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VISUAL EFFECTS—ELECTRONIC SLEIGHT-OF-HAND

INTRODUCTION

When television broadcasting first started in 1936 films had already been produced which included picture sequences made up artificially. These visual special effects, although saving production time and costs, involved extra steps in the film manufacture plus expensive processing in a film laboratory.

Early television productions used only picture switching (cutting) and mixing to provide some programme continuity. It was not until 1953 that a method was discovered which enabled parts of television pictures to be interchanged, with the inherent advantage that the final composite pictures could be seen immediately.

A further advantage of the new technique was the ability to control from an external picture the way in which the interchange occurred. It is this aspect that has given television visual effects a very important position in the production and continuity of programme pictures.

The basic switching unit, now known as the Electronic Switch, will be discussed and the various methods by which switching signals are produced described.

TYPES OF VISUAL EFFECT

Television visual effects comprise broadly the five basic groups summarized below.

Inlay

The partial interchange of two pictures using a third signal to control the transitions (Fig.1). This technique uses the very fast switching capability of the electronic switch.

Overlay

The partial interchange of two television pictures, the transitions being controlled from one of the two pictures being interchanged. This technique also uses the electronic switch.

Colour Synthesis

This is a method whereby well defined areas in a monochrome picture can have colour information added. Two methods are available, one using an electronic switch and the other a colour synthesizer.

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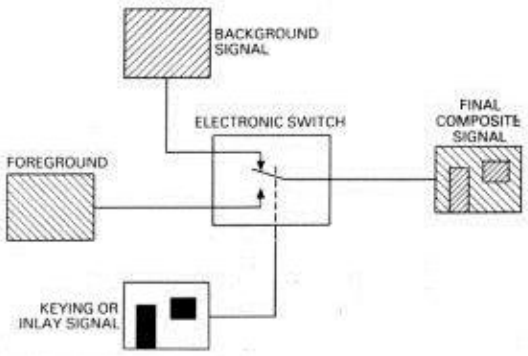

Fig.1 Inlay technique.

Change of Picture Repetition Rate

The reproduction of pictures having apparently a different speed of action to that of the original pictures.

Miscellaneous Effects

These include effects added in the camera channel such as scan reversal and negative picture modulation.

INLAY

This form of effect, sometimes called external key, was first seen on television screens in 1953 and is produced by replacing part of one television picture by part of another, (Fig.2). The shape of the inserted picture is determined by a third signal, generally called the keying signal, derived from a camera, slide scanning source or a pattern generator. The keying signal, together with the two pictures to be modified, are fed into an electronic switch.

ELECTRONIC SWITCH

This unit consists essentially of two fast acting switches with a common output and controlled so that when one switch is closed, the other is open. For successful results the switches must be capable of very fast operation (well under one ten-millionth of a second) and the switching transition must be smooth and without transient overshoots. Even when identical signals are fed into each input the transition between pictures should not be noticeable. The position at which picture interchange takes place is determined by the amplitude of a

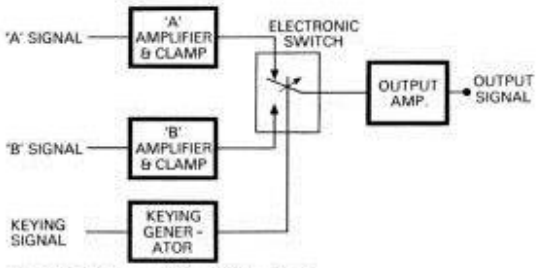

Fig.2 The Electronic Switching Unit

switching or keying signal. A critical value of this signal, called the 'Keying Level', can be preset externally and when this level is reached the electronic switch changes state.

For optimum results, the keying signal should have maximum rate of change at the keying level to exploit the speed at which the switch can change over. Figure 2 shows the basic parts of an electronic switch in which two signals which are to be modified are fed into circuits which ensure that picture amplitudes and black levels are matched. The signal used for keying is fed into a separate input of the electronic switch. Only the monochrome content of the picture is required so that any colour information present needs to be removed together with any burst signal.

