UNDERSTANDING COLOUR TV

Picture quality adjustments

by Caleb Bradley BSc.

A PAL colour television with conventional shadowmask display tube is capable of giving an astonishingly 'true to life' colour picture but this depends on correct setting of a large number of preset adjustments. Since a very large proportion of the colour serviceman's (expensive) time is spent on these adjustments, which for best results should be rechecked at intervals, an electronics-minded viewer can find it worthwhile to tackle some or all of them himself. With unhurried work he can bring his set's performance close to that of a high quality studio monitor.

CONTROLS COMMON TO MONOCHROME SETS

The following adjustments, the first few of which are accessible to the viewer, need no explanation since they are familiar from monochrome receivers:

ON/OFF – VOLUME
BRIGHTNESS
CONTRAST
VERTICAL (FRAME) HOLD
HORIZONTAL (LINE) HOLD

(Because of the critical timing functions of the colour receiver line output stage this control must be set more carefully to the centre of its 'flywheel' lock-in range than is necessary on monochrome sets.)

VERTICAL SHIFT
HORIZONTAL SHIFT
HEIGHT (FRAME AMPLITUDE)
VERTICAL LINEARITY
FOCUS
WIDTH (LINE AMPLITUDE)
AND/OR E.H.T. VOLTAGE

(This control should **only** be adjusted with reference to the manufacturer's data which generally calls for use of a special e.h.t. meter to ensure that the tube third anode supply never exceeds a specified voltage, typically 22-25 kV.)

SPECIAL CONTROLS FOR COLOUR

Surprisingly the majority of these are best assessed and set up on *monochrome* pictures although they all contribute to the colour picture. They arise from the basic shadowmask tube principle of creating a picture by combining three 'primary-coloured images on the same screen. The images are produced by three separate electron guns whose beams are made to scan by a common deflection coil assembly over three separate arrays of phosphor dots. This process depends for its success on precise positioning of the three beams relative to the shadowmasked screen and the adjustments to achieve this are grouped under the titles PURITY and CONVERGENCE. Some are electrical adjustments and some are mechanical; the mechanical adjustments on the tube neck are identified in Fig. 47.

This subject was dealt with in Part 7. To summarize, the shadowmask is only able to direct the three electron beams correctly to their corresponding phosphor dots over the whole screen area if the effective beam deflection centres are correctly located. The 'purity' adjustments available to achieve this are two flat ring magnets on the neck of the tube and a fore-and-aft sliding movement of the scan coils.

The state of purity of a receiver is best checked by switching off two of the three beams by means of the first anode cutoff switches provided and inspecting the remaining image for uniform colour. It is best to inspect the red image since any spurious tinges of blue or green are easily spotted. If the contrast can be fully reduced to give a plain red raster the job is even easier.

An uncritical viewer is unlikely to notice minor purity errors. Here is a guide to their effect on normal programme pictures. Colours of objects (which should be constant) vary — depending on their position on the screen. Large areas of uniform colour which occur occasionally in programmes (such as expanses of blue sky or backgrounds to captions) will show up any areas of impurity. On a monochrome picture a serious purity error shows as a large stationary blemish of *different* colour tinge from the rest of the picture and is the same for all pictures.

Having detected some purity error, heed a note of caution: if the purity adjustments are touched the convergence adjustments described later will certainly need to be retrimmed as well.

If you decide to forge ahead, set up a red raster, preferably plain, as

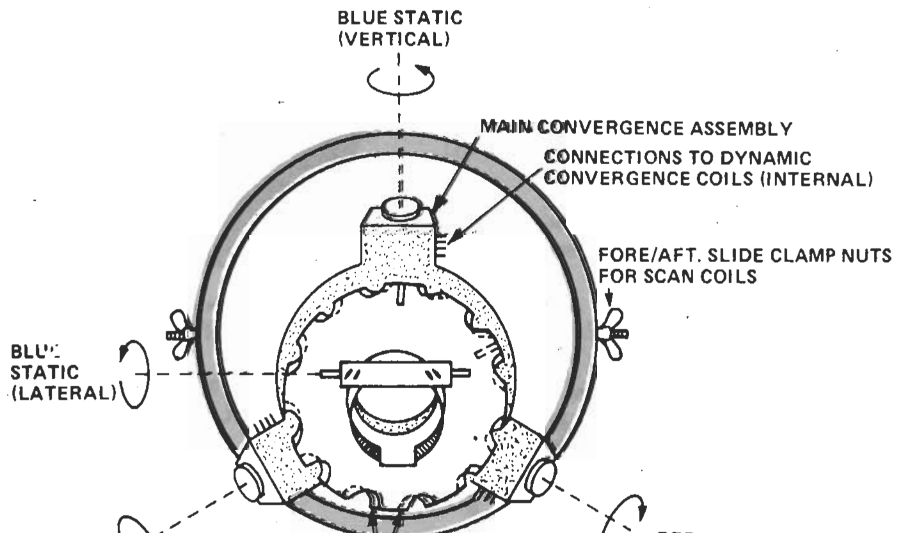
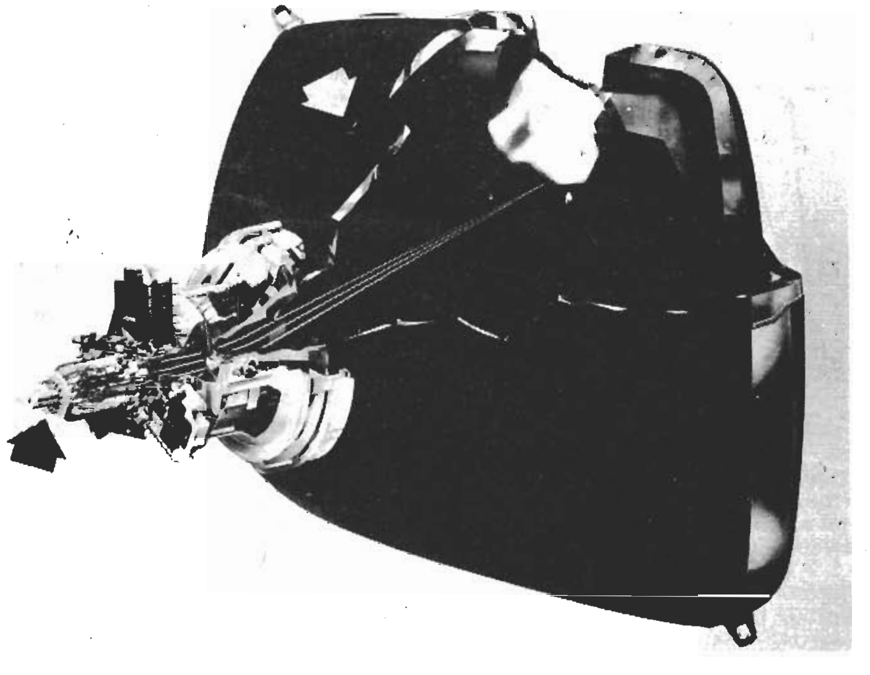


