Source: Communication & Broadcasting - Spring 1978

N. N. Parker Smith, B.Sc., F.I.E.E.

IX The Mark IX – a camera system for the 80s

Summary

The new Marconi Mark IX camera system, described in this introductory article, has been designed to cover all foreseeable television production requirements for the next five to ten years. The Mark IX system includes both a studio and outside broadcast camera head employing 30mm lead-oxide camera tubes, and a lightweight portable head using 1-in tubes. The portable head may be shoulder-mounted, or fitted to a light tripod, with either a 1in or 3in viewfinder. It may also be mounted with a 7in viewfinder on a camera dolly for studio use. The camera control unit, used with both camera heads, includes the channel power supply and colour encoder and occupies only 222mm (8¾in) of rack height.

Both standard Mark VIII multicore cable and triax cable may be used, as is illustrated in the diagrams which show the general flexibility of the Mark IX system.

The Mark IX incorporates an updated version of the well-tried Mark VIII automatic registration system, and a number of other automatic facilities, some entirely new. These facilities are, however, optional and can be omitted where the operational conditions allow.

A new feature is a dynamic gain control circuit, enabling the picture contrast to be improved where detail would otherwise be lost in the black or white regions of the picture.

Detailed descriptions of the units making up the Mark IX system will be given in further articles.

Introduction

In 1970 we presented the Mark VIII camera under the title 'The Choice for the 70s'.[1] Now in 1978 it is time to review the situation and see how changes in production techniques should influence camera design. This introductory article presents an overall picture of the new Marconi Mark IX camera system which has been specifically designed to cover all foreseeable production requirements over the next five to ten years.

Changing production methods

Over the past decade there has been a major investment in elaborate studio centres and sophisticated editing techniques. Despite this, however, artifices such as chroma-key are becoming less acceptable to the producer and more and more work is being carried out on location. Also apparent is a slow but steady take-over of film by tape, at any rate as far as inserts for studio production are concerned.

To meet these changing requirements, camera designers have gone along a variety of paths. Thus we have cameras using a single coaxial camera cable which together with an outer earthing screen has become known as triax. Such a camera is often ideal for outside broadcasts or for use on location but is unnecessarily complex and somewhat restrictive for permanent installation in a studio. Again, we have the portable camera which may be used with a light tripod or carried on the shoulder. Such cameras are well suited to much location work and to certain types of outside broadcast. On the other hand, the need for minimum size and weight limits the number of operational facilities which can be provided, and some portable cameras are not suitable for use in the more sophisticated types of studio. Considerable economy can sometimes be obtained however by associating a portable camera with a studio type viewfinder, thus enabling the basic camera to be used either on location or where less sophisticated studio facilities are required. If the above range of requirements is to be met without prejudice to the individual modes of operation, it is essential to create a camera system comprising a number of basic units rather than a single camera channel. Each unit must however be purpose designed and not merely an assembly of sub-units with add-on boxes.

The studio and outside broadcast camera head

The heart of a television camera is the optical system and the camera tubes. In neither of these areas has there been any significant advance over the past few years. The optical system for the Mark IX camera is therefore based on the system developed for the Mark VIII, which uses the unique minifier lens in the red and blue channels in order to match lag without sacrificing sensitivity. The 30mm lead-oxide camera tube is ideally suited to this arrangement and, as with the optical system, no serious contenders have yet challenged this tube for full broadcast quality applications. The in-built diascope, an essential feature in providing truly automatic setting-up facilities, has also been retained. As will be seen later, the extremely compact nature of the optical system also enables the camera to be extended to triax operation whilst retaining a small size and weight.

Portable camera head

In the interests of weight and size, a conventional optic has been used with 1in lead-oxide camera tubes. Coupled with the use of modern components and light weight

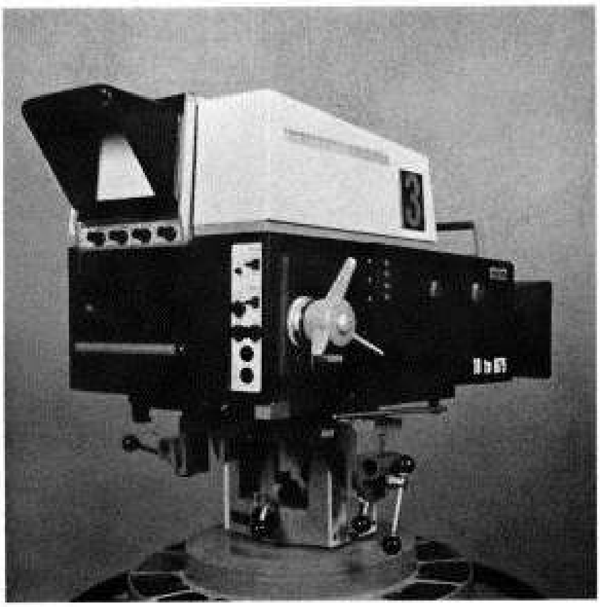


Figure 1. Studio and OB camera

materials, this has made it possible to design a completely self-contained camera head, thus dispensing with the need for an auxiliary pack up to a camera-to-CCU separation of 90m (300ft). Even above this distance, the only additional unit needed is a small rugged box 89×114×279mm ($3\frac{1}{2}\times4\frac{1}{2}\times11$in) in length – slightly longer than a conventional house brick, and devoid of any operational controls.

In its light-tripod or shoulder-mounted role, the camera may be used with either a 25mm (1in) monocular or a 76mm (3in) direct view type viewfinder.

Studio/portable

To permit the use of the portable camera head for studio applications, it may be mounted, together with a 180mm (7in) studio viewfinder, on a studio camera dolly or pedestal.

Camera control unit

Either camera head can be connected to a common CCU, via a standard Mark VIII multi-core camera cable. General advances in circuit techniques have made possible a complete CCU in 220mm ($8\frac{5}{8}$in) of rack space, and since both channel power supply and colour encoder are included in the basic height, this represents a decrease in rack height occupied of over 2.4:1 as compared with the Mark VIII CCU.

In particular, attention has been paid to keeping the total power requirement for the channel as low as possible. To this end, switched mode supplies have been employed and the relatively high efficiency obtainable with these has allowed the power requirement for the studio and OB camera channel to be reduced to under 350W, with proportionately lower figures for the portable camera in its various forms. These low input power requirements make the channel suitable for battery operation.

The studio camera head may be operated with up to 900m (3000ft) of Mark VIII multi-core camera cable between camera and CCU, and the portable head with up to 90m. The distance between the CCU and the portable head may however be increased to 900m, merely by transferring two circuit boards from the CCU power supply to the small unit mentioned earlier, and fitting this in the cable run at a distance of not more than 90m from the camera.

Triax facility

The triax system allows the separation between the camera head and the CCU to be increased to 1500m (5000ft). The system adopted transmits the three colour separation signals to the CCU on different rf carriers so that the bulk of the signal processing circuits and the coder remain in the equipment rack. Such facilities as chroma-key are thus available as standard. The triaxial units at the camera head are fitted in a special side door 50mm (2in) thick and in addition three of the camera modules are changed for triax operation. At the CCU, a 135mm ($5\frac{1}{4}$in) unit is fitted which receives the triax cable and is itself connected to the CCU, by a short length of multi-core cable.

