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R. W. FENTON

A NEW SOLID-STATE VISION MIXER

INTRODUCTION

A vision mixer is one of the most important equipments in a television studio. It is the equipment which enables live productions to be made from a number of cameras. Unique to television, it has no real time equivalent in the film industry and yet its development during the short history of television has enabled it to provide all the special effects which are common to film production. Mixers have been made in great variety to meet the requirements of particular types of production. They range from the 'home made tin box' with a changeover switch to select one or another camera in a news studio, to electronic marvels which enable pictures to be mixed to unrecognizable limits. Between these extremes it is possible to specify two mixer configurations which will satisfy a large proportion of present day needs. At the less sophisticated end of the scale, a mixer having eight inputs and offering 'cut', 'mix' and 'wipe' transitions provides for small studios and outside broadcast vehicles (Fig.1). For large studios, where film and tape inserts to a programme are required, the sixteen-input mixer (Fig.2) is ideal. This mixer offers 'cut', 'mix' and 'wipe' transitions and in addition it is possible to 'wipe' to a 'mix' or 'mix' to a 'wipe'. A separate control panel associated with the special effects equipment provides for coloured captions and self key operation (Fig.3). Both mixers are equipped with a master fader and a by-pass circuit. The fade is to 'colour black' and the by-pass routes the output of the cut buttons directly to transmission.

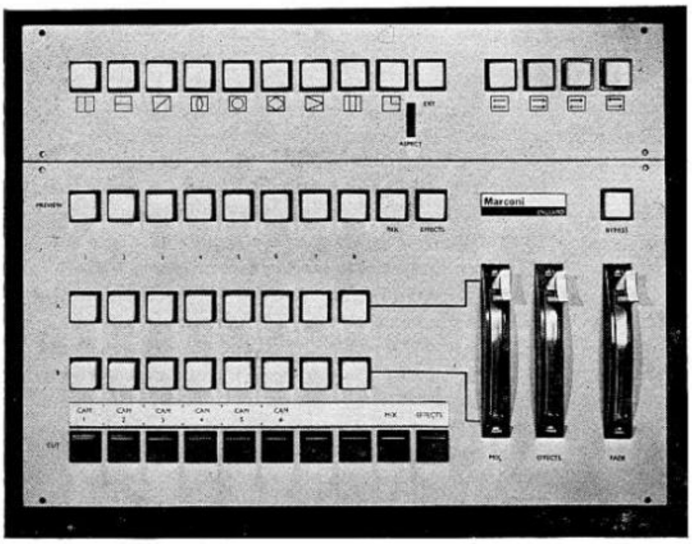

Fig.1 Control panel of the eight-input mixer; it may be used without the pattern selector panel.

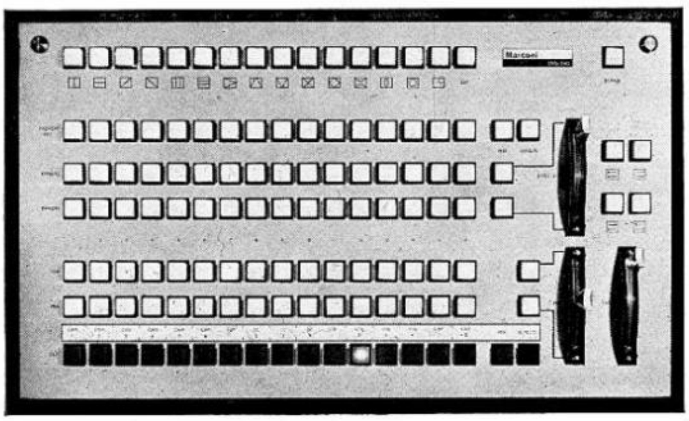

Fig.2 Control panel of the sixteen-input mixer; the buttons marked with arrows select Normal-Auto-Reverse operation of the wipe control.