The ideal signal for keying purposes will consist of fast black-and-white transitions of large amplitude. A signal obtained from a picture source will not necessarily include clean fast edges but the picture content will include various shades of grey. Circuitry is, therefore, provided which enables a portion of the picture level suitable for switching to be selected.

As the electronic switch is a symmetrical device, capable of switching either way between inputs 'A' and 'B', it is necessary to be able to select either polarity of keying signal to provide the correct switching direction.

INLAY EFFECTS

Early forms of the technique used pictures derived from a simple silhouette pulse generator which consisted of a cathode-ray-tube of the type used for flying-spot film scanning. A raster scanned in synchronism with the camera picture was focused on to a photocell and the whole assembly mounted vertically. It was possible to mask optically part of the scanned area and thus produce a signal from the photocell corresponding to the shape of the mask. Later on a separate camera source, usually a photoconductive camera, was used to generate the keying signal.

The great advantage of inlay is that it allows a predetermined area of picture to be modified. Thus a scene including a window or door can dispense with additional and expensive scenery for the background. This can be replaced with model scenery or use made of film inserts which can add realism to the action. The actors must not be allowed to stray in front of the doorway or window unless they are required to disappear.

One trick effect used recently has been to inject a rough corner insert into a picture and so give the legs of one person to the body of another. The backgrounds were carefully matched and because of the jagged inlay transition, the change of picture was not noticeable.

CAPTION INLAY

Titles and credits for programmes are not successfully displayed against a picture background by mixing, especially in colour television where a white caption tends to take on the colour of the particular point in the background. Use of the caption, however, as an external keying signal makes for good clean reproduction over any background. It is usually arranged for one of the inputs to the electronic switch to be peak white or black while the other input is the background signal. Normally in special effects the switching between two pictures is required to be as natural and unobtrusive as possible. Great care is taken to arrange for pictures to fit exactly the space in the background provided by the keying signal.

One further improvement possible is to make captions appear bolder by providing a thick edge around each character. If signal timing is purposely altered to make the space in the background take place before the signal arrives to fill it, a black edge will appear on the leading edge of the character.

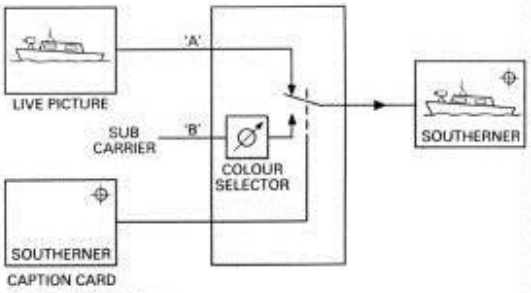

Fig.3 Caption inlay.

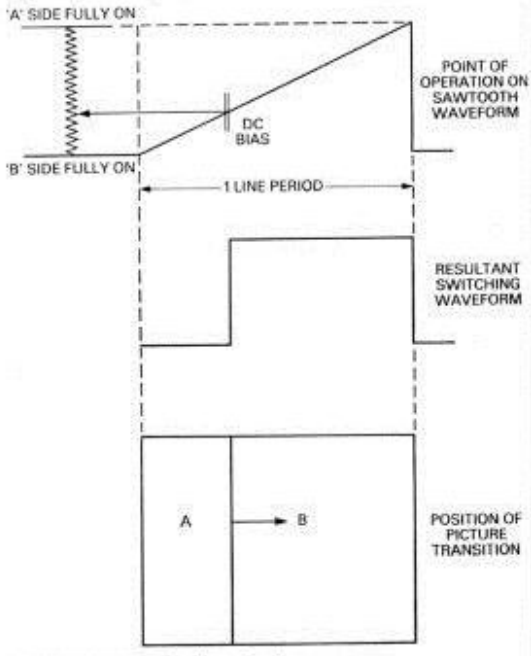

Fig.4 Derivation of horizontal wipe.

Further modification to the keying pulse by lengthening it, provides for a black edge at the trailing side of the character.

