THE VITASCAN
LIVE FLYING-SPOT COLOR SCANNER

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Introduction

The DuMont "Vitascan" Color TV system produces live color television pictures of high quality without the use of expensive and complicated color television cameras or highly trained and skilled camera and maintenance crews. It is, in fact, a modern all-electronic version of the earliest forms of mechanical live television pickup which employed the flying-spot scanning principles.

While the Vitascan cannot displace storage-type color TV cameras, it is expected that the unique advantages of the Vitascan will earn it a modest place in color TV programming. It is the purpose of this paper to explain its virtues and shortcomings.

On an historical level, it is our hope to explain how the present technical state of the art has allowed this revitalization of the old flying-spot principle. The basic principles are discussed and the evolution of a workable system leading to the present commercially available equipment is traced.

Historical Review

J. L. Baird, in England in 1932, was the first to achieve the analysis and synthesis of a subject by television. He employed a 30-line mechanical scanning system. As late as 1937, the BBC in London programmed with a Baird mechanical live pickup flying-spot scanner operating at 240 lines.

In advancing from 30 to 240 lines, the mechanical scanner system was doomed for two major reasons. First, the extremely acute mechanical problems and, secondly, the lack of sensitivity of the then available photocells. Since multiplier photocells were not available, the low signal level gave excessive noise when amplified, thus limiting the action to head and shoulder closeups.

The first non-mechanical live pickup, using a cathode-ray tube, was demonstrated early in 1947 during the first FCC color hearings in connection with the RCA simultaneous color TV system.[1] The 18" x 24" scanned area limited the device to head and shoulder pickups.[2] Although 931A multiplier phototubes were used, the light collection was severely restricted by the 5/16" x 15/16" pickup area.

The DuMont color scanner development program, which began in 1949, took advantage of the newly available 2" multiplier phototubes. Although the transmission of slides, film, and opaques was achieved with considerable success, it was not until 1954 that components and techniques had sufficiently improved to allow the contemplation of a satisfactory color scanner for limited live pickup work which would surmount some of the shortcomings of earlier equipments. The real technical breakthrough came with the commercial availability of the first 5" multiplier phototubes, the DuMont Type 6364.

At first, our efforts were directed to providing a live-action color pickup of a 7½ x 10 foot scanned area solely as a signal source for research purposes. However, notwithstanding its inherent limitations, it became apparent that a very definite use could be made of the principle in normal color broadcasting operations. A commercial version of this device was dubbed the "Vitascan" and a prototype was first publicly demonstrated at the NARTB Convention in May, 1955. This paper is not intended as a detailed description of the present commercially available equipment, but rather as a history of its parentage.

Basic Principle of Operation

The light from a high-voltage, high-beam current flying-spot scanning tube which emanates from the unmodulated rectangular scanning pattern is focused onto the subject or scene being televised through a suitable lens system.

As this light spot traverses the scene in its regular pattern, it is reflected from the various objects, the amount and color of reflected light at any given moment varying with the reflection factor and color characteristics of that part of the scene. The scanning light incident on the scene is therefore modified or modulated by the different reflective characteristics of the scene from one part to another. These variations in intensity and color of the reflected light are picked up by groups of multiplier photocells, suitably disposed around the scene, which linearly convert the light energy to varying currents for processing through the normal color video apparatus for flying-spot scanners.

The phototubes are covered with suitable color filters which, in combination with the spectral emission characteristic of the scanning tube and the response of the phototubes determine the spectral characteristics of the system.

1. RCA Staff, "An Experimental Simultaneous Color TV System," PROC IRE, Vol. 35, PP 861-870. Sept., 1947

2. RCA Review Publication - Television Vol. V (1947-1948): Simultaneous Color Television - The Flying-Spot "Live" Pickup. PP 244-248.

The major differences between the flying-spot scanning operation for the transmission of live pickup and that for transparencies are:

1. The scanned area is many thousand times larger for live pickup than for slide or film operation.

2. The scanning light is reflected from solid objects rather than transmitted through flat material as in the case of a transparency.

3. Using a multiplicity of phototubes, lighting effects similar to other live-action TV systems are provided.

4. Controlled illumination additional to the light from the flying-spot must be provided in the studio.

5. Special TV previewing techniques must be employed.

In visualizing how the Vitascan live-action scanner operates, it is helpful to regard the system as being the reverse of conventional studio television operation. Clusters of phototubes replace the studio lighting fixtures and the flying-spot tube is substituted for the image-orthicon camera tube.

Normally, light from the studio fixtures illuminates the scene, and reflected light is gathered by an objective lens onto a light-sensitive electrode, where it is transformed by the scanning process within the camera tube into electrical currents. In contrast, the scanning tube and its lens, placed where the camera would normally be, produces the light and performs the scanning operation at the same time. Some of this light reflected from the scene is intercepted by the phototube clusters and converted into electrical currents.

The analogous relationship described above was recognized by the early pioneers in television. One such printed reference by Lance and Percy in 1935, describes this relationship aptly:

"In this studio there has been a great deal of of work done to produce an artistic effect by correct lighting of the artists; in fact, it was found that, since each photocell could be controlled separately to give the correct balance between top, side, and back lighting, in imitation of the lighting of a floodlight studio, the simplest way of working out the lighting effects was to regard the scanning projector as a camera, and the photocells as light sources, placing them and altering their gain from that point of view."

Studio Requirements

Since the "Vitascan" System operates by virtue of a scanning light beam, no illumination other than that from the controlled scanning source can be allowed to reach the phototubes during the scanning period, since this extraneous light will only produce noise.

The studio, therefore, must be sealed against ambient light. Eliminating all ambient light, however, would leave the studio in relative darkness since the light from the scanner is insufficient to adequately illuminate the studio.

This acute problem was literally a stumbling block in earlier versions of live scanner operation, since lack of light seriously restricted the movement of performers about the studio, made it impossible to read, and produced a staring expression on the faces of the actors.

The difficulty of providing adequate light in the studio without interfering with the Vitascan operation has been resolved by utilizing the 60 cycle vertical blanking period, during which time the scanning beam is extinguished.

During this blanking period, pulsed or stroboscopic lights synchronized with the TV system are flashed on in the studio, providing adequate illumination for studio action without upsetting the scanning operation. During this same period that the lights are pulsed on, the phototubes or associated video amplifiers, or both, are keyed off to prevent overloading. In addition to being light-tight, noise is further reduced by employing reflective materials on the unscanned walls and ceiling, thus increasing the light directed to the phototubes and additionally softening the shadows.

Equipment Complement

In its present form, the "Vitascan" is operated as a one or two "camera" system. The "cameras" which, in actuality, are flying-spot scanners, may be fixed or mobile. One favorable arrangement, which was used at the initial public demonstration at the 1955 NARTB Convention, includes the DuMont "Multiscanner" equipment to provide a fixed scanner augmented by a mobile scanner packaged to resemble a standard image-orthicon camera.

Figure 1 shows the studio of 200 square feet at the NARTB Convention. The equipment complement included the following items:

a. Two scanning light sources, one mobile and one fixed unit - utilizing the DuMont Multiscanner.

b. Seven clusters of DuMont 5" multiplier phototubes.

c. Six pulsed light fixtures.

d. Processing amplifiers.

