RCA Engineer
Vol. 25 No.6 Apr./May/June 1980

Color TV Receivers

On the front cover, we show one of RCA's top-of-the-line color television receivers, incorporating CCD comb filter Detail Processing circuitry. The same video image, but without the benefit of this circuit, is shown on the back cover.

For further information, read the introduction by Dalton Pritchard and the articles by Jim Carnes, Don Sauer and Bill Lagoni (pages 6-15).

Cover design by Louise Carr.

RCA Engineer

A technical journal published by
RCA Research and Engineering
Bldg. 204-2
Cherry Hill, N.J. 08358
Tel. 222-4254 (609-338-4254)

•To disseminate to RCA engineers technical information of professional value •To publish in an appropriate manner important technical developments at RCA, and the role of the engineer •To serve as a medium of interchange of technical information between various groups at RCA •To create a community of engineering interest within the company by stressing the interrelated nature of all technical contributions •To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field •To provide a convenient means by which the RCA engineer may review his professional work before associates and engineering management •To announce outstanding and unusual achievements of RCA engineers in a manner most likely to enhance their prestige and professional status.

J.P. Bingham

CE Momentum for the 1980s

RCA's Consumer Electronics business has gained considerable momentum in the past several years and has provided some key advancements in television technology. Because of the strong investment RCA continues to make in research and engineering, I believe we are equipped to increase our competitive edge.

Further, we have structured our organization to move expeditiously to product from the applications research of the Princeton Laboratories and from the advanced development prototypes of the New Products Laboratory in Indianapolis. Results of this coordinated effort were seen in the introduction of ColorTrak receivers in 1975. We have followed up with the highly cost-effective XtendedLife series of chassis, frequency synthesis ChanneLock tuning, comb filter Detail Processing, and more.

The 1980s provide us an extraordinary opportunity to utilize our skills, strengths and growing momentum in a consumer electronics market that may well be explosive in growth. The advent of new video products and services, such as VideoDisk, cable TV, and Teletext, will stimulate the home video business. We face the challenge of imaginatively exploiting these new services with cost-effective, useful, and exciting products.

This issue of *RCA Engineer* gives an overview of some of the current engineering activities at CE. The work described ranges from advanced development at the NPL to manufacturability improvement in factory Resident Engineering. With the technical imagination and skills represented in these papers, I believe we meet the challenge of the next decade with strength.

J.P. Bingham
Division Vice President, Engineering
Consumer Electronics Division

Highlights

new circuits . . .

Pages 6 through 29

From research and development to product, a number of new circuits are contributing to the commercial success of Consumer Electronics' TV receivers.

systems . . .

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New systems are pioneering in sound, control, display, reliability and safety to maintain our leadership position.

business concerns . . .

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Beyond performance, what must be considered in designing a new product?

TV engineering . . .

Pages 55 through 60

The technical communications link between CE's Design and Manufacturing is provided by Resident Engineering.

in future issues . . .

Twenty-fifth Anniversary issue, large scale integration, communication trends, mechanical engineering, human aspects of engineering.

RCA Engineer
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D.H. Willis

The color TV receiver: how it works

Three electron beams are produced in the color TV receiver to strike only the phosphors on the faceplate that produce the appropriate colors.

The color TV receiver is designed to receive the NTSC color signal and produce images and audio, correspondingly. The NTSC signal is composed of a vestigial sideband VHF or UHF carrier amplitude-modulated with the picture signal and a frequency-modulated sound carrier 4.5 Mhz above the picture carrier frequency. The total spectrum space required by one TV channel is 6.0 Mhz. There are a total of 82 TV channels presently used, occupying most of the spectrum between 54 Mhz and 890 Mhz. The picture signal represents an image horizontally scanned at a line rate (15.734 Khz) and vertically scanned at a field rate (59.94 Hz). One line period of the picture signal is shown in Fig. 1. This is a composite video signal containing scan synchronizing pulses, a luminance (brightness) signal and a color signal. Dark luminance is represented by a high carrier amplitude and bright luminance by a low amplitude. The NTSC signal is designed so that a monochrome receiver ignores the color portions of the signal. Therefore, the color signal is a suppressed-carrier subcarrier that is not modulated with information on the actual colors, but with color-difference information (chrominance). A color-difference signal is a signal (Red minus Luminance, for example) which can be summed with luminance to form a color signal. The subcarrier is amplitude-modulated with color saturation (intensity) information and phase-modulated with hue information. Thus, the three dependent variables needed to reproduce a color (Red, Green and Blue) can be derived from the two independent phase and amplitude variables modulated on the subcarrier plus the luminance independent variable. The color subcarrier has the chrominance modulation removed during the blanking intervals between lines and contains a burst instead, which represents the phase of the suppressed subcarrier and is used in decoding. The color subcarrier plus its sidebands share that portion of the baseband spectrum occupied by the higher-frequency components of the luminance signal.

The block diagram in Fig. 2 depicts the major subassemblies of the receiver. The received RF from the antenna is fed to the tuner where it is amplified and converted in a superheterodyne fashion to I.F. (45.75 Mhz). The tuner control system selects both the local oscillator frequency and the RF bandpass networks within the tuner. A wide variety of tuning control systems is possible, ranging from a μP-controlled synthesizer to mechanical switching. The I.F. provides gain-controlled amplification of the intermediate-frequency signal as well as bandpass selectivity for trapping and rejecting unwanted signals. An automatic-gain-control system (AGC), usually included as part of the I.F., controls the I.F. and tuner gain to hold the I.F. output constant for different signal conditions. The color TV I.F. includes a detector for recovering the baseband composite video signal and a simple mixer for producing an FM intercarrier sound signal by intermodulating the I.F. picture and sound

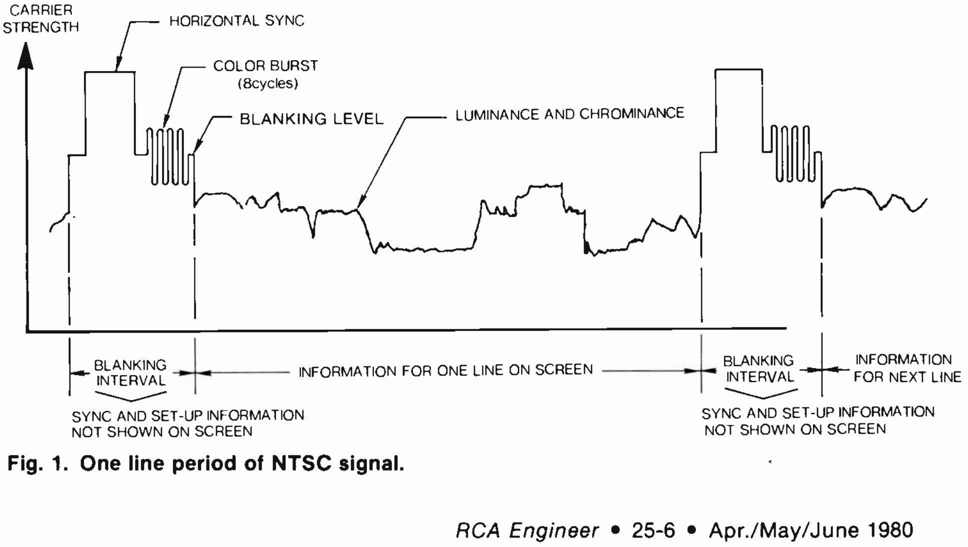


Fig. 1. One line period of NTSC signal.

Reprint RE-25-6-1
Final manuscript received Feb. 21, 1980.

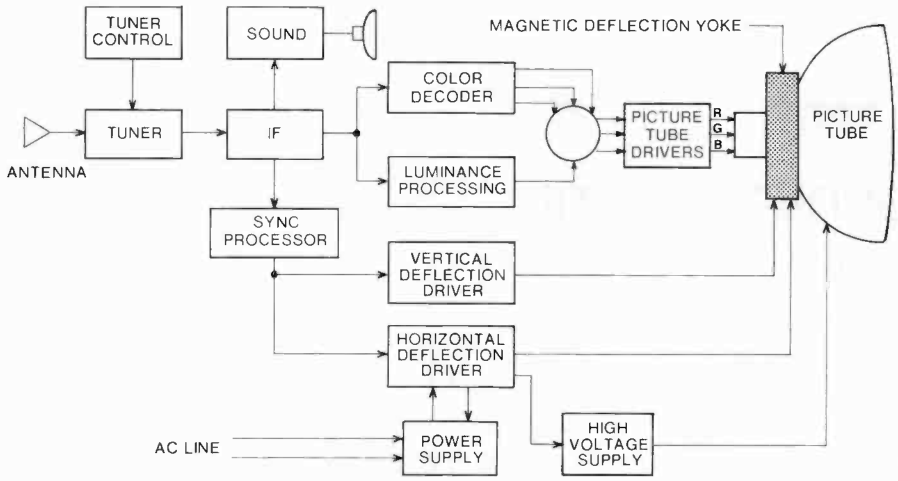


Fig. 2. Color receiver block diagram.

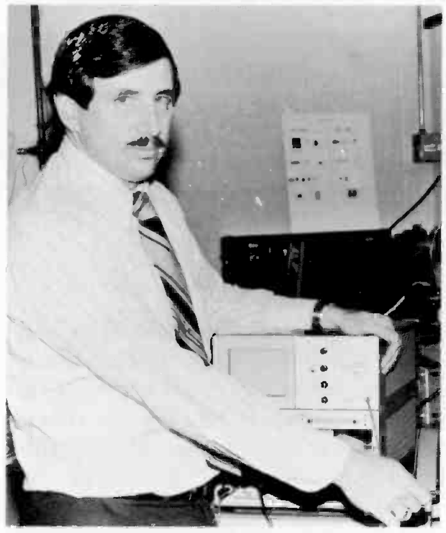
carriers. The intercarrier signal is amplified and limited by the sound circuits before being FM detected and sent to the speaker.

The luminance processing circuits provide dc restoration and transient response contouring for the luminance signal. The luminance circuits also help to ensure that the display (picture tube) is turned off (blanked) during those portions of the line and field intervals when no scene information is present. The color decoder uses the color burst to phase-lock a 3.58 Mhz oscillator, thereby recreating the color subcarrier. The chrominance components are amplified with a bandpass amplifier which is gain-controlled (ACC) to hold the color constant. The subcarrier and chrominance signals are then used to drive synchronous detectors within the decoder which produce three color-difference signals: *R-Y*, *G-Y*, *B-Y*. The luminance (*Y*) signal is subtracted from these leaving *R*, *G*, and *B*. These three color signals are applied to the cathodes of a color picture tube by the picture tube drivers.

Each cathode forms part of an electron gun in the picture tube so that three electron beams are produced. Each beam is modulated in intensity independently of the other two. The shadow mask in the tube ensures that each beam will strike only the phosphors on the faceplate which will glow with the appropriate color.

The three electron beams produced by the electron gun are scanned simultaneously across the face of the picture tube by a magnetic deflection system. The beams are scanned left-to-right beginning at the top-center. After each line ends at the right edge, the next line begins at the left edge as shown in Fig. 3. After 262½ lines are scanned, the process begins again at the top left and scans lines between the scan paths traversed in the first vertical pass. Each vertical pass is called a field and a whole picture (frame) consists of two interlaced fields. A frame requires approximately 1/30th of a second to scan. A yoke positioned around the tube neck produces a magnetic deflection field in response to line and field rate deflection currents in the horizontal and vertical yoke windings, respectively. These yoke currents are produced by sawtooth current generators shown as the horizontal and vertical deflection drivers in Fig. 2. Special circuitry within these generators also corrects for geometric errors produced by the scanning process. By careful yoke design, the errors that need correcting can be minimized. The drivers are synchronized by phase locking them to the synchronizing pulses occurring in the signal. These pulses are separated from the rest of the picture signal by a sync processor sensitive to their "blacker-than-black" level. High voltage, needed to accelerate the electron beams, is formed from the relatively high amplitude voltage pulses resulting from the quick reversal of current in the horizontal yoke winding inductance between scanning intervals. These pulses are transformed to a higher voltage by a flyback transformer and then rectified in the high-voltage supply to generate the high dc potential required.

The power supply shown in Fig. 1 may be a switching regulator type, a series-pass type, a 60 Hz transformer version, or simply rectified and filtered ac line with no regulation.



Don Willis joined RCA in 1962 to begin designing color receiver baseband signal circuits. Later he helped design circuits for a prototype consumer VTR. Recently, he has designed deflection circuits for TV receivers and is presently a Principal Member of the engineering staff of the New Products Laboratory.

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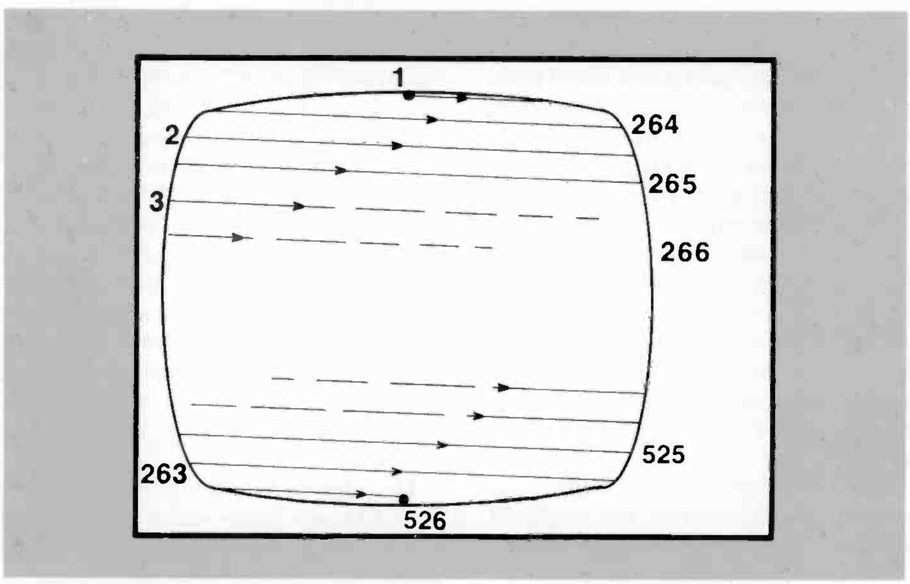


Fig. 3. Raster scanning process.

D.H. Pritchard

Color TV picture enhancement with a CCD comb filter

The papers to follow describe a program that required a high level of cooperation among research and engineering personnel from basic concept through product manufacturing. Its commercial success was announced in May 1979 as the "Dynamic Detail Processor" in RCA's Limited Edition ColorTrak line of color TV receivers. These receivers provide TV pictures that are demonstrably superior, clearer, sharper, and more precise than any other ever made by RCA.

In the standard National Television System Committee (NTSC) color television system luminance and chrominance information are both contained in a common communications channel. Recognition of the interlaced nature of the luminance and chrominance allows an innovative means for separating luminance (monochromatic brightness) and chrominance (hue and saturation) at the receiver by employing 1-H (one horizontal scan line) delay comb-filter techniques.

