COLOUR FILM AND COLOUR TELECINES

INTRODUCTION

Many of the problems confronting the telecine engineer concern the film itself, whether it is an old movie or has been specially prepared for television by the BBC or some other organisation.

The picture quality of items originally intended for optical projection in the cinema is very variable. Film material cannot usually give an accurate reproduction of the original scene presented to the camera, and the compromises accepted for cinema use may not be ideal for television. For example, the image contrast is usually too high; the contrast may be subjectively acceptable in the cinema, where the ambient light level is low, but not suitable for television, where ambient light, flare and noise tend to obliterate the detail in the low light regions of the picture, giving a poor contrast handling ability. If the film is old it may be in poor physical condition with dust and scratches and the dyes may have faded giving colour balance errors. In addition, it may have a non-standard image format, such as Cinemascope.

Films shot and processed specially for television may be expected to give better quality results. Further, in theory at least, the film material could be chosen specially for the purpose and indeed need not even produce a normal picture when projected optically. However, such material would need a specially modified telecine, and in practice only conventional types of film material are used.

For news programmes speed of production is essential, so the BBC shoots and processes large quantities of 16-mm Ektachrome reversal film, both at Television Centre and at main regional centres, whereas complete film programmes and film inserts into television studio productions are normally processed by outside laboratories. In either case, shooting may take place under difficult conditions. Also, there may be insufficient time to correct processing errors by 'grading' (altering the light balance) while reprinting, and correction for shot-to-shot neutral balance changes must then be made by the telecine, using the Tarif system.

In addition, there are certain other inherent colorimetric deficiencies in pictures reproduced by film. These can be compensated for by 'electronic masking', a system in which the telecine takes account of the errors introduced by the photographic process, and attempts to reproduce a scene as it originally appeared. The incorporation of electronic masking considerably modifies the basic design of the telecine video chain, and we shall therefore consider the film and its processing before we come to the telecine itself.

PRINCIPLES OF PHOTOGRAPHIC PROCESSES

The Sensitive Material

Colour films consist of three layers as shown in Fig. 1. The yellow dye is necessary to prevent blue light reaching the lower two layers as it is not possible to suppress their blue sensitivity. It is removed during the subsequent processing.

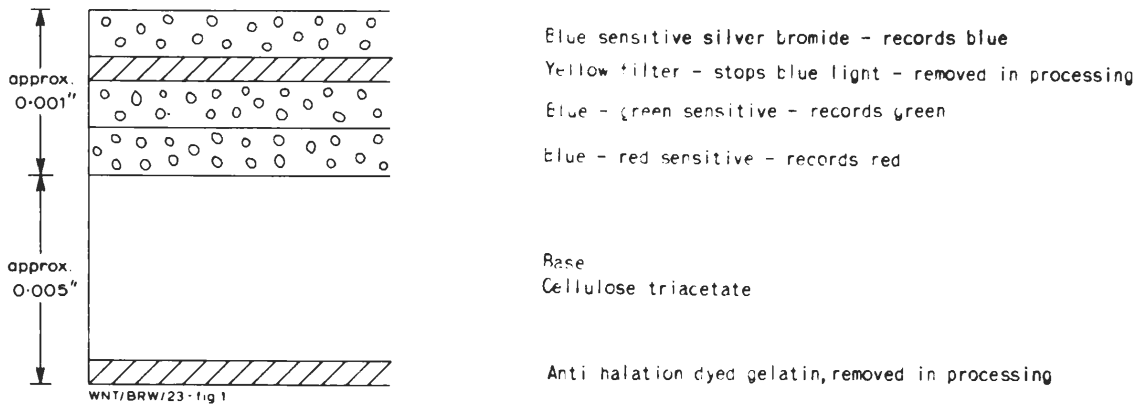

Fig. 1 The Layers of a Colour Film

The antihalation layer is to prevent light scatter due to reflections from the rear face of the film. As an alternative the film base may be dyed, giving typically about 50 per cent transmission*.

Colour of Dyes used in Colour Photography

In black-and-white film the emulsion is sensitive to all wavelengths of light and the resulting image is neutral, i.e., it absorbs light equally at all wavelengths. Note that film projection is essentially a subtractive process, the image preventing the bright white projector light from reaching the screen.

In colour photography the three layers are sensitive to red, green and blue light, just like the tubes in a television camera. The red sensitive layer must control the amount of red light reaching the screen from the projector lamp and so must absorb some red light but not green or blue. Such a dye viewed separately would appear cyan or 'minus red'. Similarly the green sensitive layer produces a dye which appears magenta or 'minus green' and the blue sensitive layer produces a yellow or 'minus blue' dye. Typical processes are shown in Figs. 2 and 3 for black-and-white and colour film respectively.

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*Transmission is the proportion of the incident light passed by the film.

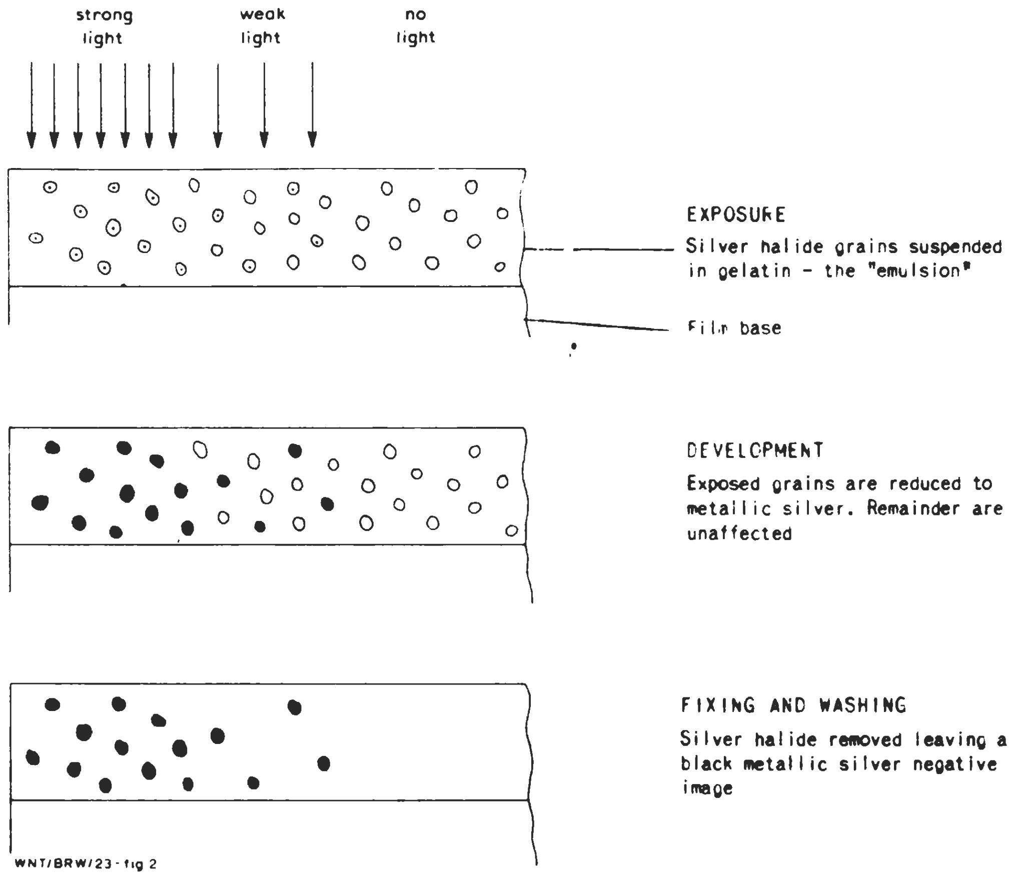

Fig. 2 The Black-and-white Negative Film Process

Summarising:-

1. The analysis is in terms of red, green and blue for the same reasons as in television - to satisfy the human eye.

2. The red sensitive layer produces a 'minus red' or cyan dye.

3. The green sensitive layer produces a 'minus green' or magenta dye.

4. The blue sensitive layer produces a 'minus blue' or yellow dye.

Example:- Green in a photograph is made up from yellow and cyan dyes which absorb blue and red light but transmit green light. The viewing or projecting light source must be satisfactorily white.

Negatives, Printing, Grading

The simplest photographic processes produce negative in which the scene highlights have the darkest image.

A typical colour process is shown in Fig. 3. Notice that, for example, where the original scene was green, the colour negative appears everything except green, i.e. magenta, and similarly for other colours.

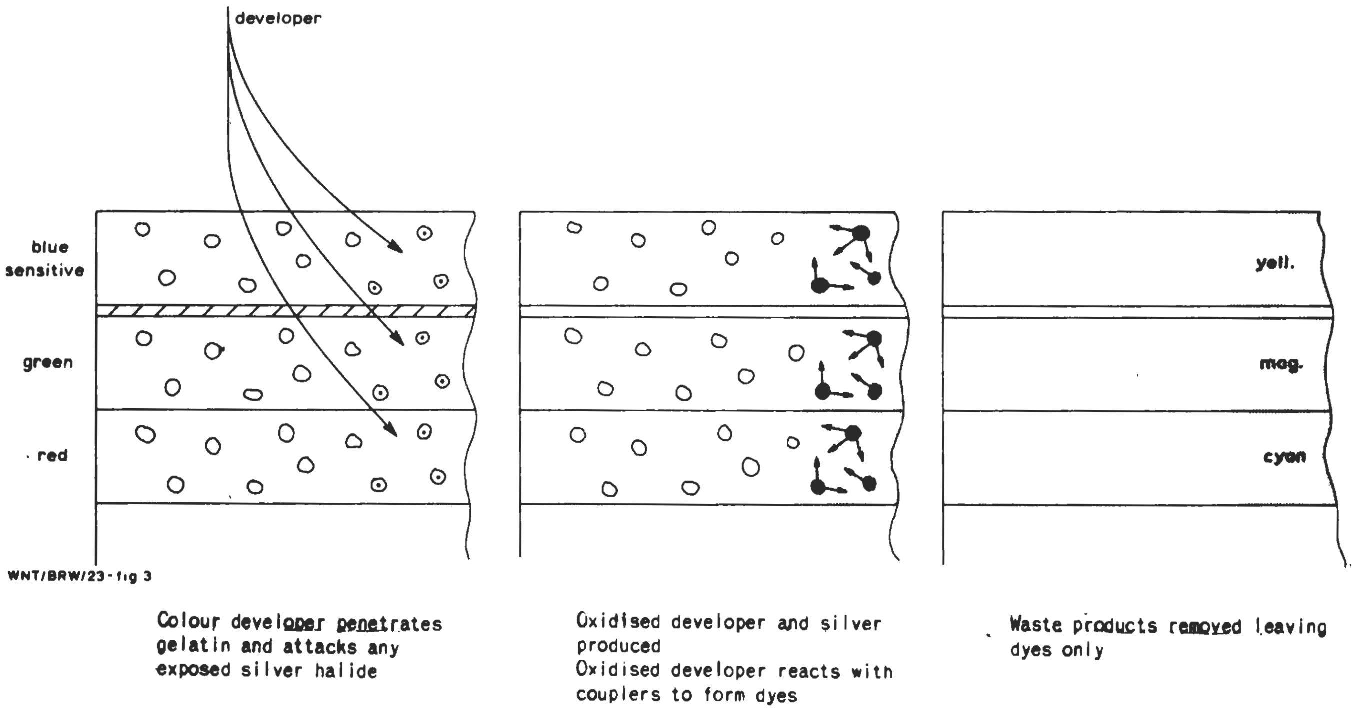

Fig. 3 Colour Development when Couplers are in the Film

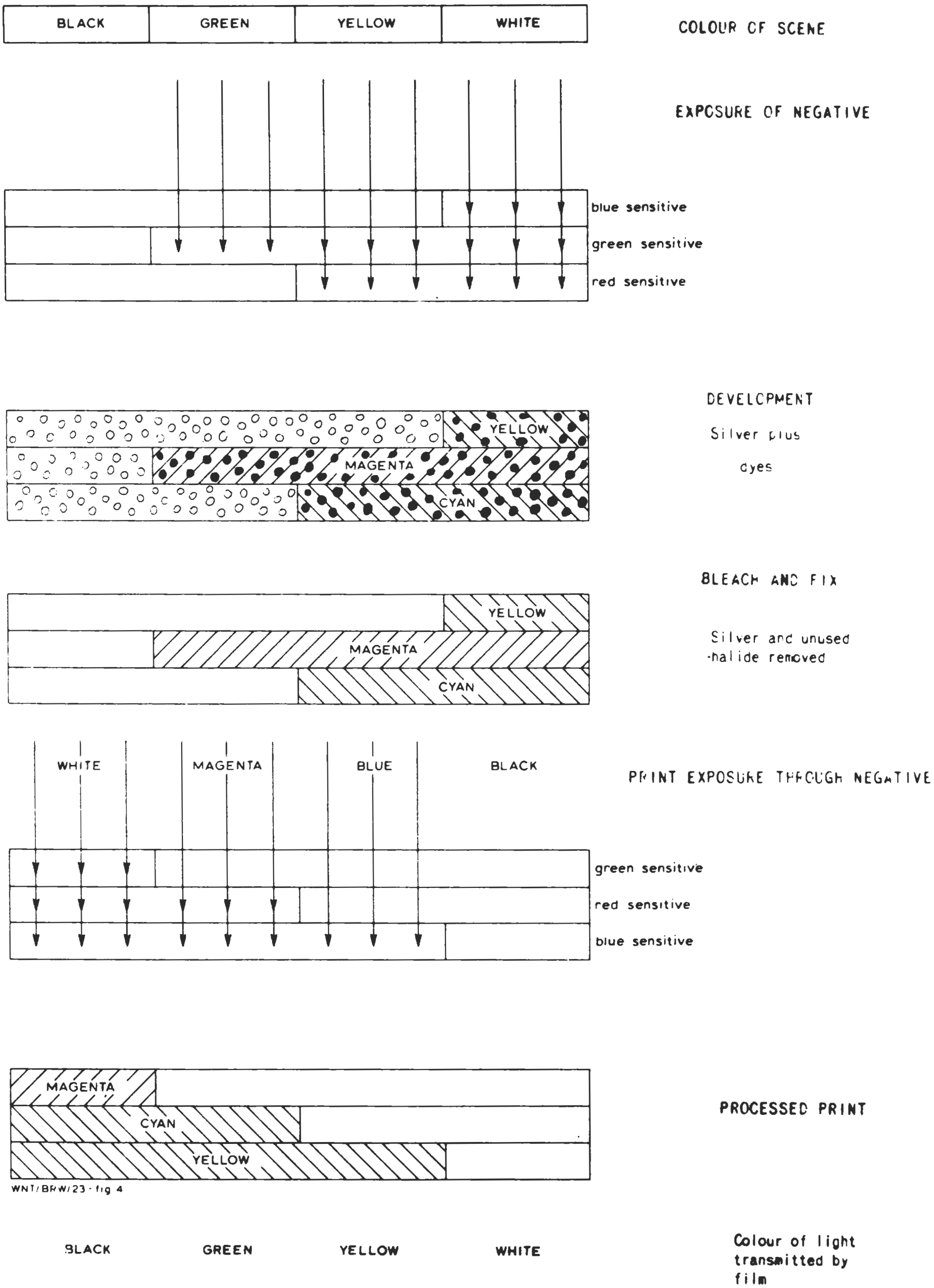

Fig. 4 Typical Colour Negative/Positive Film Process

The negatives are rephotographed or 'printed' onto another negative material, thus producing a positive print as shown diagramatically in Fig. 4.

