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PSEUDO-COLOUR ON THE SCAN CONVERTER

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1. Introduction

As has been described in the companion paper[1], the scan converter stores the scan information as a succession of 4 bit (or 6 bit) words to represent the brightness of each pixel. We wish to code this range of levels into pseudo-colour in order to try to improve the subjective appearance of the display and to improve the discrimination. It is clear that, since the number of J.N.D.'s (Just Noticeable Differences) on a CRT is fairly limited[2], colour should improve the ability to differentiate between different levels, but it is not clear, however, that this will necessarily bring any improvement in performance other than it may be subjectively more pleasant to view. In certain circumstances it might be possible to code particular levels to correspond to a particular feature, e.g. the low level background signals by a colour which is subjectively corresponding to that background, e.g. blue sea, and which might give the impression of depth to the display[3]. There is considerable controversy over the question of whether the introduction of pseudo-colour improves the display or not. This paper does not attempt to answer the question but merely describes an apparatus for providing an option of pseudo-colour on the scan converter in a very flexible way, which should enable operational experience of the use of pseudo-colour to be obtained.

2. The Colour Triangle

A colour source can be matched in an apparatus such as is shown in Figure 1 by a combination of three primary colours, e.g. red, green and blue. It is convenient to match first to a reference white and then express the values R, G and B as a proportion of the values required for matching to the reference, e.g.

$$C = R + G + B$$

These are called the tristimulus values. The chromaticity co-ordinates of the source can then be expressed as r, g and b where

$$r = \frac{R}{C} \qquad g = \frac{G}{C} \qquad b = \frac{B}{C}$$

and $r + g + b = 1$

Because the chromaticity co-ordinates sum to unity we require only two co-ordinates to define the colour and hence the colour can be represented on a two-dimensional diagram as in Figure 2.

The spectral colours are shown on such a diagram in Figure 3 and it will be noticed that for some parts of the spectrum we require negative values of the colours, particularly red. Since we cannot generate negative colours such a match is obtained by adding the particular reference colour, e.g. red, to the colour being matched, and it then appears on the other side of the equation. Thus we are limited in the range of colours which can be matched with real primaries. However, it is convenient to express colours in terms of primaries and an internationally agreed system (C.I.E.) enables all colours to be specified in terms of these non-real primaries as in Figure 4.

If we centre the co-ordinate system on the reference white as in Figure 5 the colour can be described in polar co-ordinates where amplitude corresponds to 'saturation' and angle to 'hue'. This is the basis used for colour television transmission but the television receiver decodes this information into voltages representing real primaries, red, green and blue, which are used to drive the colour tube. In our system then we shall be generating signals to feed to the colour tube and hence we require to generate the red, green and blue components. If, in setting up the colourimeter to match a reference white, we had used a white light of a luminance of 1 cd m^{-2} and the red, green and blue luminances to produce the match had been ℓ, m and n respectively, then

$$\ell + m + n = 1$$

Thus the luminance in cd m^2 of any colour with tristimulus values R, G and B will be

$$L = \ell R + mG + nB$$

3. Practical System

We require to equate the 16 various amplitude levels of the 4 bit input to appropriate colours and use the input to generate the necessary red, blue and green signals to feed to the colour tube. If we knew what colours we required the task would be very simple but since this can only be determined under operational conditions it was decided to include a good degree of flexibility.

The system is based on a programmable read only memory which stores 12 bit words and which is used as a 'look up table'. The 12 bits are divided into three sets of 4 bits, one set for each colour. Thus we have 2^{12} different colour/luminance levels from which to choose. The set of 2^{12} colour/luminance levels are fixed when we program the PROM originally but could be altered at a later date if wished in the unlikely event of this range not being sufficient.

We need to be able to select various permutations of these colours taken 16 at a time and have available a very large number possible, viz:-

$$P = \frac{(2^{12})!}{(2^{12} - 2^{4})!}$$

In fact we restrict ourselves to 2^7 possible sets and can switch from one to another by means of two thumbwheel controls on the front panel.

The block diagram of the system is shown in Figure 6. It is based on two 2716 PROM's which store 2^{11} twelve bit words. Four of the address bits ($A_0 - A_3$) are used for the 4 bit digital input and the remainder of the address ($A_4 - A_{10}$) comes from the hexadecimal thumbwheel switches.

