## CODING

A colour television camera produces three picture signals, R, G, and B, each requiring a full 5.5 MHz channel for transmission to the display. In a closed-circuit system the R, G and B signals are carried by separate cables. For transmission via an existing monochrome system the signals have to be modified so that a single 5.5 MHz channel carries the information. This modification is called coding and must meet three basic conditions :-

1. COMPATIBILITY : the colour transmission must produce an acceptable picture on existing black and white receivers.
2. REVERSE COMPATIBILITY : a monochrome transmission should produce a satisfactory black and white picture on a colour receiver without modification to the receiver.
3. BANDWIDTH RESTRICTION : the colour transmission should occupy the same bandwidth as a monochrome transmission.

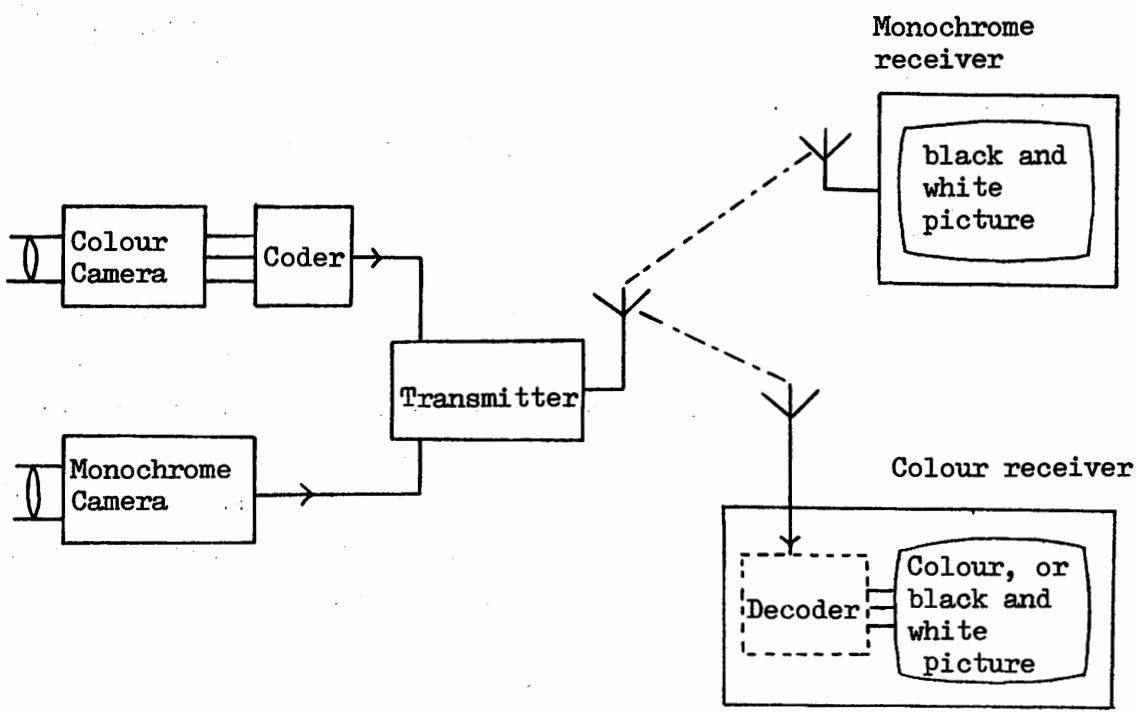



Fig. 1 : Compatible Colour System

## CODING

### LUMINANCE AND CHROMINANCE SIGNALS

The condition of compatibility can be achieved by transmitting a signal proportional to the brightness of the scene. This can be derived by adding suitable proportions of the R,G,B signals from the camera. This signal is called the luminance, or Y signal.

Luminance signal (Y) = 0.3R + .59G + .11B

The coefficients 0.3, .59 and .11 are called luminance coefficients.

The condition of reverse compatibility is achieved by transmitting, with the Y signal, two "colouring" signals which must be zero when the colour camera views a white object. The two colouring signals can be obtained from (R - Y), (B - Y) or (G - Y). These signals are called colour difference signals.

Only (R - Y) and (B - Y) are transmitted since (G - Y) can be derived by combining (R - Y) and (B - Y). At the receiver a decoder derives R, G and B from the received Y, (R - Y) and (B - Y) signals.

Thus the original R,G,B signals from the camera are coded to become :-

| Y | (R - Y) (B - Y) |
|---|---|
| Luminance | Colour difference, or chrominance signals |

The luminance signal conveys brightness information and the chrominance signals convey information of hue and saturation.

