

Single-vidicon color camera for home use

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The development of a single-tube color TV camera for use in the home involved the close cooperation of several RCA divisions. The camera is based on the principle of color encoding stripes which generate amplitude-modulated color carriers in the camera output signal. This concept was first described by Ray Kell of RCA Laboratories, Princeton, N.J., in the early 50's. The device can be used as the pickup device for a home video tape recorder, home theater systems for viewing color slides or movies, and in prerecorded video systems. It is presently being applied to the SelectaVision system. Area-sharing color systems provide some unique problems not found in multi-tube color cameras. These problems plus problems associated with the development of a color camera specifically for the home market are discussed.

THE DEVELOPMENT OF A COLOR TV CAMERA which uses a single pickup device represents a significant building block from which several new product concepts can be derived. In December, 1965, the New Products Activity of Consumer Electronics began such a development. The original intent was to develop a basic single-vidicon color TV camera which would eventually become the core of a family of new products. The production evolution chart of Fig. 1 indicates the original product concepts envisioned for such a device. Initially the camera, in portable form, would constitute the pickup device for a home video tape recorder (VTR). In this capacity, the camera could serve as a home movie camera or could be used for home surveillance. The camera/VTR combination would undoubtedly find its way into many high schools and colleges to serve educational or sporting functions. For the amateur photographer, a package which will display 35-mm slides or 8-mm home movies, or both, would permit convenient daytime viewing. The color camera core also provides another method whereby the concept of prerecorded video systems can be implemented, either through the use of film or holographic recording techniques. Products also can be conceived which combine two or more of these functions.

History

Original system studies were begun in

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1966 by the Stanford Research Institute in Menlo Park, California, under the direction of, and by contractual agreement with, Consumer Electronics Division. In February, 1967, equipment was initiated by CE in Indianapolis in close coordination with the research effort at Stanford Research Institute. In addition to the interest in such a device for the consumer market, the potential for a single-tube camera was also realized by the Broadcast and Communications Division; and by midyear, 1967, cooperative development effort was undertaken by the Division at the Burbank, California, location.⁶

It should be noted that there are

significant differences in development concepts for equipment designed for the consumer market and those developed for the commercial market. The most significant difference is in the skill level of the eventual operator of the equipment. Where TV cameras for professional or semi-professional use can be equipped with many controls, and a certain degree of operator skill can be assumed, little or no skill must be assumed when designing a similar camera for the consumer. Consequently, the camera must be designed for automatic operation. A second significant difference concerns eventual selling price of the device. Where the professional camera can be priced in the \$2,000 to \$20,000 range, the camera for the consumer must be priced at perhaps less than \$250.

Color encoding system

Since the color encoding system of the single-tube color camera has been described in much detail in various publications, it shall be only briefly reviewed here.

In operation, a color scene is focused on the faceplate of a vidicon through a set of encoding filters. The encoding filters are generally dichroic-type filters which pass certain light wavelengths and stop others. One filter, which passes blue and green light but blocks red light, is made into a set of stripes such that there are 260 stripes of filter material separated by equal

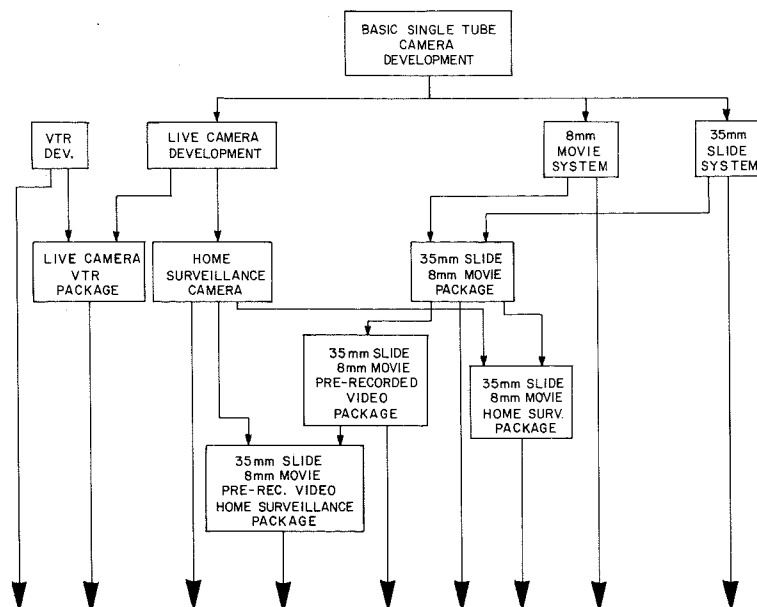


Fig. 1—Potential product evolution.

