JOE KANE PRODUCTIONS

Web: http://www.videoessentials.com

E-Mail: joekane@att.net

A Video Standard - Insert Notes

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Introduction

Do you remember the last time you were in a store with a wall full of TV sets tuned to the same channel? Did you notice that no two pictures were alike? There is something "magic" about television, where a single source can have so many different 'looks'. Up until now, getting a good picture has been pretty much an art for most of us. We "paint" the picture to our liking with the TV's front panel controls.

As we enter a new decade, the program production community has established workable standards for presenting video and audio material. High quality and consistency of video presentation is finally possible, and has become very important in the product origination stage of a program. If we, as viewers, try to follow the same display rules used in program origination, we stand a chance of getting out of a production what the producer intended us to see and hear.

A Video Standard tells the technical story of our current audio/video system from the point of view of program origination. Not all home systems will be capable of following all of the rules of good presentation, so there may be some limitations in each individual implementation.

This disc, along with the program notes, can help you get as close to a correct display as your system will allow.

There are a number of technical terms used in this book in the process of providing information about television. Those that are periodically highlighted in the main text are defined in the glossary.

Table of Contents

Getting Started

Viewing the Disc for the First Time

When viewing this disc for the first time; look at and listen to the demonstration material in the first five chapters.

Go through the calibration procedures in this section of the program notes for both audio and video, then repeat the demonstrations. A subsequent improvement in audio and video quality should be noticed.

There is only one automatic picture stop in the demonstration chapters; located at the end of Chapter One. Otherwise the disc will play through to the beginning of Chapter Six, the audio calibration section; your first system check.

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The digital audio output on some players is delayed for as much as 15 frames, or about 1/2 second, after the Play mode is engaged from a still frame. With these players it may be necessary to back up the cue point a few frames in order to have active audio output at the desired program start point.
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Audio System Check

Initial Calibration of the Audio System:

There are several basic checks that should be made on all audio systems.

Is the system wired properly? Are the levels; volume and balance, set properly?

The pink noise provided at the beginning of Chapter Six will help answer these questions. All of the test signals in this chapter work with or without Dolby Surround Sound2 decoders.

The instructions for calibrating an audio system make use of the "looping" capability of many video disc players. Looping is the ability of a player to continuously repeat a specific section of the disc.

1. Setting Up an Audio Test Signal Loop:

a. Select the video disc player on your audio and video system. You will need to be able to watch the video while adjusting the audio. Turn the volume control on the audio amplifier down, it will be turned back up later.

b. Search for Frame 24560 and then press the A/B Loop button to establish this point as the beginning of the loop. Scan forward to Frame 25415 and set the "B" point. Most machines will automatically start the loop. Once the loop is going, slowly turn up the volume control on the amplifier to a comfortable listening level.

c. Refer to the player's manual if you have problems setting up the A/B loop.

2. Audio System Checks:

a. First Determine if System Connections are Correct: When just the left speaker in the video is flashing, sound should be coming from the left channel only. When the right speaker is flashing, sound should be coming from the right channel. If this is not correct, check system connections to find the error. Start with the audio wires from the output of the disc player into the amplifier, then controls on the amplifier, then wiring to the speakers.

b. Calibrating Audio Systems Without Dolby Surround Sound2 Decoders: When the left and right speakers or the center speaker in the video are flashing, sound should appear to be coming from between the left and right speakers. When the surround speakers are flashing, the audio should have a diffuse, directionless quality. If Step 2a. is correct and Step 2b. wrong, one of the pairs of wires going to the speakers is probably reversed. Some amplifiers have a phase reversing switch. If present, check to make sure the switch is in the (+) or "normal" position.

c. Calibrating Audio Systems With Dolby Surround Sound2 Decoders: When the left and right speakers or the center speaker in the video are flashing, the audio should appear to be coming from between the two speakers for standard Dolby2 and from the center speaker for Dolby Pro-Logic2. When the surround speakers are flashing, the audio should be coming from the surround speakers.

d. Establishing Audio Levels: While continuing to listen to the sound from the pink noise loop, adjust the volume and balance controls on the amplifier and/or Dolby Surround Sound2 decoder so that the sound coming from all sources appears to be equal in volume at the primary listening area.

e. Reference Level: -20 dB on the digital audio scale = 0 VU = +85 dB sound-pressure level (spl). See Figure 5. in the "Audio" section.

If you wish to duplicate volume levels used for mastering most programs, set the speaker output level at + 85 dB spl, when listening to the pink noise. Spl meters are available at Radio Shack for under $35.00; catalog number 33-2050.

When monitoring the audio output with VU meters, note that the left and right levels, when both are on, are 3 dB below the level when one or the other is on. The spl will remain at +85 dB because the left and right sound add together in the room.

Left + Right audio information is decoded as center information. Left - Right audio information is decoded as surround sound in the Dolby Surround Sound2 system.

Video System Check

Follow these instructions to properly set Brightness (Black Level), Contrast (Picture), Color, and Hue (Tint) controls.

1. Allow the set to warm up for 1/2 hour or more. Display a normal video picture while the viewing device is warming up. Any program material will work.

2. Turn off any Automatic Color or Tint options. Leaving automatic fine tuning on is OK, as long as it is separate from the automatic color controls. The automatic color controls will remain off.

3. Connect the video disc player to the viewing device. Insert "A Video Standard" into the video disc player and search for Frame 17164.

4. Set Black Level. This is done displaying the PLUGE pattern and adjusting the Brightness or Black Level control. Start by reading the text in Frame 17164. Advance one frame to 17165. While displaying the Color Bar Pattern with PLUGE, turn the Black Level or Brightness control up until two distinctive vertical stripes are seen on a gray background. Turn the control down slowly until the dark stripe (1) and the gray background (2) start to look alike in level. The brighter stripe (3) should still be visible.

5. Set White Level. Proceed to Frame 17175. White level is set with the Contrast control; sometimes called the Picture control. The Needle Pulse pattern, Frame 17175, will help in deciding where the maximum white level can be set while keeping the viewing device in its linear operating range. While displaying frame 17175, turn the Contrast control up, from its lowest position, until the line in the needle pulse pattern starts to bend anywhere along the line. This is the peak linear capability of the set. Some sets can not be turned up to the point of bending the line. Others will bend the line long before an acceptable contrast level can be obtained. If the line doesn't bend over the entire range of the contrast control, set the contrast control so that the gray scale in the pattern on Frame 17169 looks linear, i.e., each step looks as if it is about twice as bright as the last.

6. Re-check the Black & White Levels. The Contrast and Brightness controls are interactive on most sets. Changing the position of one may effect the level of the other. Display the PLUGE pattern when adjusting the Brightness control and the Needle Pulse pattern for setting maximum white level with the Contrast control.

7. Set the Color controls. Display the SMPTE Color Bar Pattern (Frame 17177). Note that the top of the picture has seven bars, starting with a rather bright gray and ending with blue. Below the color bars are four patches in reverse sequence to the bars above them. Advance the disc to frame to 17179. The goal is to make the SMPTE bars in Frame 17177 look like Frame 17179 when viewed thru the blue filter provided with the disc. With that in mind, return to Frame 17177. Hold the blue filter up to your eyes. Look through it to view the color bar pattern. Start by adjusting the color control while looking through the blue filter at the left bar and patch of the Color Bar pattern. Match the level of the patch and bar. Note that the word "Color" is next to the bright gray bar. It's there as a reminder of which control should be used with this particular bar/patch combination. Still looking thru the blue filter, adjust the Hue or Tint control so that the center two bars appear to be equal in level with their two patches.

8. Re-check the Setting of the Color and Hue controls. These controls often interact so it will be necessary to go back and forth between the two until all four bar/patch combinations match properly.

9. * Exception to the Rule:

Setting the Color control: Once the controls have been set, look at video coming from a variety of sources, off the air, cable, VCR, or what ever else is available. If the color levels seem to be very high on other sources, relative to pictures coming from the disc, turn the Color control down just slightly to make the viewing device look good from all sources. Do not change the position of the Hue control.

When time permits, go over the details about these adjustments in the Video Application Notes. The information provided here is the first step in improving picture quality.

Once you've gone over the Application Notes, you'll be ready to go directly to Chapter Seven for test signals. In the professional world, luminance and color levels are usually checked every day.

Setting up projection television systems can be slightly different. See the "Video Application Notes" section for additional information.

General Program Notes

Many of the chapters contain "bursts" of information; still frame sequences, intermixed with motion material. There are no automatic picture stops at most of the bursts because the stops would interrupt the flow of demonstration material.

The demonstrations bring together many of the elements that can be used in producing a program. In each case, the material is simple enough to "see through" the program content to the technical elements that make it happen.

There are several levels of information in this program, starting with how to adjust the front panel controls on a home set, to calibrating a professional broadcast monitor. This book and disc will help with whatever level of involvement is needed with any audio/video system.

Bringing Science to the Art of TV

Evolution of NTSC

Remember the TV store with all the different displays of a single program source? In an ideal world, all of those sets should look the same. There is a correct way to display a video signal. There is also a rather large gap between the ideal and reality.

An understanding of the complex evolution of the technical side of video, and our culture's ability to cope with it, is important to understanding that the entire "picture" of our current system has yet to be presented. Yes, important information on how to get a good picture was left out of the owner's manual and maybe even left out of the set itself!

Our society is becoming technically competent enough to accept the challenge of obtaining a better picture in our home. More than just our TV viewing is at stake. The very things that are little known about the current system will directly effect the quality of future systems; such as desk top publishing, computer graphics, and HDTV. Our NTSC system has not reached its full potential. It can be a lot better than most of us have ever seen. The consumer, has not had enough information, up until now, to demand better quality. Program producers, manufacturers of viewing devices, and viewers have a lot to learn about making our current color system work properly.

Test & demonstration material was readily available to act as calibration reference for the evaluation of stereo audio. What was available for color television? Instructions stating "adjust the knobs until the picture looks good". There were no dependable references for video.