The DuMont Multiscanner, as seen in Figure 2, is a flying-spot scanner system for slide, opaque and motion picture film pickup. It utilizes a 7" high voltage cathode-ray tube operating at 40 kv. The tube, which is aluminized, employs a short persistence zinc oxide phosphor coated onto a high-quality, non-browning, neutral density face plate. Use of this gray face plate, rather than a clear face plate, improves the small area con-

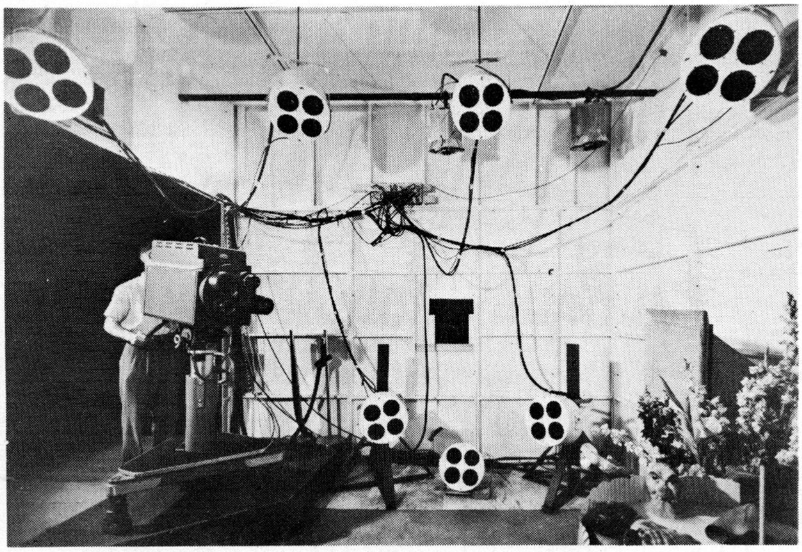

Fig. 1 - Vitascan studio.

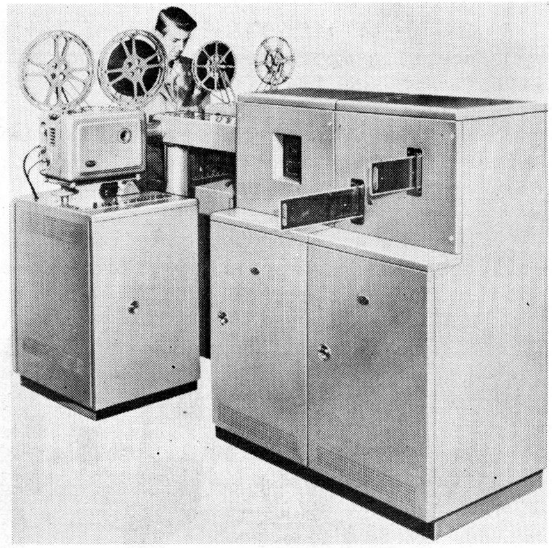

Fig. 2 - DuMont Multiscanner.

trast by a factor of ten by the reduction of halation flare.

Figure 3 shows how the Multiscanner is easily adapted to live pickup work by the removal of the cabinet for 4" x 5" opaques and the addition of the desired focal length lens to the flying-spot cabinet.

The mobile light source, seen in Figure 4, resembles a conventional TV camera and includes a lens turret to provide a choice of focal lengths for close-up, medium, or long-shot work. This mobile scanner employs a 5" high-voltage cathode-ray tube operating at 35 kv in which special precautions have been taken to minimize the phosphor grain size by careful control of the screening process.

The phototube clusters consist of four DuMont 5" diameter 10 stage multiplier phototubes, Type 6364, shown in Figure 5. They are closely spaced in a compact housing as depicted in Figure 6. Each phototube is covered with an appropriate color filter in order to analyze the reflected light from the scene into three primary color channels. One cell is allocated to the green channel and one to the blue channel. Two cells are supplied for the red channel in order to compensate for the lack of sensitivity at the red end of the spectrum. The phototubes identified with each color channel are bridged onto a coax line which is terminated at each end, thus allowing the addition of as many clusters as desired.

The pulsed or stroboscopic, lights are of two types. In one version, small commercially available Xenon flash lamps are used, five to a reflective fixture. These lamps are triggered to flash during the vertical scan blanking interval. In the second developmental version, miniature CRTS are employed, three to a reflective fixture. These tubes are operated at 15 kv and are pulsed on during the vertical blanking interval.

Operation on the R, B, G signals developed from the combined outputs of the phototube clusters is accomplished in conventional video processing amplifiers, providing phosphor correction, gamma correction, and blanking insertion, as normally used in flying-spot scanners.

We hope, in the previous paragraphs, to have whetted your appetites with a brief general look at the Vitascan System. We now plunge into an expanded explanation of some of the more novel features of the system.

Vitascan Photometry

In returning now to the basic principles of the Vitascan, it is helpful to give our definition of a live-action flying-spot scanner. A live scanner may be defined as one which televises an object having depth, and which, consequently, must provide the appearance of "effects lighting". To show simply how light modeling effects are produced, we refer to Figure 7 depicting a schematic top view of a simple monochrome Vitascan. The scene being televised is a square white card suspended some distance from a gray background. When a single phototube pickup is placed at the right of the scanner, it will be shown that the TV picture produced looks like one from a storage-type TV camera viewing, from the CRT position, the scene lit by a single lamp at the phototube position. It is obvious from the slide that a shadow from the white card would be thrown to the left on the gray background.

Now, to see why the Vitascan signal also exhibits the same shadow, we consider what happens at seven equal increments of time, T1 through T7. At the instant of Time T1, suppose that the scan is just beginning a new line in the middle of the picture. The tiny spot on the CRT is imaged by the objective lens onto the left-hand side of the gray background. The light reflects in all directions from that particular spot on the gray background, as indicated in the

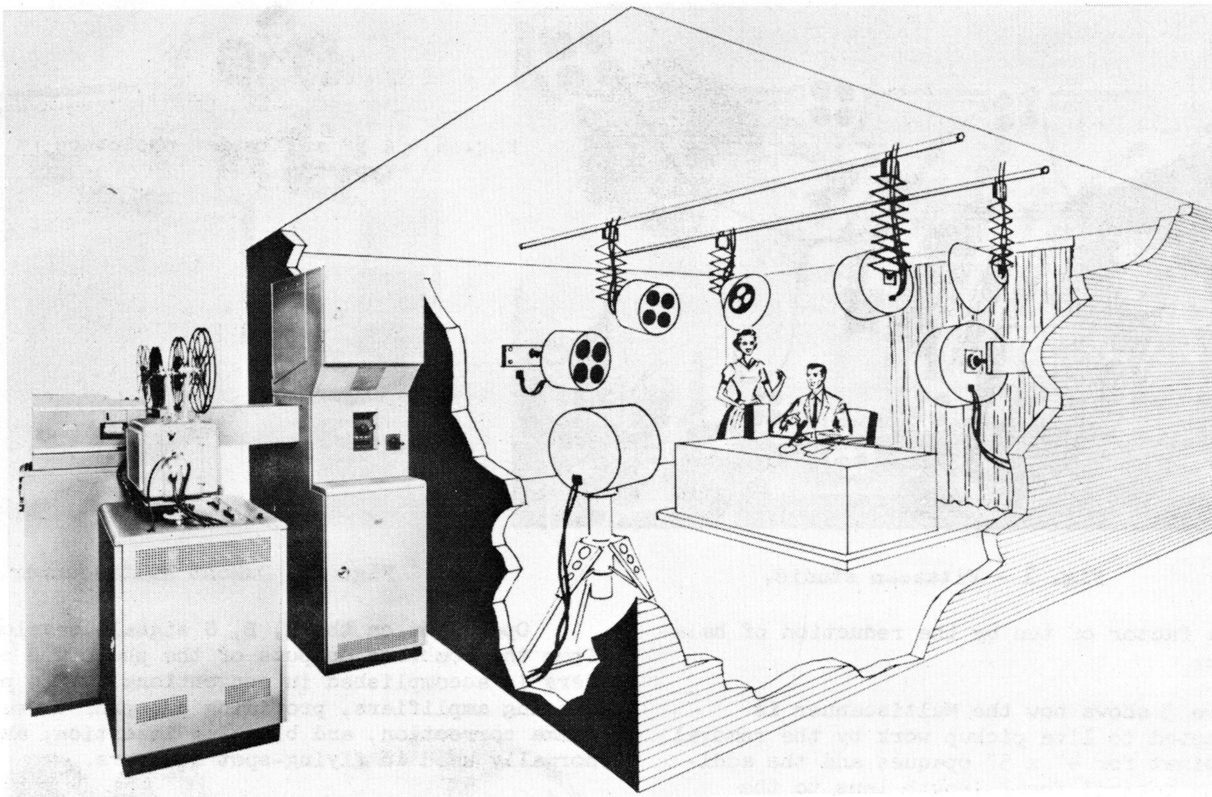

Fig. 3 - Multiscanner used as fixed Vitascan.

