BBC

ENGINEERING DIVISION

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NUMBER 69: **SEPTEMBER 1967**

A survey of the development of television test cards used in the BBC

by

G. HERSEE, M.I.E.R.E.
(Studio Planning and Installation Department, BBC Engineering Division)

BRITISH BROADCASTING CORPORATION

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FOREWORD

THIS is one of a series of Engineering Monographs published by the British Broadcasting Corporation. About six are produced every year, each dealing with a technical subject within the field of television and sound broadcasting. Each Monograph describes work that has been done by the Engineering Division of the BBC and includes, where appropriate, a survey of earlier work on the same subject. From time to time the series may include selected reprints of articles by BBC authors that have appeared in technical journals. Papers dealing with general engineering developments in broadcasting may also be included occasionally.

This series should be of interest and value to engineers engaged in the fields of broadcasting and of telecommunications generally.

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A SURVEY OF THE DEVELOPMENT OF TELEVISION TEST CARDS USED IN THE BBC

SUMMARY

A historical review of the design of early test cards is followed by a discussion of the purposes of test cards and the influence of reproduction problems on their design. After reviewing some of the designs used in recent years, the monograph describes the design and manufacture of the latest Trade Test Card 'F', which is for use with a colour service, and gives examples of some specialized test cards and their uses.

1. Introduction

1.1 *Wide Variety of Test Patterns*

A very large number of test patterns are used in television engineering all over the world, and this monograph will have to be restricted to the discussion of a very small proportion of the patterns used in the broadcasting side of television. Even in this more limited field, the number is large enough for some people to have suggested that it is of the order of the number of engineers employed, and space must limit discussion to a few of the patterns used in the BBC.

1.2 *References in Literature*

References to test patterns are not frequent in the literature. This may be because so many engineers make the mistake of assuming that to draw a design and then get a photographer to copy it is so simple that there can be nothing difficult in it. As is so often the case, this is sometimes true, but only on rather rare occasions. More often the accuracy of the card assumed by the user is not attainable by the manufacturer, despite the most meticulous processing control.[1,2]

1.3 *Nomenclature*

A point of nomenclature should be cleared up at the start. By convention all patterns used for the purposes described in this monograph are referred to as 'cards' whether they are opacities or transparencies. Both types have their uses, even today; though most of the modern ones are now made only as transparencies. The pros and cons of each type will be discussed later when dealing with specific applications.

1.4 *Uses of Test Cards*

The main uses of test cards can be classified into three groups:

1. Exploring the transfer characteristics of opto/electronic transforms, i.e. camera tubes and flying spot tube/photocell systems.
2. Exploring the transfer characteristics of the reverse transform, i.e. receivers and picture monitors.
3. Geometry tests. In this category come not only testing of the scan geometry of camera and display tubes but also such uses as the registration of multi-tube colour cameras; the registration of multi-projector systems such as are used in caption equipments and telecines, and hop and weave tests on telecines and film cameras.

Tests coming under different classes can sometimes be combined on one card, but when this is done it often complicates the design and makes production of the card much more difficult.

PART I
TEST CARDS FOR USE ON SCHEDULED TRANSMISSIONS

2. Historical Notes

It is of interest to see how the art of designing test cards has become more difficult with the increased sophistication of television.

2.1 *Test Card 'A'*

The first test card in general use in the BBC was designated 'A' (Fig. 1). It was drawn only in terms of black and white, so was easy to copy. Its purpose was to check the setting up of the high-velocity cameras used at that time. As these had no form of contrast law correction there was little point in checking the transfer characteristic, and so the design is such as to check only focus, relative frequency response, and (to a limited extent) scan geometry. The upper frequencies are produced by the blocks of bars or gratings, whilst low-frequency response errors are shown by streaking after the black bar beneath the circle. This feature is sometimes referred to as a 'letter-box'. It is also interesting to note that this card and its companion 'B' were never transmitted for other than engineering tests on the grounds that it would have been equivalent to transmitting a 'squeak'* in sound; a thing never done at a publicized time in those days.

* The BBC term for a frequency-response check.

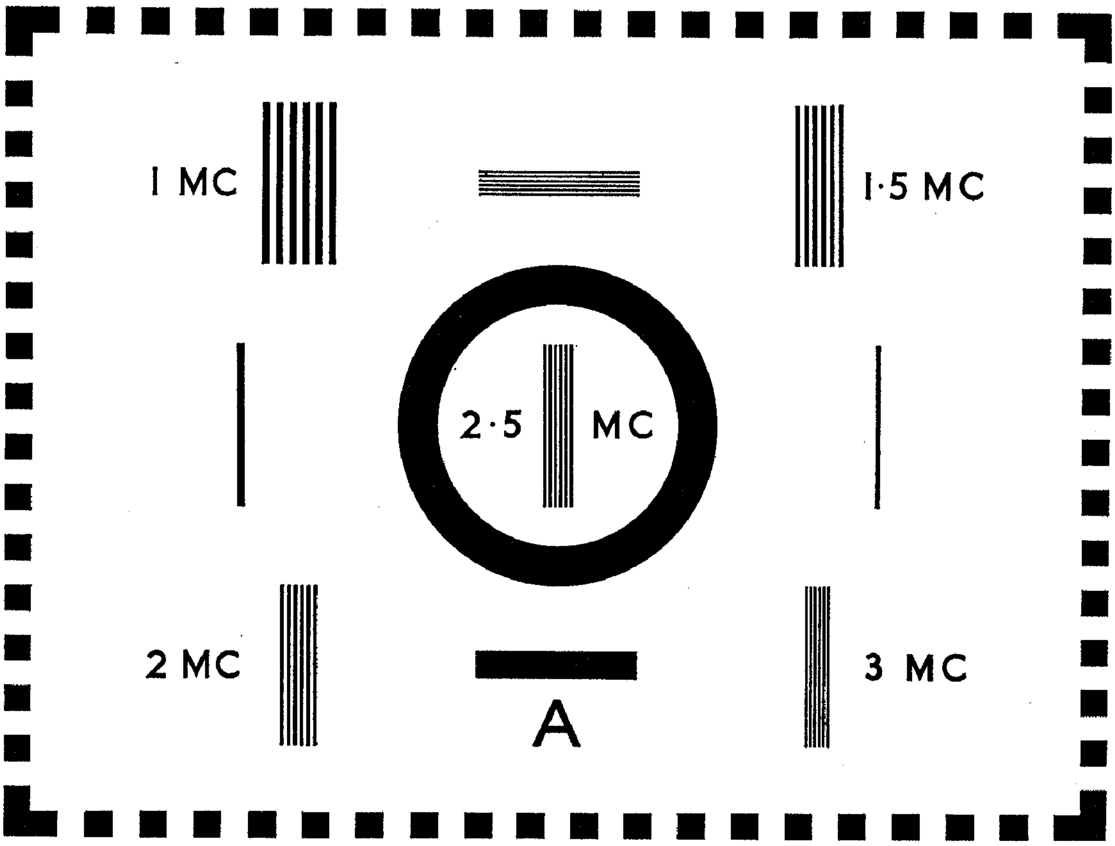


Fig. 1 — *Test Card 'A'*

2.2 *Test Card 'B'*

'**B**' was a similar design with the 'letter-box' moved to the top, the positions of the various frequency bars interchanged, and a copy of an Ilford panchromatic response chart affixed where the 'letter-box' is in 'A'. This latter chart was the cause of some confusion in as much as it consisted of a series of pigmented areas ranging through the spectrum from red to blue and a corresponding set of grey areas which showed the relative brightness of each of the coloured areas when the chart was photographed with film having a true panchromatic response. As there was no attempt to match the luminosity of the coloured areas, the grey ones ranged from light to mid-grey. Unfortunately, many engineers did not seem to appreciate the purpose of this test and often used to refer to the various areas as if they were defining equal steps between black and white, thus illustrating one vital point when using test cards—understand what each test is for; do not misuse it.

As an aside it may be mentioned that the radiated signal used for setting up receivers was an electronically generated signal of a black cross on a white background (colloquially known as 'art-bars'—short for 'artificial' because they were not optically produced). This simple signal was sufficient for those early receivers, as it checked the synchronizing circuits, showed that the picture circuits were passing signals of the correct amplitude, and permitted the setting up of the picture tube for brightness, contrast, and focus. With no daytime programmes the need to have pictures to help dealers demonstrate sets was overcome by the transmission of a demonstration film for 1½ hours each morning.

