OPERATIONAL CONTROL OF TELEVISION STUDIO PICTURE QUALITY

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OPERATIONAL CONTROL OF TELEVISION STUDIO PICTURE QUALITY

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SUMMARY

The paper outlines the operational procedures used in B.B.C. television studios for the control of television-studio picture quality, and discusses briefly the factors upon which the new techniques are based. There appears to be wide agreement that the pictures produced by modern equipment operated as described in the paper are consistent and of good technical quality. Also, application of the techniques has resulted in staff economies, and it would seem logical that the lighting and vision control functions of television operations should completely merge, as equipment design and operational techniques progress.

(1) INTRODUCTION

New operational techniques designed to exploit the potentialities of improved television studio equipment have now been in use in B.B.C. studios for some two years.[1] Apart from enabling pictures of high dramatic, artistic and technical quality to be produced consistently under day-to-day operational conditions, the application of these techniques has resulted in valuable staff economies.

Ten years ago, at the time of The Institution's Convention on the British contribution to television, equipment performance was very variable—particularly where camera tubes having high-velocity scanning beams were employed—and it was common practice to use one operator to control each television camera channel. In addition, considerable technical effort was necessary to carry out a daily line-up of the distribution system and a pre-transmission line-up of mixers and individual circuits, numerous amplifiers throughout the system having variable gain and black-level controls.

Gradually, with the development of more stable electronic equipment, and with the increasing use of camera tubes having a low-velocity scanning beam, equipment performance became more predictable. By 1955, the B.B.C. was, in general, operating 4-camera studios with three vision control operators, one operator controlling each pair of channels, and a third operator (or supervisor) being responsible for ensuring that the pictures from all four cameras were correctly matched, and having overriding control of the outgoing signal.

However, the vagaries of the distribution system, the variations in output from different studio or telecine sources, and the operational techniques in use were all such as to necessitate extensive line-up, continual adjustment of picture controls, and a quality-check position in the main network distribution designed to take up gain and lift mismatches between different programme sources.

At about this time, rapid progress was being made in the use, for television, of comprehensive production-lighting control systems, and it was realized that considerable scope existed for the standardization of operational techniques throughout the system. A detailed analysis of equipment performance and operational techniques was started.

Today the vision-control function in a 6-camera studio is carried out by one skilled operator, and the distribution system in the main studio centres operates on a fixed-gain basis; overriding controls have been abolished in quality checking and in studios, and picture quality is controlled to close limits.

(2) GENERAL CONSIDERATIONS

The techniques now in use have been derived from a logical approach to the technical and artistic requirements of the television medium, and embrace a method of technical control of picture quality based upon three main factors:

(*a*) A high degree of electrical stability, with careful specification and accurate checking of equipment performance.
(*b*) Precise instructions, which take account of the limitations of the medium and which detail testing, line-up and operational procedures.
(*c*) Equipment layout which makes provision for the complete co-operation of the lighting and vision-control functions and for the maximum ease of line-up.

The characteristics of the various components of the television system have been examined in considerable detail elsewhere,[2–4] and the operational techniques now in use are, to a large extent, a practical interpretation of this work.

(2.1) Basic Operational Procedure

If numerous controls on a camera channel have to be continually adjusted during a programme to compensate for limitations in set design, lighting, camera-tube performance and other defects of the channel, and if little or no consideration is given to stabilizing the d.c. component[5] of the picture, it is not surprising if picture matching is poor, and the quality of the pictures variable. Consideration of these factors with particular reference to the transfer characteristics of the various units suggests an operational technique which fulfils the following requirements:

(i) As many as possible of the controls to be set prior to transmission.
(ii) Standard test transparencies to be used for line-up of all picture sources prior to transmission in accordance with precise instructions.
(iii) Precise adjustment of picture monitors, enabling operational control of a camera channel to be carried out in relation to the picture, not the waveform.
(iv) Control during a production to be confined ideally to adjustment of light input. (Practical limitations to this are discussed below.)
(v) Gain and lift not to be adjusted during transmission, so as to produce at all times 100% modulation of the voltage waveform.
(vi) The d.c. component of the picture to be stabilized whenever possible.
(vii) Performance of camera tubes to be specified in detail and tubes tested to ensure that their performance lies within the specified limits.

Given good set design and immaculate lighting, an electrically stable studio equipment used as indicated above would provide consistent picture quality from all sources without adjustment to any of the electrical parameters during a transmission period, and vision control during transmission would disappear. The system has not, unfortunately, reached this ideal state, and the

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extent to which vision control has to be applied in practice depends upon a number of factors, the most important being:

(*a*) Electrical stability of equipment and accuracy of line-up.
(*b*) Consistency of lighting on a given production.
(*c*) Control of scenery design and wardrobe.
(*d*) The need for special effects.

