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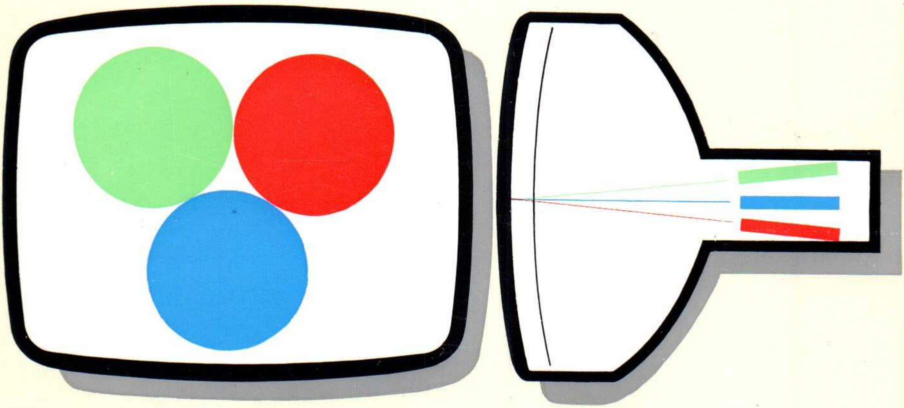
PRODUCT INFORMATION

PHILIPS ELECTRONIC COMPONENTS AND MATERIALS DIVISION

ADJUSTMENT OF COLOUR TV PICTURE TUBES



Adjustment of Colour Television Picture Tubes

Contents

1 Introduction

Since a colour picture tube is far more complex than the orthodox black-and-white version, it is essential that detailed instructions on alignment and operation of the colour tube should be available to both manufacturers and service engineers. This booklet is merely intended to give concise directions to be adhered before a receiver is taken into use or when it is being serviced; it contains no recommendations for the design of a receiver. The high quality of reproduction of our colour picture tubes can be exploited to the full only if all adjustments are made in accordance with the given directions.

2 Principle of Operation of a Colour Picture Tube

In the colour picture tube use is made of the fact that almost any colour, including white, can be obtained by *additive* mixing * appropriate amounts of red, green and blue light. The tube is able to produce three complete coincident television pictures on the screen in these "primary" colours.

This is achieved in the following way. In the neck of the tube three electron guns are present, which are driven by the "red", "green" and "blue" signal. The screen of the tube consists of a very fine mosaic of minute red, green and blue phosphor dots. At normal viewing distance, the human eye cannot discern these separate dots, so that a colour picture is obtained, with hues determined by the mixing ratio of the red, green and blue light intensities.

To make sure that every gun can hit only its own associated dots, a perforated metal plate (the shadow mask) has been provided at some distance from the screen. Now, the different angles of the three beams determine which dots will be hit (see Fig. 1). Each hole in the shadow mask is associated with one red, one green and one blue dot in the screen mosaic. The total number of holes in the shadow mask is about 350 000 for a colour tube with a diameter of 25in.

At the screen centre, each mask hole has a diameter of approximately 0.3 mm; the distance to its neighbours is about 0.7 mm. The dots have a slightly larger diameter (approximately 0.4 mm) to allow for some safety against "mislanding" (that is an electron beam not coinciding entirely

* Since in printing techniques recourse must be had to *subtractive* mixing of colours, the colour illustrations appearing in this booklet are necessarily less bright than the patterns displayed by the colour picture tube.

with its associated dot) due to tolerances and inherent deviations which are especially apt to occur at the edges of the screen. As the holes in the mask make up for only 15 % of its total area, 85 % of the electrons emitted by the three beams are intercepted by the mask.

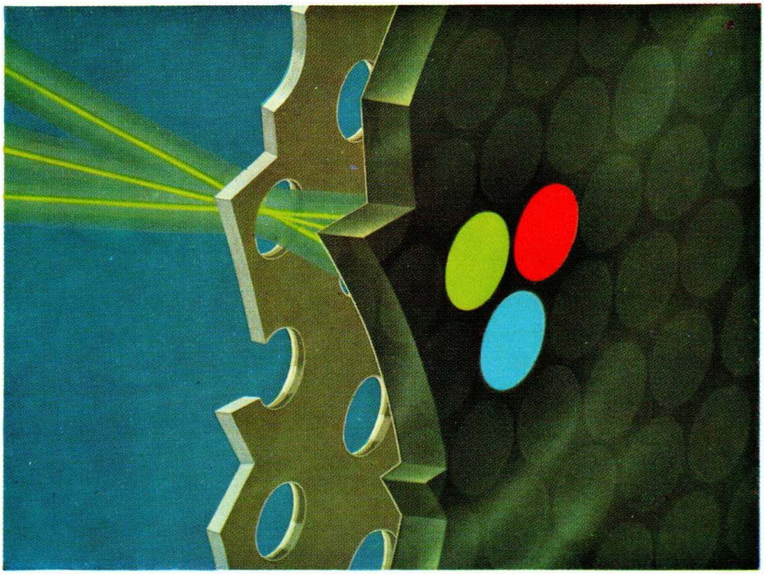


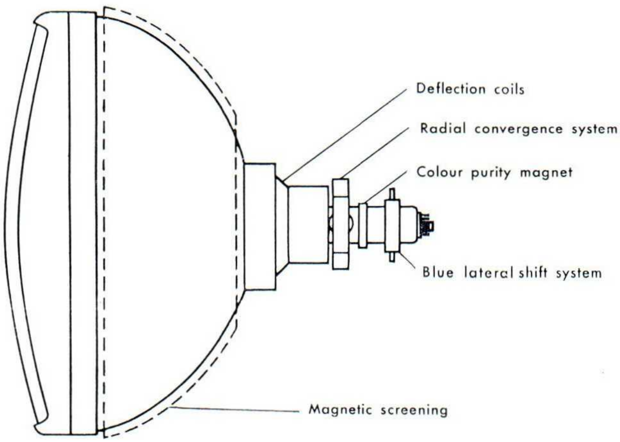
Fig. 1. Principle of the shadow-mask tube. The angle of incidence of the electron beams on the shadow mask determines which phosphor dots will be excited. In practice, the electron beams will have a larger diameter than the mask holes and will cover several holes simultaneously.

In order that the colour picture tube can properly display its three coloured, superimposed, pictures, it must be adjusted with great accuracy.

3 Required Adjustment Systems

Apart from the usual unit for horizontal and vertical deflection, the colour picture tube requires special means of correction, likewise situated on the neck of the tube. These are the radial convergence system and the lateral blue shift system and the colour purity magnet. Fig. 2 shows how they are positioned on the tube neck.

The three colour images are made perfectly coincident by proper adjustment of the convergence system. This system comprises the convergence unit, consisting of magnets and coils for radial convergence adjustment (radial shifting of the electron beams), and a unit to adjust the lateral shift of the blue beam relative to the simultaneous, opposed



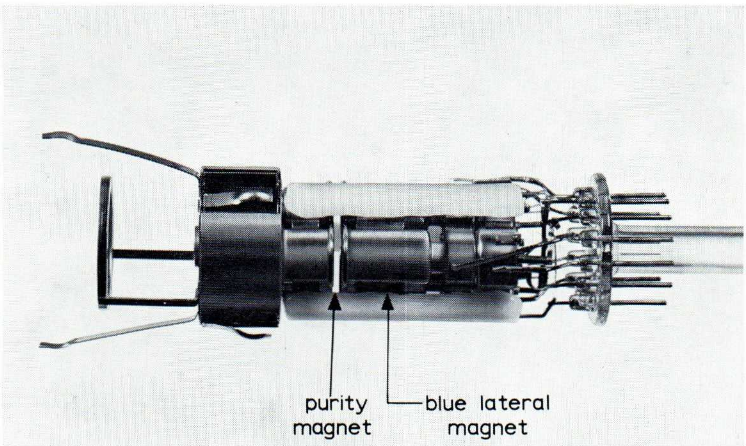


Fig. 2. Position of the deflection and correction systems on the neck of a colour picture tube. The colour purity magnet should be positioned over the gap between grids g_3 and g_4; the location of the blue lateral shift system is above the centre of g_3 (the focus electrode).

shift of the red and green beams. This arrangement, and the manner in which the electron beams are influenced by magnetic pole pieces of the electrode system, are shown in Fig. 3.

The colour purity magnet corrects the landing of the electron beams; it is fitted behind the convergence unit on the tube neck.

Ideally, the three electrode systems of a picture tube should be electrically identical. In practice, however, there will always be some difference between the three systems; for example, in cut-off voltage and slope. In addition, the red, green and blue dots on the screen require different beam

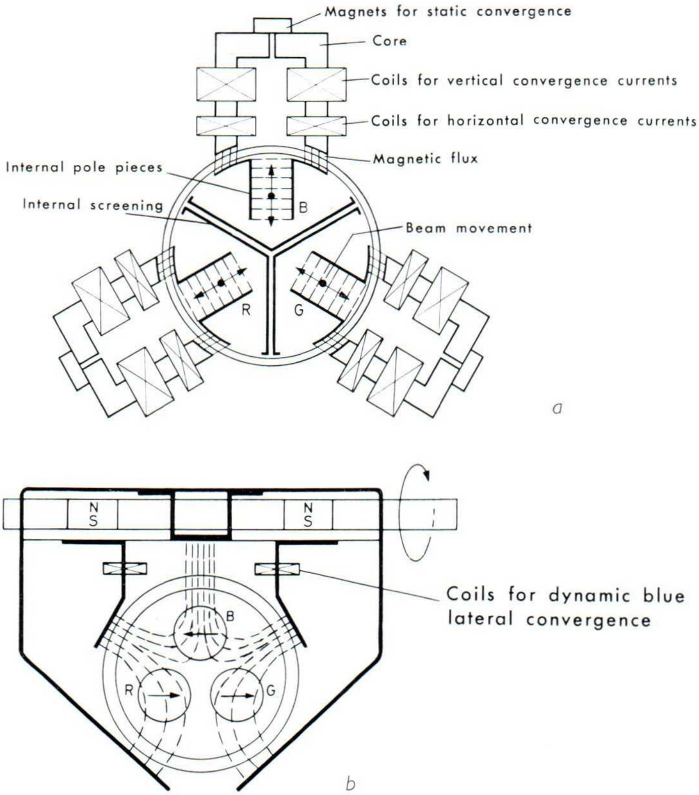


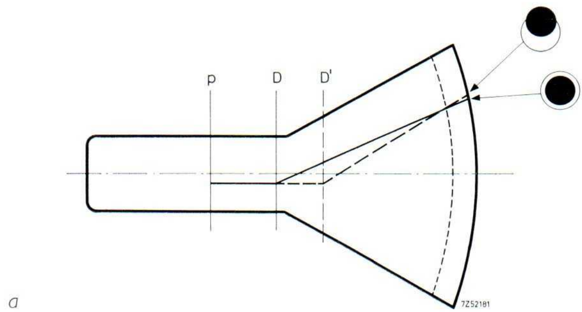
Fig. 3. Convergence adjustment. (a) The magnetic correction fields of the convergence unit act on the three electron beams by means of magnetic pole pieces. (b) The blue lateral shift system acts on the blue beam and, simultaneously, but with opposite effect, on the red and green beams.

currents in order to produce white in the case of simultaneous excitation. The correct current balance required for white and all its brightness values (grey scale) is obtained with the white and grey scale adjustment procedure.

