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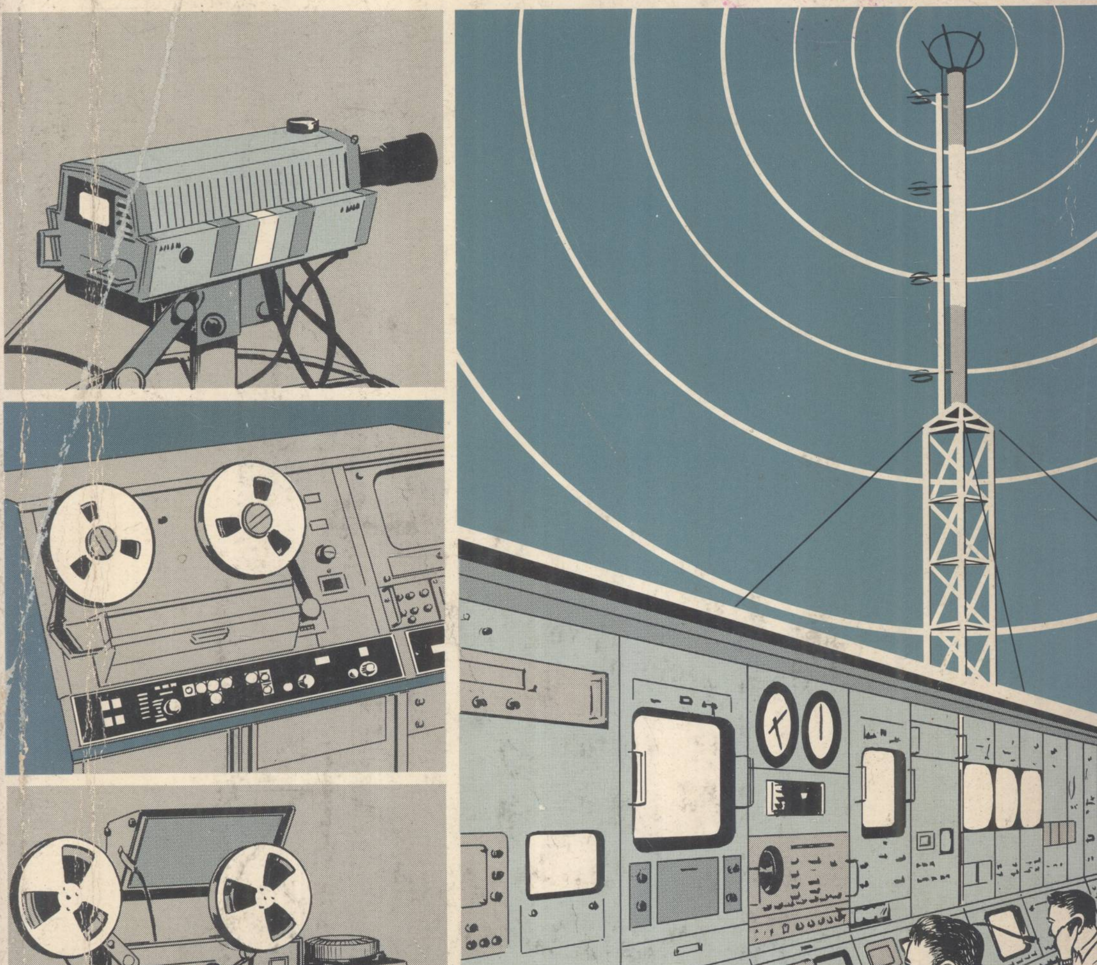
Measurement Concepts



Television Systems

TELEVISION SYSTEM MEASUREMENTS

BY

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TEKTRONIX®

MEASUREMENT CONCEPTS

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INTRODUCTION

The primary intent of this book is to acquaint the reader with the functional elements of a television broadcast studio and some of the more common diagnostic and measurement concepts on which video measurement techniques are based.

In grouping the functional elements of the broadcasting studio, two areas of primary concern can be identified -- video signal sources and the signal routing path from the source to the transmitter.