It is desirable to allow scenery designers and wardrobe as much latitude as possible in the choice of scenery and costume, particularly where, for instance, the hiring of period dress is concerned. Also, it is not always possible to obtain a consistent form of lighting for all shots of a given type in any particular production, nor is it always possible to produce certain dramatic or other effects solely by means of a change of lighting. Variations due to these factors can be compensated by controlling two parameters only of the vision chain, namely the light entering the picture tube and the contrast law. It is essential that such control be carried out on the vision signal from individual camera channels prior to transmission, and not on the transmitted signal, as has been the case. Adjustments during transmission are obvious to a viewer and, if frequent, are extremely annoying.

In a carefully planned production, very little adjustment is necessary, even to these controls, and the vision control of a number of camera channels can be carried out from one operational position. Such adjustments must be made while viewing a picture monitor (especially in low-key scenes where a great deal of the picture content is contained in dark areas), a waveform monitor being mainly of use as a quick check of the percentage voltage modulation produced by picture white.

It is of paramount importance that all picture monitors should be set up correctly and consistently if good individual picture quality and good matching are to be achieved. It is also highly desirable that the picture monitors in any one operational area should have tubes of the same make and colour.

Adjustment of the operational controls is discussed in Section 7, following a more detailed consideration of the setting-up procedures.

(3) EQUIPMENT PERFORMANCE

The basic aim of an operational system is to produce consistently a high standard of picture quality with the minimum operational effort. Such an object requires the use of equipment which is simple to adjust, simple to operate and free from drift.

(3.1) Camera Channels

Of the camera equipments at present in use, the simplest to adjust are those using the simplest tubes, i.e. the C.P.S. Emitron and the Vidicon. However, work on the 4½ in image-orthicon equipment has resulted in considerable simplification of its operation, and from the point of view of vision control after line-up, there is little to choose between any of the equipments. They are similarly free from drift.

Camera channels operated in the manner discussed in the paper must have a similar performance within close limits, and considerable work has been done by the B.B.C., in association with manufacturers, to devise satisfactory test specifications for camera tubes, camera channels, lenses and other individual pieces of equipment.

In those specifications stability is stressed, and in general the high standards demanded in this respect have been closely achieved. Some of the more important stability requirements are:

(i) *Black-level stability.*—Clamps shall maintain the reference of picture black to blanking level within 1% of maximum picture amplitude, independent of picture content and time. Care must be taken that they do not add spurious signals.

(ii) *Gain stability.*—Under stated conditions of operation the gain is required to remain stable within ±0·5 dB.

(iii) *Blanking-width stability.*—A variation in picture amplitude due to a change in picture content must not cause a change of line-blanking-pulse width of more than 0·1 μs. Nor must it be altered by more than 0·1 μs between the point at which it enters the channel and the video output.

The specification for the camera also places close tolerance limits on other important characteristics, such as signal/noise ratio, frequency and phase response, differential gain, contrast law, amplitude and positional hum, microphony, and scan linearity, size and centring.

The characteristics specified in relation to camera tubes are mentioned in Section 3.2.

(3.2) Camera Tube

Every effort has been made to derive an exact method of measuring all tube characteristics[4] and to relate the tolerances on the measurements to the subjective impression and the operational disturbance produced by the particular distortion. Each camera tube is tested prior to use in a studio camera, the tests being based upon a performance specification agreed with the manufacturers.

The most important parameters checked during operational testing are:

Sensitivity.
Signal/noise ratio.
Resolution.
Background (uniformity of both black and white areas).
Contrast range.
Microphony.
Geometry.
Freedom from spurious effects.
Colour response.

An operational version of the tests applied to a 4½ in image orthicon takes approximately 20 min to complete and ensures that tube performance is a known quantity. Prior to the use of these test procedures, tube performance was largely a matter of subjective assessment; it was not unusual for protracted discussions to occur on the performance of individual tubes, uncertainty occurring with, occasionally, some 30% of the image-orthicon tubes used in the B.B.C.'s London studios. This has now been reduced to a very low figure—generally not more than 2% or 3%.

Some practical performance figures obtained in B.B.C. studios using 4½ in image-orthicon cameras under day-to-day operational conditions are:

Tube: 4½ in image-orthicon type 822 (JEDEC No. 7389). Diagonal of used photo-cathode area, 1·6 in; orbiting, 4%.