The intensity and colour of the printing light source can be changed to compensate for variations in the negatives, caused for example by small exposure errors. This is termed 'grading' and should result in prints of consistent quality and colour balance.

Various optical effects, such as fading, mixing and titling can also be carried out during the printing process.

This 'neg/pos' process is widely used, except where speed of production is of first importance, or where only one copy is required.

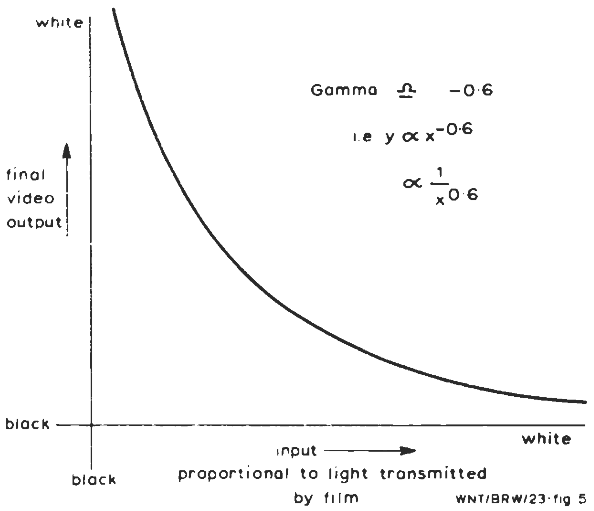

Fig. 5 Approximate Shape of Transfer Characteristic Required in Video Chain of a Telecine Using Negative Film

Reproduction of Negatives in Telecine

It is possible to put the negative film directly into a telecine and suitably invert the video signals to produce a positive output.

The system offers advantages in speed and cost, achieved by eliminating the printing process, but there are the following snags:-

(a) Any damage to the film is final.

(b) Marks such as dust scratches on the film appear white on the final picture and are very objectionable.

(c) The grading operation must be carried out on the telecine during transmission.

(d) Some negatives, particularly colour negatives using dye masking, have high minimum density. This gives a poorer signal-to-noise ratio in flying spot systems. See later sections.

(e) The telecine is required to have a negative gamma transfer characteristic which involves a reciprocal law. A typical characteristic is shown in Fig. 5.

Reversal Film Process

These produce positive images in a single step. Figs. 6 and 7 show typical processes for black-and-white film and colour film respectively.

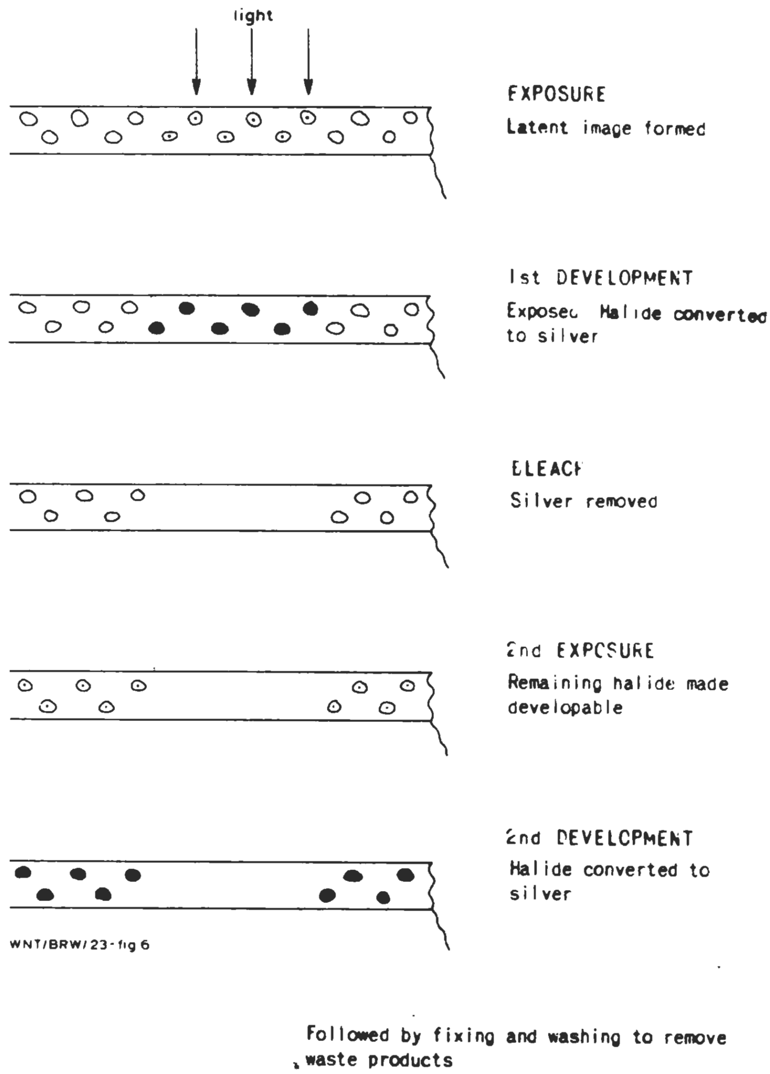

Fig. 6 Black-and-white Reversal Film Process

Printing of Reversal Film

Reversal print stocks are available for this; a less common alternative is to use an intermediate negative. Grading can be employed but the range of correction tends to be less than when using negative film.

Colour reversal film is widely used for television news programmes, either the original film or prints being used in telecines.

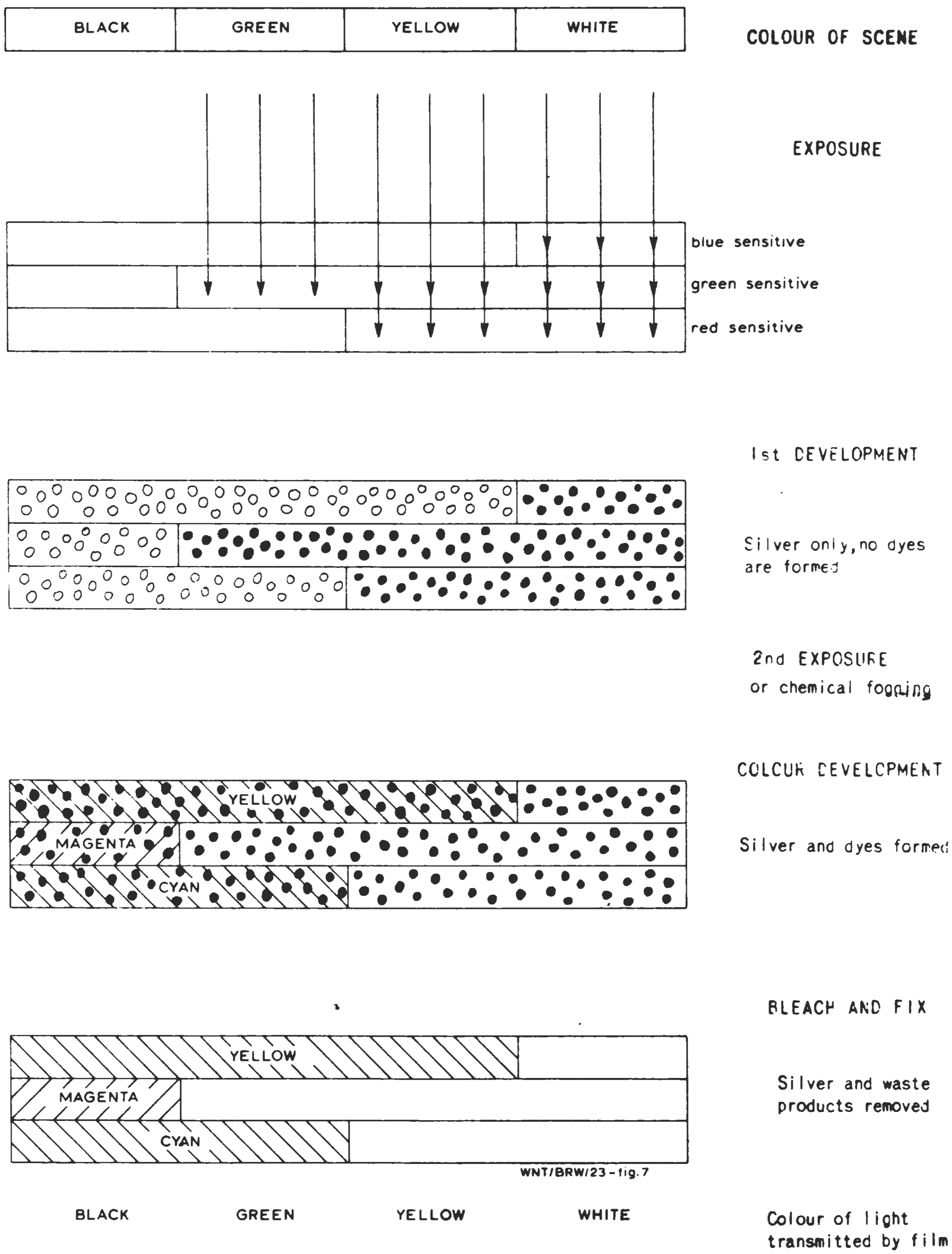

Fig. 7 Typical Reversal Film with Couplers in Emulsion, e.g., Ektachrome

Measurements of Film Characteristics

The light passing power of a processed film can be expressed as the transmission T, where

$$T = \frac{\text{light emerging through film}}{\text{light incident on film}}$$

In practice, however, the density D is usually quoted,

$$D = \log_{10}\left(\frac{1}{T}\right)$$

$$= \log_{10}\left(\frac{\text{light incident on film}}{\text{light emerging through film}}\right)$$

The density of a sample of film can be measured by a 'densitometer'. This directs light onto the sample, the emergent light being picked up by a photocell feeding a meter with a scale calibrated directly in density, as shown in Fig. 8.

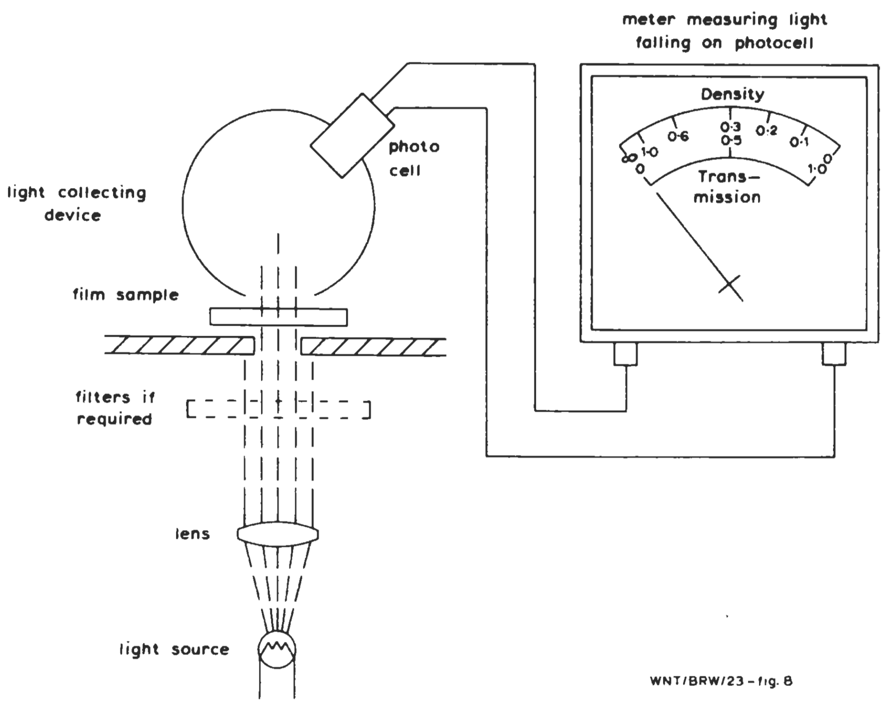

Fig. 8 Simple Densitometer

Addition of Densities

Since density is a logarithmic quantity, when light passes through two layers the total density is the sum of the individual densities, just as the loss in dB of two attenuators is the sum of the individual losses. This effect, illustrated in Fig. 9, is very convenient in calculations concerning multilayer colour films.

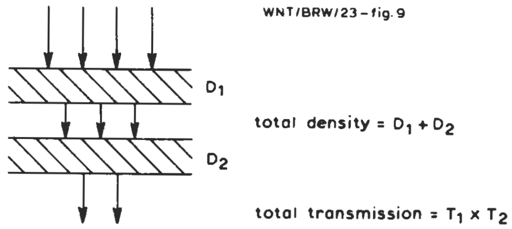

Fig. 9 Add Densities but Multiply Transmissions

Spectral Densities of Colour Film Dyes

A densitometer using monochromatic light of variable wavelength makes it possible to plot the variation of density with wavelength of a dye. This enables the spectral density to be plotted.