This approach noticeably enhances picture quality and sharpness. The conventional "dot-crawl" and "cross-color" beats are minimized, the horizontal resolution is increased (from 260 to at least 330 TV equivalent lines), and vertical detail at the receiver is maximized.

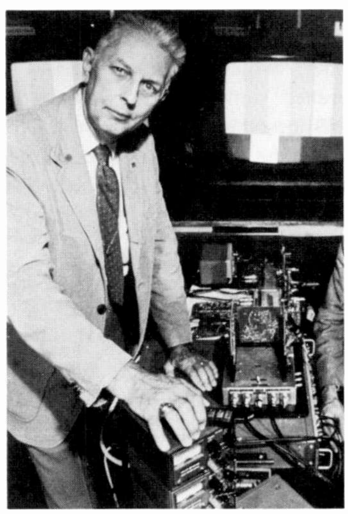
The fundamental comb filter is a two-terminal transversal filter circuit that consists of a delayed path and a direct path, along with appropriate linear summation and subtraction processing functions. In the summation process, the signal amplitudes through the delayed and direct paths are made equal; if the time delay difference is maintained precisely across the band of interest, a filter is produced that has periodic peaks and nulls, and the spacing between them is a function of the delay difference. The subtraction process (signal polarity inversion followed by summation) provides complementary response.

In the NTSC system, a comb filter may more effectively separate the interlaced chrominance signal from the luminance signal than do the conventional overlapping luminance low-pass and chrominance band-pass filters. The output of the summation process contains noninterlaced (luminance) components free of the "dot-crawl" color-signal contamination. The output of the subtraction process contains the interlaced (chrominance) components free of "cross-color" luminance-signal contamination.

The basic principles of such a filter have been known for decades. However, recent advances in charge-coupled device (CCD), NMOS, solid-state technology have made possible the development of a unique comb-filter 1-H delay device. A cost-effective integrated circuit (IC) has been designed to interface with the baseband signal-processing functions of a specific color TV receiver system. An innovative commercial design utilizes the principles of "charge-summation" in combination with a "long-line" CCD delay and a "short-line" CCD delay. They are driven by a common clock signal, and the delay *difference* is precisely the required 1-H value (63.555 μs). The delay in a CCD is determined by the number of charge transfers and is inversely proportional to the clock rate. This fact and the linear-phase characteristic of such a filter make the CCD attractive for its stability, electrical performance, IC format, and freedom from environmental effects (temperature, humidity).

The inherent baseband characteristic of the CCD as a delay element allows the enhancement of vertical detail in the luminance channel. When this feature is coupled with appropriate nonlinear processing of the vertical detail signal and with conventional horizontal peaking, picture sharpness is markedly enhanced. This sharpness and the separation of luminance and chrominance provide a high degree of picture "clarity" that better realizes the capability of the NTSC color television system and is readily apparent to the viewer.

Reprint RE-25-6-2
Final manuscript received March 25, 1980.



Dalton Pritchard has been involved with communications and information display systems since he joined RCA in 1946. At present, he is engaged in the development and evaluation of video processing circuitry for color TV receivers, particularly in areas of colorimetry, decoder matrix techniques, and CCD video signal processing.

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J.E. Carnes|D.J. Sauer

A CCD comb filter IC for consumer TV application

CCD technology for video signal processing comes of age — and promises a long and productive life.

Abstract: *1-H delay lines are useful video signal processing devices and CCDs provide the capability to delay analog signals in silicon integrated circuit format. This paper describes the first CCD 1-H delay line IC designed specifically for TV receiver applications. It resulted from a joint RCA Laboratories, Solid State Technology Center, and Consumer Electronics program and is the key to the RCA Detail Processor which provides picture quality enhancements in the CTC-101 ColorTrak TV receiver. This application is the first high quantity use of CCD technology in consumer products.*

The usefulness and value of components capable of delaying video signals by a time interval of one TV horizontal line time (1H = 63.555564 μs) have been appreciated for some time.[1] These 1-H delay lines can be used to construct comb filters and vertical aperture correctors to enhance picture quality. (A companion paper in this issue describes in detail the use and value of these functions in a TV receiver.[2]). In the past, the only practical means of achieving 1-H delay for analog signals required the use of glass delay lines. These components are difficult to use since their delay is temperature-sensitive; and to delay normal baseband signals (as used in commercial broadcast equipment) requires up-conversion (in the 30- to 40-MHz range) followed by down-conversion. As a result, previous usage in consumer TV receivers has been limited to glass delay line comb filters that delay video signals only in the 3-4-MHz range and therefore cannot provide vertical aperture correction. The development of charge-coupled device (CCD) technology during the 1970s has provided an attractive alternative for performing 1-H delay of baseband video signals in silicon MOS integrated circuit format.

Reprint RE-25-6-3
Final manuscript received April 11, 1980.

CCD advantages

Much has been written about the operation and characteristics of CCDs,[3,4] and we shall not repeat it here. It is useful, however, to review a few basic concepts which give the CCD a clear advantage over glass delay lines in the 1-H delay application. First and foremost, the delay time τ of a CCD is determined solely by the number of storage elements and the clock frequency according to

$$\tau_{delay} = \frac{\text{number of storage elements}}{\text{clock frequency}}$$

In particular, the delay time does not depend upon temperature nor on the dimensional characteristics of the integrated circuit manufacturing process, i.e., gate underetch or overetch. (To be completely correct, the delay time also depends upon transfer inefficiency ϵ, but at ϵ values required to provide suitable bandwidth in the video 1-H application, this effect is negligible.) The second main advantage of the CCD is that it utilizes standard NMOS technology and much of the required surrounding support circuitry can be put onto the same chip with the CCD. In addition, since baseband signals can be delayed in a CCD, it is relatively straightforward to perform vertical aperture correction (or vertical peaking) in a TV receiver, producing noticeable picture quality enhancement. Thus, the CCD's predictable delay, baseband signal capability and NMOS IC format make it a prime candidate for the 1-H delay element in consumer TV receivers.

In this paper we will describe the first CCD comb filter IC (TA10743) designed specifically for a TV receiver application. This device is the key to RCA's Dynamic Detail Processor system, which is part of the Limited Edition ColorTrak TV receiver introduced in August 1979 and which is described in detail in the companion paper.[2]

Main CCD channel configuration

The CCD portion of the IC is actually an integral comb filter rather than just a simple delay element. A comb filter for separating luminance signals is made by adding two composite video signals, one of which is delayed by 1-H relative to the other. Conventionally, this would be accomplished by adding a delayed and undelayed signal external to the CCD IC. This approach can have problems because of delay variations in the off-chip low-pass filter normally required between the CCD output and the addition circuitry. These delay variations can affect the filter characteristics significantly unless they are kept within ±5 ns.

In the design of the TA10743, the addition function is performed internal to the CCD by merging the charge from two channels, one from a short line, the other from a long line. The difference in delay between the short line (1 element) and the long line (683½ elements) is 682½ elements. Since the clock frequency is three times the color subcarrier of 3.579545 MHz, or 10.738635 MHz, the relative delay between the two signals is

$$\frac{682.500}{10.738635} = 63.555564\ \mu s,$$

which is exactly 1-H. Therefore, the merging channel addition function and the delay difference of 1-H provide the complete luminance comb filter function in the CCD channel.

A comb filter to separate chrominance signals is similar, except the signals have to be subtracted rather than added. The subtraction is achieved by inverting the composite signal prior to the chrominance short-line section, followed by the merging channel addition.

The topology of the CCD is evident in Fig. 1. Since the long lines for both the luminance comb and chrominance comb delay the same non-inverted composite video signal, chip area and clock power can be conserved by combining the two long-line channels into one and subsequently splitting them into two channels just prior to the addition junctions. Two separate inputs followed by channel merging are used at the long line input in order to improve the tracking between the long- and short-line input characteristics.

Note the required inverter before the chrominance short-line input. The externally-supplied Y_{ADJ} and C_{ADJ} dc voltages shown in Fig. 1 are used to adjust the gain of the short line inputs in order to equalize the charge levels in the short and long lines to achieve good signal cancellation at the appropriate null frequencies.

CCD input configuration

The basic input technique used in the TA10743 is a modification of the well-known fill-and-spill[5] approach. Normally, this input technique suffers because carefully timed strobes are required for the source diffusion, proper dc bias levels for the input gate depend upon process variations, and buried-channel devices tend to be non-linear, especially at low charge levels.

The problem of strobe pulse timing was solved by incorporating digital NMOS circuits on-chip to generate the required pulses. Linearity was improved by using the charge-skimming technique illustrated in Fig. 2. Only the modulated portion of the charge under gate G-2 is transferred into the CCD by the skimming action of gate G3 which is timed to phase-1 but is turned ON to only 5V. The modulated portion of the charge under G-2 which is skimmed off tends to have linear input voltage-to-charge characteristics because the CCD well capacitance is more linear at higher charge levels. This scheme obviates the need to expend silicon area and clock power to transfer the remaining unmodulated bias charge completely through the CCD.

The proper input bias voltage required for G-1 is obtained automatically by the automatic Y BIAS circuit shown in Fig. 3. This circuit consists of two reference registers: A and B. A is a nominal 25 μm wide (similar to the actual input) and operates exactly as the actual inputs except that G-1 is connected to dc voltage V_{REF} (Y), which controls the constant charge level being inputted to register A. This charge is transferred by CCD action to a floating diffusion (FD) which is connected to the inverting input of an on-chip differential amplifier, the output of which determines V_{REF} (Y). Register B removes charge from FD. Since register B is only 12.5 μm wide and the ϕ1D-connected gate pair will scoop out a "full-well" of charge, register B removes about one half of a normal 25-μm-wide full-well level each clock cycle. Because of the negative feedback provided by the differential amplifier, V_{REF} (Y) will be adjusted until the charge through registers A and B are both equal to one-half of the normal input full-well charge level. Since the bias charge in the signal register tracks the charge level in register A, the bias charge is also maintained at 50 percent of a full well. This level is geometrically determined by the B register width and is relatively insensitive to IC processing variations.

A final feature of the TA10743 inputs is the gain-adjust feature provided by varying the dc voltage applied to G-2. Since the capacitance of the potential well is a function of the gate voltage, the effective gain of the voltage-to-charge conversion process at the input can be adjusted by varying the G-2 voltage. Figure 4 illustrates this. This is the mechanism by which Y_{ADJ} and C_{ADJ} control the gain of the two short-line inputs.

Clock generation

The on-chip clock logic and driver circuitry are designed so that the only input required is a high-impedance 1.0-V_{p-p} sine wave

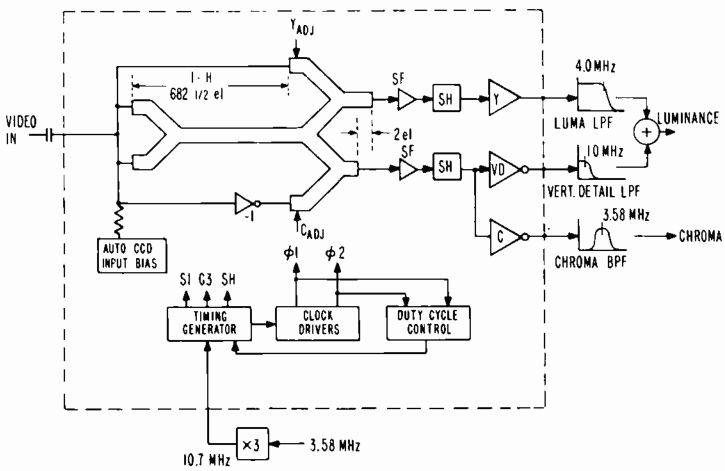


Fig. 1. Block diagram of the CCD comb filter IC.

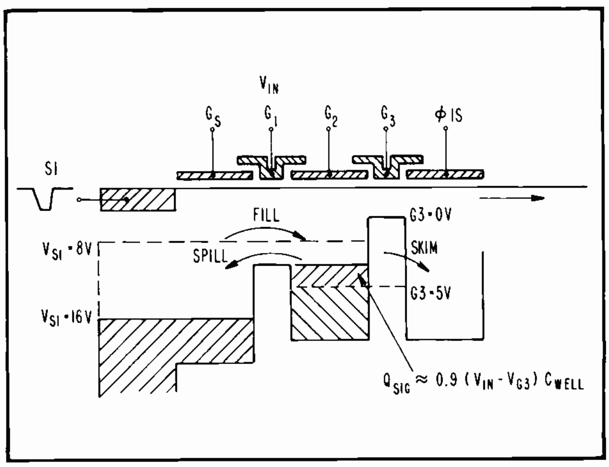


Fig. 2. CCD input stage operation.

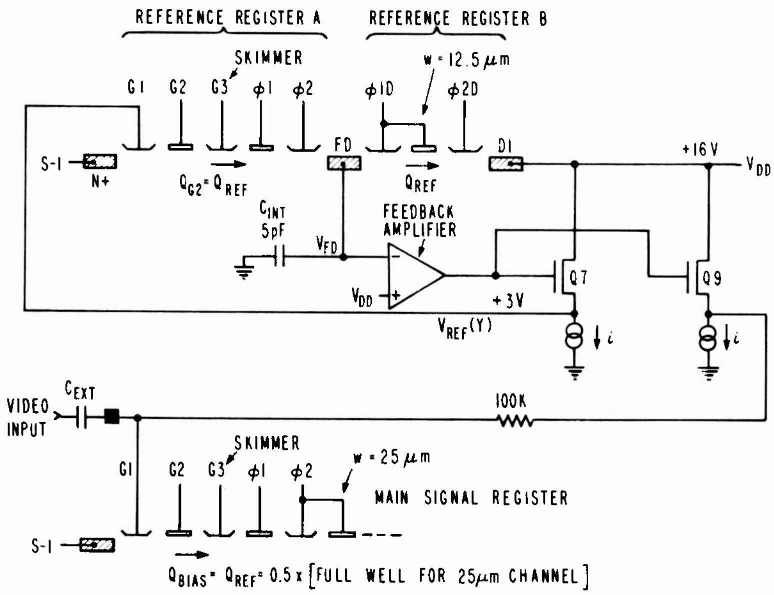


Fig. 3. Automatic input bias circuit.