Ratio of peak signal to r.m.s. noise: 38·5–40·5 dB (measured over 3 Mc/s bandwidth by comparison with calibrated white-noise source).[4]

Resolution: 60% at 3 Mc/s (measured using B.B.C. test card No. 51.[7] Aperture correction available is +7 dB at 3 Mc/s).

Sensitivity: *f*/8–*f*/11 when exposed to 25 ft-L (measured with the tube exposed so that a peak-white illumination of 25 ft-L is approximately half a stop above the knee[4] of the transfer characteristic). Tubes are rejected when they are below *f*/5·6.

Camera-tube performance remains the major single factor in attainment of high-quality pictures, and for this reason the mode of operation is under constant review. Some important factors relating to 4½ in image-orthicon operation and requiring special attention are:

Photo-cathode/target potential.—The highest possible photo-cathode-target potential is required, as this gives improved sensitivity and resolution, and less sticking. On recent equipment this potential has been raised to approximately 500 V, but even this value could with advantage be increased, yoke design permitting.

Target-mesh potential.—The potential of the target mesh has a major effect on tube performance, affecting transfer characteristic, resolution, signal/noise ratio, sensitivity, edge effect, lag and flutter. In particular, a low target voltage gives good resolution but poor signal/noise ratio and edge effect. A high target voltage gives a good signal/noise ratio but poor resolution and a picture lacking sparkle. A good compromise value is 2·75 V above cut-off. Image-orthicon tubes, even of the same type, can, however, differ in target-mesh spacing, and as a result have different transfer characteristics. The characteristics can be matched, provided that they are not extreme, by operating the tubes at different target voltages, which, for the reasons mentioned above, should not be lower than 2·25 V or higher than 3·25 V.

Beam focus.—The adjustment of beam focus is more complex than is at first apparent, and has to be set to provide a compromise between resolution, beam efficiency and dark-current variations (often referred to as black shading).

The image orthicon tends to produce an image of its dynode surface superimposed on the normal picture output, and the beam must be defocused to prevent this, even though such adjustment may cause a slight loss of picture resolution. This is particularly important if the return beam scans the emitting aperture, when a white 'dynode flare' will occur.

Also, at the best beam-focus point, the output signal falls by 10–15%, possibly owing to the beam diameter being too small to erase the full area of each element. This is an unsatisfactory situation, as it causes loss of signal and sensitivity, and, since a slight change of focus will cause an increase in output, it gives rise to a rather unstable condition of operation.

The preferred method of setting beam focus is first to find the point of maximum resolution and maximum signal dip, and then to reduce the focus potential until the signal rises almost to its peak value, a condition which is reached before the 3 Mc/s response begins to fall significantly. This adjustment will invariably remove any dynode-surface image and yet will still give good picture resolution and ensure stable operation.

Tube output-signal current.—To avoid overloading the camera-tube output circuits on the one hand, and exaggeration of noise and pick-up in the head amplifier on the other, it is desirable to operate the camera tube with a standard peak-to-peak output signal current. Individual tubes vary widely in their electron-multiplier gain, and it has been necessary to fit a variable control to one of the dynodes of the multiplier in order to set the standard output.

Shading.—All image-orthicon tubes suffer to some extent from dark-current variations causing 'black shading', i.e. areas of light and dark are visible, even with the lens cap on. The shading may take the form of large diffuse patches, of light or dark corners, or of fine diagonal patterns of swirl shapes. Several factors affect the shading, in particular the beam landing conditions on the target and on the first dynode. If shading is noticeable and troublesome on pictures, the tube must be rejected, but before this is done, every attempt is made to minimize the shading by careful adjustment of beam-focus, multi-focus and field-mesh bias.

Camera-tube scans.—Scan limits are set by adjusting them relative to the outline of a mask placed on the photo-cathode end of the tube. The mask dimensions are equivalent to the nominal optical-image size, and the use of such a device standardizes the used area of the tube and the angle of view of the lens.

All such factors are explained fully in local instructions which supplement the camera-channel line-up procedure outlined in Section 4.2.

(3.3) Vision Distribution System

The same general principles that governed the development of a standard vision control technique (Section 2) are also applicable to the complete vision distribution system, as, for example, that of the B.B.C. Television Centre.[1]

In this case a unity-gain distribution system has been installed using fixed-gain amplifiers having very high long-term stability, and stringent performance and stability requirements are placed upon the vision mixing equipment. The complete system is such that the lengthy operational line-up adjustments previously carried out prior to each transmission no longer take place, and only occasional routine checking of circuits is necessary.