For use with the portable camera, the camera head triax units are housed in a triax convertor unit together with the two camera power supply boards mentioned earlier. The CCU end is the same as for the studio camera head. With this arrangement, the separation between CCU and triax convertor can be up to 1500m, and that between camera and convertor up to 90m.

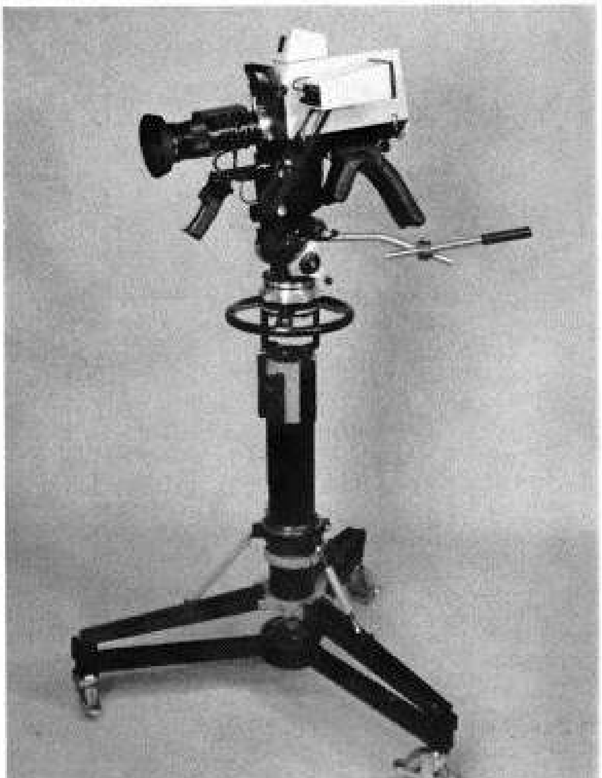


Figure 2. Portable camera mounted on a lightweight dolly

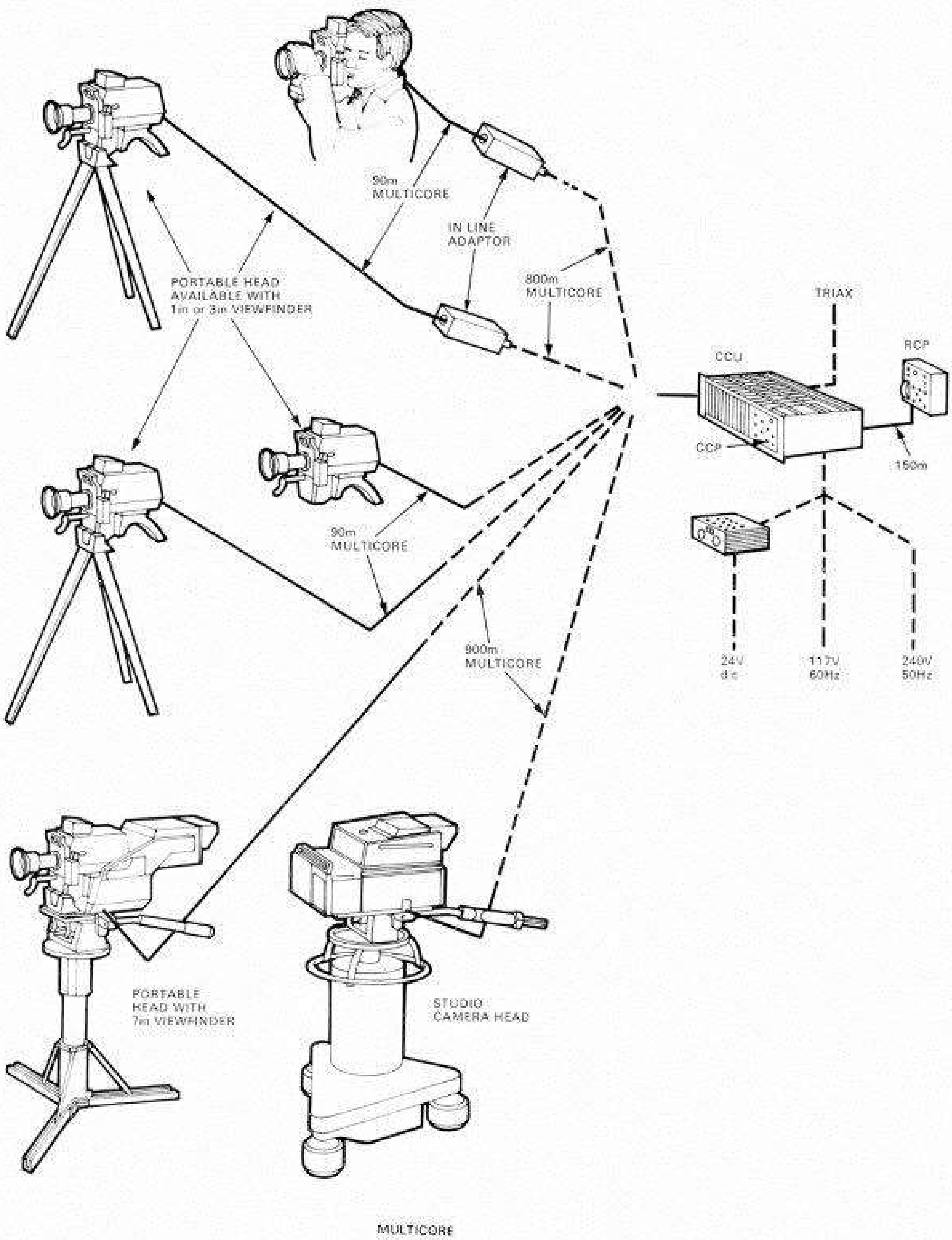


Figure 3a. Camera family using multicore cable

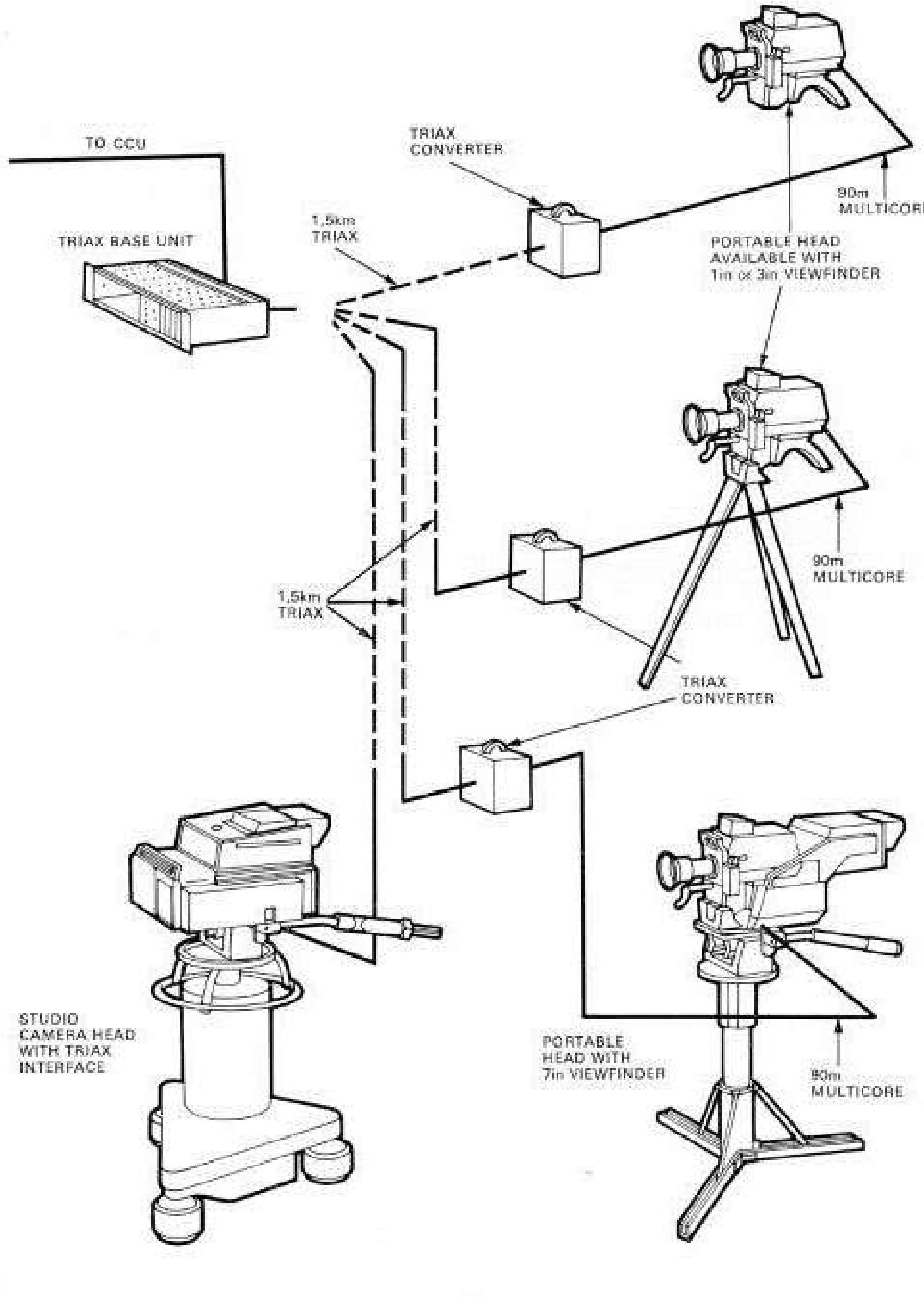


Figure 3b. Camera family using triax cable

Automatic facilities

As in most branches of modern technology the trend in camera design has been towards increased automation. It has been said that if a colour camera were adequately stable there would be no need for automation. Absolute stability is not readily achieved however and the provision of automatic systems to maintain equipment at its peak level of performance saves time and avoids the use of highly skilled operators to perform routine tasks.

Taking registration as an example, and remembering that the image on the camera tube is only some 10mm in height, a mechanical stability of better than 5μm is called for, covering tube, yoke and optical system. This tiny distance is the amount by which a 10cm length of aluminium expands or contracts when subjected to a temperature change of 2.5°C and it would certainly be difficult to guarantee that such movements will not produce differential changes in the three colour channels.

The Mark IX therefore incorporates an updated version of the well-tried Mark VIII system of automatic registration using the diascope, and also of automatic centring from picture information. These facilities are however optional and may be omitted in applications where the general environment or the operating procedures allow.

Other operational features include automatic white balance, automatic black balance, automatic black, automatic iris, and automatic dynamic gain. Apart from the white balance which operates from a reference white patch which the cameraman frames in the centre of the picture in exactly the same way as was used for the Mark VIII, the other features are essentially new. Black balance operates with the lens capped, and equates the average black level in the three channels rather than the peak picture levels as in the case of white balance.

Automatic black and automatic iris are designed to operate from picture information and to maintain sensible levels of black and peak signal during transmission.