stripes of clear area. These stripes are aligned at right angles to the horizontal scan of the camera such that during the beam-scanning action of the vidicon, they cause an electrical signal at 5 MHz to be generated. Since the stripes block red light, the resulting amplitude of the 5-MHz signal is proportional to the instantaneous amount of red light being blocked by the filter. A similar stripe filter is made up of blue-light-blocking material. Its spatial frequency is such, or it is oriented as such, that an electrical signal at 3.5 MHz is generated by the vidicon scanning action. The amplitude of the 3.5-MHz signal is therefore proportional to the instantaneous amount of blue light being blocked by the filter. In the clear areas of the stripe filters, the entire signal is allowed to pass. This signal contains the red, blue, and green information of the scene, and therefore provides the remaining information to recreate the original scene.

The composite video signal from the vidicon thus consists of wideband scene luminance information from DC to beyond 5 MHz. The red information is contained in amplitude modulation of a 5-MHz carrier on this signal, and the blue information is contained in amplitude modulation of a 3.5-MHz carrier on the signal. The luminance information is band-limited in the camera circuits to 3 MHz, and the two color carriers are extracted from the composite signal and amplitude-detected to recover the red and blue signals. In appropriate matrix circuits, the proper signals are developed and fed to a color monitor or receiver.

Developmental problems

It was recognized early that the color camera system being developed presented many unique problems. Two of the most significant problems previously mentioned are those of providing a completely automatic, "hands off" system and of providing the device at a selling price compatible with consumer products. The low price aspect of the development almost automatically ruled out any design which required the extensive use of high-quality optics. For this reason major emphasis was placed on the development of a vidicon with encoding stripes included as a built-in feature. This eliminates the need for optics of



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received the BSEE from Purdue University in 1957. He spent seven years with Allison Division, General Motors Corporation, four in the design of electronic instrumentation equipment for the testing of turbine engines and three years in the design of electronic control systems for turbine engines. In 1960, he was employed by the Hazeltine Corporation where he participated in the design and development of air navigation systems, aircraft identification systems, and telemetry decommutation equipment. In 1967, he joined the New Products Activity of Consumer Electronics Division where he has been involved in new product evaluation and system development. Mr. Boltz has specifically worked on the development of the single-tube color TV camera and the SelectaVision system. In 1969, along with six other engineers, he was named to receive the David Sarnoff Outstanding Team Award in Engineering.



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graduated from the Royal Naval Radar College, England, during World War II. After leaving the service, he worked on the design of electronic controls for machine tools. Since that time he has worked almost exclusively in the television industry. From 1957 to 1963, he was Chief Engineer of the TV division of Royston Industries, Ltd., London, which manufactured industrial and broadcast television equipment, including complete TV camera systems. From 1963 to 1967, Mr. Wharton had his own company which manufactured TV equipment for such concerns as the British Broadcasting Corporation and the Marconi Company. He came to the U.S.A. in 1967 to the New Products Engineering section of the Consumer Electronics Division. His work has been concerned with the single-tube color camera development and the "Picturecom" unit, and he is currently working on the SelectaVision project. He is an Associate of the Institute of Electronic and Radio Engineers. Mr. Wharton was a member of the team awarded the 1969 David Sarnoff Outstanding Team Award in engineering.

a quality necessary to image the high spatial frequency of the encoding filters on the vidicon photoconductor. Through the cooperative effort of Electronic Components at Lancaster, Pennsylvania, a program was initiated to develop appropriate filters and the techniques for fabricating them into the vidicon. This effort is discussed in greater detail in the section entitled "Spectraplex Development."

The extreme light sensitivity of the vidicon makes it possible, in principle, to provide a live color camera capable of operation in normal room light (approximately 50 lm/ft² scene illumination). It is desirable to preserve this feature. One problem which arises in this regard is the elimination of luminance-to-color crosstalk. As with NTSC, there are certain luminance signals within a scene which cause the

color sensing circuits to respond since they do not know if a 3.5 MHz or a 5-MHz signal is actually caused by encoding filter action or by scene content. The most effective way of avoiding this problem is to slightly defocus the scene ahead of the encoding filters such that spatial frequencies equivalent to color carriers are attenuated. Because of picture vertical resolution requirements, it is desirable to defocus only in the horizontal plane. An astigmatic lens can be used for this purpose; however, for the consumer, it provides a focusing problem because there are now two points at which the image can be focused, only one of which is correct. A vertical grating of opaque and clear stripes which diffracts the light and effectively provides a "notch" spatial filter can also be used where ample scene illumination is available. It does, however, reduce

the available light to one half. To accomplish the luminance-to-color crosstalk elimination with the least light loss, a phase grating was used in direct contact with the vidicon faceplate. When properly designed, this technique practically eliminates the crosstalk problem with a light loss of less than 20%.