Performance checks of the distribution system can be made using test facilities in the central apparatus room. These facilities provide a quick and accurate check of essential parameters and immediately show up slight variations in performance as well as positive fault conditions.

(4) EQUIPMENT LINE-UP

(4.1) Picture-Monitor Line-Up

Correct line-up of picture monitors can best be achieved by using a standard test signal for all monitor-setting purposes, and by controlling the ambient light. The test signal is required to:

(i) Enable the monitors to be set so that, in the agreed ambient surroundings, a signal consisting substantially of black is reproduced as subjective black.

(ii) Enable the contrast of the monitor to be set so that it is within its working capability, or alternatively, so that no physical discomfort is caused to the operator, whichever condition requires the lowest level of highlight brightness.

(iii) Allow for a certain level of ambient light. This level should be less than about the ¼ ft-L reflected off the monitor screen.

A suitable source of test signal has been developed by the B.B.C. and is known as the 'picture line-up generating equipment' (p.l.u.g.e.). Fig. 1 shows the output signal displayed on a picture monitor (with deliberate distortion of contrast so as to display the whole signal).

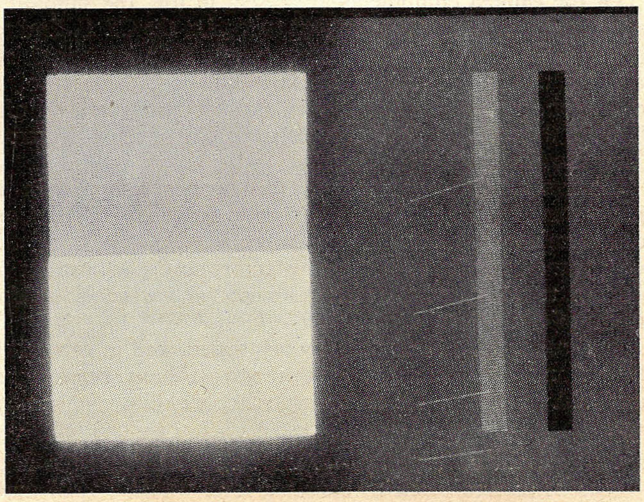

Fig. 1.—Picture monitor display on p.l.u.g.e.

The display contains two dark areas laid in, and just discernible from a dark background, and two larger white areas. In setting the brightness control of a picture monitor, it is quite easy to perceive the point at which details represented by the dark areas are discernible in the dark background. The background itself is such that, if the picture monitor brightness is set with reference to the background and the white information is then removed, the setting of the monitor just fulfils condition (i) above.

The background is in effect a 4% platform which compensates for any tendency for the monitor brightness to be adjusted, owing to the presence of the peak-white areas. If the platform is excluded, the brightness appears to be increased when reproducing a very dark scene. The voltage level of the platform has been determined empirically and is being kept under observation.

The white area of the test signal is split into two areas of 100% and 80% level, the lower level revealing any 'white crushing' which might be occurring. As white crushing is not uncommon on picture monitors, this facility offers a convenient test method enabling the screen brightness to be measured at two points in the white part of the transfer characteristic.

The picture-monitor line-up test signal is fed to all technical areas and can be displayed simultaneously on all monitors in any area by the throw of a switch.

(4.2) Camera-Channel Line-Up

An equipment line-up position designed to facilitate a quick and accurate line-up of the studio equipment is provided in the vision apparatus room of each studio. It incorporates:

(*a*) Two 14 in picture monitors, one of which can be switched to any of 23 preview sources, while the other can be switched by push-button to any local picture source.
(*b*) A high-grade oscilloscope which can be connected to either of the above or to tie-lines to the vision-apparatus-room bays. This forms the main measuring instrument of the studio.
(*c*) A variable vision attenuator, used in conjunction with the oscilloscope.
(*d*) The main control panels of all the camera channels.
(*e*) The control panels of the caption and inlay equipment.
(*f*) Mixer-change-over and pulse-change-over pushbuttons.
(*g*) A talk-back and telephone unit giving comprehensive communication with other areas.

(4.2.1) Differential Oscilloscope Measurements.

Widespread use is made of the differential measuring facility of the oscilloscope; the technique is, of course, well known, and installation is so arranged that differential measurements can be very easily performed.