CHOICE OF FACILITIES

The choice of mixer facilities is an important issue; great care has to be taken to provide sufficient operational flexibility while maintaining an adequate video performance. As part of a modern studio complex, a mixer represents a very small part of the video path and so it may only contribute a similarly small proportion of the total allowable signal distortion. Distortion may be divided roughly into two categories. The first – crosstalk – is largely dependent on general system complexity and the number of inputs used. Since there is no alternative but to accept the inputs, all attempts to minimize crosstalk must be directed at providing a simple system. The system should, therefore, contain a minimum number of parallel paths. The second form of distortion relates to signal linearity – for example, K rating, differential phase and gain, gain stability and

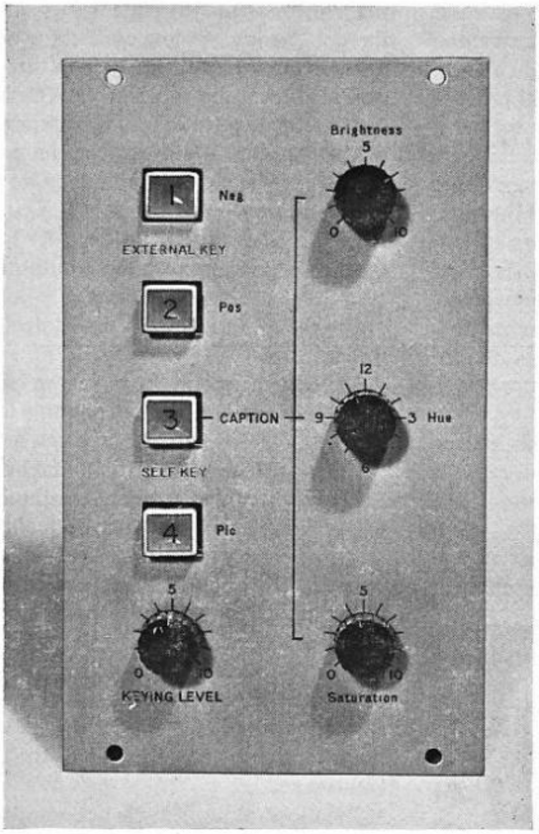

Fig.3 Special effects remote control panel; the hue control covers the entire colour triangle.

so on. All these performance aspects are dependent on the number and complexity of series connected units. To achieve the best signal linearity it is important to provide a path containing the least possible number of units. To satisfy these needs and retain maximum operational flexibility the double re-entry type of mixer is a good choice. Each operational function is derived only from those parts of the mixer necessary and remaining parts are switched away so that a maximum performance level is maintained at all times.

Further performance improvements may be brought about by the correct choice of processing amplifier. Generally a complex processing amplifier is used with a mixer. This is usually necessary to stabilize sync and burst amplitudes and to white clip when using the mixing amplifier in the split-paddle mode. The usual reason for split-paddle working is for 'burning in' captions. This facility has been commonly used in black-and-white, but in colour it has become more usual to use the special effects for captions. In this way it is possible to generate clean captions of any desired luminance and chrominance value. Furthermore they may be generated in a manner which prevents over modulation with the result that peak white clipping is no longer a necessity. If the mixer configuration allows the mixing amplifier to follow the special effects, then it may be used to fade captions in and out. To do this the mixing amplifier is used to cross-fade between the original signal and its captioned counterpart developed in the special effects. Thus there is no requirement for split-paddle working and it follows that the mixing amplifier may be designed to operate from a single paddle. Immediately single-paddle operation is chosen, improvements to cross-fade linearity specifications are practical. This is because two of the weakest crossfade performance aspects are eliminated – fader matching and mechanical coupling errors. With a properly designed mixing amplifier it is possible to ensure that the sync and burst amplitudes are constant to within one or two percent. At this level of stability there is no need to use sync and burst stabilization in the