4 Basic Points on Adjustment

4.1 Colour Purity

In the colour picture tube, each electron beam must strike only its own associated dots on the screen. To this end, it is necessary that the direction of the beams, as they pass through the shadow mask, coincides exactly with the direction of the light beams as used in the optical screen-laying process during manufacture of the tube. Thus, the deflection centres of



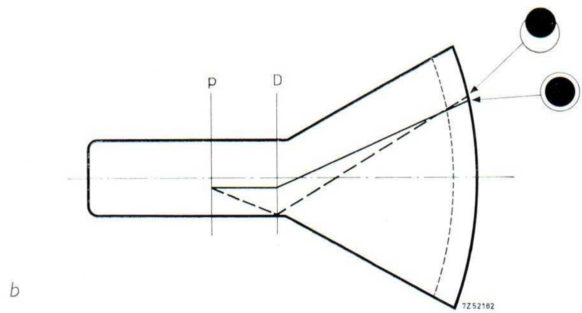


Fig. 4. (a) Path of an electron beam with incorrectly (broken line) and correctly (continuous line) adjusted deflection coil. (b) Path of an electron beam with incorrectly (broken line) and correctly (continuous line) adjusted colour purity magnet.
p = position of the colour purity magnet
D = correct deflection plane
D' = wrong deflection plane

the three beams must be carefully adjusted. This adjustment is provided by two controls: the axial positioning of the deflection coil, and an additional magnetic field provided by the colour purity magnet. Fig. 4 shows this process.

The influence of the colour purity magnet extends over the entire screen, but displacement of the deflection coils has no effect on the colour purity in the picture centre. Therefore, the colour purity should be adjusted first in the picture centre by means of the colour purity magnet, and subsequently over the entire area of the screen by shifting the deflection coils.

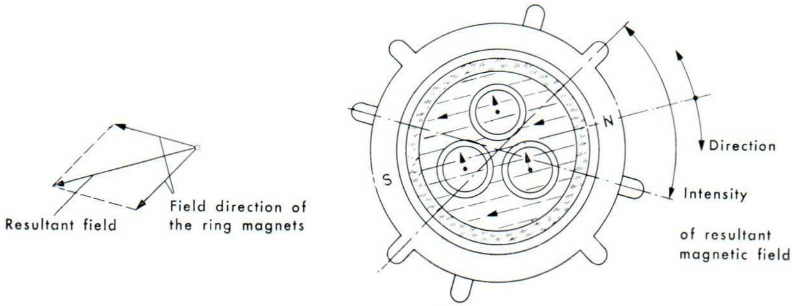


Fig. 5. The colour purity is adjustable by means of two rotatable, magnetised rings.

As shown in Fig. 5, the colour purity magnet consists of two magnetised rings, which can be turned with respect to one another around the tube neck. To adjust the *intensity* of the field and thus the amount of purity correction, the two rings are turned in opposite directions. The *direction* of the resulting field can be adjusted by turning the colour purity magnet in its entirety.

4.2 Convergence

4.2.1 Static convergence

Although the three guns in the tube neck are tilted over a certain angle to make their beams coincide at the screen centre, some adjustment will usually be necessary.

The convergence adjustment system ensures coincidence of the three colour rasters over the entire screen. This implies that it should be possible to control each of the electron beams separately. With magnetic pole pieces positioned in the convergence section of each electron gun (Fig. 6) the electron beams are radially influenced.

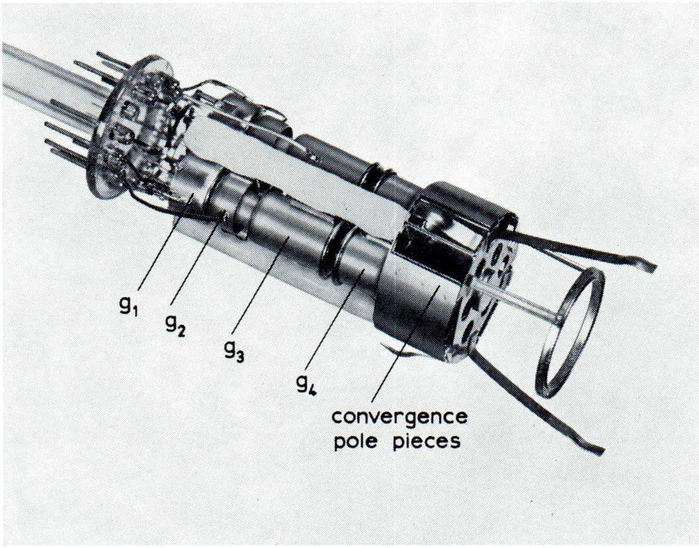


Fig. 6. Electrode system of the A63-11X colour picture tube.

Fig. 7 shows the possible displacement of the three beams. Ensuring exact coincidence of the beams necessitates four different directions of control. The green and red beams intersect at an angle of 120°. To have the blue beam coincide with this point of intersection, both a vertical (radial) and horizontal (lateral) movement control are required. For convergence control, therefore, a means of adjusting the lateral shift is also necessary.

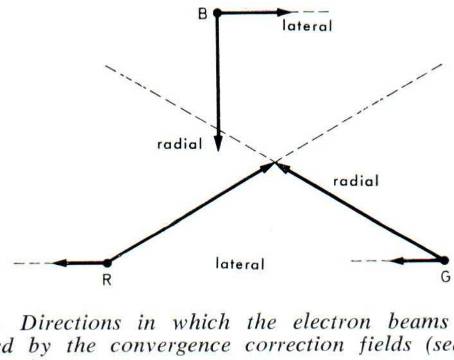


Fig. 7. Directions in which the electron beams can be deflected by the convergence correction fields (seen from the screen).

The three beams can be made to converge in the centre of the screen by adjusting permanent magnets or varying the direct current flowing through the coils of the convergence unit. This is called the static convergence adjustment. Use of direct currents is preferable, because the screen can then

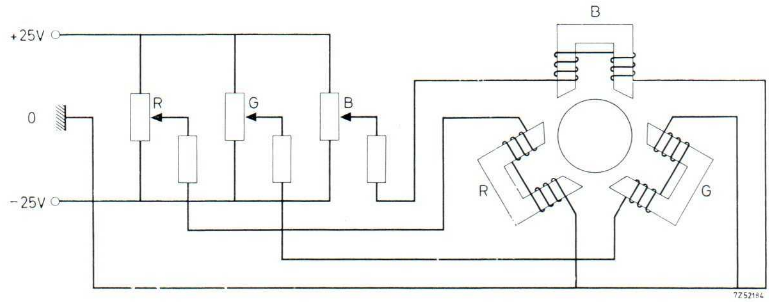


Fig. 8. Example of a circuit for electrical adjustment of the static convergence. The series resistors serve to reduce current variations due to temperature.

be better observed during adjustment. The principle of this type of convergence control is shown in Fig. 8. By means of potentiometers, the currents flowing through the red and green convergence coils are adjusted to make the red and green beams coincide in the centre of the screen. Next, the blue beam is brought into convergence by means of its associated potentiometer and the blue lateral magnet.

4.2.2 Dynamic convergence

Even if the static convergence is properly adjusted, it will be perfect only in the screen centre. At the edges, considerable convergence errors may still be present. The reason of this will be explained with reference to Fig. 9. The three electron beams may be considered to generate lines of a cone, concentric with the tube axis. This (imaginary) cone is deflected by the deflection coil. As the screen is much flatter than the sphere around the deflection centre where this cone is in focus, the red, green and blue beams will diverge at the edges of the screen, thus causing convergence errors. In addition, asymmetric errors may be present. Fig. 10 shows a typical pattern, obtained when the three rasters are converged in the centre only.

The dynamic convergence system corrects these errors by separately influencing each beam with magnetic fields, which vary with the momentary

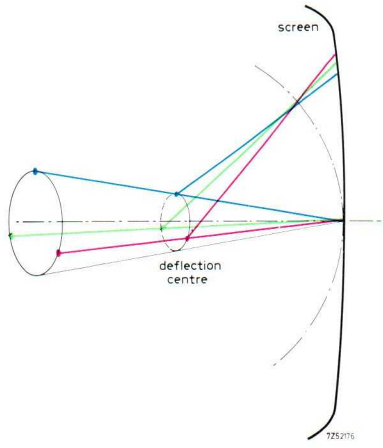


Fig. 9. The flatness of the screen causes dynamic convergence errors. The imaginary cone of which the three beams can be thought of as being parts, is not "focused" at the edges of the screen.

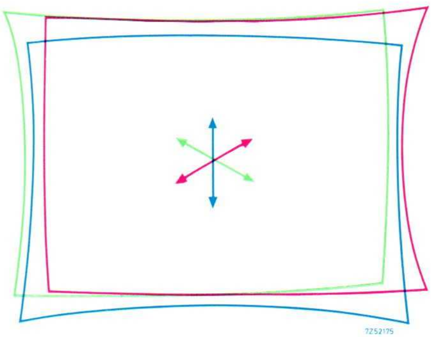


Fig. 10. Typical raster shape without dynamic convergence correction of the convergence errors.