The 4 bit outputs representing red, green and blue are latched and fed to a digital analogue converter and thence to a mixer which combines the input with the appropriate synchronisation pulses and provides the composite video signal drive. The system includes a staircase generator as an alternative input to provide a bar chart for initial selection of the colours by the operator.

4. Present Situation

Although a prototype equipment has been built and tried on some video recordings and shown to produce some interesting results, no detailed trials have yet been carried out. Because of the difficulties of reproduction no colour photographs have been included in the paper but will be included in the presentation.

References

1. Quarmby, D.J., Duck, G.M. and Goodson, A.D., 'A Scan Converter for a Sector Scan Sonar'. Ibid.

2. Griffiths, J.W.R., 'The Chemical Recorder and its use in Detecting Pulse Signals in Noise', Trans. of the Soc. of Instrument Tech., Vol. 8, No. 2, June 1956.

3. Ittelson, W.H., 'Visual Space Perception', Spring Publishing Co., New York 1960.

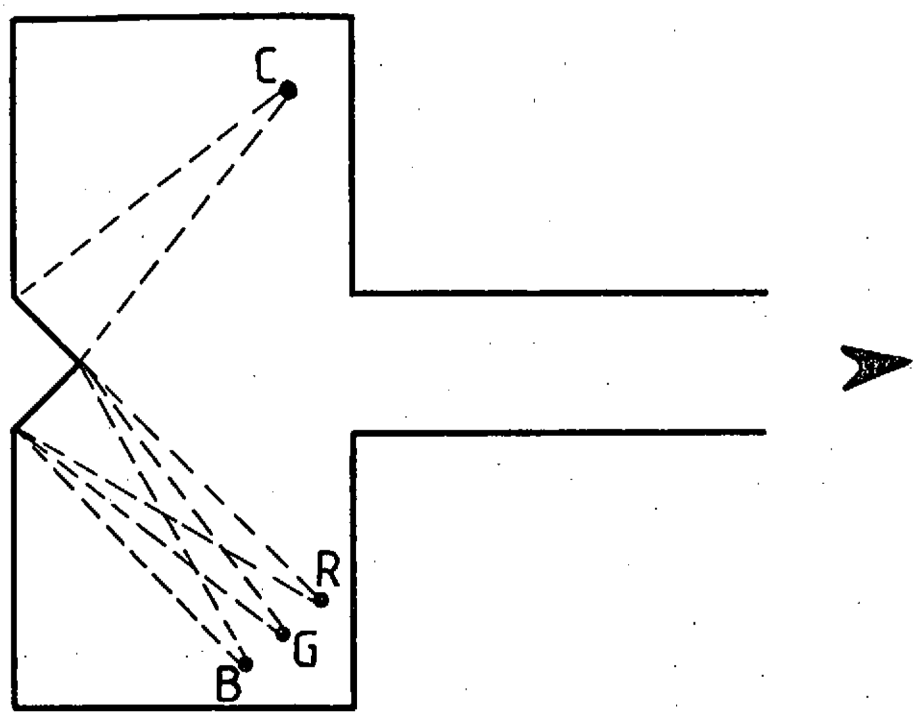

Fig. 1. COLOUR MATCHING.