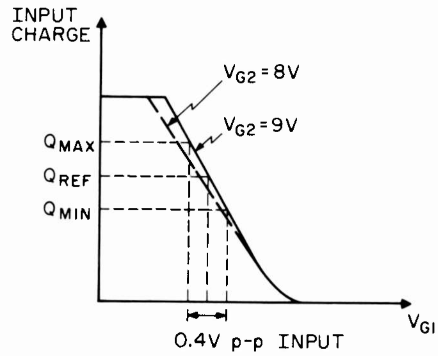


Fig. 4. CCD input stage transfer function.

noise to prevent the following video amplifiers from saturating. The overall gain of the luminance video amplifier is 10 dB. The dc biasing for this amplifier is set by a feedback circuit which compares the dc output level with an internal 4.6-*V* reference.

signal at the desired clock frequency (10.7 MHz, in this case). Because the relative delay between the long and short lines is 682.5 stages, the long-line input is sampled on phase-1 and the short-line input is sampled on phase-2. This provides a delay equal to one half of a period. It also demands that the clock waveforms are completely symmetrical with phase 1 and phase 2 crossing at one half of a cycle ±2.5 ns. Otherwise, the excellent delay time characteristics of the CCD referred to earlier would not be maintained. Symmetrical clock waveforms are maintained in the TA10743 by means of the circuit configuration shown in Fig. 5. The dc bias of the input sine wave controls the ON-OFF duty cycle of the clock waveforms. In order to adjust this level properly and automatically, the two clock phases are filtered to determine their average level and applied to the two inputs of a differential amplifier. This then adjusts the dc bias of the input sine wave until the clocks have equal ON and OFF periods.

Output amplifiers

The outputs from the CCD are buffered using sample-and-hold circuitry and linear NMOS amplifiers. This is done to reduce the 10.7-MHz clock noise and provide a low (300Ω) output impedance.

The luminance output amplifier, which is shown in Fig. 6, senses charge with a standard floating diffusion that is reset to V_{DD} by the ϕ1D timing pulse. The capacitance at the floating diffusion was reduced to about 80 femtofarads by using two source followers. The signal voltage developed on the floating diffusion is about 0.5 $V_{p\text{-}p}$ for a 0.4 $V_{p\text{-}p}$ video-input level. The sample-and-hold circuit reduces the clock

Fabrication technology

The IC is fabricated using double-polysilicon, buried-channel CCD NMOS technology. Diffusions, barrier implants and second-level polysilicon gates are self-aligned. Thick field oxide is used as well as reflow glass prior to metallization. Four ion implants are required: (1) a boron field implant, (2) a phosphorus buried channel implant (also used for depletion mode pull-up transistors, (3) a boron transfer barrier implant, and (4) an enhancement transistor threshold adjust implant. The CCD unit cell is shown in cross-section in Fig. 7. Transistor source-drain spacings are 10 μm in most cases and 7 μm where required in clock drivers and output amplifiers. The chip size is 3.3 x 3.1 mm. The typical measured CCD transfer loss is 2×10^{-5} per transfer at the clock frequency of 10.7 MHz.

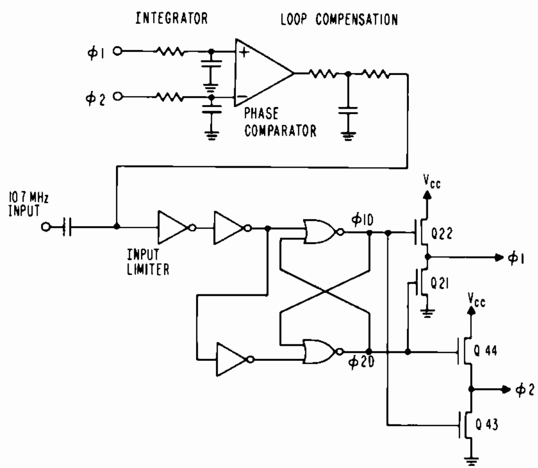


Fig. 5. CCD clock driver logic diagram.

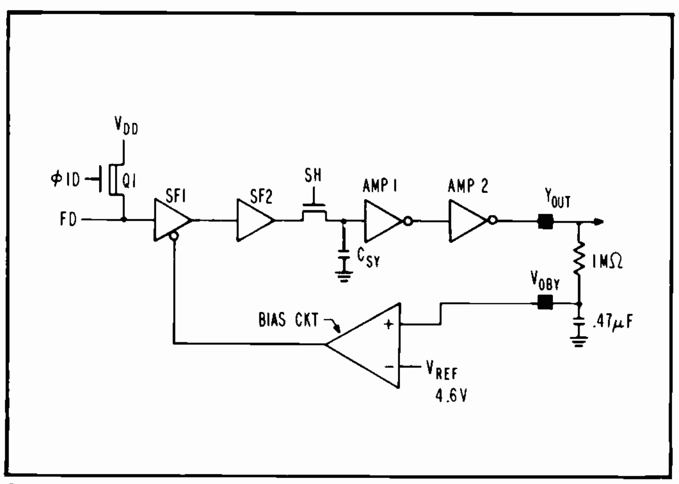


Fig. 6. Luminance output amplifier.

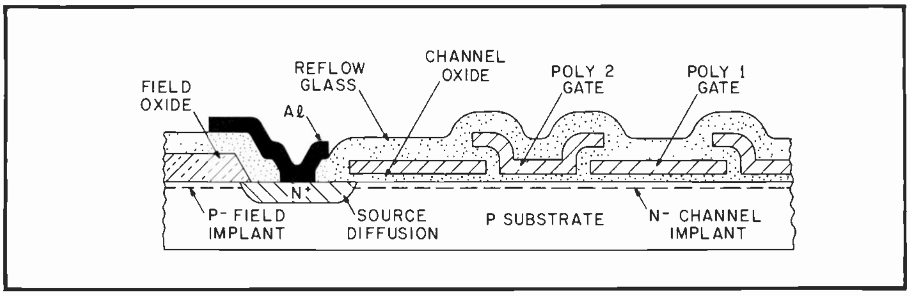
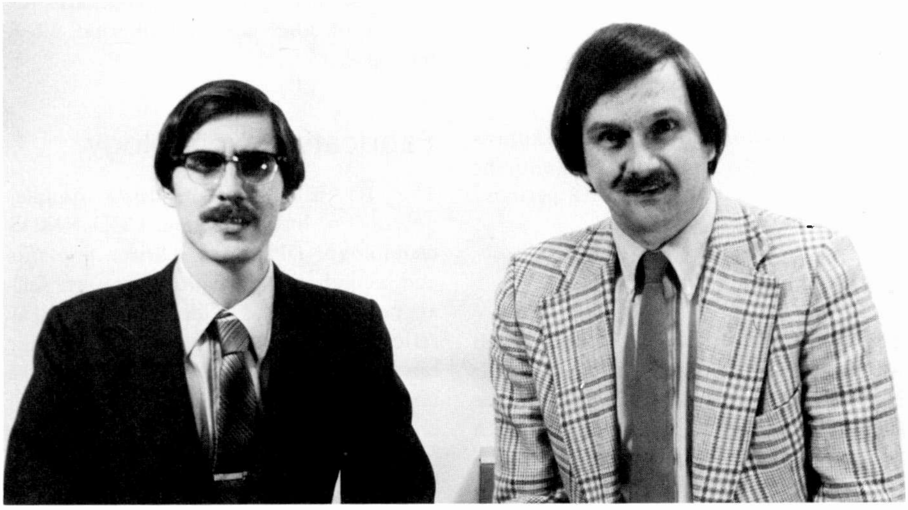


Fig. 7. Cross section of double-polysilicon gate n-buried-channel CCD.

Summary

The configuration and qualitative design concepts of the TA10743 CCD comb filter IC have been described. The salient features include the use of buried-channel CCD technology compatible with a standard NMOS "double poly" process; the use of charge addition by merging CCD channels; and finally, significant integration of required analog and digital support functions on-chip with innovative use of automatic biasing and level-setting techniques. This chip is currently being used in the production of the CTC 101 TV chassis and represents the first known high-quantity use of CCDs in consumer equipment.



Don Sauer joined RCA Electromagnetic and Aviation Systems Division in Van Nuys, Calif. in 1969. In 1973, he began working on charge-coupled digital memory devices intended for the replacement of rotating magnetic drums and successfully designed and demonstrated experimental 1Kbit and 16Kbit CCD memories. In 1974, Mr. Sauer transferred to RCA Laboratories, Princeton, N.J. as a Member of Technical Staff. He continued working on CCD technology and has been responsible for the design, layout, and correctorization of charge-coupled devices for imaging, memory, and signal-processing applications.

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Jim Carnes worked at RCA Laboratories during the summers of 1966 and 1967 and joined the staff there on a full-time basis after completing his graduate work in 1969. In June 1977, Dr. Carnes joined the Consumer Electronics Division of RCA where he was Manager, IC Development, at Somerville, N.J., and in January, 1978, moved to Indianapolis where he is Manager, Technology Applications, in the New Products Laboratory. In this function he is responsible for coordinating custom IC development efforts for the Consumer Electronics Division.

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Acknowledgments

The IC described in this paper was a major milestone in a joint RCA Laboratories, Solid State Technology Center, Consumer Electronics program to develop CCD video signal processing techniques which began in 1973 and continues today. Many persons have made significant and continuing contributions to this program. The list includes: D. Allesandrini, L. Bijaczyk, R. Dawson, J. Fuhrer, V. Frantz, J. Groppe, R. Hassell, H. James, W. Kosonocky, W. Lagoni, P. Levine, G. Meray, R. Miller, D. Pritchard, W. Romito, W. Sepp, F. Shallcross, S. Shen, and G. Thornberry. The authors are indebted to these people and value the opportunity to work with them on this successful program.

References

1. Pritchard, D.H., Schroeder, A.C., and Gibson, W.G., "High-Performance Television Receiver Experiment," *RCA Engineer,* Vol. 18, No. 3, p. 83 (Oct./Nov. 1972). [1H = 63.555564 μs is the FCC value.]
2. Lagoni, W.A., "Comb Filter Circuit Design for the CTC10," *RCA Engineer,* Vol. 25, No. 6 (June 1980).
3. Sequin, C.H., and Tompsett, M.F., *Charge Transfer Devices,* Academic Press, N.Y. (1975).
4. Howes, M.J. and Morgan, D.V. (editors), *Charge-Coupled Devices and Systems,* John Wiley & Sons Ltd., N.Y. (1979).
5. Kosonocky, W.F., and Carnes, J.E., "Basic Concepts of Charge-Coupled Devices," *RCA Review,* Vol. 36, No. 3, pp. 580-586 (Sept. 1975).

W.A. Lagoni

Product design of a base-band comb filter system

Television receiver designs provide a new dimension of picture sharpness and clarity.

Abstract: *The recent advancements in solid state technology allow the new techniques of charge-coupled device (CCD) and MOS circuit designs to be applied to consumer television receivers. Through these new technologies, the cost-effective application of comb filters in consumer television becomes reality. By application of an NMOS/CCD comb filter integrated circuit in conjunction with bipolar discrete circuit designs, a new dimension of color television sharpness and clarity is produced through elimination of crosstalk between luminance and chroma signals. This elimination of crosstalk* (cross-*color and edge dots*) *allows a television system design which utilizes the full luminance bandwidth of the NTSC television system. In addition, the technique of baseband comb filtering allows the totally new feature of vertical aperture enhancement in consumer television.*

System configuration

This paper describes circuit and system design of a television receiver incorporating a base-band comb filter with vertical aperture enhancement. In a television receiver signal system (Fig. 1), the comb filter is interposed between the IF and the luminance and chrominance processors. The inputs to the comb filter are composite video from the IF and the regenerated chroma subcarrier from the chroma oscillator. The comb filter outputs are the combed luminance, vertical detail and combed chrominance signals. A block diagram of the comb filter system is shown in Fig. 2.

Frequency tripler

The accuracy of the comb filter transfer characteristic is a function of the precision of the included one horizontal line time (1−H) delay. In a charge coupled device (CCD) delay line, this precision is assured by the frequency of the clocking signal. In the system being described, it is assured by clocking the CCD elements with a 10.74 MHz signal derived from the third harmonic of the chroma subcarrier. In addition to the frequency precision, an extreme spectral purity is also required so that contamination of the luminance, and more importantly the chroma signals, by the chroma subcarrier does not occur. The requirement imposed by the chroma system is that the clock reference signal from the frequency tripler must contain no 3.58 MHz signal nor harmonics of 3.58 MHz (other than integral harmonics of 10.74 MHz) larger than 76 dB below the desired 2 to 3 volts p.p. 10.74 MHz signal.

In the frequency tripler, the incoming 3.58 MHz sine wave generates a symmetrical square wave, which contains odd harmonics of the fundamental 3.58 MHz and suppresses most even harmonics. A band-pass filter is then used to extract the third harmonic. The suppression of even harmonics, particularly the second and fourth, eases the band-pass filter requirements, thereby allowing lower-order filtering.

The third harmonic signal is extracted from the 3.58 MHz square wave by a critically coupled double-tuned filter. The 10.74 MHz amplitude is determined by the

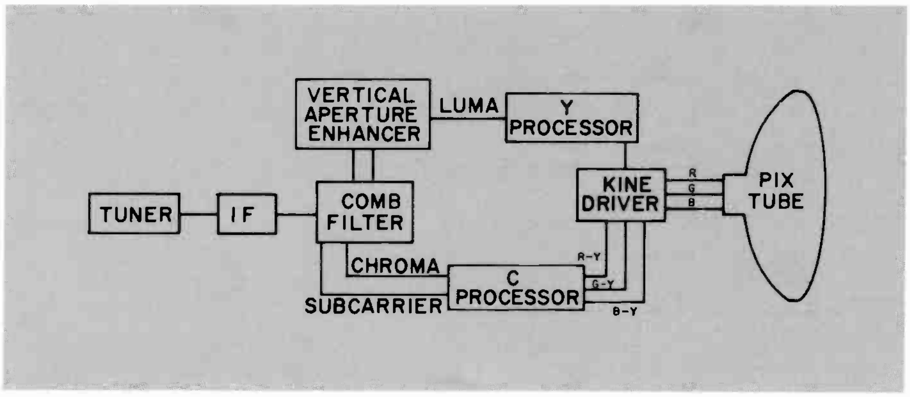


Fig. 1. Television signal system.

Reprint RE-25-6-4
Final manuscript received April 16, 1980.

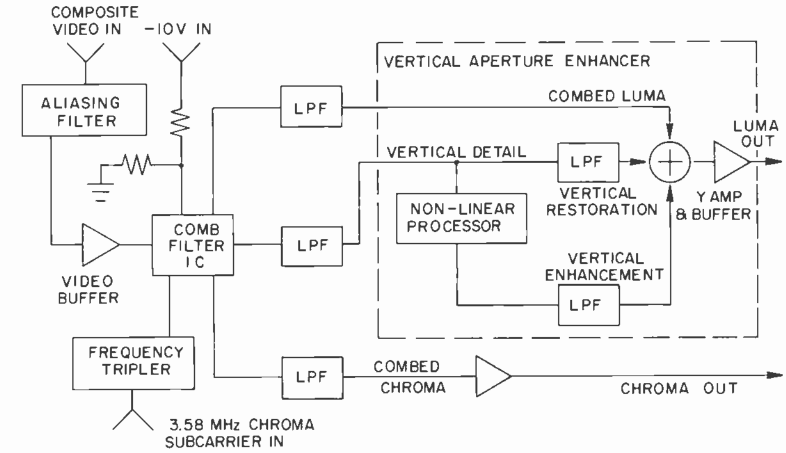


Fig. 2. Comb filter and vertical enhancer system.