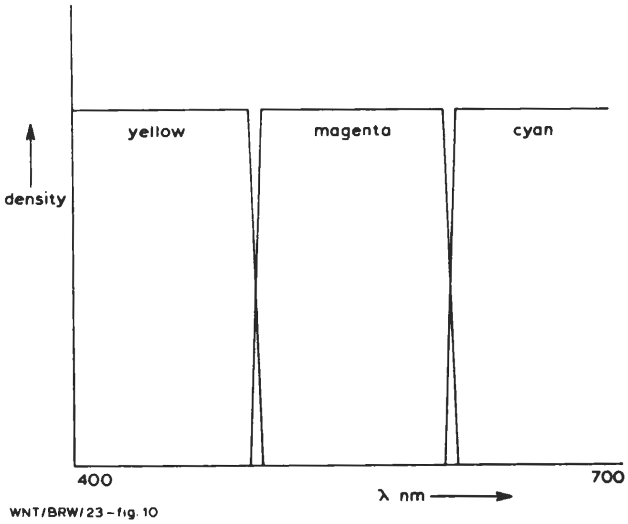

Fig. 10 Spectral Density Characteristics of Ideal Dyes

It can be seen from Figs. 10 and 11 that practical dyes differ from the ideal in that they absorb in regions where they should be completely transparent; for example, the practical magenta dye shown has considerable density in the blue region.

The disadvantages of using such dyes are:

(a) Desaturation of the reproduced picture. For example, although the green light entering the camera lens only affects the amount of magenta dye, this in turn also to some extent affects the blue and red content of the reproduction.

(b) Reduction in the range of luminances and colours that can be reproduced. For example, a magenta picture is produced by magenta dye only, and for full saturation and luminance this should remove green but leave red and blue at full amplitude. However, as can be seen, the practical magenta dye absorbs blue and some red, thus reducing the saturation and luminance.

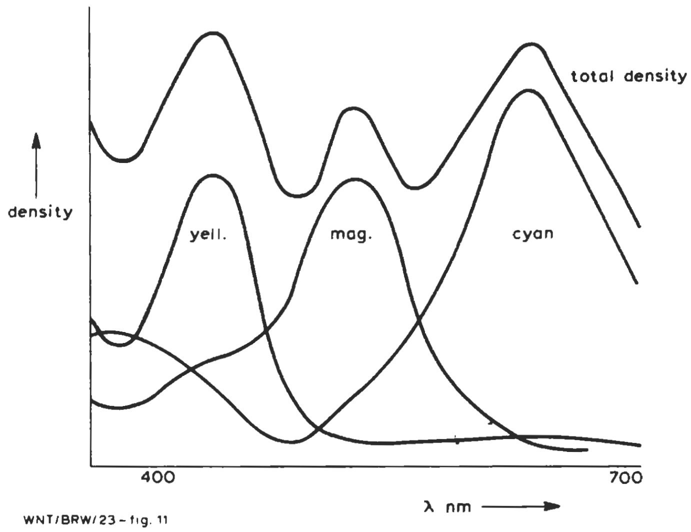

Fig. 11 Characteristics of Typical Film Dyes

Both the above effects are most serious in the reproduction of saturated colours at high luminance. The saturation is improved to some extent if a high overall gamma is employed, but although this gives good results with optical projection, the high contrast is not ideal for television where noise, flare and ambient light reduce the contrast handling ability.

Dye Masking in Colour Negatives

This technique is shown in Fig. 12. It is used in most negative processes, and it avoids the build-up of desaturation errors described above that would otherwise occur in the neg/pos system which, in effect, uses photographic processes twice.

The characteristic of the magenta dye shows that it has a significant density in the blue region of the spectrum where it should have none, and thus appears too yellow. This unwanted yellow component can be offset by using a yellow-coloured coupler to produce the magenta dye. As the magenta dye is formed, the remaining amount of yellow-coloured coupler is reduced; thus the total yellow content is unchanged, and the film appears to be a perfect magenta dye superimposed on an all-over yellow cast which is formed by either the dye or the unused coupler.

The cyan dye has unwanted green-blue absorption; it thus appears too red, and a reddish-coloured mask is produced in this layer by using a suitably reddish-coloured coupler to form the cyan dye.

Film using dye masking can easily be distinguished by the deep yellow or orange colour of the otherwise clear areas. The technique is used only for negatives, where the orange cast can be removed by suitable filtering of the light in the printing process.

Where such negatives are used directly in a telecine, the high minimum density reduces the video signal amplitude, and in a flying spot system, where the light available is limited, the increased gain required gives a poorer signal-to-noise ratio, particularly in the blue channel. This is one of the factors which had prevented the use of colour negatives in

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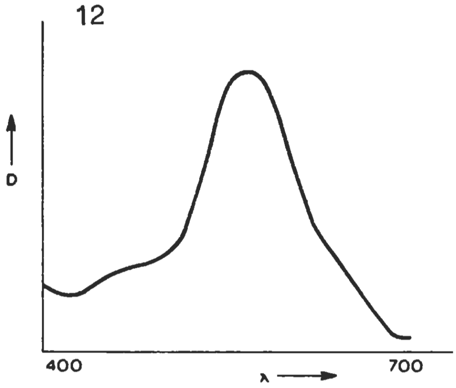
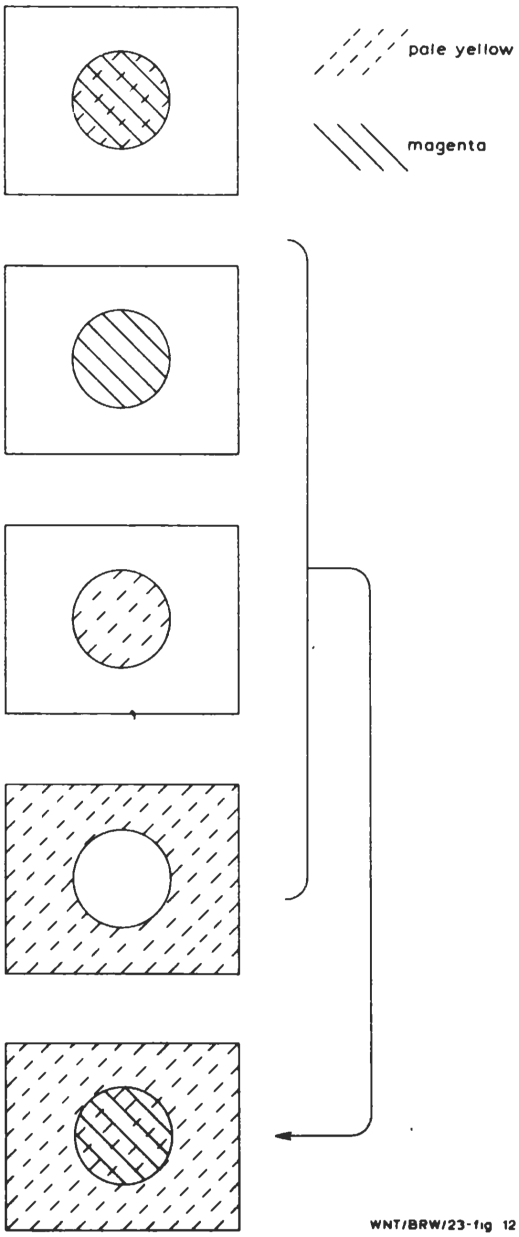
The typical magenta dye shown absorbs too much blue light - thus it appears too yellow



Thus a practical magenta dye image could be imagined to consist of:-



A true magenta image,

plus

A pale yellow image
(and this is a colour error)

The remedy is to make a pale yellow negative of the original magenta dye image - called a "mask"

and add it to the original dye image

The result is a perfect magenta image plus an all over yellow cast

Achieved by using a yellow coloured coupler. The unused coupler forms the mask. A red coloured coupler may also be used in the cyan layer.

Used for negatives only. The resulting colour cast can be removed in the printing process.

Fig. 12 Principles of Dye Masking

telecines, but cathode ray tubes with increased light output are now available to overcome the problem.

THE USE OF COLOUR FILM IN THE BBC

1. SENSITIVITY AND COLOUR BALANCE

Colour film can be obtained with the sensitivity of the three layers balanced to be correct either when exposed in 'daylight' or in 'tungsten light' (3200° K). If 'daylight' film is used in tungsten light a suitable blue filter must be used on the light sources or the camera, usually on the latter, whereas a yellow filter is required if 'tungsten light' film is used in daylight.

In either case the effective sensitivity of the film is reduced by using the filter. The loss in sensitivity is greater for 'daylight' film used in artificial light.

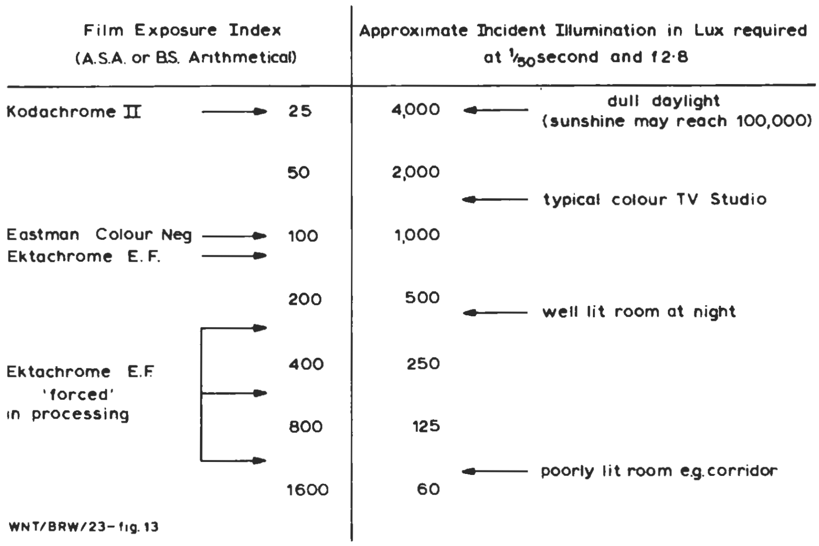


Fig. 13 Film Sensitivities and Lighting Levels

To indicate the sensitivity of a photographic material, the maker normally quotes an 'exposure index', and from this suitable settings for the camera can be estimated using either tables or an exposure meter. Some typical figures are shown in Fig. 13.

2. NEWS PROGRAMMES

Speed of production is vital, and a sensitive and quickly processed film is required. The BBC therefore uses and processes large quantities of 16-mm reversal film for news. It is almost entirely Ektrachrome EF 7242, which has the following properties:

(a) It has high sensitivity, 125 ASA to tungsten light and 80 ASA to daylight using a suitable filter, but under-exposure of up to three stops can be compensated for by increasing the first development time. (See Fig. 7.)

(b) It can be processed quickly (about 30-minutes dry-to-dry). In a continuous film processing machine the running speed depends on the machine size, but is usually 40 ft/m or greater, i.e., at least equal to the projection speed of 25 frames per second.

(c) Either the original film can be used in telecine or prints can be made using, for example, Ektachrome Print stock Type 7388. BBC printing facilities are only available at TC Spur.

(d) The picture quality is good, but reduced by under exposing and 'forcing' in development. Printing involves some loss in resolution and may reduce the colour quality.

3. PRODUCTIONS OTHER THAN NEWS WHERE SPEED IS NOT ESSENTIAL

Steps in the Production of a Colour Film

The film from the camera (the negative, or the 'master' if reversal film is used) is processed and first prints (the 'rushes') are produced. These are normally in black-and-white, though perhaps some 15 per cent may be made in colour to check the colour quality.

The first prints are edited to produce a 'cutting copy'. Sound tracks are also edited, dubbed, and so on as required to produce a sound track 'final mix', normally on separate magnetic track.

The negative or master is then cut to match the cutting copy and a graded colour print is made. This first attempt is termed an 'answer' print and may show noticeable colour or density grading errors which can be corrected in subsequent prints. Thus one or more answer prints may be produced before the show copies.

The answer print may be used by telecine for rehearsal purposes to avoid the risk of damage to the show print.

Requirements of Film Material

(a) Duplication. It must be easily duplicated; for this reason the neg/pos process is preferred.

(b) Colour quality and contrast. Telecine prefers film with lower contrast than is usual for optical projection. Colour quality is best judged subjectively and in any case it is difficult to match film/telecine output accurately to a television camera output.

(c) Grain and resolution. These are not very good with 16-mm film, so 35-mm would be preferable, but see (e) below.

(d) Sensitivity or speed. Important; higher speed gives greater depth of field and/or lower lighting costs.

(e) Convenience and cost. 16-mm film is more convenient than 35-mm, since the cameras are smaller, and it is also much cheaper. For these reasons it is most commonly used.

Neg/Pos Processes

The most usual material is Eastman colour negative Type 5254 (35 mm) or 7254 (16 mm). Its speed is 100 ASA to tungesten light and 64 ASA to daylight with a suitable filter.

It is a 'standard' film of the industry, is easily obtained and processed, gives a pleasing colour rendering and has good exposure latitude and contrast handling ability.

For optical projection purposes it is normally printed in the companion Eastman Colour Print film 5385 (35 mm) or 7385 (16 mm).

For television a lower contrast result is obtained by printing on Eastman Colour Positive TV film Types 5744 and 7744.

Other low contrast print stocks are Agfa/Gevaert Type 954 TV and Ferrania HS1.

Reversal Materials

As with news the most usual material is Ektachrome EF 7242 and it is used when higher sensitivity or faster processing is required. Various suitable reversal print stocks are available.

Technicolor (Dye Inhibition Process)

This is a complex printing process involving three separate stages of dye transfer printing. It is expensive to set up, but the prints are made on an inexpensive material; thus it is an economical proposition only if 20 or more copies are to be made. Many cinema films are printed by this method, but it is rarely used for BBC films.

