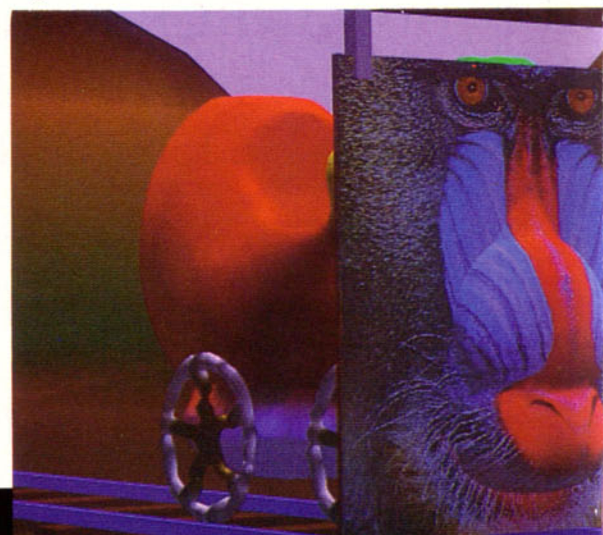

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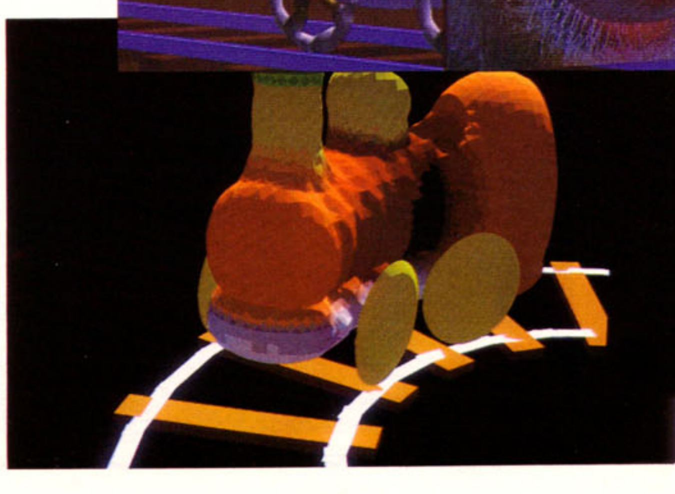

ermore, the use of geometry is by no means the best method of describing soft objects. These seem to be best dealt with by a technique for molecular modelling which began with James Blinn at the Jet Propulsion Labs at Caltech. His work was taken on by Brian Wyvill and others at the University of Calgary and given different applications. Fig 1, for example, shows a soft train bending around a track and Fig 2 shows the train about to acquire a new surface. These are stills from the Calgary film *The Great Train Rubbery* (sic). More recently, Craig McPheeters at the Dorset Institute of Higher Education has been developing the subject, as has Malcolm Kesson at Middlesex Polytechnic.

Force fields

Their techniques describe the shapes of objects not in terms of their geometries but in terms of surfaces of equal potential in force fields. (Compare this with the 2-D case of contours in a field of temperatures: the contours indicate the lines of equal temperature.) The technique scores when it comes to animating objects which are changing their shapes dynamically as they move, or building up more complex changes from simpler ones. In particular, the smooth blending of one object into another is facilitated by the intersection of scalar force fields. Figs 3, 4 and 5 demonstrate how, by changing the strengths of the fields, separate objects can be made to blend smoothly together. The Calgary group have tended to concentrate on the field approach for soft, flexible objects. Malcolm Kesson, on the other hand, explored the idea to give a different way of dealing with objects made up of pipes and rods. Figs 6 and 7 show the junction of three pipes with differing field strengths.

I have always thought that we need a battery of ways of describing graphical objects to computers. Boundary or solid descriptions based on geometry are two sorts, scalar field descriptions are another. But there is a need for many more. There are two reasons why I advocate a pluralism in the ideas and methods of computer graphics. Firstly, because it results in greater flexibility. Secondly, because you never know when a given method will be incorporated into a patented product. The astonishing results of a recent British computer graphics patent case have shown that it is effectively possible to stifle a given promising line of development if it affects a patent. This result of the case is bound to have far-reaching effects on the computer industry. It is a matter I will return to in a later issue.

