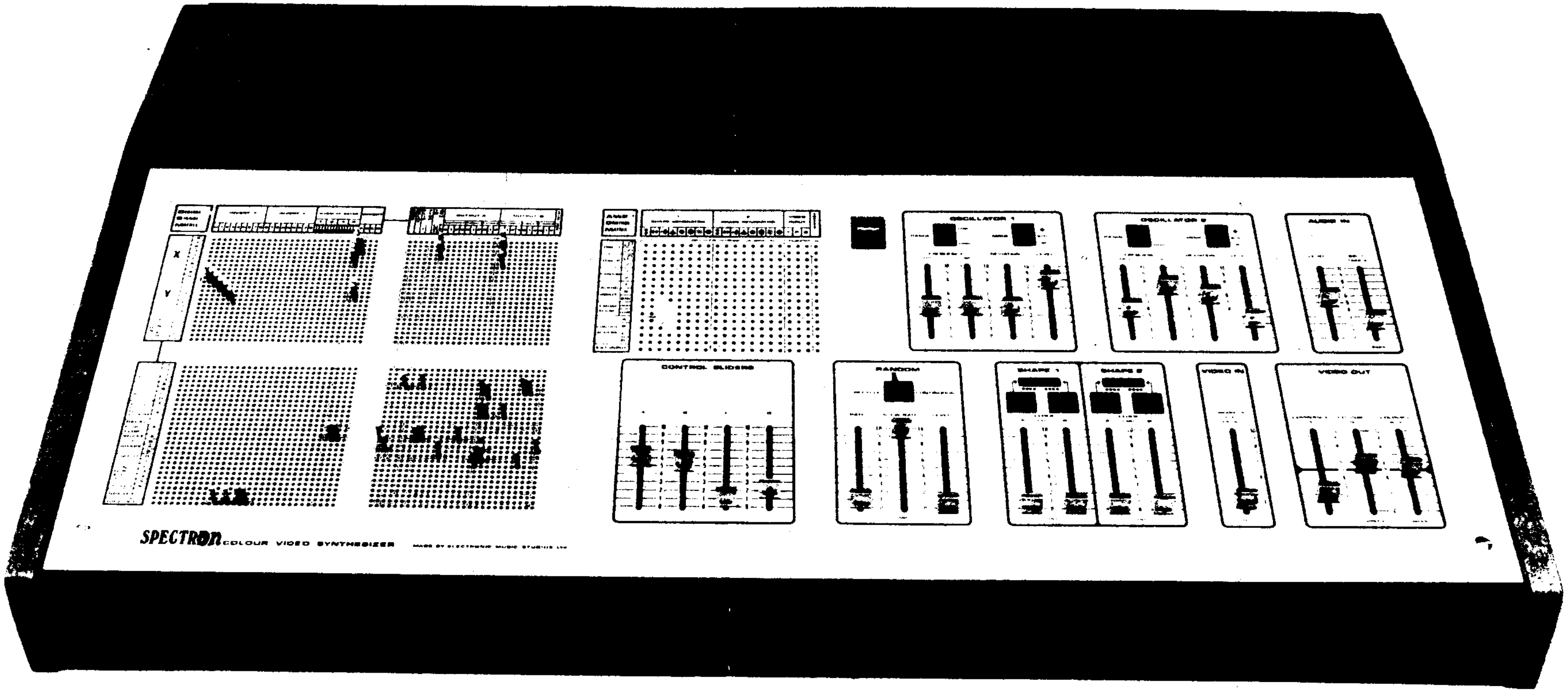
The moving art of video graphics



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The moving art of video graphics -or How to Drive a Spectre