Other Intermediate Processes

These are required for complex duplicating operations, e.g., if the original material is a mixture of negative and reversal and/or print stock. Various special negative and reversal intermediate stocks are available. There may be some loss of resolution and colour quality although the materials used are designed to minimise this.

Intermediate processes are sometimes used in the production of optical effects, such as fades or wipes. A copy negative is made from the appropriate sections of the original negatives, using a special printer incorporating the necessary optical-effect facilities. These sections of copied negatives are then edited into the original cut negative and the whole is printed in the usual way. This can produce a sudden deterioration in quality just before an effect, followed by a sudden improvement on return to the material printed from the original negative, as shown in Fig. 14.

A-B Roll Printing (Fig. 15)

This avoids the difficulties described above. The negative is assembled in two rolls; one, the A roll, consists of shots 1, 3, 5 and so on with suitable blanking between them, while the B roll consists of shots 2, 4, 6 etc.

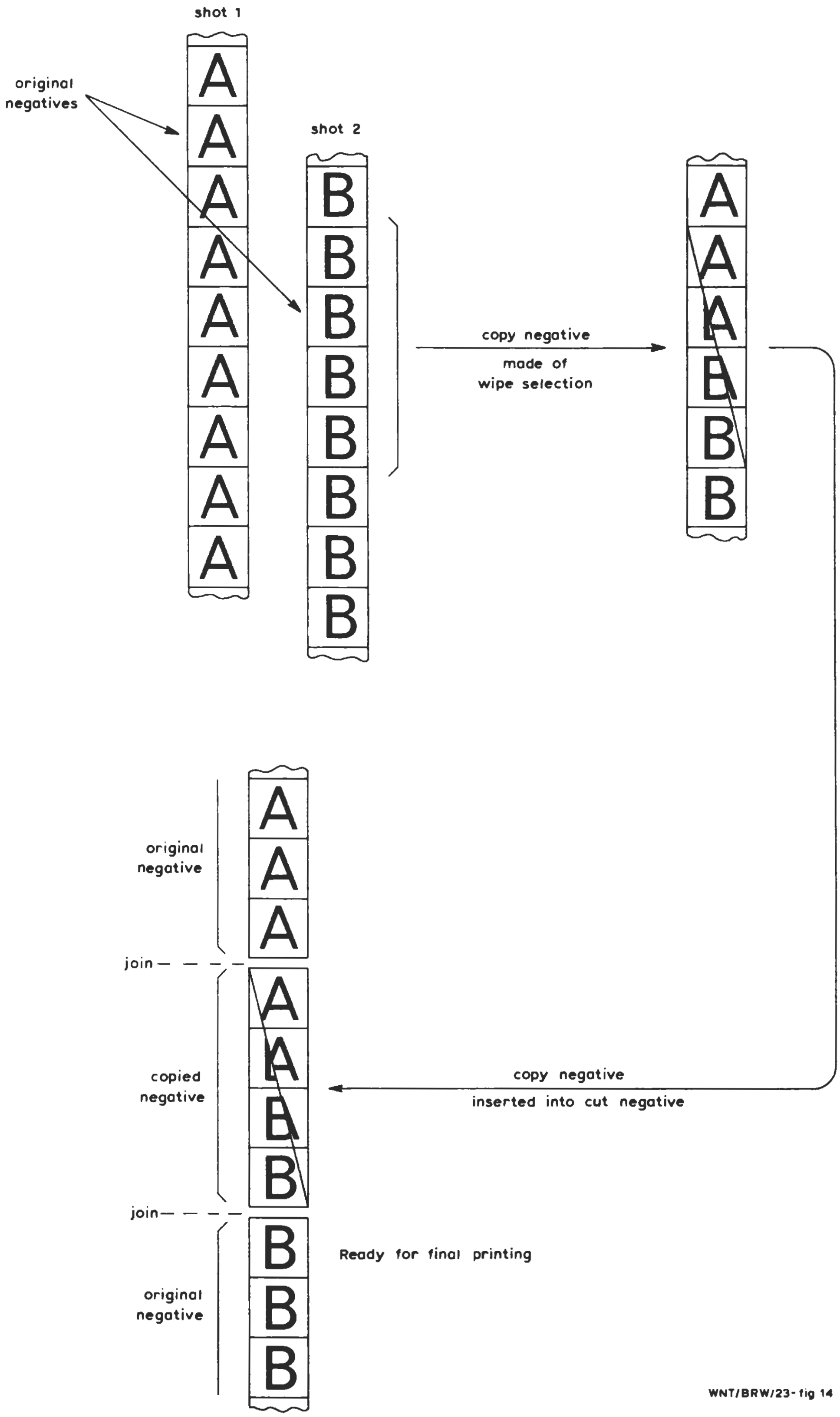


Fig. 14 Negative Cutting: Making a Wipe or Mix

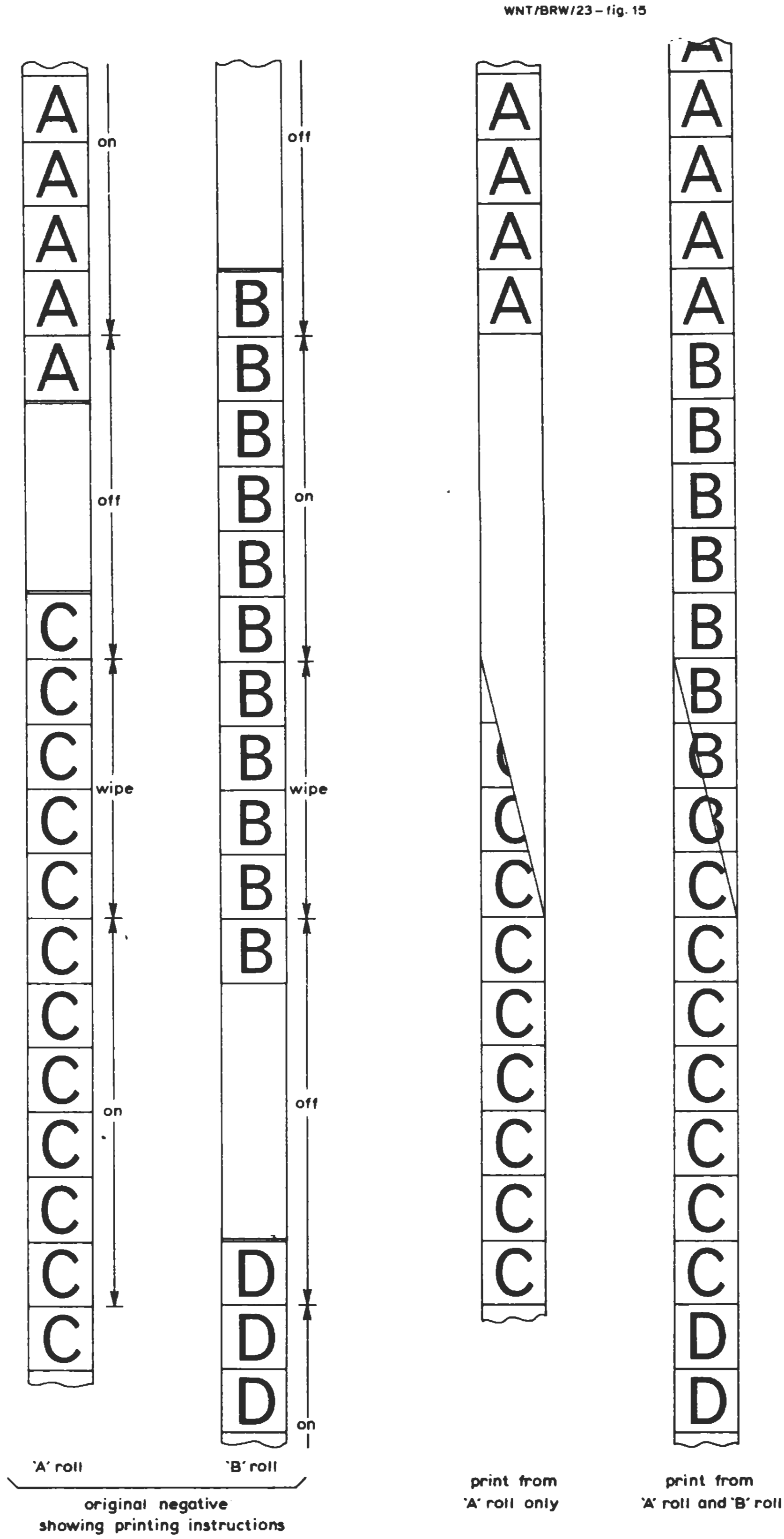


Fig. 15 Negative Cutting: A-B Roll System

One roll is printed first, the printer light is switched or faded on or off as required, the print is rewound and then re-exposed using the other roll of negative, again with the printer light suitably controlled. This requires careful programming of the printing equipment and may thus be more expensive particularly if a large number of prints are required.

Black-and-white Prints from Colour Material

Ordinary black-and-white print stock is only blue sensitive, so is not suitable for use with colour negatives.

Panchromatic black-and-white print films are available, but orthochromatic (blue-green sensitive) material is often used for rushes, giving some tonal distortion (reds appear too dark).

Colour Print from Black-and-White Material

This occurs where part of the programme is from black-and-white negative and part from colour, the whole being printed onto normal colour stock.

The black-and-white sequence can be given any selected colour bias by grading during printing, although it is not always easy to make it completely neutral.

Wherever possible, the show print should be made in one continuous operation from a suitably cut negative (or positive if reversal print is used). This helps to achieve a constant colour quality and avoids using a film with joints.

CAMERA TUBE TELECINES

Basically a conventional intermittent-motion film projector is used with a conventional three or four tube colour camera. A typical system is shown in Fig. 16.

Projection Speed

For 50-fields-per-second operation, the projector runs at 25 frames per second, and each frame is shown twice, the shutter operating 50 times a second, i.e. once per field. The phasing of the projector is unimportant, but the shutter rate should equal the field frequency within ±0·5 Hz, so a motor speed control system is required.

Still-frame operation is also possible; so is $16\frac{2}{3}$ frames per second if each frame is shown three times as this is usual for 8-mm projection.

Light Sources

Normally ample light is available with the result that unusually dense film can easily be handled.

The colour quality of the light is not critical but must be constant. A means of varying the intensity of the light is required to suit the film density and maintain a constant peak illumination of the camera tubes. This control must be very fast acting; a conventional iris would be too sluggish, so a 'light valve' is generally used.

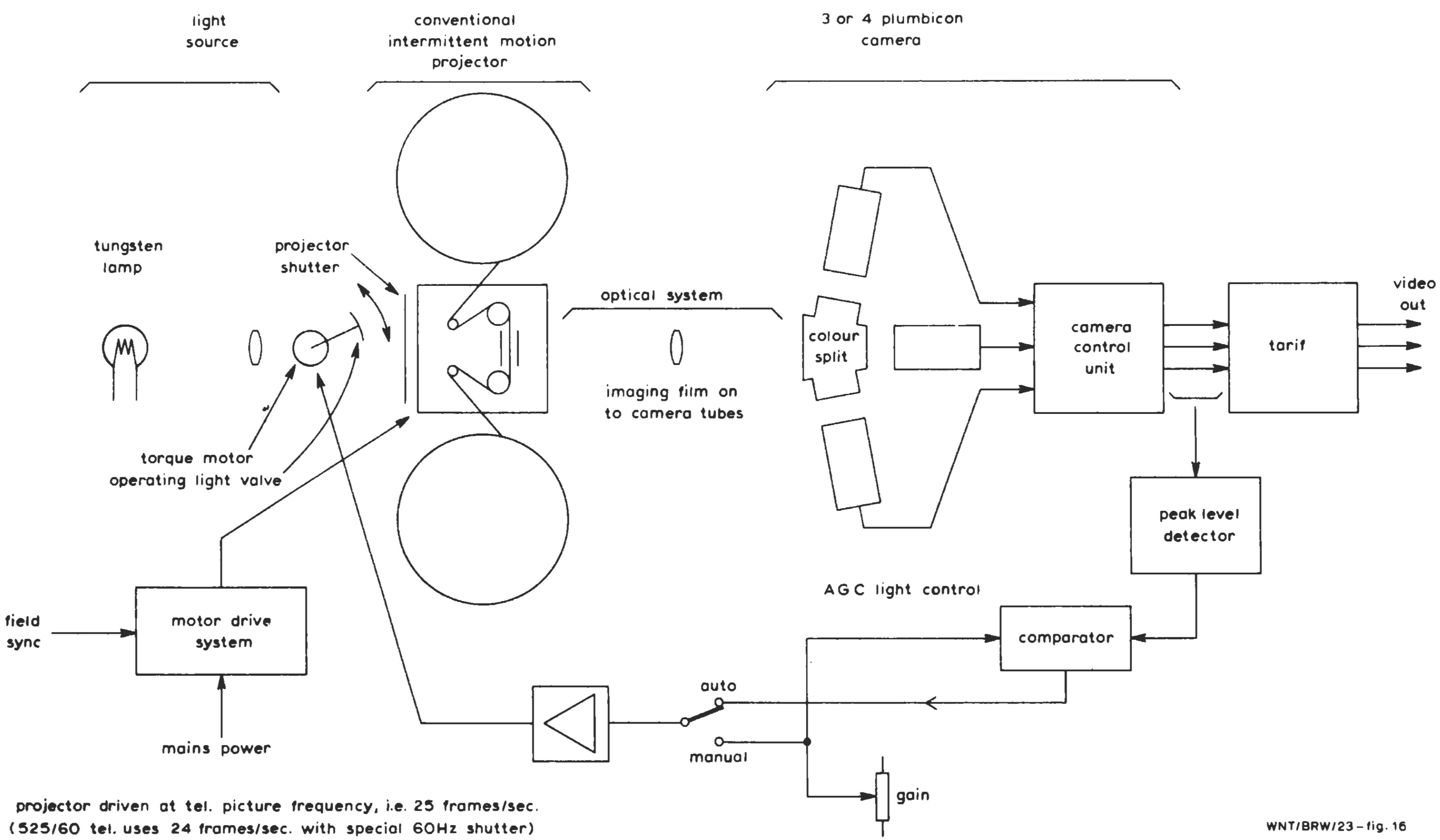


Fig. 16 General Principles of Typical Camera Tube Telecine

Control of the Light Valve

This can be manual, a potentiometer adjusting the torque motor current and hence light output, or it can be automatic. An automatic system usually controls the light valve so that the maximum output from any camera tube is just at peak level. It is closed down quickly (within a frame or so) to prevent overload but is opened up slowly (over several seconds). This latter timing is something of a compromise avoiding excessive variation with picture content.

