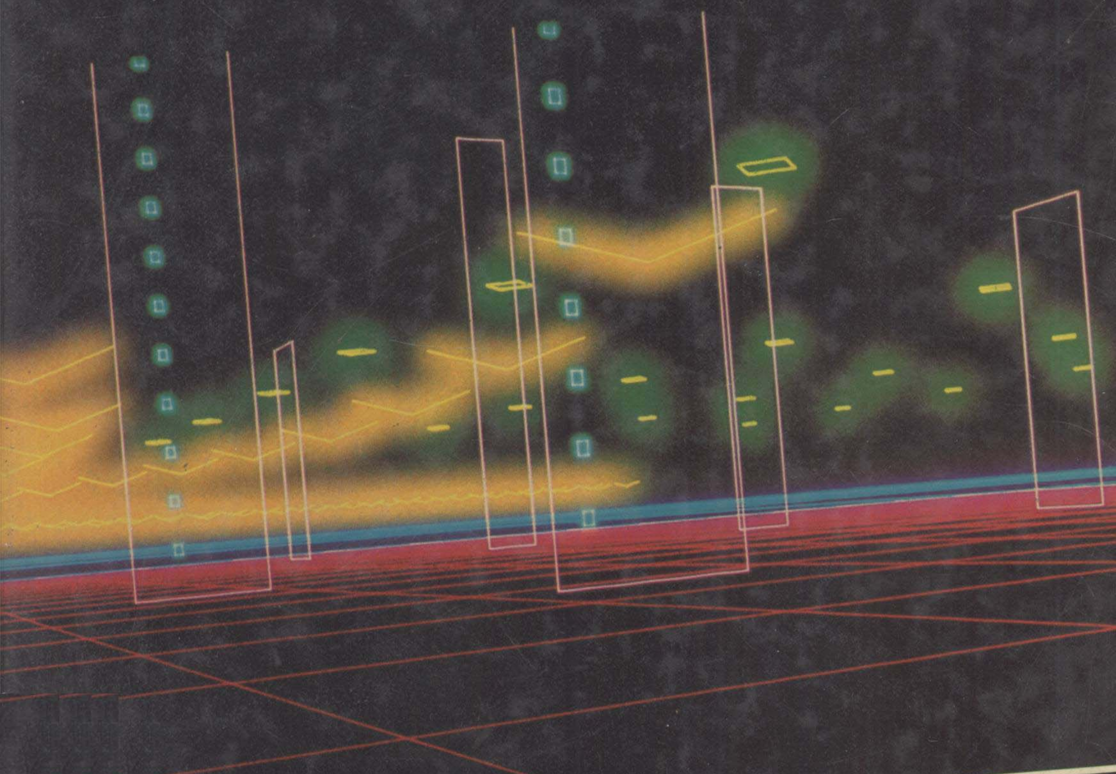
Computers for Animation

Stan Hayward



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Dedication
to Maya Kjellstrand

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Stan Hayward

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Acknowledgements

The field of computer graphics and animation is a no man's land somewhere between visual arts and data processing. Trying to draw a boundary line around this area has been the most difficult task of putting this book together. Luckily I have been aided by some of the best experts in the field. I am particularly grateful to David Kirk, Editor of *Professional Video* magazine, for many sources of information, and for permission to reproduce articles first published therein; also to Dr Ed Catmull of Lucasfilm, Brian Sloam of BBC Open University Production Centre, Junaid Sheikh of Ampex, Gwyn Morgan of Logica, Peter Dean of Electronic Arts, and Ken Cooper of NAC Animatography, all of whom supplied information on their systems and gave permission for me to use their material. The directory of suppliers is included by kind permission of Frost & Sullivan. I am particularly grateful to Alan Kitching for checking and updating the computer routines section; also to the many people whose valuable comments have helped shape the final book. Last but not least I wish to thank Mike Joyce, the illustrator, whose knowledge of both animation and computers has been invaluable in presenting these ideas.

S.H.

Introduction

The purpose of this book is to introduce movie makers to the basic concepts, techniques and equipment of computers used in image making in general and animation in particular. The term 'movie maker' is meant to describe anyone involved in the creation of moving images on film, video, or computer. The term 'animation' is here defined as 'single-frame control'.