The design and maintenance of these functional elements is based in large measure on their use and purpose. Understanding the use and purpose of any device always enhances the engineer's or technician's ability to maintain the performance initially designed into the equipment.

The functional elements of the broadcast studio will be described in the first portion of this book including a brief discussion of how these functional elements interrelate to form an integrated system.

In the broadcasting studio, once the video sources and routing systems are initially established, maintaining quality control of both the sources and the routing path becomes one of the major concerns of the broadcast engineer.

Since the picture information is transmitted as a video waveform, quality control can in large measure be accomplished in terms of waveform distortions and subjective picture quality degradations.

Four major test waveforms, each designed to observe and measure a specific type of distortion, are commonly used in a broadcast studio. The diagnostic information contained in each waveform will be described in the latter portion of this book in terms of the measurements commonly made with each of the four waveforms.

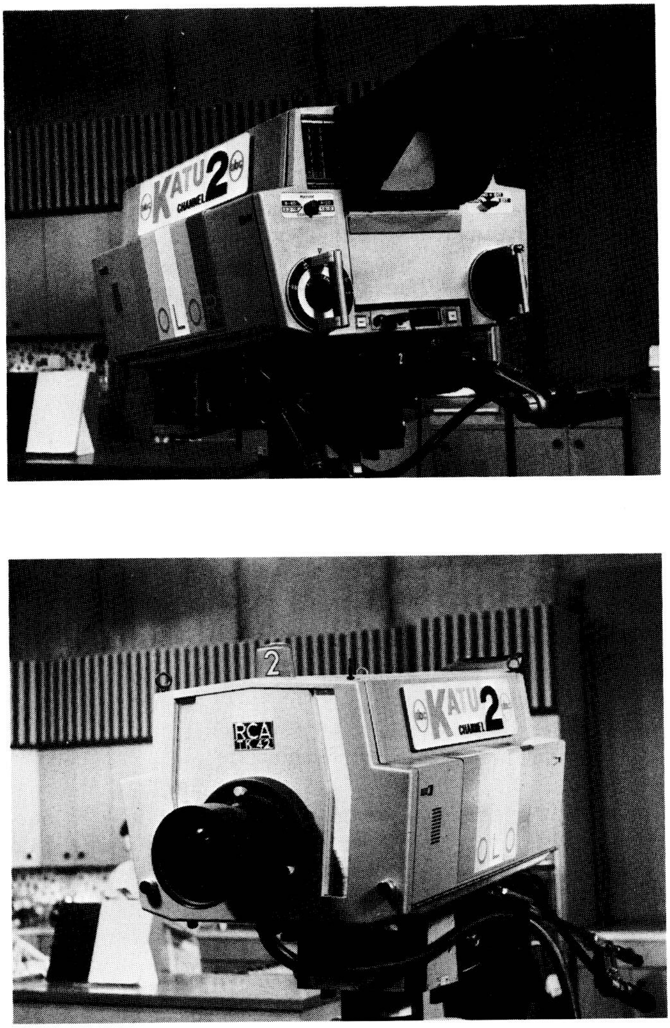


Fig. 1-1. Front and rear view of a color television camera showing the zoom lens, viewfinder, and camera controls. Courtesy of KATU.

1

CAMERA

camera function

The camera, which is usually mounted on a moveable dolly in the studio, converts the reflected light from a studio scene into an electrical waveform. To effectively perform this function, the camera contains an optical system to converge the scene onto the image targets, an image pickup tube to convert the light to a voltage, preamplifiers to amplify the signal from the image pickup tube to a usable level, and deflection circuits to scan the image pickup tube in an established pattern.

optical system

Examining the camera more closely, the camera optical system serves two purposes -- focusing the image on the pickup tube targets and optically splitting the light into the primary color components.

The camera optical system contains a zoom lens for optical focus and an iris to control the amount of light striking the image pickup tube.

color-light separation

Color-sensitive dichroic mirrors initially separate the image into three primary color images; color filters in front of each pickup tube more precisely shape the color response of each individual channel to the prescribed color responses.

