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SOLID-STATE SPECIAL EFFECTS EQUIPMENT

INTRODUCTION

One of the interesting aspects of television is the possibility of producing many artistic effects electronically. The equipment described, Electronic Switch type B3740 and Pattern Generator type B3742, has been developed to provide producers with an improved versatile tool to achieve these effects. The performance, stability and flexibility are better than the previous Electronic Switch (type 6155) and Pattern Generator (type BD855) which it now replaces. Previous Pattern Generators have suffered from the defect that as the wipe control is moved fairly quickly in either direction the actual wipe is slower in one direction than the other as viewed on the picture. This limits the rate at which wiping between two pictures can be accomplished. New circuit techniques have been devised which eliminate this deficiency and enable fast wipes to be achieved in either direction. In addition, new techniques have enabled the more difficult patterns, such as the circle, to be brought down to much smaller dimensions before ragged edges and break-up of the pattern are observed.

Operation on 405, 525 and 625 lines is provided for, no adjustments being necessary to the Electronic Switch, and the only adjustments for the Pattern Generator being to readily accessible front panel controls.

FACILITIES

Probably the most well-known use of this type of equipment is that of wiping, whereby one picture is removed from the screen and is replaced by another, the sharp transition from one to the other taking the form of a regular pattern moving across the screen. The simplest form this pattern can take is a vertical dividing line between the two pictures, revealing gradually more of one picture and less of the other. If this transition is held stationary in the centre of the screen the well-known split-screen effect is obtained whereby, for instance, two people can be seen apparently talking directly to each other, although possibly separated by a considerable distance.

Much more complicated patterns can be used to effect the change from one scene to another. The possible number of different patterns that can be achieved in the new Marconi Special Effects equipment (shown in Fig. 1) is in excess of two hundred, and by reversing the sense of direction this figure is doubled. Some of the possible patterns are shown in Fig. 2.

Provision is made for varying the aspect ratio of the corner insert pattern so that it can be used, for example, to show the time on a stop-watch during a race, or to show the starter at the beginning of the race. Different aspect ratios are desirable for these two examples and the Pattern Generator portion of the equipment is designed to provide this facility which also serves to adjust the shape of certain other patterns.

Another feature of the equipment is the facility for self-keying, or overlay as it is sometimes called, where, for instance, a ballet dancer is made to appear to be dancing on a person's hand. The dancer would be dressed to contrast with the background, often a white dancer in front of a black background, and the signal from a camera viewing this scene would be fed into one side of the Electronic Switch and also used to provide the keying signal, whilst the picture of the person's

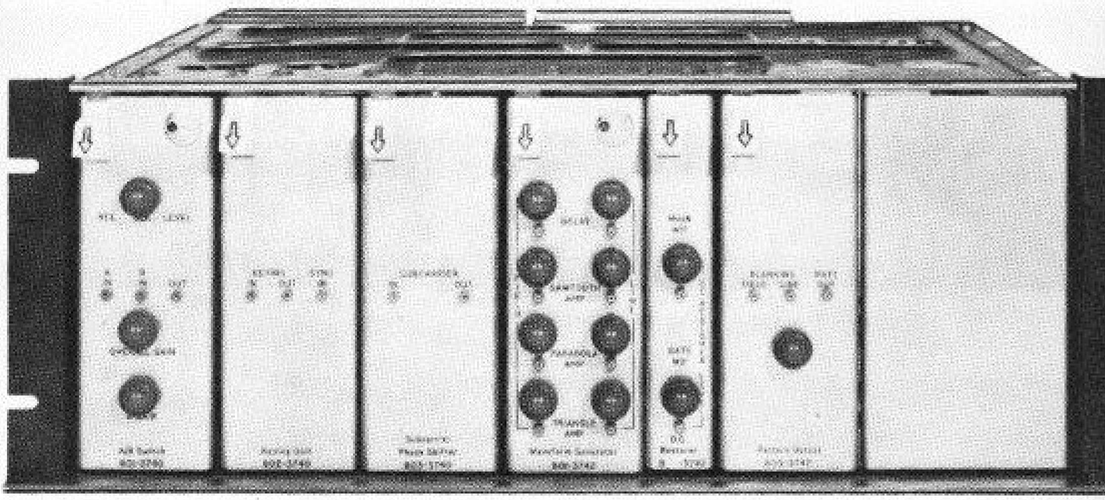

Fig. 1. Front view of Special Effects Equipment.

