A. de M. FREMONT

THE MARK VIII TELECINE CAMERA CHAIN

INTRODUCTION

The colour camera chain used in the B3404 Telecine has been based, whenever appropriate, on the Mark VIII live camera. There are areas, however, where special techniques are necessary for processing video signals derived from film if the best use is to be made of the film material. Where this has applied, for example, to such parameters as gamma and aperture correction, the telecine design has in no way been compromised. Only features particularly associated with telecine will be described in detail, as the Mark VIII live camera has been fully described in earlier issues of this journal.[1]

MECHANICAL ARRANGEMENT

Figure 1 shows an outline sketch of the complete telecine and the locations of the various units. It will be seen that the camera control unit has been split into three units and has a separate Operational Control Panel. The latter is identical to the one used for remote control. The Camera Control Panel (CCP) houses the normal set-up controls as well as the picture monitoring and waveform monitoring switches and is mounted directly below the picture and waveform monitors. Just below these in the desk top are the Operational Control Panel and Projector Control Panels.

The Vision Processing Unit (VPU) is a 19in rack-mounting unit of the same construction as the Mark VIII Camera Control Unit, having four pull-out trays containing all the printed circuit boards for vision and pulse processing. Also housed in the VPU is the optional Automatic Light Control unit. Immediately above the VPU a space is provided for mounting a B3373 Colour Coder.

The Automatic Registration Unit (ARU) is mounted below the VPU and is of similar construction. In this case there are three trays, two for automatic registration and one for the optional Auto Colour Balance circuits. When the ARU is not fitted its functions are replaced by a Registration Control Panel which is housed inside the CCP.

The Camera Electronics Frame is of simple construction and houses the scan generators and

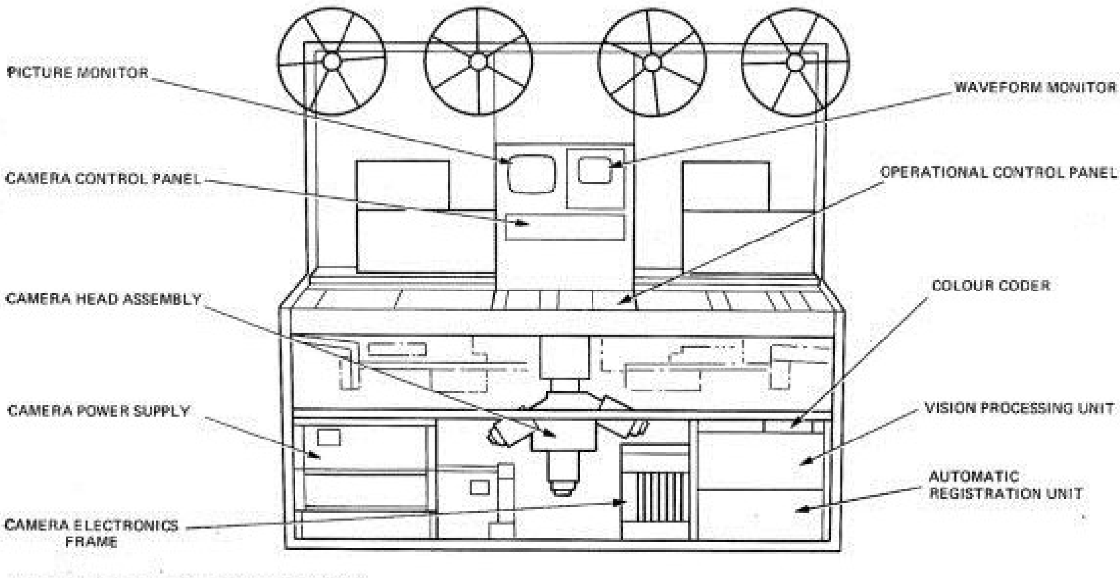

Fig. 1 Disposition of camera chain units.