A standard sawtooth waveform of amplitude 0·7 V (without sync pulses) is made permanently available at one of the oscilloscope inputs, the other input being switchable to various points in the transmission chain, e.g. to a camera-channel output. It is thus a simple matter to compare a signal at the test point with the standard signal and to adjust for equality as given by a null indication on the oscilloscope. The variable attenuator is provided to enable any inequality to be measured if required.

An elaboration of this method is used in setting up the contrast correction of the camera channel (see Section 4.2.3).

(4.2.2) Channel Gain.

A test-signal injection point is provided at the input to the head amplifier of the channel. Use is made of this injection point in setting up the overall gain of the channel by injecting a signal of precise amplitude and setting the various video gain controls of the channel so that the correct output amplitude is achieved against a standard reference signal.

There are several gain controls in cascade in the channel, and these are set in a fixed sequence.

(4.2.3) Contrast-Law Correction.

All camera tubes at present in operation require a certain amount of contrast-law correction. In the case of the $4\frac{1}{2}$ in image-orthicon equipment in use at the Television Centre, this correction characteristic consists of three regions of different gain, maximum gain occurring in the lower (black) section of the characteristic.

The correction required will vary with the picture subject and theme, and three different degrees of correction are made available to the vision control supervisor, who can select any one, as required, by a switch.

The curves in Fig. 2 indicate the contrast correction characteristics at present in use. The normal operational condition is one in which the lower (black) region of the transfer characteristic [curve (*b*)] is stretched by some 4·0 dB relative to the upper (white) region of the characteristic. Two other degrees of correction giving 2 dB and 6 dB of stretch [curves (*a*) and (*c*)], are used for scenes occupying probably some 20%–30% of programme time. The linear condition is used for special effects such as captions, night scenes, etc.

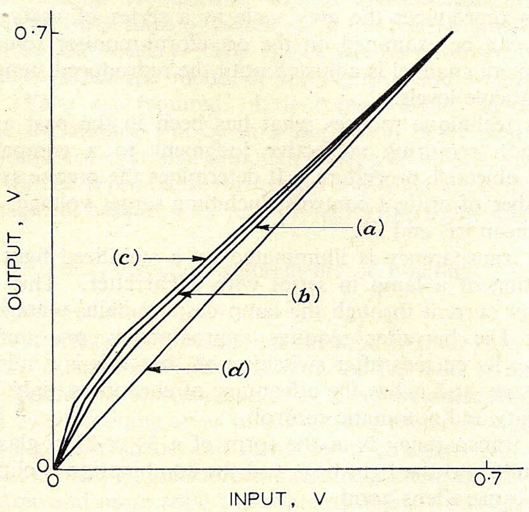

Fig. 2.—Contrast-law correction characteristics for a $4\frac{1}{2}$ in image orthicon.

(*a*) 2 dB of stretch.
(*b*) 4 dB of stretch.
(*c*) 6 dB of stretch.
(*d*) Linear condition.

All preset controls for setting up the required contrast laws are grouped in the lower portion of the main control panel on the apparatus-room line-up position and are set to preferred values using the differential methods mentioned above.

Preset lift and gain controls are provided for each of the three adjustable contrast laws to enable the peak output voltage and the lift to be set correctly for each law. Under these circumstances a change of law will not necessitate successive alterations to other picture controls. The points of onset of the different slopes of each characteristic are also variable, and the differential measurement technique is used to set these accurately to the required value. In addition, the setting-up procedure provides a check of the slope of each region of the characteristic, and as the relative slopes are fixed for each law, any variation indicates a fault condition.

Briefly, the setting up of the contrast-correction circuits is performed by injecting a sawtooth waveform into the channel, and comparing the input and output of the channel differentially on an oscilloscope. The difference signal provides a very accurate means of checking and setting the characteristics of the corrected waveform, either by using a special graticule to which the display is matched, as shown in the lower curves in Fig. 3B, or by measurement of the onset points of the different slopes using the normal measuring facilities of the oscilloscope.

(4.2.4) **Standard Sensitivity and Gradation.**

Of vital importance to the present operational technique is line-up of the overall sensitivity and contrast law of the complete camera channel (including the tube) to a predetermined standard. This could not be achieved with earlier procedures, but the method now in use is quite simple.

A stepped-grey-scale transparency, illuminated to a standard brightness, is positioned in front of the camera lens. The camera reproduces the grey scale as a series of voltage steps which can be examined on the waveform-monitor screen, and the camera channel is adjusted until the reproduced steps match the graticule levels.

This technique reduces what has been in the past a skilled operation requiring subjective judgment to a comparatively simple objective procedure. It determines the precise setting of a number of critical controls, including target voltage, dynode gain, mean iris and lift.