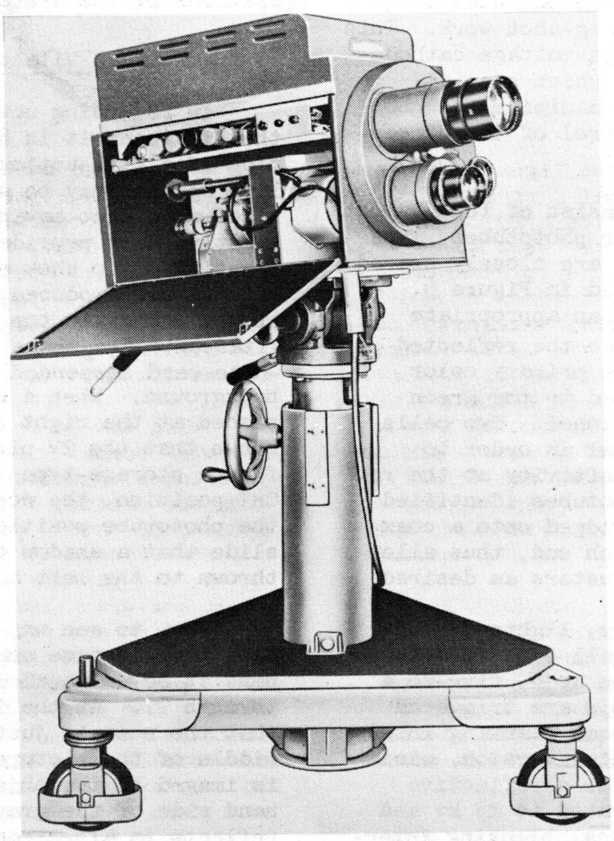

Fig. 4 - Mobile Vitascan "camera."

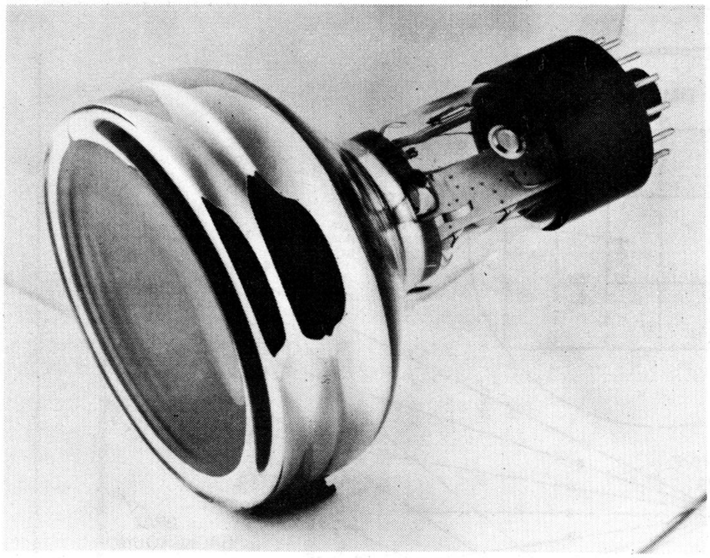

Fig. 5 - A 5" multiplier phototube, type 6364.

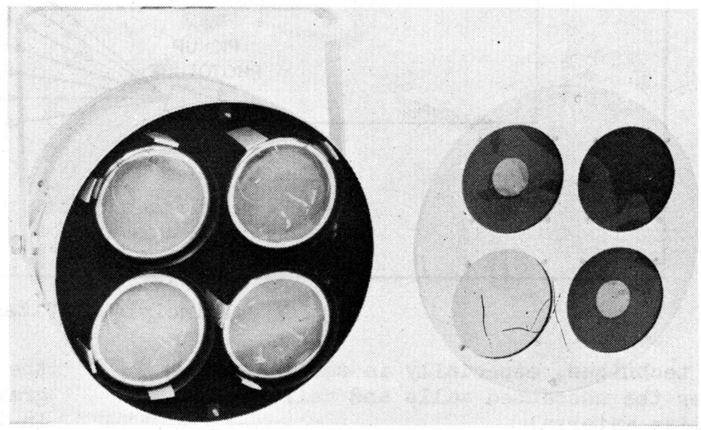

Fig. 6 - Phototube cluster.

figures. A small portion of the light is picked up by the phototube and a signal corresponding to gray is generated and thence displayed on the screen of the TV monitor. As the spot moves from T1 to T2, the phototube continues to generate the gray signal level. But, between times T2 and T3, the light reflected from the gray background cannot reach the phototube, since the white square blocks the path, and hence no signal is produced by the phototube. This results in a black shadow on the TV monitor. At T3 and continuing through T5, the flying spot hits the white square and the phototube transmits a white signal and finally, from T5 to T7, a gray signal is again displayed. If now the whole scanning period is viewed, the resulting picture resembles that on the monitor.

Suppose now that the same phototube is moved to a corresponding position to the left of the scanner. The shadow would then move to the right. In fact, if only a single phototube is employed, the resultant picture will appear to be illuminated by a light at the phototube position. For this reason, we normally think of the phototubes as representing "lights".

By employing a number of phototubes, with suitable reflectors, any desired lighting effect can be produced such as "key", "fill", and "back" lighting. The apparent intensity of these "lights" are controlled simply by the photomultiplier gain. Thus, the video level and the lighting effects are controlled by only one individual. This compares to the case with storage systems where the video operators and the lighting staff are distinct groups and thus considerable coordination must be exercised.

With the color Vitascan, the "lighting fixture" normally consists of a cluster of four phototubes, one Blue, one Green, and Two Red. From the sketch, it is apparent that the physical spacing of the 5" phototubes is apt to cause colored shadows if only one cluster is employed. Again, the picture is analogous to having red, blue, and green lamps illuminating the scene rather than a single white lamp. However, with the number of phototube clusters normally employed to obtain the desired artistic effect, colored shadows are not apparent. Added to the "fill lighting" produced by the clusters themselves is the considerable diffusion of light provided by the various inter-reflections in the scene. In addition, reflectors around the clusters are a great help in mixing the red, blue, green light to avoid colored shadows. Another useful "fill-