The use of colour in television now makes it possible to provide coloured captions. One signal to the electronic switch is arranged to be the sub-carrier signal which has already been fed through a phase-shifting circuit. It is then possible to remotely control both the colour and the brightness of the caption giving quite effective results (Fig.3).

ELECTRONIC PATTERN GENERATOR

Although it is quite possible to obtain attractive switching effects using a separate camera source the inlay effect really came into its own with the method of generating the keying signals electronically.

Modern electronic pattern generators offer hundreds of different patterns derived from only a small number of waveforms. A typical example of the way in which a waveform is used is shown in Fig.4. A sawtooth, the frequency of which corresponds to line frequency, can be derived and fed into a switching or trigger circuit. This in effect, amplifies a small part of the sawtooth, this part being selected by operation of a remote fader which sets the bias on the circuit. The resulting waveform is a sharp transition which, when suitably processed, can be used to control the switching point in the electronic switch.

This particular waveform triggers the electronic switch at the same point in each line period and so gives a vertical transition between pictures 'A' and 'B'. A horizontal transition is derived in exactly the same way except that the sawtooth has a repetition rate at field frequency.

With the bias or wipe control set to switch midway either vertically or horizontally within the picture, a split-screen effect is obtained. Thus, parts of two picture sources are shown simultaneously creating a suitable medium for an interview. The vertical split screen is often used to show two seated groups of people simultaneously, although they may be many miles apart. Moving the control of bias smoothly gives a wipe effect rather like covering one picture with another and this provides a good transition between pictures. The fader controlling the switching transition sometimes takes the form of a joystick giving simultaneous control of horizontal and vertical information. Further selector buttons give control of wipe direction and additional logic can give the effect of repeated wipes in one direction rather like the pages being turned over in a book.

Figure 5 indicates that combinations of three basic waveforms, sawtooth, triangle, and parabola, generated at line and field frequencies, provide transitions generally in use. The control panel of a vision mixer normally includes a set of control buttons with the transition shapes engraved on the buttons. These buttons select various combinations of switching waveforms within the pattern generator giving the picture transition required.

The last example of figure 5 indicates a third

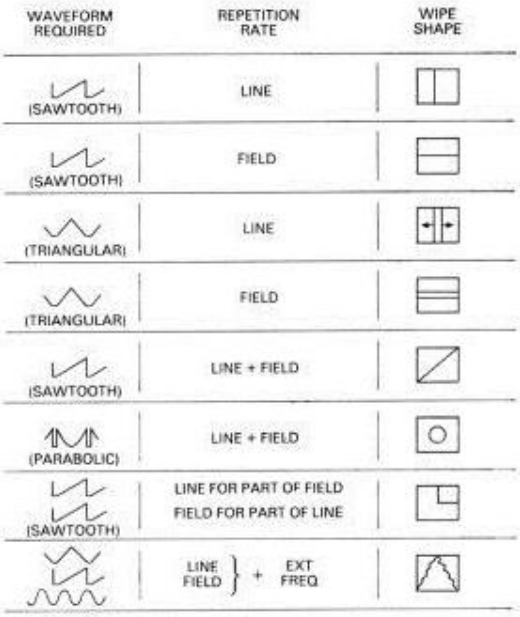

Fig.5 Electronic keying waveforms.

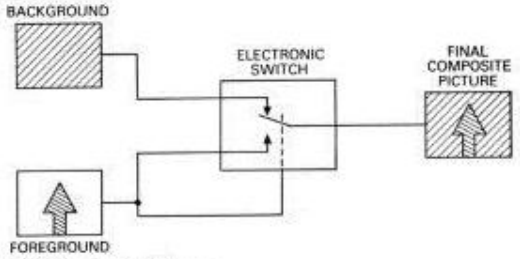

Fig.6 Overlay techniques.

waveform being added to those generated internally within the pattern generator. Quite attractive results can be achieved by adding sinusoidal signals to modulate the patterns, especially if the frequency is carefully chosen.

OVERLAY

The technique of inlay discussed above requires the use of two primary picture sources and a third signal for keying. Although providing many useful effects, the usual form of stationary keying picture limits the movement of figures in either of the two primary pictures.