hand would be fed into the other input of the switch. When the signal from the camera viewing the dancer exceeds a preset threshold level this picture would be passed through the switch. When the signal level falls below this threshold level, i.e, during those portions of the picture corresponding to the background, the second signal would be passed. Hence the dancer cuts a hole in the second picture to conform to her outline and then fills in this hole with her own picture.

Another way of achieving a similar result is by 'chroma keying', and in this case the dancer would be preferably dressed in a primary colour and the background would be of a different primary colour. One of the primary outputs of a colour camera viewing the scene (red, green or blue) would be a signal corresponding to the dancer alone. Using this as the keying signal, an improved keying performance results as there will be a much lower level of spurious signal arising from the background. Spurious signals give rise to false triggering of the Electronic Switch, but providing their amplitude is kept below the threshold level then such triggering does not occur. The 'chroma keying' method is thus a simple way of achieving this improvement. This type of keying signal would be fed into the external key input on the Pattern Generator.

A further feature of the equipment is the provision of caption facilities. A signal from a caption source, such as a flying-spot scanner or vidicon camera producing white lettering, is used as the keying signal. Whenever the caption signal exceeds the switching threshold, the picture being fed into the Electronic Switch is cut off and is replaced by an internally generated signal of adjustable amplitude. This enables the caption brightness, which is inherently uniform over the area of the caption due to its being regenerated, to be continuously varied from black up to peak white, thus enabling the producer to select the appropriate brightness to contrast the caption with the picture for maximum legibility. If the main picture is an NTSC colour signal then subcarrier may be added to the caption by using the subcarrier phase shifter module. This adds subcarrier which can be varied in phase by a remote hue control. Phase shifts corresponding to red, green and blue are provided by push-buttons supplemented by a fine hue control to obtain the intermediate colours. By using this facility the producer can control the colour of the caption in addition to its brightness. Further elaboration is possible by using the Pattern Generator as the keying signal source in place of a caption scanner, when a multitude of coloured patterns may be superimposed onto the picture.

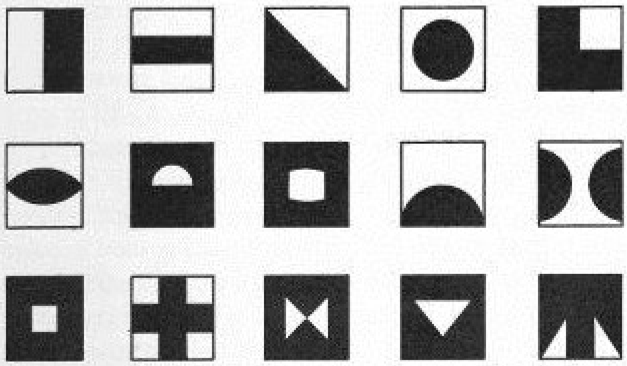

Fig. 2. Some of the patterns obtainable from the Pattern Generator.

CONSTRUCTION

The complete equipment comprises an Electronic Switch type B3740, Pattern Generator type B3742, and a power supply, all housed in a modular frame occupying 7-in height of a standard 19-in rack.