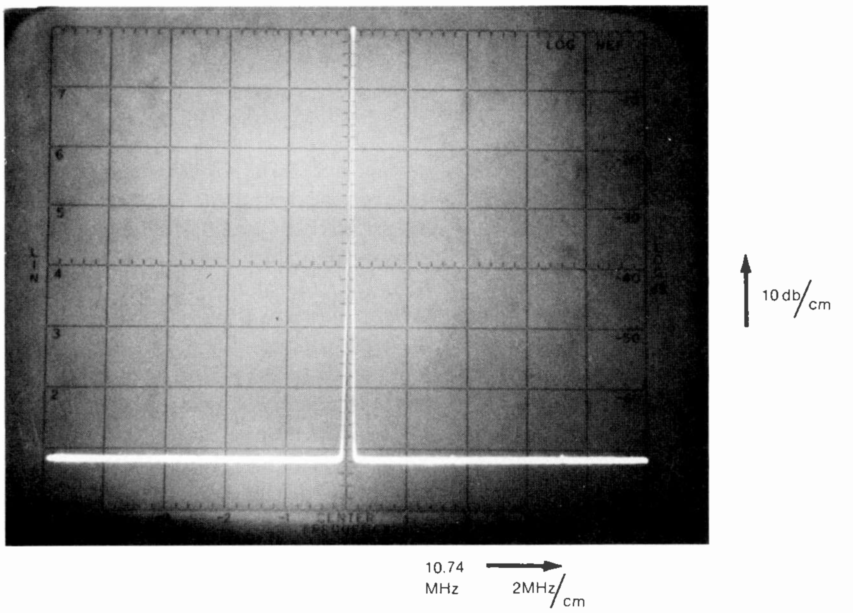


Fig. 3. Frequency tripler output.

filter characteristics and by an un-bypassed emitter resistor. As the fundamental component of a square wave is 10 dB greater than the third harmonic, the 3.58 MHz rejection of the tripler is increased by a parallel resonant trap in the emitter. This trap is fixed-tuned for resonance at approximately 3.58 MHz. The spectral response of the output of the frequency tripler is shown in Fig. 3.

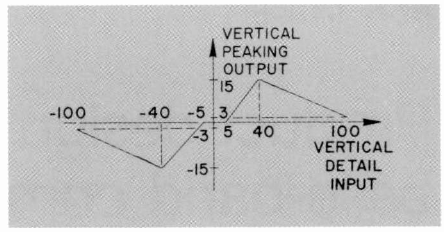


Fig. 4. Vertical enhancement function.

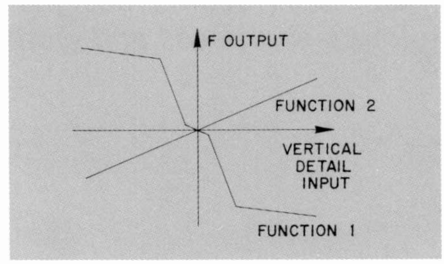


Fig. 5. Non-linear processor.

Vertical aperture enhancer

In the base-band comb filter that provides vertical peaking, field tests have shown it necessary to non-linearly process the vertical detail *enhancement* signal while processing the vertical detail *restoration* signal linearly. The non-linear transfer function used for vertical enhancement (Fig. 4) is generated by the addition of two functions as shown in Fig. 5. It can be seen that appropriate scaling of the two functions in Fig. 5 will produce an inverted function having the shape of Fig. 4. This approach was taken so that the multi-valued function of Fig. 4 could be generated by a combination of single-valued functions.

The circuit used for generation of function number 1 in Fig. 5 is shown schematically in Fig. 6. The non-linear amplifier is similar to the limiter amplifier in the frequency tripler. A transistor, Q3, operates as an inverting feedback

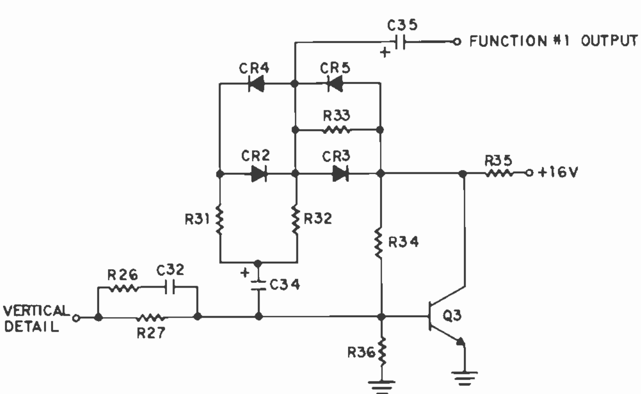


Fig. 6. Non-linear amplifier.

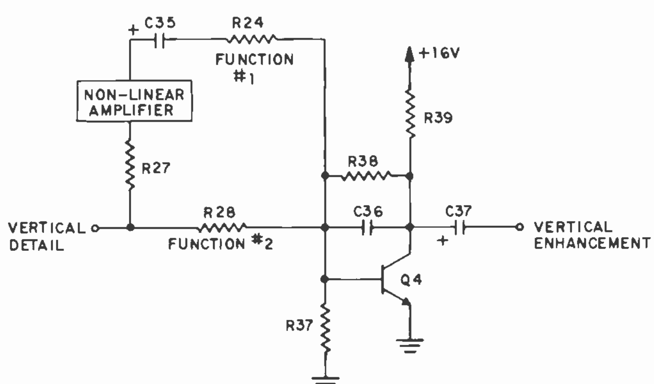


Fig. 7. Vertical enhancement amplifier.

amplifier, and two pairs of diodes, CR3 and 5, and CR 2 and 4, provide three distinct closed loop gain regions, which are determined by the input signal level and the ratio of the feedback impedance to the input impedance. As the output of the circuit is taken through C35 from the junction of the two pairs of diodes, the slope in region I is primarily a result of R33, while the width of region I is determined by the cut-in voltage of diodes CR3 and 5 in conjunction with the gain set by R34. The gains in regions II and III are determined by the appropriate parallel combinations of R34, R32 and R31.

Similar to the case of the limiter amplifier, the capacitor in series with the non-linear feedback elements charges to the difference between the collector and base voltages and maintains zero bias across the diode pairs. The open-loop gain of the amplifier is set by R35 and the amplifier frequency response is enhanced by the frequency compensation network formed by R26 and C32.

The final transfer function is obtained by the summation of the output from the Q3 amplifier stage through C35 with the linear vertical detail signal. This is shown by the schematic of Fig. 7. The capacitor C36 in parallel with feedback resistor R38 provides the low-pass filter shown in Fig. 2.

Luminance channel

The luminance signal from the comb filter IC must be filtered and the vertical restoration and vertical enhancement signals added to it. The composite luminance signal is then amplified without inversion and buffered to drive the luminance processor input. Due to limitations in the dc drive capability of the luminance output of the IC, only minimal dc current can be delivered by the IC. These conditions are all met by the circuit shown in Fig. 8.

The base of Q5 is biased by R63 and R64 to set the dc voltage at Q5 emitter to nominally the same as the Y and VD outputs from the IC. In this way, nominally no dc current will flow in the Y and VD outputs. The collector dc voltage at Q5 is determined by R62 and the sum of R65 and R49 and the positive supply voltage. Buffer amplifier Q6 is biased by R66 and R67 to the dc voltage necessary to bias the luminance processor input.

The low frequency gain of the Q5 amplifier to combed luminance is determined by the ratio

$$A_{(Y)} = \frac{R49 + R65}{R58}$$

The proper proportions of vertical restoration and vertical enhancement to combed luminance are then determined by R30 and R42, respectively.

The frequency response of this luminance amplifier is optimized by the gyrator configuration which employs C62 in a feedback arrangement to the mid-point of the Q5 collector load ($R49 = R65 = RL/(2)$). Use of this form of shunt peaking allows the capacitive loading at Q5 collector to be compensated, thus, producing "flat" frequency response of the amplifier through the video band.

Chroma channel

The combed chroma signal from the IC must be low-pass filtered, amplified and buffered to drive the chroma processor. This is done as shown in Fig. 9. The feedback amplifier is employed for its predictable gain, low output impedance and independent control of ac gain and dc bias. As the base of Q7 is an ac virtual ground, R44 is the termination impedance of the low-pass filter as well as one of the ac gain determining elements of the Q7 amplifier stage. The moderately low output impedance arising as a result of the negative feedback configuration is useful in driving the chroma signals to the chroma processing system.

Signal filters

As shown in the previous block diagrams, this comb filter system requires several signal processing low-pass filters. Three of these filters pertain directly to the fact that the comb filter IC is a sampling device. The aliasing filter shown in Fig. 2 assures that no signals beyond the Nyquist limit $f_{clock}/2$ are processed by the sampling system. The schematic and frequency response of the aliasing filter are shown in Fig. 10.

The 4.5 MHz trap shown in Fig. 10 is of conventional design. The phase equalizer is included to compensate the IF phase response to assure adequate video transient response.

The low-pass filters in the combed luminance and combed chroma signal paths are included primarily to reduce the clock signal remaining on the desired signals at the IC outputs. The low-pass filters in the vertical detail channel (Fig. 2) contribute similar clock and noise rejec-

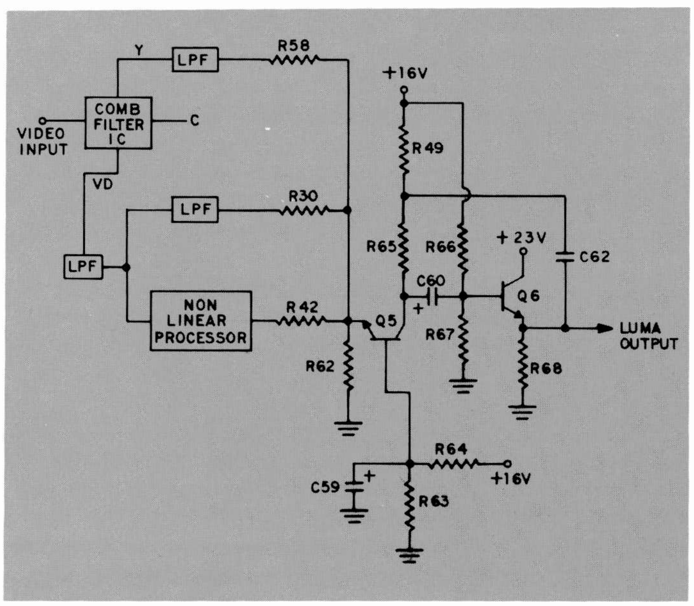


Fig. 8. Luminance amplifier.

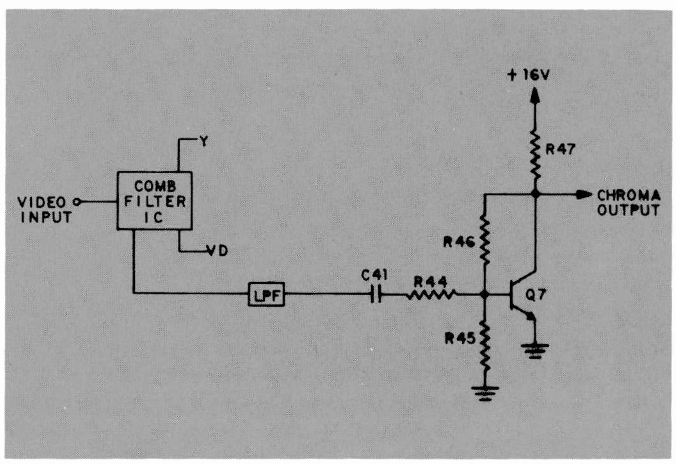


Fig. 9. Chroma amplifier.

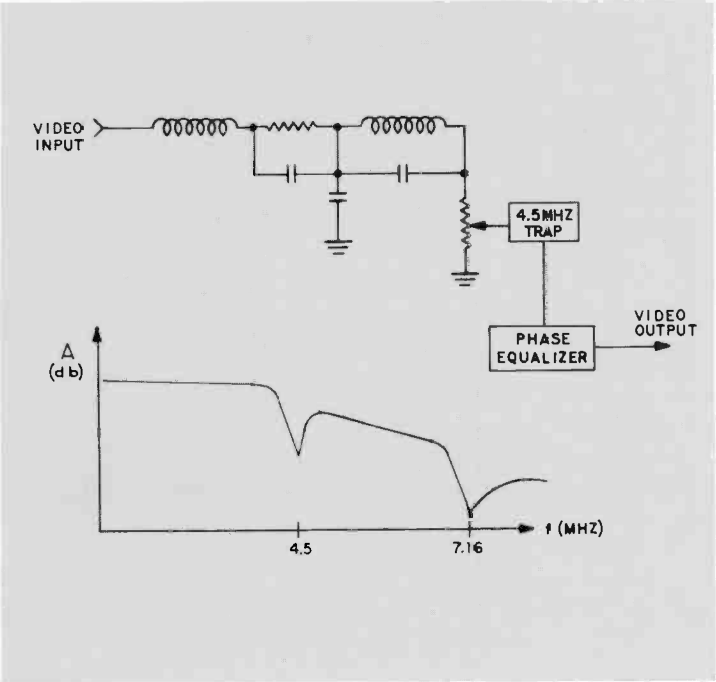


Fig. 10. Aliasing filter.

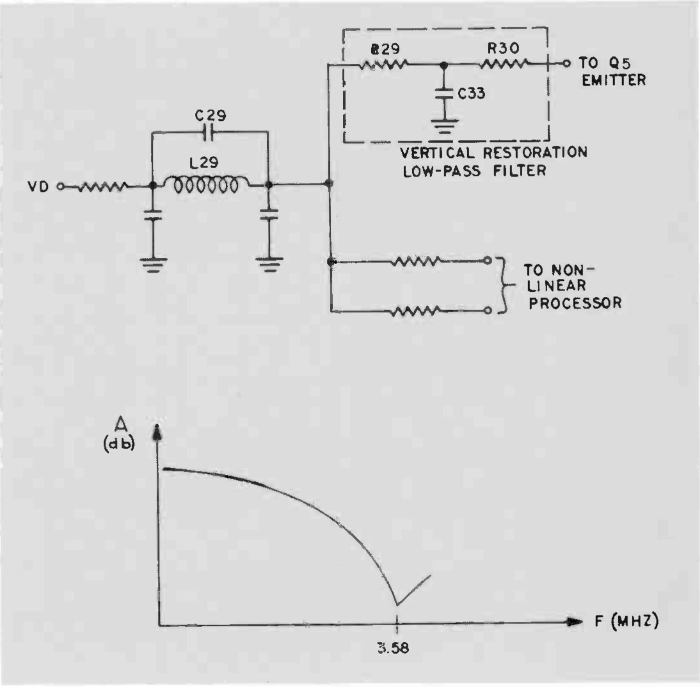


Fig. 11. Vertical detail filters.