The overlay or self-keying effect uses one of the primary sources, usually the picture with the foreground information, for keying purposes as well.

There is no limitation of movement for the foreground figure into any part of the picture as the keying signal moves in synchronism with the figure. The electronic switch is again the basic switching unit used. However, the keying input, instead of being fed from a separate source, accepts one of the primary signals before this is looped to its normal input (Fig.6).

A basic difficulty is experienced with the overlay technique which does not normally happen with inlay. The normally lit scene contains information covering the whole range of the brightness scale and, unless some thought is given to the switching

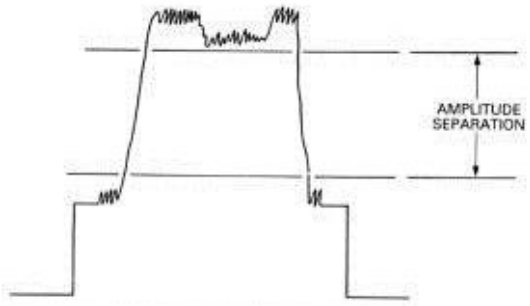

Fig.7 Waveform of subject signal for overlay.

aspect of the picture, a positive switching level will be difficult to set up.

As an example, it is required to key an artist into a moving background. The picture derived from the camera scanning the artist will be used for the final composite picture and also for keying purposes. Figure 7 shows the waveform of the subject. Although sufficient lighting on the subject results in full modulation, the signal also includes random noise which will limit the range of amplitude separation in which the electronic switch has to change over. The careful use of the keying level control on the electronic switch will give some latitude but, in monochrome television, the possibility of the electronic switch changing over in the wrong place is never far away.

There are two alternatives available :

(a) To light the subject brightly against a matt black background. This gives rather unnatural looking results in the final composite picture as the artist must wear bright or as near white clothes as possible. If the artist speaks, the final picture may suddenly appear to show the background in their mouth with farcical results.

(b) The other alternative is to show the artist in shadow against a very bright background. This has the disadvantage that the subject may look more natural against a background containing some detail but may not show up very well.

There is one further effect met when overlaying one picture into another. The keying pulse edges derived from the picture used for switching take a finite time to rise and fall thus giving a difference of width between the top of the pulse and the base. Thus a space cut in the background picture will slightly differ in size depending on the amplitude to which the keying level has been set. This usually results in a halo effect round the subject in the final composite picture. It is usual to design into the electronic switch pulse narrowing circuits which minimize this effect but, if a level rather too near black is chosen, the effect can still be apparent as a thin white line round the subject.

APPLICATIONS OF OVERLAY

The use of the overlay keying technique does not restrict the artist in movement in front of the camera. A mix between the composite picture and the background scene can be used to make the subject disappear and his size relative to any background can be changed by use of the zoom lens. One further advantage can be used by constructing a studio set such that the opening of a door on to a dark background will automatically key in the background picture. This type of effect using a moving background makes scenes inside trains and aircraft very realistic.

The advent of colour television has, for once, given the engineer an extra tool to improve picture switching effects by deriving a high-quality keying signal for controlling the electronic switch. The basic facilities are the same as for monochrome television but one additional unit is necessary, usually called a Chroma Key unit.

CHROMA KEY OVERLAY

This relatively new technique uses the difference in colour as well as brightness to obtain a keying signal with good separation between subject and background. Figure 8 shows the basic form of a typical Chroma Key unit. The primary colour outputs of the camera channel are tapped before non-linear distortion is added to compensate for the picture tube (black stretch). These three outputs are connected in sequence at 120° intervals to a ring load. Thus the colour information of any scene is spread round the load in proportion to the saturation of colour, its position depending on the relative amount of red, green and blue. Two wipers, controlled from separate spindles, enable any part of the resistive chain to be tapped. Thus two different signals can be selected each containing instantaneous brightness information derived from a picture of a subject and background. The background colour is usually chosen to be opposite to the skin tones of the subject. It is possible then to select two signals having maximum contrast.

