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VIII

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AUTOMATIC FEATURES OF THE MARK VIII COLOUR CAMERA

INTRODUCTION

During the past few years, improvements have been made in almost every aspect of colour television camera design, but the tedious camera line-up requirement has remained. This involves adjustment of a large number of controls for setting the beam alignment of each tube, registration of the images and colour balance to the scene illuminant. It was thus a prime objective of the Mark VIII camera design to simplify operation by introducing an automatic line-up system.

The most complex problem was considered to be registration and the most attractive means of automatic adjustment appeared to be to extract error information from normal picture detail and to apply correction to the scanning waveforms to remove these errors. Investigation showed that the requirements of being able to correct a relatively large registration error, and proof against malfunction caused by adjacent similar picture details, were difficult to meet. The solution adopted is to provide a test chart containing a special pattern which the automatic registration system can utilize, and which can also be used to provide picture information for the automatic beam alignment system. This test pattern may be projected directly into the optical system from an internal diascope.

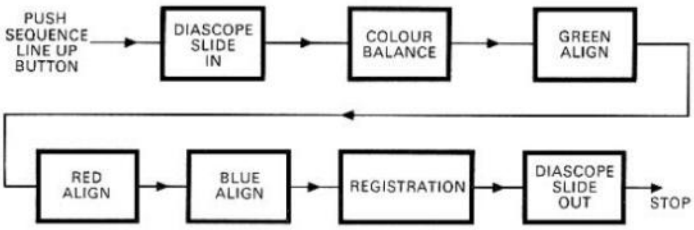

Fig.1 Automatic Line-up sequence.

The technique of detecting registration errors from normal picture detail is included as an additional feature in order to maintain good registration during actual operation. This system, called *Dynamic Centring*, continuously corrects registration errors at the centre of the picture by adjustment of the centring controls, and corrects for long term drift when the camera is in operation for prolonged periods.

The automatic colour balance feature is used to balance the camera on a standard white area under operational lighting conditions. An iris stand-by function has also been incorporated whereby the iris is controlled to maintain a reasonable picture from an unattended camera under varying lighting conditions.

As an aid to rapid fault finding the *Auto-test* feature provides a picture display consisting of rectangles which indicate correct functioning of various sections of the camera channel – a fault being indicated by the absence of one or more rectangles. The Auto-test pattern may be displayed on a black and white monitor, or on a colour monitor when each primary channel is displayed in the relevant colour.

AUTOMATIC LINE-UP

A block diagram of the automatic line-up sequence is shown in figure 1. The sequence is initiated by pushing the 'Seq. Line-Up' button on either the front panel of the CCU or on the Operational Control Panel. The camera is capped and the special diascope slide is projected into the front of the light-

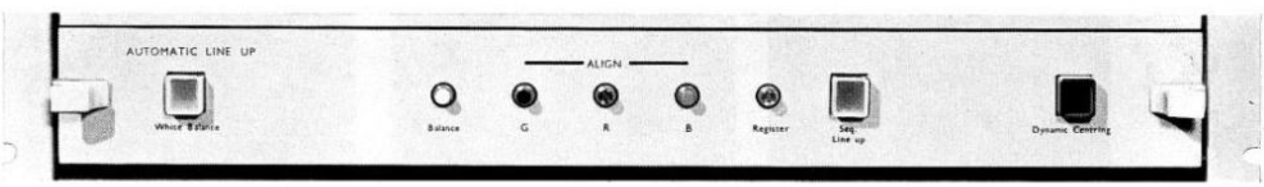

Fig.2 Camera Control Unit front panel.

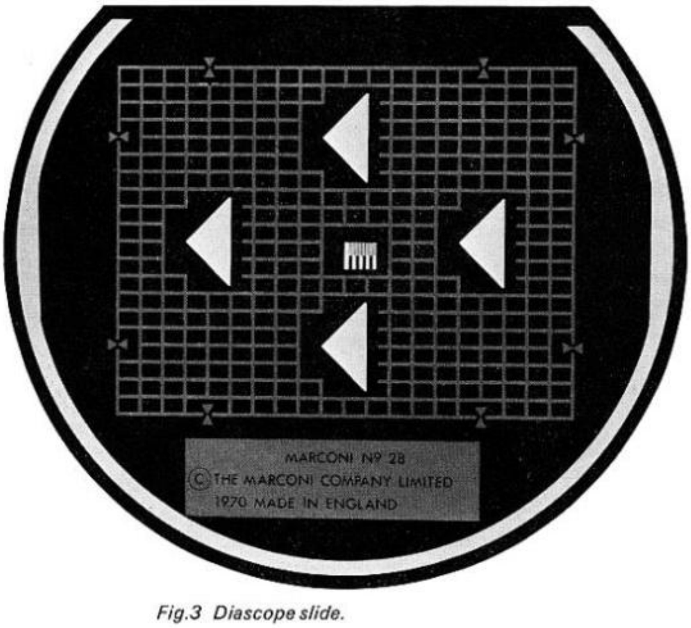

Fig.3 Diascope slide.