Although size and weight were not particularly of concern for the developmental prototype and feasibility models, in the final version these two factors will be quite significant. For this reason, all design and development concepts had ultimate size and weight considerations as factors. Cooperation between styling, marketing, and engineering will be required to arrive at a satisfactory solution to this problem.

One of the more serious problems associated with the development is that of camera resolution. Perhaps the most undesirable feature of the encoding system chosen for this work is the fact that it is an unbalanced system. The reproduction of greysteps through white all require the proper balance of the three decoded signals: luminance, red, and blue. A loss of focus results in a loss of the color carriers, a resulting loss of red and blue signal, and a consequent "fail to green" condition. By the same token, poor focus uniformity over the vidicon photoconductor can result in green shading problems. Two serious problems are, therefore, vidicon rolloff characteristics due to beam spot size and electron ballistic problems which result in focus, or focus uniformity, problems aggravated by beam shape distortion. The solution to these problems is dis-

cussed in more detail in later paragraphs.

Certainly not the least of the developmental problems associated with the color camera is that of providing the proper colorimetry.

Colorimetry

Faithful reproduction of scene colors is, of course, of paramount importance in any color imaging system. It is, perhaps, even more important in a live TV camera in the hands of the consumer. In a TV broadcast situation, there are very few scene details about which the viewer knows the true colorimetry. Where both the object and its reproduced image can be viewed simultaneously, the viewer is more aware of errors and may be much less forgiving.

In an area-sharing system such as the one being described, electronic correction of color signals is perhaps more difficult to achieve than in a device containing 3 or 4 pickups. The receiver is predesigned to assume signals produced or corrected for a particular color temperature for white, which assumes the proper luminance contribution from each of the primary colors. To avoid additional matrix circuitry which adds cost to the final product, and the additional signal handling which contributes to a lower signal-to-noise (S/N) ratio in the final signal, it is advantageous for the signals, as detected, to have their proper relationships. Unfortunately, anything in the optical path which has other than a flat spectral output, response, or transmission characteristic alters this relationship. For this reason, it is necessary to have control over the color temperature of the illumination

source, the spectral transmission characteristics of the encoding filter stripes, the spectral response of the vidicon, and even the spectral characteristics of any antireflective coatings on the optics used in the camera.

For the home camera, it was assumed that a color correction filter of some sort would eventually be used to correct for indoor (tungsten) and outdoor (daylight) differences. In order to preserve the low light sensitivity of the camera, it is desirable not to reduce sensitivity by the application of a filter during indoor operating conditions where light level may already be marginal. For outdoor operation, light levels will normally be more than adequate, and a filter can be used with little sacrifice of sensitivity limitation. It is therefore desirable to tailor the remaining parameters for tungsten illumination (approximately 3200°K).

Once the illuminant is known, the spectral characteristics of the encoding filters can be calculated, based on the assumption that the vidicon spectral response is known and that there are no other spectral changes taking place in the optical path.¹ Typical response curves for the encoding filters are shown in Fig. 2 by the dotted lines.

Perhaps one of the most important considerations in the design of the encoding filters is the spectral response characteristics of the vidicon. During the development of the camera, it very soon became obvious that vidicon spectral response was not uniform from one tube to another. It became possible to correlate, to some degree, the spectral characteristic to the visually observed color of the faceplate. Those that appeared blue did, in fact, reflect blue light and were consequently low in blue sensitivity. These slight differences in spectral response which were insignificant for black and white cameras present more of a problem in the area-sharing color system. These slight differences are also insignificant for 3- and 4-vidicon devices where each tube is only concerned with a single color detection, and not the relationship between colors. In addition to colorimetric errors in the make-up of the luminance signal, the color S/N ratio and the luminance-to-color crosstalk problem are aggravated by the increased gain necessary to re-