The book is aimed at three groups of people: first, those in the animation industry who wish to get enough knowledge of computer applications to see how these can be applied to their interests; secondly, those in the computer-graphics world who are looking at the broader areas of animation outside purely technical applications; thirdly, people who might typically be in education or advertising, and who need to understand new developments from the point of view of users of animation.

Both computers and animation are highly specialised subjects, and the field is thick with jargon. One of the reasons for the slowness in getting full acceptance for computers in film-making is the difficulty of communication between two highly-specialised groups. This book provides a reference and glossary to help overcome this problem, though to some extent with the necessity for detailing the underlying technicalities. It also deals with animation in terms of production – to include references to management and sound. It is a common error to assume that animation means drawings, and that computers only cut down the amount of drawing needed. In fact computers can be applied at every level of production, including the imagination; it is only by looking at the production as a whole that the benefits become obvious.

The idea of a 'production' is intended to convey a finished movie. This may vary from a feature film down to an animated office memo. The endpoint is much the same of expressing one's ideas as directly and fully as possible. The merging of film, video and computer techniques will make it possible for fewer people to do more stages, and will ultimately lead to one person using a movie-making system as one might now use a word processor. Animation itself is a universal language, and might well be taught as such one day to everyone. If a picture is worth a thousand words, what price a moving picture with sound? The potential is only now being realised.

What is animation?

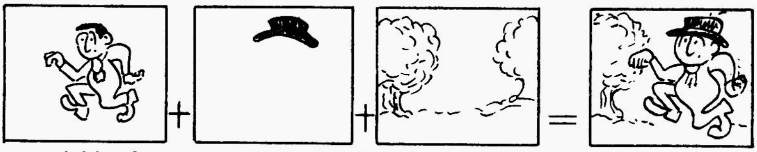
For many people animation conjures up ideas of cartoon figures, in particular those suited to children. By definition, animation covers *any* form that is recorded frame by frame, whether on film, video or digital store. In effect, it means any form where the user has control over all the elements in each frame. Combined film, video and computer techniques greatly extend the range of control, by offering new styles of machine-generated images that were not possible until recently, and by offering efficient and practical control in situations once prohibited in normal circumstances by time and cost. The elements under control include timing, movement, colour, texture, line, and the various soundtracks of voice, music and effects. The following are brief descriptions of normal techniques, and show how these can be aided with computers.

Drawn animation covers any form where the various stages of movement need to be drawn. In figurative animation it covers the posture, gestures and characterisation of the figure. The drawings are made on cels (clear acetate) or paper, coloured and shot. Computers can often handle a significant amount of this as they can display for timing and correction before realisation as a cel.

Cutout animation covers any method where flat shapes such as articulated figures are moved around under the camera. Where speed and cost are important, this method may be used as a limited form of animation. The computer can produce cutouts, and offers a range of designs in complex figures otherwise impracticable. The computer can also work out accurate paths for movements for the cutouts to follow.

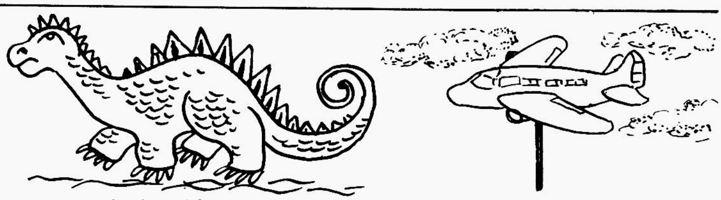
Model animation is simply moving figures and objects around on a table and shooting single-frame; the computer offers little at this level. But when the models themselves can be controlled directly, or when the stand they are on can be controlled – as with special effects in science-fiction films – the computer offers total control.

Rostrum animation has clear savings in time and expense if under computer control. A whole sequence can be set up and followed through automatically. This has led to the design of special equipment for the rostrum, e.g. the slit-scan system, in which a slit over the artwork scans the whole picture. The camera zooms in on this so that each move is exposed on the same frame. The ultimate frame has exposed the whole image but from progressively closer distances. This spreads out the image and gives it great depth.

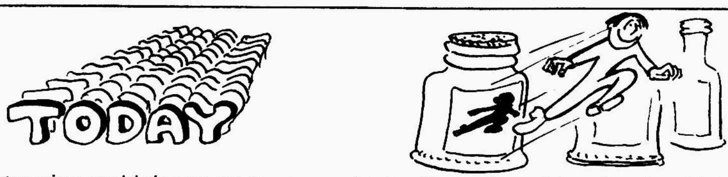


Cels are overlaid to form a composite drawing. Only the 'action part' needs to be changed.