The individual units are formed of modules which slide in the frame and plug into connectors mounted on

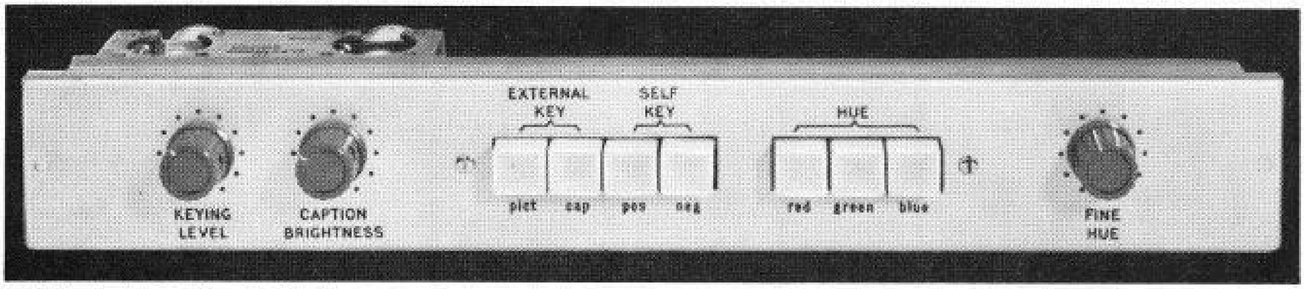

Fig. 3. Electronic Switch control panel.

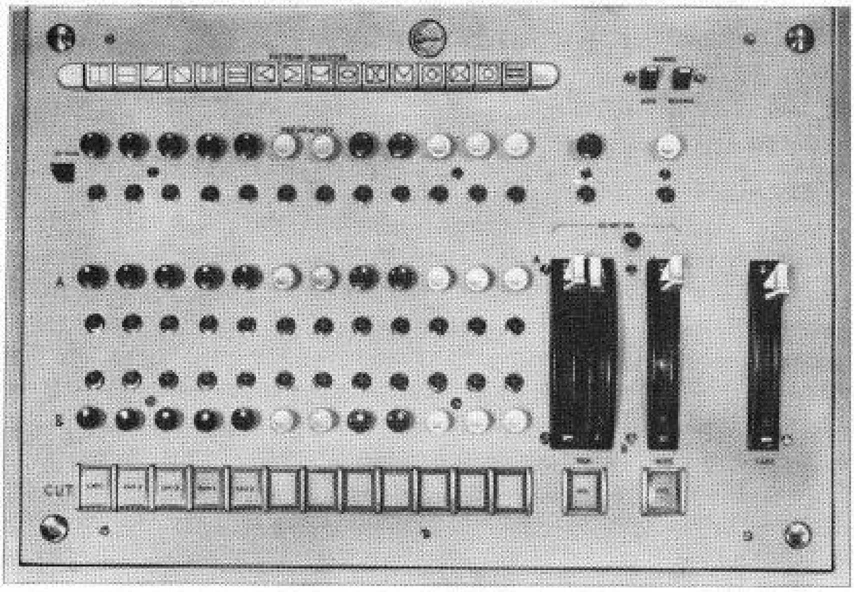

Fig. 4. B3717 Mixer Control Panel with standard pattern selection.

a printed wiring 'Mother' board at the rear. The 'Mother' board provides the interconnections between the modules and also to the external control and signal connectors at the rear of the unit.

The Electronic Switch consists of three modules, these being:

1. A/B switch.
2. Keying unit.
3. Subcarrier phase shifter for use on NTSC colour systems.

The complement of modules in the Pattern Generator is:

1. Waveform generator.
2. D.C restorer.
3. Pattern output.

A common —24-V stabilized power supply feeds both the Electronic Switch and the Pattern Generator. The 'A' and 'B' inputs may be either composite or non-composite, but if they are coded NTSC colour signals they must contain the colour burst.

The control panel of the Electronic Switch, Fig. 3, provides remote facilities for the control of (i) variable keying level, which determines the point on the keying waveform where switching occurs, (ii) function switches, comprising four interlocked push-buttons to select the mode of keying, (iii) variable caption brightness, (iv) hue switches, which are three interlocked push-buttons representing red, green and blue respectively and (v) fine hue control for obtaining intermediate colours. Two paralleled remote control connectors are provided on the Electronic Switch so that these controls may be divided between two control positions, for example production and engineering control, if required.