splitting prism. Automatic colour balance to the colour temperature of the diascope lamp next takes place and adjusts the amplitudes of the diascope image video signals to equal predetermined levels. Automatic beam alignment then begins, the green, red, and blue tubes being aligned in sequence. When this is complete the three images are automatically registered, the system is switched off, the diascope slide removed, and the camera uncapped.

A detection system is used to ensure that each stage of the setting-up sequence is completed before proceeding to the next stage, and to switch off when the final operation is finished. The line-up sequence progress is indicated by a lamp on the CCU tray front panel (Fig.2).

A rotary switch is provided inside the tray which allows the sequence to be interrupted at any point or enables a selection of separate functions. Thus registration only, or alignment of any one tube, may be selected in addition to normal full sequence operation, and an 'Off' position is provided by which the system may be positively switched off, but in all cases the system is automatically switched off when the functions selected have been completed.

The full line-up sequence normally takes less than one minute – when the adjustments to be made are small, as for example in day to day set-up. In extreme cases, as when tubes have been changed, the time taken is less than three minutes.

Diascope Slide

The special diascope slide used for automatic registration and beam alignment is shown in figure 3. The four triangles are used for the registration system, where the diagonal edges are used to detect misregistration in the horizontal and vertical directions. The centre square is used for beam-alignment error detection and also contains 400-line and 100-line resolution bars for checking beam focus settings. The pattern also contains framing darts and a grating for general line-up purposes.

The slide consists of a deposit of nichrome and gold on an optical glass substrate.

Automatic Beam Alignment

The automatic beam-alignment system employs the established principle of applying modulation to the focusing potential of the camera tube, and adjusting the current in the alignment coils for zero displacement at the centre of the picture (Fig.4). For vertical misalignment detection line pulses are gated through the vertical clock gate to a 5-bit reversible counter. The gate is opened by field pulses and is closed by video information from the top left-hand corner of the square at the centre of the diascope slide image. The count of line pulses thus obtained, which gives a measure of the position of the centre of the picture with respect to the top, is stored in the counter. The polarity of the focus modulation is then changed, together with the direction of count, and the counting of line pulses from the top of the picture to the centre square is repeated. The residual

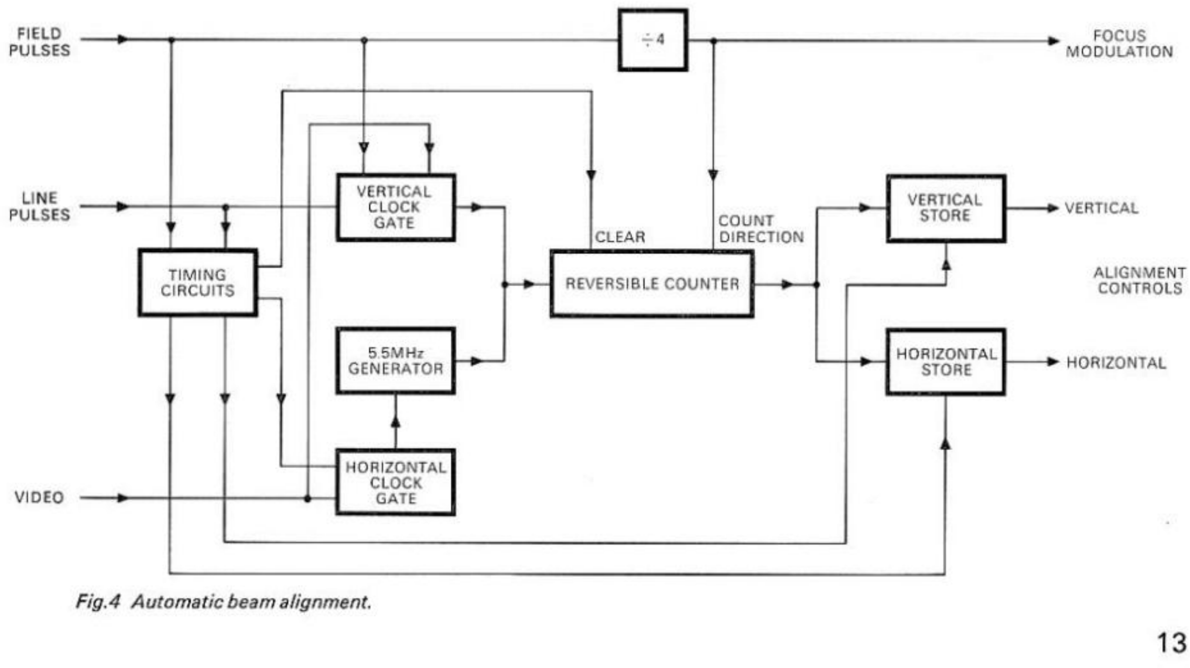

Fig.4 Automatic beam alignment.