The transparency is illuminated by a stabilized light source consisting of a lamp in series with a barretter. This ensures constant current through the lamp despite mains-voltage variations. The barretter requires approximately one minute to stabilize its current after switching on, but this is a minor disadvantage, and it has the advantage of cheapness, light weight, simplicity and automatic control.

The transparency is in the form of a $3\frac{1}{4} \times 2\frac{1}{4}$ in glass slide. It is built into the light box, and the combination is clipped on to the camera lens hood.

The transparency, Fig. 3A, consists of a grey scale, having

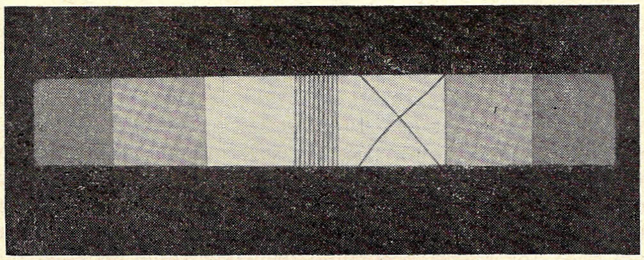

Fig. 3A.—Standard sensitivity and gradation transparency.

light transmissions of 25%, 50% and 100%, surrounded by black, i.e. 0% transmission. The grey scale is repeated in the reverse direction, i.e. 100% 50% and 25%, to give protection against false readings due to shading or dynode flares.

In between the two scales is placed a 3 Mc/s sine-wave grating. This enables the various foci to be adjusted and the resolution to be measured.

Finally, areas of 25% transmission are positioned in each corner for adjusting scan amplitudes, and are so shaped that their reproduction on a line-repetitive or field-repetitive oscilloscope does not confuse the grey-scale display. These areas extend out further than might seem necessary to ensure that the picture limits seen on the picture monitor are due to the photo-cathode mask (a device used on B.B.C. cameras to define usable photo-cathode area) and not to the edge of the test slide.

A critical part of the method of setting gradation lies in the choice of the voltage-level output to which the 0%, 25%, 50% and 100% steps in light transmission are made to correspond. The present choice has been made by a combination of theory and practice, and the levels adopted are 0%, 39%, 66% and 80%. These may be modified in the light of further experience. The 100% light step is made to give only 80% voltage output, as it has been found that, with this setting, good pictures result and that the signal swings right up to 100% on the waveform monitor, owing to overshoots and redistribution effects in the tube output. If the 100% step is set to 100% on the graticule, the resulting pictures show intolerable white clipping. The graticule at present in use is shown in Fig. 3B.

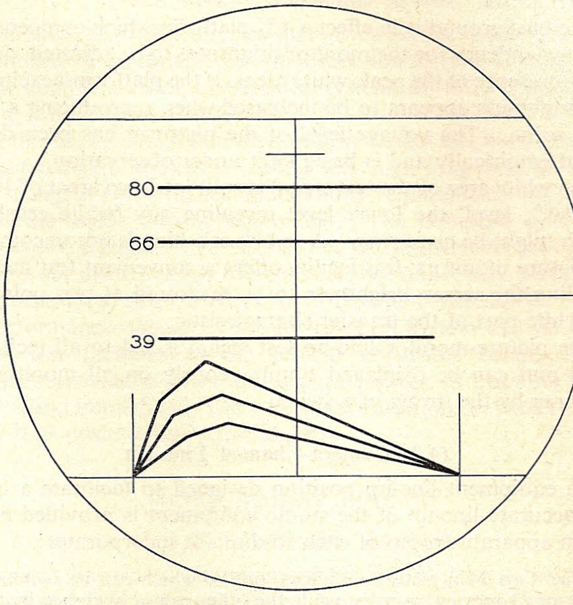

Fig. 3B.—Standard sensitivity and gradation waveform graticule.

Cross-hairs are added to one of the 100% steps to provide the test pattern for alignment adjustment.

A number of other important factors have to be carefully controlled during line-up of equipment, the above points being mentioned particularly as they either illustrate a new approach or indicate critical points of the setting-up procedure. The equipment performance checks and line-up are the responsibility of the maintenance staff. The line-up procedure sets the cameras to give a standard output when looking at a set subject, and all cameras are correctly matched. At this point, remote operational control is given to the vision control position in the lighting and vision control room.