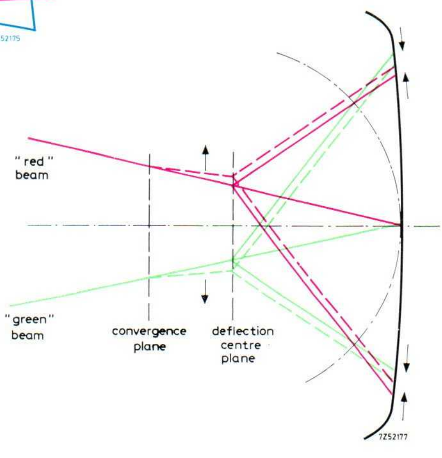


Fig. 11. Correction of dynamic convergence errors by making the eccentricity of the beams at the deflection centre to vary with the scan (shown for the red and green beams only).

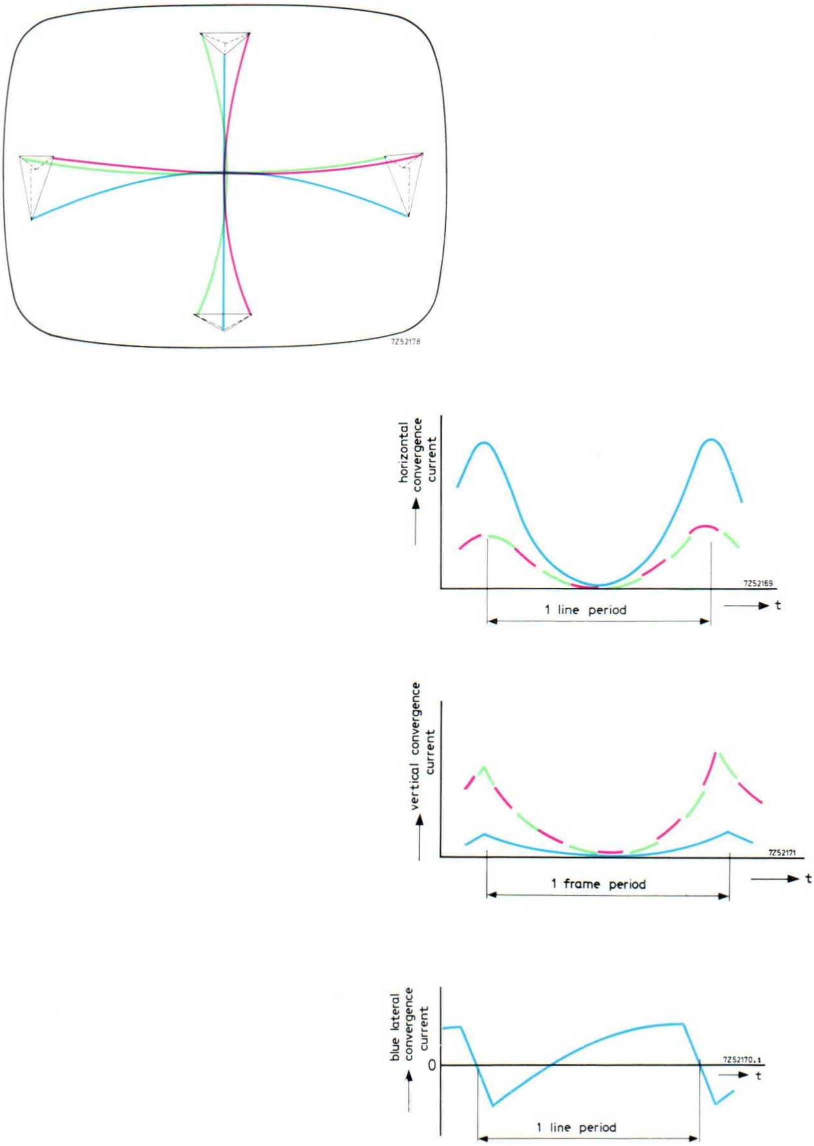


Fig. 12. Convergence errors at the screen axes, and the currents required for correction.

horizontal and vertical deflection. Fig. 11 demonstrates that in this way a correction at the edges is obtained by decreasing the convergence of the beams as the scan approaches the edge of the screen. The general waveform needed for the dynamic convergence is parabolic.

Fig. 12 shows the general character of the convergence errors at the horizontal and vertical screen axes. To correct these errors, parabolic currents of both line and frame frequency are sent through the coils of the convergence unit. Symmetry errors in the picture tube and the deflection coil are corrected by adding sawtooth signals to these parabolic currents. The exact waveforms needed depend on individual differences between picture tubes and between deflection coils, so the convergence circuit must incorporate appropriate adjustment facilities.

As is also shown in Fig. 12 a dynamic blue lateral correction signal is provided. Since the blue lateral deviations at the left and right edge of the screen are in opposite directions the signal has a sawtooth waveform of line frequency.

The dynamic convergence circuit is fed from the vertical and horizontal stages. Figs 13 and 14 give an example of the convergence circuits. The former shows the circuit for static and vertical convergence, the latter that for horizontal convergence. A short description of the circuit will be given here. The recommended adjustment sequence of the various controls is set out in section 5.2.

Static convergence is achieved with d.c. currents, fed through the vertical convergence coils. (For blue lateral convergence a permanent magnet is used.) A stabilized voltage is obtained by rectification of the line-scan pulses. By means of potentiometers the red, green and blue static convergence is adjusted. Large series resistors are included to reduce current variations due to temperature variations of the convergence coils.

The vertical dynamic convergence is fed by a parabolic voltage taken from the cathode of the field output tube, and by a sawtooth voltage provided by a winding on the field output transformer. These voltages are slightly predistorted (partly differentiated) in order that pure parabolic and sawtooth-shaped currents will flow through the convergence coils, despite of their high L/R ratio.

The red and green controls are combined to obtain matrixed operation, which facilitates their adjustment. Fig. 15 illustrates this: with one control, the currents in the red and green convergence units are equally increased. This results in a movement of only the vertical lines in the convergence (cross-hatch) pattern (Fig. 15*a*). Another control increases the red con-

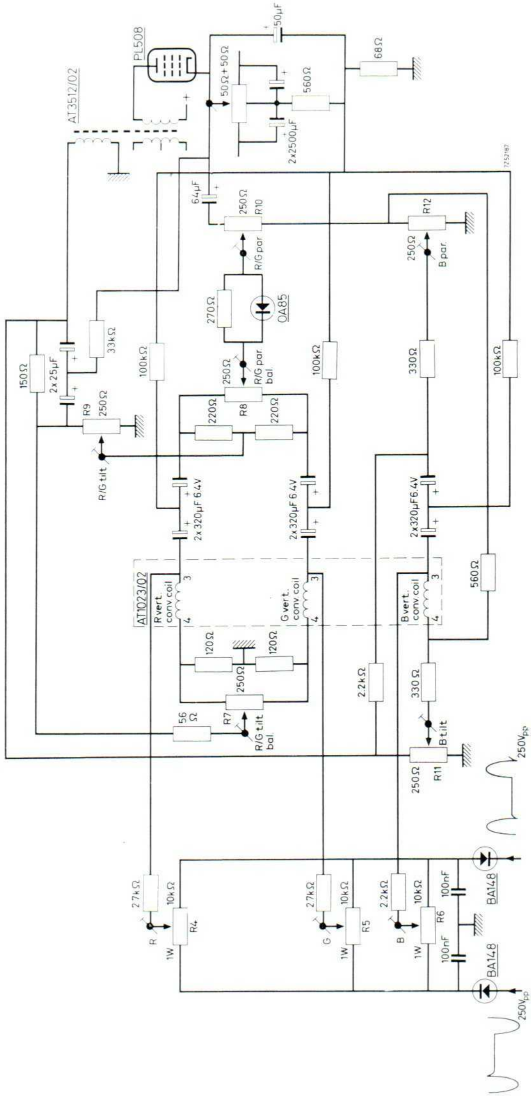


Fig. 13. Circuit for static and vertical convergence correction.

vergence current while decreasing the green current, or vice versa. This works out as a movement of the horizontal lines in the pattern, as Fig. 15*b* shows. Thus, for red and green, four controls are available: a common

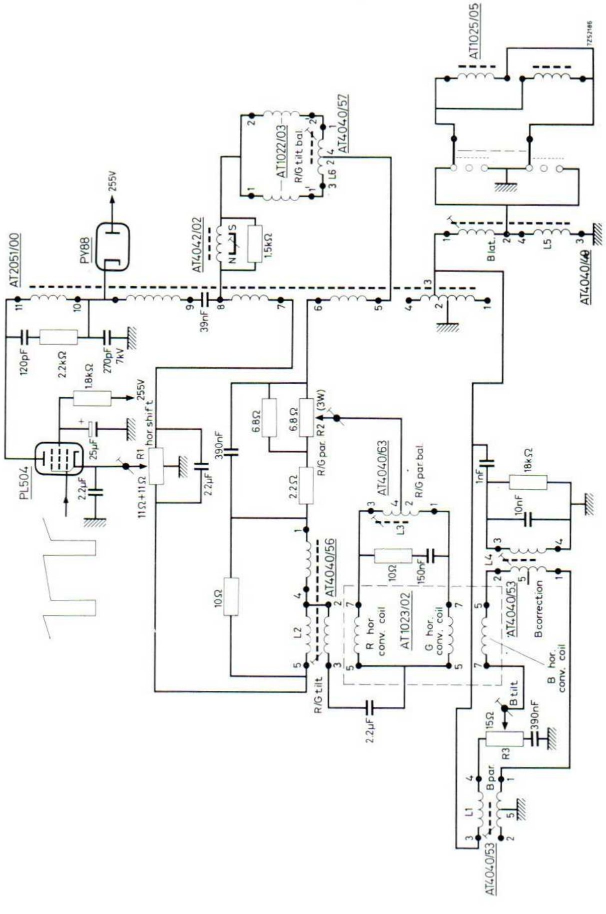


Fig. 14. Circuit for horizontal convergence correction.

parabola control, a common tilt (sawtooth) control, a parabola balance control and a tilt balance control. Blue has its own sawtooth and parabola controls.