state of the counter after these two processes have been carried out indicates the direction of vertical beam alignment error. This information is fed to the vertical beam alignment correction motor-driven potentiometer in the camera which changes the current in the vertical alignment coils to reduce the error until a count difference of zero is obtained, at which point the vertical beam alignment error has been eliminated.

Horizontal beam alignment error detection is carried out on the same principle by counting cycles of a free-running 5·5MHz multivibrator which is started by line pulses and stopped by information from the square at the centre of the chart. A reverse count is made after changing the polarity of the focus modulation and the difference in count is used to control the horizontal alignment correction motor-driven potentiometer.

As shown in figure 4, to economize in circuit components, the 5-bit reversible counter is time shared between the horizontal and vertical error detection processes and stores are introduced to maintain each error signal while detection of the other is carried out. To avoid errors in misalignment detection in the vertical direction due to line interlace, the focus modulation is effected at quarter field frequency, the counting process being carried out on alternate fields.

Automatic Registration

In the automatic registration system (Fig.5) the green image is used as a reference and the red and blue images are examined for misregistration with respect to green. Adjustments are then made to the appropriate scanning parameters to remove registration errors.

The angled edges of each triangle of the diascope slide image are used for misregistration detection. Using information from the green image a line selection system gates out detection lines through the mid-points of both leading edges of each triangle. By examining the relative timings of the video waveform transition for each pair of images at these two points the direction of the registration error may be detected. In figure 6(a) the plain triangle represents the green image and the dotted triangle the red or blue image, with a horizontal registration error. The horizontal error is indicated by leading edge displacements in the same direction along each detection line. Figure 6(b) represents a vertical registration error which is indicated by displacements in opposite directions along the two detection lines. Normally the misregistration will be a combination of horizontal and vertical errors, with the system arranged to apply correction to the dominant error until two diagonal edges are brought into coincidence. From this point, horizontal and vertical corrections are applied simultaneously to bring the second diagonal edge and hence the complete triangle into register.

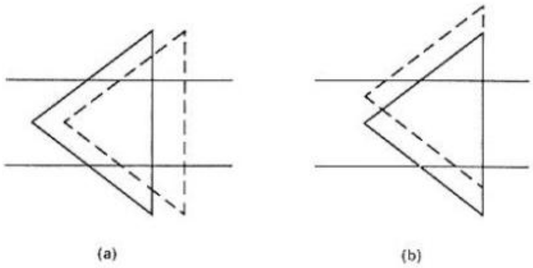

Fig.6 Displacement of diascope image triangles with:
(a) Horizontal registration error.
(b) Vertical registration error.

Horizontal error information from the left and right-hand triangles is arranged to control horizontal centring and width respectively. Vertical errors in the top and bottom triangles control vertical centring and height.

Simultaneously, control of horizontal linearity is carried out from horizontal error information in the top triangle, and skew (angle of verticals) from horizontal errors in the bottom triangle, while over-all twist is controlled from vertical errors in the left and right-hand triangles.

The seven scanning parameters for each of the red and blue tubes are controlled by motor-driven potentiometers and all fourteen are operated at the same time to achieve a rapid over-all registration of the images.

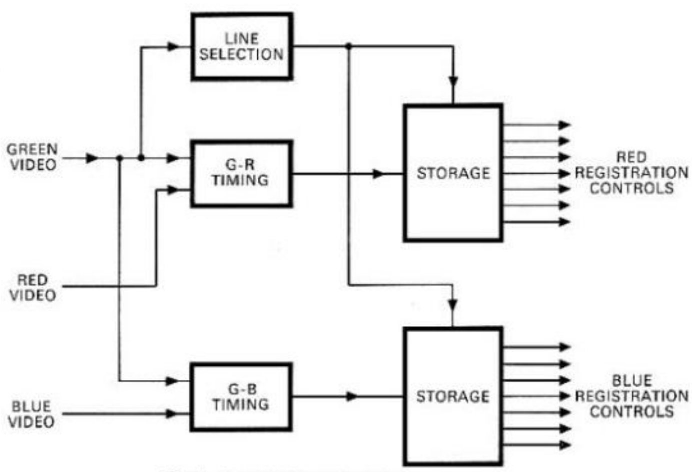

Fig.5 Automatic registration.