Marketing people have decided; either knowingly or by coincidence of circumstances, that the parameters of good television are much to complex for society to grasp. At the time, it was a good marketing decision. Ignorance and/or low expectations sold a lot of product.

Television is an example of a technology that evolved with plenty of rules for making good pictures. Unfortunately, some of the rules were impractical in the real world, while others were hard to implement. In an effort to get around the problems of the original NTSC system, several side steps were taken in compensating for NTSC; rather than fixing it. As a result, many home sets now have "features" that prevent the device from displaying a good picture.

As of 1987, the few NTSC rules that needed modification have been corrected. Consistent, high quality program origination is now the rule, rather than the exception. We now have the capability to catch up to the specifications of the system.

Some NTSC background is in order:

Our color television system was outlined, on paper, by the National Television System Committee, (NTSC) in December of 1953. Color NTSC was true technology, a hypothetical, mathematical system. There had to be significant compromises made for compatibility with the existing black and white system. On the positive side, there were some impressive goals for color fidelity. Color NTSC evolved around the best theories of the time.

In the beginning, and to some extent today, the technology didn't exist to make the system work as it was designed. From 1953, it would be almost eleven years before the commercial networks were able to implement enough of the technology to make color programs a major part of their prime time schedule. It would be twenty more years before the production community would be able to economically implement several of the most important system parameters. And yes, there are still 1953 NTSC ideals that are beyond us today! (We may yet see them implemented in HDTV.)

Trouble emerged from being idealistic in 1953. System parameters were set around goals, not something that had been demonstrated in the lab. It was thought that details could be worked out as the system was implemented. The few difficult details of the system, that hadn't been worked out, have lead us into "Never Twice the Same Color".

There are two specific problems with NTSC that are important to this discussion.

The system detail that never worked:

NTSC originally defined colors of red, green, and blue that would allow the majority of surface colors to be reproduced in the television system. The only phosphors that could generate these ideal colors were not compatible with each other. The choice of red, green, and blue became anybody's game. Both the professional and consumer industry went wild. Everybody was free to come up with the "correct" alternative.

The details that were difficult to implement:

A good gray scale, consistent and correct in "color", is one of the most important factors in producing a good color picture.

The "color" of the monitor's gray scale and specific levels for black & white were difficult to set. The proper "color" of gray is specified in terms of the color a theoretical object would emit if it were heated to 6500° Kelvin. Early professional broadcast monitors required gray scale calibration once or twice a day. The tools available to set a gray scale were difficult to use. It became easier to set the monitor "by eye" than to use the cumbersome instrumentation. Setting monitors "by eye" introduced its own variables.

Two people might not see the same color the same way, let alone seeing the same from morning to afternoon, or day to day. Setting a monitor by eye is difficult, but it was easier than using the available instrumentation.

Displaying "correct" pictures evolved into as much a free-for-all as choosing the "correct" colors of red, green, and blue. The picture monitor, the most important device for judging signal quality, limped along while large numbers of important advances were made in generating, processing and recording the video signal.

We got out of practice with a few other NTSC parameters:

Environment is as important to the perception of a picture as a properly calibrated monitor. The original NTSC specifications recognized how important the environment is to a critical evaluation of the picture.

For years the networks painted all their walls gray and lit the rooms at 6500ø Kelvin. Interior decorators, who knew nothing about television, were quick to remove the "drab" gray look and replace it with wood paneling and incandescent lighting. These changes added several significant variables to the soup of inconsistency.

So far the program production world has been addressed:

TV set manufacturers have accidently made the situation much worse for the consumer by trying to compensate for the "Never Twice the Same Color" being broadcast.

Back in the "early" days of color television, color didn't match from channel to channel, let alone program to program, or program to commercial. The consumer complained about the quality of "flesh tones" not realizing that every color was wrong. The receiver manufacturer incorporated "Auto Tint" circuits in their sets. The circuit made any color around flesh tone look like flesh tone. Color fidelity suffered near flesh tones and the other colors were still wrong.

The VIR was introduced as a reference for a properly originated picture. It had the potential of fixing many of NTSC's problems, but was never fully implemented because of cost. It still exists today, serving limited functions. It can be found in "A Video Standard" serving its original function.

More problems for the consumer:

High light output levels from the picture tube became important. Daytime television; the TV set had to compete with direct sunlight to meet "consumer demand". The consumer was never told that picture resolution and geometry would suffer with increased light output. The manufacturers just accommodated the demands by modifying the structure of the picture tube and increasing the blue drive to get more light output. The color of the gray scale was significantly changed by increasing the blue drive, further destroying color fidelity.

The list of "improvements" goes on and has been detailed in countless magazine articles. We have all gotten into a lot of bad habits, trying to make our corner of the NTSC world "look good".

Current Operating Conditions

It is actually easy to understand why people marketing our NTSC system ignored the problems of the system while otherwise making it very profitable.

Progress is being made in the professional world towards consistency and better picture quality:

Every five years the Society of Motion Picture and Television Engineers, (SMPTE), is obligated to review its rules for making good video pictures. About the time of the 1985 review, relatively inexpensive technology for monitor calibration had become available; $4,000 to $10,000 for a meter that would read the amount of red, green and blue light coming from the face of the picture tube. SMPTE "C" phosphors had been established in 1979 as workable alternatives to the NTSC colors of red, green, and blue for the broadcast world.(Several manufacturers are studying incorporating the SMPTE "C" phosphor set into consumer products.)

In October of 1987 the rules for calibrating a professional monitor, and the environment of that monitor for critical viewing were re-established. They were based on the original 1953 rules where ever possible.

Viewing environment and monitor calibration are an integral part of a good viewing experience. That is true for any video system. The rules of the NTSC system must be followed in order to see it as it was intended to be seen. The consumer needs access to the same references used by the program producers. That's where Reference Recordings' "A Video Standard" comes into the picture. It contains the test patterns necessary to analyze the viewing device's condition and assist in making it better.

In the process of using the disc one or more "features", that will prevent the viewing device from displaying a good picture, will probably be noticed. It will take time for the necessary product modifications to be made in future viewing devices. For the time being, the disc will assist in obtaining the best possible picture the set is capable of producing.

What's Next?

There is a need to get back to good basic video design. Properly implementing the NTSC system, rather than trying to compensate for it, will help in providing the consumer with better pictures. "A Video Standard" will help qualify those efforts.

The option of following the rules; seeing what the producer intended us to see, needs to be available to the consumer. Consistent colors of red, green, and blue: SMPTE "C" phosphors, and properly calibrated gray scales are needed. An RGB to NTSC decoder that follows the rules of the system is required.

There are lots of potential real improvements to our display system once the basics of the system have been implemented. Many programs that are marketed directly to the consumer are being produced in the component video format. There are plans to deliver component video to the consumer in Europe. We might follow their lead.

All video systems face most of the display quality problems encountered in NTSC. If NTSC can be made to work, future display systems will be easier to adjust for consistent quality.

Video Application Notes

Basic Color Television

RGB Domain:

Television is an additive color system. There are three primary colors of light; red, green, and blue in all color video systems. Combinations of these primaries are added together to produce the other colors displayed, including all levels of gray.

The actual values chosen for red, green, and blue in the home display device will partially determine how well the system will reproduce color. See the CIE diagrams in Frames 16798 - 16801.

A very basic overview of the television system from the light captured by the camera to the light produced by the home set is shown in Figure 1. Light entering the camera is broken down into the three primary colors by optical filters. The three colors of light are then converted into electrical signals by the camera's pick-up devices. These three signals are then converted to one composite signal.

Composite Video Signals: See Frame 20477

Compatibility with the existing black and white system was thought to be very important when systems were being proposed for color television. That meant that the three color channels (RGB), had to be squeezed into the space of a single black and white channel and still contain black & white information.

The Y or Black & White information is derived from the RGB signals and makes up the majority of information in the video frequency space. The composite signal has to contain enough additional information to re-derive RGB in a color set.

$Y = 0.30\ R + 0.59\ G + 0.11\ B$. Our perception of light is best at yellow/green, slightly less in red, and worst at blue. Therefore yellow/green, the actual color of the green NTSC point, is given the most weight in deriving Y. This equation is also used for deriving Y in the PAL and SECAM systems.

As in mathematics, where three equations are required to solve for three unknowns, three signals in the composite signal to get back the red, green and blue information for a color display. The additional information is contained in the color difference signals, R-Y and B-Y. Initially these signals are full bandwidth signals, much to large to fit into the single channel designed for black and white. It turns out that if luminance is present in full bandwidth, our eyes will forgive the lack of full bandwidth in the color signal. R-Y and B-Y are converted to I and Q, the color difference signals that are a part of the NTSC signal, by significantly reducing their bandwidth and amplitude. I and Q are modulated onto their own 3.58 MHz color sub-carriers, 90ø out of phase with each other, and added back into the black and white signal. Add a few more complications and we have a "compatible" composite video system!

The color difference signals used in PAL and SECAM differ between the systems and differ with NTSC. The modulation of the color difference signals on the color sub-carrier is also different among all three systems.

The video signal also contains synchronization information. It insures that the picture information gets displayed in the proper sequence, at the right time, in the right place. A certain amount of time within the total video signal is allocated to synchronization.

This composite video signal then makes its way to the viewing device. In a color set, the composite signal is decoded back to three channels; red, green, and blue, which are used to drive the display device. The set's decoder is continually solving three equations to find the three "unknowns", the values of red, green, and blue.

NTSC System Specifications

Highlights of the NTSC 525 Line, 59.94 Field, 2:1 Interlace System:

1. There are 525 lines that make up one complete television picture. The picture is traced on the screen in two half pictures called fields. The first field is written from left to right, and from top to bottom; as viewed, leaving space between the lines for the second field. See Frame 20473. The electron beam is brought back up to the top of the picture. The second field of lines is written in-between the lines written in field 1.