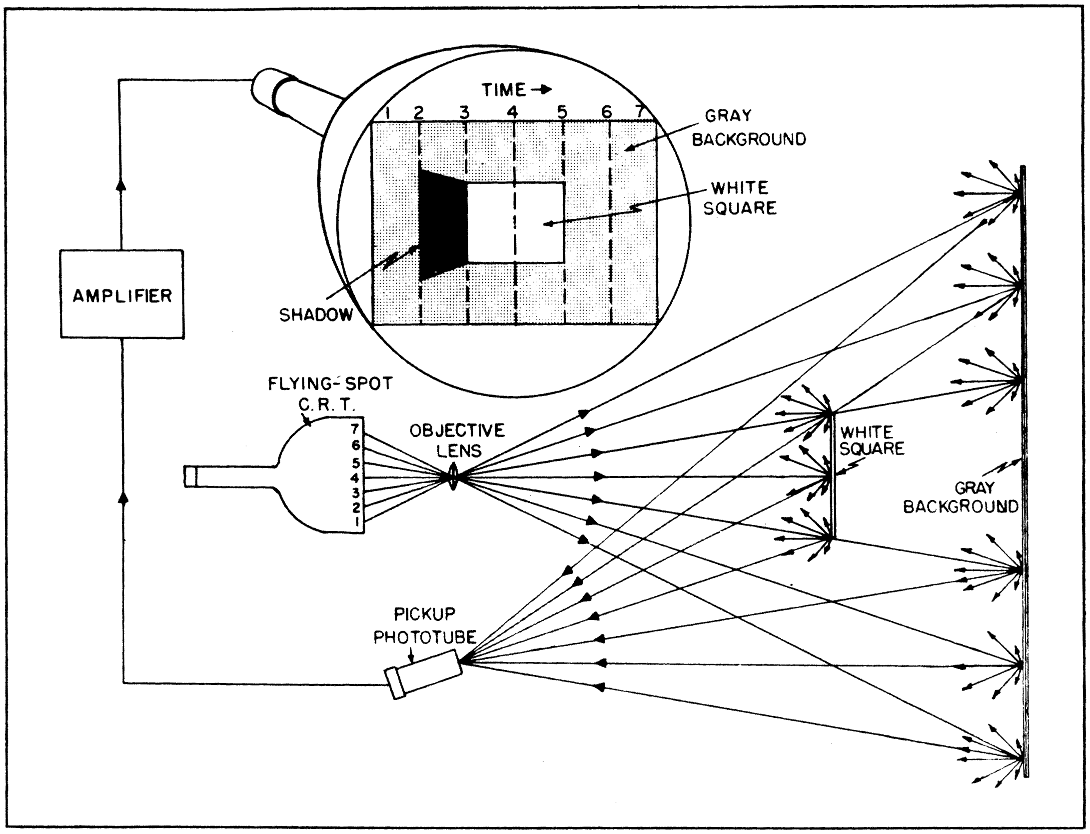

Fig. 7 - Principle of Vitascan "lighting."

light" technique, especially in small studios, is to cover the unscanned walls and ceiling with reflective material.

At this point, the operation of the fixed Vitascan has been briefly covered from an optical-photometric point of view. Depth-of-field considerations are straightforward and are treated later.

But now, what additional theoretical problems are raised when the fixed Vitascan is replaced by a mobile Vitascan? By mobile Vitascan, we mean a scanner which can be moved around the studio and which employs a turret with a variety of objective lens focal lengths. Actually, no special problems arise although the situation may appear filled with difficulties at first glance. The first situation likely to raise a mental block is where the scanner is dollied very close the subject. It might be supposed that the signal level would be greatly increased. This supposition is incorrect. For simplicity, refer again to the figure, but mentally remove the white square so that only the gray background is scanned. Instead of considering the scanning, as before, on an instantaneous basis, observe that a certain total amount of light flux passes through the objective lens in the same unit time and is spread over the scene. Of the total amount of light flux leaving the lens, a certain proportion is picked up by the phototube. Suppose now that a 6' x 8' area is scanned on the gray background, producing the corresponding gray signal amplitude. If now the scanner dollies in to scan a 3' x 4' area, the signal level will remain exactly the same. This is because the phototube remains at the same distance and therefore still collects the same proportion of the same total light flux leaving the scanner. Looking at the situation in another way, the 3' x 4' area will be four times as bright as the 6' x 8' area, but since it has only on-fourth the area the total light picked up will be constant.

Thus, with the mobile Vitascan, the same flexibility of movement is allowed as with any TV camera. The same argument holds when the lens turret is changed from narrow to wide lens. In any given scene, as long as the effective f numbers of the lenses are the same, the signal level will not vary with focal length.

Another question that might be asked is "what happens when an actor gets very close to a phototube"? The answer is that he will appear very bright, just as if he had moved close to a light in a studio employing storage-type TV cameras.

One of the important reasons for our development of the color Vitascan was to produce a live-action signal source totally devoid of color registration errors for Research Division testing of color TV equipment. Today, it is still the best signal source we have for this purpose. This absence of color misregistry is readily appreciated by reference again to the sketch. Suppose we consider the white-to-gray transition at T5. Just prior to T5, the R, B, G signals are equal and produce white. When the spot moves to the gray background, all the phototube outputs must change together. There is no way for one color channel to change at a time different from another. Thus, color misregistry , such a familiar problem with storage-type color TV cameras, is completely avoided.

Spectral Characteristics

When the Vitascan is used for monochrome TV pickup, the over-all spectral characteristic is determined by the product of the phosphor times the phototube spectral responses. This resultant curve is shown in Figure 8. Note that the peak sensitivity occurs around 500 mu and falls gradually to zero at 400 and 700 mu. In order to properly shape the Red, Blue, and Green channel sensitivities for color TV, appropriate color filters are placed before the phototubes.

Unavoidably, as in any color camera, only a minor part of the sensitivity remains after the filter shaping. The resultant R, B, G sensitivities, drawn to the same scale, are shown in the figure. The most serious loss is in the Red channel because of the poor Red response in both the phosphor and the phototube. The R, B, G sensitivities relative to monochrome, as determined by the integral area under the curve or by direct measurement, give Red 1%, Blue 17%, and Green 50%.

At the outset of our work, the Red output was doubled to 2% by employing two Red phototubes for each Blue and Green. To obtain equal R, B, G signals for white balance, as is customary in color TV, it is necessary to suitably adjust the photomultiplier gains. The spectral characteristics for equal-signal white, with the corresponding gains indicated, are shown in Figure 9.

The extremely poor Red sensitivity, requiring increased Red photomultiplier gain, results in the Red channel noise determining the over-all acceptability of the signal-to-noise ratio in the simultaneous color signal.

Figure 10 shows the spectral transmission curves of the shaping filters used in the prototype color Vitascan. To produce the desired sloping response with the peak at 600 mu, it was necessary to fabricate a composite filter with a small area of orange. This was because the gamut of normally available red filters is characterized by a sharp cutoff on the short wavelength side. Note also that the desired Green sensitivity shape obtained with a yellow shaping filter gives about double the output compared to a green shaping filter.

Improved Red and Blue shaping filters are now being manufactured. The Red is approximately the same shape, but one piece rather than composite and about 20% greater in sensitivity. The Blue has higher transmission but gives the same output since the over-all sensitivity shape is moved bodily about 10 mu down in wavelength, a desirable improvement.

As a practical matter, the Vitascan spectral sensitivities are a compromise between theoretically exact color fidelity and signal-to-noise ratio. The fact that the Vitascan does exhibit such remarkably good color fidelity is due more to

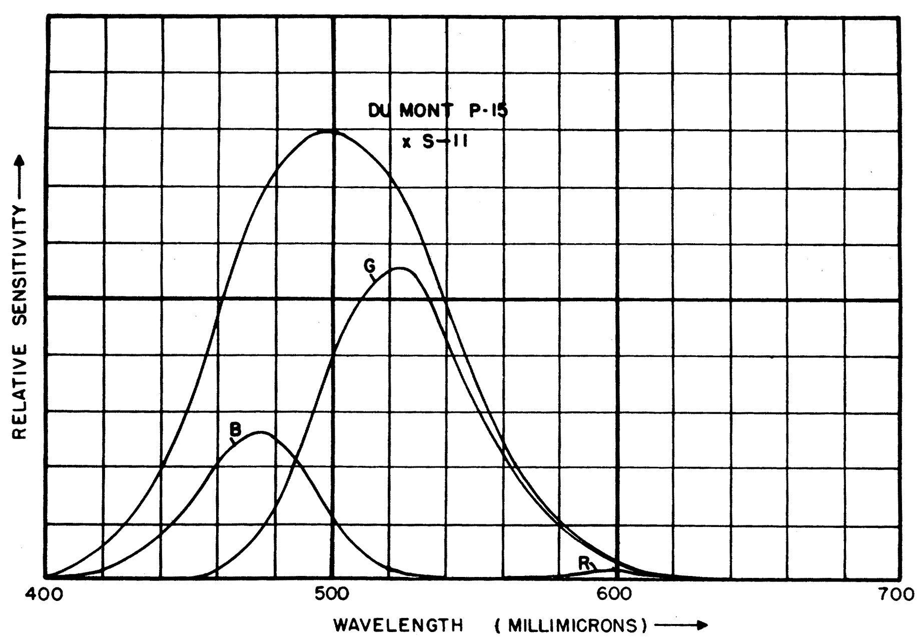

Fig. 8 - Color Vitascan filter shaping.