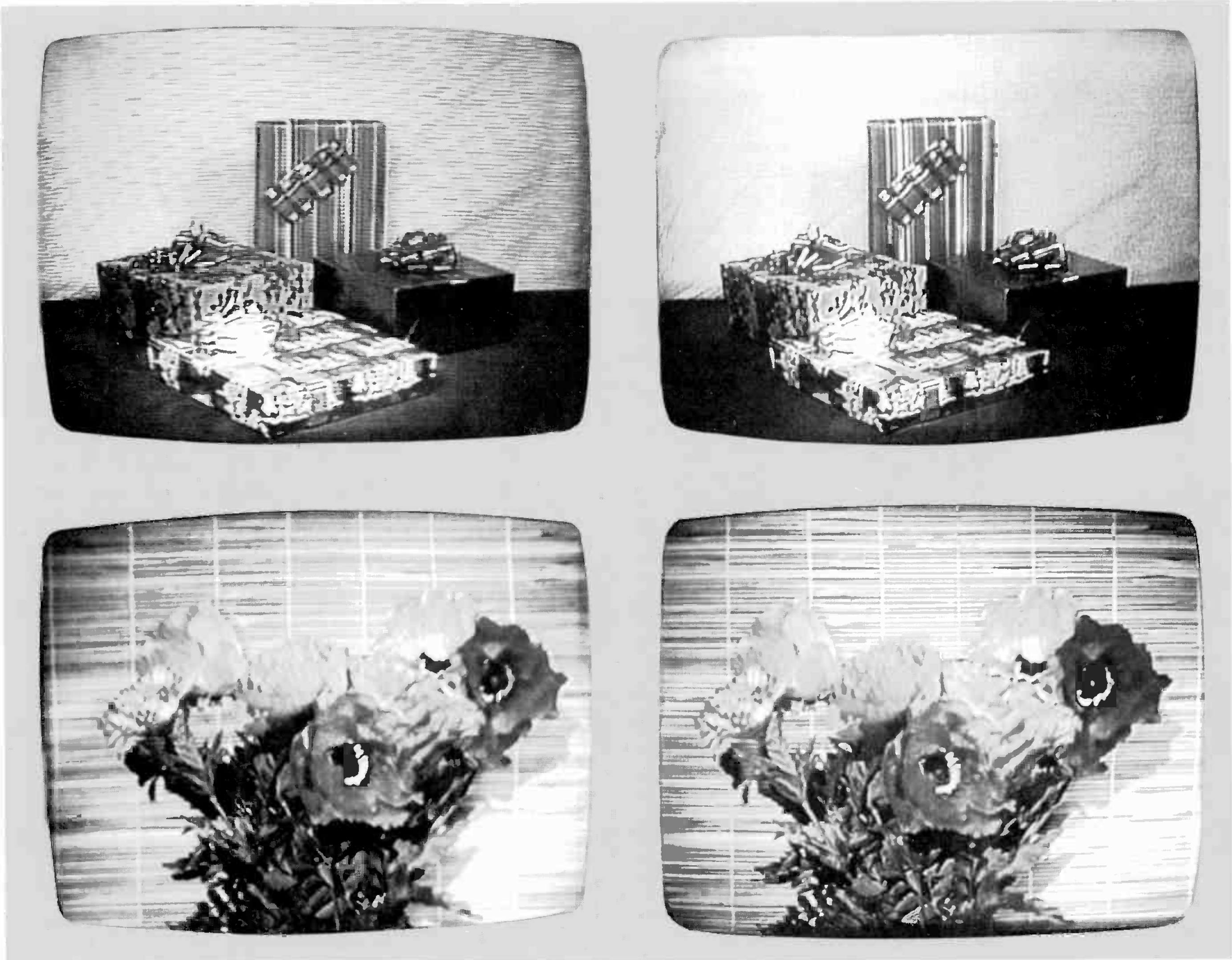


Fig. 12. Comb filter performance.

tion. They also play a key role in the optimization of vertical restoration and vertical enhancement of the luminance signal. The primary vertical detail filter, as shown in Fig. 11, is placed in both the vertical restoration and vertical enhancement paths.

Included in this filter response is a rejection trap at 3.58 MHz which is determined by the parallel resonance of L29 and C29. As the vertical detail information is derived from the low frequency portion of the chroma comb filter characteristic, it is imperative that no picture information from combed chroma around 3.58 MHz be introduced into the combed luminance signal. The bandwidth of this filter must be chosen as a compromise between the color signal rejection of the composite luminance and the picture sharpness due to vertical detail restoration and enhancement.

The restoration low-pass filter is a simple RC, included primarily to aid in matching the delays in the luminance and vertical detail paths. The vertical enhancement low-pass filter, shown in Figs. 2 and 7, is also a single-pole filter and is included to minimize the effects of harmonic distortion components created by the non-linear processor.

System performance

The television receiver employing this comb filter system produces a markedly sharper picture than conventionally designed receivers due to the wider luminance bandwidth, the enhancement of vertical transitions and the freedom from cross-color and chroma dot pattern visibility.

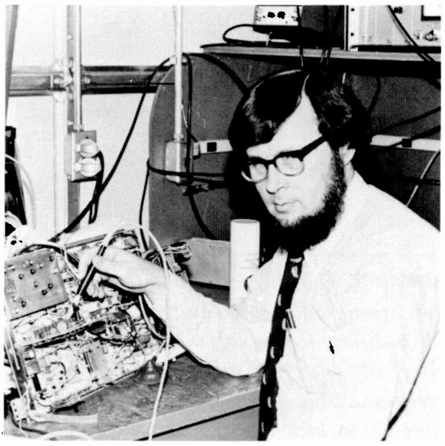
Due to the special purpose CCD comb filter IC, this system performance is obtained using only one comb filter related adjustment and is inherently stable and free from excessive environmentally related effects such as temperature, aging, and humidity.

The photographs in Fig. 12 show a comparison between pictures from a high quality conventionally designed receiver and the receiver employing this base-band comb filter and vertical aperture enhancement. The lack of edge dots and cross color in the upper right photograph is a clear testament to the effectiveness of the comb filter at separation of luminance and chrominance signals. The sharpness and clarity of the horizontal stripes in the bamboo curtain in the lower right photograph demonstrate the vertical enhancement which can be accomplished only through the use of a base-band comb filter. The detail visible in the flowers and leaves in the lower right photograph is realized by the optimal video system resolution of 330 lines combined with the vertical enhancement system.

The sharpness and freedom from undesirable responses, as shown in these photographs, are the key to a new dimension of television picture performance obtainable through use of base-band comb filters.

Acknowledgments

Although all the people who contributed to the success of this comb filter project are too numerous to mention, recognition must be made of the contributions of D.H. Pritchard whose research work at Princeton Laboratories and advice and assistance in the product design were essential. Special comment must be made of the RFI and layout design as well as the assistance in testing contributed by G.E. Thornberry.



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A chroma-luma IC for NTSC color TV receivers

A simple IC performs the essential baseband processing functions for color television.

Abstract: *The chroma-luna IC decodes the chrominance signal and produces three color-difference signals which combine internally with luminance to develop red, green and blue output signals. Automatic controls include two-threshold chroma overload loop, dynamic flesh correction and a black level clamp. Viewer controls are tint, saturation, picture and brightness. A beam limiter with dual operating modes controls picture tube average beam current. This IC increases the level of integration and helps reduce the number of discrete parts in a television receiver. It is the result of a team effort by Princeton Laboratories and Consumer Electronics.*

Introduction

In the past decade color TV receivers have matured as a consequence of an intensive engineering effort. Today's receiver may be the best bargain available — its price remains essentially the same as a decade ago, but its performance and reliability are substantially better. There have been improvements in all sections of the receiver, which have resulted in better picture quality,[2] less energy consumption, simplified operation, and reduced weight.

In this article, we will discuss a chrominance-luminance integrated circuit (chroma-luma IC) that significantly improves TV performance.

Ten years ago, many color TV receivers still used vacuum tubes, since it was too costly to transistorize them. Integrated circuits were first used in sound IF detectors, however, introduction was difficult due to power supply and vacuum tube interface problems.

In 1969, a major breakthrough occurred with the introduction of RCA's Solid State Color Receiver which employed 5 ICs. Those ICs were used in PIX-IF, AFT, sound detection, and chroma processing and demodulation. Although only marginal performance improvement resulted from this, and a substantial number of external components was still required, it was immediately apparent that ICs were the key element for batch manufacturing of pretested major functions for a color TV receiver. Improvements in performance and reliability, introduction of new features, and simplification of manufacturing were the major goals in subsequent designs.

In the chroma-luma section of the receiver, improvements were made in color signal synchronization, automation of controls (to minimize the need for frequent adjustments of saturation and tint) and automatic black level.

To reduce the number of components (ICs and discrete) and testing time, the ICs for chroma processing and demodulation were combined on one chip.[1] This simplified manufacturing and resulted in better performance since there were no chip interface problems.

Similar considerations led to the newly-developed chroma-luma IC. It contains all functions available in the one-chip chroma and the essential luminance functions. Briefly, this IC decodes the chrominance signal and produces three color-difference signals, which combine internally with the luminance to develop the R, G, and B signals. The chrominance signal is gain-controlled by an automatic chroma control (ACC) and overload detector and by a customer-operated saturation control. A separate control tracks the gain of the luma and chroma amplifiers and serves as a customer-operated picture control. The viewer sets the hue by means of a tint control, and the automatic dynamic flesh-correction circuit maintains proper flesh colors with minimal effect on the three primary colors.

The luminance peak-to-peak level is set by the previously-described picture control and a comparator circuit sets the black to a level set by a viewer-operated brightness control. Picture and brightness levels are also controlled by an automatic beam limiter. A signal derived from the kine beam current first reduces the picture amplitude to a predetermined level and then controls the brightness to prevent excessive drive to the kine.

The composite video signal is gated by a clamp circuit during the horizontal and vertical retrace intervals to keep unwanted signals from appearing on the screen. An externally generated sand castle signal provides the timing for the burst gating and blanking signals. A summary of typical performance characteristics is shown in Table I.

Major functions and signal flow

The block diagram of the chroma-luma IC and its external components is shown in Fig. 1. The chip was designed to maintain the performance and economy of the currently employed one-chip chroma, but luminance functions were added to provide an IC with complete video processing.

Reprint RE-25-6-5
Final manuscript received Jan. 17, 1980.

Table I. Survey of IC performance characteristics.

IC package	28 terminal dip
Chip area	15250 square mils
Approx. number of IC components	490
Nominal supply	11.2V
Nominal dissipation	500 mW
Oscillator stability	
Supply variation 10-14V	5 Hz typical
Temperature variation $\Delta T = 50°C$	25 Hz typical
AFPC characteristics	
DC loop gain	33 Hz/deg. typical
Pull-in range	±500 Hz typical
ACC characteristics	
100% chroma input level	250 mVpp on red bar
3 db point	@ 20% nom. input-level
Hue-control range	100 ° typical
Saturation control range	40dB min.
Overload Control	Dual level threshold
Demodulator characteristics	
R-Y	1 x @ 93°
B-Y	1.2 x @ 2°
G-Y	.3 x @ 258°
Bandwidth (chroma)	900 kHz typical
Flesh control	Restricted to signals in the + *I* half plane
Chroma overload control	2 level
Picture control range	50 dB min.
Brightness control range	Black level clamped 3-5 V level
Beam limiting	Picture limiting followed by brightness limiting
Luma bandwidth	5 MHz min.
Sand castle input	
2.2 V to 3.5 V	Blanking
≥ 4.1 V	Burst gate
R max linear output	5 V
G	3 V
B	3.7 V

The chrominance and luminance signals, derived from the composite video signal at the second detector, are applied to terminals 3 and 27, respectively. Both signals must be filtered and the luminance signal delayed with respect to the chrominance signal.

The composite chrominance signal is amplified in the first chroma amplifier, and a servo loop maintains an essentially constant burst output level. Upon amplification, the burst and chrominance signals are separated for further processing.

The burst signal is applied to two synchronous detectors. An in-phase detector, automatic chroma control (ACC), produces an error signal that controls the gain of the first chroma amplifier and maintains an essentially constant burst output level. The detected burst signal from the ACC detector passes through a sample-and-hold stage,[2] which improves the efficiency and dc stability of the servo loop.

The chrominance signal is applied to a second chroma amplifier and sent to terminal 1. Four controls regulate the gain of this stage: a killer stage amplifies the detected and filtered burst signal, as explained above, and in presence of a burst signal, it enables the second chroma amplifier. An RC filter on terminal 4 stabilizes the killer action. The viewer's saturation control, connected to terminal 2, allows adjustment of the saturation level. A picture control at terminal 26, also controlled by the viewer, operates on the luminance and second chroma amplifiers and maintains a constant chrominance-to-luminance ratio. An overload detector monitors the peak chrominance level. In the presence of excessive chrominance or noise signals, the detected and filtered signal (terminal 4) operates on the second chroma amplifier to prevent oversaturation of the picture tube. The viewer can select two possible modes of operation with a switch on terminal 16. In one mode, the detector reduces the gain of the second chroma amplifier in presence of large noise peaks only. Thus, the operation of this stage remains essentially linear. In the second mode, the average chrominance level is kept relatively constant, which reduces the need for frequent adjustments. This problem results from variations in burst-to-chroma level, which arises when the channel is switched or the program changes.

The burst signal also synchronizes the subcarrier generator. A doubly balanced phase detector (automatic frequency and phase control (AFPC)) compares the instantaneous phase of the burst and subcarrier signals. The detected error is gated by a sample-and-hold circuit, filtered by an external network on terminals 9 and 10, and applied to a voltage-controlled oscillator (VCO). Two orthogonal carrier signals are generated in this stage. The VCO output signal, on terminal 13, passes through a crystal filter and is applied to the VCO input terminal 11. An external phase-shift network connected bwtween terminals 11 and 12 generates a component shifted 90° in phase. The two orthogonal signals provide reference signals for ACC and AFPC detectors and the hue-control circuit.