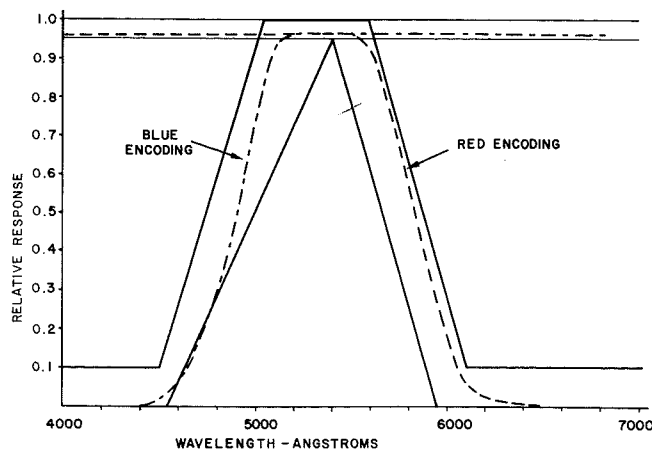


Fig. 2—Encoding filter spectral response.

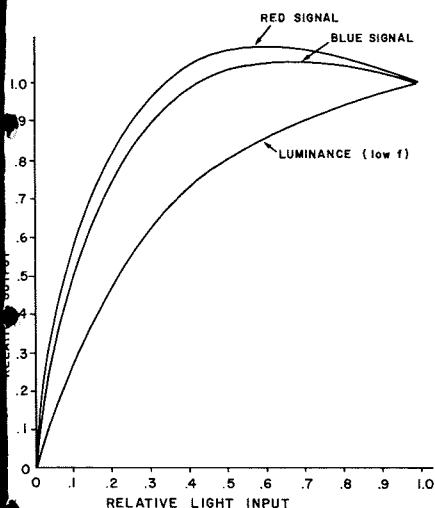


Fig. 3—Typical vidicon signal transfer characteristics as seen by camera encoding-decoding system.

store the loss of a particular color sensitivity. Too much sensitivity in the near-infrared region is also a problem because the encoding stripes encode the infrared as a visible red signal. In strong infrared illumination, such as with tungsten light sources, colorimetry can be affected quite seriously. The effect is also noticeable with outdoor lighting and infrared reflective objects such as foliage. Through interdivisional cooperation, some new techniques have been found which afford better control of the spectral characteristics of the vidicons.

Considerable effort went into the analysis of the vidicon nonlinearity problems. The dynamic signal characteristics of the vidicon contribute greatly to the accuracy of the reproduced colors. Although the average gamma of the 8507A vidicon is quoted as 0.65, the variation in gamma under some operating conditions is not negligible. The resulting effect of this variation in gamma, with this color encoding system, is that the nonlinear color signals developed do not have the same relationship with respect to illumination as does the luminance signal. Thus it is impossible to have grey scale tracking without some degree of signal modification. Fig. 3 shows the nonlinear relationship.

It is the variation in gamma with luminance level that causes the greatest problem. Since the color signals are generated as increments of the vidicon transfer characteristic, the changing gamma causes a marked difference be-

tween the transfer characteristic of the color signals and the luminance signal. The solution to this problem was to cause the gain of the color channels to be controlled as a function of luminance. This solution provides a good grey-scale tracking and does not deteriorate color S/N ratio.

Obviously, many parameters affect the colorimetry of the entire system. It was found advantageous to establish a computer program to calculate output signal changes as the various system parameters were changed at will.² The program simulates the camera looking at an illuminated slide of a saturated color bar pattern. It calculates the result of the vidicon scanning action and the signal processing circuitry and provides information to describe the output signals. Even if the computer program had not been used as an aid in the design of the encoding filters, the effort involved in obtaining correlation between the computerized system and the laboratory system led to the understanding and eventual solution of many system problems. Once correlation was achieved, the program did become a valuable tool in the overall development program.

The input data for the program contains the following information:

- 1) The date of the particular run.
- 2) Description of the run.
- 3) Type of illuminant incident on the color bar slide and its spectral distribution.
- 4) Description of the color bar slide and the spectral transmission characteristic of each of the bars.