To improve further the keying characteristics, the signal derived from the subject is inverted and added to the background signal. The composite

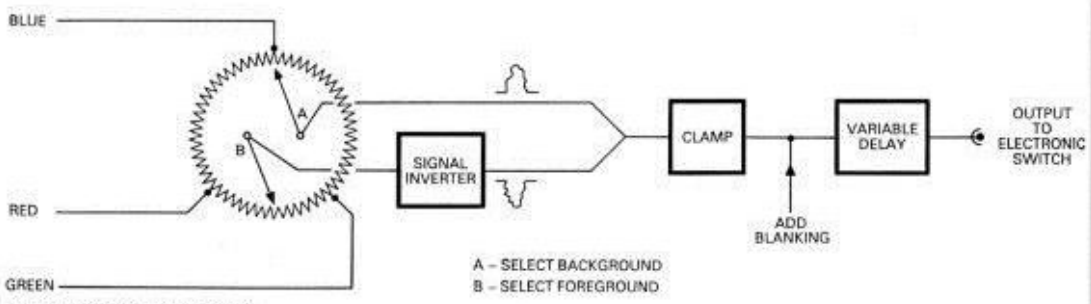

Fig.8 Basic chroma key circuit.

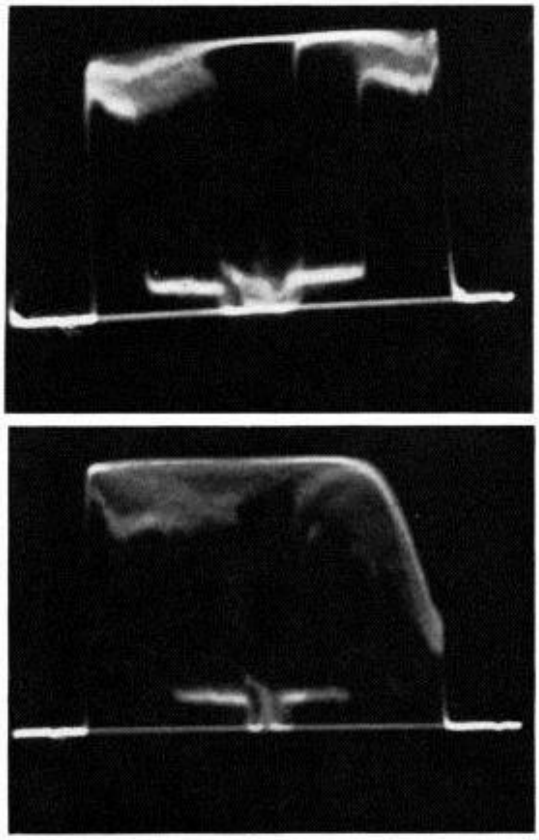

Fig.9 The difference in the chroma key signal resulting from a change in background lighting.

keying signal is then processed to stabilize the black level and passed through a delay line which can be adjusted to match the time lag of the processing required to derive the original composite colour picture from the camera channel.

Although this method of generating a keying signal gives greatly improved results, great care still needs to be taken over the lighting of the subject and background. Figures 9(a) and 9(b) show the difference in chroma key signal obtained by a slight change in background lighting. Whereas the amplitude difference on the first one gives some freedom on the keying level required, the second example would not work as the picture would show the characteristic noisy tearing where the electronic switch was not cleanly keyed to select one picture or the other.

The chroma key technique is used successfully at Southern Television during various programmes. The programme director ideally requires to choose which camera he will use for the chroma key shots. To avoid the problem of additional switching of primary colour signals for each camera channel, chroma key units have been built in modules which will plug into a space in the Marconi Mark VII camera control unit. Each camera control unit has been modified with additional wiring so that it is only necessary to plug a module into the camera control unit of the camera selected. Module outputs are linked so that the keying signal automatically arrives at the keying inputs of one of the electronic switches fitted to each vision mixer.

Although blue is the colour chosen for backgrounds as being complementary to flesh tones, it is always possible to select on the chroma key unit for any other colour combination of subject and background simply by adjusting the two rotary controls.