In the hue circuit the two carriers are matrixed to generate a resultant carrier oriented in the *I* phase direction. A dc control at terminal 14 allows a ±50° phase adjustment from the nominal position. A dynamic flesh-correction circuit,[3] enabled by a switch on terminal 16, simplifies the hue adjustment and reduces the need for frequent adjustments. In this circuit, a detector compares the phases of the chrominance signal and the *I* phase carrier (generated in the hue circuit), and the resulting signal controls the conduction of a modulator stage. This stage passes an

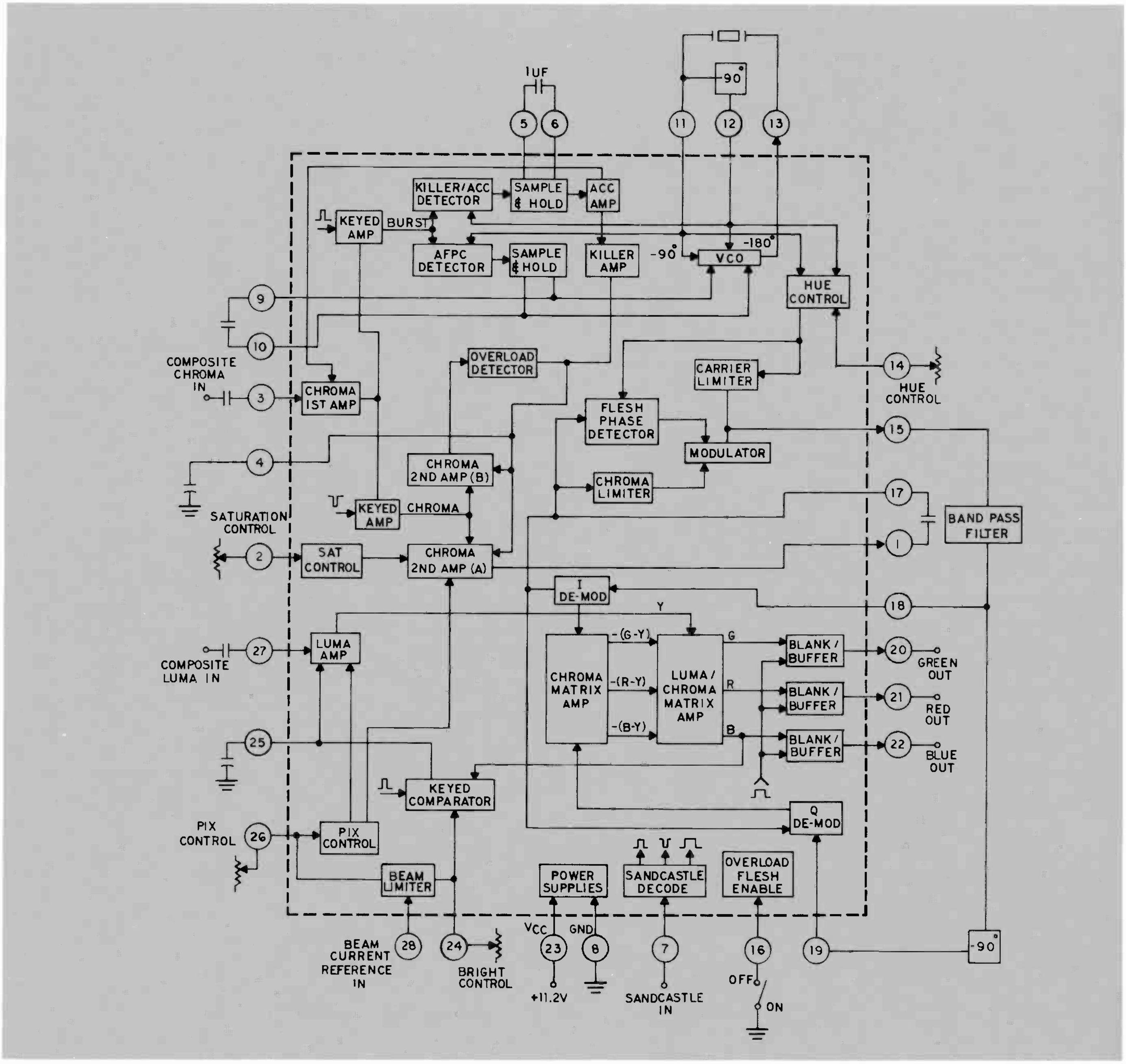


Fig. 1. This block diagram of the IC shows major functions blocks and signal flow.

amplitude-limited chrominance signal, which is added to the original carrier from the hue circuit. The resultant signal is a carrier, phase modulated by the chrominance phase, and the modulation is restricted to chrominance signals in the + *I* half-plane. This preserves the original colors in the − *I* half-plane; the signals in the + *I* half-plane are shifted towards the *I* direction.

The processed subcarrier from terminal 15 is applied to terminal 18, the carrier terminal of the *I* demodulator. A 90° phase shift network is employed to produce the correct carrier for the *Q* demodulator (terminal 19).

The *I* and *Q* demodulators decode the chrominance signal, supplied externally from terminal 1 to 17. Demodulated *I* and *Q* signal components are matrixed and amplified to produce three color-difference signals.

The luminance signal is applied to terminal 27 and its amplitude can be adjusted by the viewer (terminal 26). As previously described, this control also operates on the second chroma amplifier to maintain a constant chrominance-to-luminance ratio regardless of the position of the control. Upon amplification, the luminance and the three color-difference signals are combined in three separate matrix stages to generate R-G-B signals. The output from the B stage is used to establish a black level for the video signal. A keyed comparator is activated during the horizontal burst keying interval. This compares the backporch synchronization signal level with an externally applied dc reference and the resulting signal, filtered at terminal 25, corrects the dc level of the R, G, B output signals. Thus, the external bias reference, connected to terminal 24, establishes the picture black level and is the viewer's brightness control.

The picture and brightness controls are regulated by a beam-limiter servo loop. A signal developed from the average beam current is applied to terminal 28. If it exceeds a predetermined threshold level, a beam-limiter circuit reduces the peak-to-peak video signal. This control continues until the video signal is reduced to one half of its maximum level and subsequently reduces brightness. An overlap between the picture- and brightness-control regions secures a smooth transition of controls.

Horizontal and vertical blanking pulses gate the R-G-B signals to eliminate spurious signals during retrace from the kine. The gating is applied in the signal path between the luma-chroma matrix and the R-G-B output steps.

An externally generated sand castle signal, applied to terminal 7, provides timing for burst keying and blanking. This waveform is shown in Fig. 2.

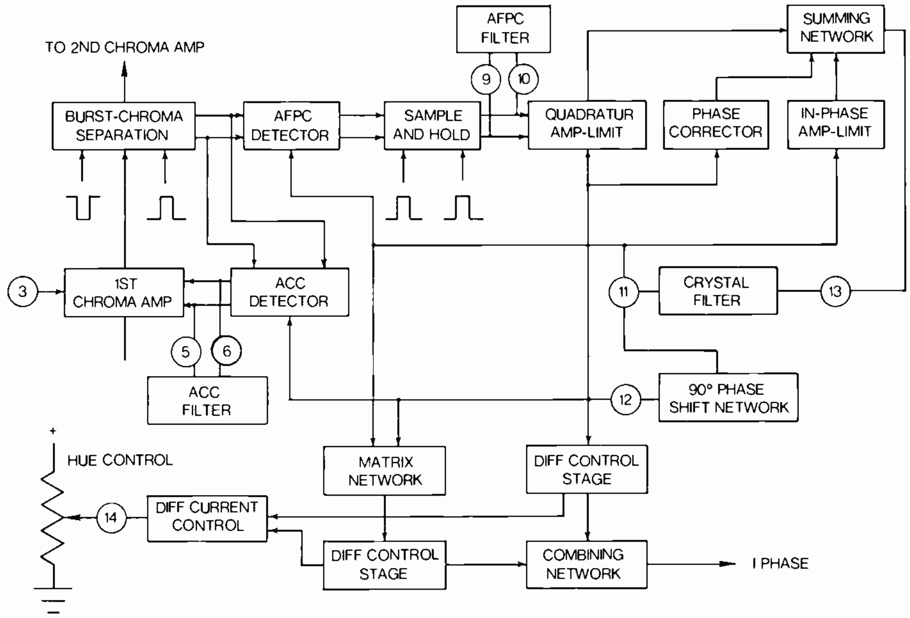


Fig. 3. This diagram shows details of chroma sub-carrier regeneration.

The chrominance section

The chrominance section of the developed chroma-luma IC provides all functions and features available in RCA's "one-chip chroma" IC (CA3151). However, some circuit changes were necessary to optimize the interface with the luminance section. The "one-chip chroma" IC has been used in RCA's TV receivers for several years and its established performance was also duplicated in the new design.

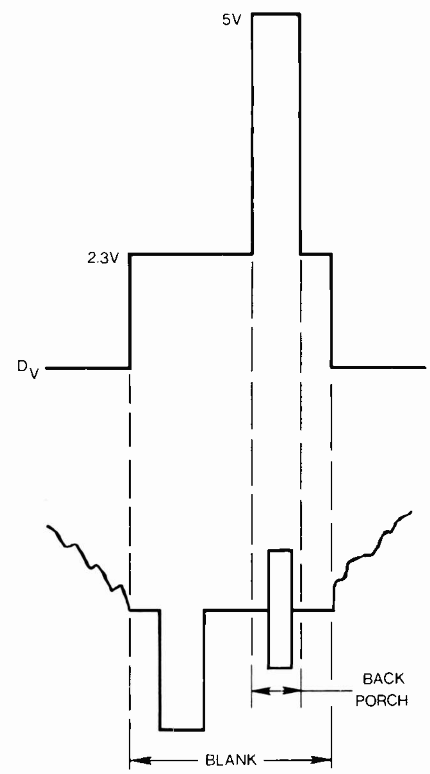


Fig. 2. The top waveform is the sandcastle signal. The lower waveform gives video signal time relationships.

The chrominance section has three major functions: subcarrier regeneration, chrominance processing, and chrominance decoding.

Subcarrier regeneration

A detailed block diagram of the subcarrier regeneration is shown in Fig. 3. The burst signal separated from the composite chrominance signal is applied to a doubly balanced detector, and the detected output is sampled during the burst keying interval and stored in filter capacitors. During the hold interval, a switch disconnects the storage filter capacitors from the detector signal path and increases the efficiency of burst detection. The balanced switching avoids such errors as leakage or beta-dependent base-current drains. The detected and filtered burst signal synchronizes a VCO. The VCO consists of an in-phase amplifier, quadrature amplifier, phase corrector, summing network, externally connected crystal filter (between terminals 11 and 13), and a 90° phase-shift network connected between terminals 11 and 12.

In conjunction with the external crystal filter, the in-phase amplifier generates a 3,579,545 Hz CW signal. This signal, phase-shifted 90°, passes through the quadrature amplifier and combines in the summing network with the signal generated by the in-phase amplifier. The quadrature amplifier, in response to the detected signal in the AFPC detector, controls the amplitude and polarity of the quadrature signal to synchronize the operation of the VCO with the burst signal. Parasitic capacitance associated with both amplifiers causes an undesired phase shift of approximately 20°, forcing the VCO to operate off design center. To compensate for this phase shift, a fraction of the quadrature carrier signal is bypassed through the phase corrector to the combining network, thus, assuring a symmetrical operation of the VCO.

The two orthogonal carrier signals also generate an *I* phase reference signal required for the operation of *I* demodulator. The signals are constructed according to the vector diagram in Fig. 4. The burst-oriented carrier passes through a control stage to produce a burst-oriented signal A. A matrix network combines the burst and (R-Y) oriented carriers to produce a signal C. Signals A and C (Fig. 3) are symmetrical with respect to the *I* signal (B vector). The viewer's hue control adds appropriate

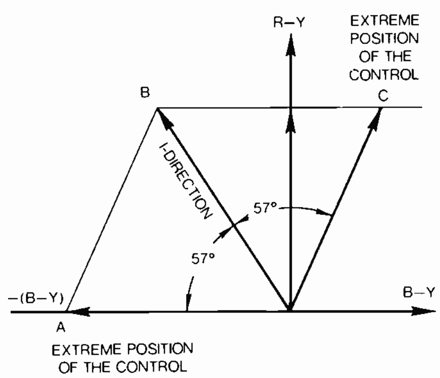


Fig. 4. The carrier for demodulation (B) is a vector sum of two signals (A and C). The tint control adjusts the phase of B between A and C.

fractions of both signals for a continuous phase adjustment from extreme A to extreme C. The control characteristic is shown in Fig. 5.

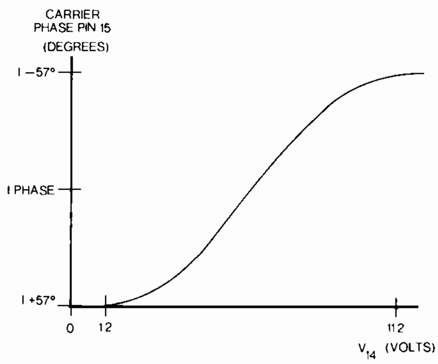


Fig. 5. Tint control characteristic.

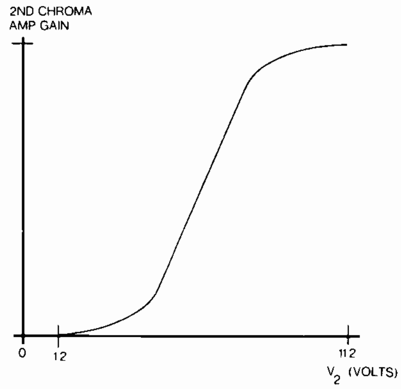


Fig. 6. Saturation control characteristic.

Chrominance processing

Two chrominance amplifiers control the amplitude of the color signal. The first amplifier is controlled by the ACC servo loop and maintains a substantially constant burst level. This amplifier is gated by horizontal keying pulses that separate the burst and chrominance information. The separated burst signal is applied to the AFPC detector to synchronize the VCO and to the ACC detector to control the gain of the first chrominance amplifier and to produce a signal for the killer amplifier. In the absence of color information and for burst signals not exceeding a predetermined level, the killer amplifier disables the second stage.

The second amplifier, driven by the chrominance signal separated from the burst signal in the first stage, is gain controlled by three separate inputs: a viewer-operated control for luminance and chrominance, a manual saturation control that provides gain reduction within a 40 dB range, and a dual threshold-level overload detector. The gain characteristic of the saturation control is shown on Fig. 6.

The operation of the dynamic flesh correction circuit is illustrated in Fig. 7. The chrominance signal is phase shifted towards + *I* direction. However, in actuality, it is the phase of the subcarrier that is altered. The action of the dynamic flesh correction circuit can be summarized as follows:

1. The phase of the subcarrier is unaffected by a + *I* phase-oriented chrominance signal and by chrominance signals with − *I* components.
2. In the presence of chrominance signals containing + *I* signal components, the original phase angle between the chrominance and the + *I* reference carrier is reduced. This phase shift is largest for chrominance signals corresponding to purple and yellow-green, and the shift is toward flesh colors. Primary colors (red, blue, and green) are essentially unaffected by the correction circuit.