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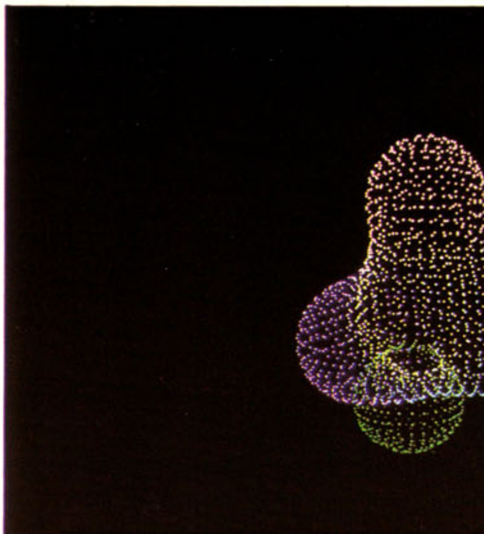

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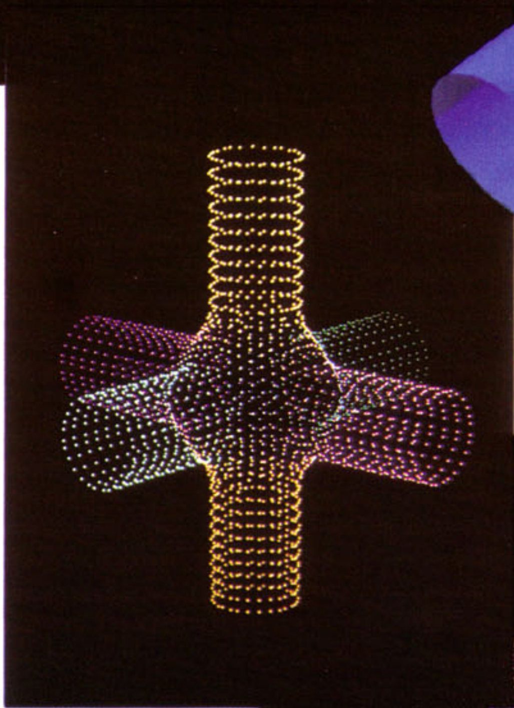

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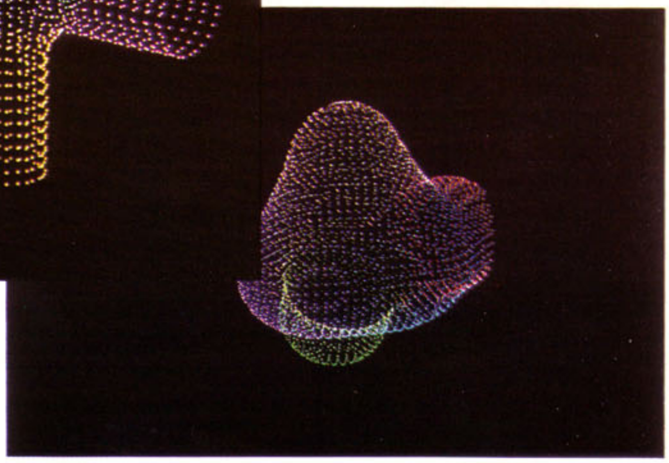

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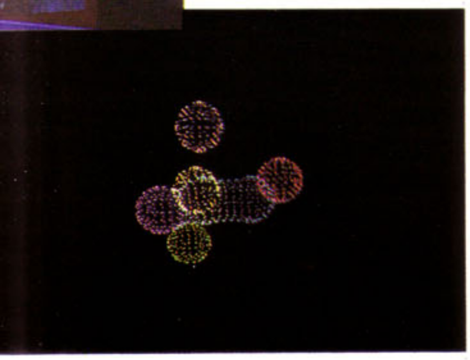

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