The Pattern Generator control panel is supplied in two versions. The simpler one consists of a kit of parts to add to the type B3717 standard mixer control panel, Fig. 4. This provides a selection of fifteen of the most popular patterns, using a sixteen-position push-button switch bank, the sixteenth position being used to route an external keying signal through the Pattern Generator[1]. The buttons are engraved with their respective patterns. In addition the kit contains the quadrant fader-type of wipe control, two miniature key switches, one for NORMAL/AUTO switching providing automatic unidirectional wiping in the auto position, and the other for NORMAL/REVERSE switching, enabling the sense of direction of the wipe to be reversed. A variable aspect ratio control is also provided for the corner insert pattern.

For more sophisticated systems a much wider selection of patterns is provided using a more complex control panel as shown in Fig. 5. This arrangement allows selection of eight of the most popular patterns on a ten-position push-button switch bank, the ninth position transfers selection to a bank of thirteen miniature binary push-button switches which enables selection of any one of the numerous other patterns available to be made. The tenth button is used for selecting an external keying signal as before. Pattern designation is achieved by film inserts mounted into the switch buttons, where the pattern being used is illuminated by a lamp built into the switch. A composite 'joystick' (shown at the right-hand side of Fig. 5) combines the function of WIPE and ASPECT RATIO controls. Vertical movement of the joystick produces the wipe, and rotation alters the aspect ratio of the corner inserts and certain other patterns. NORMAL/AUTO and NORMAL/REVERSE facilities are also provided using miniature interlocked push-button switches.

CIRCUIT DESCRIPTION

Electronic Switch

The block diagram of Fig. 6 shows the signal paths through the Electronic Switch. Two similar amplifiers are provided for the 'A' and 'B' inputs. The 'B' amplifier may be fed with the 'B' input signal for normal effects or alternatively with zero level or subcarrier for captions in monochrome or colour respectively. The 'A' and 'B' amplifiers feed an electronic switch which

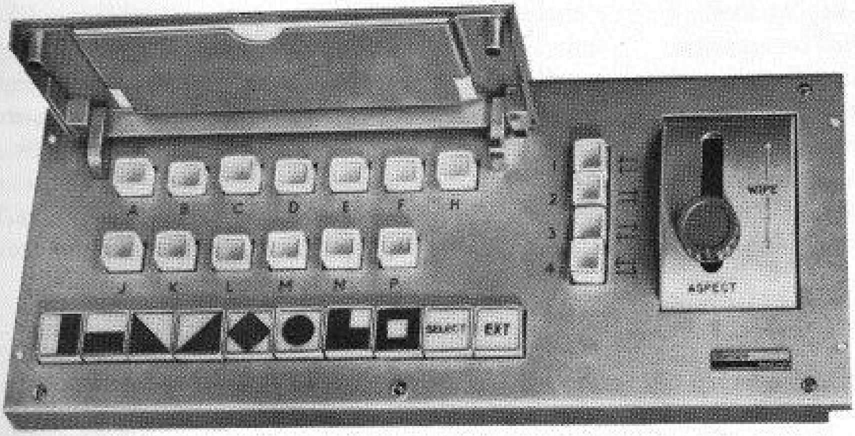

Fig. 5. Versatile control panel for Pattern Generator.