2.3 *Test Card 'C'*

When the service restarted after being interrupted by the war it soon became obvious that a need existed for a more elaborate signal to enable servicemen to check that receivers were working correctly. This should give more tests than the 'art-bars' had done, yet they should not require any equipment other than the receiver itself. After much discussion between the BBC and the receiver manufacturers the famous Test Card 'C' (Fig. 2, page 9) was evolved. This is too well known to need describing here, but suffice it to say that it remained in use for trade test transmissions from 1947 to 1964 and is still used in a modified form for 625-line standards. Furthermore, many of its features were copied in other cards which were used by many other broadcasting organizations.

2.4 *Test Cards 'D' and 'E'*

In 1964 a new trade test card was introduced.[3] This one, 'D' (Fig. 3, page 9) was designed jointly by the BBC, the ITA, and BREMA to eliminate the few troubles which had shown up with the long use of 'C'. At the same time a version for 625-line standards, 'E', was produced. This is no longer in use; all because of a small difference from 'D' which was originally incorporated as an improvement. This is a very good example of the difficulties of designing successful test cards and so is worth examining in detail.

'D' was the first attempt to incorporate frequency bars of sine-wave cross-section in a radiated test card. Now this is a good feature for a test card intended to assess camera tubes (e.g. Nos. 51 and 52, Sec. 6.2) where the depth of modulation of the bars will be measured with waveform monitors (oscilloscopes), but when used for visual checking on a picture tube the sine-wave bars do look a little soft or unsharp. Whilst the master for 'D' was being made it was suggested that it would be an improvement if, instead of being surrounded by an area of grey of the same density as the minimum of the bars, they were surrounded by a grey of mean bar density and the width of the block of bars adjusted to allow the sine-wave to start from this level, i.e. an exact number of cycles. This removed any sudden transitions from grey to sine-wave. As is so often the case, time did not permit a full trial of this variation before the master was made. The modulation depth of the bars on this card had been restricted in order to minimize distortion in non-linear circuits. This restriction accentuated the apparent softness of the sine-wave bars as seen on the receiver screen, and the additional effect of the lower-toned grey surround in 'E' was found to make the appearance completely unacceptable. Modifying the master was considered an unnecessary expense in view of the fact that the introduction of a colour service was anticipated and work was about to start on the Colour Trade Test Card 'F'. It was therefore decided that the best course was not to use 'E' pending the introduction of 'F'.

3. Discussion of some Design Parameters

3.1 *Step Wedges*

These are also referred to as grey scales, a term which is perhaps a little more descriptive of their use. Usually the steps are of various shades of grey over the total contrast range of the card. The number of steps and the density difference between adjacent ones depends upon the intended use of the card. If it is for measurement of the law of the transfer function then an equal change in density for each step is usually chosen. If this chosen value is 0·15 then each step passes $\sqrt{2}$ times the light of the previous one, a feature which is very convenient when plotting the transfer characteristics. On this scale a light range of 45:1 is covered by a set of 11 steps which is often an acceptable number. However, if the intention is to indicate equal steps of visual brightness on a picture monitor, then a wedge in which the steps do not represent equal changes of density is needed. This immediately raises difficulties in deciding what interval is required, as the relationship between the light transmitted by the card and the light emitted by the picture tube very rarely lends itself to calculation. When it is realized that this relationship can be affected by the transfer characteristic of the camera tube; contrast law correction circuits; the differential linearity of distribution networks, transmitters, and receivers; the transfer characteristic of the picture tube and the ambient light falling on it, it soon becomes attractive to use an empirical method. This was done a few years ago by the BBC Research Department in order to determine the relationship between the five steps of Test Card 'C'[4]. This was a great step forward, as up till that time the various steps had been selected at the time of making each new master negative; illustrating yet another good test-card maxim—a precise specification and only one master.

Occasionally a step wedge with a logarithmic law is useful. Such a case is the setting up of a colour camera channel. It is imperative that the grey scale of the camera shall be free from any colour cast over the whole of the contrast range. This means that the law of each of the colour channels must be identical. As the camera tubes are working on the linear part of their characteristic and the contrast law correction circuits are of the power-law type, a logarithmic step wedge in front of the camera will give a linear law when the output is examined on a waveform monitor, making it much easier to make the three tubes track accurately over the range.

3.2 *Frequency Response*

This test is one which needs to be very carefully considered if the card is not to be misleading. As usual, the purpose has to be borne in mind, otherwise gross errors can be introduced.

If the final judging will be done on a picture tube by visual inspection there is a choice of techniques which the designer may adopt. Many prefer to use a 'wedge', by which is meant the feature whereby the bars which are used to generate signals of the required frequency are gradually tapered together and made appropriately thinner (Fig. 4).

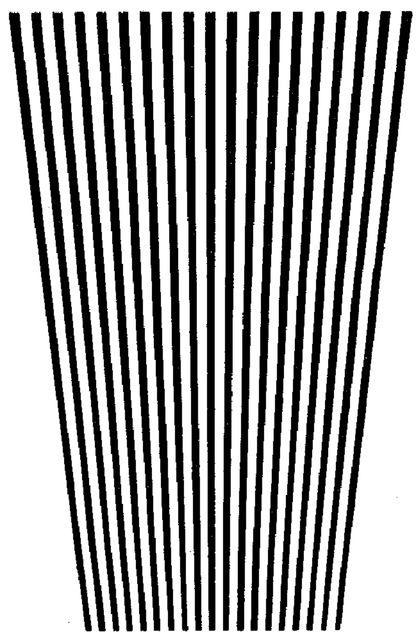


Fig. 4 — A typical frequency wedge

When using this design the technique is to place marks at the side of the wedge to indicate the positions at which the marked frequencies are generated and then the user can note the frequency at which the bars become indistinguishable. This makes it easy to note whether a change of conditions has made any improvement, e.g. checking of focus. Sometimes a wedge can also show if any astigmatism is present (indicated by the bars becoming clear again at a higher frequency). Unfortunately, this is a somewhat subjective test and different observers will obtain different results. Furthermore, engineers are usually interested in the frequency at which the response has dropped by 3 dB, but this wedge test indicates a frequency at which the loss is nearer 15–20 dB.

Where precision is needed it is better to use blocks of bars each generating a single frequency and to measure the response at these points. However, this is not so simple as many believe. There are two major sources of error and it is worth while to examine these in detail.

The first difficulty is to get a set of bars which are of sufficiently accurate modulation depth. If their cross-section is that of a square wave they may be drawn by normal drawing-office techniques and will give an equal contrast ratio for each block. There is then the inherent problem of the resolution of the film used to reproduce the card, although this does not usually become a problem until the card is made small enough to use in 16-mm telecine channels. The difficulty is that the best film for these bars is a high-contrast fine-grain emulsion known as a 'line emulsion', but this is almost unusable for half-tones, i.e. step wedges. An emulsion suitable for the latter usually produces definition difficulties. The second difficulty caused by a square wave bar is the distortion due to restricted bandwidth. When a square wave is passed through a circuit which has a bandwidth limited to less than the third harmonic the fundamental is the only component to emerge. Now by Fourier analysis it can be shown that the amplitude of this fundamental has been increased by a factor of $4/\pi$. Thus if the bandwidth limitation occurs before the distribution network (which it probably will) the result will be to overload the network with consequent severe distortion. In any case, the amplitude which is fed to the receiver or to the picture monitor will be in error and will give misleading readings.

One way to get over this is to start with sine-wave bars, but one is then back into the difficulty of producing them with a reasonably small amount of distortion and with constant amplitude. The author has tried using telerecording techniques (see the discussion on Test Card No. 51 later), but was not very successful due to the different exposure required with different magnification if a still camera is used; and with getting a phased locked oscillator to stabilize if using a cine-camera. A successful method has been developed by Archard,[2] but this is probably beyond the means available to most designers of test cards.