Camera Optical Analysis Systems

These usually follow studio camera practice except:-

(i) Space is not as critical,

(ii) Ample light is available.

Either dichroic mirrors or a system similar to studio cameras may be used.

Since ample light is available, all three (or four) camera tubes can be operated with equal peak signal currents, neutral density filters being inserted in front of those which would otherwise produce the larger signals. This gives equal and good signal-to-noise ratios on all the channels.

To get the best results from the film picture, the optical analysis may differ slightly from that of a studio camera, as may the values of components in signal correction matrices if fitted. However, in these telecines the values chosen are usually designed to give a reproduced television picture which matches as closely as possible that which would be obtained by optical projection and no correction for inherent film deficiencies is provided.

FLYING SPOT SCANNING SYSTEMS

General Principles

The light source is a short-afterglow c.r.t. displaying an unmodulated raster. An image of this is focused onto the film, which is thus scanned by a moving point of light. The amount of light passing through the film depends on the transmission factor at the point being scanned. This light is then directed, not focused, onto a photocell, the output of which is a video signal. For colour operation three photocells are used in conjunction with dichroic mirrors and filters as shown in Fig. 17.

Characteristics of Flying Spot Scanning Systems

(a) There are no registration errors, since scanning takes place before colour separation.

(b) The photocells are quite linear, so the signal output is proportional to the film transmission.

(c) Accurate black level control is provided by blanking out the c.r.t. beam during flyback. There is negligible line frequency pick-up, as the outputs of the photomultipliers are at high level (about 50 μA peak) and are well separated from the scanning assembly; 'pulse cancellation' correction is thus not required.

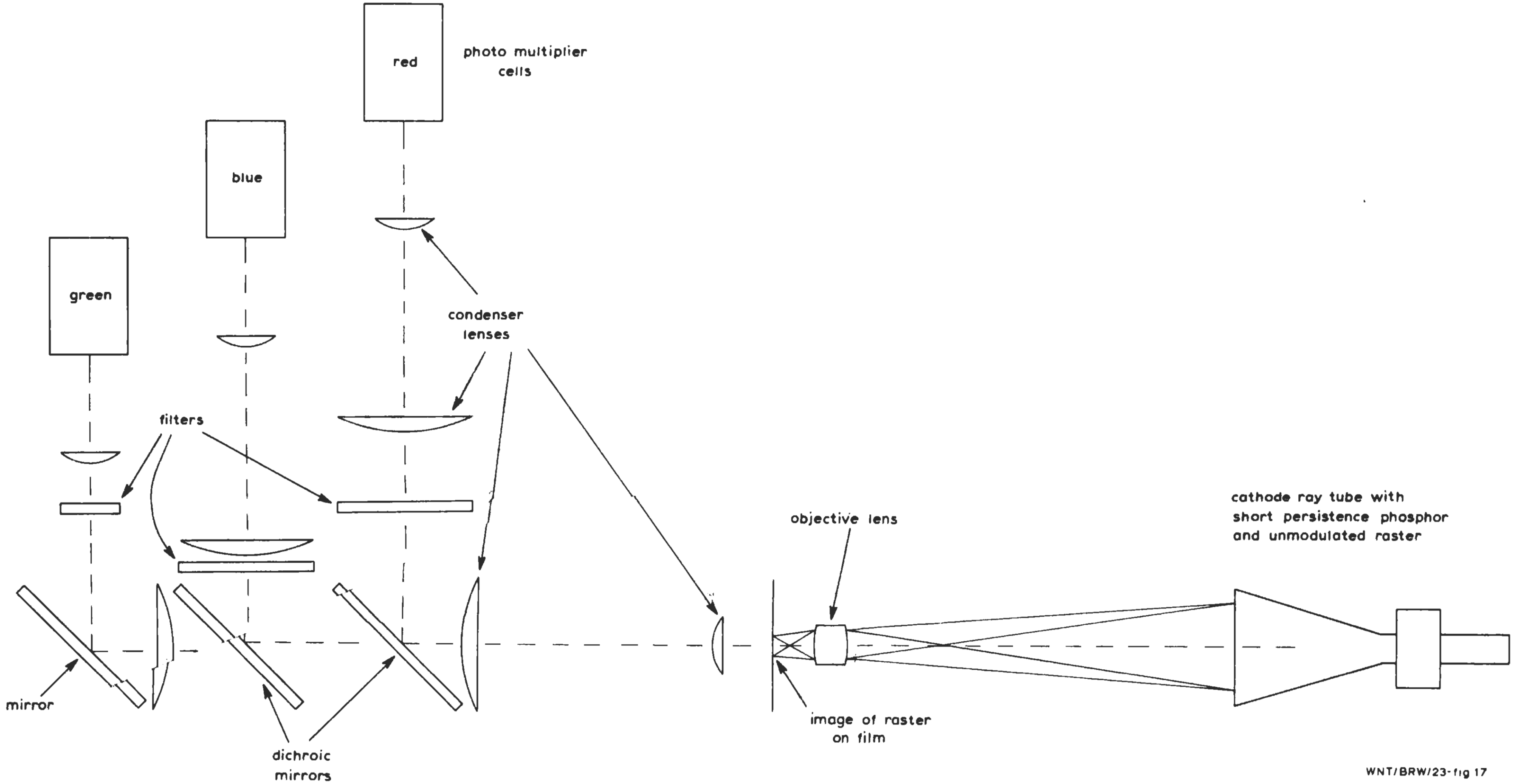


Fig. 17 Optical System of Simple Flying Spot Scanr

(d) A good signal-to-noise ratio can normally be achieved, but any reduction of

(i) c.r.t. brilliance

(ii) film peak transmission

(iii) optical efficiency or

(iv) photo emission efficiency of the photocell

would reduce the signal output and so require a higher gain of the electron multipliers or subsequent amplifiers, thus worsening the noise.

(e) Phosphor afterglow produces positive streaking which requires careful compensation with an afterglow corrector.

ELECTRONIC MASKING

This is a colour correction technique at present applied only in Rank-Cintel flying spot systems. It consists of a linear matrix, operating on logarithmic colour video signals, which corrects for certain colour errors inherent in colour film processes.

A telecine using electronic masking does not reproduce film the way the eye sees it, but instead compensates for the colour distortion that the film must have introduced, and attempts to reproduce the scene as it really was.

Main Cause of Colour Errors

The main cause of colour errors is the colour of the dyes which make up the image. In the simplest colour system of Fig. 18 it can be seen that the original red-green-blue exposure of the film results in cyan (minus red), magenta (minus green) and yellow (minus blue) dyes. Ideally these dyes should individually control the outputs of the three photocells; the method shown is clearly impractical.

The practical telecine has to look through the three dye layers superimposed. The total density at any wavelength is the sum of the densities of the individual layers but the total transmission is the product of the individual values.

Fig. 19 shows a hypothetical set of dyes, in this case only the magenta dye is imperfect (in that it interferes with the blue signal). Since the telecine responds to the transmission of the film, the blue signal is multiplied by an undesirable quanity; thus its correction would involve division. If, however, the telecine responded to density, the unwanted component would be added to the blue so its removal would evolve only subtraction, which electronically is much simpler.

Density can be found by taking the logarithm of transmission since

$$D = \log \frac{1}{T} \quad \text{or} \quad D = - \log T$$

The minus sign here indicates a simple inversion of the signal, maximum transmission occurring within minimum density.

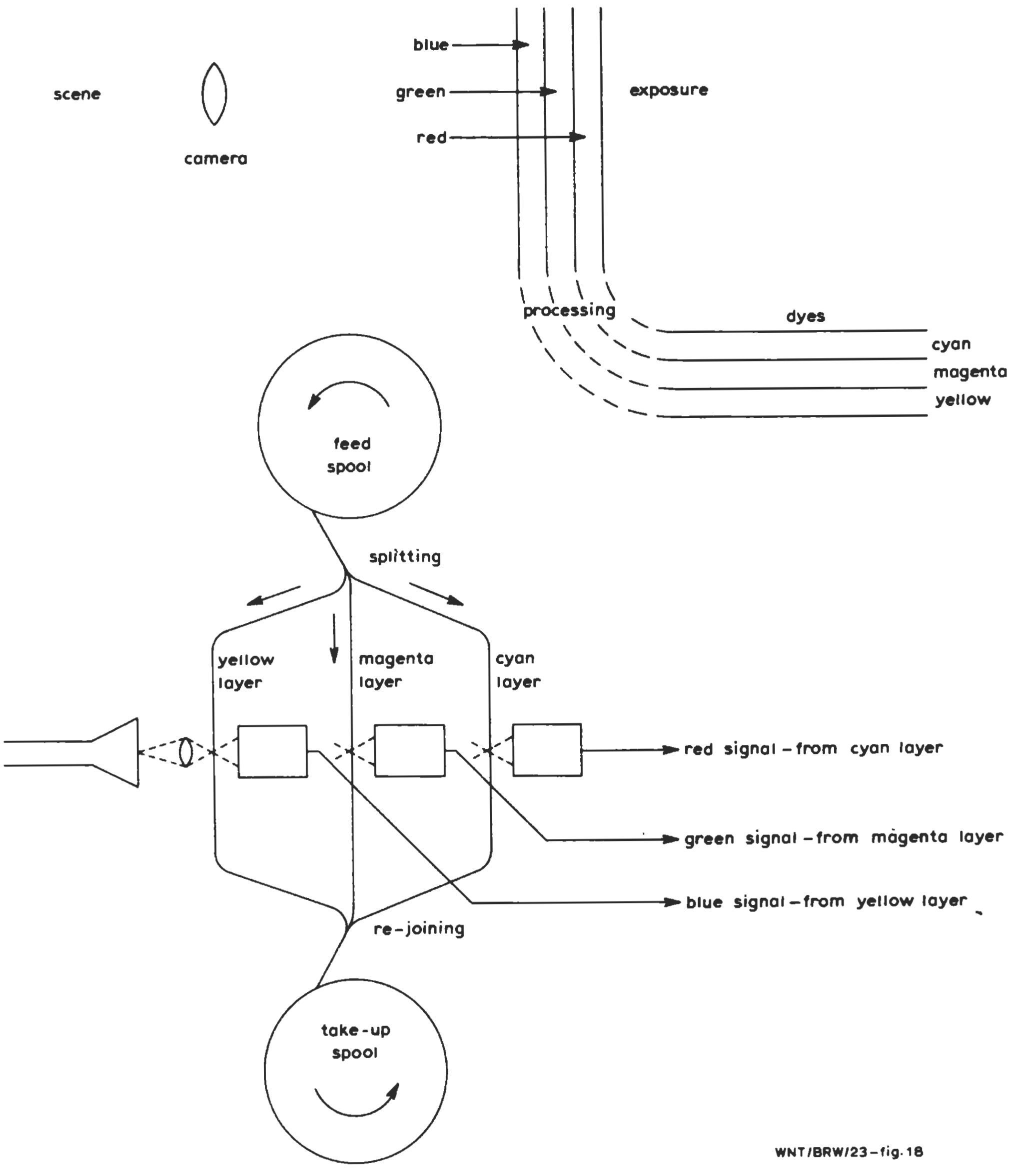


Fig. 18 An Ideal - but Impractical - Telecine

To convert the signal to a form where correction can be carried out by addition and subtraction of signals, amplifiers having a logarithmic transfer characteristic are therefore required. The resulting signal must subsequently be passed through antilog or 'exponential' amplifiers to be restored to the form required for television.

The correction for the hypothetical set of dyes considered is shown in Fig. 20. As only one error is involved in this case, only one correction path is required.