Fig. 47. The usual purity and static convergence adjustments located on the tube neck — viewed from the rear of the set.

CAUTION

Very high voltages — up to 25 kV — are common in colour TV receivers. Do not attempt to undertake the adjustments described in this article unless you are very experienced in handling equipment that operates at such potentials.

The main danger areas are indicated by the two arrows shown on the picture tube (right).



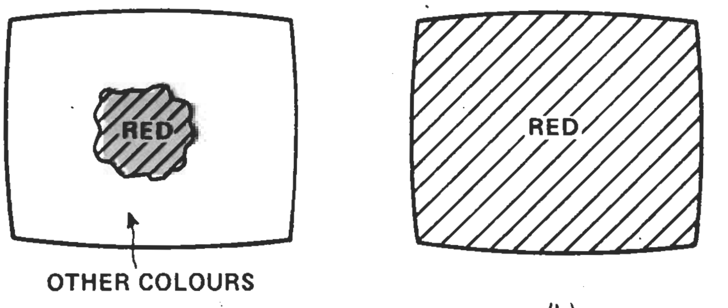


Fig. 48. Purity adjustment is done with the red gun only working. With the scan coils pushed fully forward, the purity rings are used to position the beam deflection-centre horizontally and vertically, to obtain central red spot as in (a). The scan coils are then brought backwards sufficiently to obtain a pure raster as in (b).

described. Note the positions of the purity rings (Fig. 47) — they always have identifying tabs or slots. Experimentally rotate them together and singly, noting the effect on the red raster. With large sets a mirror makes this much easier. Probably the red raster can be 'purified' in this way; if not follow the full procedure involving the scan coils as follows.

Loosen the clamp wingnuts and push the coils fully forward so they hit the tube flare. Then adjust the purity rings for pure red at the *centre* of the screen — Fig. 48. Overall red cannot be obtained at this stage. Then gradually pull the coils backward. The red area should expand to fill the whole screen. If the coils are brought back too far the purity worsens again. The 'perfect' position should not be hard to find and the rings can be retrimmed if necessary. Having purified red, check the blue and green rasters separately. These should also be pure.

If purity absolutely cannot be obtained the shadowmask may somehow have become magnetised. Check that the set's automatic degaussing (Part 7) really works; if so, treatment with a portable degaussing coil may be needed.

CONVERGENCE

This aspect of the adjustments can also be called registration since it is concerned with superimposing exactly the three colour images. In practice it is rare for a colour set to show no registration errors at all. They are most evident on monochrome pictures. Inspect the outlines of sharply defined objects in these pictures. Convergence errors cause black-to-white edges to have coloured fringes . If there is error over the whole screen, do the relatively simple STATIC adjustments (see below) which may be sufficient; if the errors occur in some parts of the picture more than others the more demanding DYNAMIC adjustments need attention.

STATIC CONVERGENCE

The static convergence adjustors are rotatable magnets mounted on the tube neck by which the three pictures can be individually shifted to achieve registration. There are three radial

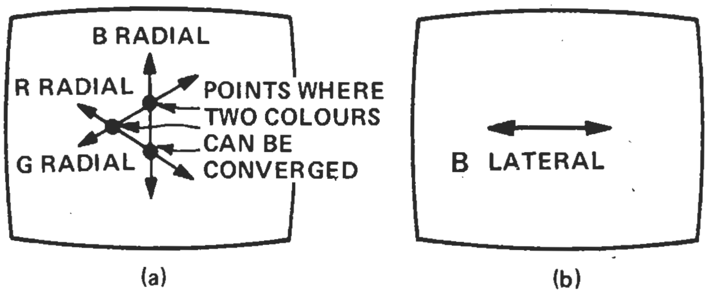


Fig. 49 (a). The R, G and B picture shifts produced by the radial static adjustors (on the main convergence assembly).
(b). The shift given by the blue lateral static adjustor which is necessary for complete convergence of R, G and B.