In the author's opinion sine-wave bars are of great use for the testing of cameras and similar pick-up devices, but for other purposes square-wave bars are better, particularly if care is taken to hold the amplitude of the bars down to 78 per cent of the peak modulation, so that the signal after bandwidth limiting will be the desired 100 per cent.

3.3 *The Place of Pictures in Test Cards*

From what has been said already the reader may have got the impression that there is no place in a test card for a picture as it does not allow any measurement to be made from it. This is not so; the inclusion of a picture not only gives a feature which the non-technical can appreciate but it also gives the necessary broken background demanded by some types of camera tube. However, any picture used in a test card must be very carefully chosen if it is to justify its inclusion. If its selection is only for the purpose of providing a decorative background the few points to study are that there are no large areas of even tone, particularly white; together with the obvious ones of sharpness and attractiveness. But if it is intended that the picture is to help the non-technical to assess the performance of the pick-up device, then the selection must take into account such features as the clear distinction between the foreground and the background (to distinguish which parts should be sharp), some very clear fine detail of high contrast to check focus, and approximately the same contrast range as that of the finished card into which it is to be incorporated. Such a picture is not seen very often, and may entail either a long search or else having one specially taken. At the time that the Test Card No. 51 was being designed one was found which fulfilled all the requirements and for which suitable copyright arrangements could be made (see Section 6.2).

When dealing with test cards for colour television there are additional requirements which have to be fulfilled. These include such features as colour rendering, restricted contrast range, and absence of a colour cast at any point of the grey scale. These will be dealt with in greater detail later when discussing Test Card 'F'.

4. New Trade Test Card for Colour Service ('F')

Shortly after the development of Test Card 'D' it became likely that a colour service would soon be approved, and a joint committee representing the BBC, the ITA, the EEA, and BREMA set to work to design a suitable card for transmission when a service started. In the early 1950's the BBC experimental colour service had used a colour card as a tuning signal (Fig. 5, page 10), but this was not suitable for servicemen's checking of receivers. There were two basic difficulties to be overcome: the fact that it must be suitable for the compatible black/white receiver; and that it might well be the only colour transmission during shopping hours and so should contain an attractive colour picture. The obvious starting-point was the pattern of 'D', but in order to include the picture the circle was reserved for this and the grey scales and frequency bars moved outside (Fig. 6, page 10). A symmetrical layout was obtained by making the step wedge of six steps instead of five. This is preferable to eliminating one of the frequency bars.

4.1 *The Grid*

Certain parts of the white grid lines are outlined in black. These are at the places on the card where it is desirable to check the colour receiver convergence (i.e. where

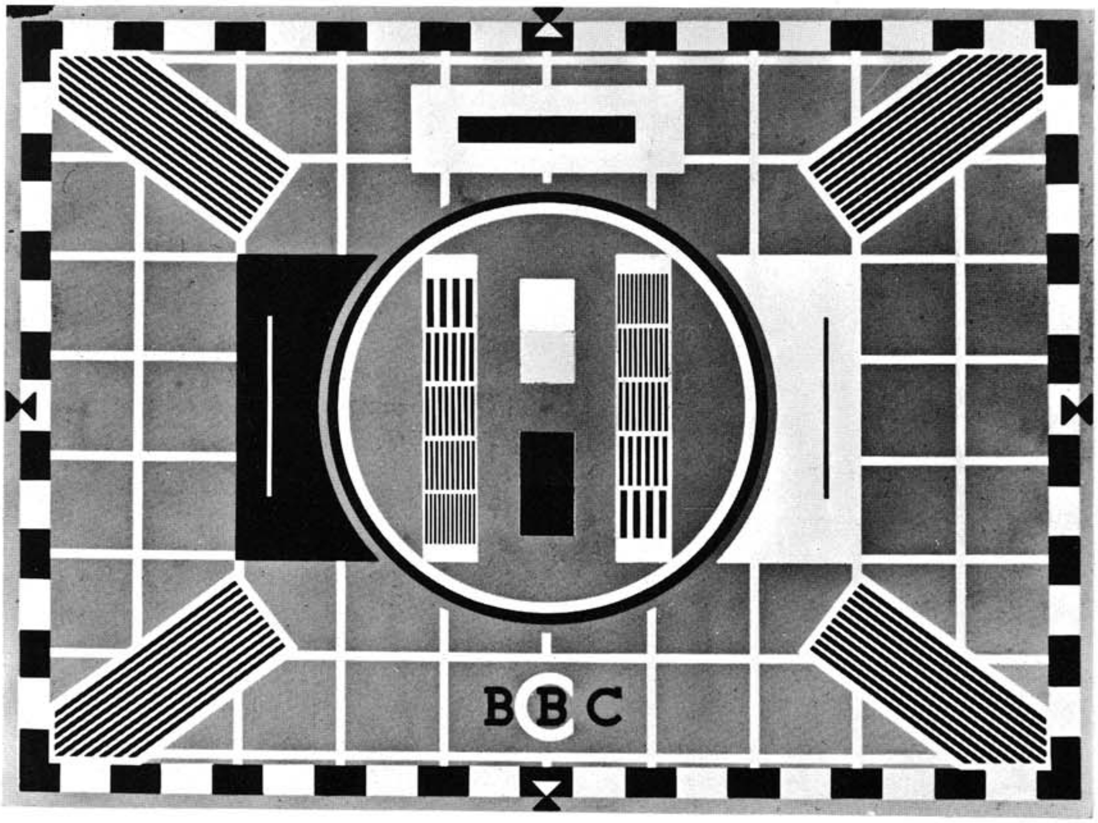


Fig. 2 — Test Card 'C'

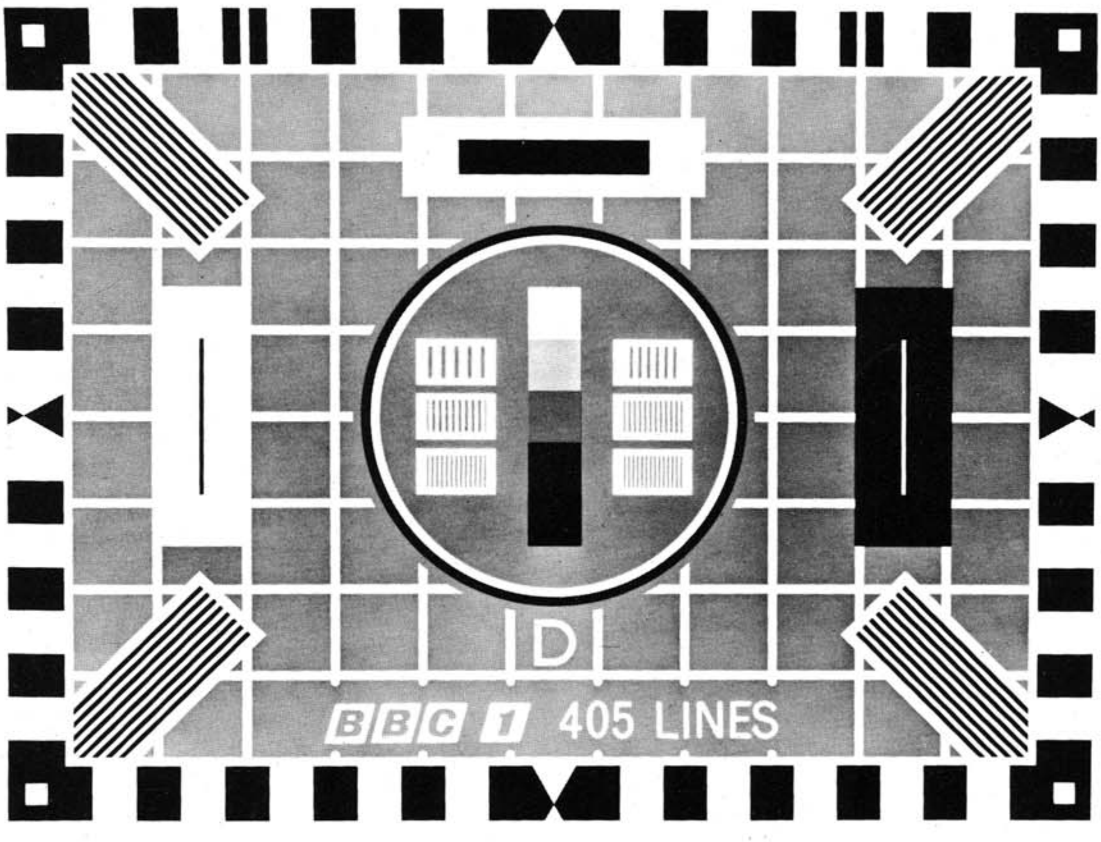


Fig. 3 — Test Card 'D'