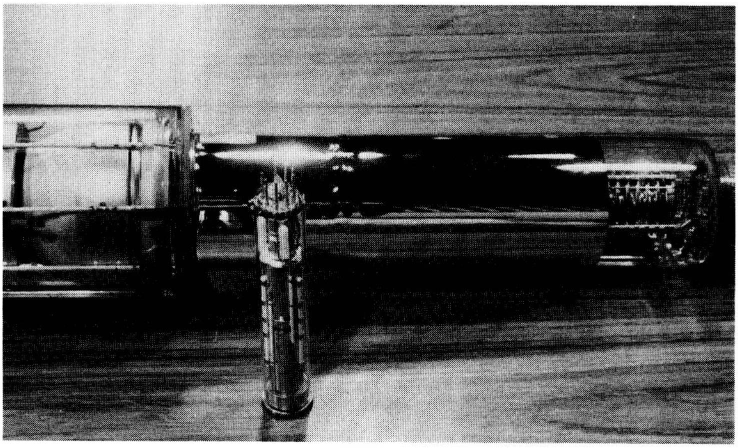


Fig. 1-2. Image orthicon and vidicon tube. Because of its smaller size, the vidicon tube is more desirable in color cameras. Courtesy of KATU.

image pickup tubes

Two alternative types of image pickup tubes are used in current color cameras: the "image orthicon" and the "vidicon". Both types are shown in Fig. 1-2.

When comparing the two types, the image orthicon generally has greater resolution, less noise, and no image retention (picture lag) while the vidicon has greater light sensitivity and smaller physical size. Both light sensitivity and size are important in a color camera in which the additional optics and filters attenuate the light and where a minimum of three tubes are needed.

preamplifiers

Voltage preamplifiers physically located close to each pickup tube amplify the video signals to a usable level.

The typical color camera contains at least three image pickup tubes and associated video amplifier channels -- one for each primary color. Some cameras have a fourth video system used exclusively for the brightness/white information.

aiming the camera

A picture monitor mounted at the rear of the camera serves as a viewfinder for the cameraman. A voice intercom enables the cameraman, located on the floor of the studio, to communicate with the technical director and program director, who are usually located in the studio control room.

camera control unit (CCU)

To minimize the camera size as much as possible, the waveform processing portion of the camera is not done in the studio camera but in a second unit -- considered part of the color camera "chain" -- called the Camera Control Unit or CCU.

The video signals from each of the image pickup tube preamplifiers are fed to the CCU through coaxial cables for further processing.