UNDERSTANDING COLOUR TV

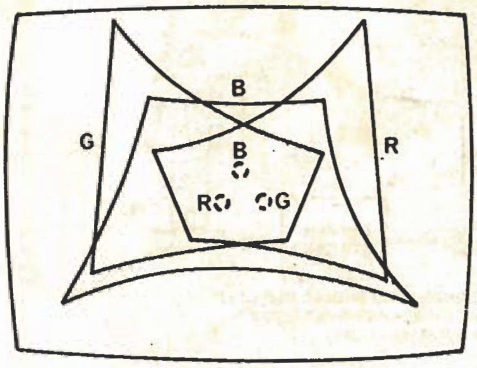


Fig. 50 As the three guns are not mounted on the tube axis, and the length of the beam paths alter over the screen area, the rasters are distorted as shown (exaggerated).

adjustors (Fig. 47) whose magnetic fields are brought to the tube by pole pieces inside the convergence assembly and focused on the electron beams by ferrous plates inside the tube. Their effects on each image are shown in Fig. 49a; alone they enable any two images to be converged, but not all three. To achieve this a fourth adjuster on one beam, conventionally a blue lateral adjuster is needed – Fig. 49b).

It is very hard to do static convergence on moving pictures and it is best to wait for a stationery test pattern transmission. Most patterns include something like a white cross or dot at the centre of the screen to make this adjustment easy. Switch off the blue gun which leaves a red + green (equals yellow) picture. Adjust the red and green radial magnets for perfect convergence at the centre of the screen. Switch on blue and use both the blue radial and blue lateral adjusters to bring all three pictures together at the centre.

Purity and static convergence are slightly interdependent so it may be necessary to retrim both of them again.

Sit back and consider whether the results are satisfactory because now is an excellent point to stop! Look over the whole screen showing monochrome pictures. Although convergence is good at the centre there may be errors elsewhere. Their cure involves the dynamic convergence adjustments whose purpose should be well understood before tackling.

DYNAMIC CONVERGENCE

In a simple world the screen and shadowmask would be shaped as part of a sphere centred on the beam deflection centre. In practice viewers demand near-flat screens and with colour there are three deflection centres at slightly different positions.

The result is that the rasters which should be rectangular are distorted as shown in Fig. 50. Dynamic convergence is an electronic process of 'counter distorting' each raster back to rectangular shape, without which overall convergence is obviously impossible. It is achieved by circuits which feed special current waveforms – mixtures of sawtooth and parabolic currents at both line and field frequencies – through coils wound on the internal pole pieces of all four static adjusters in Fig. 47. Thus the magnetic field applied to each beam comprises both a steady flux contributed by the static magnet and a complex alternating component.

The distortion of each raster in Fig. 50 is a combination of two effects. The first is pure 'pincushion' distortion caused by the flatness of the screen. Looked at another way it is caused by the increase in beam length towards the edges of the raster. This increase follows a parabolic law. Correction is possible by supplying the dynamic convergence coils with a parabolic current in the opposite sense. Correction in the vertical sense