Color signal demodulation

Two doubly balanced demodulators generate *I* and *Q* signals. Demodulation along these axes simplified the design of the dynamic flesh correction. The demodulated signals are matrixed to generate color-difference signals suitable for combining with the luminance signal. In a dc-coupled system, such as this one, the potentials at the output stages that drive the kine driver and the picture tube directly must be predictable. Undesired voltage offsets may result from excessive gain and a multiplicity of coupled stages. The matrix circuit employed in this IC is designed to minimize offset errors. Appropriate fractions of the *I* signal and fractions of the *Q* signal are combined in differential stages to produce the B-Y, G-Y and R-Y signals, respectively. Fluctuations in the dividers may affect the accuracy of demodulated signals, but will not introduce dc errors. Upon filtering, the three color difference signals are combined with the luminance signals in three separate amplifiers to produce R, G, B signals.

Luminance channel

The luminance channel consists of a video amplifier with viewer picture control, a summing amplifier that combines luminance and color difference signals to form R, G, B outputs, horizontal and vertical retrace blanking, and a blanking level clamp with associated brightness control. The gain control provides proportional adjustment of gain of both the chroma and luma channels. Retrace blanking operates on R, G, and B signals so that undesired or spurious signals from both the luma and chroma channels are removed from the output signals. The blanking level clamp operates in a sample-and-hold mode. Sampling is keyed during burst time, and the hold capacitor is driven by push/pull current sources.

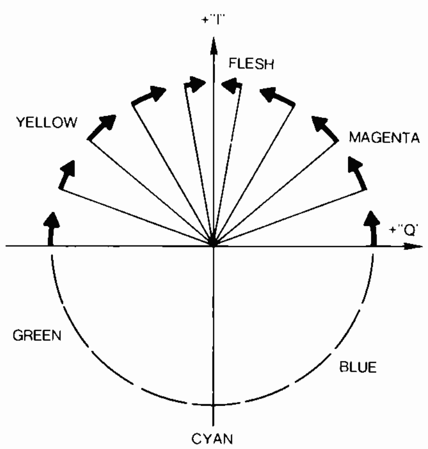


Fig. 7. The dynamic flesh control circuit effectively pulls chroma signals in the +I half plane toward "I" phase.

Video amplifier

Gain of the video amplifier is adjusted by the viewer with the picture control. One current source drives the video amplifier and a tracking current source drives the second chrominance amplifier. As the viewer adjusts the picture, the gains of the video amplifier and of the cascade chroma amplifier vary proportionally. Thus, the viewer does not have to readjust the color level after adjusting the picture. The picture control varies amplifier gain linearly with terminal 26 voltage.

Summing amplifiers

The amplified video signal is coupled to one output of each of the summing amplifiers. The other input of each summing amplifier is driven by one of the three color-difference signals from the chroma matrix. We will consider only the blue amplifier. The red and green summing amplifiers operate in identical manner.

The blue amplifier is differential. The noninverting input is driven by the luminance signal, Y, which is poled with the black portion of the grey scale negative with respect to the white. The inverting input receives the chrominance signal, Y-B, which is poled with increasing blue drive negative with respect to low blue drive. The recovered output signal is taken single-ended and coupled to a buffer. This forms the blue output at terminal 22.

Blanking circuit

When the blue signal contains synchronization and blanking information, synchronous with the retrace interval of deflection circuits, the blanking voltage is coupled to the blue output. The blue signal and any associated spurious noise signals are blanked from the IC output. This voltage is sufficient to drive the receiver kinescope into remote cutoff.

Blanking level clamp

A closed control loop clamps the signal blanking level at the R, G and B outputs to a reference voltage. The reference is developed outside the IC in the brightness-control circuit. The viewer adjustment of the reference varies the potential of blanking level.

The blue signal is used prior to the blanking function. The signal blanking interval is used to represent the potential of black level. A comparator considers only the black level as represented by the back porch of the horizontal blanking interval of the blue signal. The collector of the video amplifier is biased to determine the dc component of the luminance signal.

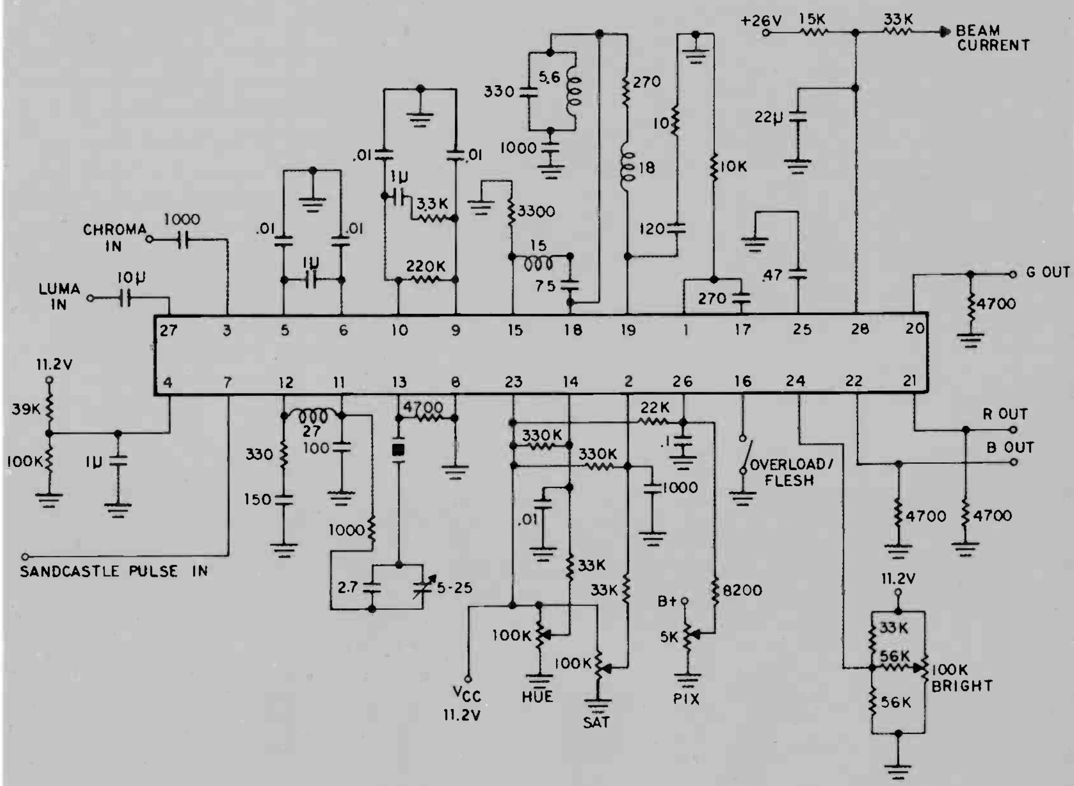
The green and red output potentials are also controlled by virtue of matching circuitry. Hence, the potential of black level of all three output signals are essentially equal to the reference established by the brightness control. It should be noted that there is essentially zero offset between the reference (brightness control at terminal 24) and the potential of blanking level of the blue output under balanced conditions.

Beam limiter

The beam limiter circuit prevents the kinescope average electron beam current from exceeding a predetermined level. Limiting action distorts video information, so it is important to minimize its perceptibility. The beam limiter characteristic is shown in Fig. 8. The onset of limiting occurs in region 1 as the voltage decreases in response to excessive beam current. In region 1, the picture control

Application Notes

External circuits to the IC, as used in the CTC 108 receiver, are shown in the following illustration.



The chroma luma IC is used in the CTC 108 receiver.

The IC is designed to accept a chrominance input (at IC pin 3) of 125 mVppfor a 40 IRE signal. Variations in this level will result in corresponding variation in relative kill point from its nominal -26 dB level. The chrominance is IF tilt compensated before input to the IC.

A luminance input of 250 mV (BLK to WHT) for 100 IRE step at IC pin 27 is sufficient to guarantee 3 Vpp luminance out. Video peaking is done before luma is applied to the IC.

The sandcastle pulse applied to pin 7 of the IC serves to establish dc operating potentials within the IC during the narrower portion of the waveform. It is best generated by a means independent of incoming signal strength in order to permit the IC to operate optimally for all luma and chroma input signal conditions.

Pin 28 of the IC receives the beam current error signal which can be generated by passing the beam current through a resistor chosen to produce a voltage equal to B+ at the limiter threshold required by the specific application.

Design of the IC permits operation with a customer control configuration which minimizes the number of leads to the front panel as well as the number of components at the front panel.

The black level at the blue output is held equal to the brightness control voltage at pin 24, permitting good control over brightness range.

Tint and Color level are permitted to swing from 1.2V to *Vcc*.

Picture control has good linearity with its end points fixed by two diode drops at the low end and *Vcc* at the high end. This permits accurate prediction of the range of contrast by the relation:

$$\text{Contrast range} = \frac{Vcc - 2\phi}{QVcc + 2\phi}$$

where ϕ is the diode drop and Q is a fraction of *Vcc* at minimum contrast.

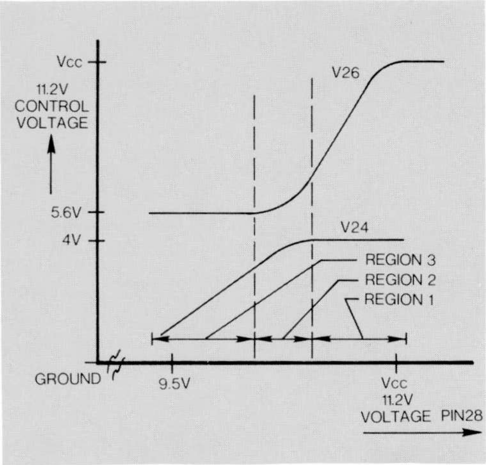


Fig. 8. Beam Limiter operation is primarily in region 1. Severe limiting occurs in region 3.

voltage (V 26) is lowered. This results in a corresponding decrease in picture amplitude (contrast). As explained, the gain of both the luminance and chrominance channels decrease proportionately while the clamp maintains picture black level at the potential of the brightness control. Further decrease in the voltage causes limiting to occur in region 2. Here, limiting action at the picture control decreases and brightness control limiting action begins. This corresponds to a decrease in picture black level. Still lower voltages, corresponding to strong limiting, cause operation in region 3 where the brightness control voltage is lowered and essentially no action occurs at the picture control.

Most limiting takes place in region 1. Picture limiting was chosen because the viewer is relatively insensitive to changes in picture level (i.e., contrast). To avoid low-contrast ("washed out") pictures, the limiter can only reduce gain to half of maximum. When strong limiting is needed, a smooth transition to brightness limiting is made.

References

1. L.A. Harwood, "An Integrated One-Chip Processor For Color TV Receivers," *IEEE Trans. Consumer Electronics*, Vol. CE-23, No. 3 (Aug. 1977).
2. L.A. Harwood, "A New Chroma Processing IC Using Sample-and-Hold Techniques," *IEEE Trans. Broadcast and TV Receivers*, Vol. BTR-19, No. 2 (May, 1973).
3. L.A. Harwood, "A Chrominance Demodulator IC with Dynamic Flesh Correction," *IEEE Trans. Consumer Electronics*, Vol. CE-22, No. 1 (Feb. 1976).

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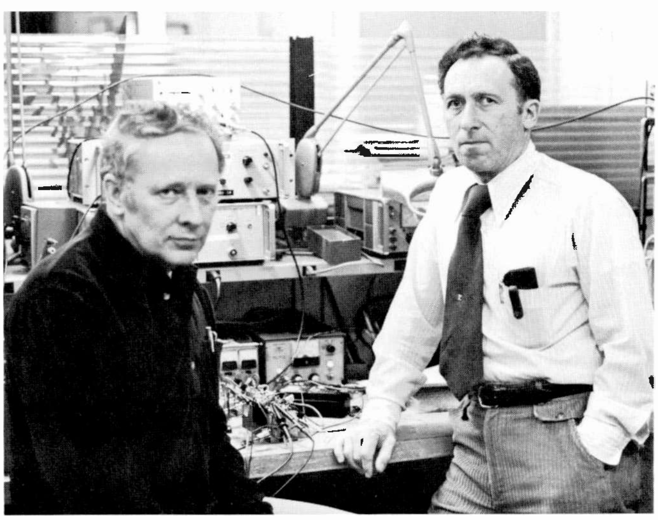

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W. Austin

Integrated circuit contributions to color TV receivers

Each new color-receiver design cycle offers a new opportunity and challenge that is now commonly based on the development of new integrated circuits.

Abstract: *The evolution of color TV IC designs is discussed from the inception to the present. The latest designs in chroma, PIX-IF, sound, horizontal and vertical deflection, and tuner and control circuits are also described. Design trends for the future are outlined.*

Trends in color-TV receiver design were not significantly affected by the transition from electron-tube to transistor circuits. For the most part, transistor designs were transitions from tube circuits to equivalent functional circuits in hybrid designs. Following the introduction of integrated circuits, however, rapid advances in solid-state technology have resulted in enhanced performance and significant contributions to the viewing qualities of color TV.

Early IC designs were simple by present standards, and made use of linear monolithic chips with areas in the order of 2500 square mils. Improvements in process control and design techniques were incorporated in a second generation of circuits with areas in the order of 5000 square mils. Where early circuits were limited to TO-5 packages with few leads, improved plastic packages soon sparked a rapid change to 14- and 16-pin dual-in-line plastic (DIP) packages. The increased number of terminals permitted the inclusion of more functional capability on a single chip. The scale of level of integration has now advanced to the point where there is a common need for a 24-pin package and larger DIP plastic packages, although the 16-pin DIP is still commonly used. The competitive nature of consumer applications has always required maximum pin utilization to maximize performance in all new designs.

Early ICs such as the CA3014, made by means of standard linear monolithic-IC process techniques, were produced with aluminum metal on wafers constructed with seven to nine mask levels. The state-of-the art in IC design and process capability has rapidly advanced: multiple technologies requiring different fabrication processes are intermixed in the fabrication of a monolithic chip, and, in some cases, the number of mask levels may reach 16. The BiMos and I^2L technologies have now been added to the design capability list for new linear-IC designs. Improvements in diffusion control along with the ion implant capability make available a wide range of component design tools that can be used to improve and optimize older designs and to aid the development of new circuits. The chip area of many ICs in current TV use exceeds 10,000 square mils. While not large by large-scale-integration (LSI) standards, this is a significantly large-scale area for the number of mask levels required to produce these circuits.

The level of increased integration in linear consumer-IC devices is controlled by many factors. Those listed below, by order of importance, will indicate to anyone familiar with the LSI market that LSI requirements for consumer linear ICs differ from LSI goals in other markets. Consumers LSI requirements include:

1. The rate of design growth directed by market demand for performance;
2. The extent of the total system to be integrated.
3. The collective grouping of compatible functions.
4. Package requirements to meet electrical performance and reliability goals.
5. Practical cost limitations for the process, material and fabrication.
6. The time cycle to establish proven reliability in a new design.