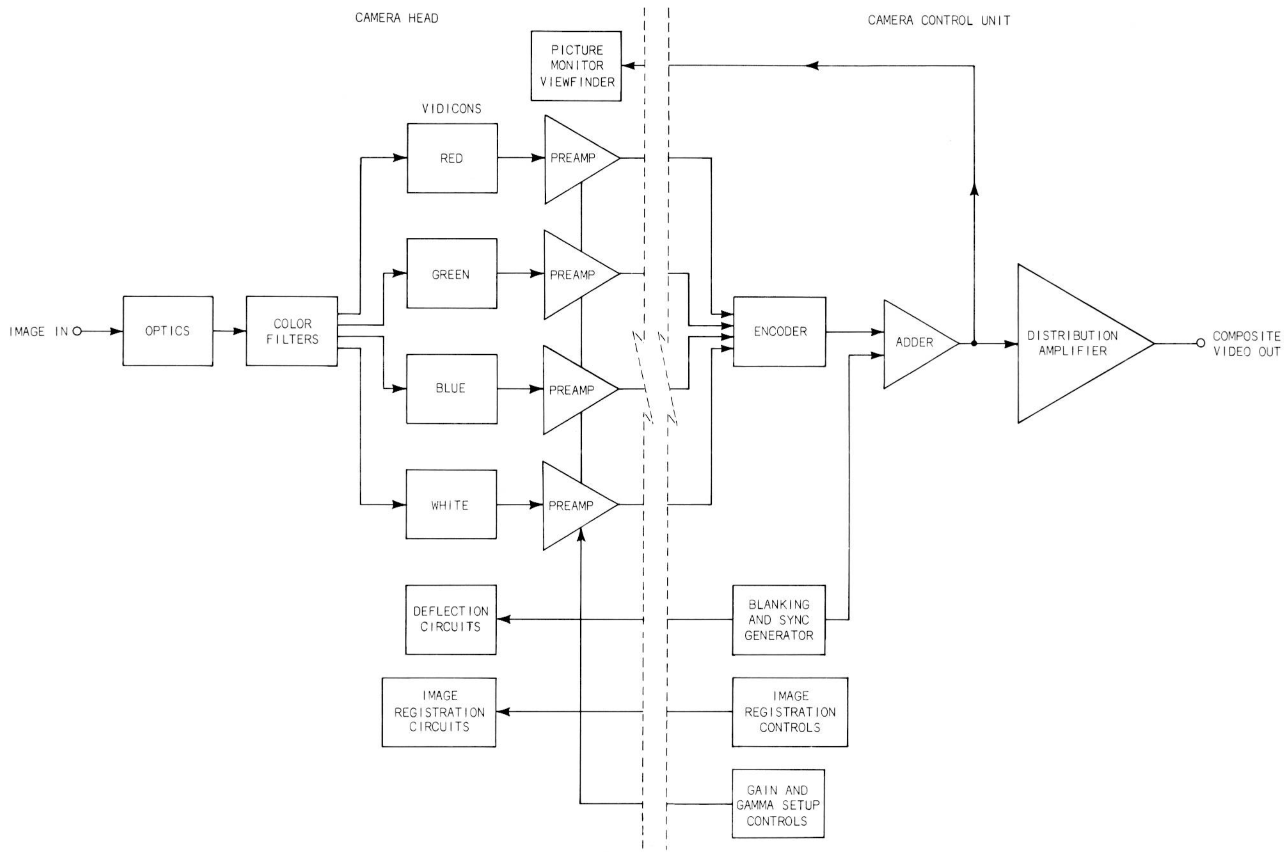


Fig. 1-3. Simplified signal flow block of a color camera chain.

CCU signals

The CCU is located either in the studio control room or adjacent to it. It contains signal generating equipment needed to drive the camera deflection circuitry as well as the signal processing equipment, called the "encoder," which processes the three video signals into a composite color video waveform. The complete signal flow block diagram is shown in Fig. 1-3.

The CCU console (shown in Fig. 1-4) includes a picture monitor and waveform monitor oscilloscope to observe the effects of the camera setup controls. These setup controls include:

1. The gain controls for each of the three or four signal channels.
2. The electrical/optical controls for image registration.
3. The focus and target controls.
4. The black setup and level controls.

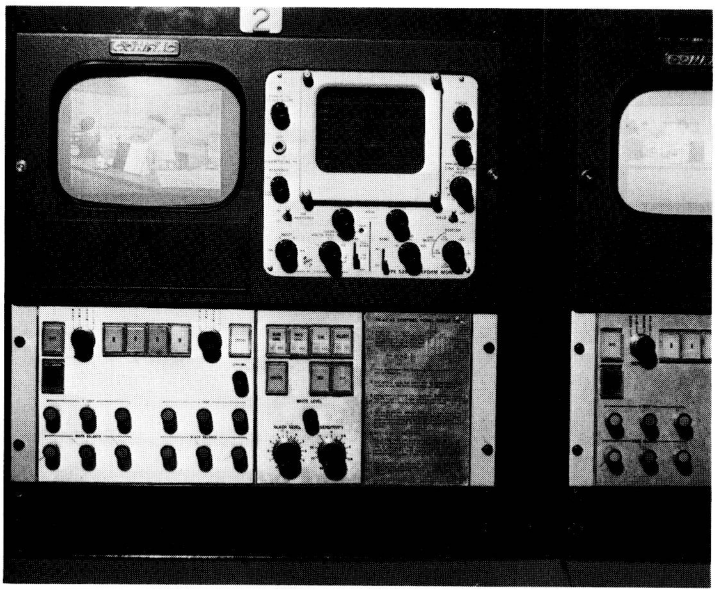


Fig. 1-4. Camera control unit panel. Courtesy of KATU.