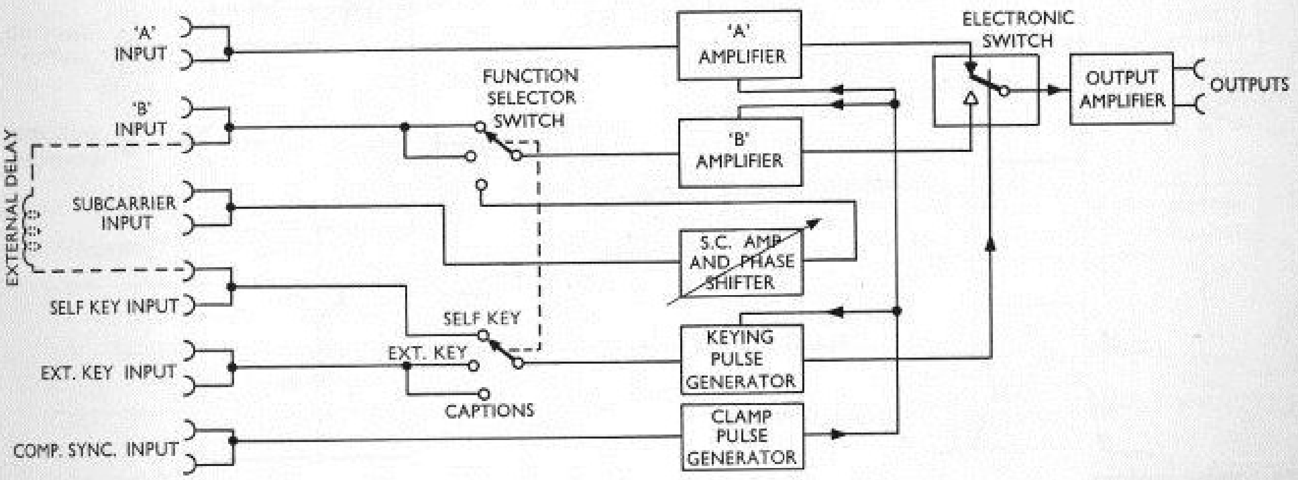

Fig. 6. Block diagram of Electronic Switch.

is driven from the keying pulse generator. The input to the keying pulse generator comes from several sources. These are the Pattern Generator for wipes, an external signal for captions and special patterns of irregular shape from a flying-spot scanner, and also the same signal as is fed into the 'B' amplifier for self-keying operation. The particular mode of operation is selected by the operation of relays from the remote control panel.

The keying signal is first clamped to a controlled variable potential (keying level) and then passed through a direct-coupled amplifier which drives a Schmitt trigger circuit. This Schmitt trigger is designed to have minimum hysteresis consistent with maintaining a reasonably fast switching speed. The output from the Schmitt trigger is then passed through a window clipper, to improve the waveshape, and into a phase splitter such that an inverted or non-inverted signal of the same amplitude may be selected. The signal is now in the form of square pulses.

The signal is again raised in level and at this point the processing necessary for the self-keying mode is carried out. The amplified pulses are fed into an open circuit artificial delay line. A pulse is reflected back from the far end of the line, arriving at the sending end delayed, and adds to the original pulse as shown in Fig. 7. By selecting the upper portion of the waveform a pulse, narrower than the original pulse, is obtained. This pulse is used to gate the original video signal avoiding a black halo occurring around the keyed portion of the 'B' signal. An important condition that has to be met is that the signal fed into the 'B' channel is delayed by a sufficient amount to make it symmetrical compared with the gating pulse which is inherently delayed by this process. External delay of approximately 0·3 μsec must be inserted into the 'B' channel to achieve this, and special sockets are provided on the back connector panel for a suitable length of normal 75-Ω coaxial cable. The pulse is passed, via a high level clamp, to a further Schmitt trigger circuit where the narrow portion of the delayed pulse is selected and shaped into a square waveform. In the external keying mode the artificial delay line is removed by the operation of a relay, so that the resultant pulse has no step in it and is also undelayed. The keying pulse is then fed into the switching module.