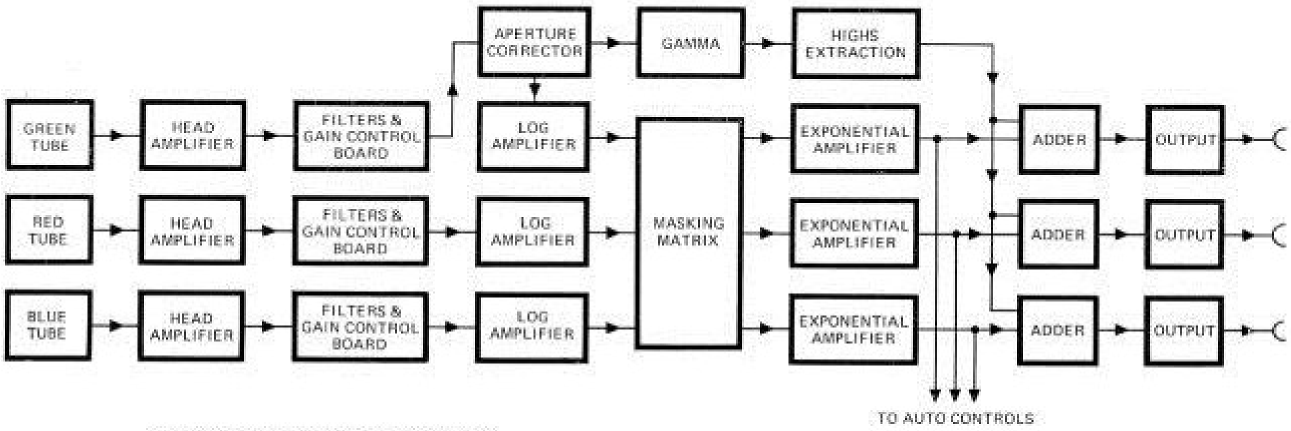

Fig.2 Simplified video block diagram.

amplifiers, tube supply voltage regulators and pulse circuits associated with the pick-up tubes. The automatic beam alignment motors board and the preview camera circuits are also mounted in this unit when they are included.

The camera scanning yokes, together with their associated head amplifiers, are mounted directly on the accurately machined optical splitter housing, thus ensuring accurate alignment and mechanical stability.

The Camera Power Supply, a 19in rack mounted unit, is on the left of the telecine frame and provides all the regulated supplies for the camera.

SPECTRAL SENSITIVITY

The colour camera has three lead-oxide target pick-up tubes to receive the red, green and blue images from the dichroic splitter block. The spectral characteristics are very similar to those used in the colouring channels of the B3402 telecine, the very narrow response loads providing the best possible reading of the film dyes.[2] Even with these narrow lobes, sufficient light is available to give a signal current of 300nA in all channels with white on the film having densities as high as 1·3.

To achieve the absolute minimum of coloured lag, the three signal currents from the tubes are balanced, and simple, pull-out neutral density filters are provided in each light path for this purpose.

The preview camera has a single lead-oxide pick-up tube which receives approximately 10% of the light from the field lenses A broad spectral response ensures adequate sensitivity and good reproduction of colour film in black-and-white.

VIDEO SYSTEM

The block diagram (Fig.2), shows the basic circuit layout of the main video channels. All the detail is taken from the green channel and it should be noted that, notwithstanding the narrow response lobes, the green signal is not entirely devoid of red and blue information; there are two reasons for this. The broad taking lobes of the original film ensure that the magenta dye encompasses information from both red and blue as well as green and, added to this, even the narrow green taking lobe sees information from the yellow and cyan dyes due to 'dye cross talk' in the film. For these reasons a satisfactory system using detail information from the green channel only can be employed This means that only the green channel need have an aperture corrector.

To obviate signal timing difficulties due to the inclusion of many stages, the wide-band green signal is gamma-corrected separately prior to extraction of the detail signal. This detail signal is then added to the gamma corrected, and masked, red, green and blue narrow-band signals before the final clipping and output stages.