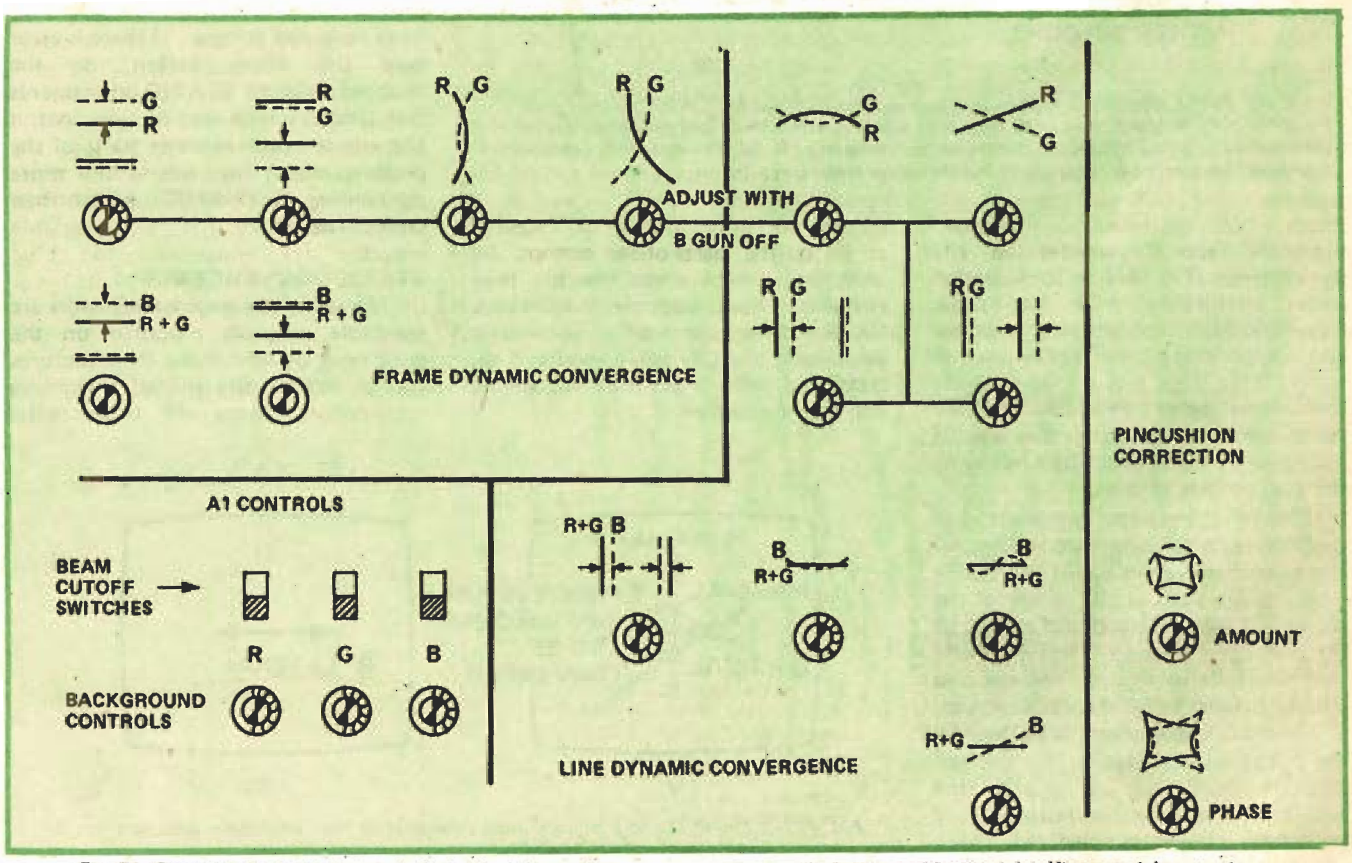


Fig. 51. Convergence control panel of a typical domestic receiver. This also includes pincushion and A1 (first anode) controls.

requires a parabolic current at field frequency and correction in the horizontal sense requires a parabolic current at line frequency.

The second distortion is asymmetry caused by the unavoidable displacement of each gun from the tube axis. This is countered by sawtooth currents, again at both line and field frequencies.

Dynamic convergence circuits therefore consist of networks of resistors, capacitors and inductors which derive from the main line and field scan waveforms (sawtooth shaped) the necessary mixtures of sawtooth and parabolic waveforms for each dynamic coil. The parabolic waveforms are obtainable by integrating sawteeth.

Most of the components are variable presets to enable the optimum convergence to be set up and the total number of controls may be more than a dozen. Circuits vary greatly between manufacturers and it is not really necessary to understand them in detail because the function of each control should be clearly marked. A typical arrangement is shown in Fig. 51.

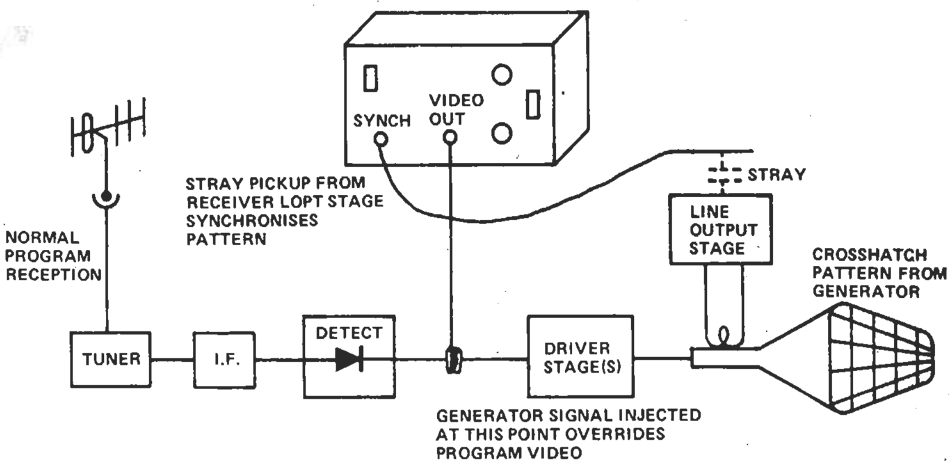


Fig. 53. Connection of direct-injection crosshatch generator to a receiver.

CROSSHATCH PATTERN

It is hopeless trying to adjust the dynamic controls on a normal programme picture. What is needed is a stationary monochrome pattern designed to show up any convergence errors. Transmitted test patterns are usually far from ideal. The perfect pattern is a crosshatch of thin vertical and horizontal lines as shown in Fig. 52. Until lately this could only be obtained from expensive workshop equipment (any colour service workshop should be equipped with generators for this pattern and the colour bars pattern for decoder alignment) which provides an r.f. signal suitable for feeding to the aerial sockets of receivers. A low-priced crosshatch generator project will be featured in a near future issue of ETI. This unit enables any owner to bring his colour set to ideal convergence.

ADJUSTMENT

Having obtained a crosshatch pattern on the screen the dynamic errors can be investigated and compared with the markings on the convergence controls. These will be found concealed somewhere on the set, often lurking behind a 'secret' panel. The correct procedure is to switch off the blue gun and concentrate on converging red and green, the aim being a yellow crosshatch without red or green fringes. Do not turn controls at random; instead make a mental note of what each control actually does e.g. 'bends red verticals to the left' or 'contracts red horizontals at bottom'. Then plan each new adjustment before making it. Soon you will find which controls are interdependent and which errors cannot be completely eliminated, only 'traded off' against errors in other parts of the picture.