In the horizontal convergence circuit shown in Fig. 14, red and green are again matrixed. The line deflection current of the receiver flows through a resistor (potentiometer R_2). The sawtooth voltage obtained across R_2 is fed to the red and green convergence coils, giving rise to parabolic convergence currents. The 390 nF capacitor across R_2 improves the waveform. R_2 functions as the parabola amplitude control, while L_3

(the parabola balance control) provides a control of the ratio of the currents in the red and green branch.

Tilt (sawtooth) amplitude control is obtained by means of L_2. Across this coil, which is also connected in series with the deflection chain, a line pulse voltage of adjustable amplitude and of either polarity is produced. This voltage is applied to the convergence coils so that a sawtooth current can be made to flow through them. Tilt (sawtooth) balance control is

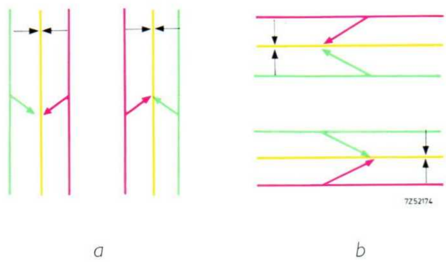


Fig. 15. Matrixed convergence adjustment of red and green by means of a cross-hatch pattern. (a) Similar shifts of the red and green beam produce a shift of the vertical red and green lines only. (b) Opposite shifts of the red and green beams produce a shift of the horizontal red and green lines only.

obtained by the centre-tapped inductance (L_6) in series with both halves of the line deflection coils. This method of control also improves the symmetry of the horizontal deflection coils, thus ensuring better convergence in the corners of the screen.

The blue horizontal convergence system is fed by pulses from the line output transformer. Integration of these pulses, provided by L_1 and R_3, produces a sawtooth voltage across R_3 which gives rise to a parabolic current through the blue convergence coil. L_1 adjusts the amplitude of the parabola, while R_3 (with the 390 nF capacitor) adjusts the tilt by shifting the phase of the parabola.

In L_4, a sine-wave of twice the line frequency is generated from the line pulses. From the second winding of L_4 a current of this frequency is fed into the blue convergence coil to improve the waveform; the shallow part of the parabola is flattened, while the flanks are made steeper.

A sawtooth current is fed to the dynamic blue lateral convergence unit; it is adjusted by means of a tapped inductance (L_5) connected to the line output transformer.

Asymmetrical blue lateral errors can be corrected by a slight rotation of the radial convergence unit on the neck of the tube.

4.3 Raster Correction

The raster shape of a converged picture on a 90° colour picture tube is not perfectly rectangular, but displays a certain amount of pin-cushion distortion. Correction of this distortion is provided by the raster correction system, which is based on mutual modulation of the horizontal and vertical deflection currents (see Figs 31 and 32).

4.4 White and Grey Scale Adjustment

For the reproduction of white there must be a specific relationship between the three beam currents. Depending on the drive method, this relationship is established by using different drives or electrode voltages for the three gun systems. By adjusting the grey scale tracking, the three characteristics are made to match each other so that the conditions required for white are obtained and preserved throughout the grey scale. This matching will be explained by means of two exemplary circuits.

The first method is provided by what is known as the "potentiometer" circuit shown in Fig. 16. This circuit can be used in receivers applying luminance and colour difference drive. The luminance signal *(Y)* is fed to the cathodes. To the first grids the colour difference signals *R-Y*, *G-Y* and *B-Y* are applied. Subtraction is performed by the picture tube itself,

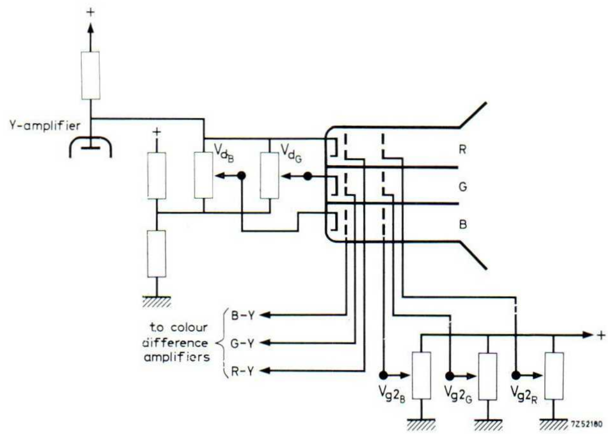


Fig. 16. Driving the picture tube with a "potentiometer" circuit.

so that each gun obtains its correct signal. For grey-scale adjustment, a black and white staircase signal is used. All colour difference signals are zero in this case, except for a common d.c. level on all three first grids. One cathode (e.g. red) is connected directly to the output of the luminance amplifier. The other cathodes (green and blue) are connected by means of potentiometers in such a way that their drive can be varied independent of each other without the black level being affected. The cut-off voltages of all three systems are made equal by adjusting the screen-grid voltages (V_{g2}). This adjustment can be performed very accurately by judging the grey scale in the darkest picture areas. By matching the drive voltages for blue and green to the fixed drive voltage for red, the white shade in the bright picture areas can subsequently be adjusted.

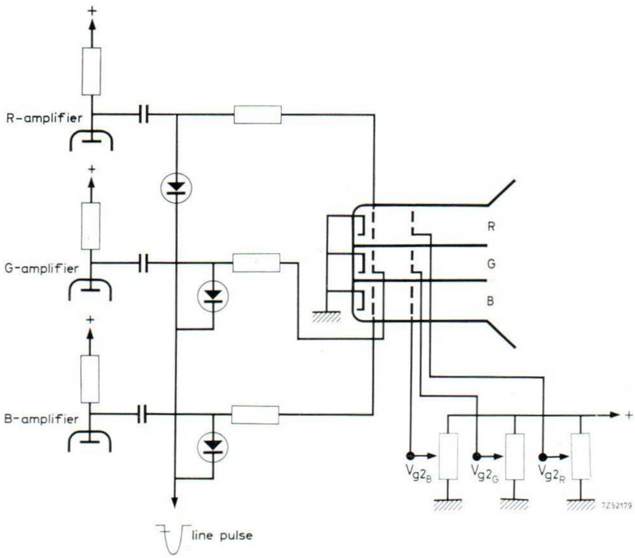


Fig. 17. Driving the picture tube with an RGB drive circuit.

An alternative drive circuit is shown in Fig. 17. This circuit employs *RGB* drive, which means that the luminance and chrominance signals are not combined in the picture tube but in the circuit, presenting straightforward red, green and blue signals to the corresponding guns. In the circuit shown, the drive voltages are applied to the grids. Clamping circuits are provided to maintain the black level at a constant voltage irrespective of variations of supply voltage or spreads in the amplifier tubes. The screen-grid voltages are adjusted to obtain equal cut-off points. This adjustment provides good grey-scale tracking in the dark picture parts. The bright end of the grey scale is set at the correct white point by adjusting the relative amplification in the red, green and blue channels.

5 Adjustment Procedure

5.1 Sequence of Adjustments

The static and dynamic convergence and colour purity adjustments described are more or less interrelated. They are also linked with certain basic adjustments, for example those concerning raster correction and picture size. Any adjustment must be checked and, if necessary, corrected after a following adjustment has been carried out. The adjustments are usually made in the following sequence, each step being discussed in detail in section 5.2.

(1) Switch on the pre-adjusted receiver
(2) Check high voltage (e.h.t.)
(3) Adjust a high average brightness (beam current $\approx$ 1000 μA)
(4) Degauss picture tube and chassis
(5) Connect a cross-hatch pattern generator
(6) Focus (by eye)
(7) Adjust picture height and width
(8) Adjust linearity
(9) Centre picture
(10) Check (7) to (9)
(11) Adjust static convergence
(12) Adjust colour purity (without cross-hatch pattern)
(13) Re-centre picture
(14) Re-adjust static convergence
(15) Adjust dynamic vertical convergence
(16) Adjust dynamic horizontal convergence
(17) Check colour purity (point (12))
(18) Adjust raster correction system
(19) Check raster dimensions (points (7) to (9))
(20) Adjust white point and grey scale (without cross-hatch pattern but with staircase signal)
(21) Adjust focus at high brightness, using an appropriate test picture

5.2 Detailed Description of the Adjustments

The following details on the various adjustments should enable you to align a colour television receiver. This is a fairly complex matter which will be greatly facilitated by adhering to the procedure outlined in this section. The adjustment of several controls affect each other, but by choosing the method described, the necessity of repetitive adjustments is minimized. The procedure has been worked out carefully to facilitate the job. One should try to get a clear understanding of the function of every control element in the circuit. The pointers set out here are intended to assist the technician in mastering alignment of the picture tube and associated circuitry for optimum colour reproduction even in the case of sets with circuitry differing from that in the examples given.

(1) *Switching-on*
The pre-adjusted set should be ready for operation, so that the picture tube is not damaged or overloaded when the set is switched on. Adjustment should include setting of the vertical and horizontal deflection, the raster correction and the dynamic convergence, and adjustment of the e.h.t. to the rated value (rated booster value). Where the e.h.t. is separately generated, the internal impedance of the e.h.t. source must also be checked. The focussing voltage should be adjusted to a value V_{foc} of 4 to 5 kV.

(2) Checking and adjustment of the e.h.t. can be performed indirectly; for example, in circuits with separate e.h.t. generation, by adjusting the booster voltage.

(3) To ensure that the set has its normal working temperature when convergence and colour purity are adjusted, it should be operated for some time with an average beam current of about 1000 μA.