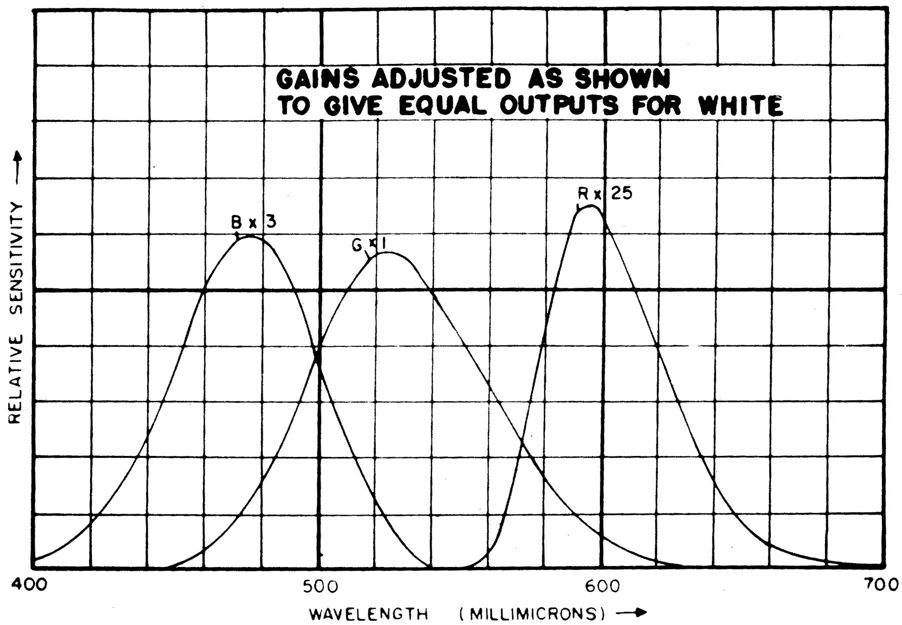

Fig. 9 - Color Vitascan spectral characteristic.

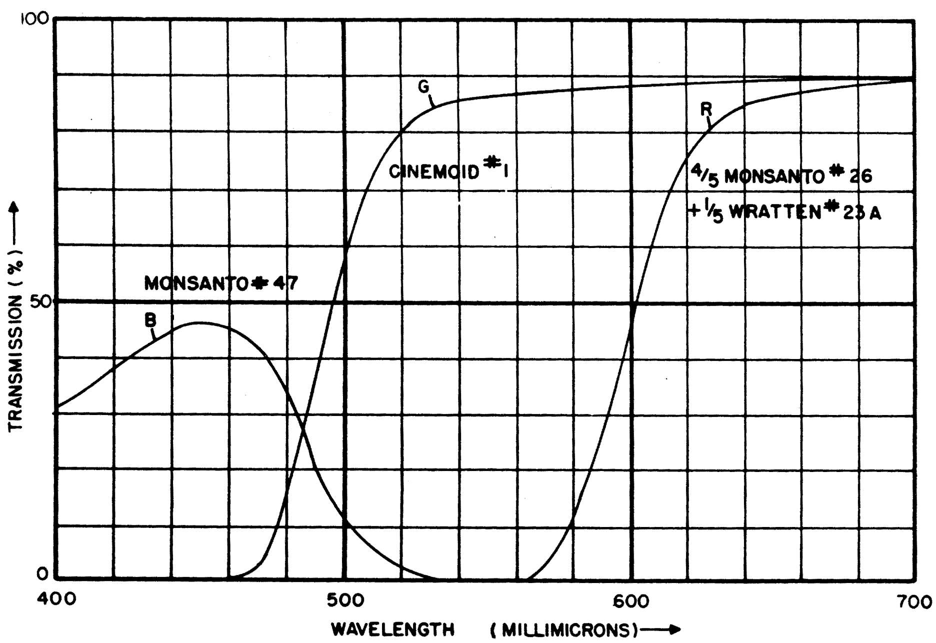

Fig. 10 - Color Vitascan shaping filters.

the linearity of the transfer characteristic, rather than to our choice of spectral sensitivities which are not theoretically perfect.

With the storage-type color TV cameras, no matter how close to the ideal the spectral characteristics may be, color contamination is present due to the non-linear transfer characteristic of each camera tube.

From the standpoint of color fidelity, we prefer the Vitascan to a slide scanner as a color signal source because we avoid contending with the colorimetric failures of the film processes. In addition, a great variety of subject matter is immediately available for test and demonstration.

Optical Parameters

From the beginning of our work, signal-to-noise and depth-of-field considerations have proven to be serious problems. Although theoretically quite independent, the economics of equipment design makes them mutually antagonistic.

Our first simple experiments utilized a standard DuMont Multiscanner which employs a 7" CRT and 7" f/2.8 lens, and a small light-tight room where a $7\frac{1}{2}$ x 10 foot raster was scanned on the back wall. At first, two clusters of four DuMont Type 6364 five-inch multiplier phototubes were used. With this arrangement, the depth-of-field was only about two feet. In order to increase the depth-of-field, the lens was stopped down, but this made the signal-to-noise ratio objectionable.

To improve the depth-of-field, it is necessary to use a smaller lens aperture, or smaller scan size, or both. In either case, the amount of light incident on the scene is decreased. Unless the same total amount of light is collected by the phototubes, the signal-to-noise will suffer. In our present Vitascan at the Research Division, which is in daily use as a high-quality signal source for color TV development, higher collection efficiency was accomplished in three ways. To recapitulate, we first added simple reflectors to each phototube cluster. This improved the efficiency for exactly the same reason as with any lighting fixture. Secondly, the walls were covered with aluminum sheeting. This increased the light level and softened the shadows. Thirdly, the total of phototube clusters was increased. An important reason for this was to obtain more interesting modeling effects in the lighting as well as greater light collection.

Although these approaches to greater light collection efficiency were entirely feasible in our small studio and allowed increased depth-of-field, it was apparent that a considerably greater economic problem would exist in larger studios employing mobile Vitascan cameras. Here the cost of the phototube clusters can be a substantial matter. And so before proceeding with the development of the mobile Vitascan camera, it was necessary to consider the depth-of-field problem purely from the standpoint of the camera design itself. This inquiry divided itself into two parts, first, a general analysis of depth-of-field as a function of CRT raster size and other variables compared to competing color TV cameras. Secondly, the final optimizing of the camera design for signal-to-noise was determined by practical problems of CRT operation.

It is well known that cameras with small film have greater depth-of-field than those with large film. For example, a 4" x 5" camera at f/8 has the same depth-of-field as an 8" x 10" camera at f/16.

The range of CRT sizes employed in flying-spot scanners today is from 4 to 7 inches nominal diameter. The useful screen area available dictates scan sizes of 2.1" x 2.8" to 3.9" x 5.2". Present image orthicon color cameras have a scan size of about 1.05" x 1.40". It is apparent then that with any of the flying-spot raster sizes above, the theoretical depth-of-field will be less than the image orthicon if the same lens f/numbers are used.