Fig. 5 — Colour card used in experimental transmissions

Fig. 6 — Test Card 'F'

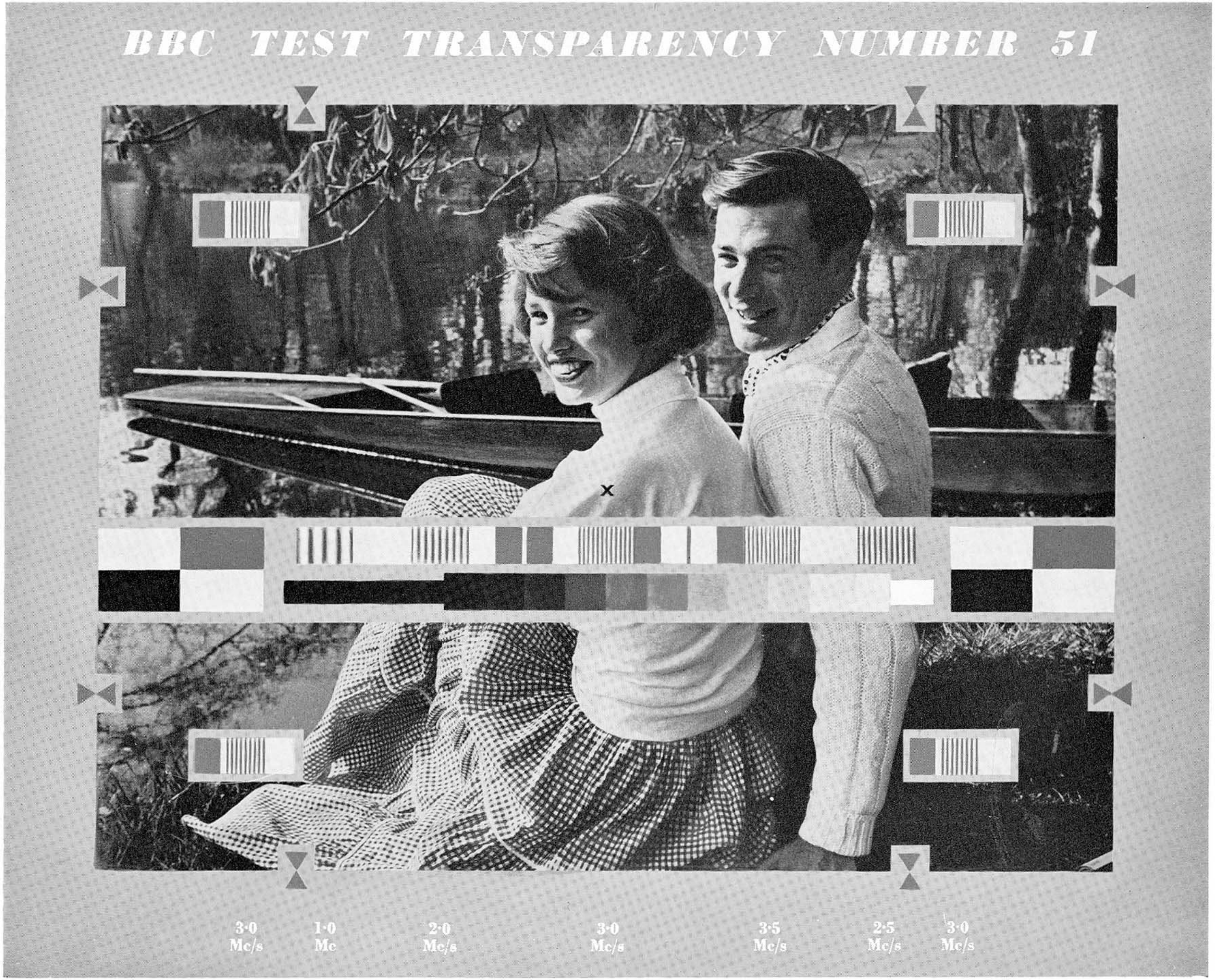


Fig. 7 — Test Card No. 51

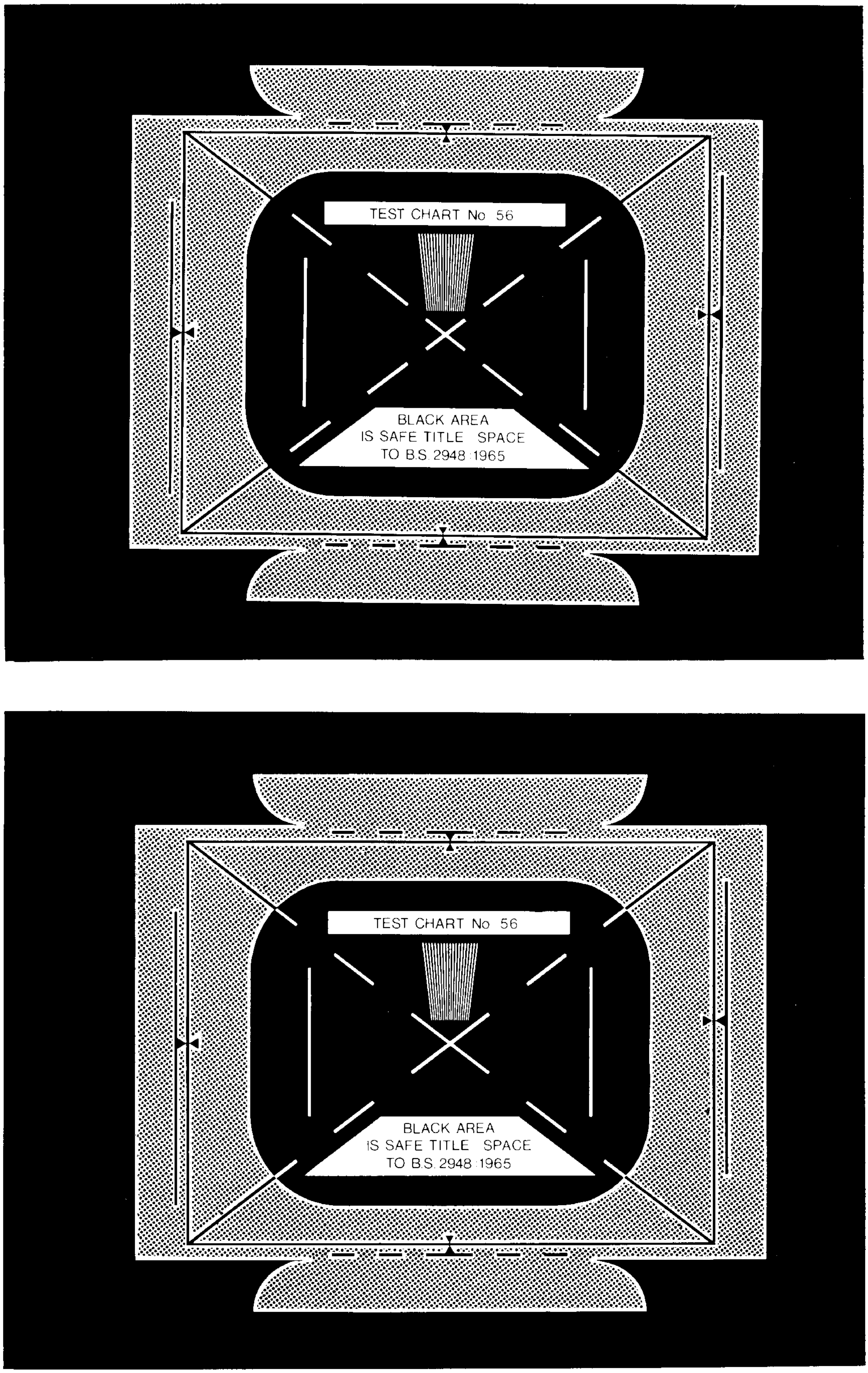


Fig. 9 — Test Card No. 56—a complementary pair

the three images on the shadow-mask tube should be in register). Not all the white lines are so outlined as it is possible to get an unusual fault condition which would be masked by doing so.