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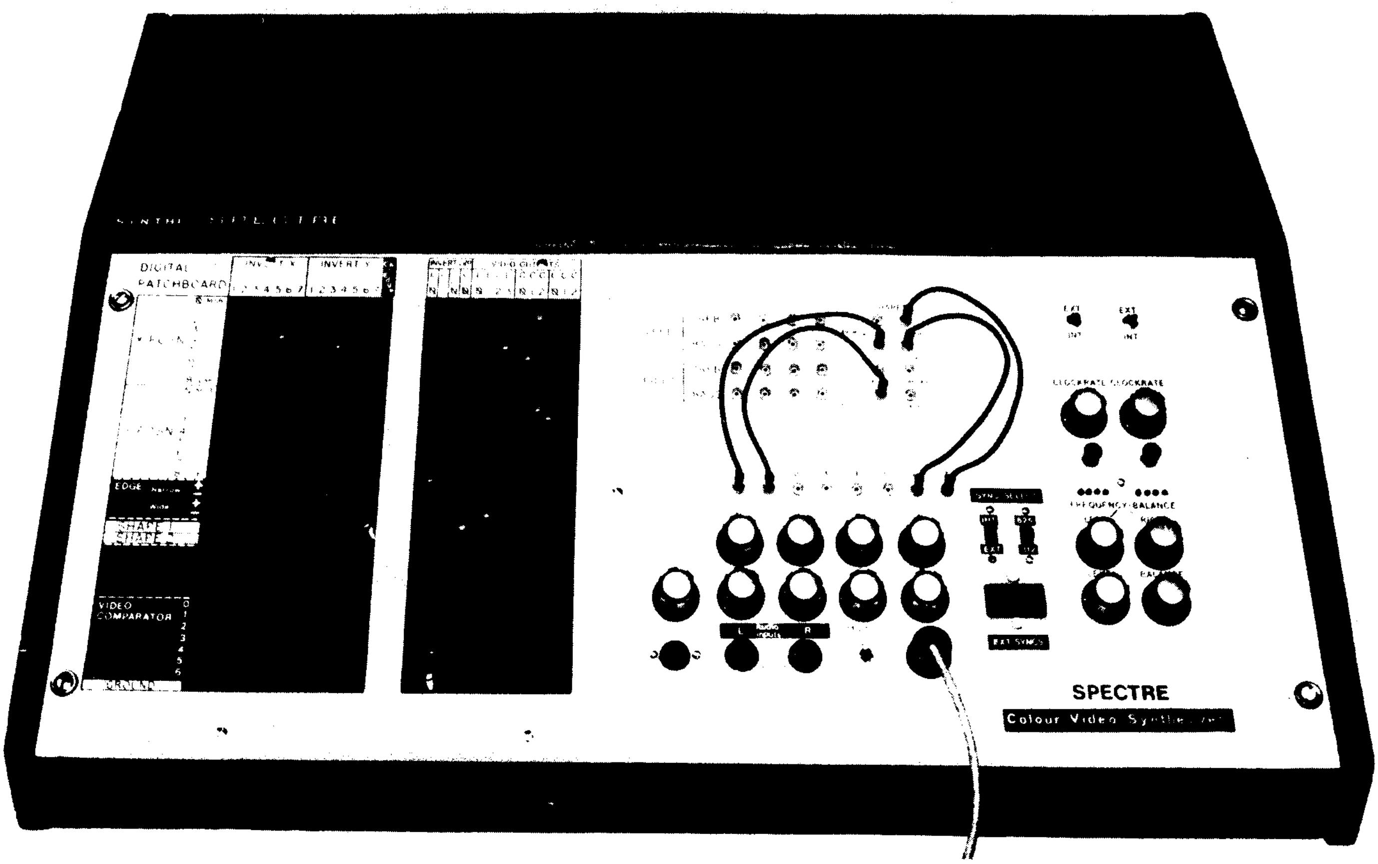


▲ **FIG. 1.** *Prototype of the EMS Spectre video synthesiser.*

JUST AS sounds of an extremely wide perceptual difference may be produced by the now well-known electronic sound synthesiser, using a surprisingly small number of sound sources and modifiers; so may a similar concept of sources and modifiers be combined to produce static and moving abstract colour images on normal 625 PAL video format.