Adjacent lines displayed in a picture come from alternate fields. The second field is interlaced with the first. The persistence of the phosphor; light is still coming from a particular spot long after the electron beam lit it up, and the persistence of vision, allow a person to see the picture in its complete form, rather than individual lines being drawn on a CRT.

Half of the 525 lines make up each field. In actuality, about 8% less of the 262.5 lines are written in each field. During the remaining time the beam is shut off to bring it back up to the top of the picture. This period is known as vertical blanking or vertical retrace.

2. Color Subcarrier Frequency:

3,579,545. Hz ñ 10 Hz, expressed as 3.58 MHz.

In designing the NTSC system, the color subcarrier frequency was derived from the requirements of compatibility with the existing black & white system. In implementation, the horizontal and vertical frequencies are derived from the color subcarrier.

A color sync burst of 3.58 MHz is part of the horizontal retrace interval to synchronize the color decoding circuits in the monitor with the source video.

The phase of the color information in the video is changed 180ø for every adjacent line. The change occurs automatically as part of the horizontal timing being derived from the color subcarrier. It has the overall effect of cancelling the display of the color subcarrier in the picture. It does, however, produce "dot crawl" at color transitions in the picture.

It takes two complete pictures for the phase relationship between the subcarrier and horizontal signal to return to zero. This presents a minor problem for the video disc player when displaying a still frame. The color phase has to be electronically reversed every other time a single frame is repeated. (A still frame gets repeated 30 times a second.)

3. Horizontal Scanning Frequency:

(3,579,545 Hz)(2/455) = 15,734.26 Hz,
Expressed as 15.734 KHz.

The horizontal frequency is derived from the color subcarrier. The factor of 2 used in the derivation puts the harmonics of the color information in-between the harmonics of the horizontal interval. The factor of 455 was chosen in the original system design to put the color subcarrier frequency at a point where it would not interfere with the audio carrier of a television transmitter, and yet be high enough in frequency to minimize interference with the black & white information.

Each complete horizontal line is 63.55 microseconds (.00006355 seconds) long. About 10.9 microseconds of that time is used for horizontal blanking, the time that the horizontal line is retraced from the right side back to the left. The color burst occupies 2.5 microseconds of that horizontal blanking interval. (See Frame 14438)

4. Vertical Scanning Frequency:

Horizontal Rate x 2/525 = Vertical Rate
(3,579,545 Hz)(2/455)(2/525) = 59.94 Hz

There are two vertical scans for each complete picture containing 525 lines, therefore 2/525 is used to derive the vertical frequency from the horizontal frequency. The Vertical blanking interval is about 21 lines long in each field. (See Frame 14446) Nine of those lines are actually used for the vertical equalization pulse. TV sets designed in the early days of black & white actually needed the time of 20 to 21 lines for vertical retrace.

Just as color burst information is present during horizontal blanking, vertical interval signals can be present from line 10 or 11 to line 20 or 21. Information such as closed captioning for the deaf, teletext, frame and chapter numbers for the disc, and test signals occupy this space.

5. Picture Frequency:

Horizontal Rate / 525 = Picture Rate
15,734.26 Hz / 525 = 29.97 Hz or pictures/sec.

29.97 pictures/sec. = 33.3667 milliseconds/picture

In our color system, the vertical rate is no longer locked to the power line frequency as it was for black and white. This change in picture rate makes it a little more complicated to translate the number of video pictures into actual program running time. Refer to the examples in the Appendix.

6. Program Operating Levels:

See the Waveform Monitor Section of the disc for pictures of the electrical display of a video signal. Frames 14436 - 14446.

The nominal peak to peak amplitude of a video signal is 1 volt. That 1 volt is translated into 140 IRE units. There is a zero volt reference in video. Active picture information is above zero volts, occupying 100 IRE. Vertical and horizontal synchronization signals occupy 40 IRE units below zero volts.

a. Picture Black Level: 7.5 IRE (above zero volts)
b. Picture White Level: 100.0 IRE (above zero volts)
c. Blanking Level : 0.0 IRE (zero volt level)
d. Burst Pedestal : 0.0 IRE (zero volt level)
e. Synchronization :- 40.0 IRE (below zero volts)

Black was raised above 0 IRE in the early days of color television to get around some transmitter problems. The practice has been with us ever since.

Displaying a Picture:

Film or video pictures are "flashed" on the screen. Film is a parallel format, where the entire film frame is flashed at once. Video is a serial format, where the picture is drawn on the screen, one pixel at a time.

Flashing information on a screen creates flicker. If the flicker rate is fast enough light from the picture is perceive as a steady light. It turns out, depending on duty cycle and brightness of light, that something in the order of 50 flashes per second is the human steady state threshold. Anything faster than that will improve perception of a steady state.

In the United States, our original black and white system was clocked at the power line frequency of 60 Hz. The European system uses their 50 Hz power line rate, resulting in a slightly more noticeable flicker in their television picture.

Early television service in England started out with 405 lines per picture. The U.S. introduced the "high definition" 525 line system at the 1939 New York World's Fair. The Europeans later introduced a 625 line system for black and white.

Trying to present 525 lines in 1/60th of a second required scan rates that were much to fast for the technology of the time. The 2:1 interlaced scan system resulted where only half of the 525 lines were displayed in 1/60th of a second.

The horizontal scan frequency of the system was derived from the vertical rate and the number of lines per picture. (30 Hz)(525 lines) = 15,750 Hz.

When color came along, the horizontal and vertical rates had to be derived from the color subcarrier frequency. There were minor frequency shifts as a result.

The black & white TV channel allocation called for a video bandwidth of 4.18 MHz. In reality, when the color system was being developed, only about 3 MHz of video bandwidth was being transmitted. Early black & white video systems couldn't do any better. It left lots of room above 3 MHz for the color information.

Completing the story of film, the flash rate of 24 frames is much too slow. A two bladed shutter was introduced in the projector. Each film frame is flashed twice on the screen before the next film frame is pulled down into the projection gate. When screen brightness requirements are large a three bladed shutter is used.

Color Monitor Display Specifications

Highlights of the SMPTE Type A Monitor Display Specifications with comments:

1. Color Coordinates of the Three Primary Phosphors:

SMPTE "C" Color Display Coordinates expressed in terms of the 1931 CIE chromaticity diagram.

Red x = 0.630 y = 0.340
Green x = 0.310 y = 0.595
Blue x = 0.155 y = 0.070

See Frame 16798 - 16800. The triangle in Frame 16798 shows the original NTSC points. The difference between the current SMPTE "C" phosphors and the original NTSC points are shown. As mentioned earlier, it is hoped that the original NTSC points can be made workable in a future HDTV system.

Before the SMPTE assigned a "C" designation to the current phosphor colors they were known by a lot of other names such as "American Broadcast Type", "American Standard Phosphors", and "Color Match" phosphors. Conrac, a broadcast monitor manufacturer, is credited with establishing the phosphors. That is where the "C" designation comes from.

2. Color of Gray:

Known by several names; Illuminant D, D6500, 6500ø Kelvin, it is properly defined by CIE coordinates:

D6500 x = 0.3127 y = 0.3291

It is just off the "Black Body Curve". See Figure 3. "Tolerance of the D6500 Specification" for details.

3. Gray Scale Tracking:

Maximum change of 6 delta C* CIELUV units from 0.15 Foot lamberts to reference white, measured at the center of the CRT. That change is about three times as large as an MPCD (Minimum Perceptible Color Difference) unit.

4. Aim Point for Peak White:

35 Foot lamberts

When this specification was first proposed in 1987, the largest CRT size that would meet the SMPTE Type A specifications was a 19 inch. Peak white was established as high as it is to accommodate large viewing area requirements. Many of the Delta-Delta tubes won't make this level and will continue to be operated at or slightly below 30 Foot lamberts. If the room lighting is reduced accordingly, the pictures should be acceptable to a single viewer in the ideal viewing position. (The 35 Foot lambert level is too high for the 50 Hz PAL & SECAM systems because of problems with flicker.)

5. White Field Uniformity:

Purity: Symmetrical change no greater than
6 delta E* CIELUV units, or about 3 MPCD's.

Luminance: Symmetrical change no greater than
25% over the entire picture area. (Many large screen TV sets have a change greater than 50%. See Frame 17138. Look for light intensity changes.)

Color of White: Symmetrical change no greater than
6 delta C* CIELUV units. (Once again, see Frame 17138. Look closely for color changes.)

6. Geometry:

Linearity within 1% of total picture height.

No more than 1% change with 10 - 90 APL Picture bounce at 35 Foot lamberts peak white. (To get an idea of what this means, bounce back and forth between Frames 17168 and 17169. Watch for any change in picture size.)

7. Display Pitch:

No more than 0.44 mm for a 19 inch diagonal tube.

No more than 0.32 mm for a 13 inch diagonal tube.

See Frames 20478 - 20483. The sizes indicated are for the individual red, green, and blue elements. Provisions have been made in the specifications for larger CRT's, if any can be designed to meet the rest of the SMPTE Type A requirements.

CRT sizes larger than 19 inches are not detailed because there are currently none that meet the rest of the SMPTE's Type A specifications. Many video facilities in Europe do not consider the capabilities of a 19 inch CRT adequate for critical viewing.

8. Display Resolution:

Minimum of 500 horizontal lines at 35 Foot lamberts. There is a detailed discussion of display resolution further on in "Video Application Notes".

Remember that display resolution should be better than the normal incoming video. The video bandwidth required to display 500 lines is about 6.25 MHz. The display resolution goes down as peak white level goes up, therefore the value of peak white is part of the resolution specification.

9. Display Gamma:

2.2, + 0.4, - 0.0 over a 40:1 luminance range.
(See Frame 16694 for a graph of the monitor and camera gamma. Figure 1. also details gamma.)