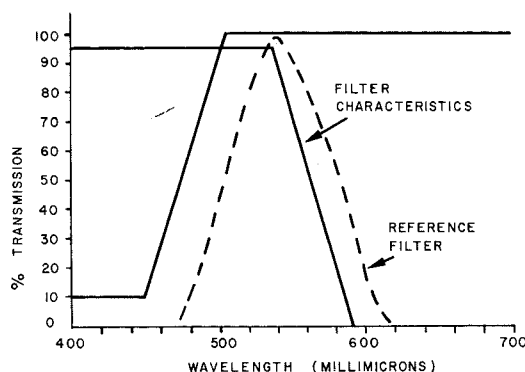


Fig. 4—Typical useful output information derived from a computer run. At left are the filter transmission characteristics; at right is a typical vectorscope display. Typical noise figures relative to base systems using the reference filter are: red $S/N=+0.22\text{dB}$; blue $S/N=2.86\text{dB}$; red crosstalk figure of merit $=0.0\text{dB}$; and blue crosstalk figure of merit $=-1.18\text{dB}$.

- 5) Vidicon data and its spectral response characteristic.
- 6) Red-encoding filter spectral transmission characteristic.
- 7) Blue-encoding filter spectral transmission characteristic.

The output information from the computer run consists of the following information:

- 1) Luminance signal (Y).
- 2) $P-P$ red carrier signal.
- 3) $P-P$ blue carrier signal.
- 4) $R-Y$, $B-Y$, and $G-Y$ signals.
- 5) Green signal.
- 6) X and Y coordinates for Vectorscope presentation.
- 7) Relative red and blue S/N ratios in dB .
- 8) Relative red and blue luminance-to-color crosstalk figures in dB .

A typical plot of the most useful output information is shown in Fig. 4. As a result of many test runs on the computer program, the desirable vidicon spectral response was defined, limits were established on the spectral characteristics of the encoding filters, and the effectiveness of the gamma corrective circuitry was determined. Encoding filter limits are shown in Fig. 2 by the solid lines. Fig. 5 shows the desirable vidicon spectral response for this system.

Choice of camera tube

The camera tube must be small, inherently inexpensive, and suitable with modifications for mass production. It must also be capable of sufficient output at 400 tv lines to give good S/N . These requirements dictate the use of the 1-inch vidicon

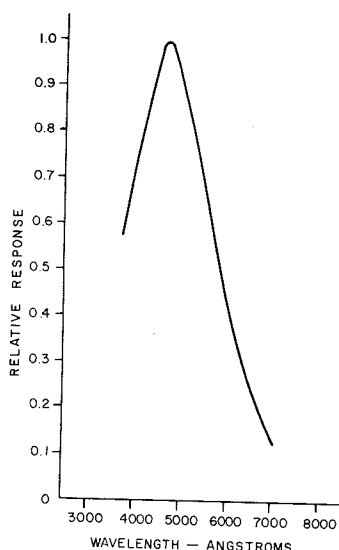


Fig. 5—Desirable vidicon spectral response.

camera tube. The high sensitivity, low lag, low dark current, and linear transfer characteristic of lead oxide photoconductors would also be advantageous. However, this type of photoconductor is unlikely in the near future to be inexpensive. The tube chosen is therefore the 1-inch vidicon with the antimony trisulphide photoconductor.

There remains the choice of electromagnetic or electrostatic deflection vidicons. Electrostatic vidicons do not require a focus coil with its attendant power consumption; also, they have more uniform but lower resolution. Electromagnetic vidicons have higher resolution and the capability of simpler construction, but would require close control over both the operating voltages and the focus current to provide focus stability. Tests using external optical filters with both types of tubes led to the choice of the 8507A electromagnetic vidicon for its superior resolution characteristic.

The dark current of antimony trisulphide photoconductors varies with target voltage and temperature. This produces a pedestal in the green signal but not in the red and blue signals derived from carriers. The result is a background and grey-scale tracking problem. The solution is the elimination of the pedestal in the green signal. The simplest solution, that of cancellation, was employed in the feasibility cameras with the amount of cancellation dependent on target voltage and temperature. Clamping on scene black

rather than dark current is a more elegant but more costly solution.