Switch on blue and use the blue controls to approach the ideal white fringe-free crosshatch. The static magnets can be trimmed at any time if necessary.

SECRETS OF GOOD CONVERGENCE

There is a degree of skill in converging which becomes second nature after one has converged two or three sets. The following adjustments affect convergence in varying degrees and should be finalized *before* convergence adjustment: Height, Width, Linearity, Focus, EHT Voltage, Purity. However the controls for contrast, brightness, grey scale (to be described), tuning and decoder adjustment have no effect on convergence so can be moved at any time.

During adjustment keep a clear view of the entire screen at all times — it is so easy to over-concentrate on removing an error in one part at the expense of the rest. Go through the interdependent adjusters several times moving each control slightly *less* than seems necessary. If the variable inductor for converging the blue verticals goes to one end of its range the wires to the blue lateral coil may need interchanging. Every dynamic

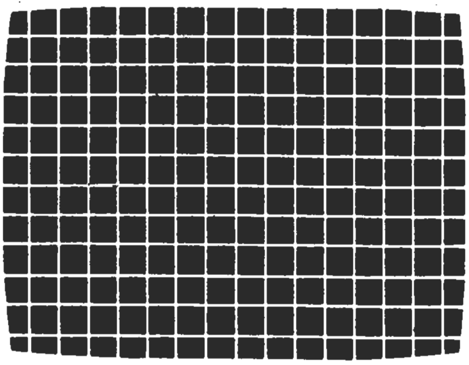
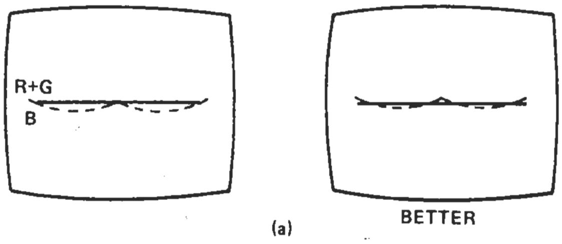


Fig. 52. The crosshatch pattern of white lines on a black background which is virtually essential for dynamic convergence adjustment. It enables any error to be related to the typical control set up shown in Fig. 51.



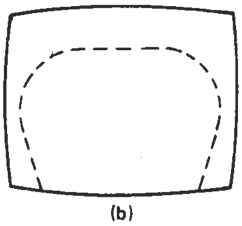


Fig. 54. Tips for good convergence.
(a) If two colours cannot be perfectly converged it is better to distribute the residual errors, with less attention to the edge of the screen, than to insist on perfect convergence at the centre.
(b) The viewer is more likely to notice convergence errors inside the area shown. Thus small corner errors can usually be tolerated.

UNDERSTANDING COLOUR TV

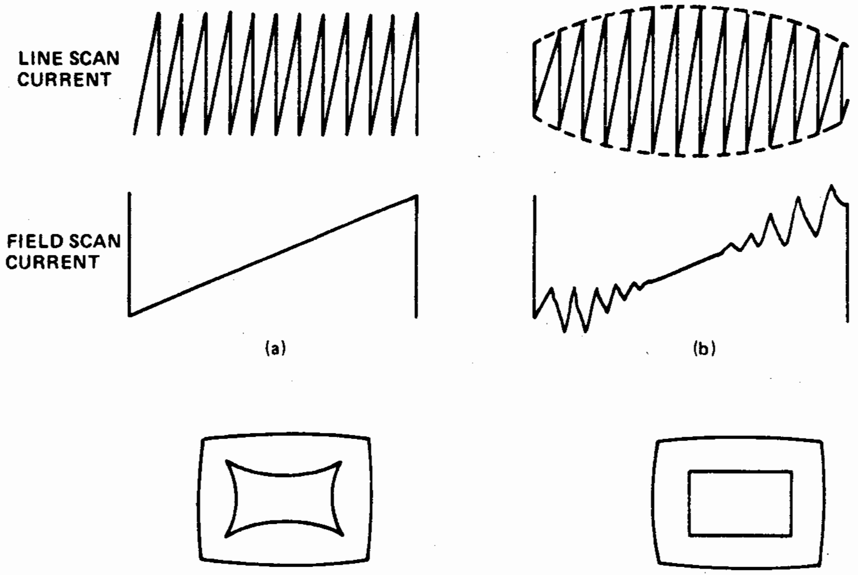


Fig. 55 (a). Line and field scan currents without pincushion correction.
(b). Pincushion correction obtained by cross modulation in transductor — see text.

control should have a visible and progressive effect on the crosshatch pattern and failure to do this suggests a fault in the convergence circuit. If a wirewound potentiometer has an abrupt effect at one point of its travel it may have burnt out — regrettably these components are often over-run.

It is rarely possible to achieve perfect convergence over the whole screen including the corners and the real skill lies in distributing the residual errors so they are not noticeable to the viewer. Fig. 54 should be helpful here. Once converged as finely as possible a colour set should ideally not be moved since merely rotating it through 90° relative to the earth's magnetic field can have a minute upsetting effect.

GENERAL RASTER CORRECTION

A certain amount of pincushion distortion is common to all three rasters and is usually corrected by a special transformer called a transductor. This consists of three windings on the limbs of an E-shaped Ferroxcube core. The two outside windings are in series and are connected in shunt with the line scan coils; the middle winding is connected in series with the field scan coils. The transductor causes a degree of cross modulation between the line and field scan amplitudes due to progressive saturation of the E-shaped core with increasing flux. The effect is shown in Fig. 55. Usually there are one or two controls associated with the transductor to allow the form of correction to be varied to obtain a truly rectangular raster. ●

UNDERSTANDING COLOUR TV

In this final part, Caleb Bradley describes grey scale and decoder adjustments.