Patterns with very deep psychological ambiguity – resembling the illusions used by the graphic artist M. C. Escher - may be produced in many forms. Such ambiguity is often found in video patterns, especially when edges are introduced making the layers more apparent.

Up to now there has been little work on direct video synthesis – most effects units (such as wipe generators, chromakey units, and colourisers) have been kept separate, and only used directly to treat signals that originate from a conventional camera-scene set up. In our *Spectre* video synthesiser, a different concept has been used; rather than produce another special effects unit I have endeavoured to group together units with a high perceptual impact in a way that gives total freedom to combine shapes and colours logically, and in a very general way.

A picture of the prototype video synthesiser is shown in **fig. 1.** The heart of the video synthesiser is its digital signal matrix board. Similarly arranged to the analogue patchboard used in our sound synthesiser, video sources and modifier outputs appear down the left hand edge of the board while inputs to modifiers, and to the video outputs that produce the final image, appear at the top of the patchboard.

Signals on this patchboard are carried in digital form because crosstalk problems at video frequencies make an analogue patchboard well nigh impossible. This digital method of building up images does however, have definite advantages:-

A purely digital (high or low, 0 or 1, only two states) signal, in video terms, will only give information on form. For example, a digital signal representing a circular disc might be low over the portion of the scan within the circle, and high outside this area. The signal specifies shape and area, but not texture, colour, brilliance, or apparent spacial position. These secondary parameters may then be added as desired by combining the original signal with other digital signals in logical ways and finally controlling the output columns for colour and brilliance in a particular combination to produce the required hue.

Let us examine in more detail the basic operation of this method of digital signal patching. For those unfamiliar with the matrix board method of patching, I suggest you refer to the review of one of our audio synthesisers in *Studio Sound* (February 1973).

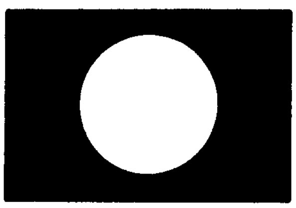
The functions

The sources available to the user on our production model will be as follows:

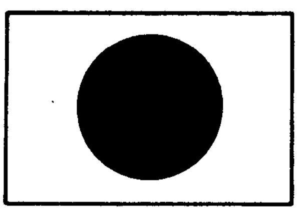
X (horizontal) counter. This produces vertical stripes, the width going down by a factor of two between adjacent

FIG 2. Function of inverters

Start with black screen

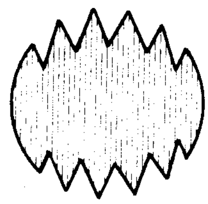


Circle (shape No 0) patched to output LO



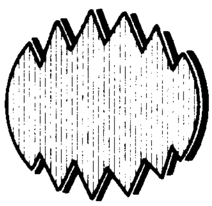
Circle patched to inverter. Inverter patched to LO

FIG 3. Action of edge generators



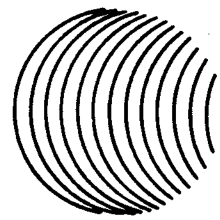
'Gear' shape alone.

Output of edge generator with Gear patched into it



Gear with edge (the edge may be any independently chosen hue and shape).

FIG. 4 Echo oscillation.



Echo oscillation on the inside of a circle shape.

pairs of the nine different outputs. Each output may be phase-inverted by grounding its appropriate 'invert' input. These invert inputs provide all the necessary logic to produce very interesting patterns using only the counters.

Y (vertical) counter. This produces horizontal stripes analogous to the *x* counter.

Slow counter. This gives six outputs that change state during frame flyback. They have binary multiples of frequency, varying from 6 Hz to 0.15 Hz. These outputs may be used to produce all sorts of flash changes and movements.