The original gamma of a black and white tube is 2.2, the NTSC system specification. Color tubes have a gamma somewhat higher than 2.2. The current SMPTE specification allows for that in the + 0.4 tolerance.

10. Contrast Ratio:

50:1 under specified viewing conditions.

Viewing conditions are detailed in Chapter Five of the disc and in "Monitor Environment"; part of "Video Application Notes".

11. Picture Stability:

A display device and drive electronics parameter.

Parameters:	Luminance	Color, Differential RGB
Short Term:	2%	2%
Long Term:	1%	1%

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Short Term: Parameter variations over a temperature
change of 10ø C above and below an ambient of 25ø C.

Long Term: Parameter variations over a time period
of 500 hours under constant ambient conditions.

These parameters involve leaving the monitor on 24 hours a day, seven days a week. All bets are off if the monitor is shut off for much more than a few minutes, then turned back on.

12. Monitor Circuits:

The electronics to support these display requirements and allow their calibration must also be present.

Principles of Monitor Calibration

The ability of a monitor to properly reproduce a gray scale is one of the most important parameters in obtaining a good color picture. "A Video Standard" provides the needed test signals. The procedure in the disc advocates the use of instrumentation to calibrate the color of gray from black to white. (Frames 17130 - 17175) It is important to have a good idea of what needs to be accomplish before making any adjustments. Hints are provided for monitor gray scale calibration without the use of instrumentation in the Gray Scale Calibration notes.

1. Defining Gray:

Red, green, and blue are the three primary colors in television. All other colors, including gray, are created by combining various amounts of the primaries. Gray, in the NTSC television system, is defined as a particular color, 6500ø Kelvin, near the Black Body Curve of the CIE Diagram. (Frames 16798 - 17130).

If an ideal object is heated to a particular temperature, indicated in degrees Kelvin, it will emit a particular "color" of white light. Lights that are said to be "white" range in color from 2800ø K, the color of a 60 watt light bulb, to 10,000ø K, a blue white from some outdoor, high intensity, lamps. Some imported consumer monitors come into the U.S. with their gray scale adjusted to 9000ø K or above; a blue scale. (Color pictures on such monitors will be tinted blue.)

The best broadcast grade monitors will hold their calibration for about a month before instrumentation can detect changes. It would take two or more monitors, placed side by side, before most trained observers would notice the same drift.

2. The theory behind monitor calibration is fairly simple.

Calibrate a gray scale, set black level, white level, and color controls. That's it. Accurate implementation of the theory has only recently been made workable with the introduction of "Standards Transfer Devices" or "Color Analyzers". Setting a good gray scale is and always has been the difficult part of monitor calibration.

3. Getting Started:

Warm up the monitor for at least 30 minutes before making any adjustments. In most cases the Automatic Color controls have to be turned off as they will limit color fidelity. See Monitor Automatic Functions later in this section.

Particular controls must be present in order to calibrate a gray scale. See Gray Scale Calibration later in this section.

In properly setting a gray scale both black level and white levels; brightness and contrast, must be established first.

4. What is Brightness? What is Contrast?

Brightness or black level is a base line; a ground zero, for video level. (The word "brightness" for black level control will change to "black level" in the near future.) Video exists from this base line on up to the level of peak white. Contrast determines the distance between the base line and peak white. In other words, video gain (how far away from black the white level is positioned) is the contrast of the picture. The black level control, in positioning the base line for video, will effect the level of peak white. That is why black level is always set first, then contrast.

5. Rules are not always followed.

Some manufacturers have chosen to make this simple function much more complicated. As an example, in some sets that use a Picture control instead of a Contrast control, the Picture control adjusts both contrast and color level, independent of the Color control. Use the SMPTE Color Bar signal with the blue filter to watch color level while changing the Picture control. The relative intensity between the blue in the gray bar and blue patch should remain fixed.

In some sets the color controls may have to be set prior to setting a gray scale. Determine if this is the case before proceeding. Search Frame 50781 or 50782, Field or Line Rate Gray Scales. Turn the Color and Hue controls, one at a time, over their full adjustment range. If a significant change in the color of gray is noticed, while adjusting either control, set the correct position of the color controls before setting a gray scale.

Black & White Levels

Proper black and white levels must be set before proceeding with other adjustments. Black level is set using one of the many PLUGE patterns in the disc.

1. Determine the correct PLUGE pattern to be used for setting black level.

While displaying the PLUGE Pattern with the White bar, Frame 17168, turn the Black Level or Brightness control up until two distinctive vertical stripes can be seen on a gray background on the left side of the screen. Turn the control down slowly until the dark stripe and the gray background start to look alike in level. The second, brighter, stripe should still be visible, and of course the white bar on the right half of the screen will be very bright. Once this adjustment has been properly completed advance the disc to Frame 17169. Look at the PLUGE stripes in this pattern (a gray scale substituting for the white bar). Without touching any knobs on the viewing device, does the PLUGE pattern appear to be set at the same level? (If necessary, go back and forth between the two patterns several times.) The majority of viewing devices in use in the consumer market will not hold black at black, independent of picture content. If black level has remained fixed when switching between the two patterns, use the PLUGE with the Gray scale for setting black level. If the PLUGE appears to be brighter in the pattern with the gray scale, use the PLUGE in the bottom right corner of the SMPTE Color Bar Pattern for setting Black Level, Frame 17165 or 17177. The PLUGE with Gray Scale, should not, under any proper circumstances, look darker than the PLUGE pattern with the White bar.

2. Set black level.

Frame 17169 or 17177 in Chapter Five or Frame 50785 or 50788 in Chapter Seven.

Turn the Black Level or Brightness control up until two distinctive vertical stripes on a gray background of the PLUGE can be seen. Turn the control down slowly until the dark stripe and the gray background start to look alike in level. The second, brighter, stripe should still be visible.

The correct setting for black level will be dependent on the amount of ambient light in the room, and specifically on the amount of ambient light hitting the surface of the display device. Generally, if there is a lot of ambient light, black level needs to be set higher than in low ambient conditions. See Monitor Environment later in this section.

3. Set White level.

White level is set with the Contrast control; sometimes called the Picture control. The Needle Pulse test pattern in frame 17175 or 50787 will assist in deciding where the maximum white level can be set while remaining in the linear operating range of the viewing device.

While displaying the Needle Pulse, turn the Contrast control up, from its lowest position, until the line in the pattern starts to bend anywhere along the vertical line. This is the peak linear capability of the set. Higher contrast levels will distort the geometry of the picture, just as it bends the line in the test pattern. Some sets can not be turned up to the point of bending the line. Others, projectors in particular, may bend the line long before an acceptable contrast level can be obtained.

If at all possible, operate the set with white level below the point where the line starts to bend. On the other hand, if the line doesn't bend over the entire range of the contrast control, set the contrast control so that the gray scale in the PLUGE pattern, Frame 17169, looks linear, i.e., each step looks as if it is about twice as bright as the last.

If a light meter that reads in Foot lamberts or NITS is available, display frame 50783 and set the contrast control for no more than 35 Foot Lamberts or 120 NITS at the center of the Window pattern. The disc recommends 30 Foot lamberts (100 NITS) because the Delta-Delta picture tubes are usually not linear above that level.

4. Check the settings for both black and white levels.

Brightness and Contrast controls are interdependent. Black level is always set first because changing it has a direct effect on the level of white. Go back and forth between the PLUGE and White level patterns. Make any necessary adjustments in both black and white levels.

Gray Scale Calibration

Certain controls must be present in order to set a gray scale. Check the viewing device for the presence of three "screen" controls, one each for red, green and blue. There must also be at least two "gain" controls for red, green or blue. These controls will most likely be on the back of the set, along the base of the set, or on the neck of the picture tube.

CAUTION! should be exercised for shock hazards in making any rear panel adjustments. Refer the actual operation to a trained television technician if there are any questions.

A small change in any of these controls often creates a large change in the gray scale. Be careful about how far or how fast these adjustments are made.

The object of setting a gray scale is to set the color of gray at 6500øK from black to white. Human perception of color is relative. It is difficult to judge the correct color of gray without a reference. Use proper room lighting, described in Frames 20457 - 20460, as a reference for the color of 6500øK if a calibrated optical comparator is not available.

Gray Scale Setup Without a Color Analyser:

1. Start by setting the screen controls to the manufacturers recommended settings.

Find the manufacturers recommended practice before proceeding. On some sets there is a service switch on the back that reduces the picture to horizontal lines. With a low level flat field as an input from the disc, Frame 50797, the screen controls are usually turned down until there is no light coming from the screen. Each of the three controls is brought up individually until it can be just seen on the screen, then backed off until it just disappears. Return the switch to the "Normal" position once all three have been set. This is a starting point for adjusting a gray scale.

The procedure detailed here will go beyond information provided by most manufacturers. Check the warranty before going further.

2. Make sure the correct levels have been set for black and white.

Before trying to set a gray scale, search frames 50785 and 50787 to set brightness and contrast controls. (Details in Black & White Levels) A gray scale has to be set within the proper black and white levels.

3. Calibrate the gray scale.

Display Frame 50781 or 50782 on the set. The screen controls are used to set the color of gray near the dark end of the scale. The gain controls will set the color of gray at the high end of the scale. Adjust the screen and gain controls to match the color of gray on the screen to the 6500ø Kelvin reference. When adjusting the controls, make small corrections. Then review the change made on the gray scale. In most sets, a small change in the control position will produce a large change in gray scale color.

The screen and gain controls interact, so it will be necessary to go back an forth between the two sets of controls several times before a good gray scale can be obtained.

4. Re-check brightness and contrast levels.

Setting the Color Controls

Make sure all Automatic Tint controls are turned off and remain off. Most of these functions limit color fidelity in the process of trying to make anything near flesh tone a single color.