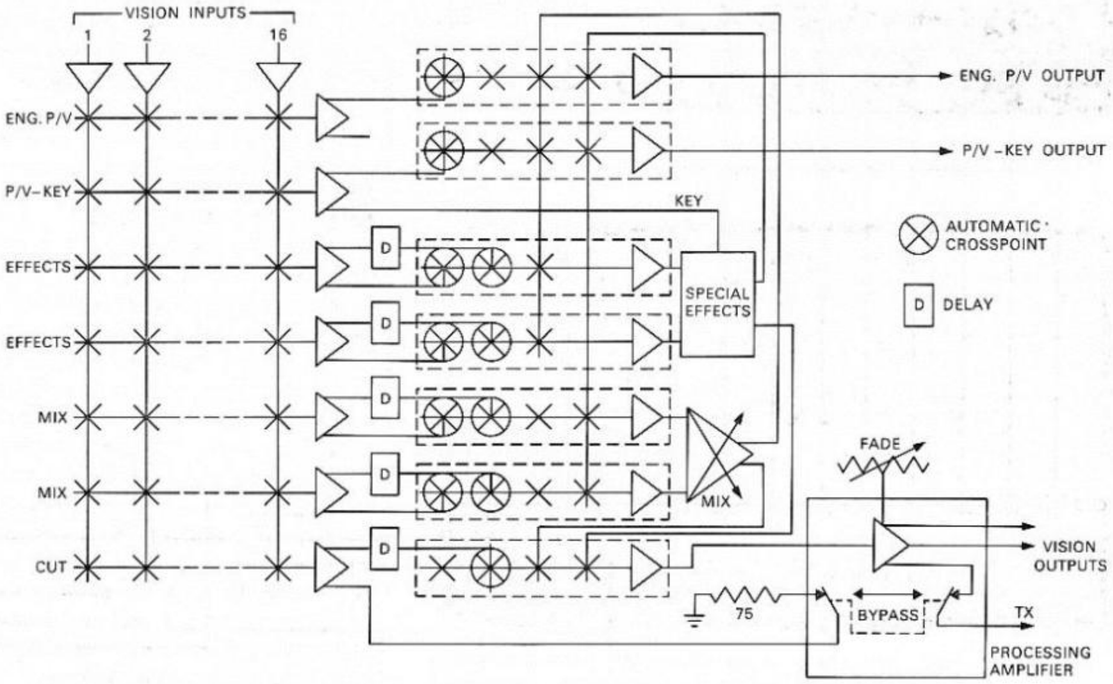

Fig.4 Vision facilities of the sixteen-input mixer; two outputs are available from both preview rows.

processing amplifier. The processing amplifier is merely required to clamp (to remove unwanted low-frequency distortion) and to provide fading facilities and a by-pass circuit. Mixing and processing amplifiers of these types are used in both the eight and sixteen-input mixers.

Figure 4 shows the video facilities diagram of the sixteen-input mixer. The matrix has seven outputs; two are used for preview and are backed up by four input, one output switches to enable the effects and mix outputs to be previewed. The local preview is also used for keying the special effects when it is required, for example, to produce captions or special keying patterns. The engineering preview is controlled from a separate preview panel which is normally mounted alongside the special effects remote control panel. The effects and mix outputs are fed via 4×1 switches to the respective effects and mix equipments. The 4×1 switches allow either equipment to feed an input of the other and they also select the delayed or undelayed outputs of the matrix as appropriate for maintaining proper timing. The crosspoints controlling selection of the delayed and undelayed signals are automatically operated from the mixer logic. The logic, which is built from integrated circuits, maintains a knowledge of the status of the mixer circuits and directs new instructions from the control panel to the appropriate automatic crosspoints. The cut output of the matrix is also backed up by a 4×1 switch and is used to select mix or effects outputs for transmission. It is automatically reset to take the cut output of the matrix whenever a new selection is made in the cut row.

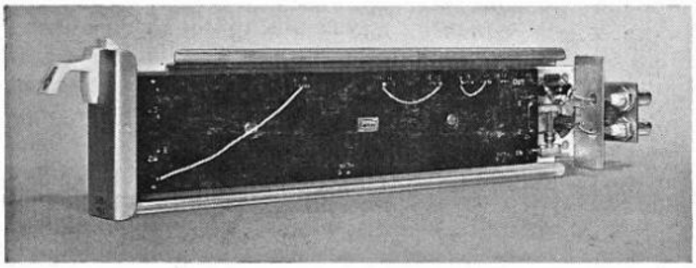

Fig.5 The lumped constant delay unit which is equivalent to over 100 metres of coaxial cable and is continuously variable.