Considering the 'A' channel of the switch only, and referring to Fig. 8, the operation of the switch is as follows. The clamped video signal is applied to the base of transistor VT1. This provides a constant-current signal drive through the emitters of transistors VT2 and VT3. When both transistors are conducting equally, that is when their base potentials are identical, the signal divides equally between the two collector resistors R1 and R2. If the base of transistor VT3 is made slightly negative with respect to the base of transistor VT2, then the collector voltage of VT2 will fall whilst that of VT3 will rise. This applies a forward

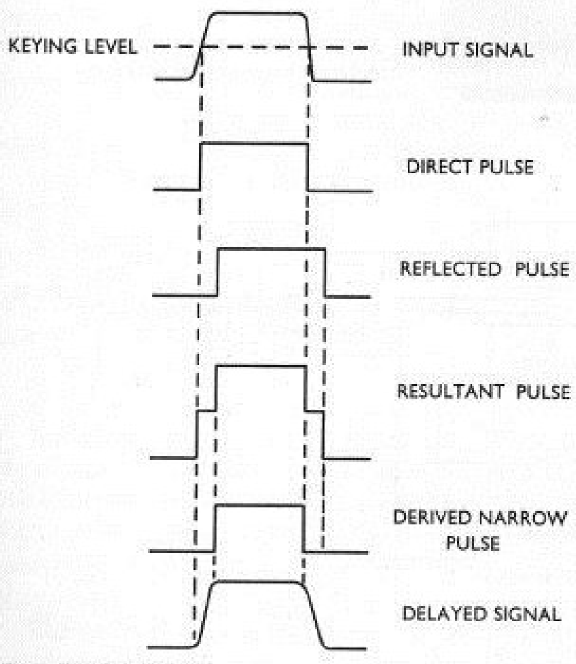

Fig. 7. Keying waveforms.

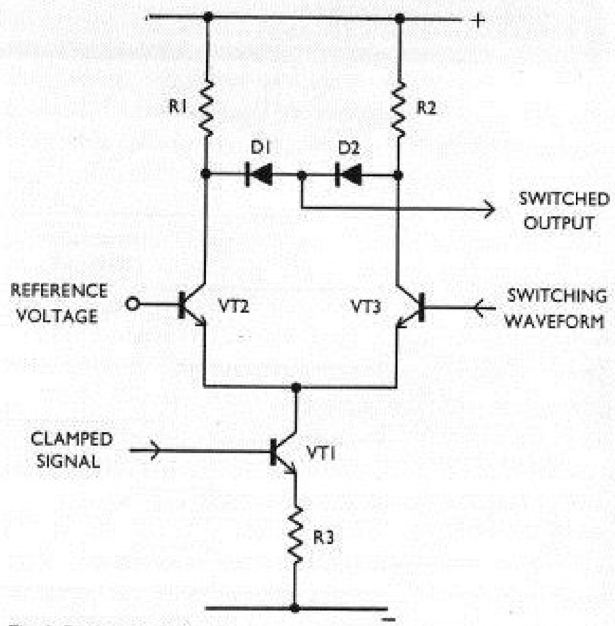

Fig. 8. Basic switch circuit.

potential across the diodes D1 and D2, causing them to conduct and become a low impedance. Hence any signal voltage being developed across resistors R1 and R2 appears at the midpoint of the two diodes. If the base of transistor VT3 is made positive to the base of VT2 then the collector voltage of VT2 rises and that of VT3 falls. This reverse biases diodes D1 and D2 into their high-impedance state and no signal can be obtained at their midpoint. By connecting the midpoint of the diodes of a second similar circuit, but with the diodes D1 and D2 reversed, to the output point of the original circuit, then, by driving both circuits together with the same keying pulse, one set of diodes will always be conducting, and, hence, an output is always obtained from one or other of the clamped input signals.

Due to the stray capacity across the diodes some high-frequency information is fed to the output when the channel is switched off. By connecting a second set of diodes between the collectors of VT2 and VT3 of Fig. 8, but reversed in polarity to D1 and D2, these diodes conduct when D1 and D2 are non-conducting. If the midpoint of these additional diodes is connected to earth via a capacitor then any signal appearing at the collectors of VT2 and VT3, during the period the other channel is switched on, will be shunted to earth, thus greatly reducing the crosstalk.