Cut-outs using hinged figures greatly increase speed of animation, but at the expense of flexibility offered by drawings.

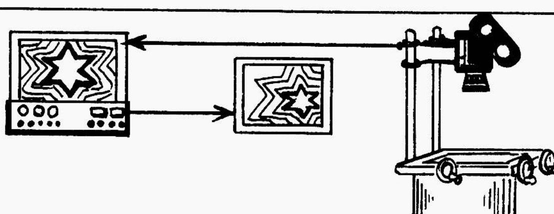


Model animation uses articulated figures or models on stands. Both can be computer-controlled.



Special effects using multiple exposures or combining live action with animation. This is done on the animation stand.

By shooting the figure against a blank background, live-action shots can be combined with a drawn background back-projected.



Film transferred to video can be given a range of electronic effects.

Computer graphics users

The broad areas of computer-generated, -modified and -recognised images are somewhat fuzzy-edged. But as all of these areas contribute to the field, one area of development is often taken up by another, seemingly unrelated, area.

Management Data graphics convert numbers to pictures such as histograms, bar charts and the like. These can show a trend much more clearly than a row of figures. The graphics are usually simple, and on low-resolution screens.

Process control Control rooms of railways, oil refineries, steel works, etc, where there is a flow of information on production processes or movement, are often aided by *mimic* displays which show a schematic layout of the system and the state of progress. These also include warnings and alarms, and can pinpoint a situation.

Simulation Large systems such as space landings, weather prediction, astrophysics (simulating the Universe), and the control of aircraft, may use very sophisticated methods. In the case of training, the graphics are under the control of the user, and the image changes as though viewed through the control window.

Education Computer-assisted learning (CAL) may produce graphics together with text and speech. The user interacts with the screen. Questions are asked by the computer, and answers are checked and displayed.

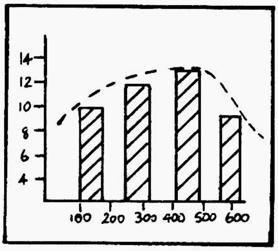
Draughting Computer-aided draughting, as used by engineers and architects, allows drawings to be composed from files of elements (units of the system such as nuts and bolts, doors and windows etc), and displays the final artwork in perspective as seen from various angles, and with the added elements of light and shade. In engineering, computer information may actually be used to operate the machine which manufactures the parts.

Pattern recognition Used in robotics for sensing objects, but also used in banks for recognising signatures; used by police for identifying fingerprints and faces, and by movie makers for digitising images produced by camera systems.

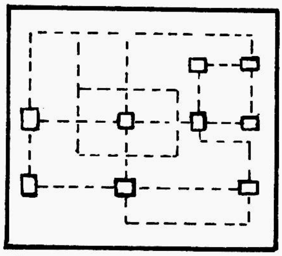
Design This is similar to draughting in technique, but usually includes a greater range of facilities for users to create their own designs and manipulate them. This field is the one closest to animation, in the sense of being an extension of drawing techniques.

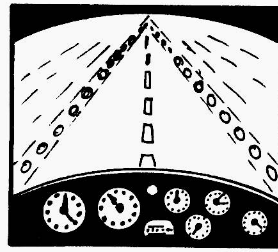
Numerical control Where this is related to the control of image making equipment such as camera stands, video machines etc, the computer offers the ability to operate more controls, and faster, than can be achieved manually. Apart from actual control, the speed itself often permits the making of complex images that would otherwise take too long.

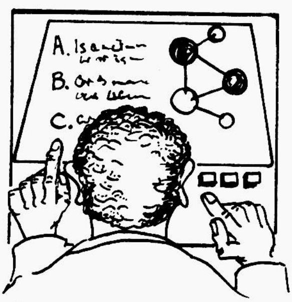
To some extent the movie maker has to look at what exists in these fields, and to see how it can be used for his own purposes, as no total system exists embodying them all.

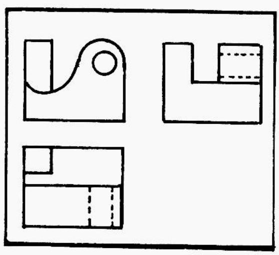


Data graphics.