The delays used in the mixer are lumped constant lines. They are binary tapped with a least significant section of 2·5ns and incorporate a fine trim delay section of 3ns range which enables precision adjustment of delays to equalize all mixer paths. The delay unit has a built-in equalizer to correct response errors and a typical unit is shown in figure 5. The values of delay selected are arranged to maintain the total mixer delay time equal to the sum of the mix and effects delays. This is the longest path in the sixteen-input mixer and is of the order of 450ns. The delay in the cut path is equal to the sum of the mix and effects delays whilst those in the effects inputs are equal to the mix delay and *vice-versa*.

The eight-input mixer is not equipped for self-key operation and the delay time is consequently very small – about 50ns. The delays required in the cut and mix paths to equalize them to the effects are small and are made up from short lengths of

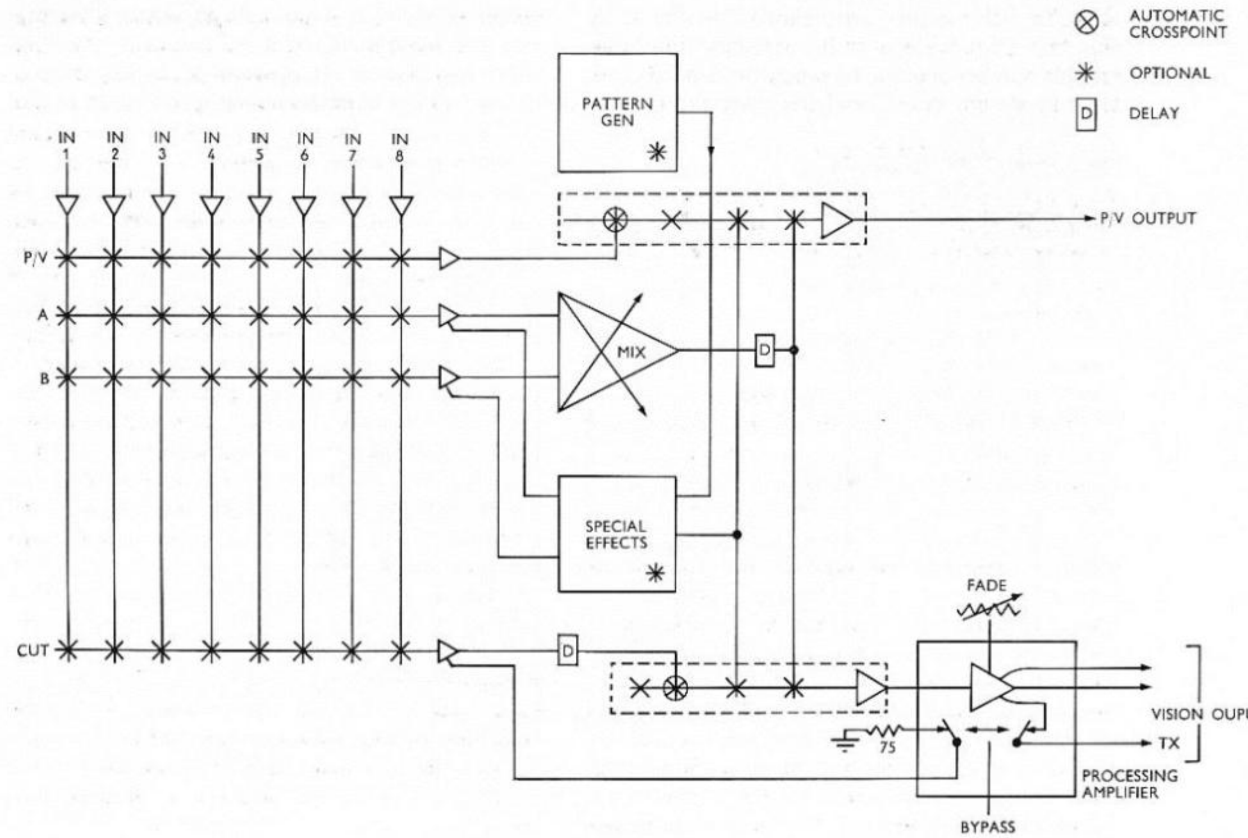

Fig.6 Vision facilities of the eight-input mixer; the delays are each made up from less than 10 metres of coaxial cable.