To be sure, the present Vitascan units operate at a distinct theoretical disadvantage to image orthicon cameras in regard to depth-of-field, but it is important to emphasize that, in reality, this difference is less than that indicated by the figures since the theoretical depth-of-field advantage is far from being attained in image orthicon color cameras because of certain effects which reduce the sharpness. Anyone who has compared the softness of the average live color TV signal with that from monochrome image orthicon origination is aware of this fact. This lack of crispness is caused, first, by optical aberrations introduced by the complicated lens relay system and second, to misregistry of the Red, Blue, and Green camera scans.

The inherent Vitascan sharpness is definitely superior to the image orthicon, whether expressed in aperture response or in limiting resolution. Stated another way, the Vitascan will produce a crisper image of a test pattern. On the other hand, with the usual lens apertures employed, the depth-of-field will be less.

Figure 11 compares the theoretical depth-of-field at various apertures for the image orthicon color camera and illustrative scan sizes for fixed and mobile Vitascan cameras. It must be clearly kept in mind that the apparent depth-of-field of Vitascan signal, because of its inherently crisper response, will more nearly approach the theoretical figures. The raster sizes and lenses were selected so that all the systems have the same field angle of 30 x 40 degrees. In normal color TV studio operation, the image orthicon color camera is operated at f/5.6. The theoretical depth-of-field produced at various distances is shown along the bottom row. In order to match these figures, the Vitascan camera scan size and f/number must obviously equal the image orthicon camera. Unfortunately, under these conditions, it is simply not possible to achieve the necessary CRT brightness because of existing phosphor light output limitations. In addition, phosphor grain size with the 1.05" x 1.40" scan is excessive. On the other hand, these limitations are not serious with the 3.9" x 5.2" scan size of the fixed Vitascan but, a glance at the table reveals that the depth-of-field seriously limits the TV programming applications. A compromise clearly had to be made in the mobile Vitascan design. A 5" CRT allows a 3.0" x 4.0" scan size or smaller. Our experiments indicate the smallest practical scan size to be 2.1" x 2.8", determined primarily by the current saturation, grain size and life of the phosphor. Typical operating conditions are 35 kv accelerating voltage at 250 ua beam current. Countering these disadvantages is the considerably improved depth-of-field revealed in the table. Coupled with the inherent sharpness of the Vitascan, we feel that the depth-of-field of the 2.1" x 2.8" raster at f/2.8 is adequate for many types of TV programming. Notice in the table that at 10 foot focus, nearly a four foot depth-of-field is realized. This is a marked improvement over the fixed Vitascan at f/2.8 and ten foot focus where only a two foot depth-of-

SYSTEM	RASTER	FOCAL LENGTH	APERTURE	FOCUS DISTANCE – FIELD AREA			
				5' 30" x 40"	10' 5'2" x 6'11"	15' 7'10" x 10'6"	20' 10'6" x 14'
FIXED VITASCAN	3.9" x 5.2"	180mm	f/2.8	+ 3" – 3"	+ 1'1" – 11"	+ 2'6" – 2'	+ 5' – 3'6"
			f/4.0	+ 4" – 4"	+ 1'8" – 1'2"	+ 4' – 2'6"	+ 8' – 4'6"
MOBILE VITASCAN	2.1" x 2.8"	100mm	f/2.8	+ 5" – 5"	+ 2'2" – 1'6"	+ 5'6" – 3'	+ 11' – 5'
			f/5.6	+ 12" – 9"	+ 5'6" – 2'8"	+ 18' – 5'	+ 50' – 8'
IMAGE ORTHICON	1.05" x 1.40"	50mm	f/2.8	+ 12" – 9"	+ 5'6" – 2'8"	+ 18' – 5'	+ 50' – 8'
			f/5.6	+ 33" – 16"	+ 25' – 4'	+ ∞ – 8'	+ ∞ – 12'

Fig. 11 - Depth-of-field tables (based on 600 line tv cutoff).

field is obtained. Figure 12 was photographed from a 15" color monitor and shows a picture produced from the fixed Vitascan focused at 10 feet. While the depth-of-field is perfectly adequate for this type of subject, a 4 foot depth obviously gives more programming flexibility. Incidentally, the slide from which this figure was reproduced is in color and the absence of color shadows is readily apparent in the original.

The complement of lenses available for the commercial mobile Vitascan unit includes 100 mm f/2.8, 150 mm f/2.8, 210 mm f/2.8 and 300 mm f/3.5. This corresponds exactly with a 50 to 150 mm complement for the image orthicon camera.

Studio Strobe Lighting

As previously pointed out, we have developed two different methods of lighting during the vertical blanking interval. The first method utilizes miniature Xenon flash lamps and the second method small, short-persistence cathode-ray tubes.

At the present time, the production version of the Vitascan uses Xenon flash lamps, pending the quantity manufacture of the light source cathode-ray tubes. While there are points for and against both methods, we believe that the scheme utilizing cathod-ray tubes is ultimately to be preferred.

The Sync-Lite equipment, as it is called, operates on the same principle as the Xenon photographic flashlamp. A trigger voltage of several thousand volts is applied to the external electrode of a U-shaped Xenon Amglo Type U-35K shown in Figure 13. This voltage ionizes the gas and a DC potential of 350 volts from a charged condenser applied across the internal electrodes maintains the ionization, producing a blue-white light output for approximately 100 microseconds duration. Since the trigger voltage is synchronized with the vertical drive from a standard sync generator, the flash occurs during the vertical blanking interval.

To provide a suitable light level, five Xenon lamps are used in each fixture, as shown in Figure 14. The fixtures are constructed in a housing similar to the Vitascan pickup clusters, the lamps being inserted in a chrome reflector, on the front of which is mounted a glass cover to confine the noise caused by the high current surge through the lamps. Additional units required for the operation of the Sync-Lite are the Trigger Unit and the Power Panel shown in Figures 15 and 16, respectively.

In contrast to the Xenon flash lamp, the second method of providing strobe lighting utilizes miniature short persistence cathode-ray tubes as light sources, DuMont Type K1388 as shown in Figure 17. Each tube consists of a $1\frac{1}{2}$" diameter glass envelope with a special triode gun at one end and a metal phosphor plate, inclined at 45^{o}, welded to the other end. This method of construction gives a three times improvement in light output over conventional tube construction by enabling the phosphor to be efficiently air-cooled. The special gun is designed to produce an unfocused flood of electrons over the phosphor surface, typical operating figures being 15 kv accelerating voltage at 200 uamps average current.

The short persistence DuMont P15 phosphor is used in these tubes. This is a zinc oxide, zinc activated phosphor with a decay of $\frac{1}{2}$ u second to the 1 point, having high efficiency and

Fig. 12 - Vitascan reproduction (panchromatic copy from original color positive transparency).

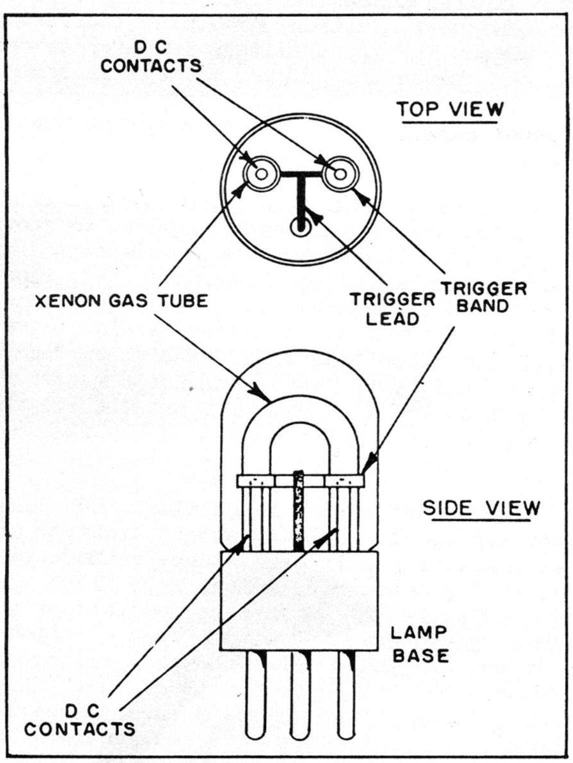

Fig. 13 - Xenon flash lamp.