(4) *Degaussing*
As the picture quality of a colour television picture tube can be adversely influenced by external magnetic fields, the picture tube is magnetically shielded within the set. The shielding, consisting of the (recommended) cone shield, the reinforcing metal rim band, and the shadow mask, and also the various parts of the chassis might, however, be magnetised by external sources.
Before alignment, therefore, the receiver should be degaussed. This is done by moving an air-core coil (800 turns, 0.8 mm enamelled copper wire, approximately 30 cm diameter, connected to a variable

transformer or direct to the 220 V mains) in front of the picture screen and around the cabinet, while the set is operating. The magnetizing force must be strong enough to bring the ferrous parts of the picture tube shielding to saturation and should be gradually weakened either by reducing the transformer voltage to zero or by gradually removing the coil from the receiver. In the latter case it must not be switched off at a distance closer than 3 metres from the picture tube. This method of degaussing is required even if the receiver incorporates an automatic degaussing system.
Since the influence of the axial component of the earth's magnetic field cannot be compensated by the purity magnet, the colour purity should be adjusted at the setmaker's production line with the picture in the set pointing East or West, that is, with the axial component being zero. The colour purity error due to the other components of the earth's field is kept so small by the magnetic shielding that the colour purity will then be correct even if the set is operated in other orientations. A condition here, however, is that the automatic degaussing system is switched on each time the position of the set is changed. This is necessary since, with automatic degaussing by means of a diminishing alternating field, the shielding is magnetized in such a way that, within the shielding area, a magnetic field is induced that opposes the original earth's magnetic field. Whereas the effect of the shielding — or the absence of a field within the picture tube — is thereby increased, the magnetic field of the shielding will no longer counteract the earth's field when the position of the set is changed.
When the set is switched on, the automatic degaussing system will function again to make the shielding effective in the new position of the receiver.

(5) The raster geometry and the convergence should be adjusted with a cross-hatch pattern with low average beam current.

(6) Exact focusing is the final operation in the sequence of adjustments (see point 21)). When starting this sequence, it is sufficient to adjust the cross-hatch pattern for optimum sharpness.

(7) *and* (8) *Picture size and linearity*
The currents for the convergence system are supplied by the vertical and horizontal deflection circuits. To prevent the convergence from being upset afterwards, the deflection currents should have the form

and value required for subsequent normal operation. This calls for adjustment of picture height and width, as well as vertical and horizontal linearity.

(9) *Picture centering*

Influence of spreads of the deflection units and picture tubes on the position of the picture cannot be compensated with centering rings known in the black-and-white technique, as such magnets would affect colour purity. Small additional compensating direct currents must therefore be fed to the deflection coils for final adjustment of the picture centering.

(10) As there is always a certain degree of interaction between raster adjustments, such as picture width, picture height, linearity, and also centering of the picture, any previous adjustment must be checked after a following adjustment has been made.

(11) *Adjustment of the static convergence*

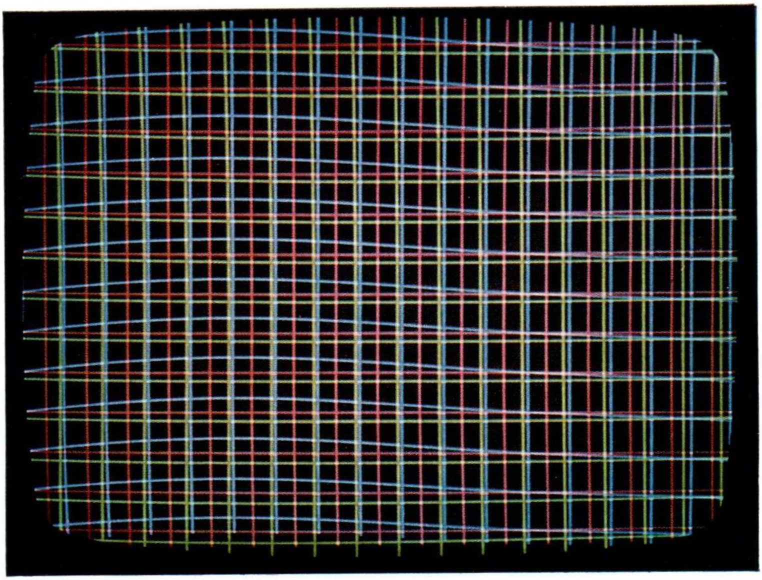


Fig. 18. Cross-hatch pattern before convergence adjustment. Lack of convergence also gives rise to colour impurity.

A medium luminance cross-hatch pattern is recommended for the test picture signal. Fig. 18 shows a cross-hatch pattern for convergence adjustment with the raster correction switched on, but with the convergence severely mis-adjusted.

Adjustment of the convergence will be explained by means of a circuit similar to that in Fig. 13. For adjustment of the static convergence (see Table I) *the central picture area* (marked S in Fig. 19) *should be observed.*

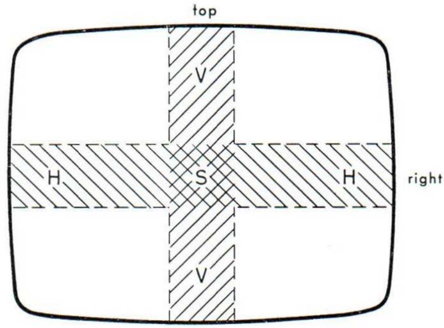


Fig. 19. Area of static (S), dynamic vertical (V) and horizontal (H) convergence adjustment.

If the receiver has permanent magnets for static convergence, adjustment of R_4 is replaced by adjustment of the red magnet. Likewise, R_5 is replaced by the green magnet and R_6 by the blue one.

The following sequence of adjustment is recommended:

(a) Switch on only the red and green beams.

(b) Shift the red raster by means of R_4 so that lines through the intersection of the red and green rasters are at 30° to the horizontal (see Fig. 20*a*).

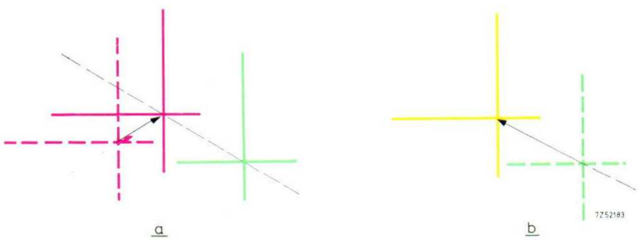
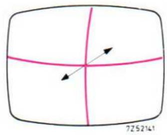
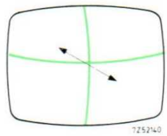
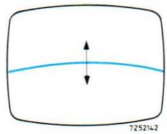
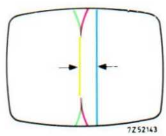
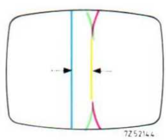


Fig. 20. Static convergence adjustment. (a) Shift of the red grid. (b) Shift of the green grid.

(c) Adjust R_5 until the intersection of the green cross-hatch lines and those of the red cross-hatch lines coincide (Fig. 20*b*). There is then static convergence between the red and the green electron beam (yellow cross-hatch).
(d) Switch on the blue beam.
(e) Make the blue horizontal lines coincident with the yellow (by means of R_6).
(f) With the blue lateral magnet make the blue vertical lines coincident with the yellow (white cross-hatch in picture centre; see Fig. 21).
(g) Check the static convergence.

Table I. *Static convergence adjustment*

System with d.c. currents (see Fig. 13)	System with permanent magnets	Designation	Operation
R_4	red magnet	red radial shift	
R_5	green magnet	green radial shift	
R_6	blue magnet	blue radial shift	
blue lateral magnet	blue lateral magnet	blue lateral shift	 

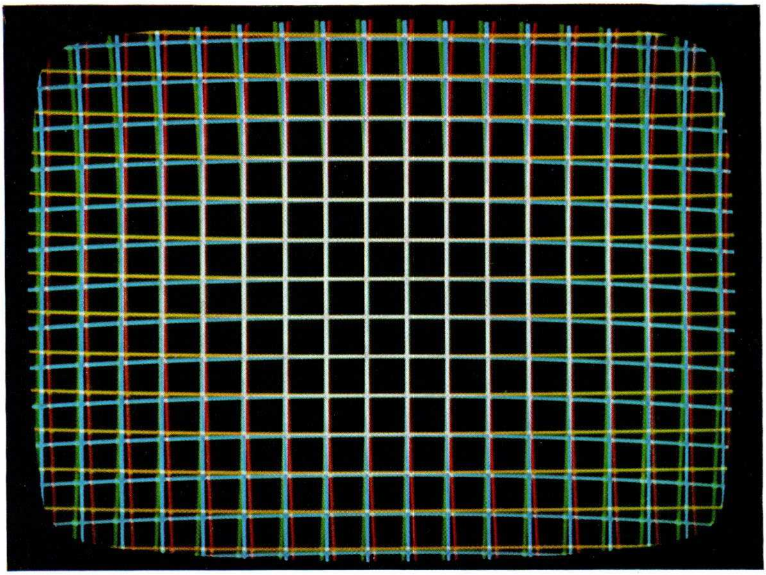


Fig. 21. Cross-hatch pattern after adjustment of the static convergence.

(12) *Colour purity adjustment*

Adjustment of the colour purity is the most important single adjustment when the colour television picture tube is taken into service. The operation should be performed with utmost care, for it is decisive for the quality of the colour rendition. Figs 22 and 23 show photographs of the screen at non-adjusted and properly adjusted colour purity respectively.

The set must be degaussed and the colour purity adjusted while the set is pointing East or West (see (4), p. 22). Allow the picture tube an uninterrupted warming-up period of at least 15 minutes at high beam current (about 1000 μA) before adjusting the purity.

The colour purity is adjusted with a raster of medium luminance and non-detailed picture (grey area, beam current about 600 μA) as follows:

(a) Adjust the colour purity magnet to zero, i.e. with the fields of the two magnetic rings cancelling each other. If the rings are not marked, zero position can be recognised as such when simultaneous turning of the rings has no effect on the electron beams.

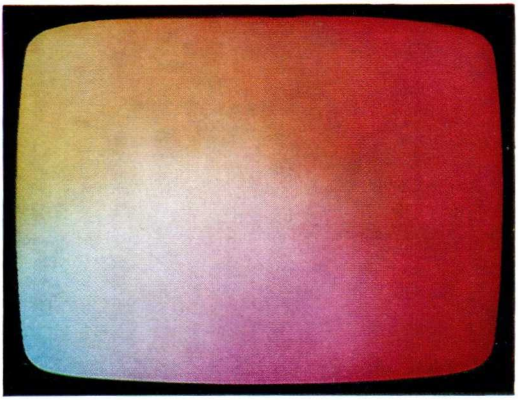


Fig. 22. Picture with non-adjusted colour purity. Only the red beam is switched on.