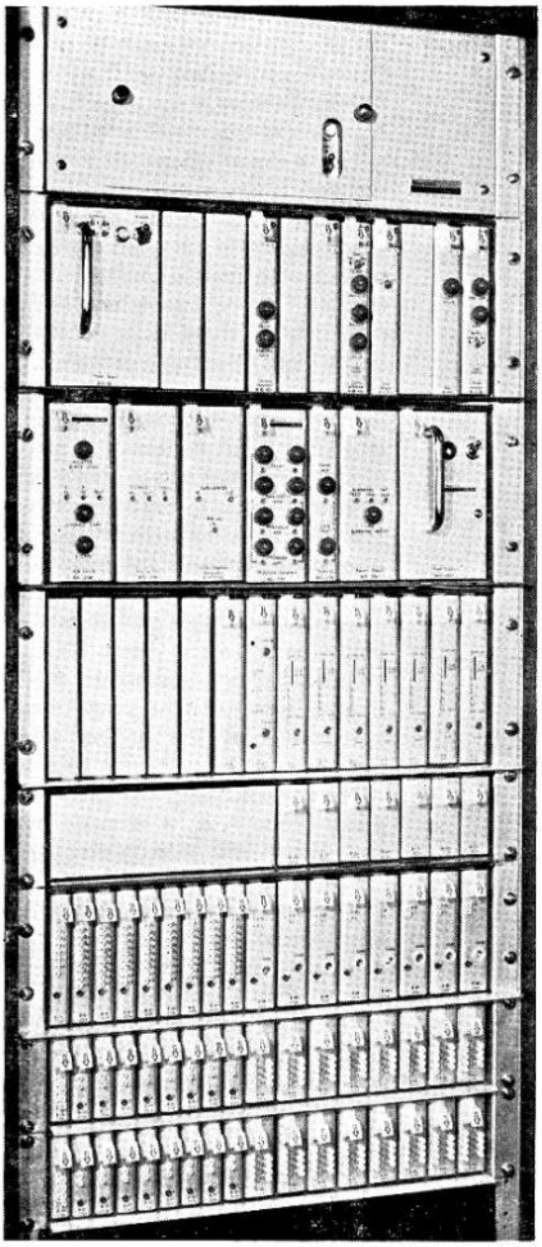

Fig.7 The rack layout of the sixteen-input mixer; the space taken is 110cm.

coaxial cable. The facilities offered by the eight-input mixer are illustrated in figure 6.

It will be noted that with the exception of the re-entry facilities and separate mix and effects matrix outputs, the two types of mixer are similar. Both utilize a sync/non-sync panel which is normally mounted at an engineering position and may be pre-set to prevent the selection of non-synchronous sources to the mix and effects equipments. The panel has eight keys and like the main control panels and preview panel carries a designation strip which can either take film markers or chinagraph pencil inscriptions. The modules used in the construction of each mixer are identical and may be used in special cases to provide other mixer configurations. The rack equipment used for the sixteen-input mixer is shown in figure 7. The lower three frames house the matrix, the next frame the delay units and

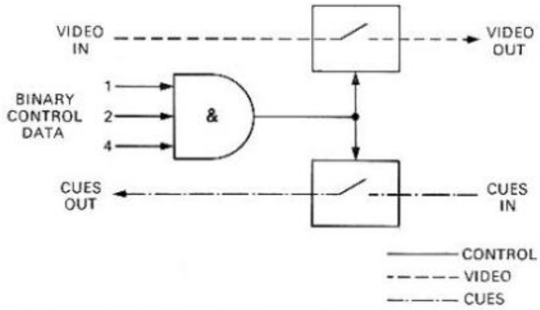

Fig.8 Functional diagram of the microcircuit crosspoint; the video and cue switches are identical.

above this is a frame housing the 4×1 switches, mixing amplifier and logic modules. The special effects and line clamp amplifiers are self-powered and are next above; these units have been previously described in detail in this journal.[1,2] At the top of the rack is the power supply unit which provides power to the remainder of the equipment. It has been designed to enable two or more units to be operated in parallel where extreme reliability is essential. The total rack space used is 110cm of which the matrix occupies 31cm.