4.2 *The Step Wedge*

This has been altered to have six steps, but nevertheless to have approximately equal changes in brightness when viewed on the receiver. The densities of the end steps have not been altered; only the intermediate steps. This has been done for aesthetic reasons only, in order to give symmetry to the layout.

4.3 *The Frequency Bars*

These have been made rectangular in cross-section, but of only 78 per cent amplitude so that when the $4/\pi$ effect occurs the amplitude becomes approximately 100 per cent. The reason for returning to rectangular bars is that they are so much easier to manufacture and also that they do not suffer when reproduced with curved transfer characteristics; their amplitude may change, but this can be allowed for. The chosen frequencies are the same as those for 'E', and it is worth noticing that 2MHz and 3MHz are not chosen because the harmonics of these can cause buzz on the sound channel when using receivers with intercarrier sound systems.

4.4 *Reference Oscillator Tests*

Apart from all the usual tests which this card performs there are additional ones which are peculiar to the performance of a colour receiver. The convergence checking has already been mentioned in Section 4.1. (N.B. checking, not aligning. This pattern is unsuitable for the aligning of convergence circuits which needs electronically generated dot patterns.) Another test is one which shows whether the reference oscillator is being affected by picture information. If so, the oscillator will have the wrong phase and the whole of the line will have an error of hue. The left-hand edge of the picture area, i.e. the castellations, is made with areas of two colours instead of white. If an error is present, there will be bands of colour cast across the picture, the edges of these bands coinciding with the changes of the castellations from colour to black. On the right-hand side, one of the castellation areas has been coloured so that the effect of peak signals at the end of the line on the synchronizing circuits can be checked. To make it easier to decide which error is causing trouble the black/colour transitions of the castellations are placed at different heights on the two sides of the card.

4.5 *The Picture*

The picture requirements were quite exacting:

(*a*) To have a reasonable area of flesh tones.

(*b*) To include areas of bright colours to counteract the large black/white areas of the rest of the card.

(*c*) To have a white-on-black contrast near the centre of the circle. This is necessary in order to apply the convergence check.

(*d*) To be a pleasing picture as it is probably going to be seen on receivers in dealers' windows for several hours per day.

This list is quite formidable, particularly the white-on-black highlight near the centre. However, the first problem was to select a model. The contrast range of the brightness had to be restricted so that dark hair was unacceptable. After many tests a child's face was eventually chosen, not only because of the appeal of such a face but also because an older face would involve make-up, and fashions in this change yearly. This could lead to having to remake the picture each time the fashion changed, or else be accused of being out of date. Furthermore, an older model would have involved considerably more difficulties over modelling and reproduction fees—designing the card was trouble enough. Having once had the happy idea of getting the highlight by means of chalk on a blackboard, the rest of the composition soon fell into line. Numerous experimental photographs were made, however, before this stage was reached. To help selection they were back-projected on to a screen inset into an opaque sketch of what the finished card would look like. This allowed size and trim to be altered at will until an acceptable result was obtained.

4.6 *Manufacture*

Manufacture of such a card was originally considered to be formidable, but a series of trials established that the simplest way was satisfactory, i.e. to make the black/white information on one film and to make the colour information on another and to bind the two together in register. This does mean that the colour information has a cover of the base emulsion of the black/white film, but it was found to be acceptable, as was the covering of the black/white information with the unexposed emulsion of the colour film. To guarantee that the colour reproduction is as constant as possible between cards it is intended to make a large number of copies using film from the same emulsion batch and processed in the same baths. This is quite often done with such test cards, as it is almost impossible to reproduce colour pictures on different occasions to the accuracy required.

4.7 *Electronic Insert*

An essential test on a colour receiver is to ensure that the chrominance demodulator circuits are functioning properly. For this purpose an optically generated signal cannot be made sufficiently accurate, and so it is intended that when Test Card 'F' is transmitted the first four active lines of each field shall not carry picture information, but shall carry the standard electronic colour-bar signal (100 per cent modulation, 95 per cent saturation). By inserting the signal in this position, it is only a part of the castellations which is obliterated, yet it is possible to use a simple servicing oscilloscope triggered by the field display to obtain useful information. It proves possible to examine the signal for easily recognized changes of waveform shape and asymmetry or difference in amplitude from line to line; these being the type of errors produced if the demodulator is not working in true quadrature for the (R–Y) and (B–Y) signals or if the subsequent switching and amplifying stages are out of adjustment.

4.8 *Tests for PAL System*

Dr Mayer of I.R.T.[5] has proposed a comprehensive set of electronic test signals for PAL receivers, but it was felt that these were more applicable to production alignment and testing than to the purposes of this card. Furthermore, they take up a considerable area, which would seriously reduce the usefulness of the card to the black/white receiver on the compatible picture—and this will be in the majority for some time.

PART II
SPECIALIZED TEST CARDS AND THEIR USES

5. Introduction to Part II

In 1958 a new range of precision cards for testing camera tubes and other items of studio equipment was introduced. These cards are not normally radiated, and in order to distinguish them from earlier designs most of them have been given numbers in a new series starting at No. 50. The series includes cards for checking registration, sizing of the image, and other preliminary adjustments to the working conditions of a camera tube which have to be made before it is possible to start comparative tests. These and other registration test cards are described in Section 7, while Section 6 deals with the sophisticated designs which are used when the camera is in working condition and comparative tests are started, as these cards happen to have been given lower numbers in the series. Other precision designs have been included in the series for reference purposes, although they are intended primarily as trade test cards. The discussion of camera and registration test cards is set out in some detail and illustrates the influence which test conditions have on the design of these cards.

At present there are eight cards in this series: Nos. 50, 51, 52, and 53 are intended for camera testing; Nos. 54, 55, and 57 (otherwise known as 'D', 'E', and 'F' respectively) are for trade test purposes and have been described in Part I; whilst No. 56 is for the registration of caption equipment.

6. Cards for Camera Testing

6.1 *Test Card No. 50*

This card was produced as a test for the colour response of a camera tube. It consisted of three large areas of the three primary colours, red, green, and blue, with a step wedge inset into each area. If always used with the same illumination it gave a quickly determined reading for the tube's response to these three areas of the spectrum. The step wedges had steps of density 0·15, so that a change of two steps gave twice the light level. For production testing of tubes it was easy to block out all but the acceptable levels of the step wedge, giving a 'go-no-go' test. Care had to be taken to make sure that the density of each patch was constant from card to card, and when necessary neutral density films were incorporated to correct this. This card is now obsolescent.

6.2 *Test Cards Nos. 51 and 52* (*Fig. 7, page 11*)

These are identical designs except that No. 51 is fitted with frequency bars for the 405-line standards whilst No. 52 has bars for the 625-line standard. As the earlier monograph, No. 21, is now out of print, it will not be out of place here to summarize the portion dealing with these cards.[6]

As they are intended to be used for the testing of camera tubes, the requirements can be listed as:

(*a*) Measurement of the frequency response, using sine-wave bars.

(*b*) Measurement of the contrast law over a range of at least 60:1.

(*c*) Measurement of the loss in definition towards the corners.

(*d*) Provision of a picture with a background which breaks up the even tone and gives non-technical viewers a chance to assess the quality of reproduction.

The first requirement was to find the picture, adding the extra requirements that it should have a clearly defined foreground making it clear which parts are in focus, a pattern which allowed the quick assessment of focus since the sine-wave bars will appear soft to visual inspection, a composition that is not seriously affected by the inclusion of the technical test areas, and a contrast ratio of not more than 30:1. This was quite a problem, but such a picture was eventually discovered in the files of Ilford Ltd, and arrangements were made for the BBC to be granted the copyright of this picture for use in television test cards with the proviso that such cards were not radiated on a regular basis. Occasional radiation for engineering tests may be allowed, but not during regular or scheduled transmission hours. The selected picture fulfilled all the requirements, the check pattern of the girl's skirt being a very useful focusing check. At first sight many comments are made regarding the graininess of this picture, but this is so fine that it does not show through the television system, whilst it does help to limit the contrast ratio to about 30:1.