Gamma correction

As already explained the red and blue signals from the camera output do not track the luminance signal, and the carrier signals must be gamma corrected as a function of luminance. Another possibility is to linearize the composite camera signal. A nonlinear circuit of this type, however, could introduce beats between the carrier frequencies of 3.5 and 5 MHz. Additional gamma correction would then also be required to compensate for the kine gamma. For these reasons, and in the interests of simplicity, it was decided to correct the carriers as a function of luminance. This was accomplished with the circuit of Fig. 6. In this circuit the composite camera signal is clamped to ground and applied to the base of transistor Q1. The collector load comprises the tuned circuit tuned to one of the carrier frequencies. Diode D1 in the emitter circuit can be biased by VR2 to conduct when the signal at the junction of R1 and R2 exceeds the voltage set by VR2. The emitter resistor R2 is then bypassed by the diode, VR1, and capacitor C. The gain, when the diode is conducting, can be varied by VR1. The gain of the stage can therefore be made dependent on the amplitude of the luminance signal at the emitter. By adjustment of VR1 and VR2, the detected red and blue signals can be made to track. However, there are still some errors due to gamma. Theory shows that the green vector amplitude is too low.³ The simplest solution found is to amplify the negative-going portions of R-Y and B-Y more than

the positive-going portions. This can be performed by diode resistor combinations across the collector loads in the R-Y and B-Y matrix amplifiers.

Vidicon focus and deflection

The most difficult problem in any camera of this type is uniform resolution of the filter stripes. The camera tube must resolve the vertical and diagonal stripes equally over the entire scanned area if a uniform white or magenta field, for instance, is to be reproduced. In addition the carrier amplitude recovered by the camera tube must be of large enough amplitude to give an acceptable S/N ratio.

Striped filter cameras particularly illuminate all the electron optic problems of camera tubes. Examination of the recovered carriers from the camera using existing focus-deflection units shows poor corner focus and severe astigmatism to be present. While some of the defects can be attributed to the camera tube, the major errors are in the focus-deflection assembly.

For a home instrument, a low-cost solution to generation of the vidicon high voltage would be to use a flyback-type of high-voltage supply. To maintain focus, very good regulation of the vidicon electrode voltages is required. In addition, scan amplitude must be kept constant to maintain the carrier frequencies in the center of the pass-band; otherwise color smearing and even loss of carrier amplitude can result. Horizontal scan linearity also must be good, and it was decided that a total variation due to nonlinearities and scan amplitude changes of $\pm 2\%$ was probably acceptable. Coupled with this, the vidicon voltages must be controlled to better than $1/2\%$.

Calculations showed that there was insufficient stored energy in the existing deflection assembly to provide a usable high-voltage supply, and some additional scan energy would have to be expended to provide enough flyback energy for the vidicon voltages. It was also unlikely that the focus uniformity problems in the existing assembly could be solved satisfactorily.

Otto Schade at the Harrison, N.J., plant showed us a vidicon focus and deflection assembly that solved the electron optic problems and would

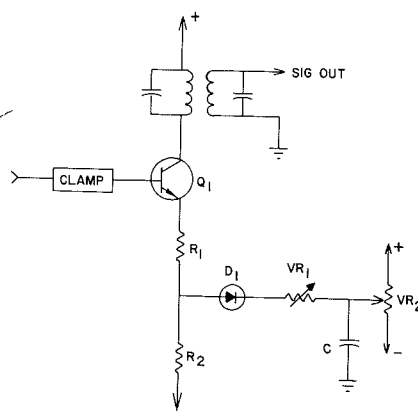


Fig. 6—Color gamma correction circuit.

be most suitable for a striped filter camera. Unfortunately, the power requirements were too high for a home instrument.

Castleberry and Vine in 1959 disclosed a vidicon focus and deflection assembly with the deflection yoke outside the focus coil to improve the resolution and eliminate the beam landing error, at that time a problem in vidicons.⁴ The beam landing error has since been solved by the use of an electrostatic lens between G3 and G4, but it was thought possible that this type of inside out assembly could be tailored to improve corner focus and spot shape.⁵ It was also felt that a cheaper assembly could be made this way. Valuable assistance was given by the CE's Magnetics section in selecting and modifying an existing yoke. The vidicon G3, G4 voltage ratios were kept at their standard values. Previous work had shown this ratio to be about optimum for minimizing the beam landing error. The best focus coil field for minimum spot was found by trial and error. The improvement in focus uniformity was very marked. With some vidicons, corner carrier amplitude went from 20% of center to 75% of center. While there is still plenty of room for improvement, the design was considered satisfactory to show feasibility.

Scan nonlinearity was corrected by integrating the yoke sawtooth and adding the resulting waveform to the sawtooth in the correct phase to correct the nonlinearities. Carrier frequency changes due to scan nonlinearity were kept to less than 1%.

It was found desirable to add horizontal dynamic focus to G3. The waveform for this was produced inexpensively using color receiver techniques.