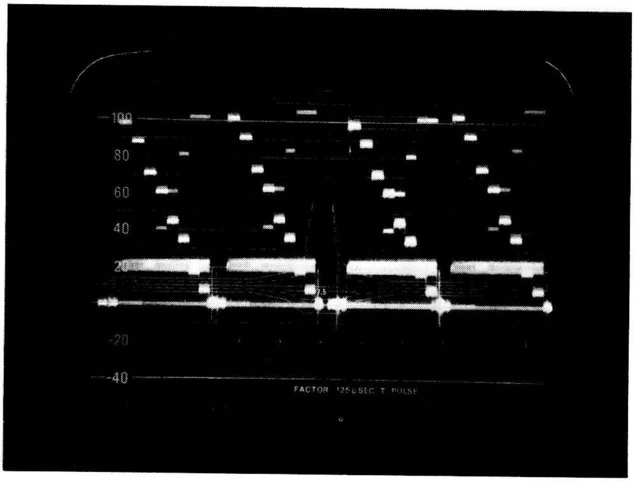


Fig. 1-5. Four-channel YRGB display (simulated).

camera signal monitoring

Since a minimum of three identical video channels are processed by the encoder, a special waveform monitor display is provided so all the channels can be observed simultaneously. This display is called RGB (or YRGB). A special signal from the encoder horizontally positions the output of each primary-color video amplifier so the three outputs lie side-by-side on the oscilloscope CRT. Comparison of all the video channels can then be easily made. A typical display is shown in Fig. 1-5.

Composite sync, the color burst, and black setup level are all added to the video in the encoder. The composite color video waveform at the output of the CCU is then ready for signal routing.

2

TELEVISION TAPE RECORDER

The television tape recorder is the most widely used video source in the broadcast studio. The tape recorder is an electro/mechanical device which can either deposit or recover a composite video waveform from magnetic tape.

The tape recorder has become a valuable production tool since most current recorders can be equipped with special electronic editing devices to permit a program director to literally "put together" a finished program complete with inserted commercials.

The tape recording machine contains four basic elements:

tape transport

1. The tape transport -- the mechanical mechanism that moves the tape past the recording or playback head gap. Four distinct recording tracks are deposited or recovered from the tape:
    a. Video
    b. Audio
    c. Cue
    d. Timing control

servo control

2. Servo control -- the servo control is a tape-to-head velocity control system to maintain very precise tape movement. The servo control also allows the taped video to be synchronized with other studio video sources.

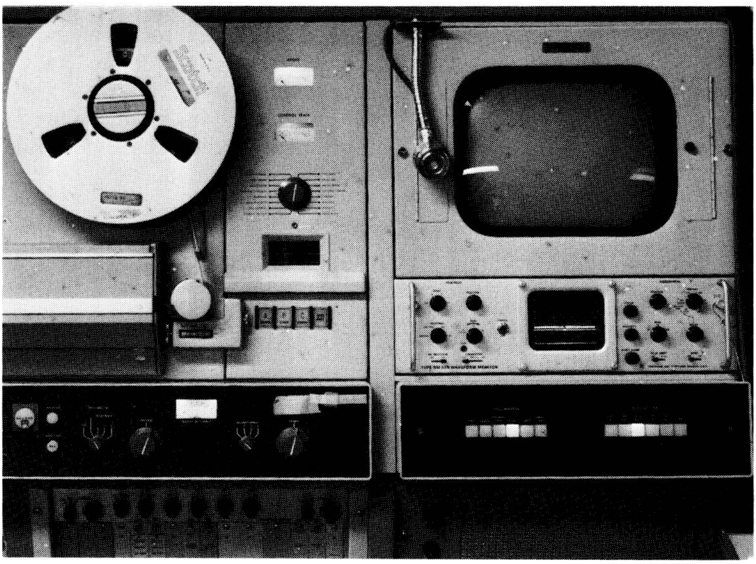
recording electronics

3. The recording electronics -- the recording electronics consists of a FM modulator, equalizing networks, and wideband amplifiers.

playback electronics

4. The playback electronics -- the playback electronic equipment consists of the FM demodulators, amplifier system and playback frequency-response equalizer.