### BANDWIDTH RESTRICTION

The luminance signal requires the full 0 - 5.5 MHz band, thus the only way the chrominance signals can be transmitted is by superimposing them on the luminance signal. This would not be possible if the chrominance signals also required the full 5.5 MHz bandwidth. Fortunately an acceptable colour picture can be produced by superimposing a fine detailed black and white picture and a coarse detailed colour picture. The chrominance signals can thus be restricted to approximately 1 MHz.

The combining of the signals should, ideally, meet two conditions :-

1. The signals must be easily separated

2. The signals must not interfere with each other

Signal separation can be achieved by modulating the (R - Y) and (B - Y) signals onto a sub-carrier to shift the band occupied by the chrominance signals to the upper part of the luminance channel, as shown in Fig. 2.

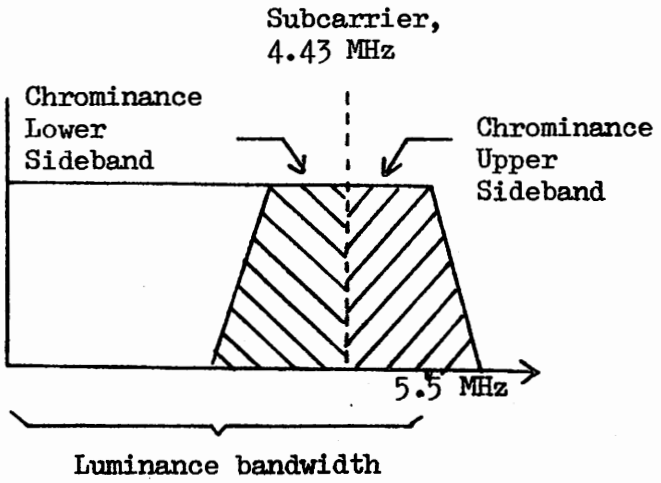



Fig. 2 : Chrominance bandwidth

Mutual interference between the signals can never be avoided but can be minimised by the type of modulation system used and careful choice of the subcarrer frequency.

P.A.L. CODING SYSTEM

The P.A.L. system uses suppressed carrier amplitude modulation for (R - Y) and (B - Y). Two carriers are used, both at the same frequency but $90^{\circ}$ apart in phase; this permits the simultaneous transmission of both signals. The modulated (R - Y) signal is phase inverted on alternate lines, hence Phase-Alternated-Lines, P.A.L. The carrier frequency (approximately 4.43 MHz) is precisely related to line frequency to minimise the interference produced on monochrome receivers - it appears as a fine dot pattern in coloured areas of the picture.

CODING

Fortunately, in a suppressed carrier system the level of subcarrier depends on the level of modulation, thus interference only occurs in brightly coloured areas and in the average scene is hardly noticeable.

The decoder (in the receiver) separates the chrominance signals from the luminance signal by a high pass filter; the two chrominance signals are then separated in the demodulator, (see Fig. 4). Since the carrier has been suppressed by the coder, a subcarrier reference must be transmitted in order to facilitate separation of the colour difference signals in the demodulator. The transmitted reference is called reference burst and consists of about ten cycles of subcarrier transmitted in back porch, (see Fig. 3).

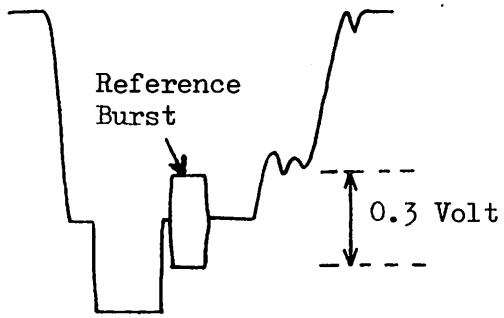



Fig. 3 : Reference Burst

A simplified system diagram of a decoder is shown in Fig. 4.