COLOUR SYNTHESIS

The use of colour synthesis in television is of necessity rather small in a field where the accurate reproduction of live scenes and film is always the main criterion.

The caption, giving useful title and station identity information, has always been the 'Cinderella' source, usually being scanned by a basic vidicon camera. The problem is made far worse with colour television as the scanning of coloured captions by a colour camera seems a very expensive way to reproduce this information.

A novel method of obtaining a coloured reproduction of a black and white caption has been obtainable for some years. This unit using only the output of a monochrome vidicon camera provides a composite television signal with preselected colour information. For example, captions are normally white lettering on a black background and so the waveform produced by the vidicon camera will consist of black with peak white modulation for the lettering. The basic system of processing in figure 10 shows the input monochrome signal split into foreground positive and background negative components which are each distributed to the three primary colour output amplifier pairs of the device.

It is thus possible to control the level of foreground and background signal for each primary colour output. For example, if the white areas are required to be red in the colour picture, the red foreground amplifier is biased to 'on' and green and blue foreground amplifiers biased to 'off'. The foreground signal with the original white information now appears at the red output. The background signal is also controlled in the same way.

The control of the colour and brightness in the final picture is also shown in figure 10. Two potentials, each selectable on separate potentiometers, are fed to the wipers of a rotary selector. The two wipers are at 180° so that, for any selected position on the rotary selector, a pattern of potential is set up. Three tappings are provided on the stator of the selector at points equidistant round the perimeter. These points each being connected to control the output amplifiers, the colour can be selected purely by adjusting the rotary selector. These controls are provided for both foreground and background, thus giving unlimited range of colour for captions with two distinct levels of brightness. In addition to the manual control described above, further switching is provided so that preset colours for both foreground and background can be selected. Some care is required when selecting the saturation and brightness for a particular colour. This is to prevent modulating the signal beyond the value recognized as 100% saturation for that colour. The generation of a standard colour test signal is a further example of

colour synthesis in general use in television. Narrow, fully saturated, bars of each primary and its complementary colour are generated together with peak white and black. This signal is then used to check the colour performance of various pieces of equipment and is used as a line-up signal.

ALTERATION OF PICTURE REPETITION RATE

The ability to alter speed of movement has always been viewed as a legitimate device for making special effects in films. In early films the camera speed could be reduced which resulted in very quick sharp movements when the film was projected at normal speed. Speeding the camera up during filming had the opposite effect, making everything appear to move in slow motion.

Pictures for television have to be scanned at a precise rate so that various picture sources are in synchronism. It is not possible to copy the methods used by the film maker. Several techniques have appeared recently, however, which do offer methods of reproducing already recorded television pictures, both in slow motion and as a still frame.

Telecines, which use a camera to scan the image of film using an intermittent projector, can be stopped for one film frame to be continuously scanned. A coherent display is not possible during the run down from standard speed so that this facility is rather limited. The helical scan type of tape recorder also can be stopped and displays one whole frame continuously. This again, although showing a still picture, needs the tape to be set exactly so that the complete single frame is displayed. Experiments have also been carried out using four-head video tape recorders to give slow playback facilities, and these were successfully used during the Olympic Games in Tokyo.

More recently, a system using discs has appeared for the playback of selected parts of sporting events. This system uses the four surfaces of two rotating discs. Up to 30 seconds of incoming television material can be recorded which is then erased as further material becomes available. It is possible to select any part that is required very quickly and to replay this material either in slow motion, forward or reverse. One particular frame after another can be displayed while still giving a coherent display on any television screen.

EDITING – ANIMATION

The introduction of the video tape recorder quickly revolutionized the business of broadcasting. It is unusual at the present time for any television programme, with some exceptions, to be produced 'live' for transmission. Having recorded a programme, usually with an excess of material, the final programme can be assembled using a video tape recorder with a second machine providing the fresh material. Most video tape recorders have the capability of switching from the replay mode to the record mode between the end of one frame and the start of another. As one of these points can be found quite easily, the machine can replay some material and then, at the selected spot, start to record fresh material without the tape stopping. In this way selected sections of the original recording can be assembled in the required order on the new tape. When replayed, the cuts are so clean that the viewer does not realize that the sequence being shown was made up of many parts recorded at different times.