A new feature of the Mark IX is the dynamic gain control circuit which is provided in the coder. This circuit enables the picture contrast to be improved in cases where the majority of picture detail would otherwise be lost either in the 'blacks' or in the near white region of the picture. For manual use a knob is provided which increases the gain in the black part of the picture relative to the gain near white or vice versa according to whether the desired picture detail is being 'lost' in the black or white parts of the picture.

Looked at in another way, the requirement is usually to vary the incremental gain in order to bring the average picture level to a point half-way up the grey scale. On this basis, the dynamic gain can be controlled automatically rather than manually, the aim being to maintain average picture level at the mid-point of the grey scale, and a position on the dynamic gain control switch is provided to do this.

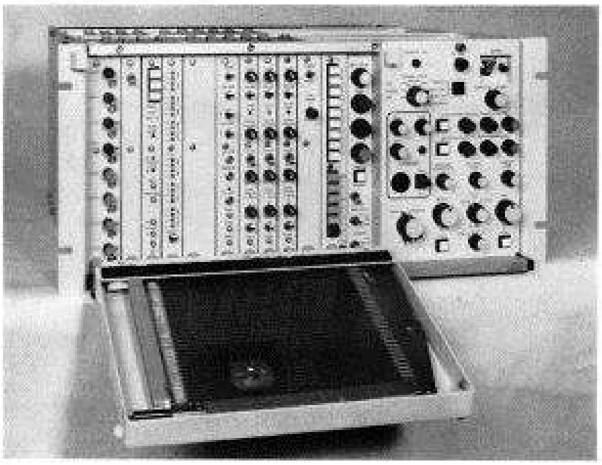


Figure 4. Mark IX camera control unit with front cover open

Protection against highlights

Both the camera heads are designed to use the HOP (Highlight Overload Protection) or ACT (Anti Comet Tail) versions of the lead-oxide camera tube. Because the 30mm and 1in versions of these tubes operate most satisfactorily at approximately 300nA and 200nA respectively, the basic channels are arranged to operate at these currents at normal gain, although operation at a 3dB lower gain setting is obtainable by a link change. The maximum highlight tolerated is a five stops overload regardless of the area of highlight involved. Care has been taken to provide equal bandwidths in the three head amplifiers up to the point where the excess signal is removed, and this avoids the situation where different head amplifier characteristics can introduce coloured edging to the highlights.

Registration

In both cameras, the main registration controls have been retained in the camera head in order to eliminate drifts due to temperature changes on long lengths of camera cable. Two per cent of the control range is however remoted to the CCU, to provide the necessary trim controls, whether for automatic or for manual registration.

In the studio camera, controls of picture geometry have been provided in addition to the normal registration controls, which solely affect the amplitude and linearity of the scans. Geometric distortion due to imperfections in the tube or scanning yoke are likely to produce image displacements which are proportional to field radius. In other words, all points lying on a centrally placed circle will be moved by an equal distance towards or away from the centre of the image by an equal amount. Such 'pin-cushion' or 'barrel' distortion cannot be corrected by simple adjustments to the scanning circuits, and the provision of a true geometry corrector is particularly important in the case of the studio camera head in which the image size in the red and blue channels has been optimized with respect to noise and differential lag.