1. Set the color controls, Color & Hue or Tint

Use the SMPTE Color Bar Pattern, Frame 17177, and the blue filter provided with the disc. In the Color Bar Pattern, note that the top of the picture has seven bars, starting with a rather bright gray and ending with blue. Also note four patches just below the main bars. Now advance the disc two frames to 17179. This is the goal. Make the SMPTE bars in Frame 17177 look like Frame 17179 when viewed thru the blue filter. With that in mind, return to Frame 17177. Look directly through the blue filter to view the color bar pattern. Start adjustments by changing the color control while looking through the filter at the left most bar and patch of the Color Bar pattern. Adjust the Color control until the level of the patch equals the bar. Note that the word "color" is next to the bright gray bar. It tells which control should be adjusting when looking at that particular bar/patch combination. Still looking thru the blue filter, adjust the Hue or Tint control so that the center two bars appear to be equal in amplitude with their patches. The Color and Hue controls often interact so it will be necessary to go back and forth between the two controls until all four bar/patch combinations match properly.

2. Exceptions to the Rule. Please Note:

This description for setting the color controls fits professional color monitors. Compensation may have to be made for some consumer monitors.

a. There are a number of consumer display devices that do not properly handle the SMPTE Color Bar pattern; the standard NTSC test pattern of the professional industry. The error shows up as very noisy, over saturated color in the standard picture content of the disc, once the color bars are properly set. If this problem is found, it is a signal handling error in the display device, in particular, a circuit known as ACC (Automatic Color Control), that in most cases can not be defeated. The viewing solution to this problem is to turn down the Color control by as much as half of its intensity, once the Color and Tint have been properly set. The long term solution is for the manufacturer to redesign the set to allow ACC to be easily defeated. Color level AGC (Automatic Gain Control) is the only necessary correction in the color decoder circuit on a consumer viewing device.

b. If the pictures from any disc looks correct in color level, once the adjustments have been made, but color pictures from other sources look slightly over saturated, it may be necessary to decrease the Color control very slightly to get an acceptable picture from all sources.

The video explanation in this disc for setting color controls clearly shows that the intensity of the blue bars, as seen through the filter, will be equal at the transition points of the blue bar/patch combinations, when the Color and Hue controls are properly adjusted. In the real world of off-the-air reception and video cassette recorders, correct incoming levels of color are rare, making AGC circuits necessary. Slight differences in color saturation, from different sources, can come from the amount of gain being applied to the signal. The output of the automatic gain circuit may actually make a picture with weak color look over saturated, by over compensating for a low incoming level.

Turning the color saturation down slightly is a compromise to readjusting for each source. One setting can be used for everything.

c. In dialing through television program material, flesh tones, and other colors, may not be exactly perfect. Once the set has been properly calibrated; acceptable pictures are seen from the majority of laser discs, offending pictures are probably not correct from the source. As the SMPTE Recommended Practice rules get implemented industry wide, such problems should be nearly eliminated.

Use of the Blue Filter

In the SMPTE Color Bar test pattern Gray, Cyan, Magenta, and Blue all contain equal amounts of blue once the NTSC signal is properly converted to RGB. Adjusting the chroma gain (Color) and phase (Hue or Tint) controls is part of properly calibrating the decoding process.

Now that the SMPTE Color Bar pattern for color calibration is available, a "Blue Only" capability is needed. Most home sets don't have this capability. The Blue filter provides the "trick" needed to obtain that function. (Refer to "Setting the Color Controls" for procedures.)

Blue was chosen; rather than red or green, because blue is altered more in amplitude; in the encoding/decoding process, than the other two colors. (There are also equal amounts of red and equal amounts of green in combinations of the colors in the color bar pattern. See Figure 2.)

Video Projectors

There are additional considerations, beyond those listed in monitor calibration, to be made when aligning a projector. Some are different for front and rear screen projection systems.

Just as in the procedure for a monitor, the projector should be turned on for at least one half hour before any adjustments are made. Any automatic color devices should be shut off and left off for best color reproduction. Ambient light in the room should be reduced to minimum, to a point where a flashlight is needed to find the projector controls.

1. Background

Projectors are often driven well beyond their linear operating range in the process of delivering the desired light output. Maintaining dynamic focus and picture linearity over the entire gray scale becomes difficult. It is important to make all focus, gray scale, picture linearity, and convergence adjustments in the linear operating range of the projector. This will ensure that the majority of picture information will be properly displayed, even if, in the final adjustment, peak white level is above the maximum linear operating range of the set.

2. Determine the Linear Operating Range of the Projector

In the Black & White Levels section, instructions are provided for using the Needle Pulse (Frame 50787) to determining the maximum contrast level. The same procedure applies here. If possible, set the contrast below the point where the line in the Needle Pulse starts to bend. The light output level of the crosshatch pattern used in the following procedures must be below the maximum linear operating range.

Most two or three tube projectors have their own built-in convergence or crosshatch pattern. Check the light output level of this pattern versus the light output when displaying the Crosshatch pattern from Frame 50820. The internal pattern should be much lower in light output level. If this is the case, use the internal pattern when a crosshatch is needed.

If the disc's Crosshatch pattern is chosen for the focus, geometry, and convergence procedures, set the displayed light output level well within the linear operating range of the projector. The brightness limiter or black level control can be used if the contrast control won't reduce the peak white level to a linear operating range.

3. Focus

There are two kinds of focus adjustments that must be made on a projector. Electronic focus of each CRT and mechanical focus of each lenses in front of each CRT. All focus adjustments should be done on a fine line pattern such as crosshatch. Make sure the operating level is well within the linear operating range of the projector. (See Step 2 above.)

Focus each CRT, lens combination, one color at a time. Cap or shut off the other two colors while making adjustments on a single color. Refer to the projector manufacturer's notes for details. If it is possible to view each CRT directly, electrical focus should be easy to set independent of lens focus. Otherwise go back and forth between the two sets of adjustments to ensure proper focus for each CRT/lens combination.

The SMPTE Resolution Chart, Frame 50789, or the Indian Head Pattern, Frame 50828 can also be used to check focus. Focusing a projector at the proper light output level will partially resolve the "soft picture" complaint often heard about projectors.

4. Geometry and Convergence

Refer to the manufacturer's instructions for details. Make sure that any convergence pattern used for this procedure is well below the maximum linear operating level. (See Step 2 above.)

The green channel is usually set first for proper geometry. Then red and blue are converged onto the properly calibrated green, one color at a time. A final check is made with all three colors turned on.

It is often difficult to converge blue to green in a front projection system because of perceived light level differences. A "trick" often used in the industry is to first match red to green, then match blue to red. The perceived difference between red and blue is much less than green and blue.

5. Establish the Color of Gray

As in the disc, this procedure advocates the use of monitor calibration instrumentation. The procedure provided in "Gray Scale Calibration" and "Gray Scale Setup Without a Color Analyzer" applies to a projector. Additional considerations for projectors are covered here.

Set the proper black and white levels using the PLUGE pattern and the Needle Pulse. See the Black & White Levels section instructions.

Display the Window Pattern from Frames 50803 to 50812 that most closely matches the light output level of the reference source. (See Frame 17146 for an example of what should be seen.)

Match the screen light and color output to the reference using the CRT gain controls and the contrast control. There are many factors in a projector that will make this task difficult. If the projector is aimed at a screen with a gain of more than one, the screen is going to have a hot spot.

The "color" of white will shift depending on the viewing position. It will be necessary to pick a "prime" viewing spot and position the reference at that spot aimed at the center of the window pattern. If a rear screen projector is being calibrated, the reference gray must be set while looking at the viewer side of the screen.

Now that the "prime" spot has been carefully chosen, adjust the gain controls of each of the tubes on the projector to match the light from the projector, screen combination to the reference. The screen will effect the color perceived by the viewer. If at some time the screen is changed, a new reference will have to be established for the correct color of gray.

6. Calibrating the Color Analyzer

Once the reference is set, position the head of the Color Analyzer at the screen, aimed back at the projector. (A rear screen system should be treated in the same way a monitor is calibrated.) Calibrate the Color Analyzer for the particular proportion of red, green, and blue needed to produce the proper color of gray. The Color Analyzer is now calibrated for that particular projector, screen, color temperature combination.

7. Setting a Gray Scale With the Color Analyzer

The light sensing part of the color analyzer must be located very close to the image focal plane; the position of the screen. In a front screen system, it can be a long way between the focal plane of the projected image; the screen, and the projector. It may be necessary to lengthen the cord between the sensor head and the Color Analyzer itself, if the Color Analyzer is to be located back at the projector. An extension cable of about 20 feet can be made for the Philips PM5539 Color Analyzer. Extensions may not work with other brands of equipment. The head of the color analyzer can be mounted on a post and properly positioned in the focal plane, aimed back at the projector. The base of the analyzer can then be located at the projector, where it will be easy to read and change scales.

The projector must be the only light source in the room since the light sensing head of the color analyzer will be sensitive to any light hitting it.

Set the gray scale over the linear operating range of the projector. The procedure is nearly the same as with a monitor. Use the screen controls to adjust the low end of the gray scale while displaying a low level window pattern. Set the gain controls for the white end of the scale while displaying a high level window pattern.

8. Setting a Gray Scale Without a Color Analyzer

The procedure is much the same for a projector as for a monitor. Note: The gray scale must be set to be correct for the "prime" viewing position as discussed in Step 5 above.

9. Re-set Black & White Levels

It may be necessary to run the contrast control of the projector higher than the maximum linear operating range. Use the SMPTE Color Bar pattern as a picture source, Frame 50788, for setting acceptable black and white levels.

10. Set the Color Controls

Continue displaying the SMPTE Color Bar Pattern. Once again, a "blue only" configuration is required. In a three tube front projector system, cap the red and green lenses so only the blue light hits the screen (or use the filter provided with the disc). Match the bars as described in the monitor calibration procedure. Return the projector to normal operation.

11. Check Projector Calibration Often

Drift problems can be much worse in projectors because they are usually driven harder than monitors.