(5) LAYOUT OF LIGHTING AND VISION CONTROL ROOM

The closest co-operation is essential between lighting and vision control and the layout of the lighting and vision control room has been designed with this prime requirement in mind, the lighting control console and vision control desks being placed side by side in front of a common group of high-grade 14 in monitors.

Positioned in the vision control desk in a convenient regular pattern are the combined iris/lift controls for the studio cameras. One such dual control is provided for each camera channel, and is such that a quadrant-type movement operates 'iris' whilst a rotary movement of the same control operates 'lift'. Adjacent to each combined iris/lift control is a fine-gain control, and a switch by which the range of adjustment given by the iris control (normally ± 1 stop) can be increased for special purposes.

To the right of the main control position is a panel containing a number of useful auxiliary controls, including contrast-law selection, scan reversal, etc. Remote control is also provided at the vision control position for the brightness and contrast of the picture monitors standing in front of the control desk.

The layout pattern of the picture monitors correspond to that of the combined (dual) controls, so that a picture is readily associated with its control. One picture monitor is provided for each operational camera channel along with two other monitors for other selected pictures. Beside each picture monitor is a waveform display, providing quantitative information to the operator, and also a meter which indicates the deviation from the mean setting of the camera iris.

The waveform display unit was developed by the B.B.C. to fulfil the special requirements for an operational waveform monitor of compact design yet providing a large vertical display by which the voltage excursions of the picture signal could be accurately monitored. The unit is approximately 14 in high by 3 in wide by 24 in deep and fits neatly on to the side of its associated picture monitor. Parallax reading errors are avoided by the provision of internally generated voltage limits of the video signal. The display is clamped and shows the field waveform only.

Pressing the combined iris/lift control on any channel operates a micro switch which switches the output of that channel on to the vision operator's general-preview monitor. In this way the various camera pictures can be displayed in quick succession on a single preview monitor for balance checking purposes.

On the lighting console are switch and dimmer controls for all the lamps in use in the studio, and these are adjusted and balanced by the lighting supervisor so as to produce the optimum technical and artistic quality, as described in Sections 6 and 7.

(6) LIGHTING

(6.1) Technical Requirements of Lighting

The first aim of lighting is to satisfy the requirements of the television camera in terms of incident light level and contrast range, so as to produce on the viewer's receiver pictures which are a satisfactory reproduction of the studio scene. The lighting must not aggravate any spurious effects due to technical limitations or unwanted distortions through the programme chain.

(6.1.1) Incident-Light Level.

In general the sensitivity of the camera tube governs the incident lighting level required in a studio. However, the lowest overall or base level of illumination must be greater than the normal domestic lighting in dressing rooms, corridors, etc., adjacent to the studio, otherwise it will have a depressing effect upon the performers; this is particularly so with variety artists, who like bright lights.

A practical level of lighting which has been arrived at during day-to-day operations is 60–75 lm/ft^2 incident light for a normal mean aperture of $f/5\cdot6$–$f/8$. The actual apertures can be set by use of neutral-density filters in the more sensitive cameras, so that depths of field can be matched when cameras are cross-shooting.

If it is a production requirement to work with less than the normal depth of field, in order to put scenery out of focus, then it is better to use filters and open up the iris control rather than reduce the general lighting level in the studio. It is not only undesirable to work at very-low lighting levels from the performers' point of view but also because of the difficulties of lighting balance at a low basic level.

(6.1.2) Contrast Range.

The measured contrast range of large detail on a scene will generally be of the order of 30 : 1, while for the smaller detail a contrast range of 100 : 1 is probable. The balance between key and filler lighting is normally used to control face tones, and the effect upon costume and scenery is regarded as secondary in the first instance. If the exposure of face tones is correct, there is a limit to the range which can be accepted either side of this, and an attempt is made to keep the tonal value of costume and scenery within a specific tolerance. To this end scenery designers use charts which show the Munsell neutral values and percentage reflectivity for specially chosen paints.

In working out a lighting plot the lighting supervisor takes into account the camera technique in use, the pattern of action of artists' movements, and the degree of complexity of sound pick-up. As far as possible, careful consideration must be given, at an early stage in planning, to the relative tonal values of costume and scenery. The choice will be governed by such considerations as the mood of the lighting and whether any special effects are required. It is necessary also to consider whether the surface will be in a horizontal or vertical plane; table-cloths, for example, although chosen to have a low tonal value, will be reproduced further up the tonal scale than was first imagined, because they pick up light from many angles.

(6.2) Artistic Requirements of Lighting

(6.2.1) Illusion of Depth.