The clamping level of the 'B' channel is made variable so that the balance between the two switches can be altered and the black level of the two pictures made identical. When working in the caption mode this relative black level balance control is removed by the operation of a relay, and is replaced by the caption brightness control. This adjusts the amplitude of the keyed-in caption so that it may be set anywhere between black and peak white.

If the 'A' signal is an NTSC coded colour picture, complete with burst, then subcarrier may be fed into 'B' channel and the caption will now consist of set-up plus subcarrier and will hence be coloured, the hue depending upon the phase relationship between the added subcarrier and the burst on 'A' signal. Passing the subcarrier through the subcarrier phase-shifter module first enables the phase to be adjusted through 360 degrees in three fixed steps of 120 degrees, corresponding approximately to red, green and blue, when the subcarrier entering the equipment is correctly phased. The fine adjustment of ±60 degrees enables any intermediate hue to be obtained.

From the switching circuits the signal is fed into an output amplifier. This has a very low output impedance enabling two identical outputs to be fed with very little interaction between them. The keying module also contains a voltage regulator to feed −20 V to the switching and keying modules. It also embodies a clamp pulse generator to drive the clamps in these two modules. Module front panel preset controls are provided on the switching module to adjust the overall

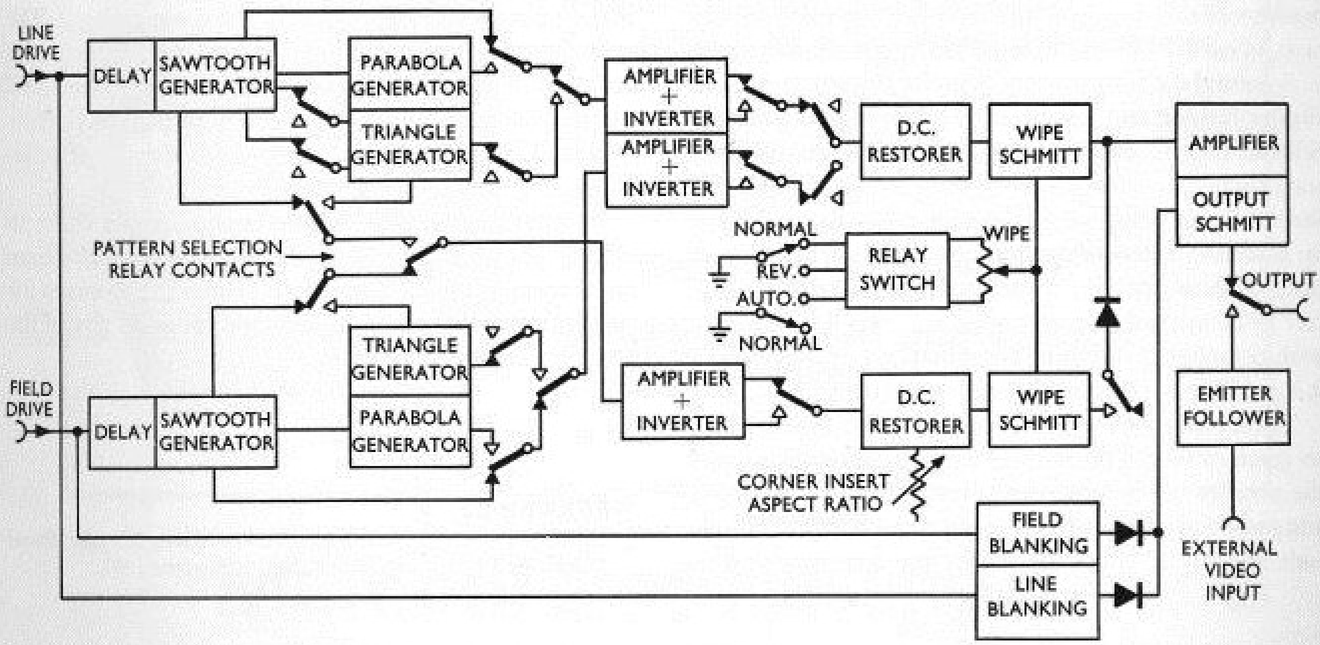

Fig. 9. Block diagram of Pattern Generator.

gain as well as the relative gain and relative black level of the two channels.