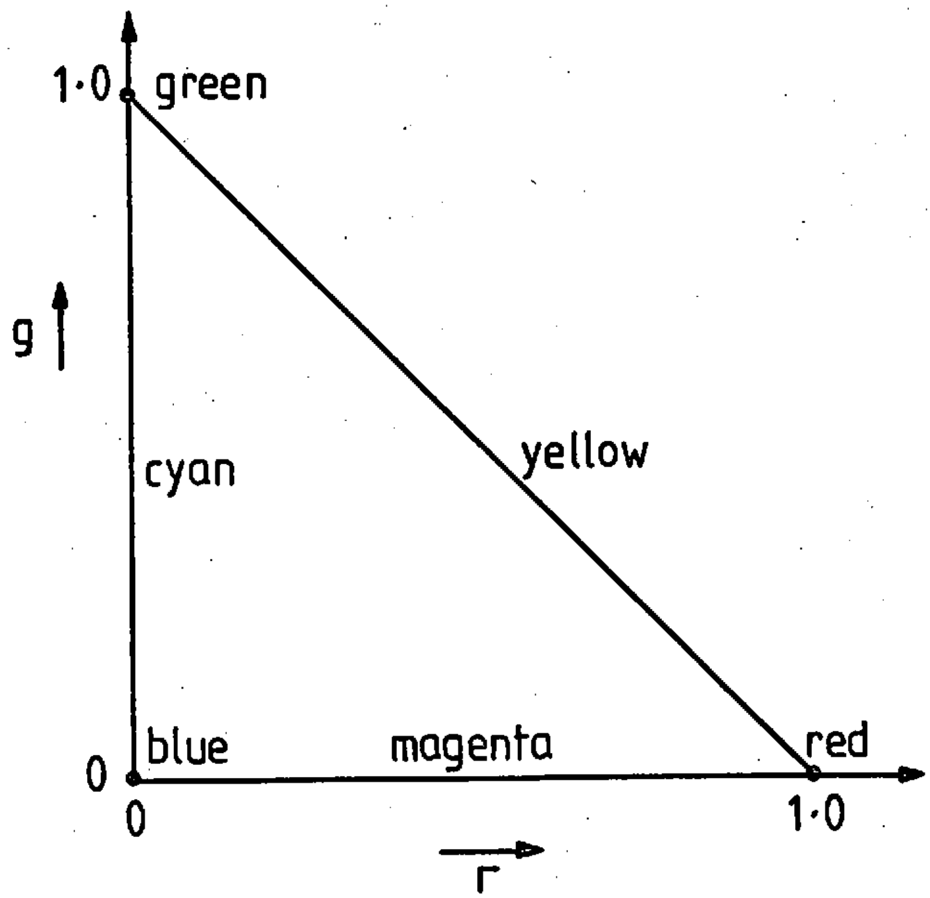

Fig. 2. COLOUR TRIANGLE.

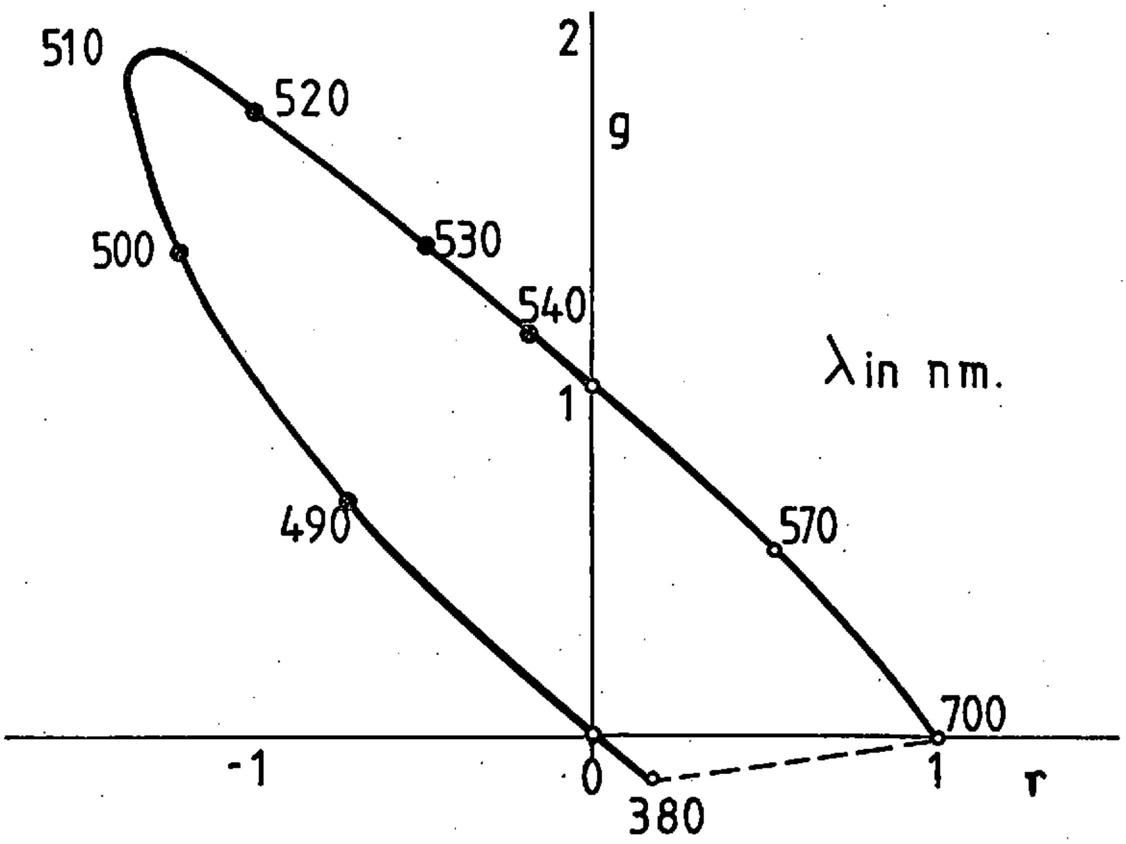

Fig. 3. CHROMATICITIES OF THE SPECTRAL COLOURS.