Spectraplex development

Spectraplex was the name given by Lancaster to vidicons with integral-color stripe filters, with the goal being a low-cost color camera tube. Dichroic filters were initially made in two parts on very thin glass cemented together. The thickness of glass restricts the maximum lens opening. In fact, about one *f*-stop is required for each mil of glass between the filters. As we had the potential of a color camera that

would make good pictures in much lower light levels than a movie camera, the *f*-stop restriction could only be a temporary measure. The second stage was the formation of an integral faceplate. The faceplate had first one dichroic deposited, then etched to produce stripes. This was followed by the other set of dichroic stripes, a conductive coating, and the photoconductor. There was a great deal of interchange between the materials processing group at Lancaster and Indianapolis with regard to these faceplates. Faceplates would be sent to us for evaluation at the dichroic filter stage, returned to Lancaster for application of the TIC coating, further evaluation here, back to Lancaster to have the photoconductor added and be made up into vidicons, which were again returned to us for test. Much new knowledge was gained from this cooperative process.

From the many tests carried out here on vidicons, several suggestions to improve the performance and reduce the price of vidicons have been made to Lancaster. More accurate gun alignment would help the electron optics problems. The lead length of G4 inside the tube causes unwanted horizontal glitches in the signal which would be reduced if G4 was brought out as a separate connection at the target.

If the mass of the target ring were reduced, the target capacitance could hopefully be reduced. From a signal-to-noise standpoint, every pF of capacitance at the target is worth fighting for. In our yoke-focus assembly, the target connection terminal capacitance was reduced as much as possible.

Signal-to-noise

This is possibly the next most serious problem to electron optics in an area-shared color camera.

A coil tuned by the preamplifier input capacitance is an often-used technique in TV cameras, usually called a Percival coil after its inventor. Great care must subsequently be taken to correct the frequency and phase response at some later stage in the camera amplifier. The advantage is to increase the amplitude of high-frequency video before the major noise producer—the preamplifier.

In the color camera being discussed, the blue carrier was at 3.5 MHz and the red carrier at 5 MHz. The reason for this is that luminance transients cause false signals in the color channels—crosstalk—and this is most severe in the 3.5-MHz channel. Eyes, for instance, are “white-black-white,” the transitions causing unwanted color signals. If the resultant color signal causes blue eyes, this is less objectionable than red eyes, the so-called “red eye glint” defect.

Unfortunately red noise is very noticeable. To improve this, the Percival coil technique was elaborated on. Two coils were used (see Fig. 7); L1 between the target capacity and the preamplifier board capacitance; L2 between this and the FET-preamplifier input capacity. An improvement in *S/N* of 15dB at 5 MHz was obtained. The peak in the response at the input to the preamp now becomes part of the bandpass for the 5-MHz carrier.

To enable the total camera frequency response to be measured, a special test chart was prepared. This chart, Fig. 8, produces in the camera output a frequency sweep which shows the response of the entire camera including the lens and vidicon. This chart has been found to be a very useful tool in the development of video amplifiers and in the investigation of crosstalk.

Automatic target control

In color cameras of this type, amplifier or vidicon overload will result in loss of carriers, leaving only luminance and green. In other words, the highlights in scenes will turn green. To prevent this and to enable the camera to operate in differing light levels, an efficient automatic target

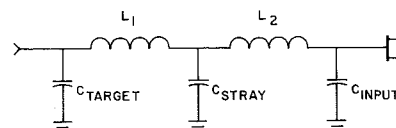


Fig. 7—Preamplifier input network.

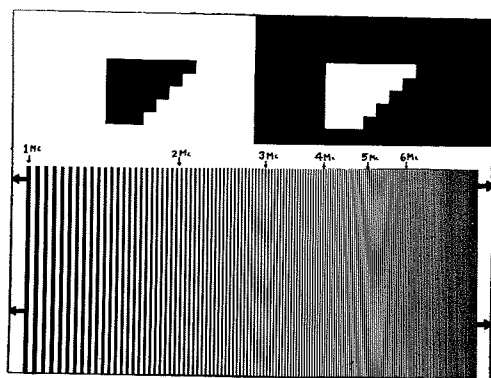


Fig. 8—Video sweep test chart.

control is required. However, most automatic target controls used in broadcast cameras are quite elaborate and unsuited for an inexpensive instrument.