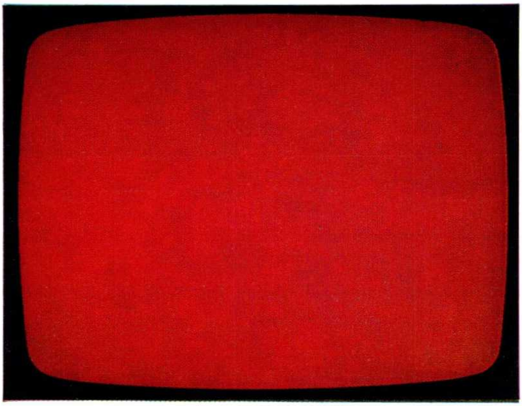


Fig. 23. Properly adjusted colour purity of the red raster.

(b) Observe through a microscope (minimum magnification 20 ×) the landing of the electron beams. A laterally positioned light source (cross light) is employed to render the non-excited area of the phosphor dots visible (Fig. 24).
Examine the centre of the screen through the microscope and, with the colour purity magnet, adjust the colour purity so that the gravity centres of the two triangles formed by the phosphor triple and the excited phosphor areas coincide (see Figs 25 and 26).

(c) Switch on the red beam only. Adjust the colour purity for the picture edges by shifting the deflection coil (Fig. 23).

(d) Secure the deflection coils.

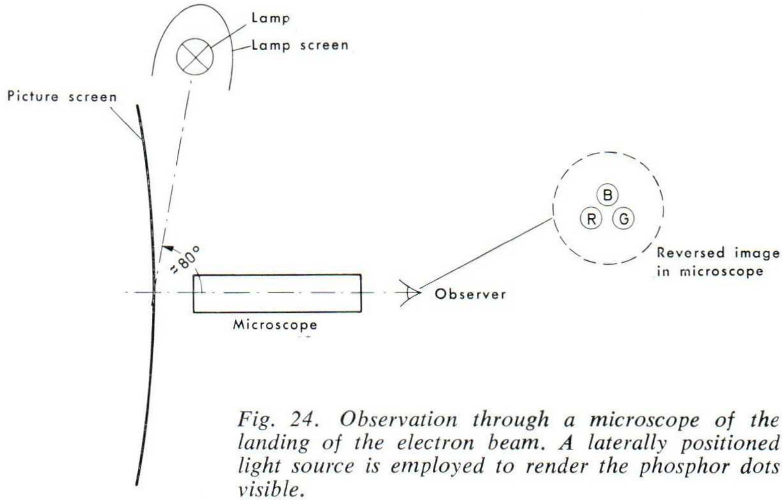


Fig. 24. Observation through a microscope of the landing of the electron beam. A laterally positioned light source is employed to render the phosphor dots visible.

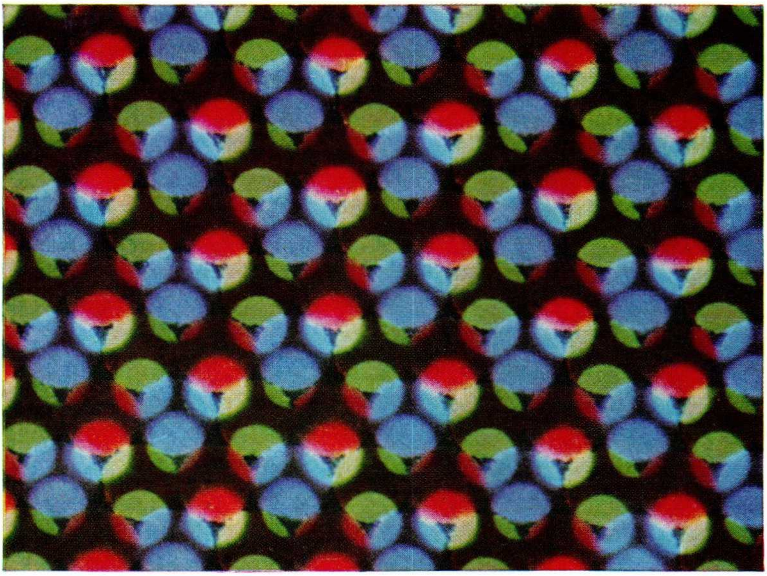


Fig. 25. Enlarged view of the phosphor screen with mal-adjusted colour purity.

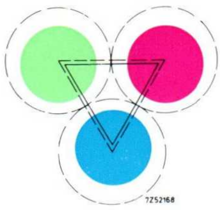


Fig. 26a. Colour purity adjustment. In the centre of the picture the gravity centres of the two triangles formed by the phosphor triplet and the excited phosphor areas must coincide.

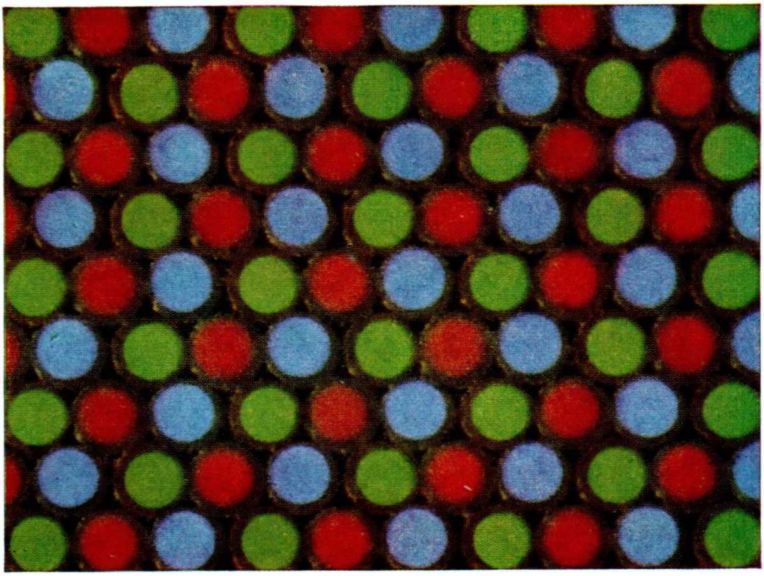


Fig. 26b. Enlarged view of the centre of the screen with properly adjusted colour purity.

(e) Check the colour purity at green and blue, and the white uniformity over the entire screen. A properly adjusted colour tube should show no visible purity errors anywhere on the screen. Fig. 27 shows the average registration pattern of our tube type A63-11X, with the AT1022/03 deflection coil, at the centre and the edges of the screen.

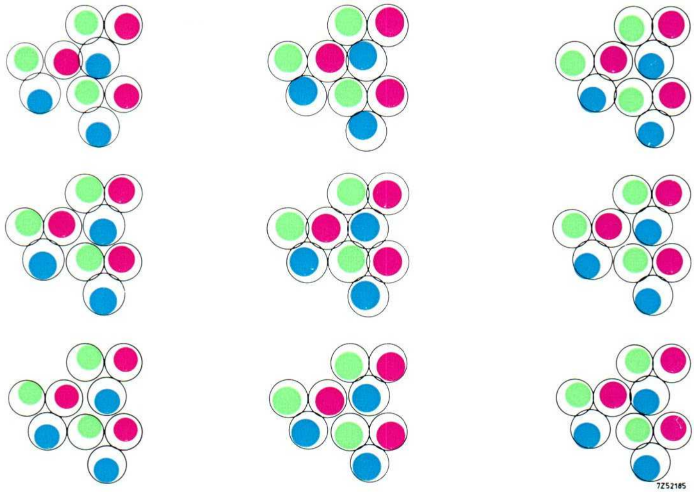


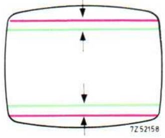
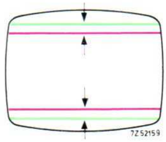
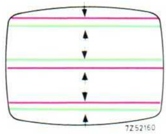
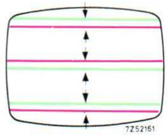
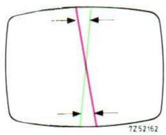
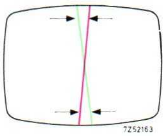
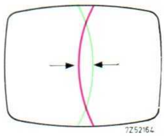
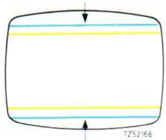
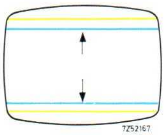
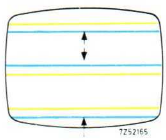
Fig. 27. Average landing pattern of an A63-11X colour picture tube with deflection coil AT1022/03. The picture shows the landing at the corners of the screen and in the intermediary areas.

(13) Centering of the picture is affected by the colour purity magnet and should therefore be re-adjusted, if necessary (see (9)).

(14) Static convergence should now be checked once again and re-adjusted if necessary.

(15) *Adjustment of the dynamic vertical convergence*
The test picture signal should preferably display a cross-hatch pattern. The brightness should be as low as possible. The controls are assumed to correspond with the circuit diagram in Fig. 13.

Table II. *Dynamic vertical convergence adjustment*

Control (see Fig. 13)	Designation	Operation
R_7	red/green tilt balance	 
R_8	red/green parabola bal.	 
R_9	red/green tilt	 
R_{10}	red/green parabola	
R_{11}	blue tilt	 
R_{12}	blue parabola	

When adjusting the vertical convergence (Table II), the *vertical axis of the screen (the perpendicular area V in Fig. 19) should be observed.*

During vertical dynamic convergence adjustment, some re-adjustment of the static convergence may be necessary to keep the cross-hatch pattern lines in the centre of the screen coincident.

(a) Switch on the red and green beams only.

(b) Render the red and green horizontal lines at the top and the bottom of the screen equidistant by adjusting R_7.

(c) Render the red and green horizontal lines at the top, the bottom and the centre of the screen equidistant by adjusting R_8.

(d) Render the red and green vertical lines equidistant at the top and the bottom of the picture by adjusting R_9.

(e) Straighten the vertical red and green lines by adjusting R_{10}.

(f) Switch on the blue beam.