PATTERN GENERATOR

This is shown diagrammatically in Fig. 9. Line and field drives are each delayed by 3-transistor dual monostable multivibrators. These generate fixed width pulses, the delay of which may be adjusted to centre the patterns on the picture area. The delayed line and field pulses are then used to produce sawtooth waveforms, from which the other waveforms required for pattern generation are derived. These are parabola for circular functions, and triangle for linear symmetrical functions, patterns being made from any one or combination of waveforms.

A linear sawtooth is produced by charging a capacitor from a constant current source. Integration of this waveform results in a parabolic function. The sawtooth is also passed into a Schmitt trigger whose threshold is set to half the amplitude of the sawtooth, thus producing a square wave of equal mark to space ratio. Integration of this results in the triangular waveshape. All these processes are performed for both line and field waveforms.

The outputs from the various waveform generators are selected by means of relays for the pattern required. After amplification and phase splitting, the line and field waveforms are combined and passed to a d.c restorer. The output from this restorer is fed into a Schmitt trigger with very low hysteresis. Instead of the restoration level being varied it is held constant and the Schmitt trigger supply, of 8 V, shifted in level. The position of this supply with respect to the main supply rails, of earth and −20 V, is varied by the wipe control.

A second d.c restorer and Schmitt trigger is used in similar fashion and its output is used to gate the main Schmitt trigger output on and off in order to produce such patterns as the corner insert. In addition to this second circuit being set by the wipe control it is also set by a second independent control, allowing the aspect ratio of those patterns generated when using this circuit to be altered. By supplying the two d.c restorers with completely different combinations of waveforms it is possible to obtain many different patterns.

The signal now comprises square waves whose mark to space ratio is a function of the pattern selected and the position of the wipe control. It is further amplified and passed to another Schmitt trigger where the amplitude and rise times of the pulses are determined. The output of this stage is gated by line and field blanking pulses, which are internally generated from the incoming line and field drives. These blanking pulses are designed to be somewhat narrower than normal system blanking so that the whole of the picture area is wiped. This signal is then passed to a relay, together with an external signal, if required, and either of these can be selected to feed to the output of the unit and on to the Electronic Switch.

Relays are used to provide the auto-wipe facility. In this mode when the wipe control reaches the end of its travel it operates a microswitch which in turn triggers a relay binary. This reverses the ends of the wipe control and inverts the waveforms in the generator, hence always giving the same direction of wipe irrespective of the direction of movement of the wipe control. In addition, the wipe control only may be reversed in direction, reversing the sense of wiping.

The output module contains a voltage regulator, similar in design to that in the Electronic Switch, producing the main supply rail of −20 V. In addition, a buffer stage is incorporated for the external keying signal input. Module front panel controls are provided for the adjustment of the delay, amplitude and symmetry of the various waveforms.

GENERAL DESIGN FEATURES

Semiconductors are used exclusively throughout the equipment, resulting in a considerable saving of space and power, the total consumption being only 24 W. This reduces to a minimum internal temperature rises due to the power dissipated in the form of heat. The transistors used are silicon types, apart from the series transistors in the regulators which are germanium, and all the components used are run well within their specified ratings so that a very high degree of reliability is achieved.

Temperature compensation is provided in order to obtain the high degree of stability expected from modern equipment. The circuit design is optimized for minimum distortion of signals operating on any of the existing colour standards.

REFERENCE

1 G. Farnworth: A New Studio Vision Mixer BD 920; *Sound and Vision broadcasting*, Vol. 5, No. 2, Summer 1964.