Overlay gates. These are designed to create the illusion of depth by placing layers of moving patterns, one on top of another. The signal representing the back pattern is patched into SIG and all the patterns that are to cover this back pattern patched into DIS. The output of the overlay gate is then fed to the output columns as required. The procedure is then repeated for each pattern layer. There are many other uses for the overlay gates, which effectively only allow the signal to pass through when the disable input is not pulled low.

Inverters. It may be desirable to use the background of a shape or pattern rather than the pattern itself, in which case the signal must be patched through an inverter (see **fig. 2**).

Edge generator. This produces an apparent edge to a pattern or shape which may be used in conjunction with the shape itself to produce a 'cut out of plywood' appearance (see **fig. 3**). There are four edge outputs depending on whether a narrow or wide edge is required and whether it is to appear on the left or right of the original shape.

Delay. This just delays the signal by 0.6 μs. This gate may be used in conjunction with inverters to produce different edge effects and echo oscillation (see **fig. 4**).

Flip flops. These will halve the horizontal spacial frequency of any form patched into them, the phase of the output depending on which flip-flop is used. They may be used to divide down the width of the 'echo-oscillation' described above. One output may be patched into the other to make a divide-by-four circuit. They can also be used to fill out shapes that start as outlines.

Shape generators

There are two identical shape generators; both produce two outputs, each of which is preselected from one of sixteen possible outputs. The selection is indicated in binary form by the combination of four panel light-emitting diodes (for example, 0000 is the circle output, and 0010 is the 'gear' output mentioned before). The selection number may be advanced manually, or allowed to cycle round at a predetermined rate.

The shapes themselves are not fixed, but may be distorted by analogue control voltages. There are eight control inputs to each shape generator, namely:

1) Horizontal position.
2) Vertical position.
3) Horizontal 'zoom'.
4) Vertical 'zoom'.
5) Circle size.
6) 'Gear' size.
7) 'Frizz' size.
8) 'Lantern' size.

Not all of these control inputs apply to every shape. For example, the circle

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is only altered by horizontal and vertical position and by circle size.

Suppose we select a circle (panel combination 0000) on shape generator One, output A, and patch it to LO. We will get a light green circle on a dark green background. Now, using the control patchboard we may patch oscillator One to control the circle size. If we use a sine wave at a frequency of about 1 Hz, the size of the circle will undulate once every second. Now if the oscillator frequency is increased to 50 Hz (the vertical scan rate), the circle will appear distorted in the way shown in **fig. 5.**

The 'blob' thus produced will go through gyrations similar to the motions of the oil in a decorative mobile lamp.

If the oscillator frequency is once again increased to a few kiloHertz, the circle will take on a spiney appearance. These spiney patterns assume beautiful symmetry if the oscillator frequency bears an integer relationship to the line frequency (for example $nH=mO$ where H is the line frequency and O is the oscillator frequency; m and n being integers). The oscillators are specially designed to lock to such frequencies with the possibility of a small deviation so that the pattern may be made to rotate in one direction or the other.

By using two oscillators on two control parameters of a shape, an almost unlimited amount of variation and movement is possible. Apart from the circle, there are 15 other possible shape outputs.

Video comparator

This takes a black and white camera input signal and splits its grey scale up into seven bands. The spacing of these bands may be altered by a panel control or by a control voltage available on the control patchboard. On the digital patchboard there are seven output rows corresponding to the seven grey scale levels. When the camera 'sees' a particular brightness level, only one output will be active (low). This level (say on the second output row) may then be patched to a particular combination of output columns to obtain a particular hue and brightness level. Each of the seven grey scale levels may thus be independently coloured.

Because of its availability to all units on the digital patchboard, the video comparator has more potential than a straight colourer. By using it in conjunction with the overlay gates, the levels may be 'patterned' as well! The outputs of the comparator may feed any of the modifiers to produce some very strange effects. These are extremely striking when used on an

FIG. 5. Modulated circle.
Appearance of circle when size modulated by 50 Hz sine wave.