AUTOMATIC COLOUR BALANCE

Correct colour balance of the Mark VIII camera to the actual scene illuminant is achieved by adjusting the gains of the blue and red video channels to obtain equal signal output levels with respect to green when the camera is viewing a reference white area. By monitoring directly at the outputs of the camera channel inaccuracies of balance due to the tolerances in the terminating resistors are eliminated.

A block diagram of the automatic colour balance system is shown in figure 7. Green, red, and blue signals from the centre part of the picture area are fed into identical peak detectors which produce d.c output levels proportional to the peak signal amplitudes. A level detector is used to compare the output of the green peak detector with a reference voltage, and this output used to drive a motor-driven potentiometer which controls the lens iris servo. By this means the iris is adjusted to obtain a

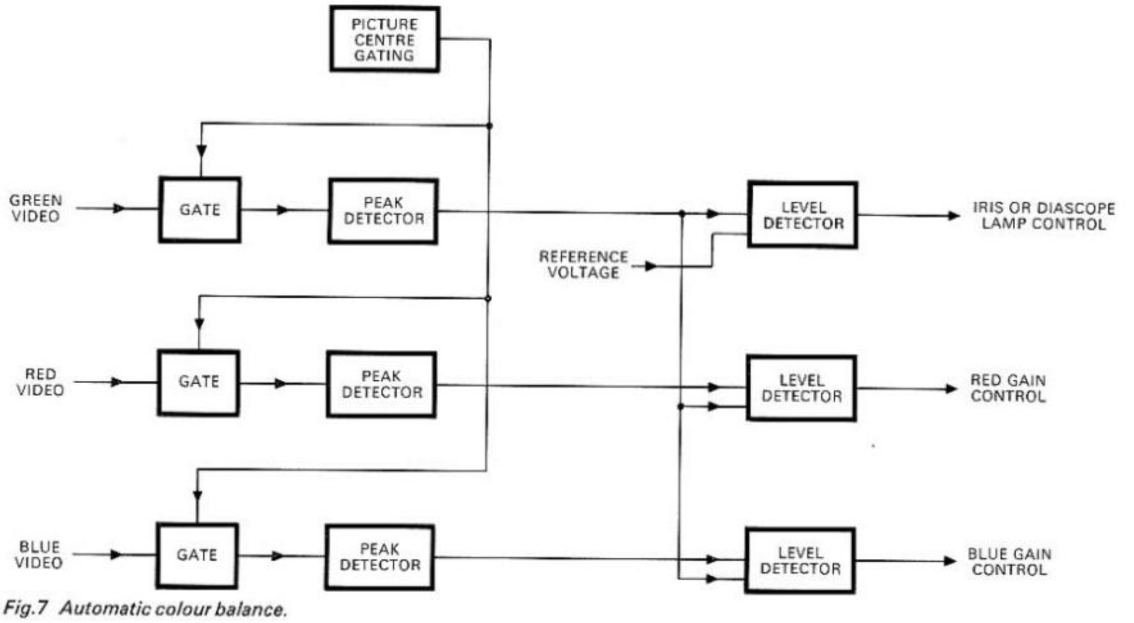

Fig.7 Automatic colour balance.

predetermined peak amplitude of green signal which has been chosen to be 0·65V in order to keep clear of the video clipping level. For the red and blue channels the video amplifier gains are adjusted by motor-driven potentiometers controlled by level detectors which compare the outputs of the red and green, and the blue and green peak detectors, respectively. In this way, the peak amplitudes of the red and blue outputs are adjusted to be equal to the green. The system operates on approximately 10% of the picture area at the centre and the active area is indicated on the camera viewfinder when the balancing operation is taking place.

The automatic colour balance system is used by framing a suitable white area which is exposed to the scene illuminant and pushing the 'Colour Balance' button on the CCU front panel or Operational Control Panel. The control of iris is transferred from the normal control to the motor-driven potentiometer and the colour balance process is automatically carried out. When equal output amplitudes of 0·65V have been achieved the system switches off and the control of iris is returned to the manual operational control. Operation of the system is indicated by illumination of the colour balance push button and this is extinguished when the process has been completed.