The separate processing of the signal covering the detail has certain advantages For example, the logarithmic amplifier does not have to handle the high-frequency harmonic components generated in the non-linear processing of the detailed signal. Also, the amount of gamma correction applied to the detail signal may be adjusted to be different from the main signal. This allows a rational answer of the often asked question as to whether it is better to mix 'highs' before or after gamma. In fact, a compromise can be arrived at

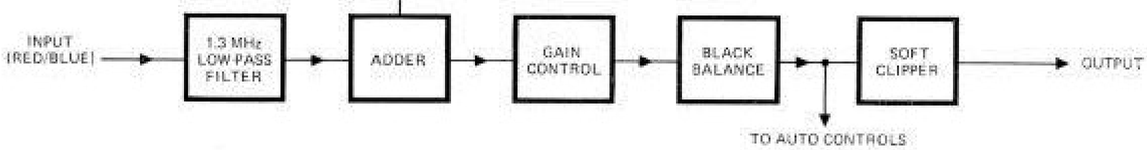

Fig.3 Red/Blue filters and gain control board.

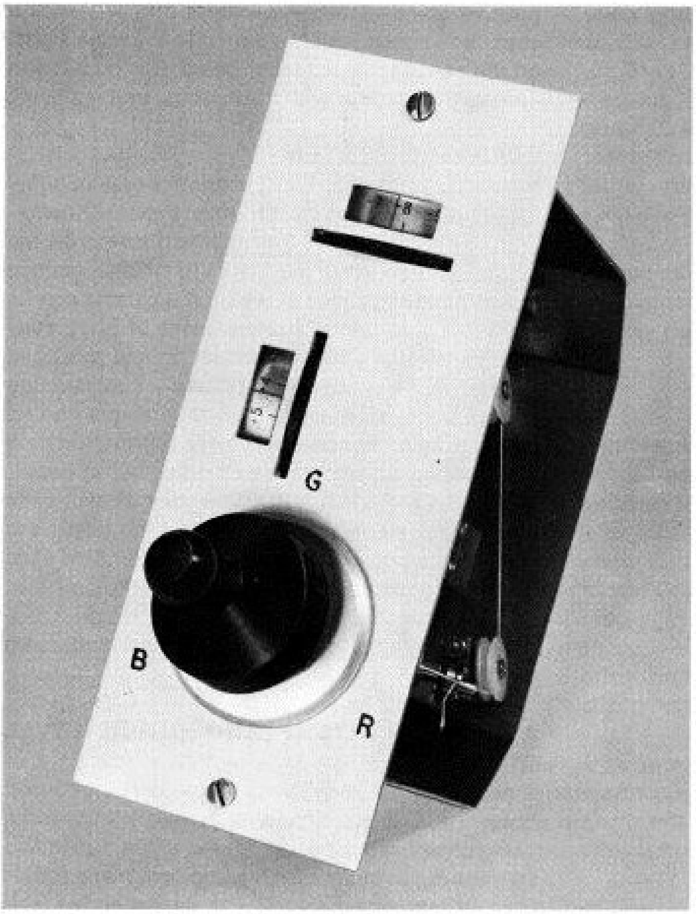

Fig.4 Colour balance control unit.

which is better than either extreme.

For a more detailed look at the circuits the point of picture origination is a good starting point.

HEAD AMPLIFIERS

The head amplifiers employ a field-effect transistor in the first stage and the circuit differs only slightly from the B3402 telecine and Mark VIII live camera head amplifier in the first two stages. The general construction is the same as is used in the Mark VIII camera. Full advantage has been taken of the high signal currents obtainable on the telecine system and it has been possible to utilize the same printed wiring board in all channels. On the editions of the board used for the red and blue channels, the *Percival* circuit is not fitted and these units have slightly less bandwidth than is employed in the green unit. Mechanical polarizing ensures that the narrower-bandwidth units are not plugged into the green channel. The preview camera is designed to use the 'green' edition. The outputs of the main channel units are fed directly to the VPU for processing.