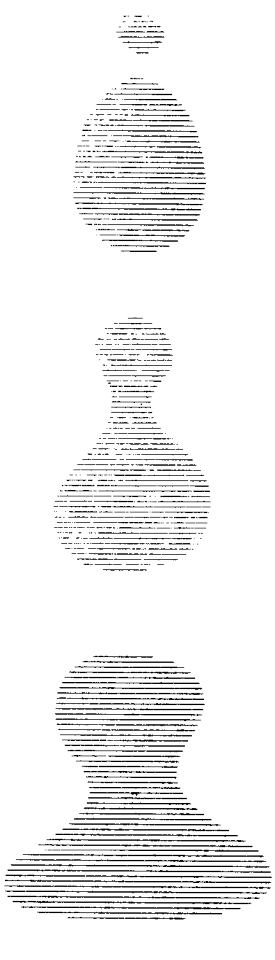
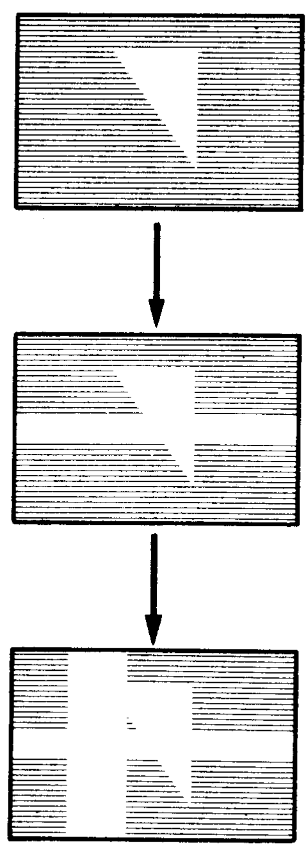
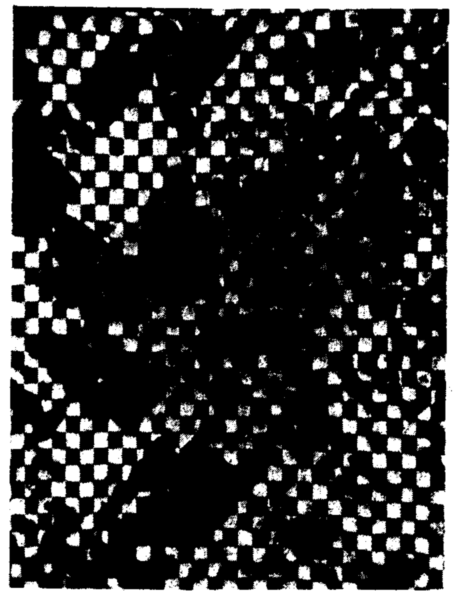


FIG. 6. Wired OR action of output column.
Patching more signals into the same output column combines them in a way rather like cutting out cardboard. The same combinational logic applies to all the columns on the matrix board.





▲ *Geometric pattern produced with X-Y generators, with circle overlay. Video feedback is combined to produce colour shifts.*

▼ *Simple geometric pattern and 'zoom' shape, with feedback superimposed.*

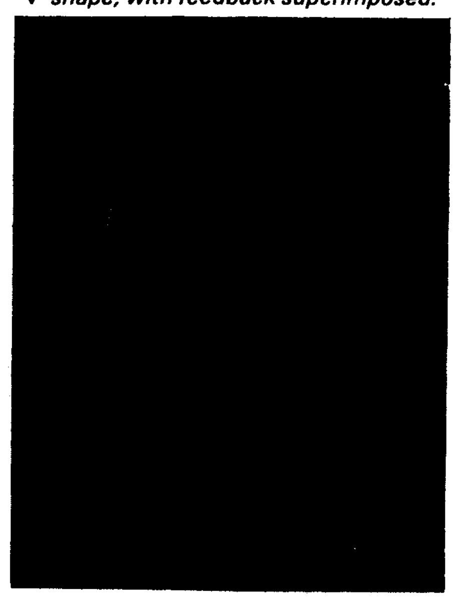


image of a human face, as can be seen from the front cover of this issue.