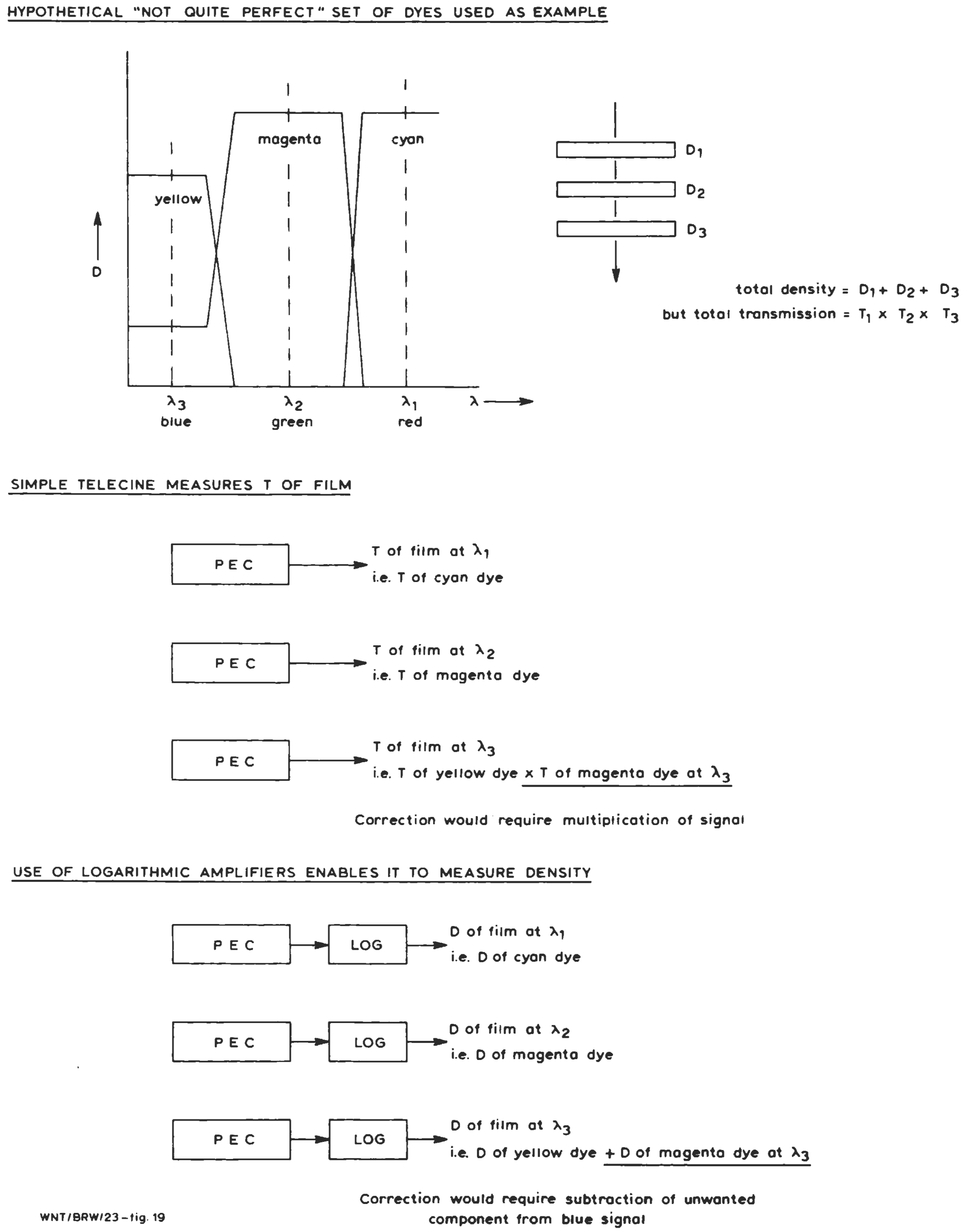


Fig. 19 Addition and Subtraction of Signals is Easier than Multiplication

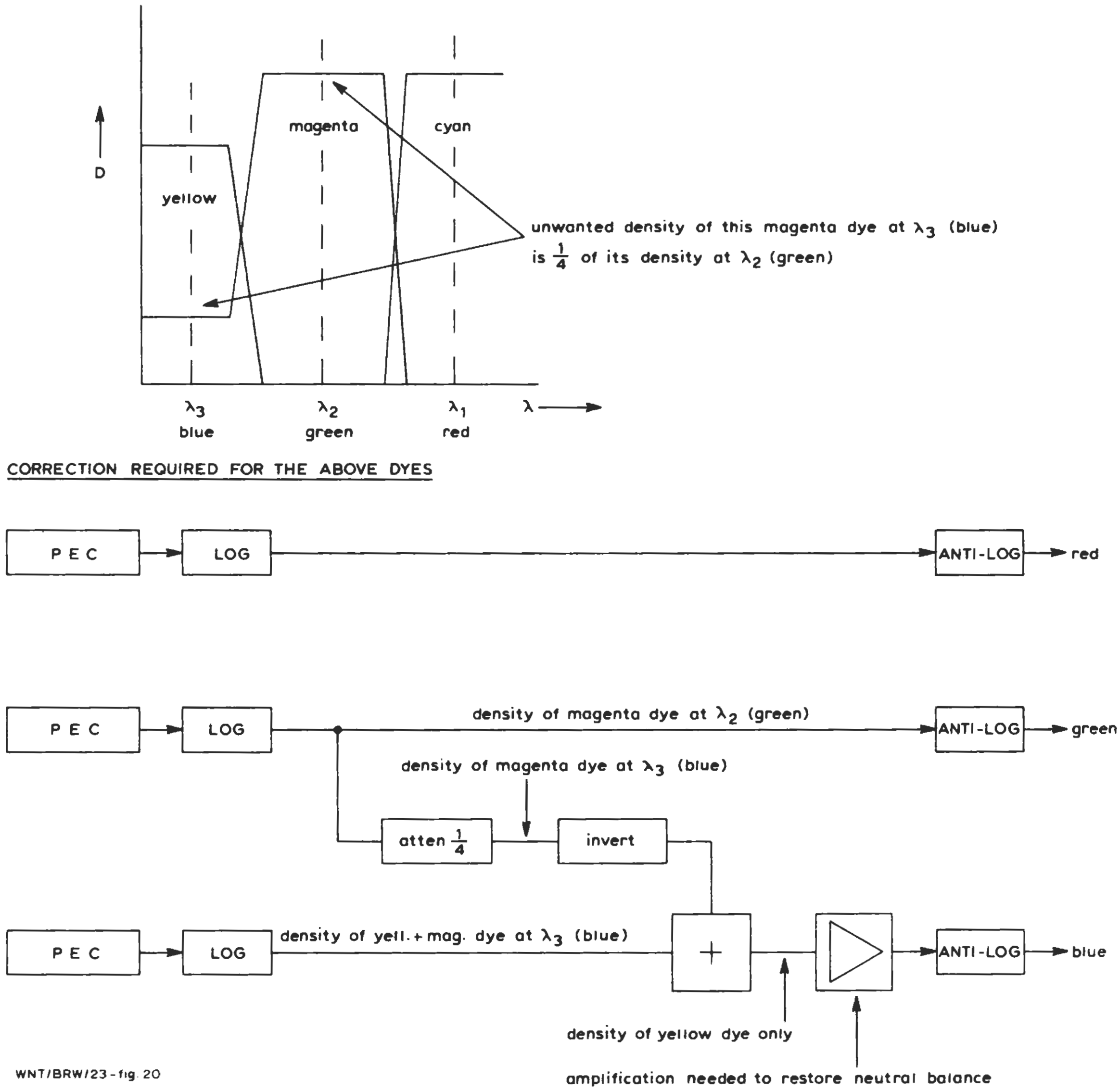


Fig. 20 Correction for the Dyes of Fig. 19

Extra Advantages of the Use of Logarithmic Amplifiers

As Fig. 21 shows, if logarithmic and antilogarithmic amplifiers are used, then gamma correction, either positive or negative, can be achieved by simply altering the gain or inverting the signal while in its logarithmic form. Adding at this point is equivalent to multiplying the linear signals and this enables gain control to be achieved very simply.

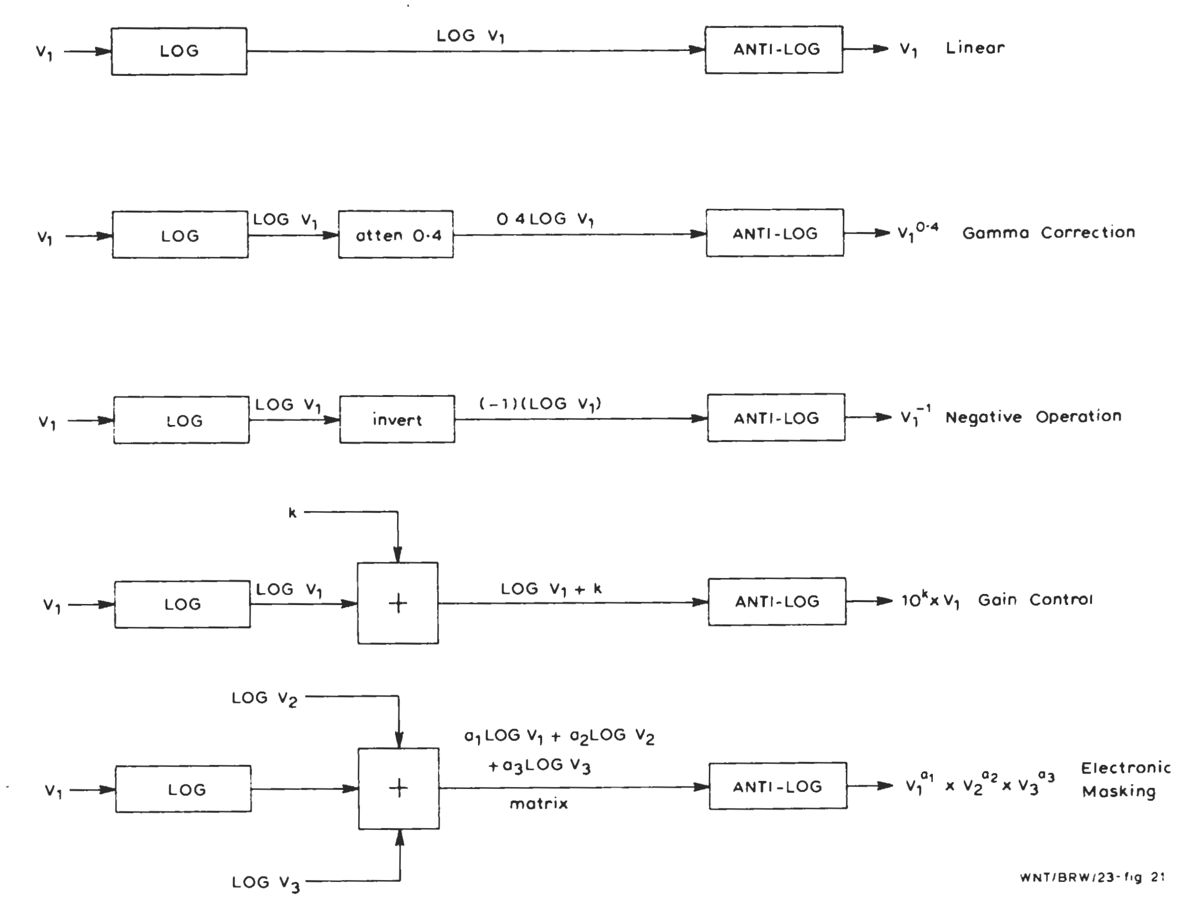
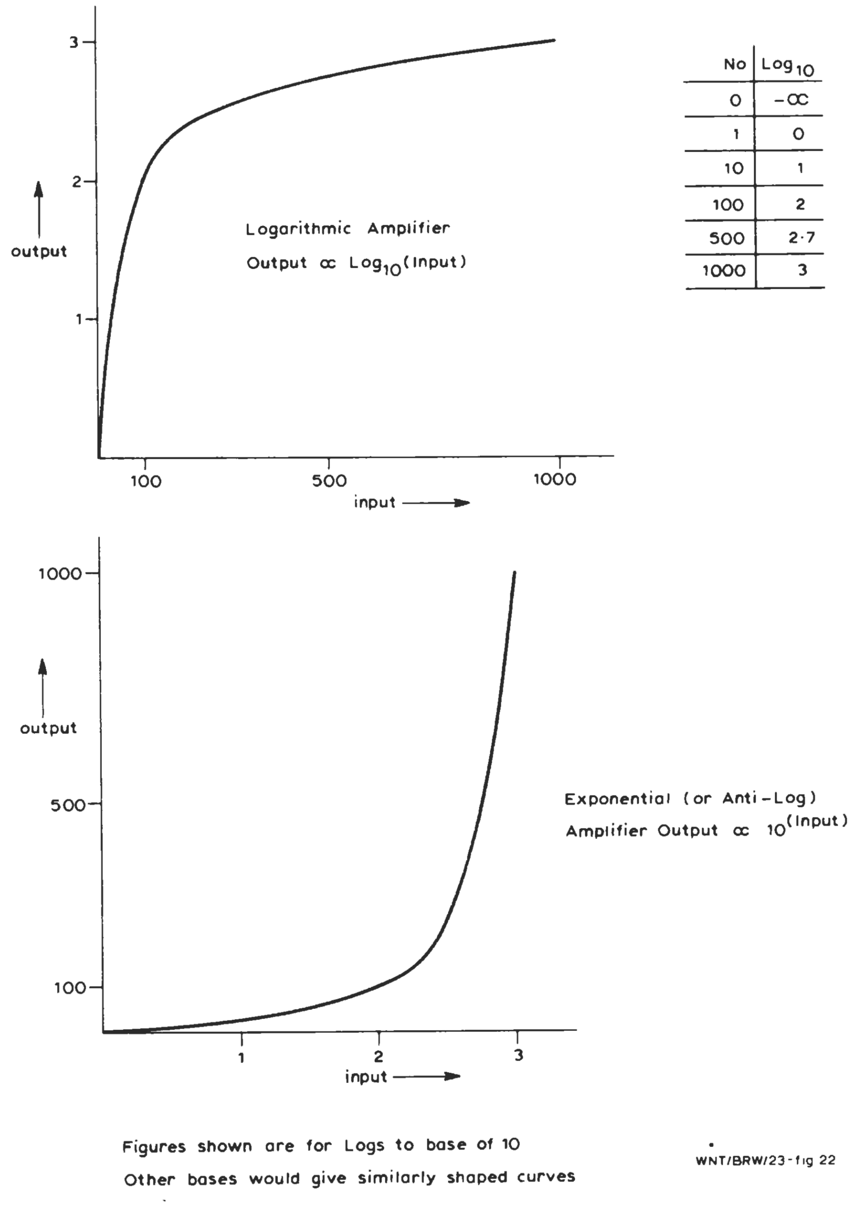


Fig. 21 Use of Logarithmic and Antilogarithmic Amplifiers

Approximate curves for log and antilog amplifiers are shown in Fig. 22. It will be appreciated that amplifiers with such characteristics require careful design and adjustment.

Electronic Masking for Typical Film Dyes

The spectral density characteristics of typical film dyes are shown in Fig. 23. All three dyes affect all three signals, so for each signal a correction is required in the form of a 3 x 3 matrix as shown operating on the logarithmic signals. This is followed by attenuation to reduce the gamma of the final video output; a value of 0·4 or 0·33 is used, compensating for the receiver c.r.t. and giving some compensation for the high gamma of most film material.



No	Log_{10}
0	$-\infty$
1	0
10	1
100	2
500	2·7
1000	3

Fig. 22 Curves for Log and Antilog Amplifiers

Electronic Masking Matrix: Choice of Values Required

In practice the calculation of these values is very complex because many other factors such as film colour analysis and other effects ought to be taken into account, but suitable matrices have been produced for the various types of colour film commonly used. Therefore various different fixed matrices are provided and the one required can be selected by a single switch on the telecine or transparency scanner.