FILTERS AND CONTROLLED GAIN STAGE

Figure 3 shows, in block form, the layout of the red and blue signal channels which share a common printed board. The green channel is the same as the red and blue channels except that the 1·3MHz low-pass filter is omitted.

The controlled-gain stage employs a field-effect transistor in the feedback path of a complementary pair amplifier and, as is usual with this arrangement, the temperature of the FET is stabilized by a self-regulating oven. The gain setting may be controlled by automatic means as well as by the operational colour balance controls (Fig.4). These controls are now fitted with two logging dials, a new feature. The automatic control facilities will be described later as will the black balance which is also part of the automatic facilities. The final stage of this section is the soft clipper which is designed to compress high light signals.[2] In this way the telecine can handle input contrast ratios up to 500 : 1.

APERTURE CORRECTION

The aperture corrector is very similar to that in the Mark VIII camera channel and has been described in a previous article.[3] Only the special telecine printed board which replaces the original 'Adders and Filters Board' and the associated 'Correction Gamma' are new (Fig.5).

As can be seen, the vertical correction signal is formed in the normal way using undelayed (E_0), one-line delayed (E_1) and two-line delayed (E_2) signals. Variable depth 'combing' is provided which acts on the in-band correction only. The amount of in-band correction is selected to be greater for 16mm film than for 35mm or slides. The wideband

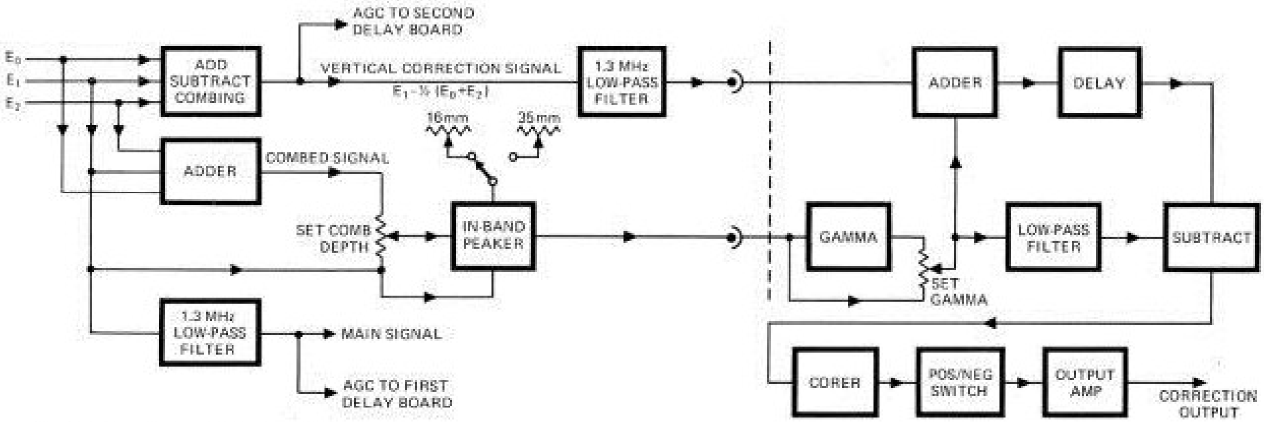

Fig.5 Block diagram, 'highs extraction.

signal is fed to the detail gamma correcting stage where a maximum correction of index 0·5 is available. By using such a law rather than, say 0·35, an effect similar to level-dependent aperture correction is obtained with no additional circuitry. The highpass characteristic of the correction signal is obtained by subtracting a lowpass filtered signal from a delayed full-bandwidth signal. Following the highpass function, the signal is 'cored' to improve further the noise performance. The output correction signal is fed to the exponential amplifiers in the main path where it is added to the narrow-band signals.