(g) Render the blue and yellow (red-green) horizontal lines at the top and the bottom of the picture equidistant by adjusting R_{11}.

(h) Render the blue and yellow (red-green) horizontal lines at the top, the bottom and the centre of the screen equidistant by adjusting R_{12}.

(i) Check the vertical dynamic convergence (see Fig. 28).

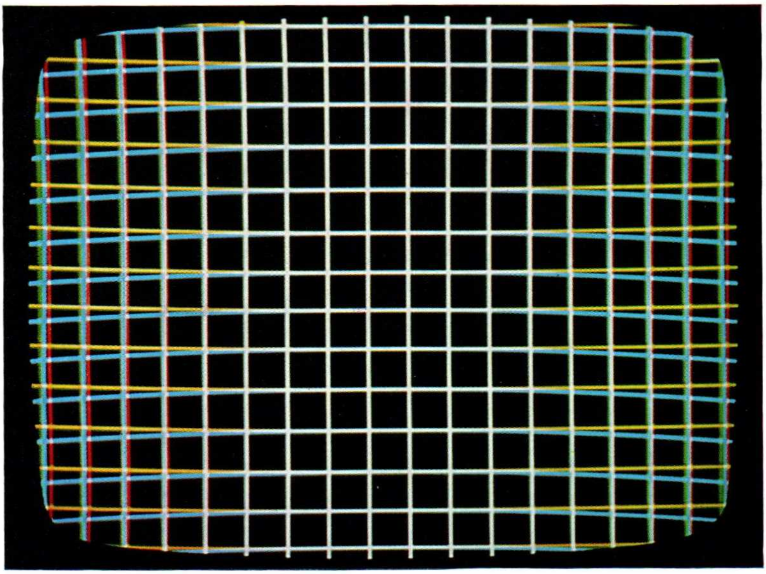
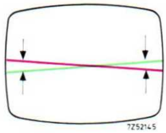
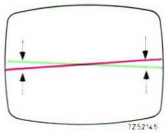
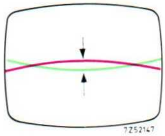
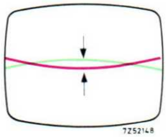
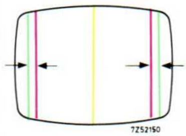
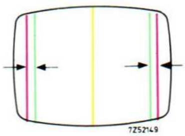
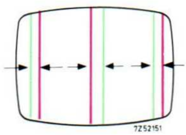
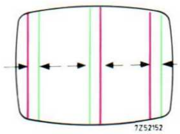
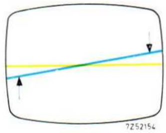
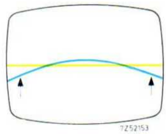
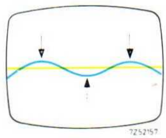
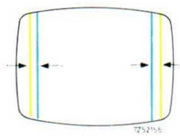
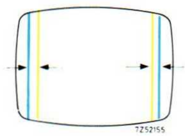


Fig. 28. Cross-hatch pattern after adjustment of the static and dynamic vertical convergence.

(16) *Adjustment of the dynamic horizontal convergence*
Test picture signal as in (15). *For this adjustment the horizontal screen axis* (area H in Fig. 16) *must be observed.*
During horizontal dynamic convergence adjustment (Table III), some re-adjustment of the static convergence may be necessary to keep the cross-hatch pattern lines in the centre of the screen coincident.

Table III. *Dynamic horizontal convergence adjustment*

Control (see Fig. 14)	Designation	Operation
L_6	red/green tilt balance	 
L_3	red/green parabola balance	 
L_2	red/green tilt	 
R_2	red/green parabola	 

R_3	blue tilt	
L_1	blue parabola	
L_4	blue waveform correction	
L_5	blue lateral convergence	 

Of the following adjustments (a) and (b) are provisional; they concern some controls which noticeably influence the other controls and should therefore preferably be adjusted first.

(a) Switch on all beams.

(b) Make the horizontal blue line as straight as possible by adjusting L_1 (blue parabola), L_4 (blue waveform correction and R_3 (blue tilt). The correct adjustment of L_4 can be made by means of an oscilloscope, if necessary. In doing so, the voltage across the blue horizontal coil on the convergence unit should be observed. It should consist of a sawtooth waveform with a horizontal step on the sawtooth slope. L_4 is adjusted correctly if the step is exactly halfway the slope (Fig. 29).

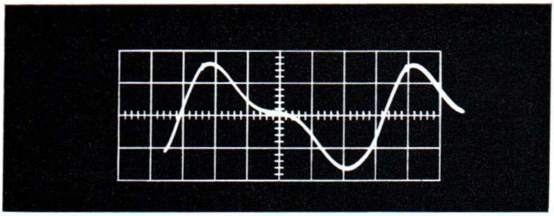


Fig. 29. Voltage across the blue horizontal convergence coil (vertical: 10 V/div, horizontal: 10 μs/div).

(c) Suppress the blue beam.

(d) Render the horizontal red and green lines equidistant at the left and the right edge of the screen by adjusting L_6.

(e) Straighten the horizontal red and green lines by adjusting L_3.

(f) Render the vertical red and green lines at the left and the right edge of the screen equidistant by adjusting L_2.

(g) Render the vertical red and green lines at the left and the right edge and at the centre of the screen equidistant by adjusting R_2.

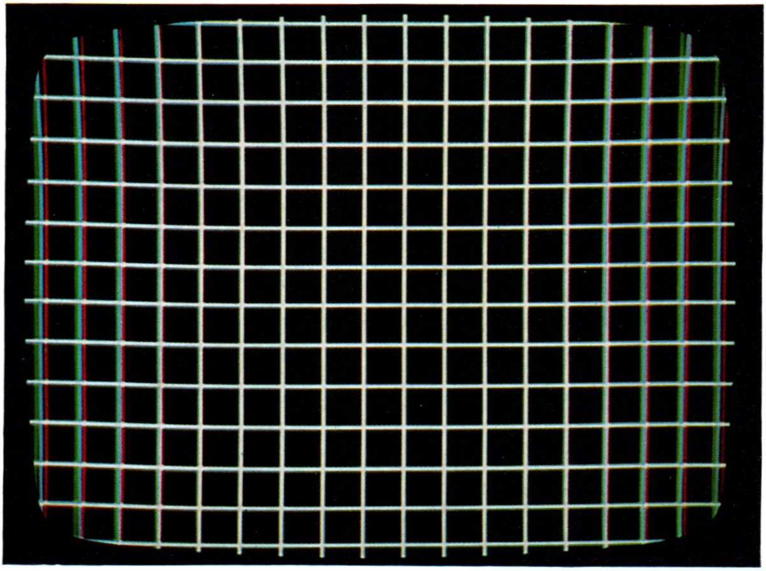


Fig. 30. Cross-hatch pattern after adjustment of the complete radial convergence, but without dynamic blue lateral convergence.

(h) If necessary, re-adjust the static convergence.

(i) Switch on the blue beam.

(j) Render the horizontal blue line and the yellow (red-green) line equidistant by adjusting L_1 and R_3. With L_1 the left and right edge and the centre are equalized; R_3 corrects any difference between the left and right edge.

(k) Smooth out any ripple of the blue line in the left and right centre region by adjusting L_4. As an alternative, L_4 can be adjusted by means of an oscilloscope as described under (b) (see also Fig. 29). Fig. 30 shows a cross-hatch pattern after adjustment of the complete radial adjustment, but without dynamic blue lateral convergence.

(l) Render the blue and yellow (red-green) vertical lines at the edges coincident by adjusting L_5. Any remaining left-right asymmetry can be corrected by slightly turning the radial convergence unit. The blue vertical lines at the edges are then shifted in the direction in which the upper part of the convergence unit moves. After this manipulation the static and dynamic convergence must be checked again.

(m) Check the horizontal dynamic convergence.

General remark on the convergence adjustment

The convergence adjustment as described in points (11), (15) and (16) has been carried out, observing the centre and the horizontal and vertical axes of the screen only. In the corners, slight convergence errors may remain. However, after proper adjustment these errors should not exceed 2 to 2.5 mm (measured horizontally and vertically) which is hardly noticeable at normal viewing distance.

(17) Adjustment of the convergence affects the colour purity, so that a purity check as described under (12e) is essential.

(18) *Raster correction*

The raster correction is adjusted as to yield straight horizontal lines in the cross-hatch pattern. Fig. 31 shows a raster without correction, displaying pin-cushion distorsion. In Fig. 32, this has been corrected by the raster correcting system, which modulates the deflection currents.

(19) After final adjustment the raster dimensions should be checked again (see points (7) to (9)).

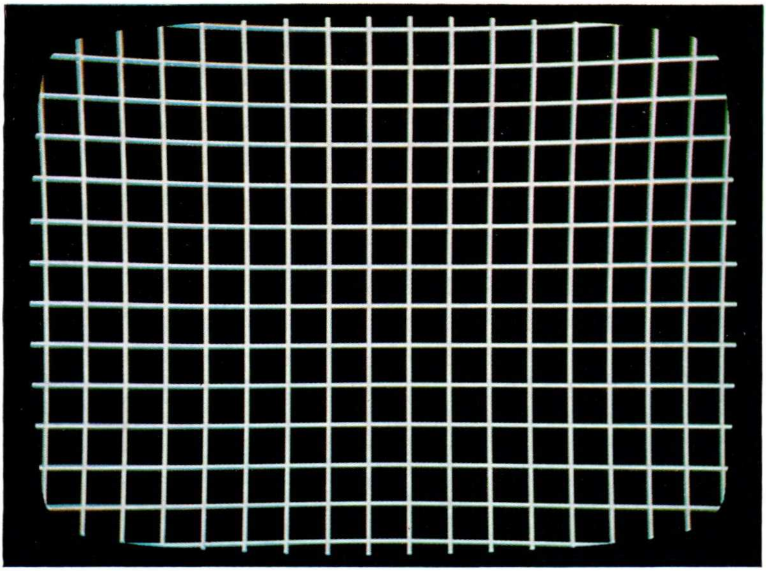


Fig. 31. Cross-hatch pattern after adjustment of the static and dynamic convergence, without raster correction.