Audio facilities

In addition to the normal communication facilities, two programme quality audio circuits are provided in the studio camera channel for use with commentators' or effects microphones. A single circuit is provided in the portable.

Overall system

A diagrammatic presentation of the overall system is given on pages 6 and 7. The left hand page shows the various modes of operation using multicore camera cable. The shoulder mounted and light tripod modes of operation can employ either a 1in monocular viewfinder or a 3in viewfinder. The arrangement shown with the 7in viewfinder employs lenses mounted directly on the front of the portable camera head, and an alternative version also exists which enables the portable head to be used with larger lenses such as are normally used with the studio camera head.

The right hand page shows how the various configurations given for multicore operation are adapted for triax operation.

A large team of engineers has been involved in the development of this completely integrated camera system, and detailed descriptions of individual units will be contributed by members of the team in further articles.

References

1 N. N. PARKER SMITH and W. T. UNDERHILL: 'The Choice for the 70's', *Sound and Vision Broadcasting*, Vol.11, No.2, pp.3–11 (Summer 1970).

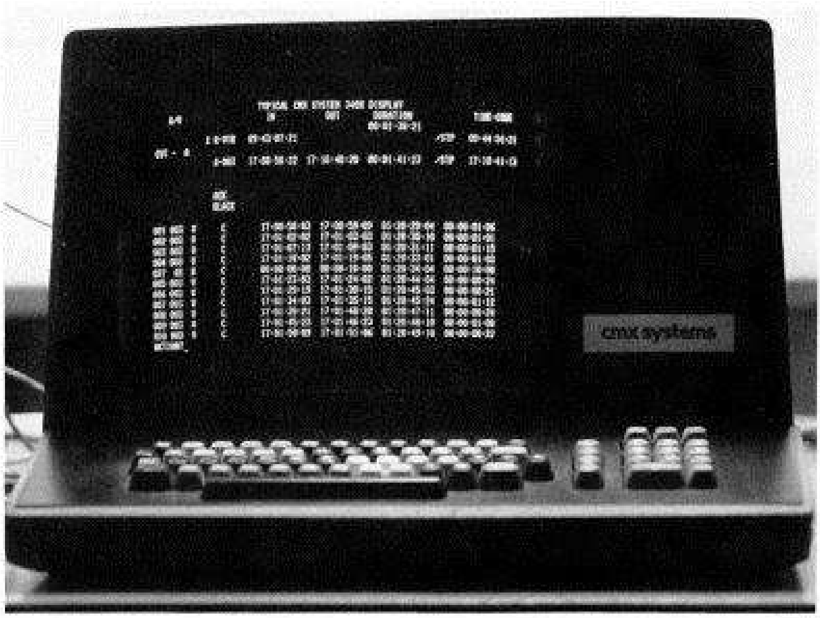
New agreement extends Marconi video tape capability

With the signing of a new agreement, Marconi Communication Systems has been appointed the distributor for one of the world's most advanced ranges of video tape editing systems – the Orrox Corporation's computerized CMX series.

Under the terms of this agreement, Marconi will have virtual world-wide distribution rights for all CMX brand tape editing systems, and exclusive UK distribution rights for Orrox's new modular CMX340X system. This follows the agreement announced in May 1977 for Marconi to manufacture and market the new Ampex range of 1in helical video tape recorders as the MR1 and the MR10, described in our last number.

The Ampex agreement was an important step for Marconi Communication Systems – not only did it complete the company's product range and make Marconi the only supplier able to deliver all main items of television broadcast systems which are of UK manufacture, but it also established a strong position from which the company could exploit the booming video tape equipment market. The new agreement to distribute Orrox's video tape editing systems will strengthen Marconi's position in the video equipment market and further enhance the company's overall competitive capability in the world's television broadcast markets. The Orrox Corporation of Santa Clara, California pioneered computer-assisted video tape editing when it introduced the Emmy award-winning CMX System 600 in 1971. The CMX Systems 400, 300, 50 and 40 were all logical extensions of the technology which fostered the 600. Recent advances in microprocessor LSI technology have resulted in the introduction of the CMX System 340X – a modular system capable of expansion from a simple two machine formation to complex 32 machine configurations to meet all video tape editing needs.

The CMX 340X embodies a new concept in computer-assisted tape editing. Instead of placing all logic and control in the central processor, separate microprocessors are used for each machine plugged into the system. This approach frees the central processor to perform 'house-keeping' and 'look-ahead' functions while the memory in the microprocessor is concentrated on the device under its control. There are, therefore, no significant pauses while the system waits for one action to finish before re-setting for a subsequent one. This compression of editing time is one of the major benefits achieved by the CMX 340X. The flexible CMX 340X utilizes separate microprocessor interfaces that can inter-marry, control and mix both quad and helical recorders together with video discs, telecines, synchronous audio recorders and video switchers.



Control console of CMX System 340X

J. R. Crook, C.Eng., M.I.E.R.E. and I. E. Gibson, B.Sc., C.Eng., M.I.E.E.

IX A new studio outside broadcast camera channel

Summary

A studio/outside broadcast camera which forms part of the Marconi Mark IX camera system is described in the article. The use of a unique optical system has resulted in a compact design employing three 30mm lead oxide camera tube types. The camera may be used with a wide range of tubes including those which incorporate Highlight Overload Protection (HOP) and light bias. Two filter wheels are fitted, one remotely controlled and one controlled by the cameraman. The optical system also contains an integral diascope and a remotely-controlled capping shutter.

The Mark IX camera control unit which includes an integral power supply, occupies only 222mm (8$\frac{3}{4}$in) of rack height. The low power consumption allows the option of uninterrupted battery operation for several hours. A self-contained colour coder module is included in the CCU, with versions for NTSC, PAL and PAL(M). Comprehensive automatic facilities are provided, including automatic adjustment of registration, white balance and black balance, and automatic control of iris and black level.

Introduction

The Marconi Mark IX camera system provides the versatility and performance demanded by today's broadcasters by offering the choice of three top quality broadcast colour cameras. The studio/outside broadcast camera is a compact three-tube design which is equally suited to studio or outside broadcast use. The triax camera is primarily for outside broadcast operators who prefer the convenience and economy of triaxial camera cable. The portable camera is a self-contained lightweight design capable of producing pictures which are difficult to distinguish from those produced by the studio camera. In this article the features of the Mark IX studio camera will be described.

Design philosophy

It is nearly eight years since the Marconi Mark VIII colour television camera was introduced. Its small size, low weight, low light level performance, and above all its automatic facilities have helped to make it one of the most successful broadcast quality colour cameras ever produced. By the end of 1977 about 450 Mark VIII cameras had been sold worldwide.