The practical result of using such a system is a worthwhile improvement in the colour fidelity of the reproduced picture, in particular an improvement in the brightness and saturation of coloured areas. In some cases, however, this may be undesirable as it may exaggerate neutral balance errors or other faults in the film (or even faults in the original scene). For this reason 'partial masking' or 'no masking' can be selected.

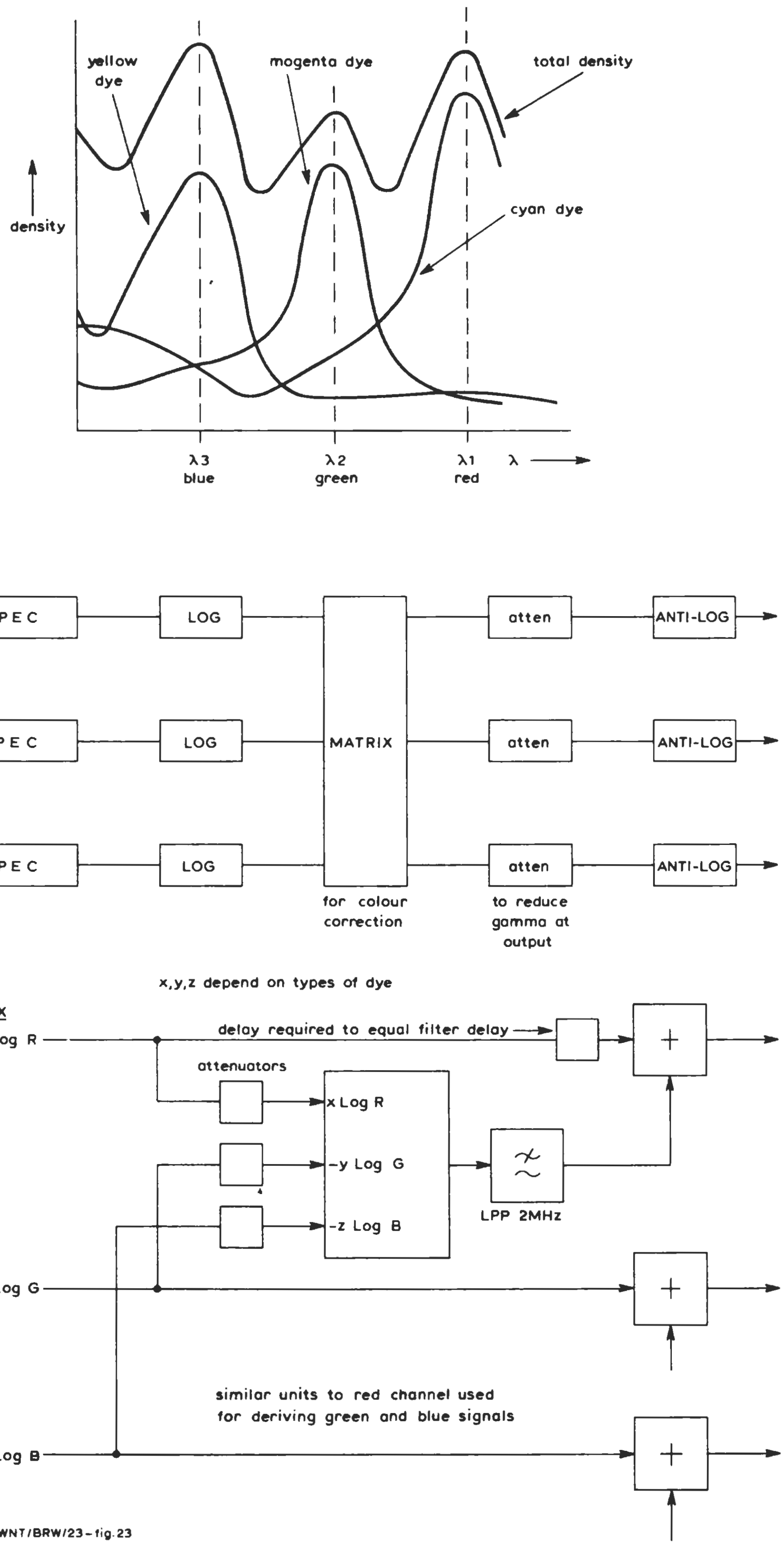


Fig. 23 Practical Electronic Masking System

15K

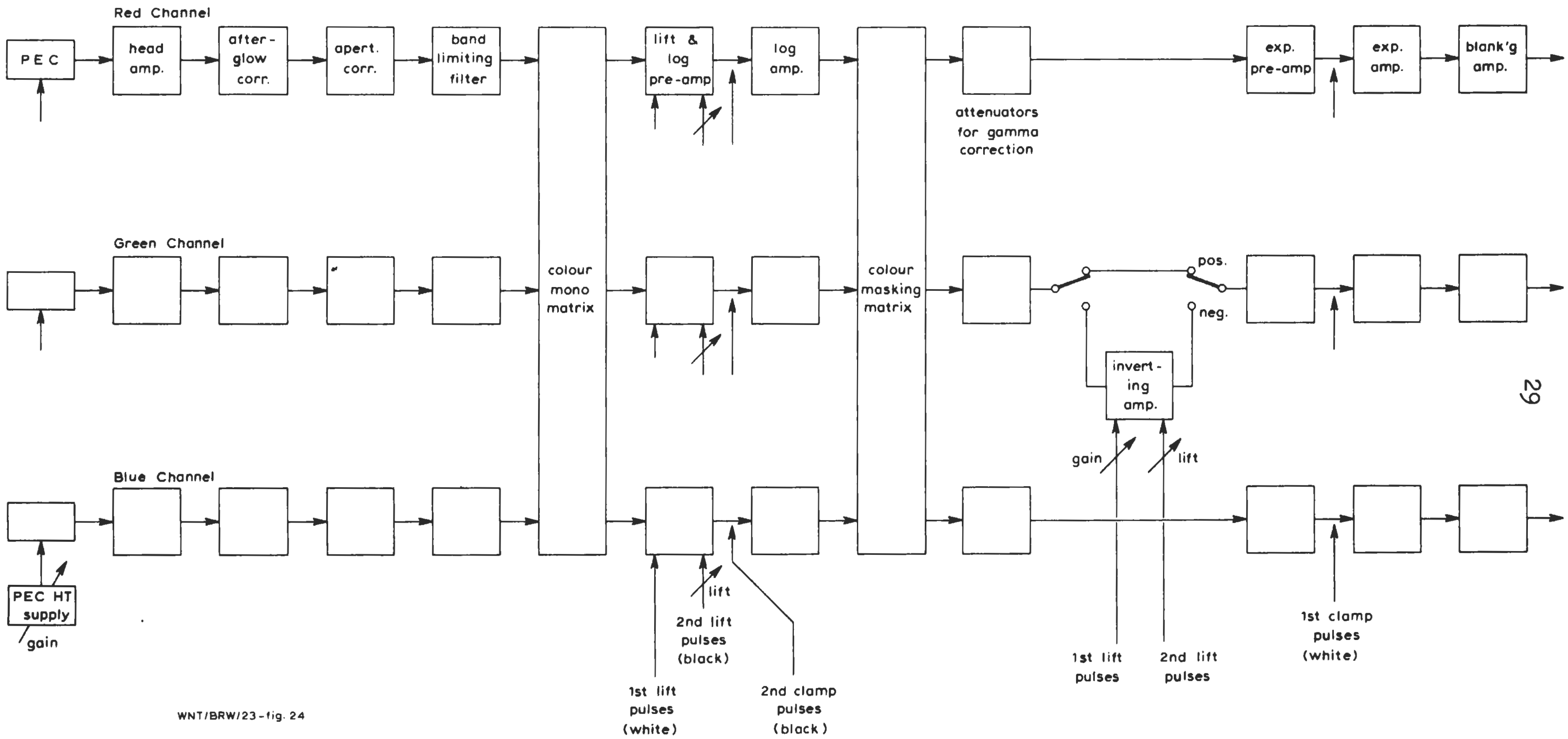


Fig. 24 Video Chain of a Rank-Cintel Flying Spot Scanner

When 'no masking' is used, the matrix becomes three straight-through connections, but because the telecine optical analysis has been designed to give the best results when a matrix is used, some correction is applied in the form of small alterations of gain of the three logarithmic signals which improve the grey scale tracking when a colour film is used.

THE RANK-CINTEL FLYING SPOT VIDEO CHAIN

General Description

Detailed information is available in the maker's handbooks and Technical Instruction TVX.15, so only a brief description is given here. See Fig. 24 (page 29).

The photo-electric-cells (PECs) are of the electron multiplier type with 9 or 11 stages. Their dynode supply is adjusted to give the required overall gain. The head amplifier is conventional.

The afterglow corrector is an adjustable RC equaliser providing h.f. boost to remove the streaking caused by the phosphor afterglow. It is described in detail elsewhere*.

The aperture corrector is of the cosine-law type giving adjustable h.f. boost.

The band-limiting filter removes noise components, and so on above the highest required video frequency of 5·5 MHz.

At this point all the scanning losses have been corrected. For colour operation the colour/monochrome matrix is simply three straight-through connections, but for monochrome operation the red, green and blue signals are combined in suitable proportions (0·3, 0·59, 0·11). The resulting monochrome signal is passed through all three channels.

When the signal is in the logarithmic form, it must be clamped at white level, not black level because

(a) white is zero signal from the electronic masking point of view since it represents zero dye density,

(b) the signal at black is noisy due to the high gain at black level of the logarithmic amplifier.

The 'lift and log preamplifier' adds two pulses to the video signal during the line blanking period, one at peak signal level, the other at black level. (The latter may be positive, negative or zero depending on the setting of the lift control.) The pulses allow the signal to be stabilised at either level as required at various points in the chain. The pulses are termed first and second lift pulses respectively, and clamp pulses are suitably timed to operate on the appropriate part of the waveform; thus the first clamp pulses will stabilise the peak level of the signal and the second clamp pulses will stabilise the black level of the signal. All these pulses are subsequently blanked out of the final video

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*'Afterglow correction in flying spot scanners.' E.T.C. Information Sheet No. 21P RJC/DF 20.8.68

signal. Fig. 25 illustrates the timing of these signals. It will be seen that the clamp pulses are somewhat narrower and sit inside the lift pulses on which they operate.

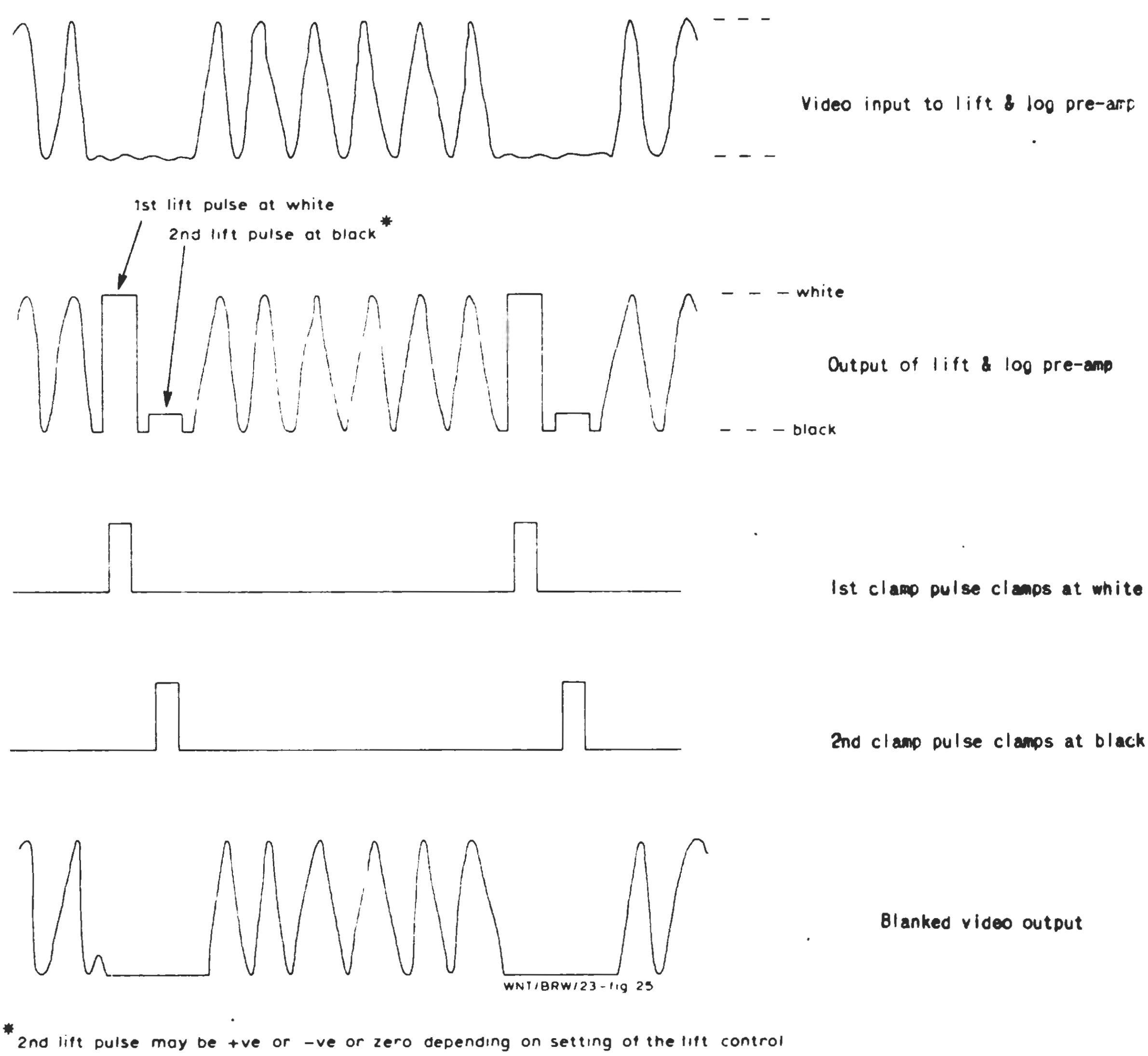

Fig. 25 Lift and Clamp Pulses in a Rank-Cintel Channel

At the input of the log amplifier the signal is clamped at black level and applied to an amplifier having the required nonlinear transfer characteristic.

