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MARK VII—ONE YEAR LATER

THE MARK VII COLOUR CAMERA CHANNEL was first introduced in December 1965,[1] since when development has continued to ensure that subsequent design improvements are incorporated in current production.

Recently a new design of input amplifier has resulted in a dramatic increase in the camera sensitivity—the light input required being halved, reducing it to little more than the level normally used for studio black-and-white cameras! A demonstration of cameras incorporating this modification was made in the studio at the Marconi Television Laboratories in December 1966. The modification to the input amplifier is being applied to all cameras in production and kits of parts are also being manufactured so that all Mark VII channels already in the field can be modified retrospectively.

The importance of this development to colour broadcasters is emphasized when it is realized that colour cameras at present in use for broadcasting require studio lighting levels between two and ten times that of black-and-white cameras. The considerable capital and running costs of these illumination levels together with the associated ventilating system necessary to maintain a bearable temperature in the studio have contributed to the high cost of colour television productions.

DEFINING SENSITIVITY

The sensitivity of a television camera (fitted with a pick-up tube of known sensitivity) may be expressed as the minimum light input:

(i) At a given effective lens aperture (related to depth of focus).
(ii) Giving a picture of satisfactory definition.
(iii) With an acceptable signal-to-noise level.

It is generally agreed that the conditions for sensitivity comparison should be:

(a) Lens aperture *f*/8 (for image orthicon type lenses).
(b) Correction applied to provide full modulation depth on a pattern of 400 lines per picture height.
(c) The measured signal to noise ratio (of the luminance signal) should be greater than 40 dB integrated over a video bandwidth of 5 MHz.

ACHIEVING MAXIMUM SENSITIVITY

The transmission of the optical system must be as high as possible, and the pick-up tube should be operated under conditions where the minimum aperture loss is incurred, but the greatest single factor affecting the sensitivity of the camera is the equivalent noise voltage at the input of the camera video signal amplifier. It is important to appreciate that not only must the absolute value of the noise sources be kept to a minimum, but the spectral distribution of the noise components must be such as to produce the minimum visibility in the picture.

VISIBILITY OF NOISE

The visibility of noise in the picture varies with picture content and the nature and spectrum of the components. Noise in the lower video spectrum is far more objectionable than in the higher spectrum, since the latter becomes almost invisible by its very fine nature. It is the practice in black-and-white television to add a subjective weighting factor to measured results to allow for this. In the compatible colour transmission, however, there is, contained within the video bandwidth, the subcarrier to provide the additional colour information and its presence modifies the effects of noise. Firstly, the subcarrier can beat with noise components in the region of the frequency of the subcarrier transposing the higher frequency noise components to a lower frequency where visibility is increased. Secondly, noise components in the luminance signal in this region are interpreted by the colour detectors as colour information, producing objectionable colour patterns in the picture.

Noise in the colouring channels is less significant; observations clearly demonstrate that the eye can tolerate considerably more noise in the effects that it produces on the hue of the colour picture than it can in the effects produced in the brightness of the picture.

NOISE SOURCES

The load impedance presented to the signal electrode of the pick-up tube is essentially capacitive at the middle and higher video frequencies. This capacitance is made up of the capacitance of:

(a) the tube target when mounted in the scanning yoke,

(b) the connecting lead between the tube target and the video amplifier input point (this lead must be screened thus adding further capacitance),

(c) the input of the amplifier,

(d) the video load resistor and associated components.

The effect of the total capacitance shunting the load resistor is to cause the output voltage of the pick-up tube presented to the input of the video amplifier to fall off rapidly as the frequency of the video signal current increases. This falling frequency response must be corrected in the video amplifier which is therefore designed to have a complementary response, i.e. an increasing gain with increasing frequency. Since both signal and input noise will be amplified, the resultant noise spectrum will be triangularly shaped with little noise at low frequencies but increasing with frequency. However, a technique is available to modify the shape of the noise spectrum to reduce the high-frequency components. The technique is the use of a resonant circuit immediately at the pick-up tube output which effectively increases the video load impedance at the higher frequencies. This is followed by a complementary notch filter which restores the frequency response by gain reduction over this band of frequencies. The overall signal noise spectrum thus obtained is shown in Fig. 1.

Another small but important contributing factor is the fact that with an improvement in the noise performance of the video amplifier, the output current of the pick-up tube may be reduced in proportion. This has the effect of improving the resolution, both horizontally