MATRIX DESIGN

The heart of any mixer is the video switching matrix and the one used with the mixers described here is of a completely new design, laying special emphasis on minimizing crosstalk and making extensive use of microelectronic techniques. In formulating a design procedure for the matrix it was realized at an early stage that inactive crosspoints of the diode and relay types are not suitable if the best crosstalk performance is to be obtained. This type of crosspoint suffers from the disadvantage of transmitting signals in both directions. It is well known that the worst case crosstalk in a conventional matrix occurs when all outputs are connected to the wanted input. This situation exists because the crosstalk suffered by each output is fed back through operated crosspoints to the wanted input. This feedback may be eliminated by the use of active crosspoints which are virtually switched amplifiers, the use of which provides a matrix whose crosstalk is largely independent of the switching pattern. In large matrices, group switching is also useful in minimizing crosstalk; this in effect means dividing the inputs into groups, selecting one input of each group and then selecting the output of that group containing the required input. In this way unwanted groups of inputs each count as a single crosstalk signal. The crosspoints used are active and two similar crosspoints are packaged together with an 'and' gate in the form of a multichip microcircuit (Fig.8). The second crosspoint of each microcircuit is used for switching cues and the 'and' gate is used to decode binary data to control the switching circuits. Binary control has been chosen for its wiring simplicity; five wires can carry all the information needed to select one of thirty-two inputs.

The matrix inputs are arranged in groups of eight

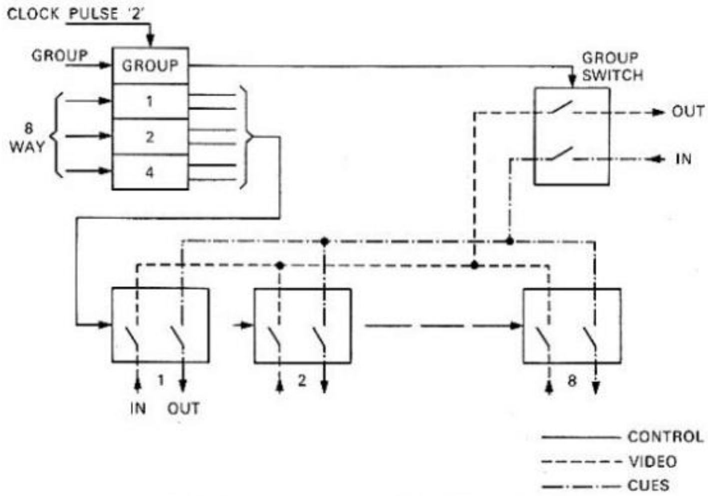

Fig.9 Function diagram of the 8×1 switch; the numerals 1, 2 and 4 indicate the decimal weightings of the flip-flops.