From the technique just described, a very short step brings the possibility of the assembly frame by frame of animated sequences. To do this for film is a very difficult and specialist technique but for television this technique is fairly straightforward, requiring only the additional switching and counting equipment.

MISCELLANEOUS EFFECTS

Mixing and Fading

Mixing and fading between picture sources had been the only alternative to switching prior to the

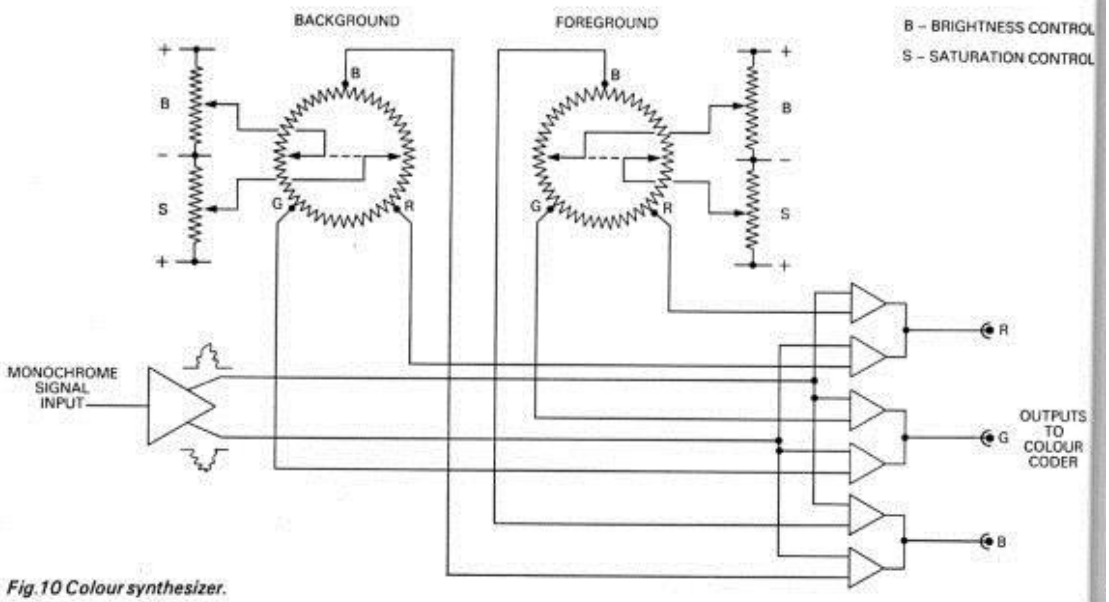

Fig.10 Colour synthesizer.

introduction of special effects. Under certain lighting conditions one picture can be dissolved into another providing an artistic result. The method is also useful in making figures appear nebulous and ghostlike.

Star Filters

Filters are now available which consist of glass discs, one side of which have been etched with a fine pattern of lines. The filters are placed in the optical path in a colour camera and depend upon the etched pattern of the filter to interfere with picture highlights. These then show up as star shapes.

Reverse Scanning and Negative Picture Modulation

The reverse scan facility is usually fitted to each camera channel. Thus shots using mirrors can be corrected or the scan direction purposely changed. Negative picture modulation is another standard facility fitted to all monochrome telecine machines for scanning negative film. Some types of camera channel are also fitted with this facility and the effect has been used in drama sequences.

CONCLUSIONS

The medium of television is outstanding when broadcasting a historical or sporting event actually taking place. The normal run of television productions, however, require an extra ingredient such as special effects to build up the presentation of programme material and which, when measured against the cost of picture source equipment, is relatively inexpensive. The camera channel is usually at the centre of interest of television studio equipment but the finished programme is judged on the polish and professionalism of its presentation. Special effects, intelligently used, adds its full quota to this professionalism.