The final output

Up to now we have not really discussed the logic of the patchboard and how the output columns show different effects. On the digital patchboard there will be seen two sets of output columns (A and B). Each set consists of ten columns, split into three groups: L, C1 and C2. L (Luminance or brightness) has four columns, C1 (bias red) has three, and C2 (bias blue), has three also.

The state of any row or column on the digital patchboard can only be high or low. With no pins in the matrix board, the output columns will be high. Signals patched into an output column will pull its logic state low when they are low. Only one of the signals patched into the same output column needs to

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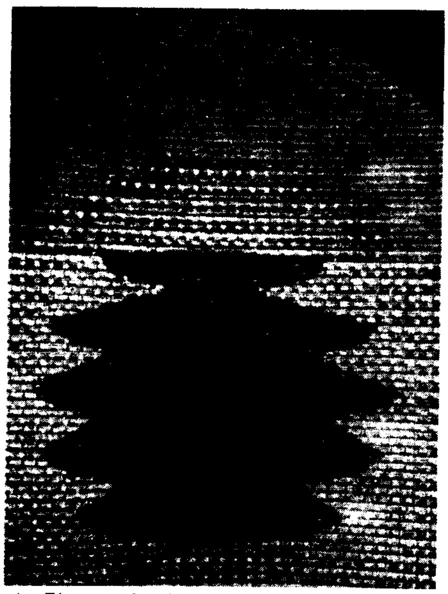
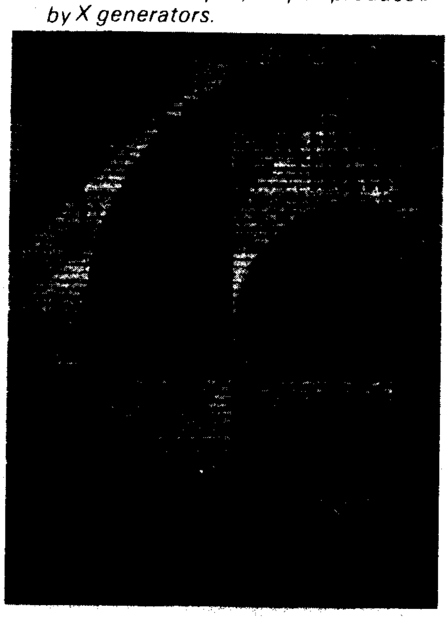
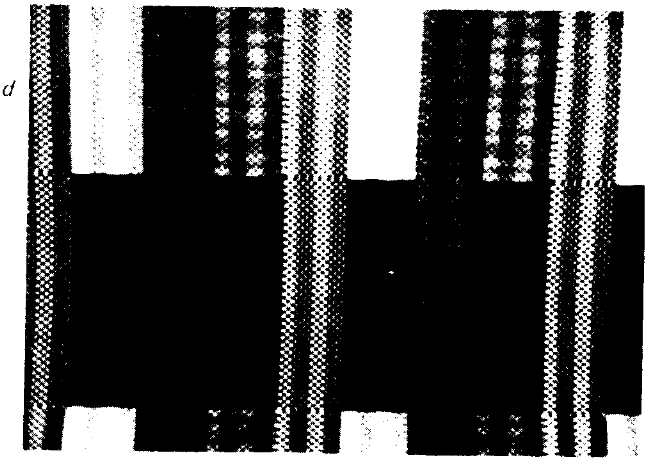


▲ *Electronically-generated image using circle, gear and lantern shapes.*

▼ *Also purely electronic – using lantern and 'zoom' shapes, stripes produced by X generators.*