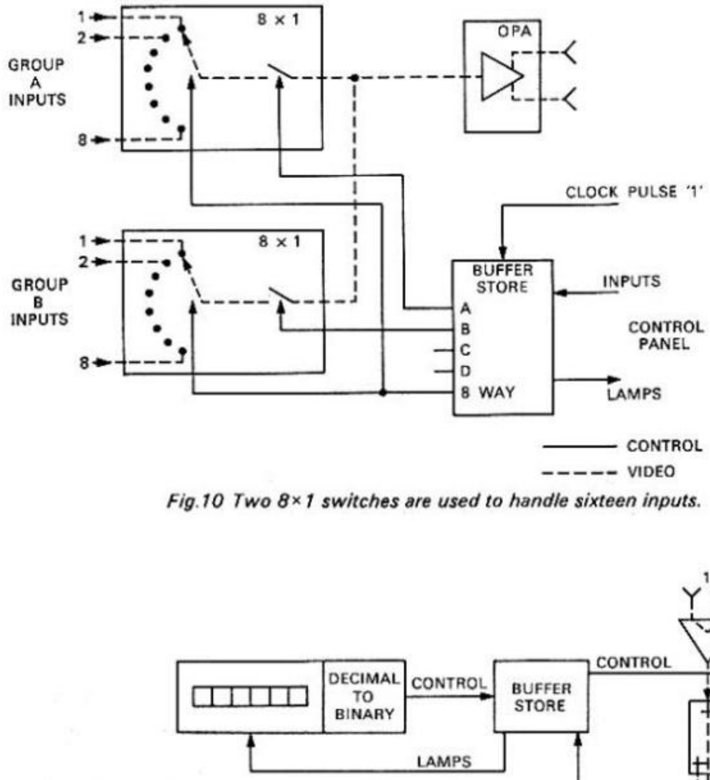

Fig.10 Two 8×1 switches are used to handle sixteen inputs.

which are handled by 8×1 switching modules each containing nine crosspoints (Fig.9). Eight crosspoints are controlled by binary signals fed from the flip-flops shown at the top left. The video output of the selected crosspoint is fed by the parallel output circuit to the group switch. Here it is passed when required to the output amplifier and at the same time incoming 'on air' cues are passed by the group switch to the eight crosspoints for routeing back to the matrix sources. The three flip-flops labelled 1, 2 and 4 each have one of their two outputs uniquely wired to each of the three data inputs of the input selecting crosspoints. In this way each of the eight possible patterns of stored information activates a single crosspoint. The fourth flip-flop, labelled 'group', controls the group switch. When input instructions select a new input, all four flip-flops are clocked by the common clock pulse. A very fast video switching action results, so fast in fact that unwanted transients fall outside the video band, leaving the video signal completely clean.

Two 8×1 switches may be used to handle sixteen inputs as shown in figure 10 in which the eight inputs-selecting crosspoints are represented by rotary switches and the group crosspoints by single-pole switches. The control information to the eight-way switches causes each to select an input of the same number. The final choice of input from either group A or B is made by the single-pole switches. It will be seen that there are only eight crosstalk signals, seven from the selected group and one from the other. Without group switching there would have been fifteen, making the overall crosstalk nearly 6dB worse for the same crosspoint specification.

The buffer store at the bottom right is used to back up the momentary control panel switches. It stores five-bit binary information sent from the control