As with most technically advanced products, the Mark VIII camera has been subject to a continuous process of improvement and updating since it was introduced. However, about two years ago there was a need becoming apparent for a camera system that could be adapted to suit a variety of operational requirements including studio, outside broadcast, portable, triax, and battery operation. The Mark VIII camera together with its portable version, the Mark VIIIP introduced in 1975, goes a long way towards meeting the requirements of this versatile camera system. However, it has a rather bulky camera control unit and power supply, which occupy valuable space in compact outside broadcast vehicles, and also a relatively high power consumption which precludes battery operation except for short periods. In addition there is no triax version of the Mark VIII, and many outside broadcast operators are finding triax cable more convenient, cheaper to install permanently in frequently used locations, and essential if more than a kilometre of camera cable is required between the camera and the camera control unit. It was realized that the Mark VIII and Mark VIIIP were not sufficiently flexible for some types of operation, and that a new Marconi camera system was required. What was needed was a studio camera that combined the size, performance and operational facilities of the Mark VIII with a camera control unit about half the size, and with half the power consumption. Such a camera control unit could then form the basis of a camera system consisting of a studio/outside broadcast camera, a portable camera suitable for small vehicles, and an outside broadcast triax camera.

Choice of camera tubes

Having recognized the need for a new camera the next step was to review the technological advances of the 1970s to determine which, if any, should be incorporated in the new design. Probably the most exciting development was the introduction of self-scanning solid state imaging devices, principally charge coupled devices (CCDs). These are much smaller than camera tubes, do not require scanning yokes and have much lower power requirements than the camera tube/yoke combinations. They have already been used to produce compact monochrome closed-circuit cameras, and they are likely to be used extensively in the future in this type of application. However, they have two serious drawbacks that will probably preclude their use in broadcast quality cameras in the foreseeable future; namely the lack of blue sensitivity and the difficulty of producing blemish free devices containing the large number of picture elements required. The lack of blue sensitivity is fundamental to silicon which is a poor transmitter of blue light. Current research is aimed at thinning the devices and illuminating through the rear. However, this produces very fragile components, makes the achievement of a good yield of blemish free CCDs even more elusive, and limits the choice of device structure.

In the meantime the first choice of imaging device for a colour camera is still the lead oxide camera tube, just as it was in 1970. The only two questions that need to be answered about camera tubes when designing a new camera are 'How many?' and 'What size?'. Early colour TV cameras used four tubes, but improvements in registration through improved deflection yokes led to the almost universal adoption of three tubes for broadcast cameras. It is possible to reduce the number of tubes to two or even one by the use of colour filters in the form of stripes on the surface of the tube or tubes. However, if sufficient resolution is to be achieved, the stripe spacing has to be so close that it is sensitive to defocussing, which produces shading. Another drawback is that the stripes act by absorbing light, thus reducing sensitivity. Colour cameras have been produced using tubes with striped filters, but none of these produce broadcast quality pictures.

The choice of tube size is by no means simple. There are three sizes that can be considered: 30mm, 1in, and ⅔in. The ⅔in size is primarily used for Electronic News Gathering (ENG) cameras in which there is a compromise between picture quality and size, but to date it has not been a serious contender in studio or high quality portable cameras. The choice for broadcast quality is therefore between 30mm and 1in. In low light situations there is little to choose between the two formats, but in normal lighting the higher signal current capability of the larger tube gives superior noise and lag performance. We therefore decided to continue to use 30mm tubes in the Mark IX studio camera where weight is not a problem. The Mark IX triax camera, to be described in a future article in this journal, also uses 30mm tubes for the same reason. In a portable camera on the other hand, low weight is essential, provided it can be achieved with minimal degradation of picture quality. The 1in tube size is therefore the obvious choice and has been used in the Mark IX portable camera, also to be described in a future article.

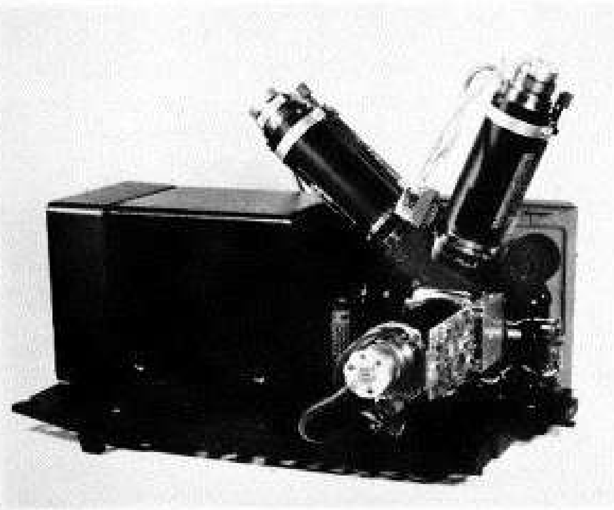


Figure 1. Camera baseplate with optical assembly and yokes

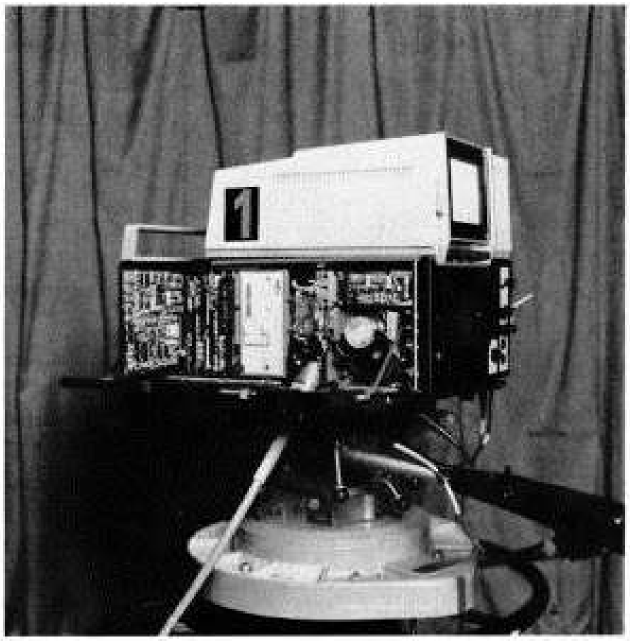


Figure 2. Camera with covers open and board withdrawn

The camera head

Having decided to use 30mm camera tubes, it was sensible to consider retaining certain features of the Mark VIII camera. These include:

(1) the unique optical arrangement giving a particularly compact design;

(2) the remotely controlled capping shutter and integral diascope, useful features in their own right and almost essential if comprehensive automatic line-up facilities are to be incorporated;

(3) the minifiers fitted to the optical system, which are special lenses that reduce the areas of the red and blue images by 50% to increase the brightness of the images and thereby reduce the lag relative to green. A reasonably neutral lag is achieved without loss of sensitivity and this can be further enhanced by the use of either fixed or variable light bias tubes.

We have therefore used the Mark VIII optical assembly and baseplate in the Mark IX camera, making it possible to use Mark VIII lenses. The Mark VIII yokes and scan circuits have also been retained (figure 1). A new electronic package has been designed to go into the camera head, including new head amplifiers, talkback circuits and a new power supply module. It is intended that the Mark VIII lenses will be supplemented by a new range of self-contained lenses.