Monitor Environment

The environment around the monitor is as critical to the proper perception of a picture as the accurate calibration of the monitor itself. The "Ideal Viewing Environment" animated sequence (Frames 17183 - 20456) and subsequent still frames (20457 - 20470) in Chapter Five present the essential elements of the SMPTE Recommended Practice document as they should be applied to the home environment. An understanding of these specifications will help in adapting them to specific room conditions.

1. Perception of Light and Color

A person's absolute perception of individual colors is not very good. (The same holds true for hearing. Very few people have perfect pitch.) On the other hand, most people are good at determining small differences in objects that can be directly compared. Put two slightly different colored objects next to each other and most people will see their differences. If the two objects are separated by a larger distance than the field of view of an individual, it will be more difficult for the average person to distinguish the small differences in the objects.

Extending that beyond two objects to an object and its environment, the object is now being judged in reference to its environment. A person's perception of the color of the object is dependent on the environment of the object. A case in point; the art of mixing and matching colors of clothing. If a person were to ware a cyan (blue-green) shirt with a green sport coat, the cyan shirt would appear to be blue. If the green sport coat were changed to a blue sport coat, the cyan shirt would now appear to be green. While these extremes in color may be beyond being fashionable, mixing colors has long been a trick of extending one's wardrobe. The important point here is that the color of the shirt did not change. The environment of the shirt changed the viewer's perception of the color of the shirt.

2. Environment as part of TV viewing

What does all of this have to do with watching television? Viewed from the proper distance, (covered later in this section) a television picture makes up about 20% of a person's field of view. The other 80% of the optical input, the environment of the monitor, can have a significant influence on the perception of the color coming from the 20%; the monitor.

Conclusion? The 80% of the field of view has to be controlled if the 20% is going to convey the desired information. What's involved, how much control is necessary? An initial thought might be to eliminate external light, remove the environment altogether. (Watching TV in a totally dark room seems to be very common.) There are two difficult things with this approach. The perception of individual colors by the viewer is going to be totally dependent on the rest of the picture content. More important is the problem of eye strain. In an 80% black environment, the iris of the eye is wide open, the eye is trying to collect any light it can get. Along comes a bright picture from a particular scene and there is an instant overload of the optical nerve. In addition, the iris is forced to try to close down quickly. In short, the constant change in brightness from the picture can cause significant eye strain. Moving closer to the monitor, trying to duplicate the theater experience, doesn't work because of the course line structure of the television system and the higher light output from the CRT.

In a motion picture theater the image on the screen can represent a much larger percentage of the field of view. In terms of picture height, most movie viewers sit much closer to the screen than television viewers should sit from the monitor. That's ok because the resolution of a projected motion picture image is much better than a television image. Another important factor is that the light output from the motion picture screen is not anywhere near as bright as from a television set. Most theaters can still use two bladed shutters because peak light output at the screen is only about 18 Foot lamberts.

Before leaving the category of human perception of light, it is important to emphasize that eye sensitivity to color follows a bell shaped curve, much like the CIE diagram. Sensitivity is best in the yellow-green spectrum and falls off in either the red or violet directions. Sensitivity is less at the violet end of the spectrum than at the red end. Most people are not able to see either ultra-violet or infer-red.

3. Ambient Light is Required for Ideal Viewing

In an effort to get around the problem of the eye's iris being wide open, ambient light is added to the environment. The eye's iris is biased by the ambient light. It is closed down a little, from the original wide open position, and better able to handle the very bright picture transitions. If the bias light is set properly, the eye still has enough dynamic range to allow the person to see into the dark areas of the picture. The need for a "bias" light has been clearly established as a result of several years worth of human factors research. Introducing this light introduces an environment to the monitor, which will influence the color perception of the picture coming from the monitor. The conditions of this "bias" light become very important.

What are the major considerations of introducing this light? There are some obvious points. The light needs to be in the environment of the display device. It shouldn't be positioned where it can shine directly on the display or the viewer or be reflected back to the viewer by the display. Ideally, that means that the light should be behind the display aimed in the opposite direction of the viewer. The conditions perceived by the viewer of the light/environment combination are very important.

Knowing that a person's perception of color is dependent on the environment, is it possible to specify a single environment that will assist in properly determining the color spectrum capability of the television system? Yes, just as the "color" of gray on the monitor itself will effect all the other colors, it turns out that a neutral surround, gray; which contains all colors, is the right choice for the environment. Ideally, the gray in the environment has to match the properly calibrated gray of the monitor.

What about intensity of the light? The SMPTE Recommended Practice document says the level should be less than 10% of the peak white level on the viewing device. How much less? Most viewers in the professional world settle in at around 5%.

Be prepared! The initial reaction of most interior decorators is going to be "off the wall" when this information is first presented. In the past they have managed to destroy proper perception of color in the process of creating a "warm, friendly" environment. There are times when the viewer would like to see the information the system is trying to present. The warm, friendly colors in the environment are not warm and friendly to proper color perception.

With a little creativity, gray does not equate to "drab". The background grays should have shades, relief, texture, and/or design. There is a great deal of room for individual expression within two basic parameters; the maximum level of light coming from any point in the background should be no more than 10% of the peak white level of the display device, (measured in the plane of the display device), and the background color should be neutral, the same color of gray as the gray scale of the properly calibrated monitor.

4. Elements in the Environment

In the home environment, mostly neutral gray, plus elements that are close to gray, if desired, are usually acceptable for the field of view in which the monitor is located. The choice of colors that may be used with gray should be limited to what Munsell calls "Nearly Neutral".

Munsell5 is an organization that defines colors of pigments. They provide samples to the art, fabric, and paint industries as references.

The use of fabric and/or texture is encouraged. Several examples of elements in the environment are provided to help with ideas. They are intended only as examples.

Paint the wall behind the monitor any desired shade of matt gray, anything from a deep gray to white. Hang gray vertical blinds on the wall. The blinds can be gray fabric or gray plastic. The blinds may or may not provide a contrast to the gray on the wall. Gray fabric may contain elements of the "Nearly Neutral" colors mentioned. The vertical blinds might be covering a window or sliding glass door or made to look as if they were. The bias light (which is detailed later) is aimed at the blinds. The amount of light reflected back into the room is controlled by rotating the blinds open or closed. The cost of this mechanical control of the ambient light level may be in the same order as an electronic control. It will help if the wattage of the light is chosen so that the maximum reflected light does not exceed 10% of the monitor peak white level.

The picture monitor does not have to be placed out away from a flat wall, as shown in the animation. If it fits better out away from the corner of a room, and the sound quality is not compromised, there is no problem in using that configuration. Very creative things can be done with lighting in a corner of a room.

5. Choice of Lighting

As for lighting, "soft white" fluorescent lamps can be filtered to about the right color using Rosco's 3202 filter material. Rosco6 filters are common in the motion picture and television industry. They, or their equivalent, should be available from lighting supply places that work with these two industries. The filter material is inexpensive.

Filtering "soft white" lamps is presented as a cost effective option. These lamps are available in many sizes and shapes. The lamp/fixture combination can be small and easy to fit behind the monitor in addition to being inexpensive. The light output of a 15 watt lamp is often about right, after being filtered, for the 10% of peak white specification.

Filtering other commonly available colors of fluorescent lamps to a neutral gray is also possible. Combinations of existing filters may have to be used to obtain the desired gray.

6. Color and CRI of Lighting

Color Rendering Index (CRI) can be another important factor in choosing one particular light source over another.

Background: In terms of light, the color of "white" is obtained when all colors of light are added together. Most room lighting sources produce colors of light that include the primary colors; red, green, and blue, plus other colors in the visible spectrum. In most lamps, the amount of light output of a particular color is greater than other colors in the visible spectrum; a factor in determining the "color" of white the lamp produces.

CRI is a measure of how well a particular "color" of white will render an object familiar. CRI is scaled from 0 to 100. Any "color" of white along the black body curve of the CIE diagram can have a maximum CRI of 100. The CRI of a lamp becomes important when many pigment colors are added together to form the neutral gray in the background. How well these objects are rendered to human perception is important. The actual color of the background material, as seen by the viewer, will depend on the CRI of the light source. If the light source has a CRI below 80, chances are good that a multi-pigment background will look different in color than when lit with a bulb having a CRI near 100. In critical environment conditions it is important to use an ambient light source with a high CRI.

Fluorescent lamp colors are given names. There is some consistency in color of light among manufacturers for a given color name and sometimes even consistency in CRI. Knowing the approximate color of the bulb, proper filter material can be chosen to correct the bulb color to the desired "daylight" color. Examples of names, with colors referenced to the black body curve on the CIE diagram, and CRI's are listed below. The abbreviation "Inc." is used for incandescent lamps.

NAME:	COLOR øKelvin	CRI:
25 W. Inc. :	2700	95 to 98
Warm White :	3000	56
150 W. Inc. :	3100	98 to 100
Soft White :	3200	75 to 85
Cool White :	4200	68
D50 :	5000	90 to 100
Daylite :	6500	75 to 95
D65 :	6500	95 to 98
D75 :	7500	90 to 98

The lighting industry in general and individual manufacturers in particular have their own terminology. So called "Warm" colors of light, those at the red-orange end of the black body curve of the CIE diagram, are usually below 3500ø Kelvin. Anything above 3500ø Kelvin is said to be "Cool". The terms "Warm" and "Cool" refer to color rather than color temperature. Just another example of where "Warm" is cool and "Cool" is warm. The "scale" is biased by the color of incandescent lighting.

Filtering incandescent bulbs to a neutral gray color is less than ideal. While the light output is easily controlled and the CRI is high, the color of light changes dramatically as the light output is changed. The heat generated by these lamps is rough on the filters needed to make them the right color. The wattage of the lamp is also a factor in color of light produced by the bulb.