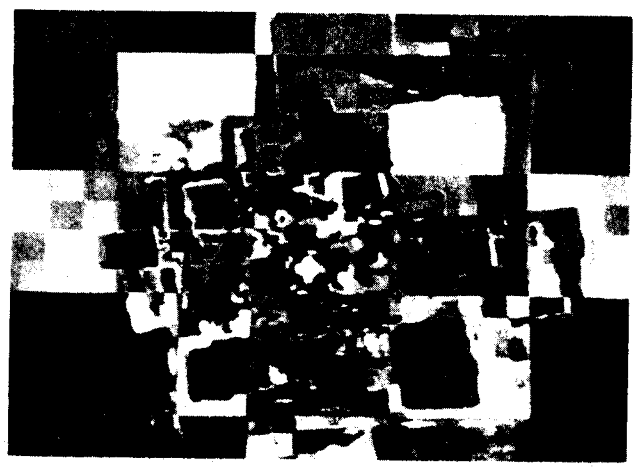


▶ *Complex electronically-generated pattern, making extensive use of signal inverters.*



▶ *Black-and-white camera signal colourised and superimposed over an electronically generated background pattern.*

▶ *Geometric pattern with circle and feedback used to invert colours.*



▶ *Horizontal 'zoom' shape being modulated by the sine wave output of an oscillator, feedback superimposed.*

be low to pull the output low. In image terms, patching more and more signals into the same output column is like carving away a piece of black card to expose a white surface behind – one can never add a new area of black (see **fig. 6**).

Referring back to the two output columns; with nothing patched into output column B, the screen will be dark. Connecting one of the output A luminance columns to ground (bottom row) will increase the brilliance. L0 will have twice the effect of L1, which in turn will have twice the effect of L2 and so on.

The output columns may be used in combination. The code for these combinations to achieve gradually increasing levels of brilliance, is the usual binary code shown below:

	L0	L1	L2	L3
1 Black				
2				X
3			X	
4			X	X
5		X		
6		X		X
7		X	X	
8		X	X	X
9	X			
10	X			X
11	X		X	
12	X		X	X
13	X	X		
14	X	X		X
15	X	X	X	
16 White	X	X	X	X

It may be of help to refer to the drawing of the front panel (**see fig. 7**).

The three C1 columns give eight binary combinations which bias the picture red. The C2 columns also give eight binary combinations, but these bias the picture blue.

A special matrix ensure that colours do not lose their saturation as the luminance is increased. For example, once we have set red up using the C1 and C2 columns, grounding more luminance (L) columns would just make this red brighter – not more pink and pale.

Control parameters

Voltage control inputs exist for biasing the two colour parameters, the brightness of the picture, the video comparator level spacing, and for the shape generators. These are available to the user on a smaller 'analogue control matrix'. Sources which may be patched into these voltage control inputs in any combination are as follows:–

1) Two oscillators with sine and square wave outputs. These have a very wide range (0.1 Hz to 30 kHz), are extremely stable, and may be very finely controlled.

2) A random voltage generator with two outputs and slew rate control. A switch allows the last 16 events to recycle.

3) Four control slider input voltages.

4) Treble and bass envelope following from any audio input. The buffered audio signal itself being available.

5) Two buffered filtered outputs from the digital signal matrix, one with a time constant of about 700 μs and one with a time constant of about 1 μs (on the DSM there are two columns to which signals may be patched to influence these outputs).

6) A buffered external input for adding control signals from any external input. If two external signals are required, the audio signal input may be used as well.

Video graphics

As one can see, the possibilities are almost limitless. Camera feedback, in my opinion, forms an essential part of video graphics. The recycling transformations that it can produce can barely be done electronically at the moment – certainly only at the borderline of technology, with obvious expense. A random access frame store is what is necessary, with ultrafast trigonometric computation for simulating the zoom and rotation of the camera. More than one picture-point value would have to be mixed to simulate defocusing.

Certainly this is just the beginning of a whole new era in visual art, in which video graphics are going to play a large part.

Monochrome off-screen reproductions of colour originals, being Spectre-processed versions mainly of the centre monochrome photograph. ▶

FIG.7