The automatic balance system also forms part of the sequential line-up procedure, where it is used to adjust the diascope image signals to equal amplitudes of 0·65V in order to establish a predetermined signal amplitude for the automatic registration and beam alignment systems. In this case, the diascope lamp brightness is controlled in place of the lens iris.

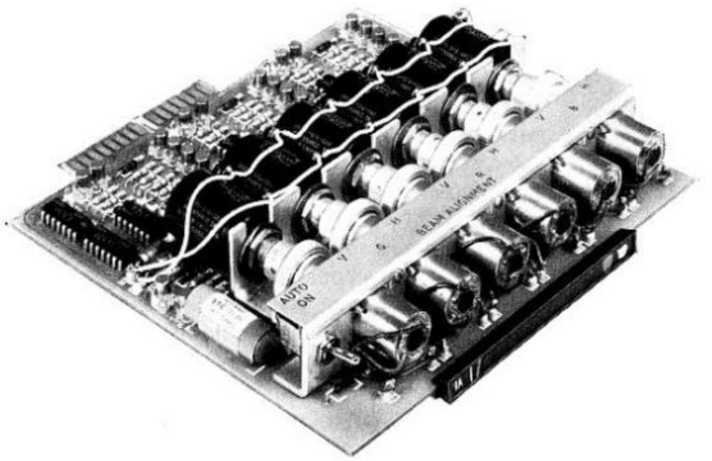

Fig.8 A Typical group of motor-driven controls.

Iris Stand-by

The iris stand-by system utilizes a section of the automatic colour balance circuitry and is intended to be used primarily as a safety device to prevent overexposure of the tubes in an unattended camera. This facility cannot be regarded as an automatic iris control for operational use. Nevertheless, reasonable pictures can be obtained in varying light conditions with the use of the iris standby.

CONTROLS

It is a requirement of an automatic line-up system that, when the automatic processes have been carried out, the settings of registration, alignment and colour balance must be stored while the camera is in operation. Preferably storage should be maintained when the camera is switched off, so that when it is switched on again a usable picture is obtained.

Storage systems considered were a digital store, capacitor storage and motor-driven potentiometers. Motor-driven potentiometers were chosen as they provide storage when the camera is switched off, are relatively inexpensive, and have the additional advantage that they can be manually adjusted.

A typical group of controls, consisting of miniature d.c motors driving multi-turn potentiometers through a slipping clutch mechanism incorporating a thumb wheel control, is shown in figure 8. The d.c motors may conveniently be driven directly from the digital circuits employed in the automatic control systems. Figure 9 shows the motors tray in the CCU containing colour balance and registration controls.

DYNAMIC CENTRING

Even if the camera is initially registered correctly long-term differential drifts mainly due to mechanical and electrical instabilities are virtually impossible to eliminate. Such instabilities appear mainly as a shift in centring accuracy and dynamic centring has been designed to overcome these errors.

Requirements were that the system should be reliable, reasonably simple since it is only a back-up feature, sensitive, but immune to spurious signals which might cause malfunction. A digital system was chosen which selects and compares edges of video transitions in the horizontal and vertical directions and applies corrections to the centring controls of the camera in a direction to reduce the errors.

The detection of errors is carried out along horizontal and vertical search lines situated near the centre of the picture (Fig.10). To avoid ambiguous error signals from low-definition information, which would limit the accuracy, the detection system operates only on sharply defined edges. This is achieved by dividing the picture into discrete steps and processing this information to select transitions having a rise time faster than a predetermined value.

The block diagram of the system is shown in figure 11. Each level detector produces a digital output the state of which depends on whether the video waveform is above or below a reference level.

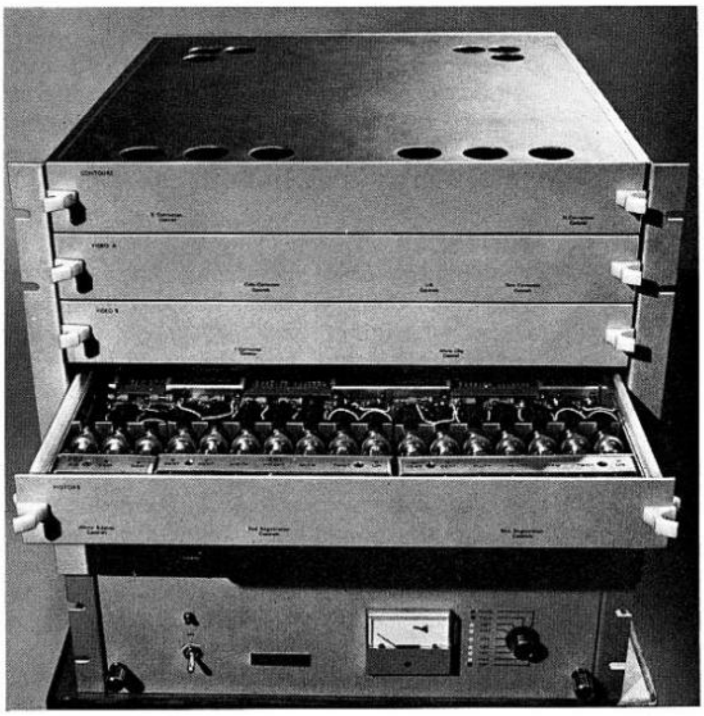

Fig.9 CCU motor driven control group.