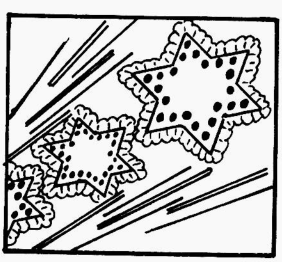

Process control simulation display.

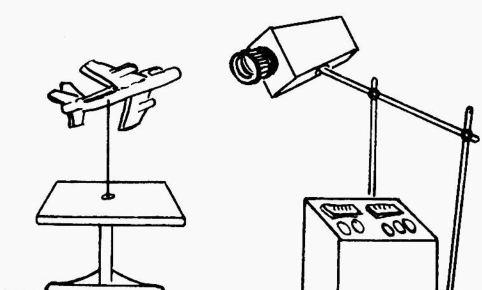

Cockpit view in aircraft simulator.


Computer-assisted learning system.


Computer-aided draughting.


Pattern recognition as used for reading facial characteristics.


Complex computer-generated artwork.


Numerical control of models and cameras.

Computer-aided production

In the film industry a great deal of money and effort is spent in finding people and communicating ideas. Problems are most likely to occur at the points where the production is transferred from one person to another. By offering more information to more people, and at an earlier stage of production, the computer benefits the studio as a whole over and above the jobs it does at each stage. In a studio equipped with a suitable computer system, the production will operate along the following lines.

The client receives a list of suitable films from the databank, so that he can see a spectrum of work broadly resembling his requirements.

The producer uses the databank to list freelance personnel and services, with their availability and costs. The computer's management programs give estimates on time and cost for the client's film.

The writer uses a word processor for the original draft, and for any changes. This avoids the irritation of a script full of amendments, and allows scripts with individual parts printed in bold type or different colours.

The designer draws up the rough storyboard and shoots this on the video line testing machine on to a dummy track (i.e. reads out the script for timing). The director makes suitable changes. The client examines and corrects the result.

The editor shows a printout of the line test to the actors, who assess timing and feeling before recording the final voicetrack with the director.

The director gives the final soundtrack to the editor, who fits it to the line test of the storyboard.

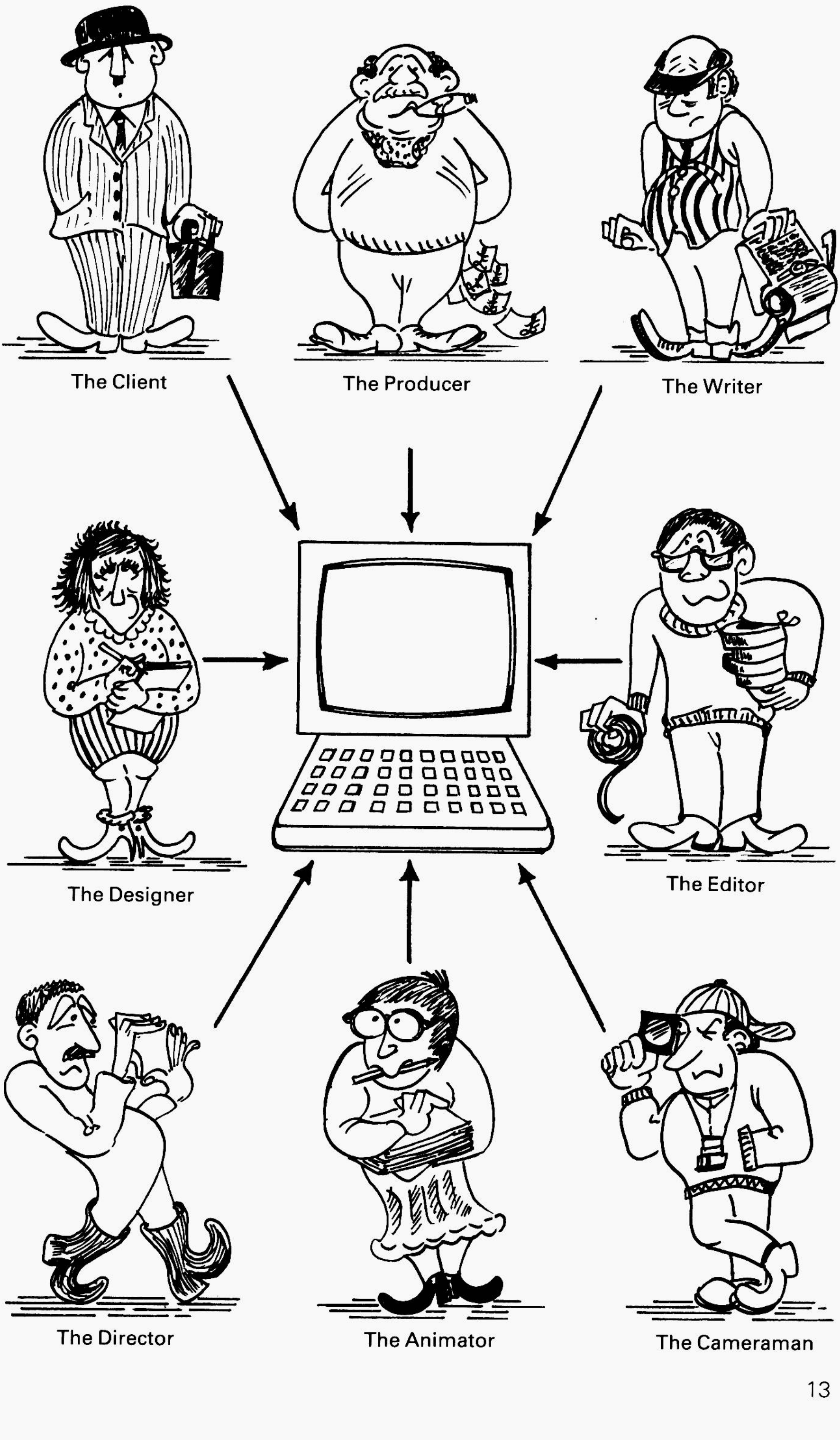
The animator fills out the storyboard with line animation (rough drawings). The timing is now accurate. Background can now be added.