Gamma Correction and Masking

Figure 6 shows detailed diagrams of the logarithmic and exponential amplifiers. The three signal channels are identical except that the masking factors differ from one another.

As shown, the logarithmic amplifier uses a diode as the non-linear element and this is used as the feedback element in what is basically a high-gain amplifier. Virtually all the signal drive current flows in the diode and the voltage variation at the diode cathode is, of necessity, the logarithm of the drive current.

Conversely, in the exponential amplifer a high-gain stage is used to control the voltage across a diode. In this case the current feed to the diode is sampled. A feedback clamp is utilized to keep the whole system stable.

Changeover relays allow for the use of positive or negative film and provisions include the choice of three masking matrix settings, two fixed and one variable. In addition, a four-position switch gives 25%, 50%, 75% or 100% of the correction selected. The appropriate matrix is selected at the Operational Control Panel. The masking unit accepts positive and negative log signals and produces a correction signal which is added to the main signal on the exponential amplifier board. It is possible to operate the channel with the masking unit removed.

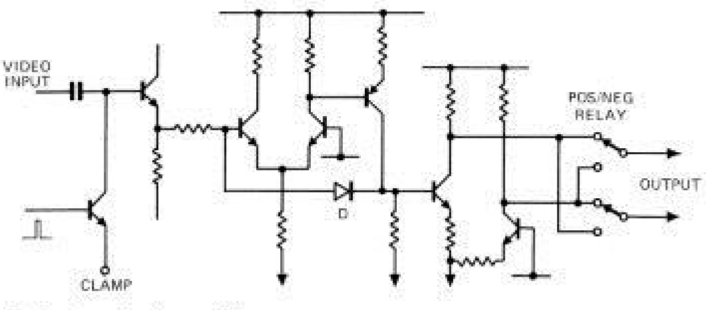

Fig.6a Logarithmic amplifier.

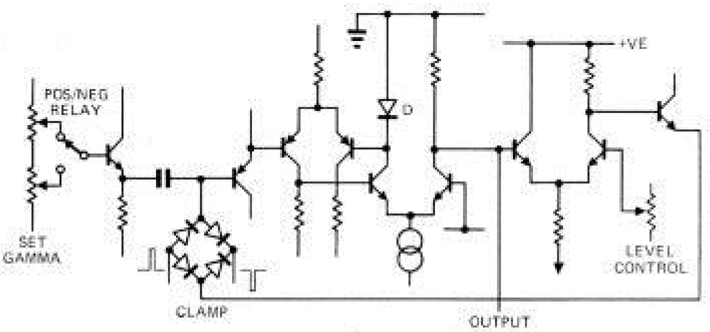

Fig.6b Exponential amplifier.

SCANNING SYSTEM

Variations to the Mark VIII scanning system allow for full-sized images on all tubes and for CinemaScope® on 35mm film. The minified images on the colouring channels of the Mark VIII camera improve the ultimate sensitivity at which the camera can be used, but this is not a requirement in photoconductive telecine where abundant light is available.

Registration is controlled either by a registration control panel mounted within the camera control panel, or by an optional automatic registration unit. This optional unit employs the printed circuit boards used with the Mark VIII.[4] The special test slide required for automatic alignment of the telecine is housed in a pocket at the end of the standard slide projector carriage and is selected automatically. The 'diascope' light control signal in this case drives the neutral density light control disc servo amplifier.

AUTOMATIC LIGHT AND BLACK LEVEL CONTROL

Automatic Light and Black control were introduced in the B3402 telecine and this very successful design has been repackaged and slightly modified for three-tube operation. By using power and pulses from the main channel, the inclusion of this optional facility has been made simple and economic (Fig.7).

A previous article has described the operation of the four-tube version and only a brief description showing how the new circuit differs from the original will be given here.[5] The method of exposure control is shown at the top of figure 7.