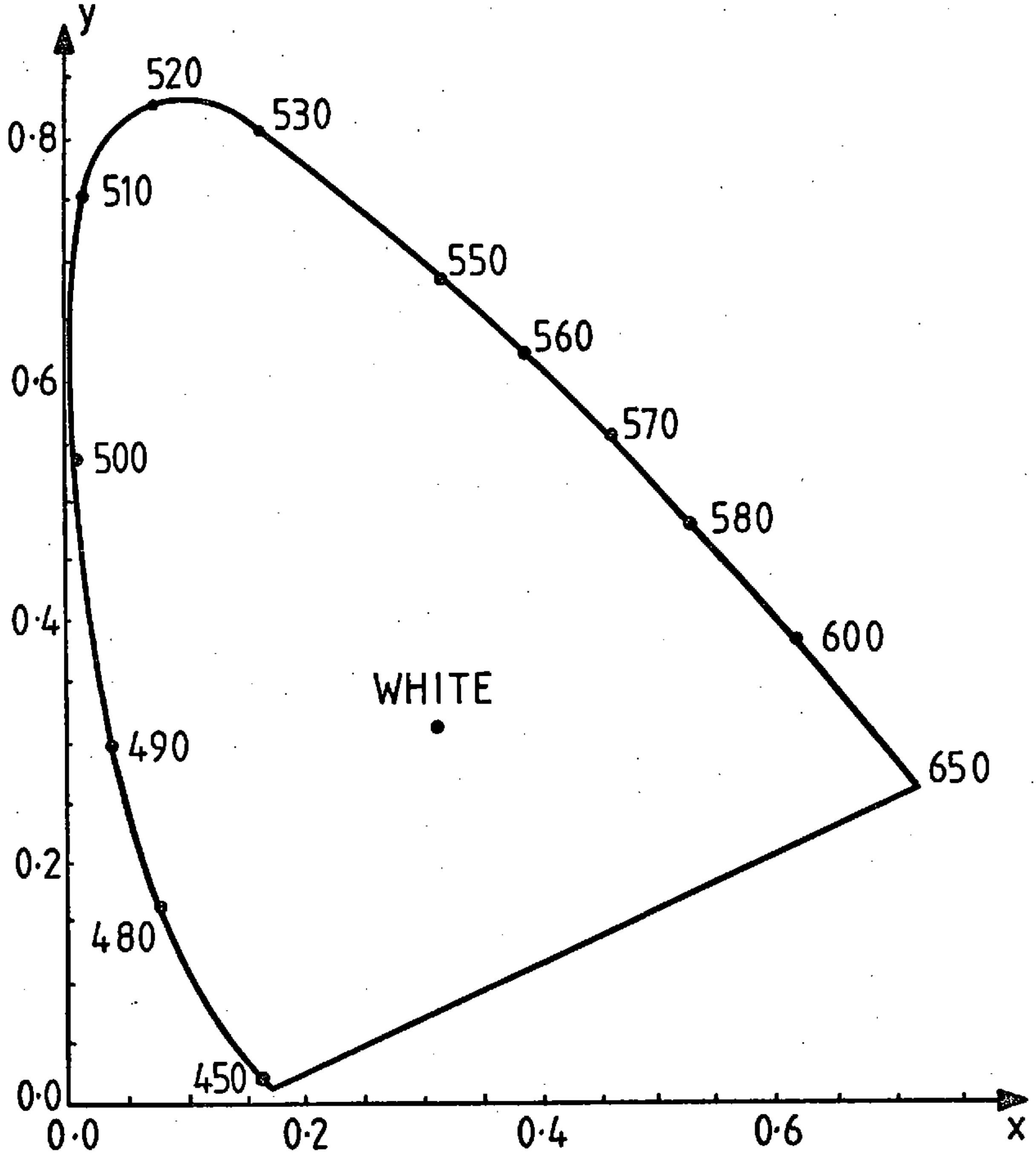

Fig. 4. C I E (x,y) CHROMATICITY DIAGRAM.