7. Control of the Amount of Light

There are two levels of control that must be considered. The first is the lighting in the entire room and the second is the light providing a background for the monitor. Ideally there should not be any room light falling on or reflected by the display device towards the viewer. In most home environments, where the viewing room serves functions beyond viewing, absolute control of ambient light may be difficult. The room lighting should allow implementation of proper viewing conditions when that is the principle activity in the room. The perceived level of picture black is dependent on ambient lighting conditions, meaning that a fixed black level on the set will require tightly controlled ambient conditions.

Having control over the monitor background lighting, up to the maximum reflected value of 10% of the peak white level of the monitor, is often a matter of convenience. Fluorescent lamps can be dimmed to about 25% of their full light output without flicker or change in color, if the correct ballast is used to control the lamps. That makes them ideal for use in highly controlled ambient light application. The special ballasts for fluorescent lamps will most likely be available from a professional lighting supply centers or lighting contractors. Their use is becoming common in many video production and post-production facilities.

Fluorescent lamps that produce the proper color of light, without being filtered, come in four foot lengths, as of the beginning of 1990. They require a large fixture with a dimmable ballast so that the light output can be accurately controlled. (These four foot bulbs produce much more light than is normally needed.) There are a verity of fixtures available that can accurately control the area being lit in addition to controlling the amount of light. As lighting fixtures go, these are among the more expensive. Even at that, they represent a small fraction of the total investment in audio and video equipment. They are like interconnecting cables, a necessary part of making the entire system function properly.

Many other options are available. Look for papers written for the television industry for additional help. Reference Recordings may publish separate application notes on this subject by the end of 1990.

8. Getting Accustomed to the New Look

A note of caution to the viewer about this new environment is in order. From experience in working with post-production facilities that have made dramatic changes in monitor gray scale and room environment all at once, it can take up to two weeks to get used to all of the changes. The picture will look completely different when the monitor gray scale is changed from blue to gray and the lights and background changed from orange to gray. Not everyone will see the change the same way. There will be comments about being able to see green for the first time from some, and seeing much more red from others. Within one or two weeks there should be a general consensus of perception among all the viewers. During this transition period in particular, share ideas with other viewers about the changes being noticed. Use the CIE diagram in the disc to help analyze the changes everyone is seeing. A great deal will probably be learned about the perception of color in this transition period.

9. General Exceptions and Compromises

Placement of the monitor and viewer within the room are well defined in the "Ideal Viewing Environment" animation. The information provided in the disc; taken from the SMPTE Recommended Practice document for Monitor Environment, evolved out of human factors research. Many of the dimensions are specified in terms of the height of the picture being watched. This way, the specifications can easily be applied to individual circumstances. Major exceptions to these rules will probably have to be made for front projection video systems. Knowing the reasons behind the rules of the ideal viewing environment will assist in making compromises, if or when they become necessary.

When putting together large screen viewing systems, either front projection or single piece rear projection sets, provisions should be made for a bias light behind the screen. The level of the light should be reduced to much less than 10% of the peak white level coming from the screen, probably in the order of less than 5%. The bias light of the proper color will make viewing the big screen much more enjoyable.

10. Viewing Distance

When watching a video display it is desirable to see the entire pictures as a picture rather than seeing elements that make up the picture. If the observer sits close to the display, the horizontal line structure making up the display becomes as much a part of the perceived information as the picture. Some display devices, such as the original consumer version of the Trinitron4, have their own structure that can also become an observed part of the picture.

In the 525 line display system, most "trained observers" have to be eight times the picture height dimension away from the monitor before the line structure is no longer a factor in the picture. If there were more lines making up the picture, the observer could be closer to the display without seeing the line structure. In a motion picture theater the observer does not need to be as far away from the screen. In some special film formats, the ideal viewing distance is such that the projected image extends beyond the field of view of the observer. The observer's entire optical environment is filled with the motion picture image. In short, the size of the structure making up the picture, relative to the entire picture size, is an important factor in how far away from the image the observer must sit.

In television viewing there are real world conditions that call for viewing distances of less than the ideal eight times the picture height. The SMPTE Recommended Practice document allows for this by reducing the minimum distance, as noted in Chapter 5's animation.

Viewing distance from a large front screen projection device will probably have to be less than five picture heights. Many projector manufacturers recommend a minimum viewing distance of 1.5 to 2 times the picture height. The projector will often exaggerate the vertical dimension of each horizontal line so that they will blend together better. The line structure is not as noticeable at such a close viewing distance, but the focus of the picture appears to be a little soft.

There are IDTV (Improved Definition TV) monitors and projectors available that electronically double the 525 incoming lines. In theory, the observer should be able to sit closer to such a display. In reality, most of the line doubling schemes introduce their own structure to the picture that is very noticeable at a close viewing distance.

11. Viewing Angle

The proper viewing angle is within 15ø on either side of a center line coming out from a CRT based display device. The total wedge (shown in the "Ideal Viewing Environment" in Chapter 5 of the disc) is 30ø. Light fall-off and color changes can become significant at angles greater than 15ø from center. This is particularly noticeable in projection television systems, especially where the gain of the screen is greater than one. Many projection systems have screen gains in the order of 15. In their case, any movement away from center, in any direction, will cause a very noticeable shift in both light output and color.

12. Space Behind the Monitor

The principal reason for placing a monitor out away from the wall is to help reduce eye fatigue. When viewing the monitor in its free standing environment, only the monitor is in focus. Most everything else lit up in the field of view is out of focus (and out of mind). This promotes concentration on the picture content. When the viewer wishes to relax, there is another area in the controlled environment on which to re-focus. The eyes can relax without ever loosing their "color", gray, reference. It is desirable to have some sort of pattern in the background. The pattern makes it easy to focus on the background when the viewer wishes to relax.

Usually the depth of the monitor itself will place it 1.5 to 2 times the picture height away from the wall. The extra distance required to get to the minimum of 2.5 times the picture height is not that much more.

There is an added incentive in the home configuration in adapting this system. Most speakers need to be away from the wall in order to sound their best. Pulling them into the room, along with the monitor, will improve both sight and sound.

When setting up a system around a large screen projector, there often isn't enough space to pull the screen more than a few inches away from the wall. Enough space should be provided to get a light behind the screen, aimed at the wall.

Setting the Sharpness Control

1. Sharpness Control Function

Sharpness correction is amplitude control over particular frequencies in the video signal, usually 2.8 to 3 MHz. This control primarily compensates for loss of picture detail in the NTSC to RGB decoder. It also attempts to compensates for overall detail loss from consumer video tape sources.

Search Frame 17020. Adjust the Sharpness control through its full range. Notice that extra white lines are added to the picture, adjacent to the black lines, as the Sharpness control is turned up. The extra lines result from an over-enhanced image, to much sharpness correction.

2. Setting the Sharpness Control

Display the Multiburst (Frame 14384, 50790 or 50816) as a test chart for adjusting the Sharpness control. Set the Sharpness control so that the gray background around the 3 MHz burst, fourth burst over from the left side of the picture, is about the same level as the gray in the lower frequencies. Once this is completed, go back to Frame 17020 and make sure the black lines don't have any extra white edges.

The SMPTE Resolution Chart and the Indian Head Test Chart can also assist in properly setting the Sharpness control. Watch for a change in brightness along the horizontal resolution wedges.

NTSC to RGB Decoders

There are two basic types of NTSC to RGB decoders, the "Notch Filter" and "Comb Filter".

The Notch Filter removes all information, luminance and color, around the 3.58 MHz color carrier for use in decoding color information. With this type of decoder the luminance frequency information above 3.2 MHz will be displayed as color information.

The Comb Filter separates the color information from the video, leaving black and white high frequency information as luminance information. Some vertical resolution is lost in the process of gaining horizontal picture detail. Both types of decoders are usually present, and switch selectable, on industrial and broadcast grade monitors. Each decoder has its advantages.

Multiburst or the SMPTE Resolution Chart can help determine what type of color decoder is present in a video display device. If the frequency information above 3 MHz is displayed primarily as color information, chances are that the decoder is the Notch type. If the high frequency lines are displayed as black & white information, chances are that a Comb filter is being used. Early versions of the Comb filter were not as good about treating Multiburst as a luminance test signal. Some color will be displayed in the 3.58 MHz frequency burst in these older decoders.

Picture Resolution

1. Vertical Resolution

Vertical resolution is a measure of how many horizontal lines can be fit into a picture, how many light to dark transitions can occur from the top to the bottom of the picture; in the vertical direction. This of course is limited by the number of lines in the television system.

In the NTSC system there are a total of 525 lines. Since forty two of these lines are used for vertical retrace; part of the picture synchronizing signals, the maximum possible number of displayed transitions is 483 or about 241 line pairs.

In most sets, the raster that generates the picture is scanned beyond the edges of the picture tube. This makes the picture look full. The number of lines remaining is true vertical resolution, often less than 450 lines.

2. Horizontal Resolution

Horizontal resolution is the detail resolving power of a horizontal TV line. That translates to a measure of how many vertical lines can fit across a picture. In other words; how small can a picket fence be in size and still have the individual slats show up? Horizontal resolution is directly related to the frequency bandwidth of the video, then limited by a number of factors. Numbers being quoted for horizontal resolution are inconsistent.

Looking at horizontal resolution from the point of view of real NTSC picture information, RGB video source devices are usually limited to 10 MHz or less; 800 lines of resolution. If these signals are recorded, using standard component video tape recorders, the maximum recorded bandwidth is 6 MHz. That translates to less than 500 lines of horizontal resolution. Eventually the signal has to be encoded to NTSC. Many encoders limit the composite video bandwidth to 4.18 MHz to comply with transmitted video restrictions. Horizontal resolution is reduced to about 330 lines.

Once the composite NTSC signal reaches the viewing device it is decoded from NTSC back to the original RGB signal. A notch filter decoder will limit the video frequency response to about 2.8 to 3.2 MHz or about 220 to 260 lines. A good comb filter should be limited by the incoming video bandwidth, but vertical resolution can suffer with this type of decoder.