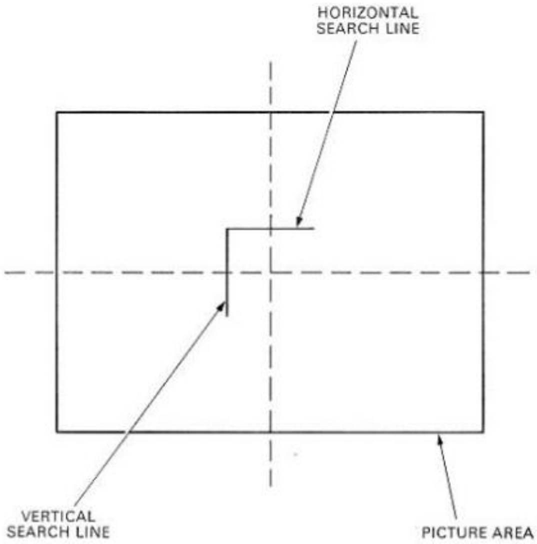

Fig.10 Search lines for dynamic centring.

Each tube has two level detectors and the two reference levels are close to and symmetrically displaced about the half-amplitude of the video signal. The outputs of the level detectors are sampled at line frequency for the duration of the vertical search line, and at 5·5MHz for the duration of the horizontal search line, and stored for the period of one sampling pulse. The horizontal sampling frequency is chosen to give the same resolution in the horizontal and vertical directions.

The sampled signals then pass to the edge detector stages where they are examined for patterns representing video transitions suitable for error correction. The green signal is used as a reference and the red and blue signals are arranged to time share the second edge detector circuit by passing them through an electronic switch the switching frequency of which is chosen to include an even and an odd field in order to achieve better vertical resolution. The edge detection is carried out by a synchronous sequential logic system synchronized to the sampling waveform. The edge detector circuit recognizes positive or negative going transitions where the video waveform passes through both reference levels within the duration of one or two sampling pulses. Slower edges are rejected.

The outputs of the two edge-detector circuits are fed into the comparator. This produces an output signal when it receives information from both edge-detector circuits indicating that suitable transitions have occurred in both video inputs which are of the same sense (that is, either both positive going or both negative going), followed by a second set of transitions of opposite sense, and which are separated by at least seven sampling pulse periods, with both sets of transitions displaced in the same direction by not more than two sampling pulses.

In common with any automatic registration system working on picture information there is a danger of operating from a luminance detail unaccompanied by a colouring detail, and a colouring detail unaccompanied by a luminance detail which are in close proximity in the picture area. Had the