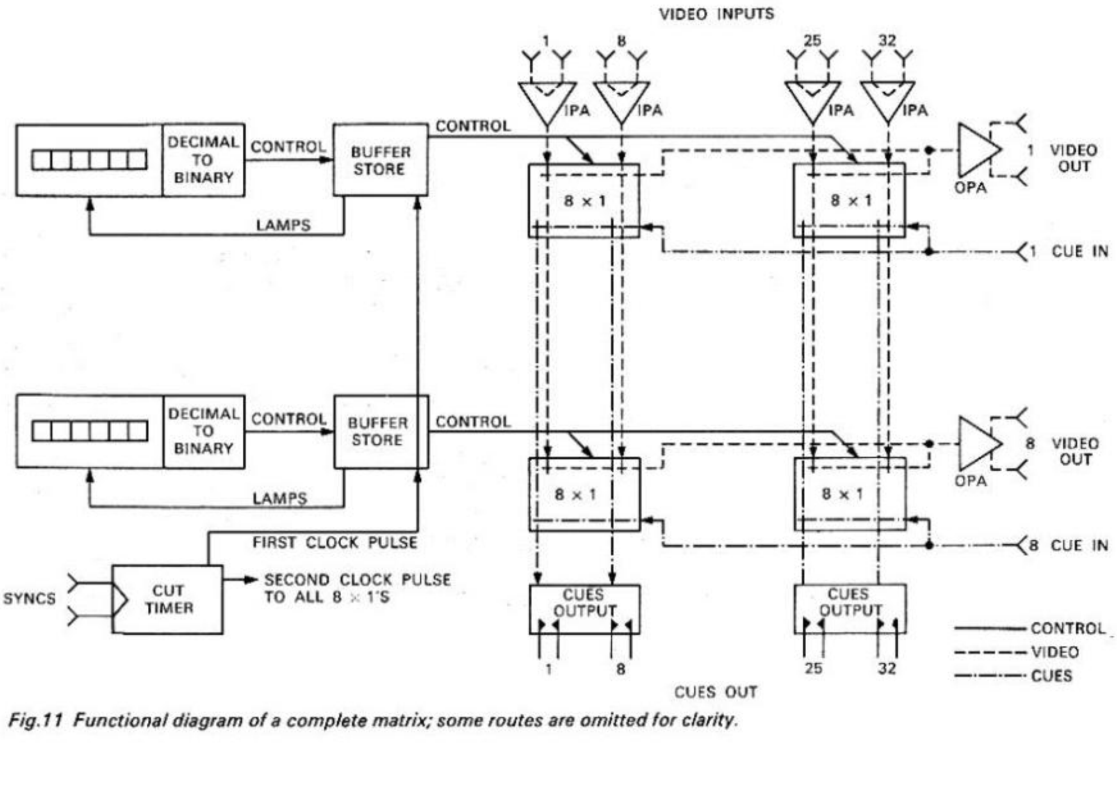

Fig.11 Functional diagram of a complete matrix; some routes are omitted for clarity.

panel and also operates the control panel lamps. Output signals to the 8×1's comprise a three-bit binary signal which are the three least significant bits stored and control the eight-way switching. The A, B, C and D outputs each control the group switches of up to four 8×1's and are decoded from the two most significant bits stored. Fully used, the buffer store can control the thirty-two inputs of four 8×1 switches.

Video switching occurs in the field blanking interval and is timed from a cut timer module which accepts a local mixed sync input and produces two outputs. In the absence of a sync input, the outputs are maintained by an internal field-frequency oscillator. The two outputs are used to control first, the buffer stores and second, the 8×1 switches. The first output – clock pulse one – occurs during field syncs and causes the buffer stores to be loaded with control panel information. At the same time the control panel lamps are switched and control information is passed to the 8×1 switching modules. The second pulse occurs about 500μs later and clocks the flip-flops of the 8×1 modules to cause the selection of the new video source. This timing ensures the transmission of the field syncs from the last video source selected before a new selection. This feature is necessary to prevent monitor vertical roll when switching to a non-synchronous source.

The build up of a complete matrix is shown in figure 11, at the left of which are the input selection buttons – one set for each output. The control information is encoded to binary by simple diode encoders at the control panel. It is accepted by the buffer stores at the time of clock pulse one and passed to the 8×1's. At the arrival of clock pulse two the 8×1's switch to the selected source. Video input amplifiers, one for each input, feed the 8×1's in parallel. The video input amplifiers incorporate a d.c restoration circuit, thus minimizing picture level shift when cutting between sources. This feature helps to provide clean cutting at the preview outputs and greatly reduces the task of the line clamp amplifier at the transmission output. Output amplifiers provide two isolated 75 ohm outputs from a parallel combination of up to four 8×1's. Cue inputs, one for each video output circuit, are switched via the 8×1's to the cues output units. These handle eight outputs, each in the form of a pair of closing reed relay contacts. The use of relays for this function is necessary because equipments which require cues have various voltage and current operating levels for which relay contacts are the best interface. It is hoped that in the future such cues may be transmitted as logic signals and the use of relays completely eliminated. The maximum size of the matrix is thirty-two inputs by eight outputs and it is interesting to note that in this case, each output sees only ten crosstalk signals.

CONCLUSIONS

Two mixers have been described which will satisfy a large number of production requirements; they are built up from modules which may be used to furnish other mixer configurations. The matrix, utilizing microcircuit crosspoints, has a wide application in the mixer field. Built up towards its maximum size it becomes an ideal matrix for use in presentation mixers and assignment switchers. The use of active crosspoints and group switching enables crosstalk figures as low as 60dB to be obtained for full sized matrices. Vertical interval switching is used not only in the matrix but also in the 4×1 switches and provides transient free switching while binary control techniques reduce cabling requirements and improve reliability.

REFERENCES

1 R. L. Greenfield: Solid-State Special Effects Equipment; *Sound and Vision broadcasting*, Vol.8, No.1, Spring 1967.

2 R. L. Greenfield and J. N. Helsby: Versatile Line Clamp Amplifier; *Sound and Vision broadcasting*, Vol.9, No.2, Summer 1968.