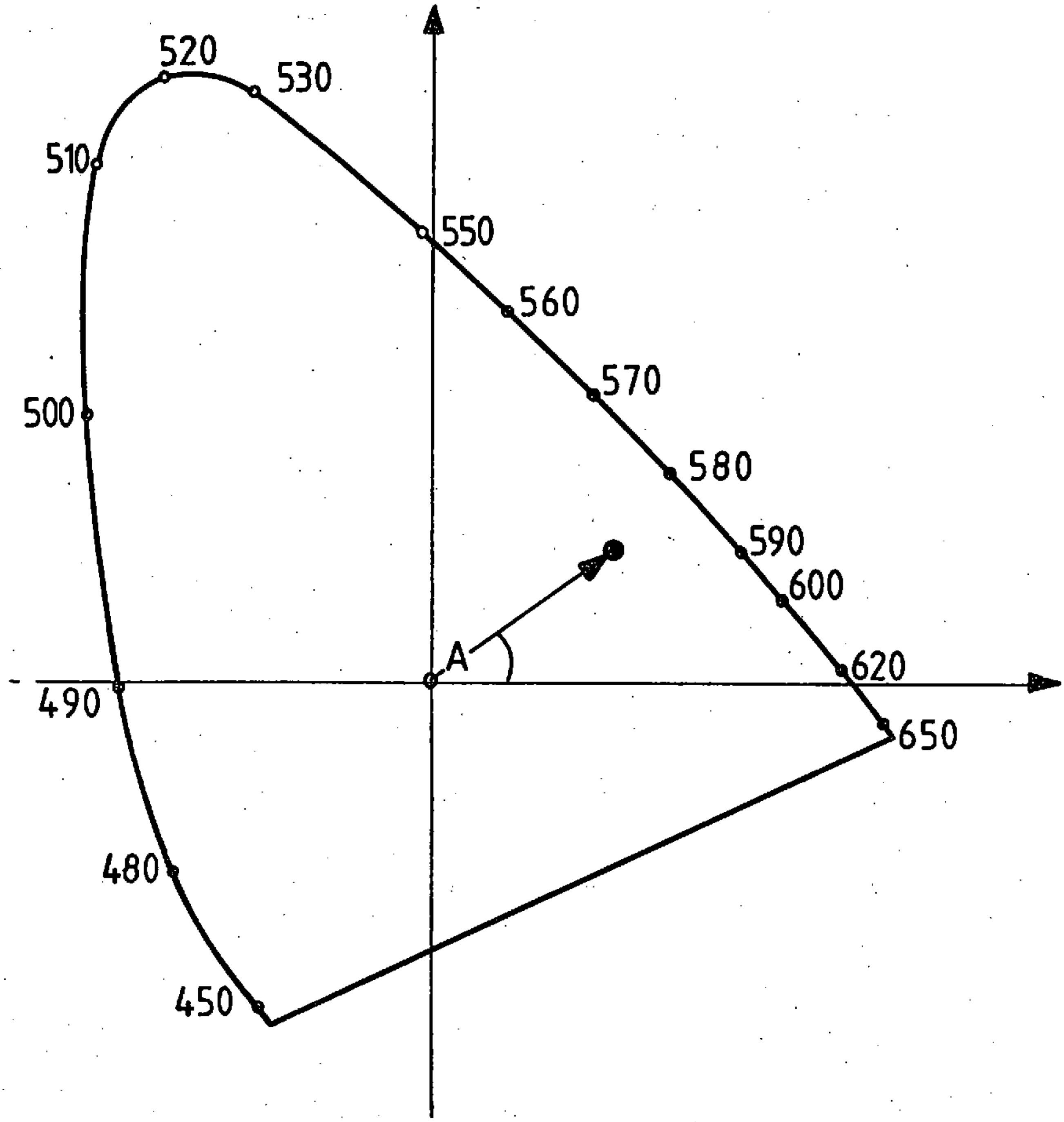

fig. 5. CIE CHROMATICITY DIAGRAM

POLAR COORDINATES.

Fig. 6. PRACTICAL SYSTEM.