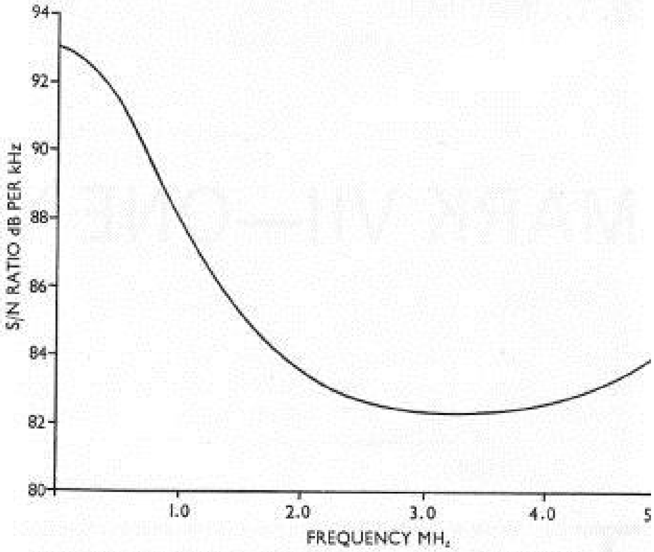

Fig. 1. Signal-noise ratio of input amplifier relative to $I_s = 0.3\ \mu A$ (input circuit tuned to 5·0 MHz).

and vertically, so that less aperture loss correction is required, which in turn means the high-frequency noise is less boosted.

DESIGN CHANGES

It is clear from the foregoing that any reduction in the already small total input capacity will bring worthwhile returns in camera sensitivity, and it was to this end that efforts were made to design an improved input stage for the luminance channel of the Mark VII camera. The first aim was to reduce the size of the connecting lead between the target connector and the input of the amplifier. This was achieved by mounting the Nuvistor, which is the first stage of the input amplifier, on the scanning yoke as closely as possible to the pick-up tube target connection, Fig. 2. Among other changes contributing to the end-result was a reduction in the number, and the physical size, of components used in this stage. Each component produces a stray capacitance to ground which, in a given environment, is proportional to its physical size. The existing head amplifier unit, which plugs into the scanning yoke, has been retained but with removal of the now redundant components associated with the input stage. The new detached input stage is wired by a small cable form to this amplifier and the pair form an interconnected assembly.

The considerable reduction in input capacity of the input amplifier also affected the design of the compensating network in the subsequent Luminance Video

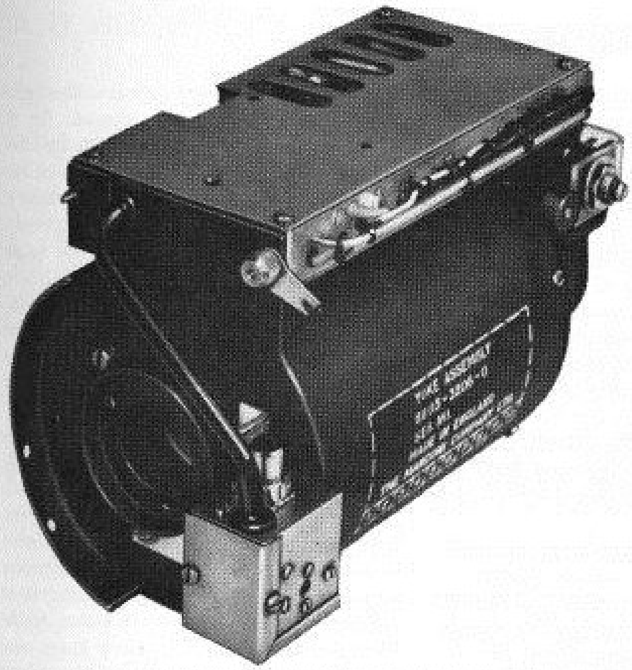

Fig. 2. The Nuvistor amplifier is mounted directly on the front of the yoke.

Amplifier Unit and a new printed wiring board replaces an existing board in the unit. The Colouring Video Amplifier in the camera remains unchanged apart from the adjustment of a preset control to increase the gain by the required amount due to the reduced operating signal currents.

The control of the voltage applied to the target of the luminance tube required several components to be mounted at the front end of the input amplifier, unfortunately adding shunt capacities to the video load. In the new design, these components have been removed and the target held at a fixed potential with respect to chassis. Control of the target-to-cathode voltage is made at the tube cathode. This mode of operation is obtained by a modification to the Beam Blanking printed wiring board (BB 14–3206) by the addition of a small sub-board carrying the new components. The target potential is held at 48 V and the cathode potential at 10 V or 22 V by switch selection with a variation of ±4 V by a continuously variable control. Thus, the target-to-cathode voltage can be varied from 22 V to 42 V. To obtain the supply for the cathode potential, a wire is added in the camera connecting to the 250-V supply.

NEW SENSITIVITY PERFORMANCE

The overall performance of the camera has been improved to the following degree:- with the lens aperture set to *f*/8 and the aperture correction adjusted to provide 100% modulation at 400 lines per picture height, a signal-to-noise ratio of greater than 40 dB will be obtained with a scene highlight brightness of 70-ft lamberts. (This may be obtained from a white chip having a reflectance of 60% and illuminated at 120 ft candles.) The camera tubes are assumed to be of a good average sensitivity.

REFERENCE

1 A. N. HEIGHTMAN and W. T. UNDERHILL: A New Four-tube Colour Camera; *Sound and Vision broadcasting*, Vol. 7, No. 1, Spring 1966, p. 8.