The animation assistant cleans up the rough animation and reshoots this on the video line testing machine so that final corrections to timing and movement can be made, with the addition of music and effects.

The client checks the final version before it is committed to film. On his approval this now goes to the cameraman.

The cameraman uses the camera information sheet (usually called the *dope sheet*) to operate the computer-controlled rostrum camera. A printout of the final shoot includes instructions for the cutting laboratory.

At all stages the management computer keeps track of production and gives times and costs, notifying the producer if these are excessive.


The Client
The Producer
The Writer
The Designer
The Editor
The Director
The Animator
The Cameraman

Production sequence

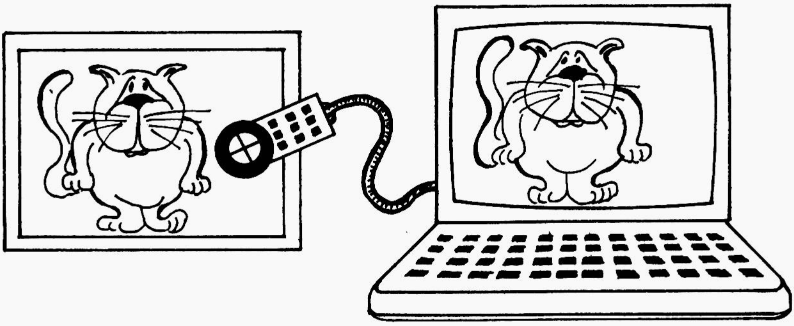
The sequence begins with some method of putting the artwork into the computer. This is known as *digitising*, as it consists of converting the artwork to binary digital form. The artwork may vary considerably: a simple line drawing such as a blueprint; a complex figure drawing with varying line thicknesses and unbounded areas; a full-colour photograph with hundreds of variations in hue and tone. The type of artwork used dictates the type of equipment required. The final part of this book describes the range available.

Once the artwork has been put into the computer memory it can be called up and displayed on the screen, in any desired sequence. It is now possible to begin putting pictures together and composing the complete frame. Parts of the picture may need to be scaled up or down, duplicated, reversed, realigned, coloured, etc. This is all done directly on the screen, and the final result stored away for later use.

When all the drawings have been set up and stored the computer can then be used to carry out a desired routine between any two 'key' frames. In a simple case this could be just the *inbetweening* (see p. 42) from one to the other in a given number of frames. If more complex routines are required, e.g. multiple transformations on different parts of the picture, then this has to be worked out and set up. An example might be the operation of an internal combustion engine. The flywheel turns; the piston moves up and down; there are ignition and exhaust. The first three might be treated as cycles, while the exhaust smoke would need a random effect. When the sequences have been worked out and tested separately, the complete scene can be run in real time at 24 frames per second for film or 25 for video. The test run will be to check movement, add sound, colour, improve timing, work out transitions, etc.