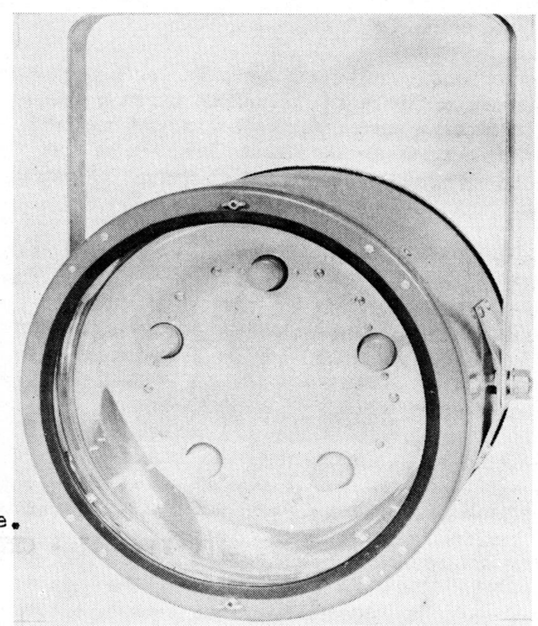

Fig. 14 - Xenon sync light fixture.

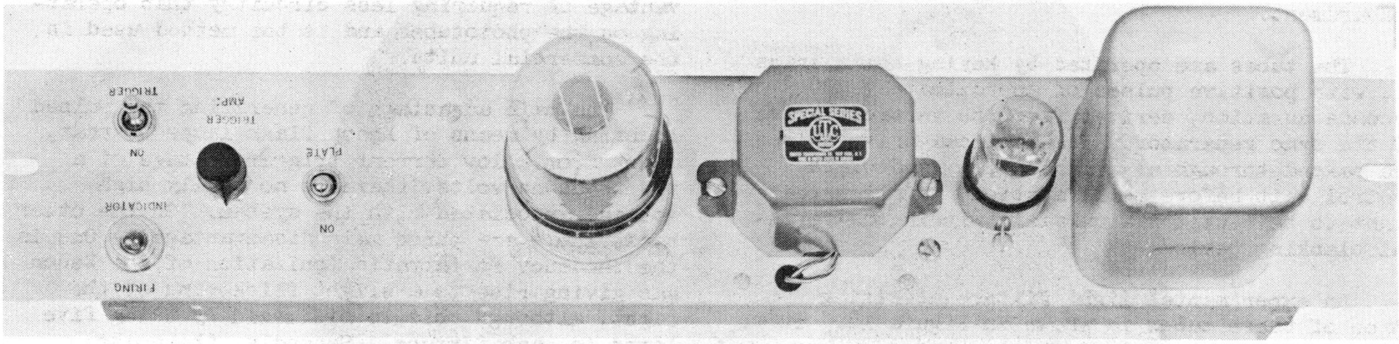

Fig. 15 - Sync light trigger unit.

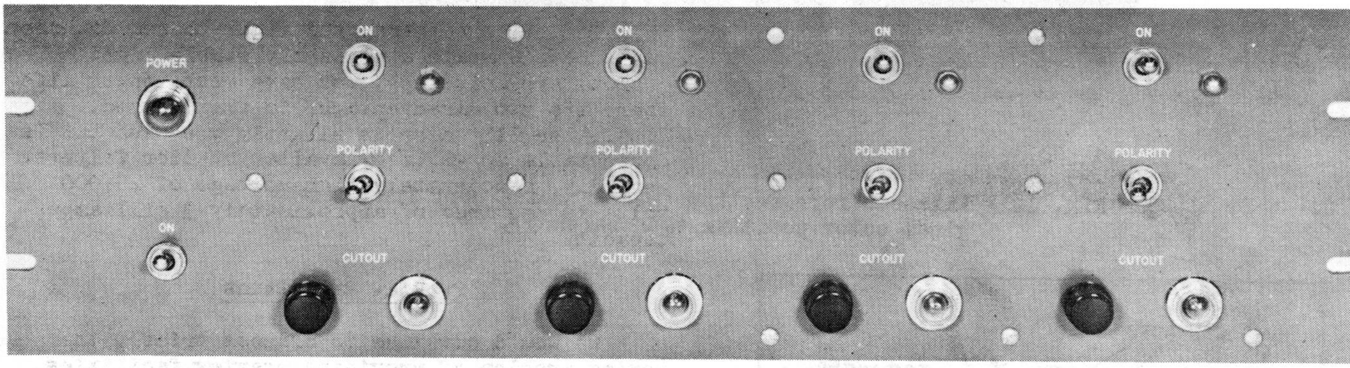

Fig. 16 - Sync light power panel.

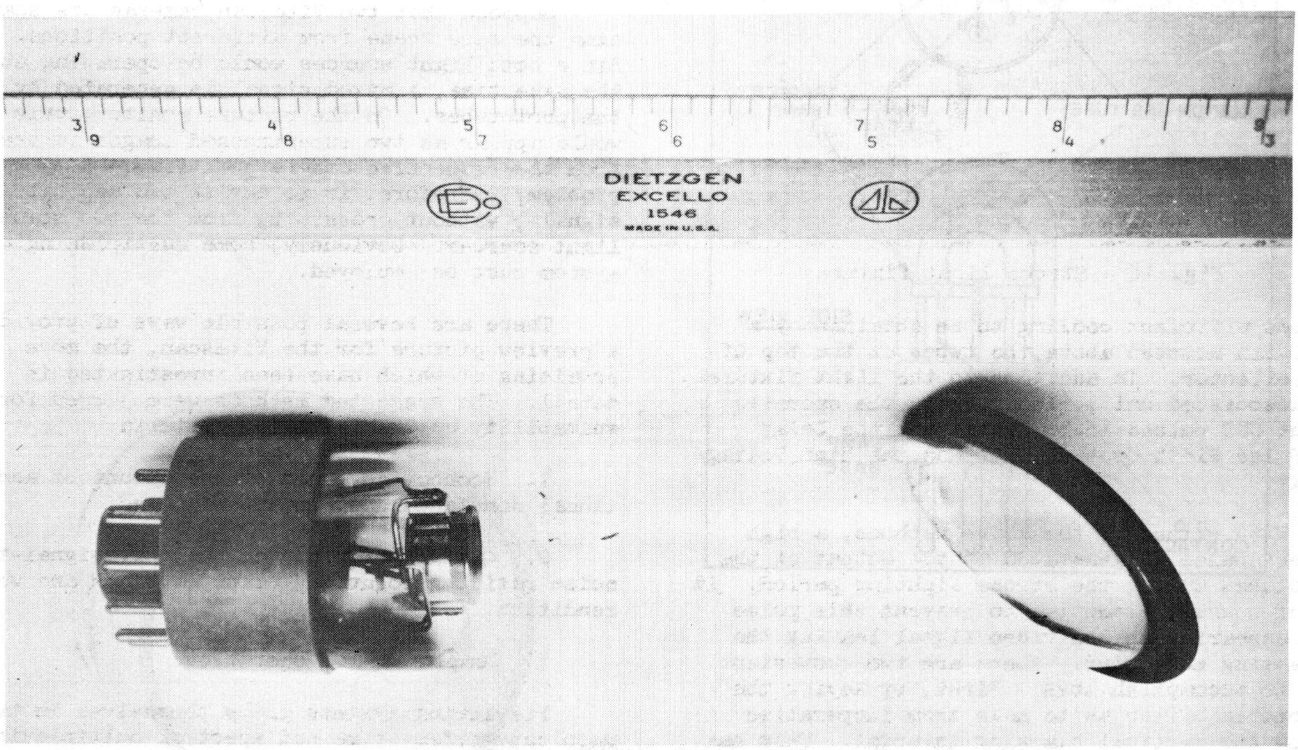

Fig. 17 - CRT strobe light, type K1388.

considerable resistance to burning under electron bombardment.