Second filter wheel

A second filter wheel has been added to the optics and this is normally fitted with two daylight to studio conversion filters. When selected, these filters give a nominal colour balance at colour temperatures of

4300°K and 7000°K in addition to the studio colour balance at 3000°K. A wide range of colour temperatures can therefore be accommodated with only minor changes in the red and blue signal currents, and this helps to maintain the neutral lag characteristics of the camera when used in daylight. A spare position on the filter wheel can be used to fit a special effects filter such as a star filter.

Commentator's/effects microphone channels

Two commentator's microphone channels have been added to the camera. Each channel has a gain control, an input overload indicator, and an automatic compression circuit, allowing a wide range of microphone levels to be accommodated.

Highlight overload protection

The Mark IX is designed to be used with Highlight Overload Protection (HOP) tubes fitted with variable light bias, but standard tubes or light bias only tubes can also be used. An HOP tube contains a special gun assembly which partially discharges highlight overloads during the scanning flyback period, thereby preventing blooming around stationary highlights or comet-tailing behind moving highlights. The Mark IX incorporates a special circuit[1] to ensure that the full HOP action is available at the top of the picture.

Additional monitoring facilities at the camera head

A wide range of picture monitoring facilities is available on the viewfinder, all selectable at the camera head, including negative green mixtures for registration and colour signals before highs from green addition for lens tracking. Control of the iris and the remotely controlled filter wheel, which contains the neutral density filters, can be selected at the camera head (figure 3). It is therefore possible to perform lens tracking adjustments without the assistance of a CCU operator. All the coarse registration controls are situated in the camera head, together with the various preset scanning and geometry controls. The additional viewfinder monitoring makes it possible to perform major adjustments to the registration entirely at the camera head. It is also possible to start the automatic registration circuit (situated in the CCU) at the camera to check the effectiveness of the adjustments. Any CCU controls that have been overridden at the camera are automatically returned to normal CCU control when the camera covers are closed.

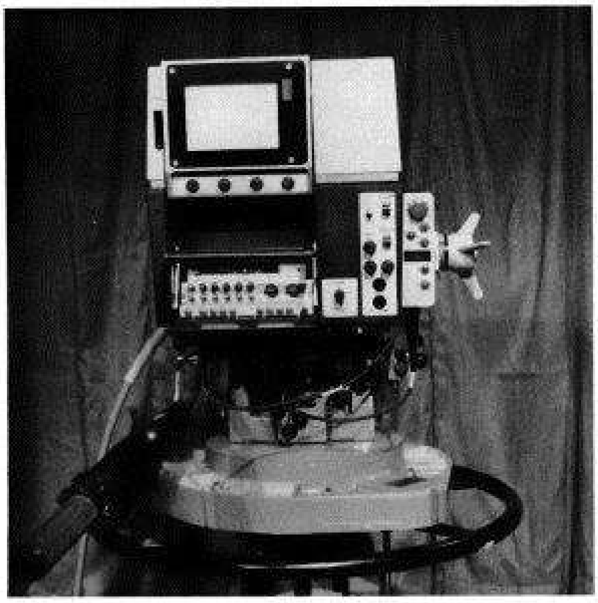


Figure 3. Rear view of camera showing access to control panel and shot-box

The camera control unit

The complete CCU, including the integral power supply and integral coder, is contained in a 222mm high (8¾in), 19in rack mounting unit (figure 4). A typical figure for the power consumption of the Mark IX studio camera is 350W. This represents an improvement of more than 50% in the size and power consumption compared with the Mark VIII. The implication of this power consumption is that the Mark IX camera can be operated for about three hours using a 60 ampere-hour 24 volt battery, assuming, say, 80% for the inverter efficiency. When the CCU is used with the Mark IX portable camera, and this is the configuration which is most likely to be powered by a battery, the power consumption is about 250 watts.

The CCU has a straightforward modular construction with eleven plug-in printed board modules. These include three automatic facilities modules, three identical video processing modules, a self-contained aperture corrector, and a self-contained colour coder with versions available for NTSC, PAL and PAL(M). The plug-in power supply unit is reached by hinging down the camera control panel. The form of construction can be clearly seen in figure 6.

The switched mode power supply unit

The small size of the Mark IX CCU owes a great deal to the introduction of a switched mode power supply (SMPS) (figure 7). The high efficiency of the SMPS has also contributed to achieving the lower power consumption. By far the largest component in a conventional power supply is the 50/60Hz transformer. Any attempt to reduce the size of this component in a given situation is likely to impair the efficiency by increasing the losses. In a switched mode supply the mains input is rectified directly and the resulting d.c is switched across the primary of a transformer at a frequency of about 20kHz. At this frequency the transformer is small and makes a relatively minor contribution to the overall size of the power supply. The dimensions of the Mark IX power supply unit are approximately 165mm × 165mm × 305mm (6.5in × 6.5in × 12in). Space is included for two printed boards which allow the Mark IX portable camera to be connected directly to the CCU without an intermediate unit or backpack.