The first artistic consideration is the need to create the illusion of depth, otherwise pictures tend to be flat and uninspiring. Also monochrome reproduction takes away the interest normally created by contrasting areas of colour, and therefore it is necessary to light for shape and form, tonal contrast and surface texture. Generally, the more broken the picture area becomes, the clearer and more solid the contents appear, but this should not distract from the centre of interest—usually the human face.

(6.2.2) Script.

The script requirements have to be satisfied in such a way as to keep up a balanced picture content which will provide a fairly constant mean d.c. level regardless of the nominal lighting condition specified by the script. This approach is necessary to offset the effects of a.c. coupling in the viewer's receiver and to minimize the amount of vision control required.

One of the biggest problems is with low-key scenes. For example, where scenes take place in a darkened room, it should be arranged, if possible, for curtains to be left open so that the room appears to be lit by moonlight or street lighting. It is then possible to throw window-pattern shadows on to the set wall in order to break up the picture and give an excuse for providing lighting in areas where close-ups are required. In all cases it is important when planning a production to avoid scenes with no apparent source of illumination.

It is important under all circumstances to have very early planning with the producer and designer in order to evaluate script or production requirements to see if any helpful changes can be made prior to ordering scenery and costumes.

The script may call for day or night lighting, but the correct interpretation of these conditions, in relation to the style of writing, the acting and the camera direction, is subject to the visualization of the producer and lighting supervisor. It is in the field of interpretation that the lighting supervisor exercises his art and skill with an individual style of lighting balance, and given that all other lighting requirements are satisfied, the value of lighting to a production is in this creative sphere.

This brief description of the artistic and creative aspects of lighting illustrates that there is much more to be considered in lighting than merely satisfying the technical needs for minimum vision-control adjustment.

(7) LIGHTING AND VISION CONTROL OPERATIONS

An important aspect of vision control is the use of the lighting console to achieve the correct lighting levels. Each production light in the studio is on dimmer control, and it is important for speed of operation that the lights for a particular set are grouped closely together on the console. This is achieved by use of a variable patching system, which enables any outlet on the motorized lighting barrels[1] to be connected to any dimmer. The memory system, which enables groups of lights to be recorded, is specially adapted for B.B.C. use to minimize delays in rehearsals.

To accommodate the inevitable small variations in lighting level on a studio set, the vision operator has a fine iris control with which the lens aperture on the cameras can be altered by ± 1 stop about the mean setting. Any deviation from this setting is indicated by an iris meter on a picture and waveform monitor stack.

From the start of a rehearsal the lighting and vision control staff must work as one unit; at this stage no vision control adjustments are made, the lighting itself being adjusted to produce the best results using the cameras as fixed photometers.

After the first run-through lighting levels are approximately correct, and the vision control operator can then check shots which are considered to require alteration of exposure. The controls are recentred after each check and any exposure correction referred to the lighting supervisor.

At this stage it may also be possible to improve the rendering of low-key scenes, etc., by reducing black stretch or lowering lift. The former is preferable as it gives a greater reduction of noise in the darker tones and a more stable operating condition.

The actual control exercised depends upon many factors—mood, setting, actors, etc.—and is a matter of subjective judgment. In a case of low-contrast pictures with a rather indeterminate picture black level, it is important not to set the pedestal too low and attempt to increase picture signal level by over-exposure. Fine control of lift may be necessary to trim out glare, tube background and similar effects.

As the final run-through or transmission approaches, the operator will have become conversant with the run of the production, and vision control adjustments will have been reduced to a minimum.

(8) CONCLUSION

The final assessment of any visual image is subjective and inevitably gives rise to some divergence of opinion; such is the case regarding the quality of the visual image produced by a television signal. However, there appears to be wide agreement that the pictures produced by modern equipment operated as described in the paper are consistent and of good technical quality.

The factors which most influence technical quality are definition, tonal gradation and noise, along with spurious effects such as overshoots, background variations and geometric distortions. Each of these factors is given due attention in the specifications and operational techniques now in daily use, and it is this attention to detail that leads eventually to increased economy of operation and greater flexibility in the use of the medium.

Future developments must inevitably result in even closer integration of the lighting and vision control functions, which, logically, should completely merge as equipment design and operational technique progress.

Work carried out in the B.B.C. experimental colour studio has shown that these operational control techniques can also be used for colour productions if attention is paid to the stability requirements and line-up of colour cameras.

Each new refinement of equipment and operational technique requires considerable technical effort. The aim of such effort must be to improve equipment performance, simplify operation and enhance facilities for transferring to the viewer the artistic and dramatic impact envisaged by the producer.

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