The circuit finally used was a peak signal detector following a black level clamp. The output was the DC target voltage operating to keep a constant peak voltage out of the camera. A double time constant was used; fast acting when the camera output was increasing to prevent green highlights and slow, of the order of ten seconds, to a decreasing signal. This was found to be a good compromise on both movie film and live scenes.

Live camera

Although not completed, work was begun on the refinement of the camera core in the configuration of a live camera for VTR or home surveillance work. For this purpose the camera was packaged for tripod mounting, and some initial tests were made to investigate the problem of automatic color correction for outdoor-indoor lighting conditions. Techniques being considered were those of color correction filters which could be manually or automatically inserted into the optical path, and a system whereby color signal gains could be automatically adjusted to provide a reasonably acceptable compromise for the two situations. The problem of automatic iris control and vidicon protection from direct sunlight was also being considered at that time. Fig. 9 shows a single package version of the camera used for live tests, and Fig. 10 shows a modified version which illustrates a two-package concept being considered for ease of portability. Fig. 11 shows

a "styled" mock-up of the portable, two-package concept of Fig. 10.

Slide and home movie player

The color camera was made up into a unit with a slide projector and a movie projector. A proprietary Super 8 movie projector was obtained. The shutter was modified so that the "flashing rate" of the projector was a multiple of the 60-Hz field rate while the film was run at 18 frames per second, the standard Super 8 film speed. Acceptably flicker-free results were obtained. The alternative of running the film at 20 frames per second was considered, but it proved simpler to modify the projector shutter. For the final product some form of continuous motion projector was envisioned. The noise of an intermittent movement was considered undesirable in a piece of TV equipment.

Current status

The color camera core development program undertaken by CE has been very beneficial. In addition to proving the technical feasibility of such a device, it is also felt at this time that the initial price goal can be achieved, contingent upon vidicon cost. While a single-tube color camera was operating at Indianapolis in July, 1967, throughout the development effort, for competitive reasons, a certain degree of security was maintained concerning CE's involvement. The first demonstrable product concept was shown at a meeting of the RCA Board of Directors in May, 1968.

References

1. Boltz, C. D., "Optical Filter Characteristics for Single Vidicon Color System," *private communication* (May 1967).
2. Cooksey, J. A., "Computer Analysis of Single Vidicon Encoded Color Camera," *private communications* (October 1968).
3. Macovski, A., "Encoded Color Systems," Stanford Research Institute.
4. Castleberry, J. and Vine, B. H., "An Improved Vidicon Focusing-Deflecting Unit," *S.M.P.T.E.*, April 1959.
5. Lubszynski, H. G. and Wardley, J., "Some Problems of Resolution in Low-velocity Camera Tubes," *IEEE Paper, No. 4006E* (June 1963). Presented at International TV Conference on June 1, 1962.
6. Wagner, T., "New One Tube Color Camera for Live or Film Use," *RCA Engineer*, Vol. 15, No. 6.

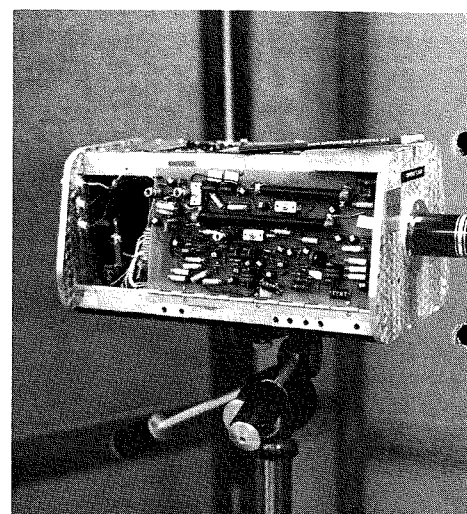


Fig. 9—Live camera prototype package.

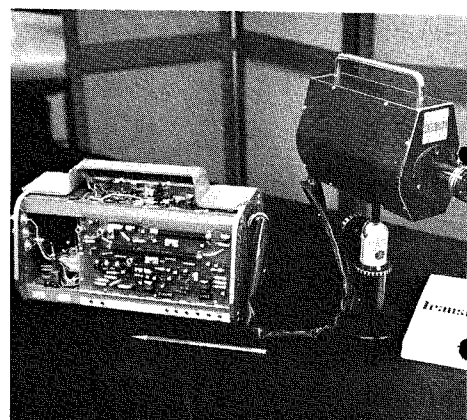


Fig. 10—Two package version.



Fig. 11—Styled mock-up of two-package version being demonstrated by author, Boltz.