The non-additive mixer (NAM) is fed with 'linear' signals. A luminance signal is made by adding gamma-corrected red, green and blue signals and this is also fed to the NAM. By comparing peak and average signals it is possible to get correct exposures of all scenes, whether high or low key. The 'luminance' signal is also fed to the fade-to-black inhibit circuit. The purpose of this circuit is to limit the extent to which the lamphouse light output is increased on a 'fade to black' in the film. The output signal is fed to the servo amplifier which is again a repackaged and modernized version of the B3402 design.

The Auto Black circuit is fed with the green signal (the same signal as is fed to the NAM). The peak-black level is detected and the resultant control signal is fed to the clamp reference of the green and the red and blue channels. A clipping stage, following the clamp, is then used to correct the black error.

AUTOMATIC COLOUR BALANCE

The Automatic Colour Balance, designed for on-air use, balances the average white levels and the peak

®Twentieth Century Fox

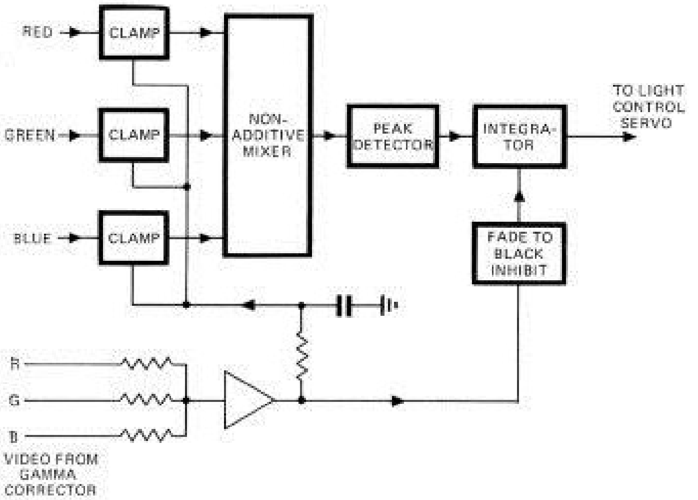

Fig.7a White control.

Fig.7b Black control.

black levels of the three colour signals. This is a separate function from that of the White Balance system which detects and sets peak levels.

The White Balance system is brought into operation by depressing either the **'WHITE BALANCE'** or the **'SEQUENTIAL LINE UP'** button on the ARU. The circuit employed for this function is similar to that used for the Mark VIII camera, but has been modified to make it suitable for operation on small areas of picture information. (It is not possible, of course, to pan and zoom a telecine onto the appropriate area as is done when white-balancing the studio camera.)

The Auto Colour Balance facility is brought into operation by the 'Auto Colour Balance' button on O C P (Fig.8). The function of the system is to maintain the average levels of the signals. To do this the average levels of the red and blue signals are compared with the average of the green signal. This is achieved in comparators the outputs of which are fed to the red and blue channels where they are used to set the gain of the appropriate controlled amplifier. This system also involves control of peak black levels. The black levels are detected by a method similar to that used on the Auto Black System, but in this case the signal feeds are taken after gamma correction has been applied. The black levels of the red and blue signals are compared with that of green, and the result of the comparison is used to actuate a motor-driven potentiometer. The output of the potentiometer is added to the output of the Auto Black circuitry and the resultant d.c level controls the black clipper already described. Both the white and black level controls may be overridden by operating the manual Colour Balance Controls.