If both types of decoders are present in the viewing device, look at Frame 11395 while switching between the two. Watch for the loss of vertical detail in the comb filter mode and picture information turning to color information when the notch filter is used.

Some consumer set manufacturers specify the video bandwidth for their sets in the order of 7 to 10 MHz. How flat in amplitude and phase is this bandwidth? Most of the visible picture information, that can be seen from the proper viewing distance, is contained in information below 5 MHz. If video information does not exist from the source above 5 MHz; and it doesn't in most cases, the additional bandwidth could add a significant amount of noise to the picture, if it were a flat bandwidth. In short, many of these types of claims are meaningless as they are presented. Much more information is needed to determine if the large bandwidth claimed is good or bad for the picture.

The next potential resolution limiting item is the picture tube itself. How small are the elements of red, green, and blue that are needed to make a line? The structure of these elements will also effect overall resolution. Most of today's picture tubes will display a better resolution than can be delivered by most consumer video systems when the picture tube is properly converged. Yes, picture tube convergence is also a factor in picture resolution.

3. Overall Picture Detail Resolution

Look at the drawings of the various picture tube types, Frames 20479 - 20483. Imagine what the picket fence would look like if the vertical slates were slowly rotated towards the horizontal direction. The Delta-Delta tube configuration clearly has an advantage in overall apparent resolution capability, given equal red, green, and blue element size. The overall picture resolution, where detail is not necessarily vertical or horizontal, is more uniform in the Delta-Delta configuration.

Motion detail is part of overall picture resolution. The European PAL system has 100 more lines per picture and a slightly higher video bandwidth but about five less pictures per second than the NTSC system. There is more motion detail potential in the NTSC system than in PAL.

The vertical resolution of the actual picture in the "letterbox" format is probably between 260 and 390 lines. The film picture doesn't occupy all of the 480 lines available for a video picture.

4. Picture Detail Resolution vs. Peak Light Output

Display the Needle Pulse, Frame 14411, 17175 or 50787. Watch the black bar in the white background shrink in size as the contrast control is increased from its counter-clockwise position. Picture resolution is lost as contrast level is increased.

In the SMPTE specifications for a critical viewing monitor, picture resolution is stated as a factor of light output. That same form of specifying picture resolution should be applied to all viewing devices.

5. What About the Disc Resolution?

Actual numbers are going to be dependent on the player being used with the disc. Numbers in the order of slightly more than 400 lines of horizontal resolution can be justified.

Better yet, look at some of the information frames, such as 5076 - 5080, 11388 - 11394, 14453 - 14461, and 20459 - 20463. On a "utility grade" monitor, in the comb filter or mono position, all of the text in these frames is easy to read. It should also be readable on any high end consumer product. If not, the monitor has less than 400 lines of horizontal resolution, no matter what the monitor specification sheet says (or the video disc player is defective).

6. Other Important Parameters

There are of course many other parameters that are part of a picture's capability of accurately conveying information. Included are convergence, white field uniformity, correct choice of colors for red, green, and blue, picture geometry, contrast ratio, proper decoding of the NTSC signal, proper luminance and color calibration, and monitor environment. They must all be considered in any critical viewing application.

As of the first half of 1990, there are no CRT's larger than 20 inches that are acceptable for critical viewing of video, according to the SMPTE's specifications.

Emphasis must be placed on qualifying the specifications of a viewing device. Many examples have been provided in this document where specifications are not what they seem to be. "A Video Standard" is one of the few tools available that will assist in sorting out reality from fiction.

CRT Scanned Area

In displaying video on a consumer set, the CRT is overscanned, picture information exists out beyond the edge of the displayed area. There are lots of historical reasons for this, including fitting rectangular pictures on round or round cornered tubes, and the consumer's perceived desire not to see any black boarders around the edge of the picture. The picture has to look full. It doesn't seem to bother people that information, including real picture resolution, is lost in the process of overscanning a CRT.

In producing television programs, there is something known as "safe action" area and "safe title" area. They are both well inside the boarders of the active picture area to make sure that information a producer wants to convey, gets to the viewer. In other words, the producer expects the consumer to loose part of the picture information.

Monitor Automatic Functions

There are a number of places in this book that indicate that all automatic color or tint controls should be turned off before calibrating a monitor. Details are in order.

In the "old" days, color quality didn't match from channel to channel. Errors were noticed in flesh tones. In an effort to compensate for complaints about changing flesh tones the receiver manufacturer incorporated "Auto Tint" circuits in their sets. These circuits took a small area of the entire color spectrum, a window around flesh tone, and made it a single color, that of flesh tone.

Next comes the question: How much of the color spectrum should be inside the window? There were a lot of answers, some large enough to included red and yellow. If "Auto Tint" or "Auto Color" is present on a viewing device, try the following experiment.

Properly calibrate the viewing device with the automatic controls off. Display Frame 50794 on the viewing device. This combination pattern can be used as a first order approximation of what the auto-tint circuit might be doing to color fidelity. While watching the color portion in the lower half of the test pattern turn the automatic color function on and off.

Red and yellow are on either side of flesh tone. One or both of these colors may change when the auto-tint is turned on, depending on how wide the capture "window" is in the circuit. This pattern provides a third color, much closer to flesh tone, positioned to the right of R-Y and B-Y. If there is a change in the red and yellow, when auto-tint is turned on, it will be in the direction of this third color.

In order to display full color fidelity, any function that limits color fidelity must be turned off and left off. (There are cases where such circuits can not be defeated.)

Function that can be encountered on consumer viewing devices:

1. Auto Color: This can mean a variety of things, depending on the set manufacturer. In many cases switching it on selects a second set of controls for color, hue (tint), brightness, and contrast. These controls are usually preset at the factory and are often available to the consumer for re-adjustment. Auto Color may also engage Auto Tint. If the Auto Color control just selects a second set of controls, use it and the second set of controls when calibrating the picture. If Auto Color also engages Auto Tint, it is best to leave Auto Color off at all times.

2. Auto Tint: This function usually limits color fidelity when turned on. It is designed to help produce good flesh tones from the large variety of "Never Twice the Same Color" signals that are available.

3. Picture Control: This is normally another name for the contrast control. It may also change color level; independent of the Color control, in addition to contrast, therefore it should be set before any of the color controls are adjusted.

4. AFC: Automatic Frequency Control, or AFT, Automatic Fine Tuning, usually found in the TV channel tuning section of the receiver. It insures that the channel being watched is properly tuned. It is usually turned off when making adjustments to the channel tuning and then turned on to compensate for any drift in the tuning process.

5. AGC: Automatic Gain Control. AGC can be applied to a number of circuits in a viewing device. The incoming RF or TV channel signal is amplified or attenuated to provide the proper level to the tuner. Automatic gain is often applied to the color sub-carrier of the video signal to make sure the color decoder is presented with the correct level of color signal.

6. ACC: Automatic Color Correction, a circuit that grossly compensates for anticipated color errors, is found on many receivers. This circuit will not allow proper display of a standard Color Bar pattern. Some manufacturers do not provide the consumer with the ability to defeat this circuit.

Several broadcast quality monitors have automatic gray scale calibration. A light probe is attached to the surface of the CRT to provide the monitor's internal computer with the information it needs for adjusting the red, green, and blue content of the gray scale. This function is making its way into the "utility" grade monitors. It is something that should find its way into the consumer market just as soon as the manufacturers realize how much it is needed.

VITS & VIR

Vertical Interval Test Signals, (VITS), of which one is the Vertical Interval Reference, (VIR), exist throughout this program. VITS are located near the beginning of each television picture field; in an area above the top edge of the picture tube. They can be seen by miss-adjusting the vertical hold control, bringing the top of the picture down into the picture. Actual evaluation of the VITS is done with a waveform monitor or vectorscope. Test signals are normally only one line long, sometimes existing in both field one and field two of the video. The main purpose of test signals in the vertical interval is to allow for continuous engineering checks on a video signal path, even as normal program material is being presented. A good example of their use is in keeping track of a remotely controlled television transmitter. The engineers back at the studio can tell how well their transmitter is functioning without interrupting normal programing.

The VIR was originally designed as a much needed fix for "Never Twice the Same Color". It's purpose was to help the consumer get a better picture in the home. The signal contains a reference for color; both saturation and tint, a reference for black; 7.5 IRE, and a reference for gray; a 50 IRE level. Many consumer monitors and/or receivers can "look" at this signal and automatically adjust the set's video parameters to make the VIR signal correct. Properly implementing this presumed that a VIR was attached to a program; somewhere in the production process; after color quality had been judged as meeting the producer's standards, and passed through the distribution chain; video tape duplication, network transmission, and local station transmission, to the viewer. Any changes to the video in this signal path would also occur to the VIR. By applying correction to the entire video signal needed to make the VIR correct, the original picture parameters could be obtained.

In reality, when a VIR goes through many distribution levels, it is usually a different VIR coming out than went in, often the one coming out having nothing to do with the original. That is one of the major failures of the VIR system idea for the consumer. The original VIR would get substituted without first correcting the video.

In the mid to late 1970's, television engineers realized they could use the VIR to control the parameters of their transmitter. Industry wide, it was much cheaper to put VIR correction in the transmitter rather than in the viewer's home sets. The VIR coming from the studio to the transmitter, was stripped and a newly generated VIR put in its place before the transmitter. It was at that point that the VIR became useless to the consumer.

In this program, the VIR is inserted for the first time at the disc mastering secession. The video tape program, used to master this disc, has video calibration signals that allowed the mastering facility to properly set up their system before inserting the VIR. Anyone using a VIR capable monitor, may want to calibrate it both in and out of the VIR mode. There should be two sets of controls for brightness, contrast, color, and tint. Once calibration is complete, there should be no difference in picture quality between the VIR mode and the standard mode while watching this disc.

Joe Kane
Joe Kane Productions