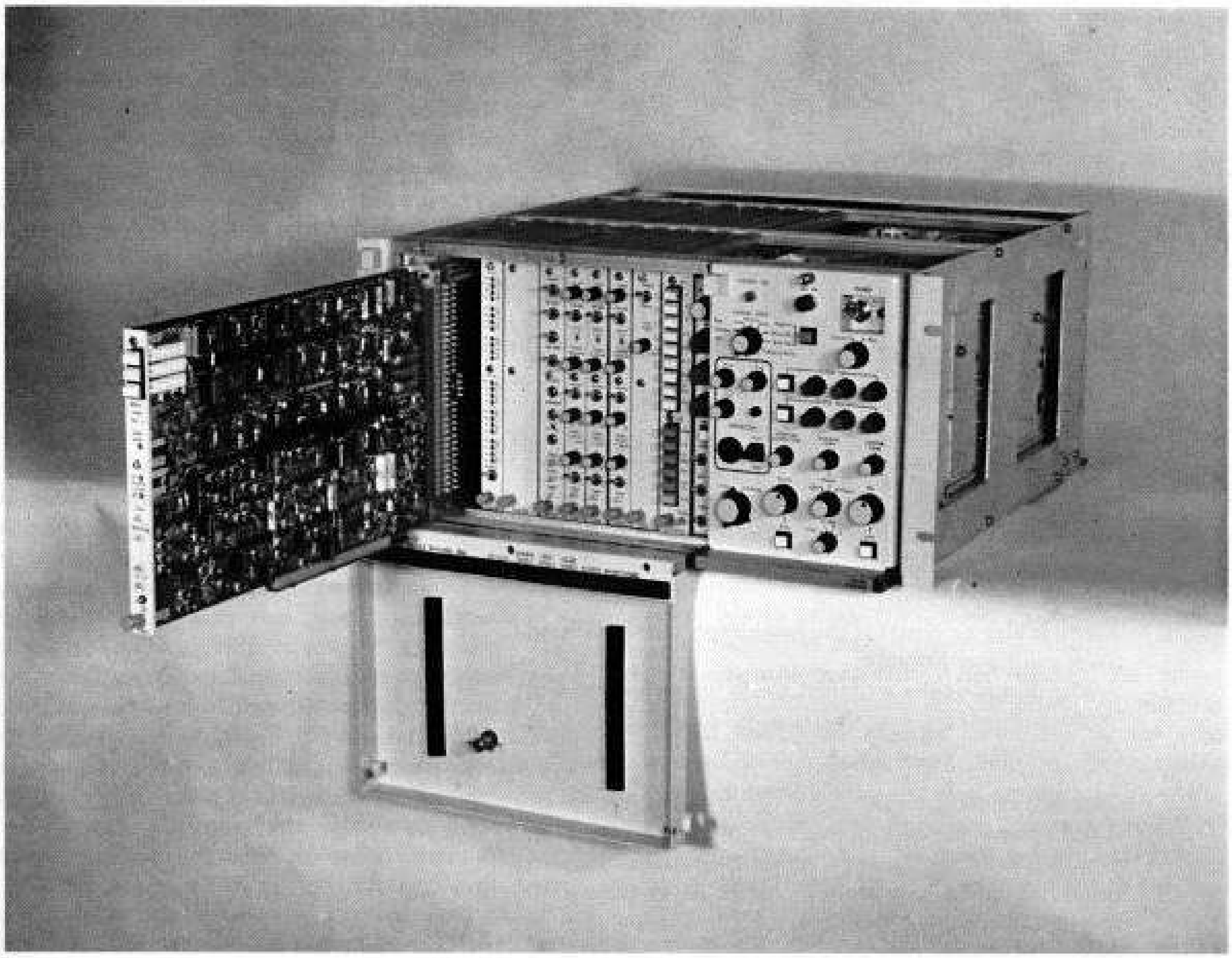


Figure 4. CCU showing access to the modules

The feature which distinguishes an SMPS from a simple convertor or invertor is the feedback controlling the width of the current pulses in the transformer primary. By this means the output is regulated against variations in input voltage, and this is achieved without the power loss associated with a series or shunt regulator that has to cope with a wide range of input voltage.

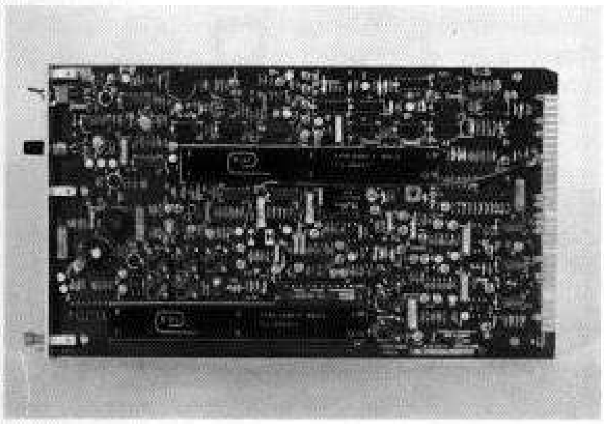


Figure 5. Integral NTSC colour coder module

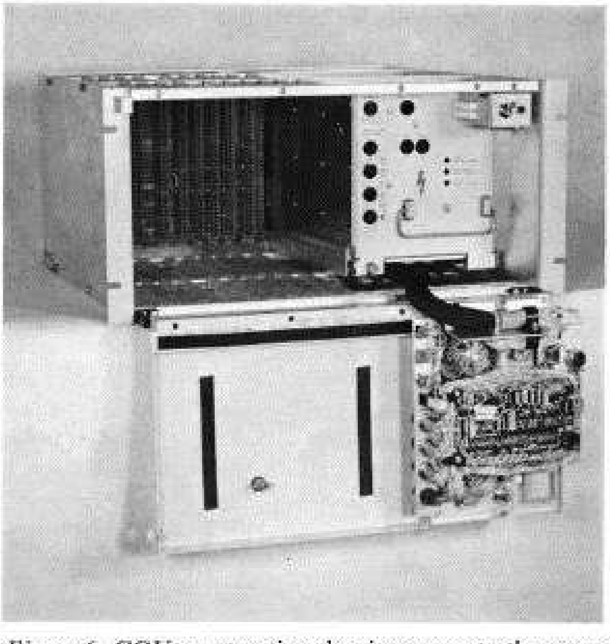


Figure 6. CCU construction showing access to the power supply

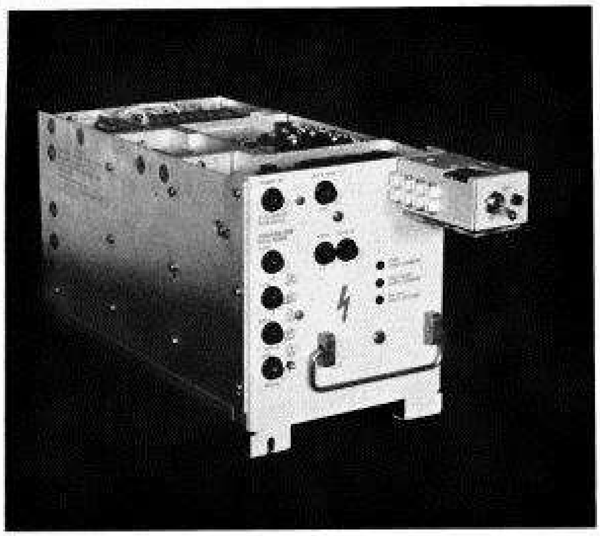


Figure 7. Channel power supply

There is also no need for the fine adjustment of taps on the transformer primary.

The design of the switched mode power supply will be the subject of a future article in *Communication & Broadcasting*.

Camera control panel

A full operational control panel is provided on the front panel of the CCU (figure 8). All the operational controls can be switched to a remote control panel (figure 9). Any of the automatic facilities described below, can be selected at the control panel.

Signal processing

With the exception of the initial gain provided by the head amplifiers, all the signal processing is performed in the CCU. The camera can be connected to the CCU by up to 900m of Mark VIII camera cable, which is a multiway cable 13mm in diameter.

Identical video processing modules, one for each of the channels G, R and B perform the following functions:

Cable correction;
Black level clamping;
Flare correction;
Shading correction at black and white;
Gain normalization;
Matrix colour correction;
Gamma correction.