The next problem was to make the masters of the sine-wave bars. The first attempts (used in No. 51) were made by displaying the output of a phased-locked oscillator on a high-quality picture monitor and then photographing it at various magnifications. This change in magnification called for different exposures for each plate, but even using the same shutter speed (approximately 1/10th sec to integrate several frames) and varying the brightness of the display gave variable results after processing the plates as a batch. So the next attempt (for No. 52) was made using a phased-locked oscillator and a 35-mm telerecording channel. The required oscillator frequencies were calculated so that the developed film could be inserted in the master being prepared (10 in. × 7½ in.) and give the required spacing between bars. Whilst the film was running the oscillator was swung about these calculated frequencies. After development the film was projected and the frames with the correct spacings were selected for incorporation in the master. This ensured that the frequencies finally generated were correct (those for No. 51 were in considerable error, owing to the difficulty of measuring the bar spacing on the ground-glass screen), but unfortunately the low frequencies needed from the oscillator did not allow it to settle down in amplitude before the width of the frame was reached. So the amplitude of the lower sets of bars is not constant.

Meanwhile, the master negative was being prepared by a complex process which included the inlaying of areas of film in the same manner that marquetry is done.

6.2.1 *Method of Production*

Since the technical positive was the most complex to manufacture, it will be described first.

(*a*) *The Step Wedge*
This consisted of a standard Kodak step wedge with the densities above 2·4 cut off. This cut wedge, with a density range of 2·3, was then ready for mounting on the glass 'key-line' which will be described later.

(*b*) *Black/White Areas*
These were made by exposing sheets of film to the various densities required. Four of these were necessary, since the contrast range of the sine-wave definition bars is less than that of the step wedge.

(*c*) *Rectangular Pulses*
These were cut from the same film as the black/white areas (sine-wave line) and produce a pulse width of one two-hundredth of active line time. There are two of these pulses, one positive and one negative.

(*d*) *Sine-wave Resolution Bars*
The production of these has been discussed above. When the films were finally produced they were then cut and mounted on the glass 'key-line' together with the other technical films.

6.2.2. *The Picture Positive*

The original picture negative supplied measured 4 in. × 3 in. and had a density range of 0·2 to 1·68. From this negative a positive was made in the camera and enlarged to 10 in. × 7½ in., great care being taken not to distort the contrast range. Several attempts at this were made in order to ensure the most accurate copy possible. The resulting best positive was set aside for use as 'the picture positive'.

Two of the remaining picture positives were used in constructing the 'technical' and 'background' positives, the quality of picture being unimportant, but the accuracy of size being maintained.

6.2.3. *The Master Key Drawing*

At this stage some method had to be found to 'print' a key-line on each of the four component positives to enable very accurate registration to be made between them. Only a photomechanical method would ensure perfect registration between the four positives.

The first step was to make a precision key-line negative from the BBC drawing, and this was done by photographing it. This negative showed the general outline required, but its lines were still much too thick for the precise demarcation of boundaries. It was therefore corrected by cutting very fine lines into the negative emulsion and obliterating the false lines. After this correction it could be used as the basis for an extremely accurate layout.

At this stage the 'key-line' had to be superimposed on each of the master positives. This was done by coating them with a slow-speed, light-sensitive coating and exposing each one through the key-line positive to an arc light.

When developed, the image formed by the key-line positive was dyed with a methylene dye which gave a fine blue line over the existing positive image.

It was these blue lines to which all component parts on each of the positives were fitted or painted out (see Fig. 8), so that, for example, the technical information areas on the picture positives were removed in order to prevent light passing through and affecting the sensitive photographic plate when the final composite print was made.

After the four positives had been treated in this manner they were contact-printed one by one on to another photographic plate, using register marks on each side of the plate to obtain exact register.

This part of the job was the most difficult, due to the exact balance needed between technical and picture negatives, i.e. the picture had to be within the broad part of the step wedge in range. Several attempts were necessary before the required condition was met. The master negative produced by the above methods was then retouched by the artist and some minor modifications made to it. Further prints were then made from it as required.

At this time no attempt was made to correct for the curved transfer characteristic of the emulsions used, so that the final step wedge is not linear and tends to crush at the denser end. Because of this the manufacturer labels each slide with the densities of the lower four steps. Modern practice always corrects for this curvature, following methods similar to the one described by Holmes.[7]

6.3 *Test Card No. 53*

Like No. 50, this card is intended for testing of the spectral response of camera tubes, but with greater precision. It divides the spectrum into six bands rather than the three of No. 50, and does this by the use of dielectric filters instead of gelatine ones.[8] It is still under development, as

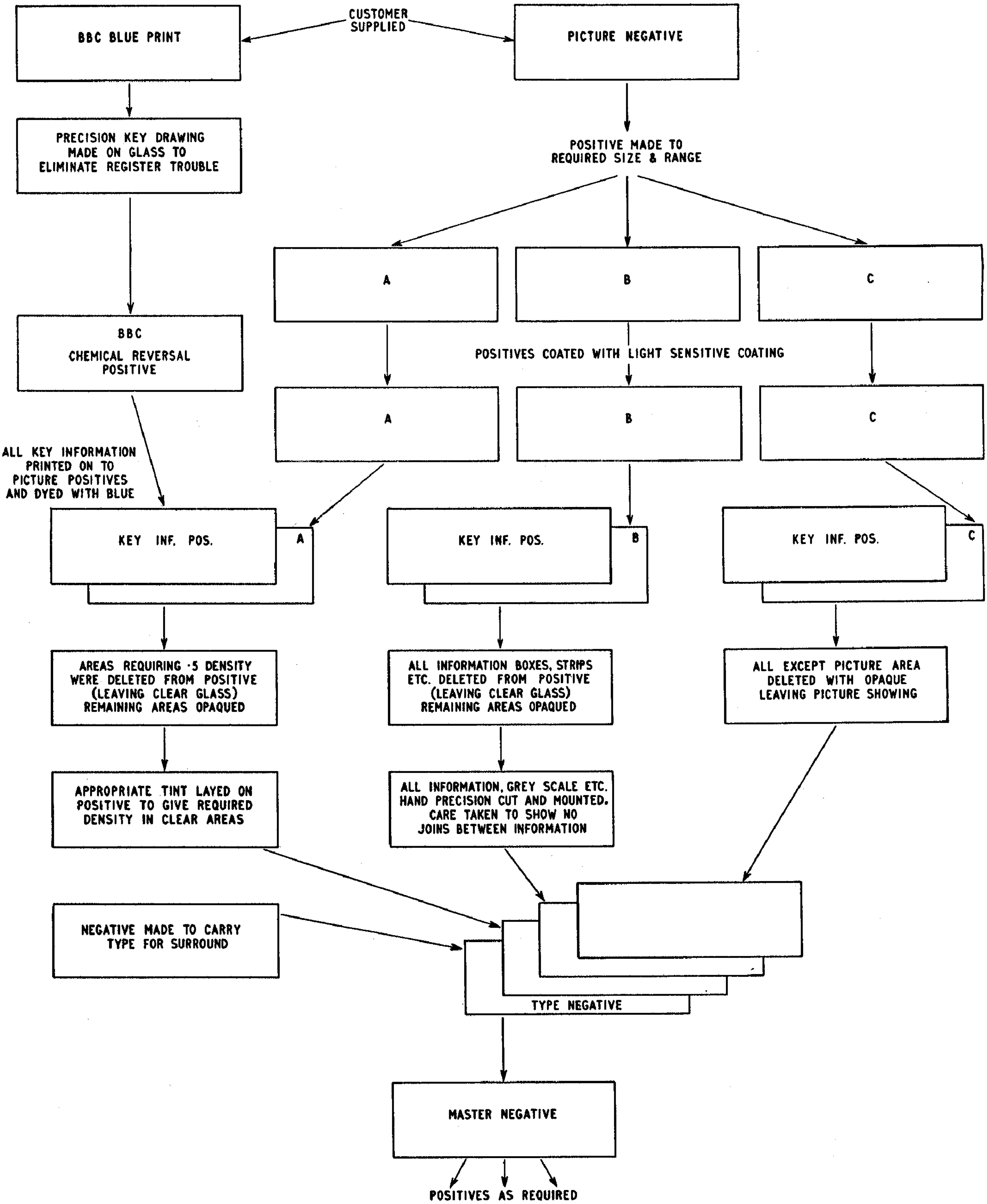


Fig. 8 — Manufacturing schematic for Test Card No. 51

even in a revised form it has shown up certain discrepancies in spectral response measurements, and this may necessitate recalibration of the neutral density filters which are behind the dielectric filters.