Courtesy of KATU



Courtesy of KGW

Fig. 2-1. Two common video tape recorders for recording and playing back quality color television programming.

mechanical system importance

Since the tape recorder is both mechanical and electrical in nature, adjustments of mechanical tolerances as well as circuit adjustments will affect the condition of the composite video. Knowledge of the mechanical components and their effects on the overall system is therefore important.

In order to record the relatively wideband composite video signal on magnetic tape, the magnetic head gap must be very small and/or the head-to-tape speed must be very fast.

For practical head-gap spacing, a tape speed of 1500 inches per second -- at least 100 times faster than audio tape recorders -- is required to record the necessary bandwidth.

Using conventional techniques, a considerable amount of tape would be consumed since the tape would be moving past the recording head in excess of 100 miles per hour.

The tape speed (and tape consumption) can be reduced by moving *both* the tape *and* the tape head. This technique is used in current video tape recorders by mounting four heads on a 2-inch cylinder as illustrated in Fig. 2-2.

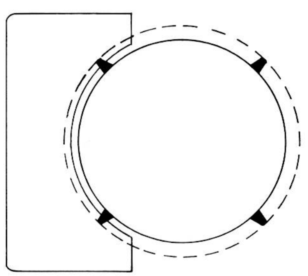


Fig. 2-2. Profile view, drum and guide.

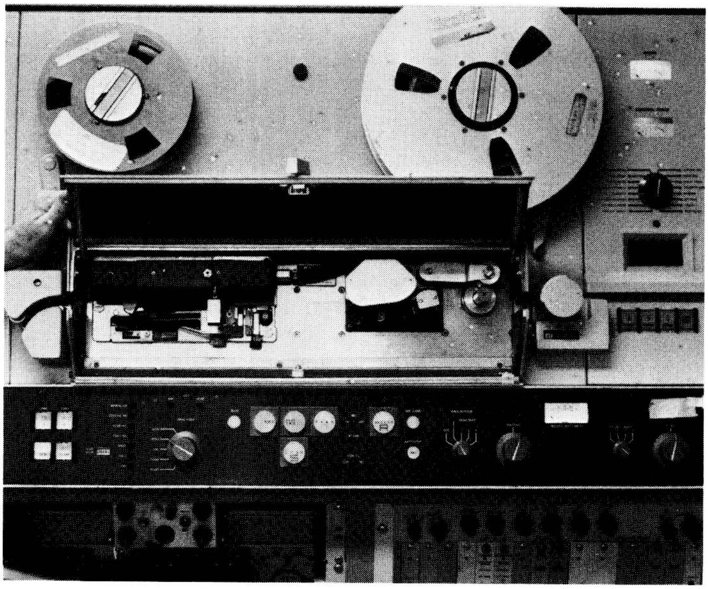


Fig. 2-3. Video head assembly. Courtesy of KGW.

revolving head

The head cylinder or drum then rotates at 14,400 revolutions per minute (or 240 revolutions per second) creating a *relative* head-to-tape velocity of 1500 inches per second when the tape is moving past the rotating drum at the rate of 15 inches per second. A guide, located adjacent to the rotating drum, cups and holds the tape against the drum. The complete video head assembly is shown in Fig. 2-3.

head band

With the rotating heads revolving at the rate of 240 revolutions per second, each head then records 16 to 17 television scanning lines on the tape, forming a "head band". One complete rotation of the head produces 1/4 of a picture field. All four heads are mechanically and electrically arranged to have identical gain and bandwidth characteristics to prevent picture banding. Adjustments for the individual heads and associated video channels permit identical characteristics between each head to be achieved.