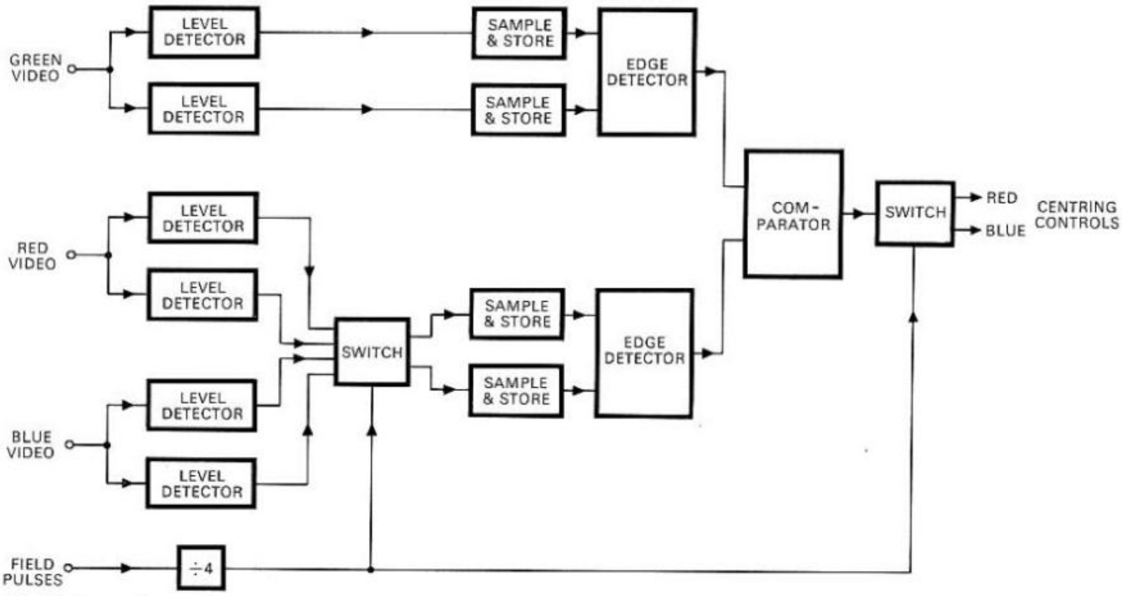

Fig.11 Dynamic centring system.

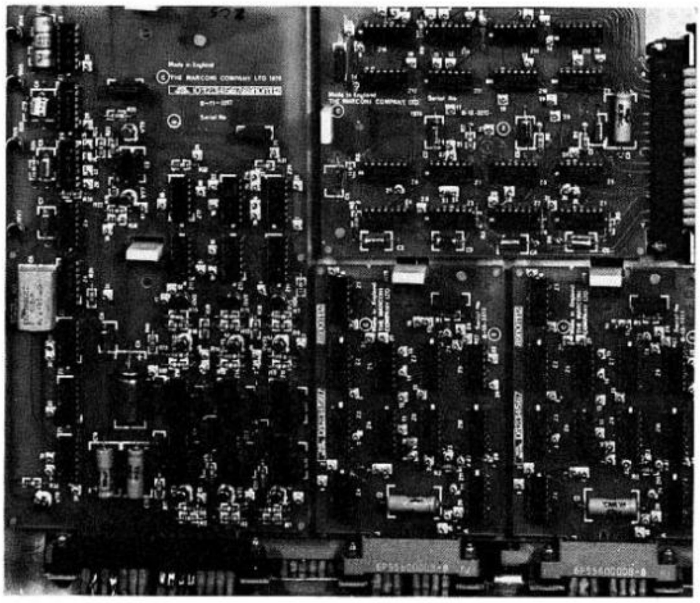

Fig.12 Dynamic centring circuitry.

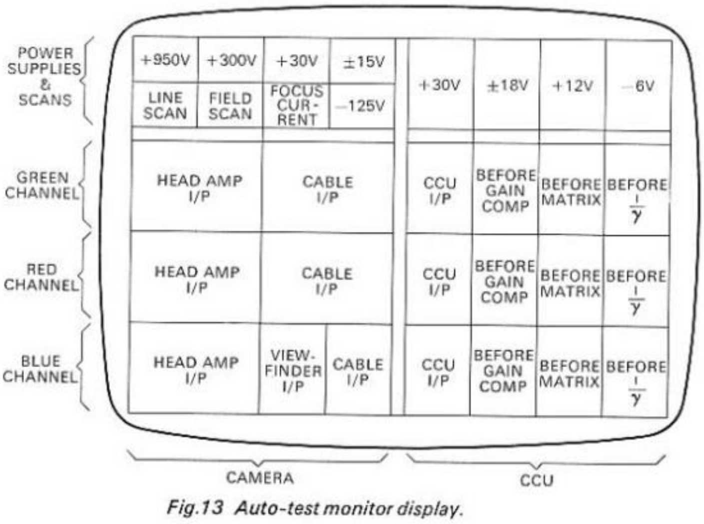

Fig.13 Auto-test monitor display.

comparator worked on a single transition only the chances of malfunction for this reason would have been significant. In the present design, where both senses of transition are required, this has been reduced to statistically negligible proportions. The maximum displacement of transitions for operation of the comparator is limited to two sampling pulse periods to prevent the system operating on picture information in which there are adjacent edges which could be misinterpreted as registration errors.

The outputs of the comparator are in digital form and consist of signals that are present for one field period whenever an error is detected. These outputs are fed to the centring controls of the colouring tubes via a second electronic switch, synchronized to the first, thereby separating the red and blue controls. The same motor-driven centring potentiometers are used as for the automatic registration system so that dynamic centring continually updates the registration of the camera channel. Figure 12 shows the four printed circuit boards used for the dynamic centring system. A fully digital system has the advantage that, as the operation is frequency independent, the same circuits may be used for horizontal and vertical registration error detection.