PREVIEW CAMERA

The black-and-white preview camera is designed to use a single lead-oxide target tube in a standard Mark VIII yoke. The signal is taken from the head amplifier to the Preview Video board which is mounted in the main camera electronics frame. The video board provides horizontal aperture correction and simple gamma correction with the possibility of positive or negative operation. A level detector is incorporated to give automatic exposure control. This not only ensures that the preview camera is correctly exposed, but that a reasonably accurate exposure is assured when that source is first taken on-air. The pulse and scan circuits are based on the main channel design and are mounted on a single

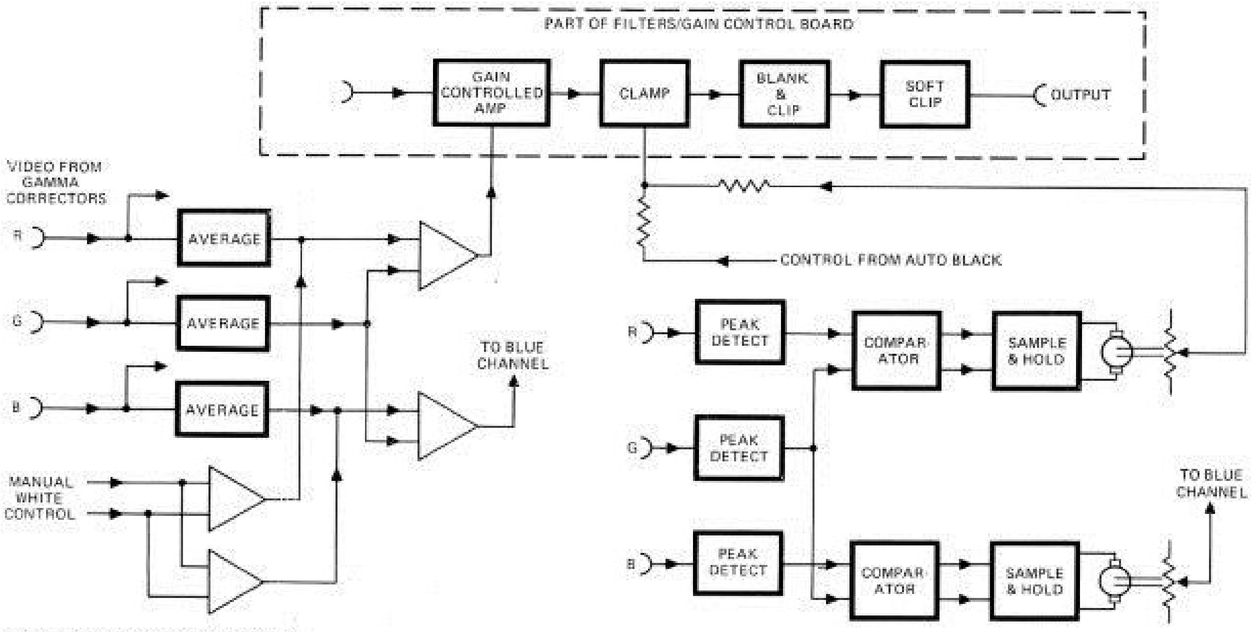

Fig.8 Auto colour balance system.

printed board which is also fitted next to the video board.

When the preview camera is fitted, the extra light control servo and an extra multiplexer control board are fitted into the main projector logic frame.

CONCLUSION

The camera channel design has been based on known and well-proven techniques. Many parts are common with the Mark VIII live camera offering the possibility of common spares where applicable. By including more automatic features the camera offers modern facilities in keeping with the rest of the television equipment.

REFERENCES

1 N. N. Parker-Smith: The Choice for the 70's, Sound and Vision broadcasting, Vol.11, No.2, et seq.

2 D. A. Pay and A. Fremont: Gamma in Telecine, Sound and Vision broadcasting, Vol.13, No.1, Spring 1972.

3 A. Fremont: The Mark VIII Colour Camera – Aperture Correction Facilities, Sound and Vision broadcasting, Vol.12, No.2, Summer 1971.

4 D. V. Ryley and G. Claydon: Automatic Features of the Mark VIII Colour Camera, Sound and Vision broadcasting, Vol.12, No.1, Spring 1971.

5 A. J. Butt: Automatic Exposure Control for Telecine, Sound and Vision broadcasting, Vol.11, No.1, Spring 1970.