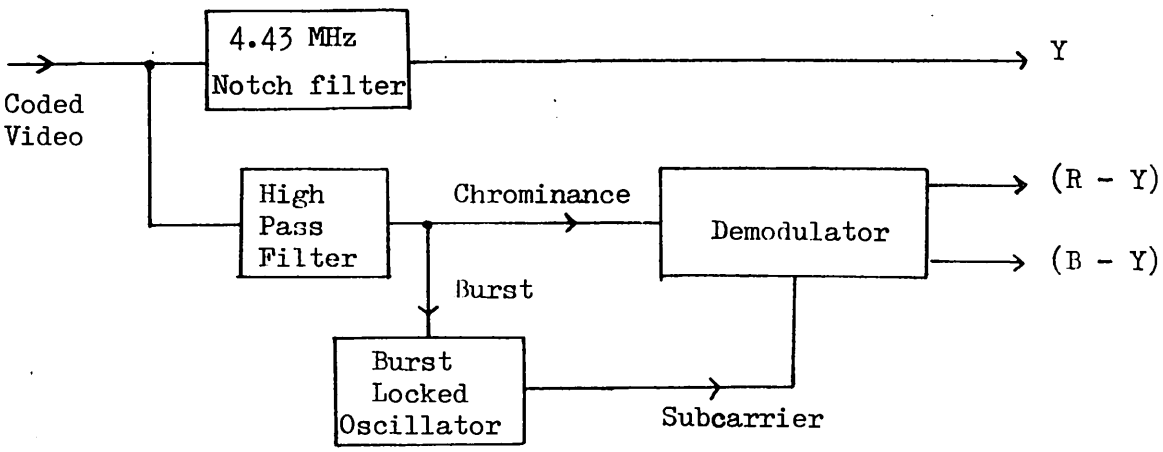



Fig. 4 : Simplified System Diagram of Decoder

## CODED COLOUR BARS

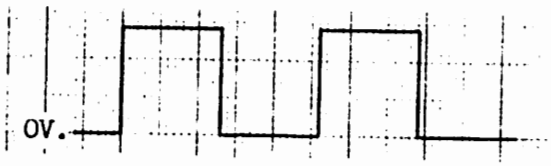
The waveforms that result from coding a set of fully saturated (100%) colour bars are shown below.

↑ 1 cm = 0.5 Volt

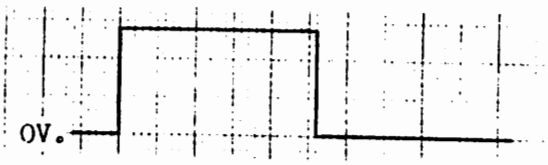
Scale : → 1 cm = 10 µS

Colour Bar Generator Outputs

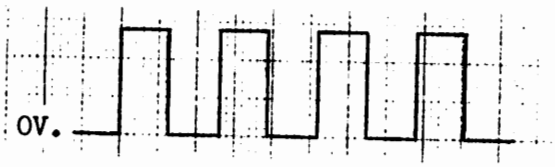
Red




Green

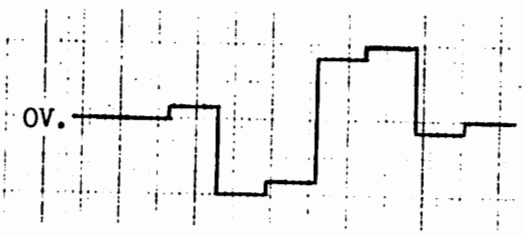



Blue

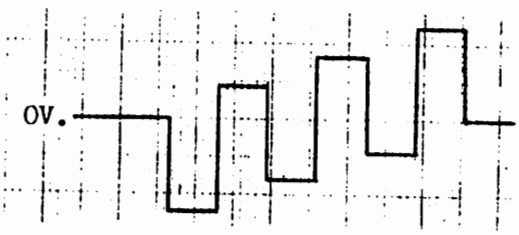



Y (=0.3R + 0.59G + 0.11B)

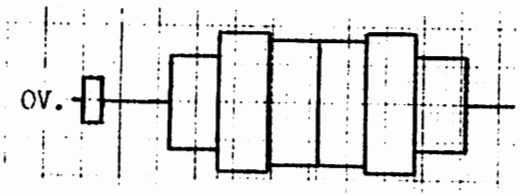

(R - Y)



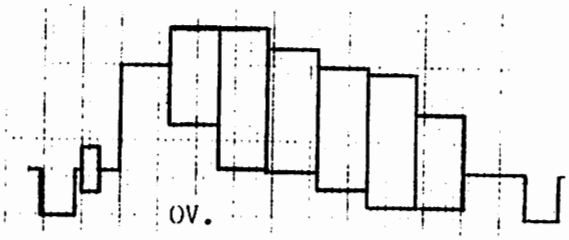

(B - Y)




Chroma (Modulated (R - Y) and (B - Y) and reference burst




Coded Colour Bars (100% Sat.)
(= Y + Chroma + burst + syncs)




J.E. Shepherd/MAG
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