The colour masking matrix is a linear additive and/or subtractive mixer. Various resistive matrices can be selected to suit the film in use. The attenuators are fixed at 0·4 (or 0·33 on some machines) to provide gamma correction.

The exponential pre-amp is a simple amplifier; the signal is clamped at white level before application to the exponential amplifier which is very similar to the log amplifier but with a different law.

The blanking amplifiers are conventional.

Monochrome Operation of a Colour Telecine using colour or black-and-white film

There are three possible methods:-

(a) Remove the subcarrier at coder. This involves least disturbance of the system and is the method normally recommended.

(b) Use the colour monochrome matrix to provide the monochrome output from the three colour signals.

(c) Replace the colour splitting optics with a single photocell unit and use only the one channel. This gives the optimum signal-to-noise ratio, but involves greatest disturbance and is only available on the later telecines.

With the camera tube telecines, method (a) or (b) can be used.

Negative Operation of Flying Spot Telecine

In the original form of the Cintel colour telecines, negative operation is available in monochrome only. The monochrome signal, derived by either method (a) or method (b) above, is passed through the green video chain and inverted while in the logarithmic state in order to give the required negative gamma. The inverting amplifier (see Fig. 24) also re-inserts the white and black level reference periods (1st and 2nd lift pulses) at the appropriate levels under the control of the machine gain and lift controls.

Colour negative operation is available on some 16-mm telecines; three inverting amplifiers are required. The masking built into most negative films produces a high minimum density and hence a poor signal-to-noise ratio in a flying spot system; nevertheless with the improved c.r.t. phosphors which are now available this method of operation is satisfactory.

LINE-UP OF A COLOUR TELECINE

Only a general outline can be given since detailed instructions are produced in each telecine area.

Camera Tube Telecines

Using a test card film the optical line up should be checked to ensure that the images are correctly positioned on the camera tubes.

Scans and registration can be adjusted in the usual way. The video chains can be checked by electronically generated test signals injected at suitable points. The video gains are adjusted for equal signal currents from each plumbicon.

Neutral test wedge films made from colour film material are generally used for a final check of gain, lift and gamma. The light control is the main gain control.

For all the above tests the Tarif must be 'bypassed'.

The simplest test of the Tarif is to put all the controls to the 'no correction' condition. No change should then be visible on switching to and from 'bypass'.

Flying Spot Scanners

The video chains can be checked with suitable test signals but very little adjustment is normally required. Electronic masking would normally be 'out'.

There are no registration problems, but the scans and optical line-up can be checked by a running test card loop or suitable transparency as appropriate.

The c.r.t. should be run for at least half an hour and its operating volts and beam current checked.

The afterglow performance should be checked with a 'de-streak' test card film. If slightly out, the 'beam focus' is in practice the parameter most likely to have drifted. It is thus permissible to tweak this slightly to eliminate any streaking, PROVIDING THE AFTERGLOW CORRECTION IS CHECKED REGULARLY AND NOT OTHERWISE DISTURBED.

The main R, G and B video gains are controlled by the photocell h.t. supplies. These are adjusted according to local instructions, usually with the aid of neutral filters giving signals corresponding to white and black level; the linearity of the photocells can be relied upon, so no grey scale check is required. Individual photocell controls can be adjusted at the maximum and minimum settings of the master p.e.c. h.t. control to give correct tracking as the latter is varied. However, this control is not normally adjusted, any extra control being applied by the Tarif.

The Tarif operation can be checked as described before.

The electronic masking can finally be set to the position giving the most satisfactory results with the film being used.

TARIF

General Description

The Tarif unit provides an operational adjustment of the colour balance of the reproduced picture without disturbance of the preset controls of the telecine or transparency scanner. It compensates for errors in relative sensitivity and gamma of the three layers of the colour film which otherwise would cause colour casts to be produced in the bright and/or dark parts of the scene. These errors are caused by tolerances in the film manufacture and processing so may vary from sample to sample; however, when a correctly graded print has been made from a cut negative, the errors, if any, should be consistent throughout the roll.

The Tarif equipment consists of three amplifiers AM1/542 having independently adjustable gain and gamma (black stretch - linear-black crush). These are controlled by d.c. potentials produced from a control panel which may take one of several forms and may be at the telecine or at some remote position such as a studio vision control room. The general principle is shown in Fig. 26.

The standard panel is shown in Fig. 27 and the action of the controls is as follows:-

COLOUR GAIN	This correction affects the neutral balance of the highlights of the picture. The upper knob, a 24-position switch, determines the channel or channels to which extra gain is to be applied, and hence the colour axis along which the correction will be made; the lower knob determines the amount of correction applied.
COLOUR GAMMA	This correction affects the neutral balance of the dark parts of the picture. Again the upper knob determines the channel or channels to which the correction is applied, and the lower knob the amount of correction, which in this case can be black crush, linear (i.e., no correction) or black stretch.
MASTER GAIN	Adjusts all three channels together from -2 dB to +4 dB.
MASTER LIFT	Adjusts all three channels together by ±30 per cent.
	Note:- For colour operation, unlike monochrome, the telecine lift and gain controls are preset under test and not subsequently adjusted.
R.G.B. SHORT OUTPUTS	Connects the three channels together at the output of the Tarif. Thus the monitor balance can be checked as a neutral picture should be produced.
R.G.B. SHORT INPUTS	By shorting together the R.G.B. channels at the Tarif input, any colour corrections applied are displayed on the monitor as a colour cast.
CORRECTION OUT	In this position no colour correction is applied, only the master lift and gain controls being operative.
BYPASS	The unit is bypassed completely.

Method of Use

It is intended that the settings for the correction controls shall be determined at a preview session and that these settings, except possibly those of the master lift and gain controls, shall not be altered during the running of the reel.

To help in determining the correct settings, colour film may have a grey scale photographed at the beginning of each reel. The grey scale then contains identical errors to the rest of the reel and the correction controls can be adjusted to obtain the best near-neutral scale. These settings should apply to the rest of the reel.

If a grey scale is not provided, the controls must be adjusted while the film is running to obtain the best subjective effect, adjusting the gamma correction for dark areas and gain correction for highlights. Compromise settings for the reel or sequence can then be obtained.

Note:- Tarif correction is generally required whether or not electronic masking is used; the two systems are quite different in effect, electronic masking being a fixed correction improving the reproduction of coloured parts of the scene, the Tarif adjusting the grey scale balance.

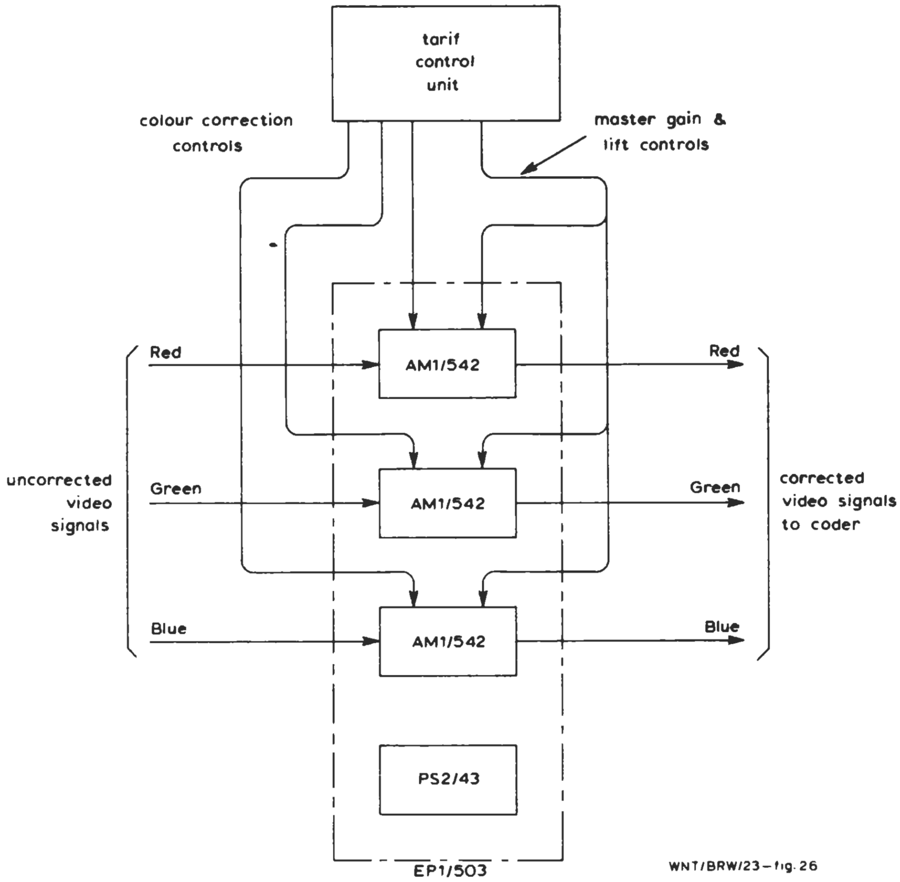

Fig. 26 General Principles of Tarif System

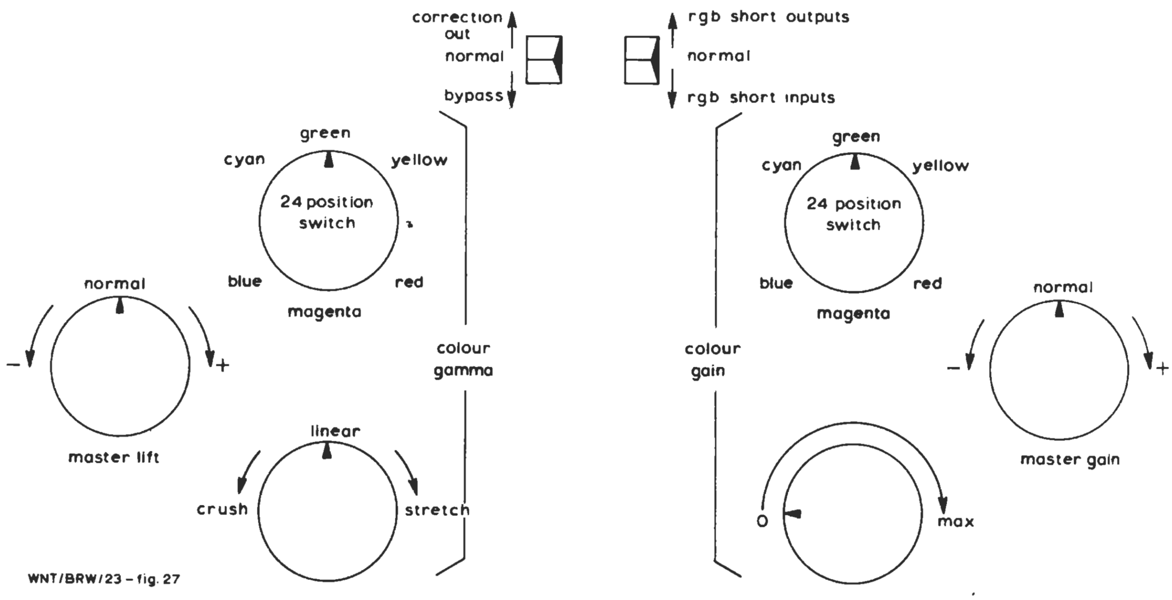

Fig. 27 Layout of Typical Tarif Control Panel

Alternative Tarif Control Systems

Some films may suffer from shot-to-shot variations in neutral balance, caused either by variations in lighting quality or exposure at the time of shooting and inadequate grading during printing, or by the use of a show copy consisting of different samples (or even types) of film spliced together to form a continuous sequence. (This latter situation is undesirable but may sometimes be unavoidable.) Under such conditions, adjustment of the Tarif controls during transmission is helpful and the original control system described above is not ideally suited to this.

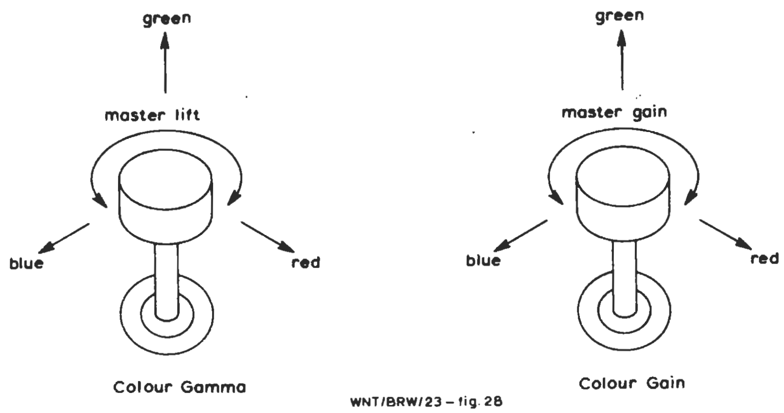

Fig. 28 Layout of 'Joystick' Tarif Control Panel

Two alternative methods are possible using the existing Tarif amplifiers:-

(a) To use a 'joystick' type of control panel such as shown in Fig. 28, where the axis of the colour correction is determined by the direction in which the 'stick' is displaced from its central position, the amount of displacement determining the amount of correction. In the case of the colour gamma control, moving the stick towards, say, red gives black stretch to the red channel and black crush to the green and blue, both effects making the shadow areas more red (or less cyan). Knobs on the top of the sticks adjust the master lift and gain, thus giving two-hand control of eight variables. This unit makes it easier to 'ride' the controls manually during transmission.

(b) If sufficient rehearsal time is available, the Tarif settings required for each shot can be determined and stored in a suitable memory system. During the subsequent transmission, these settings can be applied automatically to the Tarif unit at the appropriate times. This involves considerable complexity, but such a system is at present under development. A simpler system uses in effect five Tarif panels which can be preset as required and selected as appropriate during transmission.

R.J. Carr
12th December 1971