Black shading correction is provided to compensate for any shading that may be introduced by using light bias, and white shading correction to compensate for any tube or optical shading. Individual horizontal and vertical sawtooth and parabola shading controls are provided. The colour matrix coefficients are determined by a computer program for optimum colour rendition of a set of 26 test colours. Alternative matrix coefficients can be substituted, if, for example, extended red tubes are used, by replacing a small plug-in dual-in-line package on each video processing module. There is no need to change the matrix coefficients for daylight operation since daylight to studio colour conversion

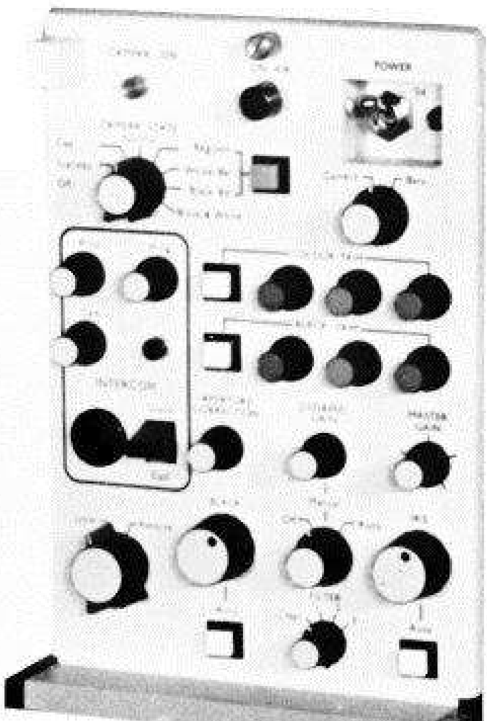


Figure 8. Camera control panel

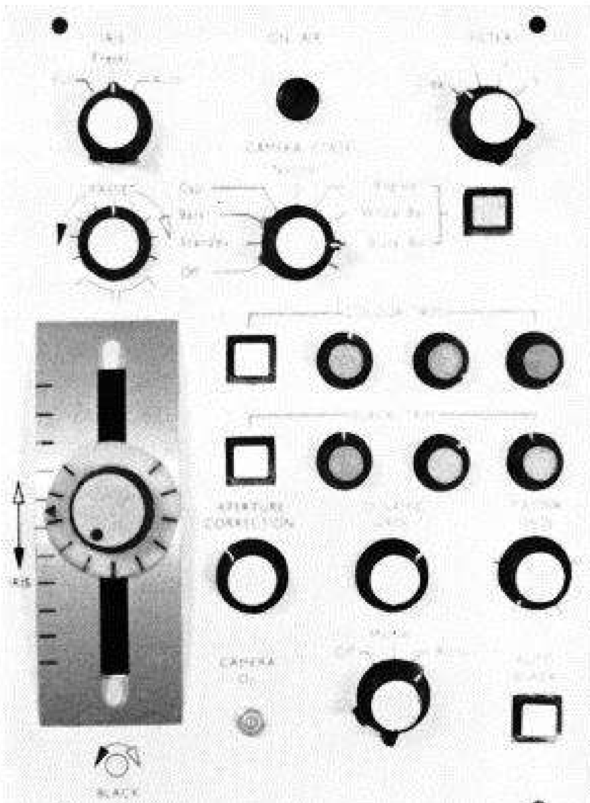


Figure 9. Remote control panel

filters are provided in the camera head. The gamma law in each of the three colour signal paths can be continuously varied over the range 0.4 to 0.55. The overall or master gain of the signal paths can be varied continuously over a range of 12dB.

The camera uses the now conventional system for three tube colour cameras of highs out of green. The green signal is used to provide the high frequency detail in the composite colour signal. In addition the detail is enhanced by horizontal and vertical aperture, partly to compensate for aperture loss in the camera tubes and partly for aesthetic improvement of the final picture. A fixed horizontal correction, peaking at a frequency of 10MHz is provided to compensate for the falling high frequency response of the camera tube. In addition a mix of vertical and in-band horizontal correction, peaking at 3MHz, is provided and can be varied at the control panel to suit different picture subjects. The visibility of noise is reduced by the techniques of comb filtering, coring and level dependence.

Dynamic gain

The integral coder contains a circuit which allows the gain or contrast of the composite signal to be varied near black or near white.[2] This allows the otherwise low level of information in high or low key scenes to be stretched and made more visible in the final picture. This is achieved without a significant change in the colour rendition of the picture information. The degree of stretch can be varied at the control panel or, alternatively, it can be controlled automatically to give a constant mean level at the output. In the latter case the mean level that is maintained can be varied at the control panel. When the dynamic gain is not required it can be completely switched out of circuit.

Automatic facilities

The following automatic facilities are available in the Mark IX camera:

1. *Automatic registration.* When selected, the following sequence occurs automatically. The diascope, which contains a special chart, is projected into the camera optics (figure 10); the green, red and blue signal levels are normalized, each of the four registration points on the diascope chart is examined for any horizontal or vertical errors; the red and blue height, width and centring controls are adjusted to cancel the registration errors. Automatic control is achieved by the use of motorized potentiometers situated in the CCU.
2. *Automatic centring.* The central area of the picture is strobed for picture information which indicates a horizontal or vertical centring error. Detected errors are corrected automatically by adjustments to the centring controls.
3. *Automatic white balance.* When selected, the cameraman has to point the camera at a white reference and the red and blue gains are adjusted automatically to achieve balance. An outline circle is displayed on the viewfinder while the circuit is operating. The circle indicates to the cameraman the area of the picture that has to contain the white reference, and also indicates when balance has been achieved.

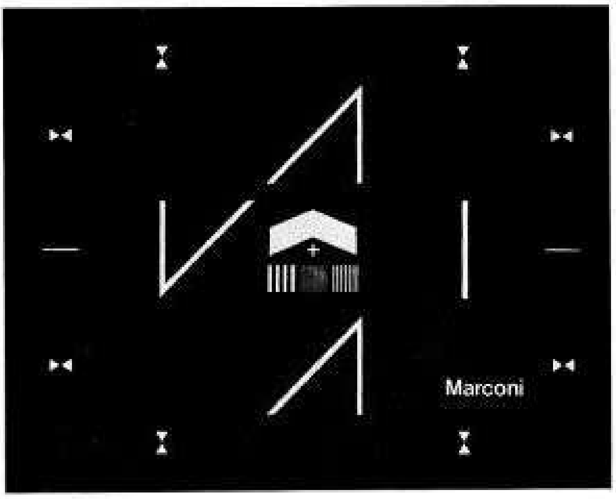


Figure 10. Diascope registration chart

4. *Automatic black balance.* When selected, the camera is capped automatically and the green, red, and blue black levels are adjusted automatically for zero output levels. A solid white circle is displayed on the viewfinder while the circuit is operating.
5. *Automatic iris.* When selected, a centre-weighted non-additive mix of the green, red and blue signals is used to control the iris automatically. The mixed signal is filtered to give a combination of peak and mean level control. The iris potentiometer on the control panel is motorized and is automatically adjusted to track the changes in the lens iris, thereby allowing the automatic iris to be overridden at any time without causing a sudden change in exposure. When the remote control panel is in use, the preset iris control is automatically adjusted, again allowing the automatic iris to be overridden smoothly.
6. *Automatic black.* When selected, the overall black level is adjusted automatically such that the blackest part of any of the green, red or blue signals is set to zero output level.
7. *Automatic dynamic gain.* As described above.

Conclusions

This brief description of the Marconi Mark IX studio camera channel has inevitably concentrated on those features which are new. It has not been possible to describe all the details that contribute to the overall performance and operational convenience of the camera.

Thanks are due to all the engineers who contributed to the design, and also to the English Electric Valve Company for its continuing work and co-operation in the field of camera tubes.

References

[1] I. E. GIBSON, *and* S. T. MANSFIELD: U.K. Patent Application No. 7308/76.
[2] R. W. FENTON: U.K. Patent Application No. 38498/76.