AT THE START of this series we showed that natural reproduction of each colour depends on three primary colours being combined in exactly correct ratio of strengths. Unfortunately the shadowmask tube cannot be guaranteed to be equally efficient for each primary colour; the efficiencies of the screen phosphors are unequal (red is usually much less efficient than the other two) and the situation is made more unpredictable by manufacturing tolerances in the electron guns which cause variations of gain and cut-off voltage. The relative performance of each gun of a particular tube might be as sketched in Fig. 56a.

GREY SCALE

The 'grey scale' adjustments are concerned with matching the three gun responses. Only when this is done can colours be correctly reproduced, in particular the *fully desaturated* 'colours', i.e. shades of grey or white, will be reproduced as perfectly neutral shades without any colour bias caused by relative excess or shortage of a primary.

To assess the grey scale quality of a colour receiver look at a monochrome programme and compare the picture colour with a neutral white source such as a typical overcast sky — *not* a tungsten lamp (too yellow) or a white object whose actual colour depends of course on its illumination. The cause of any overall tint can be found from Fig. 56b.

To confuse this, some receivers feature a rather spurious 'Tint' control which enables the viewer to upset the grey scale slightly to give a 'warm' or 'cold' picture impression — leave this control at mid position. Another point to watch is that a few sets have a special circuit associated with the decoder colour killer to give a deliberate blue tint to monochrome pictures. This is to resemble the appearance of normal monochrome sets since a monochrome picture displayed on a colour set in truly neutral grey seems somewhat 'warm' by comparison.

Besides relating any grey scale error to Fig. 56b one must decide whether it affects the dark greys, the light greys (whites) or both.

BACKGROUND AND HIGHLIGHT CONTROLS

In Fig. 56a it is necessary to match the three gun characteristics for both cutoff voltage and slope (gain). The grey scale controls for this are simplest on a receiver using colour-difference drive — Fig. 57.

When grey is being displayed the colour-difference voltages on the tube grids are equal; this was ensured by clamps in the decoder. To obtain neutral dark grey the cutoff voltages of the guns are equalized by the first anode (A1) voltage controls which are often called the background controls. If the grey scale is already approximately right it should only be necessary to trim one of these controls with reference to Fig. 56b, seeking neutrality exclusively in the *dark* greys and ignoring white. This is best done in a darkened room.

With correctly neutral background setting, the highlights may need balancing. In the circuit in Fig. 57a this is achieved by two potentiometers which allow the luminance drive from the valve output to the blue and green cathodes to be varied so that the differing slopes in Fig. 56a can be matched. The red gun permanently receives full drive since this usually has lowest overall gain due to the phosphor characteristic.

The lower end of each potentiometer is returned to a dc level which is approximately equal to the luminance black level, conveniently in this circuit the decoupled screen grid supply. This is to minimise the effect of highlight adjustments on the background settings.

The procedure is to look for any pastel tinting of picture whites and from Fig. 56a decide which highlight control to trim to remove it. As a tube ages, the gun efficiencies change and at some stage it may prove necessary to back off the drive to the red gun; if so it is easy to swap two cathode connections to put the full luminance

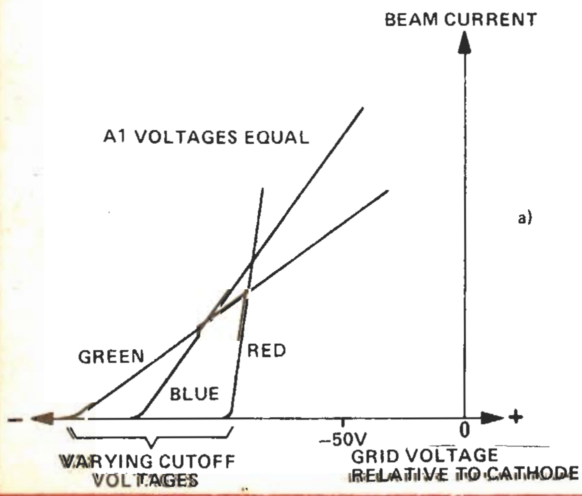


Fig. 56 (b)

GUN RESPONSE: / GUN	TOO STRONG	CORRECT	TOO WEAK
RED	red-brown tint	NEUTRAL GREY OR WHITE	blue-green tint
GREEN	green tint		purple tint
BLUE	blue tint		yellow tint

Fig. 56 (a) Unequal responses of the primary colour guns need compensating by means of the grey scale controls for correct monochrome and colour pictures. (b) This diagram shows the effects on a desaturated (grey) picture area (e.g. any part of a monochrome picture) of incorrect gun response.