6.4 *Trade Test Cards Nos. 54 and 55*
These are the Trade Test Cards 'D' and 'E'. The latter has not been used (see Section 2.4), but 'D' is sometimes used for camera testing as well as trade tests although this is to be deprecated.

7. Registration Test Cards

7.1 *Test Card No. 56*
This card has recently been introduced for the purpose of aiding the alignment of two optical projectors whose images are multiplexed into a single camera. This card is in fact made in two versions forming matched pairs (Fig. 9, page 12), because it is easier to see the errors if the design is such that parts of the pattern are complementary rather than having to be superimposed. For this purpose the diagonal lines have been interrupted in different places so that when the images are in accurate registration the lines are continuous, but if there is any error then this is immediately obvious.

The bars in the centre are intended solely as a focusing aid, and so they have been made in the form of a wedge. The surround of the pattern has been left at a mid-grey so that it is possible to see the edges of a rectangular mask which is in contact with the tube face and which is used to define the scan amplitude. Because high definition is required, a high-contrast emulsion is used. This means that no intermediate greys are possible and these are, therefore, obtained by covering the area with a dot structure similar to that used for screen printing of half-tones.

7.2 *Colour Camera Registration Chart* (*Fig.* 10)
Another very useful chart, which is made with high-contrast emulsion, is this one which is used to register the images formed by the separate tubes of a colour camera. For this purpose it is necessary to align the scan patches on each of the tubes with the optical images on the photocathodes. The simple pattern of this card does all that is necessary, as the grid shows when the images are out of alignment or are of different sizes. Although the card is black and white, any misregistration shows as colour fringing when viewed on a colour monitor. The designs at the sides are intended to help in assessing orthogonality errors in scan coils.

7.3 *Hop and Weave Tests for Cine Equipment* (*Fig.* 11)
The usual technique used to measure the variations in picture position when using a cine-camera is to run the film through the camera photographing some test object, to rewind the undeveloped film, and then double expose it to rephotograph the same object, having moved either the object or the camera slightly between the two sets of exposures. Similar techniques can be applied to printers

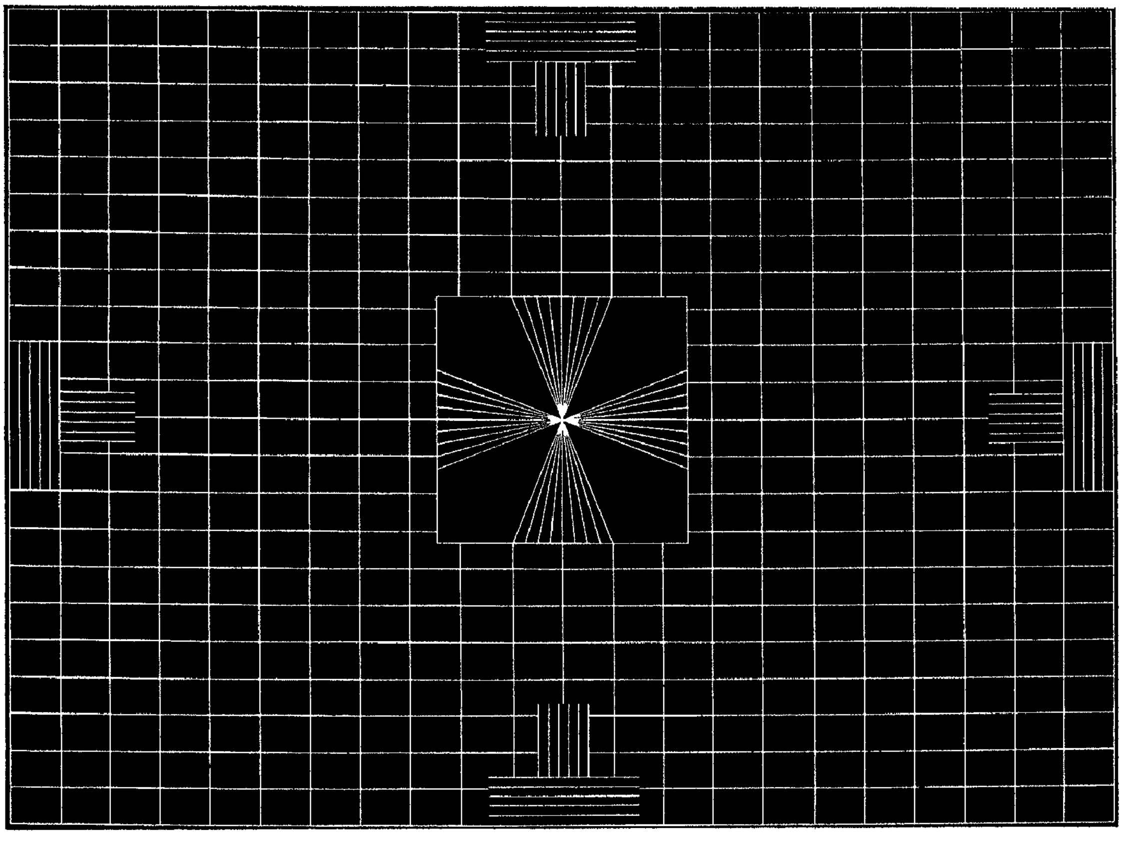


Fig. 10 — *Colour camera registration chart* and projectors (see below). Examination of the processed film will then show any variations of the relative positions of the two images; these can only be caused by variation of the film position between the two exposures. The vertical component of this movement is termed 'hop' and the horizontal 'weave'.

The particular chart described here, Fig. 11(*a*), was designed by Branson[9] to measure these components to an accuracy of approximately 0·1 per cent of picture width or height. To do this it uses a vernier method whereby an image of a scale of twenty divisions, each 2 per cent of the width, is compared with the image of a scale of the same length divided into nineteen divisions. A similar scale is used for the height. Then a relative movement of these scales will show an error of 0·105 per cent for each mark on the vernier.

The chart may be either a transparency or an opacity, but in either case means must be provided to black-out either the scales labelled 'EXP.1' or those labelled 'EXP.2'. The method used is not critical and may range from sticking on black tape to mechanically linked shutters.

To test a camera, the film is first exposed to the chart with only the scale 'EXP.1' showing. It is then rewound; scales 'EXP.1' obliterated and 'EXP.2' shown; and the same length of film is exposed a second time. Any failure to repeat the position of each frame can be seen by the relative movement of the scales and measured by the coincidence of the lines of the vernier scales.

To test a printer, either step-by-step or rotary, it is necessary to produce two negatives to be printed in register. Each contains one of the scales with the other one covered with a black patch (so as not to obliterate the scale). To make these a further length of film, beyond that used for the camera test is exposed to 'EXP.1' and a further length to 'EXP.2'. The scales are then removed if a transparency or covered in white if an opacity and the two lengths re-exposed with the masks set to show 'EXP.2' and 'EXP.1' respectively. Processing the film then produces the two negatives (Fig. 11(*b*)). The printer may then be tested by double printing first one and then the other on to the same frames of a print and examining it after processing (remembering to subtract the camera error found on the first part of the film).

To test a projector or telecine machine, only one negative is used and its image is compared with a still picture of the other.