The final run will include all the modifications. There may still be other additions such as titles, credits, text, but these are often 'still' frames. If all is correct the sequence can be transferred to film or video, or made into hard copy in the form of photographs or drawings, or in some cases stored in a digital form on a disc, tape, or other form of computer memory. Some systems are capable of replaying these at normal viewing speeds.

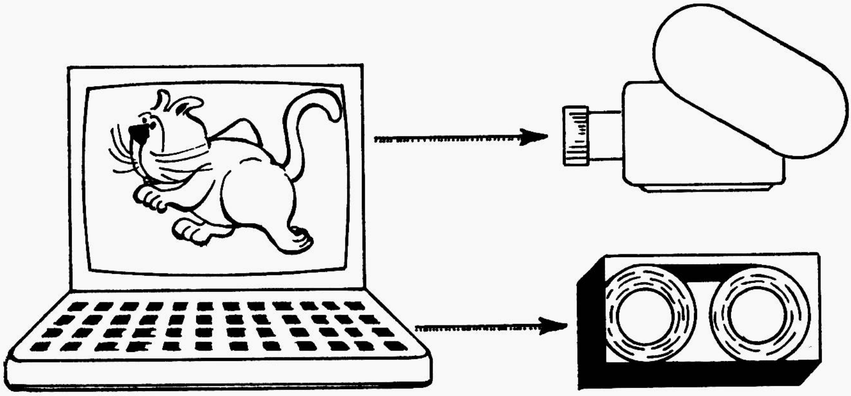
Generally speaking, there are two ways to approach computer animation. Either all the artwork and sequences may be prepared as a storyboard, in the way a normal film goes into production, or the machine may be approached with a basic idea and final story developed by trial and error. In practice the method used will be somewhere between these extremes, with a rough storyboard and development of ideas within this as required.



Artwork is first digitised and shown the display before being corrected, tested and filed.

Animation routines	Squash	Stretch	Twist	Flip	Scale	Inbetween
Editing	Point	Line	Component	Macro	Frame	Erase
Filing	File to Display	Display to file	Display to plotter	Display to video	Picture level	Frame sequence
Symbols	Arc	Circle		Rectangle	Ellipse	Fillet
Draw	Line types: ———	-----	....	Digitise: Freehand	Fixed mode	Scan

Part of the menu showing typical commands and routines available. These are used to correct, test, file and output to various peripherals.



Final version checked on display and then put directly onto film or video, or plotted for shooting.

Management

When a producer is offered a film to make he has two problems to consider. First he must be able to produce the film required by the client at a competitive cost, and secondly he must be able to produce it to a deadline even though his resources may be stretched by other productions going on at the same time. In practice, it is very common for films to go over budget and deadlines. Two programs that can aid production management are the *spreadsheet* programs that allow financial modelling, and the *critical path analysis* programs that allow costing and scheduling to be done. The spreadsheet program deals with anything that can be set out in rows and columns. The example opposite uses the Visicalc program for this.

The first two columns show the items costed and the estimated rates. The rest of the columns show the weeks (this is only a portion of the printout). The figures in each row show these estimated costs on a weekly basis, and when they are likely to occur. The bottom two rows show the cost for each week, and the accumulated cost on a weekly basis. As these are estimates, they can be changed easily just by typing on a new rate figure. The whole set of figures will be immediately recalculated by the computer. Figures may also be moved to different columns if necessary, and again the figures will be recalculated accordingly. The program allows the producer to get various estimates on costs, and, once into production, to see how close his estimates come to the actual costs; he can then re-estimate the final figures, and take action accordingly.

The scheduling program (pages 18–21) assigns a time and sequence to each job showing the earliest and latest times it may be started to meet a given deadline. It also shows the skill and resources required for each job, and the estimated costs for these. Once set up, the information on each job is regularly updated. The program then reschedules the whole sequence accordingly, and warns of deadlines that cannot be met. This will allow the producer to use his resources in a different way if required. Although the example shown is a very simple one, the method offers considerable aid to a producer on a large project such as a feature or a series which may be done in several separate studios.