The tubes are operated by keying their grids on, with positive pulses of approximately 700 u seconds duration, derived from the vertical drive of the sync generator. The vertical drive pulses are passed through a variable delay and width control unit before amplification, to allow the light to be centered accurately within the vertical blanking period.

An experimental light fixture utilizing three of these tubes is shown in Figure 18. It consists of an aluminum reflector housing into which the cathode-ray tubes are inserted with their metal phosphor plates uppermost. This enables efficient cooling to be obtained by a small fan mounted above the tubes at the top of the reflector. In addition to the light fixtures, the associated units required for the operation of the CRT pulsed light system are the Delay and Pulse Width Control unit and the High Voltage supply.

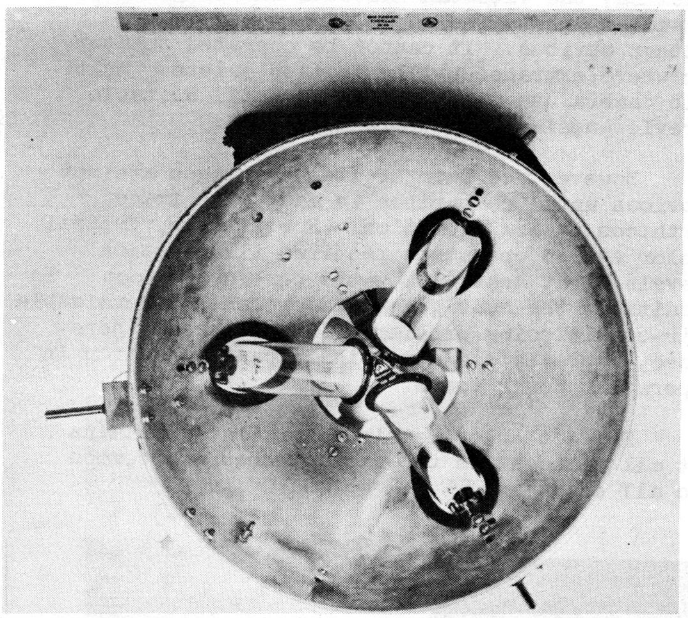

Fig. 18 - Strobe light fixture.

With either of the above methods, a high current pulse is generated at the output of the phototubes during the strobe lighting period. It is, of course, essential to prevent this pulse from appearing in the video signal leaving the processing amplifier. There are two convenient ways to accomplish this: First, by keying the phototubes off so as to make them inoperative during the vertical blanking interval. This has the advantage of protecting each phototube from damage which might arise due to the high peak current overheating the anode. The second method clips and keys out the unwanted pulse in the video processing amplifier. This has the advantage of requiring less circuitry than operating on the phototubes and is the method used in the commercial units.

The main advantage of generating the pulsed lighting by means of Xenon flash lamps is that, apart from a low current trigger voltage of a few thousand volts, there is no really high voltage associated with the system. On the other hand, there are three main disadvantages. One is the tendency for erratic ionization of the Xenon gas giving rise to a slight flickering of the light, although this is minimized by using five lamps in each fixture. Secondly, the noise generated by the high current surges in the Xenon lamps. Thirdly, the life expectancy of the Xenon lamp is 500 hours.

On the other hand, the light-source cathode-ray tubes generate a perfectly stable light output, are noiseless, and have much longer life. There are two disadvantages to this method. First, the P15 color is slightly greenish but is correctable to white by available color filters. Secondly, a moderately high voltage of 15,000 volts is required of approximately 3 milliamps capacity.

Preview Facilities

We would now like to discuss briefly the vexing problem of providing preview facilities where more than one scanner televises the same scene.

Suppose that two Vitascan cameras are scanning the same scene from different positions. Since both light sources would be operating at the same time, a mixed signal is generated by the phototubes. On the picture monitor, this would appear as two superimposed images as seen from the respective camera positions. The problem, therefore, is to derive two separate signals, without crosstalk, from the two scanning light sources. Obviously, some multiplexing system must be employed.

There are several possible ways of providing a preview picture for the Vitascan, the more promising of which have been investigated in detail. The suggested methods were judged for suitability by the following criteria:

1. Economy governed by the amount of additional nonstandard equipment required.

2. Quality of picture, that is, signal-to-noise ratio, resolution, color or black and white rendition.

3. Complexity of operation.

Previewing systems group themselves in two main categories, time and spectral multiplexing.

As an example of time multiplexing, one could utilize the retrace portion of the horizontal scanning cycle for the preview.

Spectral multiplexing systems can be operated within or outside of the visible spectrum. The preview may utilize the existing phototubes or an auxiliary-storage camera associated with the scanning source.

While it may be argued that for a considerable number of installations, such as those encountered in small station operation, one scanning source will be adequate and no preview problem exists, we cannot ignore the requirement for preview facilities for multiple camera operation nor can we fail to accept this challenge to our ingenuity. During the initial phases of the development of the Vitascan system, there were a number of fundamental considerations concerned with the production of adequate color pictures which occupied our time. Now that these problems have been satisfactorily resolved, the final intriguing technical problem, that of the preview, is receiving our close attention.

At the risk of appearing unduly secretive, we feel that it is too early at this juncture to say what final form the preview system will take. A number of methods have been discarded; among them the horizontal retrace method because of insufficient resolution. Others hold considerable promise of ultimate success and we expect to be able to report in the near future on the system finally chosen. The main purpose of discussing the preview problem in this paper is to bring to your attention the fact that it is a problem and that considerable effort is being made to solve it.

Conclusion

There appear to be three major fields wherein the Vitascan should find application. These are:

1. Industry
2. Color TV Research
3. Color TV Broadcasting

Our experience with the color Vitascan leads us to be enthusiastic concerning its place as a Research tool. It has definite advantages over a transparency scanner. It provides excellent color TV signals especially in respect to resolution, color rendition and lack of color misregistry. From an operational standpoint, it is the simplest and most reliable live-action color TV pickup system in existence. Its initial cost is relatively low because of the inexpensive components employed. Operating costs are also low because of the long life and smaller number of components.

In the field of color television broadcasting, the Vitascan has both advantages and disadvantages. The major disadvantages are rather obvious. It cannot be operated outdoors or where extraneous illumination exists. Multiple camera use will be limited until suitable previewingsfacilities are developed.

However, certain of its advantages are not obvious until comparison is made with image orthicon camera operation. For example, typical color studio operation requires illumination levels of at least 100 watts per square foot. In addition, the heat generated presents a formidable air-conditioning problem. The Vitascan, therefore, represents a very significant reduction in operating power costs.

Perfect colorimetric camera match obtains at all times since the pickup tubes are common to all scanners.

Fig. 19 - Illustration of Vitascan picture sharpness (panchromatic copy from original color positive transparency).

Because of its excellent color reproduction, no special makeup is required with the Vitascan system. There is no image burn-in so that a scanner may be left undisturbed on a scene at fixed focus for any length of time. Finally, the warm-up and adjustment time required is only a few minutes compared to the hour or longer needed for the image orthicon color camera.

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