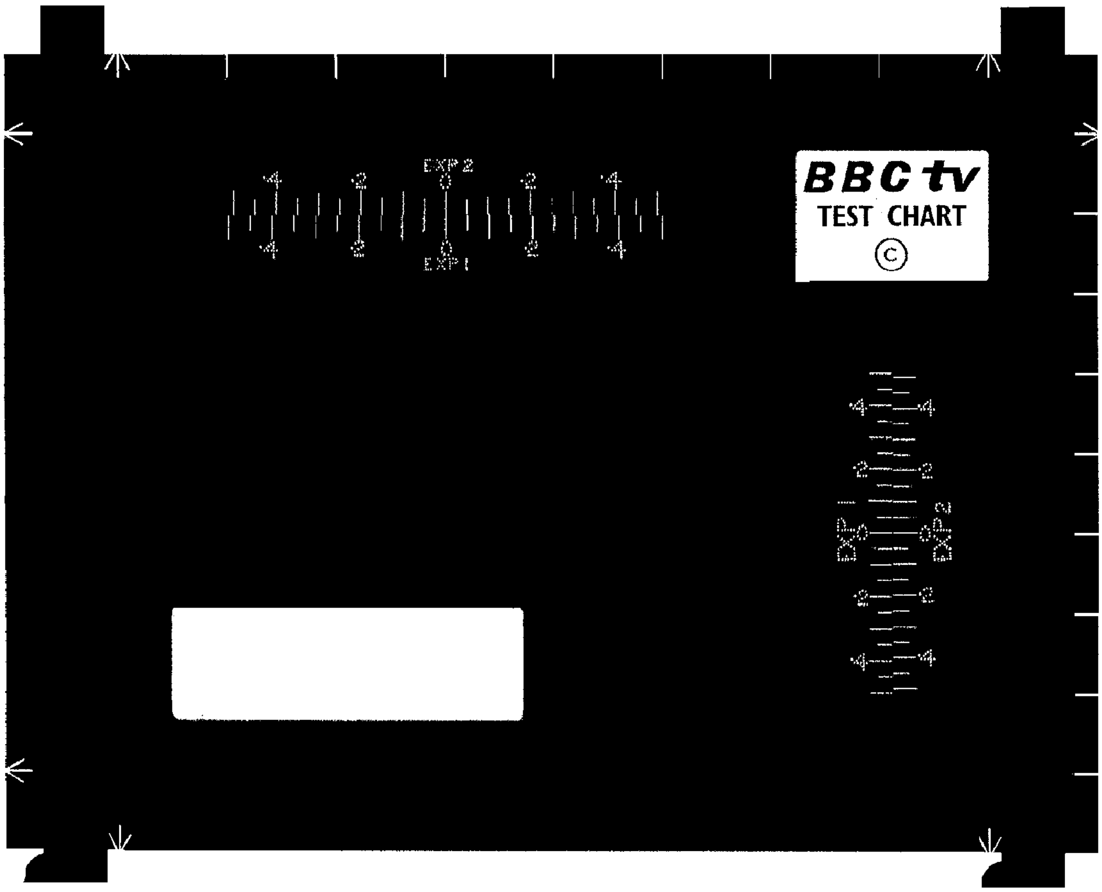
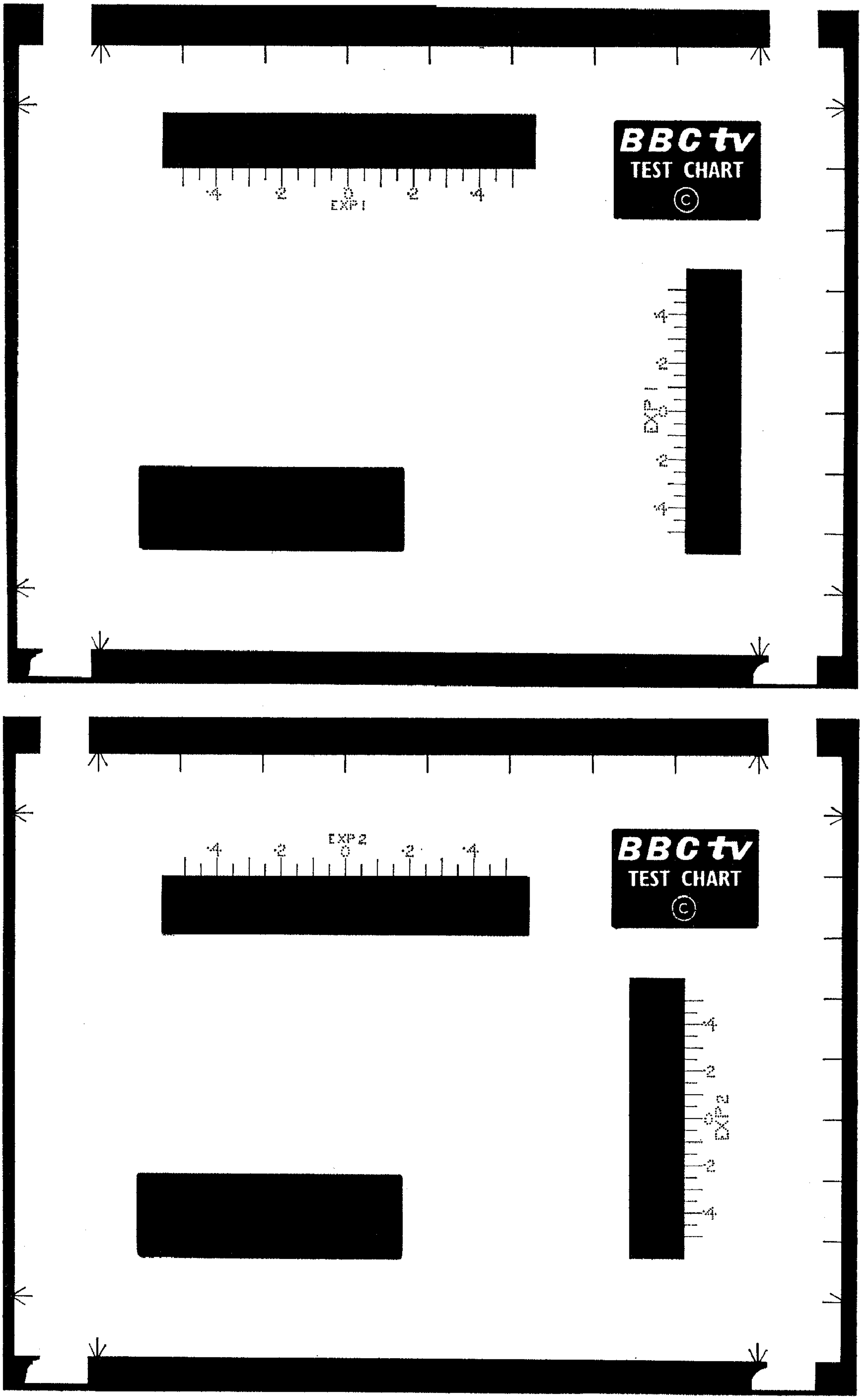


Fig. 11 — *Hop and weave tests*

(*a*) Complete chart



(*b*) Paired negatives

8. Future Problems

It is not out of place to finish with a review of some of the problems which will become important in the future. The first one is registration accuracy of the pattern in the mount. This is of importance with slides used for such purposes as No. 56, where the solution adopted is to have the film (used for convenience of handling) cemented between sheets of 'Perspex' which are then trimmed for size and position of image. This is rather expensive, but a cheaper solution is in sight with the imminent introduction of a precision mount.

Another problem will be posed by the increase in contrast range needed to match the increased contrast range of modern pick-up devices. Whilst ratios of several hundred to one can be obtained with 'line' emulsions, reaching 100:1 with 'half-tone' emulsions can be difficult and needs carefully reproducible processing to enable corrections for the non-linear characteristic of the film to be computed and applied.

A third problem which has already been posed on occasions is the production of a pulse to give the optical equivalent of the sine-squared pulse used for testing circuits. So far this has not been applicable in the same form to pick-up devices, as their characteristics are usually non-linear over the contrast range in use and/or the correction circuits are not precise enough to give any meaning to the test. Improvements, however, are always being made and performance is approaching the point where the transfer characteristic can be examined in this manner. In this connection, Seyler[10] claims that measurements of half-height duration and pulse/bar ratio using a rectangular pulse of duration 2T are of use for routine checking.

No doubt these problems will be resolved, but either new techniques will be developed or else progress will depend upon the increase in performance of photographic film towards the ideal of high contrast ratio (density range) and high definition (low graininess) together with a long linear region in the transfer characteristic for good half-tone rendition. As an example of the former, some experiments have already been done using photo-etching of metal foil, after the manner of printed wiring; half-tones being obtained by normal screening techniques.

9. References

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