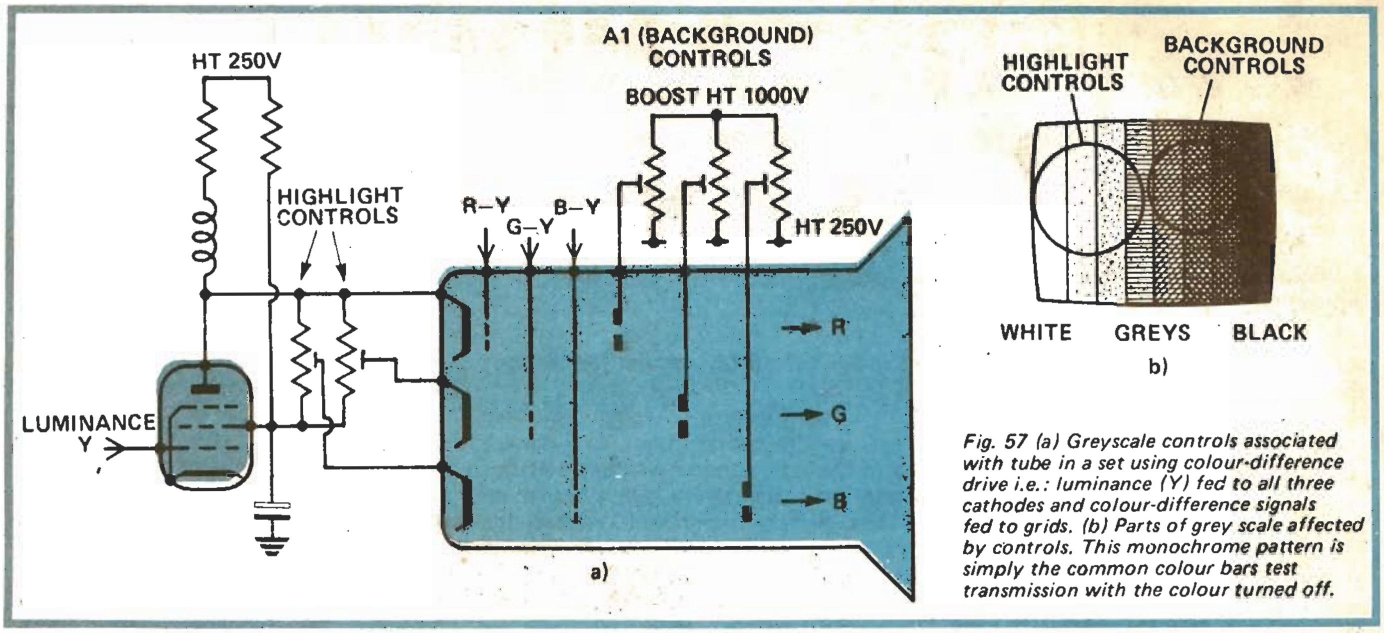


Fig. 57 (a) Greyscale controls associated with tube in a set using colour-difference drive i.e.: luminance (Y) fed to all three cathodes and colour-difference signals fed to grids. (b) Parts of grey scale affected by controls. This monochrome pattern is simply the common colour bars test transmission with the colour turned off.

drive to another gun. Avoid excessively bright (defocussed) whites where the least efficient gun, particularly of an old tube, may be driven into forward grid current which ruins the whole grey scale.

BEAM LIMITING

Besides ruining the picture, over-advancing the brightness control can in extreme cases cause damage by overheating the shadowmask so it distorts, or overloads an eht multiplier. To avoid this possibility most receivers incorporate some form of beam limiting device. Three representative circuits are shown in Fig. 58. Circuit a is common on early sets which use the bulky but efficient valve rectifier plus stabiliser circuit for eht. As beam current through the overwind and VR increases, the stabiliser grid is driven negative. Beam limiting is accomplished by diode D which conducts if it becomes excessive and pulls down the brightness control voltage. A similar circuit but with the diode connected to the contrast control has also been used.

Circuit b uses a low-value resistor to sense the emitter or cathode current in the line output stage – which increases with increasing beam current due to the internal stabilisation feedback. If the current becomes excessive the transistor turns on and again pulls down the brightness control voltage to keep the beam current in hand. The 'beam current' control should be set so this happens at a beam current of about 1 mA. The capacitors in this kind of circuit are important because they restrict the bandwidth of the control loop; they sometimes fail which causes symptoms of oscillating brightness and picture size.

Circuit c is much simpler and is connected in series with the tube cathodes (shown for one cathode only). Normally the diode is forward biased and provides a low impedance path for the luminance signal. However if the luminance drive goes too negative the diode blocks and the peak beam current is limited by VR. The capacitor prevents hf loss in the diode impedance.

DECODER

With correct grey scale established, the final step is to assess the decoder performance. As a colour transmission is tuned in, the picture should initially be monochrome and the colour suddenly pop in at the correct tuning point. This indicates correct action of the colour killer which enables the decoder only when adequate chroma is received. Distant (grainy) colour programmes will therefore be received in monochrome only.