AUTO-TEST

Auto-test has been designed to give an immediate visual indication of faults in the video systems, power supplies and scanning circuits of the camera. A number of pulses are fed into selected points along each video signal path, progressively timed, such that a series of pulses is obtained at the outputs which are displayed on the monitor (Fig.13). Electronic switching is introduced to divide the television field so that the red, green, and blue video outputs are displayed one below the other. The top row of rectangles indicates the presence of supply voltages, focus current and scanning currents.

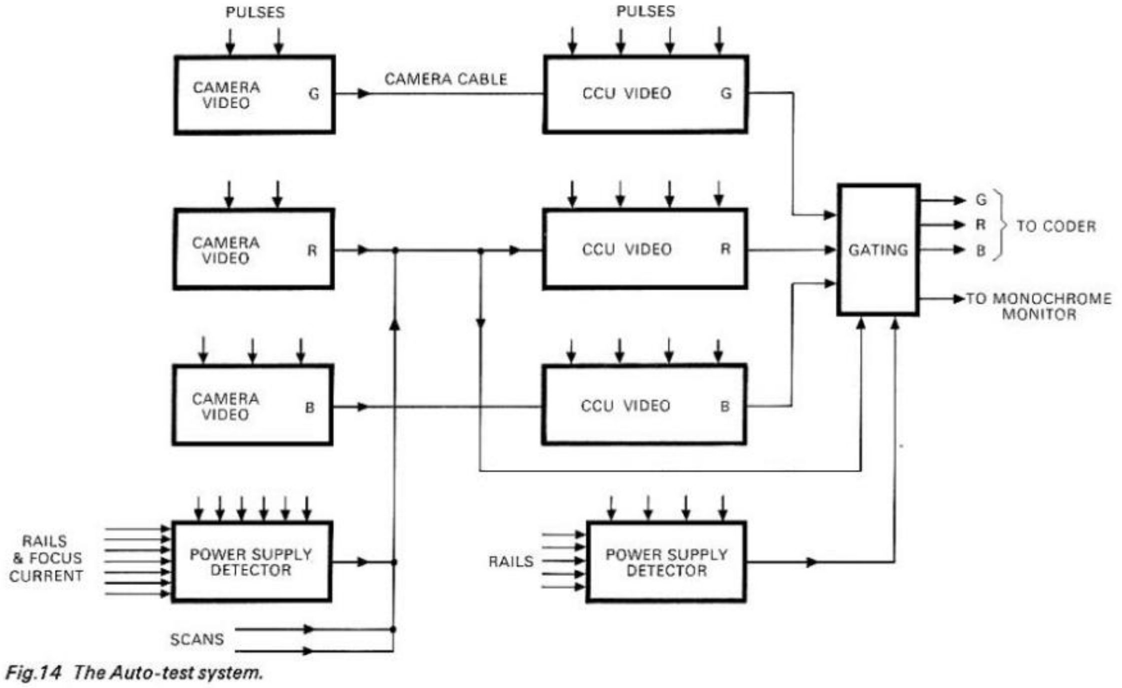

Fig.14 The Auto-test system.

Failure of any section of a video signal path is indicated by the absence of rectangles preceding the point on the display representing the location of the fault. A power supply voltage outside a predetermined tolerance removes the appropriate white rectangle and absence of the line or field scan rectangles indicates loss of the appropriate scanning current (Fig.14).

In the camera a number of pulses are generated which represent each of the squares on the left-hand side of the display (Fig.13). These pulses are fed to each head amplifier input and camera cable input and, in the case of blue, also to the viewfinder demodulator input. Pulses are also taken to the power supply detector circuit where six voltages and the focus current are monitored for correct level. Signals indicating the presence of line and field scans are obtained from scan protection circuits and fed, together with the power supply detector output, to the red camera cable.

Similarly, pulses are fed to the four points in each video path in the CCU shown in figure 13 and the outputs of the video channels are taken to an electronic switch. The output of the CCU power supply detector, which monitors five supply voltages, is also fed to the electronic switch together with camera power supply and presence of scanning current information directly from the red camera cable input, by-passing the red video circuits in the CCU. The electronic switch gates through the power supply and video output information, each for a section of the field, to obtain green, red, and blue outputs for the colour monitor display, and an additional monochrome output.

To ensure reliability, the complexity of the Auto-test circuits have been kept to a minimum and they are operated from only one supply voltage in the camera and CCU.

Acknowledgement

The authors wish to thank Mr A. N. Heightman and Mr W. T. Underhill for their help and guidance given in the design of the automatic systems. Many of the features described in this article are covered by Provisional Patents.

REFERENCES

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3 Dynamic Centring Provisional Patent No.37994/69.
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