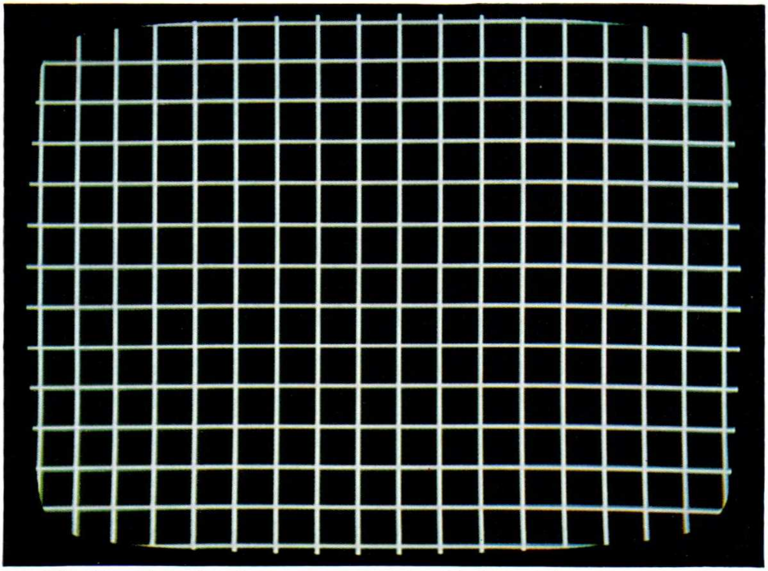


Fig. 32. Cross-hatch pattern as in Fig. 31, but with raster correction.

(20) *White and grey scale adjustment*

The adjustment at the correct hue of white is best made by comparison with a white reference source (e.g. another, properly adjusted colour receiver). If the white is compared with that of a normal black-and-white receiver, the latter should look slightly bluish. If the colour set has different white points for colour and black-and-white transmissions, the black-and-white colour point should resemble that of a black-and-white receiver. For this adjustment distinction should be made between circuits in which the drive voltage of two guns can be varied and those in which RGB drive is applied.

In circuits in which the drive voltage of two guns can be varied (for example, the potentiometer circuit shown in Fig. 16), adjustment is made with a black-and-white staircase signal, as follows:

(a) Set brightness control to central position.
(b) Adjust contrast so that all shades in the grey scale are visible.
(c) Switch-off the screen-grid voltages of the green and blue guns.
(d) Adjust the red screen-grid voltage so that the red lines are just visible in the black region.
(e) Switch-on screen-grid voltage for green and blue.
(f) Adjust for grey in the dark picture area by means of the screen-grid voltages of the green and blue system.
(g) Adjust for white in the bright picture area by means of the drive potentiometers for green and blue:
    - — if the tinting is purple, the drive voltage of the green system must be increased;
    - — if the tinting is yellow, the drive voltage of the blue system must be increased;
    - — if the tinting is red, the drive voltages of green and blue must be increased;
    - — if the tinting is blue or green, the drive voltages of blue or green must be reduced.
(h) Check the hue of the dark, medium and bright picture areas for uniformity.

In circuits in which RGB-drive is applied (as, for example, in Fig. 17), adjustment is made (also using a black-and-white staircase signal) as follows:

(a) Set brightness control at the central position.
(b) Adjust contrast so that all shades in the grey scale are visible.

Fig. 33. Grey scale with excessive red component. The colour shifts in the bright picture area are more difficult to perceive than those in the dark area. →

(c) Switch-off the screen-grid voltages of the green and blue guns.
(d) Adjust the red screen-grid voltage so that the red lines are just visible in the black region.
(e) Switch-on screen-grid voltages for green and blue.
(f) Adjust for white in the *dark* picture area by means of the screen-grid voltages of the green and blue system.
(g) Adjust for white in the *bright* picture area by means of the amplification controls of the red, green and blue video amplifier:

if the white of the bright area shows the tinge:	decrease:	increase:
red	red amplification	
blue	blue amplification	
green	green amplification	
yellow		blue amplification
purple		green amplification
blue-green		red amplification

(h) Check the hue of the dark, medium and bright picture areas for uniformity.

Figs 33 and 34 show photographs of an incorrectly and a correctly adjusted grey-scale respectively.

(21) *Focusing*

By means of a black-and-white test picture, the sharpness of the three electron beams is adjusted with the focus voltage control. Optimum focus should be sought at picture details of high brightness. For the RMA test picture, for instance (see Fig. 35), focusing should be adjusted for optimum rendition of the frequency wedge in the central bright picture area, while the average beam current should be about 1000 to 1200 μA. In this way optimum general sharpness is ensured. If the beam current is too low when focusing, there will be considerable blur in the bright picture areas, and Moiré effect may become

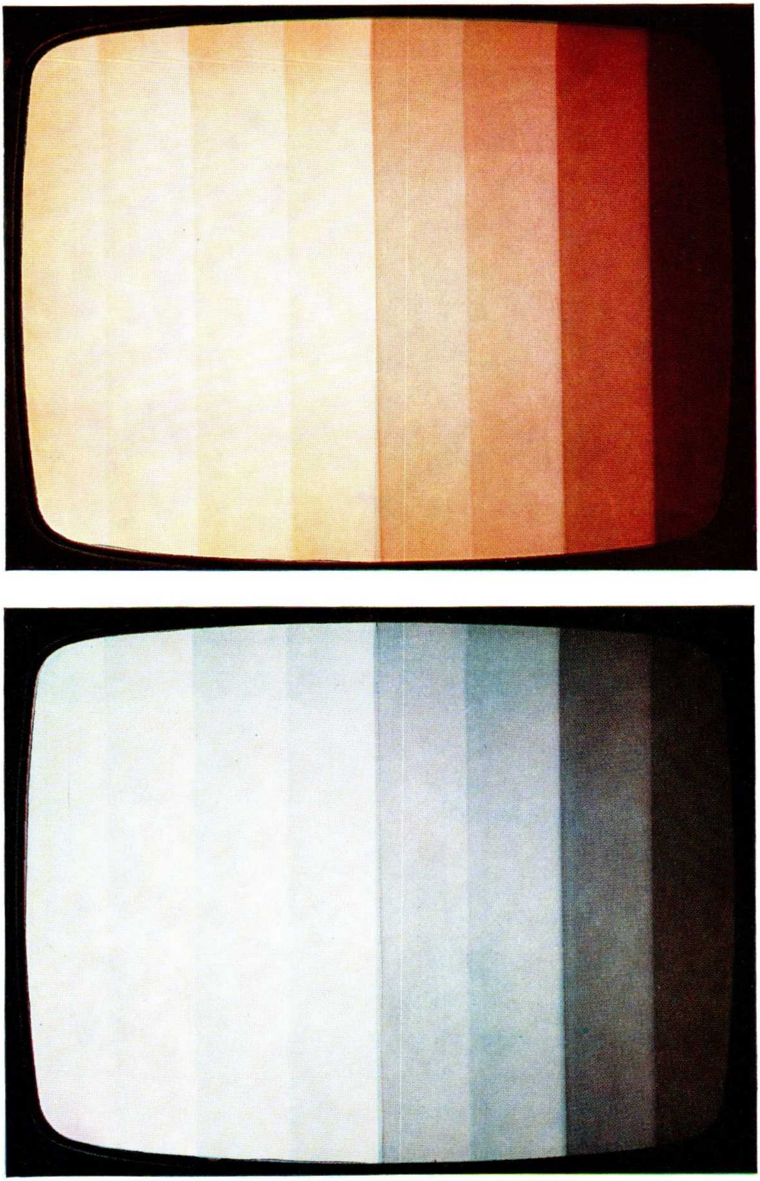


Fig. 34. Correctly adjusted grey scale in the colour picture tube.

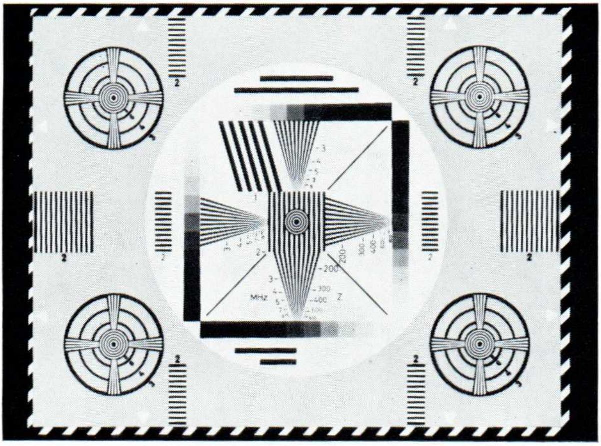


Fig. 35. RMA test picture.

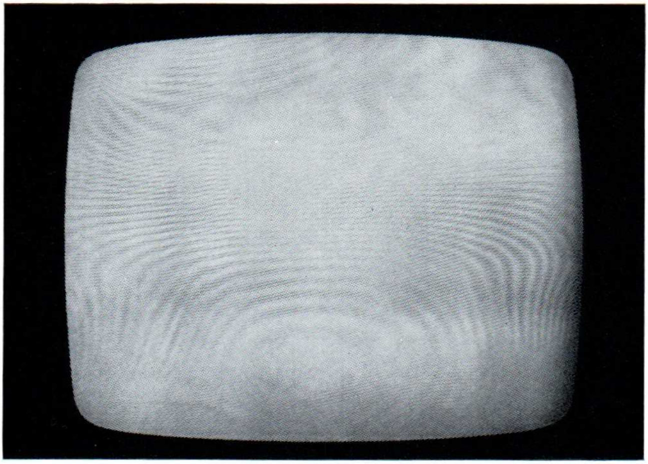


Fig. 36. Moiré effect as may occur in dark parts of the picture when focusing is adjusted at too low a beam current.

evident; this is due to interference between the line and dot raster in the dark areas (see Fig. 36). Focusing the colour television picture tube requires greater care than does the same operation with a black-and-white tube. The reason is that the accelerating lens of the colour picture tube reacts more acutely than the uni-potential lens of black-and-white tubes, as it is particularly sensitive to voltage differences between the electrodes g_3 and g_4.

Printed in the Netherlands

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