Complete failure to receive colour calls for servicing action which we can only describe in a general way. The first step is to disable the colour killer so that demodulated chroma should be fed to the tube regardless of whether the reference oscillator is in lock. If doing this produces a perfect colour picture there is a simple fault in the killer stage itself. Another possibility is

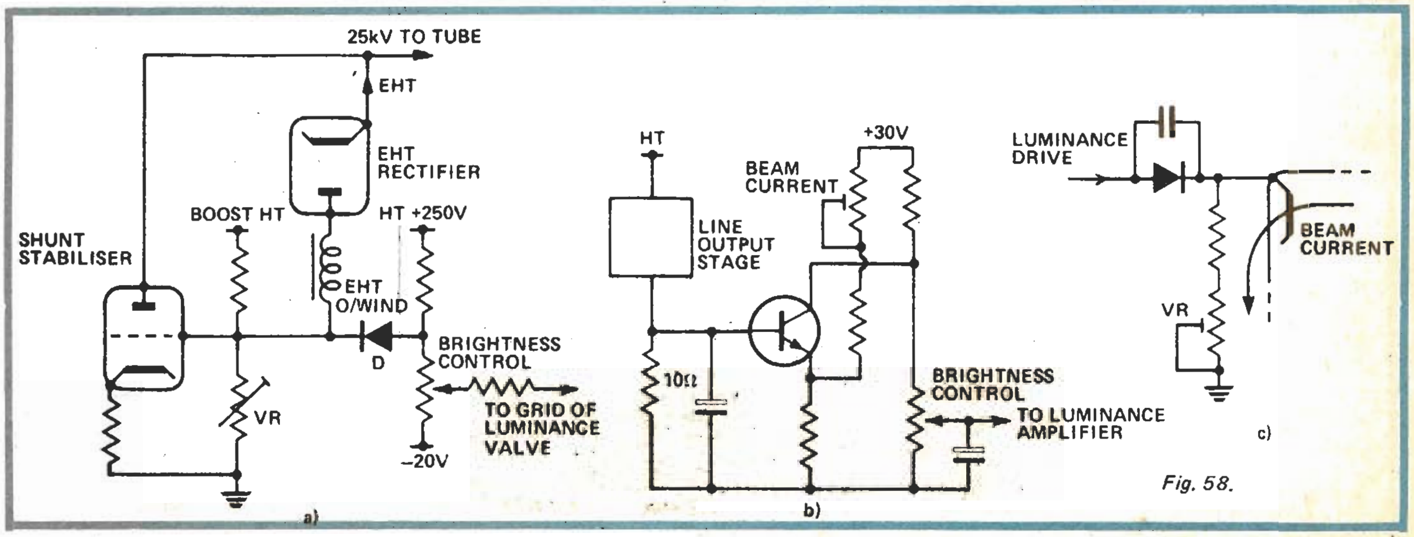


Fig. 58.

UNDERSTANDING COLOUR TV

that alternate picture lines will show different colours (like Hanover blinds but with more extreme differences). This means the PAL bistable has stopped working and should be easy to cure.

A common fault is the reference oscillator failing to lock to the burst. An unlocked oscillator produces a cyclic variation of colours from top to bottom of the screen, caused by it passing in and out of correct phase, with a large number of cycles if its frequency is far removed from the burst. The cure may be found by adjusting the oscillator frequency control to bring it into lock. Set it to the centre of the lock-in range which is best found by monitoring the varicap diode bias voltage. If lock cannot be obtained or is unstable the next thing to check is the timing of the pulse which gates the burst into the phase discriminator; usually this is determined by an adjustable coil. At this stage an oscilloscope becomes necessary for fault finding.

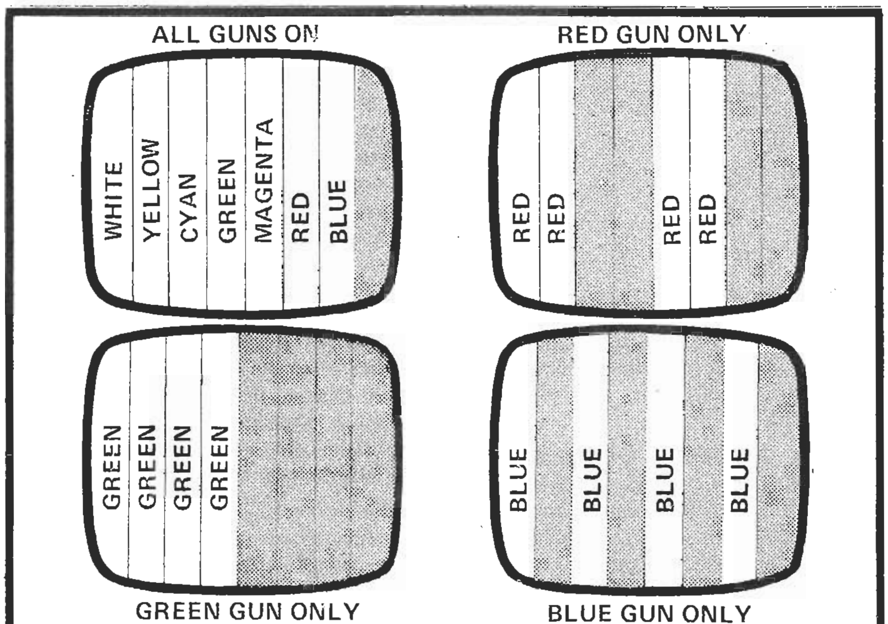


Fig. 59. Correct appearance of standard colour bars test pattern.

With a functioning PAL decoder it is child's play to assess the colour performance if a colour bar transmission is available. Switch on the red gun alone. Set contrast and colour saturation so the red bars of the pattern are equally bright. Then change to the blue gun alone which should also be producing equally bright bars. Likewise the green gun. The correct positions of the bars are shown in Fig. 59. Incorrect ident phase has the effect of reversing the red bars. If necessary trim the colour channel gains in the decoder to achieve equally bright bars across the screen from all three guns.

Check the colours for freedom from Hanover blinds (chroma delay amplitude and phase adjustments) and your PAL receiver is ready for action. ●