While reference is commonly made to the LSI achievements of more integration per chip area, this is not the ultimate goal of LSI. A larger, more highly sophisticated IC replacing other circuits must still meet cost and performance guidelines. As such, the primary goals for each new generation or design must stress performance and reliability with only secondary emphasis on advancement of the level of integration. This perspective has been particularly true in the case of the performance goals for RF and IF integrated circuits, where the package is a limiting factor in determining gain and stability criteria. The package is also a major limiting factor for high-temperature, power ICs.

Reprint RE-25-6-6
Final manuscript received Feb. 21, 1980.

Design evolution

The initial introduction of the CA3014 sound-IF IC was immediately recognized as an epoch event in new television circuits. The CA3034 automatic fine tuning (AFT) IC closely followed the CA3014. The CA3014, as a single-chip sound-IF amplifier and detector, replaced two electron-tube stages of sound-IF amplifiers plus a pentagrid tube, a portion of a quadrature detector, and provided a substantial cost reduction with a performance improvement in the sound-IF limiter circuit. The AFT circuit, the CA3034, was a new AFC performance feature used to correct for tuner local-oscillator drift problems. With the addition of the AFT circuit, the viewer could change channels without having to make the frequently needed fine tuning adjustment.[1] The CA3014 and CA3034 marked the beginning of several performance improvements economically achieved through the introduction of ICs.

An outstanding example of IC designs that have advanced the state-of-art is noted in the progression of chroma and luminance-IC design changes. Figure 1 illustrates a progression of changes in circuits that, for each change, incorporated new features with much improved performance. In finished products, the new IC design achievements made possible the features of the ColorTrak system.[2, 3, 4, 5] But as the figure shows, this progression of features through design innovation does not stop with the CA3151G and CA3144G ColorTrak chroma and luma* circuits. The next logical step was to totally integrate the chroma and luma sections of the TV receiver. This integration has been effectively accomplished in a developmental circuit now available for PAL chroma/luma applications.

	Chroma Processor	Chroma Demodulator	Luminance Processor
First Generation	CA3066 · Chroma Bandpass Amp. · Subcarrier Osc. · DC Chroma Control · ACC and Killer	CA3067 · DC Tint Control Circuit · R-Y,B-Y Demod. & G-Y Matrix · Buffer Amplifiers for Flexible Use of IC	Discrete Transistors
Second Generation	CA3126 · PLL Osc./Chroma Amp. · New Sample & Hold APC/ACC · Linear DC Gain Control · Overload Det. Added · Chroma Burst Gating Improved	CA3067	Discrete Transistors
Third Generation ("ColorTrak")	CA3126	CA3137 · Flesh Control Circuit Added · I & Q Demodulator Circuits · Improved DC Tint Control	CA3143 · DC Brightness, Contrast & Peaking Cont. · Keyed Black Level Clamping · Vert. and Horiz. Blanking · Transversal Filter Peaking System
Fourth Generation	CA3151G All features of the CA3126 and the CA3137 were incorporated on a single chip and packaged in a 24-pin dual-in-line plastic package.		CA3144G Same as the CA3143 except reverse phase video output.
Fifth Generation	The TA10313 PAL Chroma/Luma development circuit is now available. (NTSC circuit is in development.)		

Fig. 1. Progression of changes in ICs used in color-TV receivers.

Figure 2 shows the totality of functions integrated on the TA10313 in block diagram form. No significant compromises were required to achieve this complete integration of the PAL chroma/luma system. In addition, average and peak beam-limiter circuits were added to control both contrast and brightness by sampling the current and voltage drive to the picture tube.

The features of the TA10313 were primarily limited by the number of terminals available in the 24-pin DIP package. Because the tint-control function is not a requirement in the PAL system, 24 pins were sufficient. However, to achieve the same features in a one-chip chroma/luma circuit for the NTSC system which does require additional terminals for the tint function, more pins are needed. A 28-pin DIP package is planned for the NTSC market;[6] that package will effectively include all of the features of the CA3151G and the CA3144G.

The technical advances made in ICs for the chroma/luma area have contributed significantly to the quality of color-TV viewing. Such features as a "back-porch-keyed clamp" and flesh correction were introduced before ICs were broadly available for television. However, cost-effective use of these features, and the substantial circuit improvements required for their effective implementation were made possible only through the economy offered by the integration of such features on IC devices. For example, the TA10313 IC chip measures 106 x 124 mils and includes 433 components. The scale of integration represented by this circuit is seven times greater than that of the early chroma circuits introduced for color-TV receivers.

Gains in the component count to chip area ratio are limited by the need for larger area resistors, and in some cases larger transistors, to achieve good differential balance in cascaded gain stages. Large value resistors are also needed in bias circuits to keep dissipation within economical package ratings. The process for ion implantation of resistors has provided a major step forward in chroma design capability: the thermal B & R (base and resistor) diffusion provides a 200-ohm per square resistivity; the ion-implant resistivity is 1000 ohms per square. The resistor aspect ratio is, therefore, improved for large value resistors, and the resultant geometry provides improved tolerances in resistor ratios. In addition, improvements in process and layout techniques applied to lateral PNP transistors have increased their useful performance range. For example, the frequency, beta, and current-handling characteristics of the transistor have been improved by an order of magnitude. Both of these advances, large ion-implant resistors and improved PNP transistors, enhance future LSI circuit-design potential.

Another improvement of benefit to the color-TV consumer is circuit reliability. There has been an increasing demand from the TV-set manufacturer for increased reliability of solid-state devices to reduce rework costs on the production line and to reduce warranty costs. Beginning with the CA3151G and the CA3144G, new concepts in reliability goals for consumer circuits were introduced. Better chip protection through the use of improved passivation, improved bonding techniques, improved plastic packaging compounds and generally improved processes to reduce chip defects are among the continuing quality improvement programs.

Latest IC designs

Figure 3 illustrates the signal areas of the color TV receiver now integrated.

*Luminance circuits are frequently called "luma" circuits.

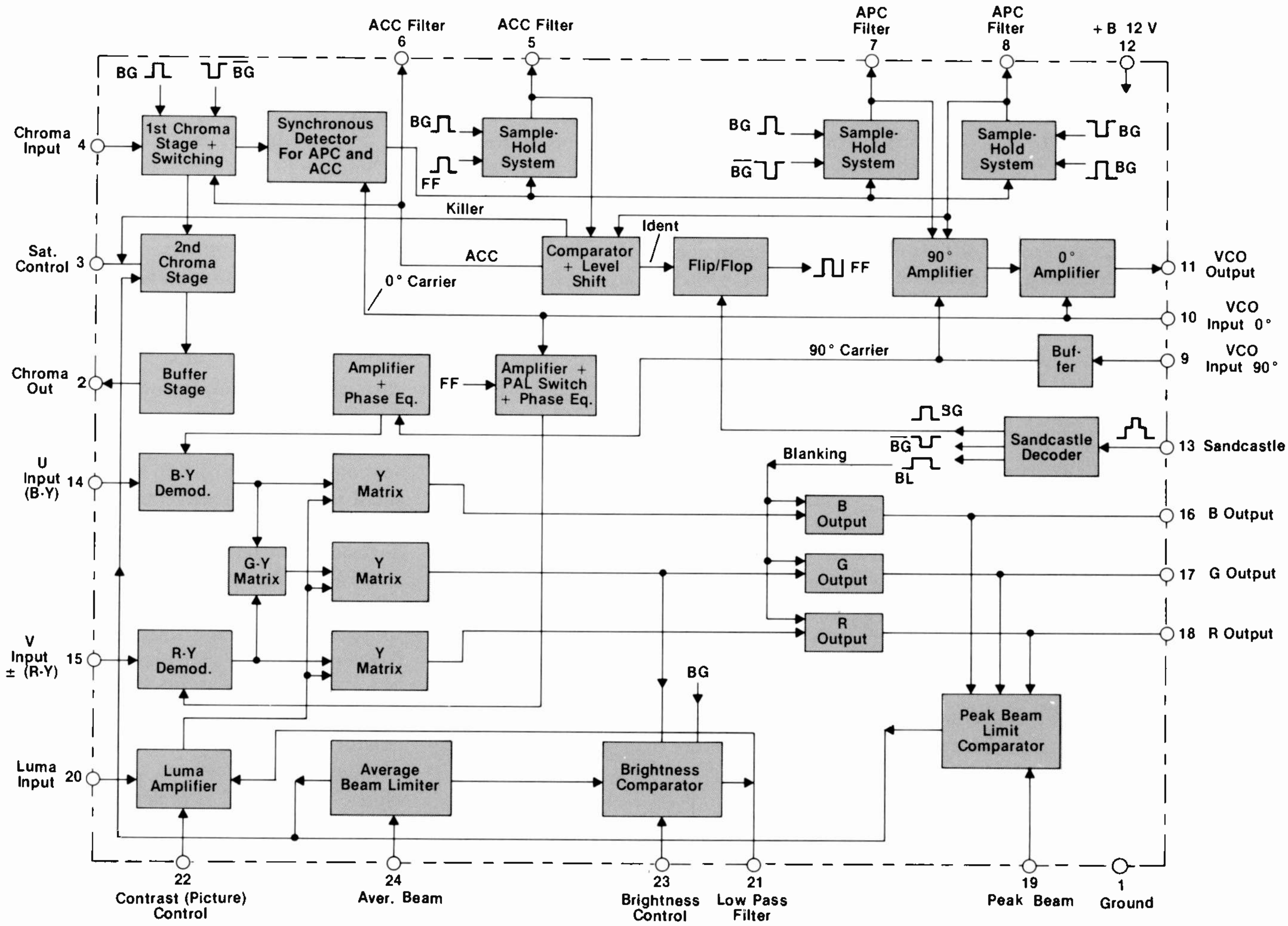


Fig. 2. One-chip luma/chroma processor.

Functional partitioning of the sync and AGC circuits remains controversial, with differences related to designer preference. Integrated circuits for all of the functions shown in Fig. 3 are identified in the following text. Because of the numerous options involved, all of the IC types available for NTSC systems are not listed; a complete listing is available in the Solid State Databook SSD-240A.

Chroma

New features have proliferated in all of the signal-processing areas of the TV receiver faster than the worldwide-industry acceptance of their use, and countries that have been slow to adopt television standards are yet to be counted. There is a continuing technical controversy regarding PAL and NTSC systems.[7] Arguments for PAL were valid because of the performance improvement potential of that system: a complex delay line was required, but it solved to some extent the phase problems that caused tint-shift errors. Advances in IC design have resulted in improvements in NTSC receiver performance which makes these arguments academic. An example of such achievement was introduced with the CCD (charge-coupled-device) system in the CTC101 chassis.

The SECAM FM approach to color decoding is substantially different from the PAL and NTSC systems, but is a factor in new-feature requirements for consumer television. In fact, in many areas of Europe, there is market demand for dual PAL/SECAM receivers. The latest circuit requirements in those areas call for automatic recognition of the signal and switching to the appropriate PAL or SECAM color decoding circuit. Work is presently being done on a new SECAM transcoder IC (the TA10461) that will provide a SECAM option with the PAL TA10313 decoder. This technique includes an automatic switch to SECAM, FM decoding, and a remodulation of the color signal in a PAL encoder. The TA10313 works as the primary decoder for direct PAL signals or SECAM signals converted to quasi-PAL in the TA10461 transcoder.

The advantage of this system approach is that the low-cost automatic option is included without changing the RGB driver interface to the picture tube; therefore, gray scale and color balance are maintained without an extra set of adjustments. The system also represents a cost-effective approach to the provision of basic SECAM decoding.

PIX-IF

Synchronous detectors for the PIX-IF (video-IF) signal were not considered practical until integrated circuits made high-gain limiter amplifiers available at a reasonable cost. This type of detector is usually cited for excellent low signal linearity, but has a problem with "whiter-than-white" pulses under noise interference conditions. Designers now tend to prefer the synchronous-detector approach, but add a peak white-noise inverter in the detected video output. Synchronous detectors have other problems, such as spurious output from the limiter circuit. In addition, there are the potential problems of sound buzz, Moire disturbances and "color firing" related to filtering requirements.[8] Nevertheless, European designers have for some time chosen synchronous detectors over envelop detectors using such circuits as the CA270 (TCA270), TDA440 and TDA2541 (these latter two are not RCA types). The latest trend is toward the use of parallel sound systems to avoid the intercarrier sound-related problems.

In the U.S., recent practices have been generally split between synchronous and modified envelop detection. Envelop detector circuits specially designed for good weak-signal linearity include the CA3153 and the CA3192. The CA3136 is a synchronous detector circuit that makes use of a phase-locked loop (PLL) to avoid the problems of carrier dropout. It appears that future designs of PIX-IF ICs will lean toward the use of synchronous detectors as solutions to the negative aspects of their use are solved through the application of the new technologies available to the IC designer. However, it should be noted that a well-designed envelope-detector IC is equivalent in performance to presently available synchronous detectors, and requires fewer external components in the TV application.

The recent announcement of the CA3191, an AGC gain-controlled PIX-IF circuit, marks a significant, new technical achievement, as it includes a PIN diode equivalent circuit component that is used to control the AGC gain reduction. Pin diodes, which have the characteristic of wide resistance variation with current bias, have been used for some time as discrete components. They have been preferred in high-frequency gain-control applications where the cost could be justified. Compromises related to the "AGC window" are greatly improved, allowing a larger signal-control range with signal-to-noise improvements.

Sound

The differences in system standards plus world market differences in acceptable power levels have left the design trend in sound circuits varied and unpredictable. The controversy over the inclusion of power amplifiers and low-power signal circuits on the same chip and in the same package remains a question of economic trade-off. The choice of parallel, quasi-parallel, or intercarrier sound systems will, no doubt, fluctuate for some time. European standards (B-PAL) call for a lower sound carrier level and a higher sound-IF carrier frequency than the U.S. standards,[9] so that the design of intercarrier sound systems must be approached with caution to avoid sound buzz problems. A continued interest in higher-quality audio has, for the most part, directed that designs remain open to new options as they become available.

Any discussion of sound ICs must include the CA3065 because of its long-term success. It has been the major sound-IF/detector circuit used in the U.S., South America and the Far East since its introduction over ten years ago. Initially introduced in color-TV receiver applications, where its use has diminished, its cost and performance advantages still make it the prime type in black-and-white receiver applications. Several million units per year have been sold for these applications. The production rate remains quite high, although the CA1190GQM and CA3134GM have now reduced their U.S. market share. Both the CA3134GM and the CA1190GQM include sound-IF amplifiers, detectors, and power amplifiers that provide more than two watts of audio-output power.

Horizontal and vertical

The horizontal and vertical circuit areas of the TV receiver were slower to be integrated. As early as 1970, a developmental IC horizontal oscillator, the TA5627, was developed, and was technically successful.[10] However, its cost was unacceptably high, particularly in relation to discrete-transistor prices, which were eroding rapidly at that time. Later, integrated RC oscillators gained in acceptance. Horizontal AFC and oscillator design approaches did not change technologically until horizontal-to-vertical countdown circuits became cost effective through the use of the integrated injection logic (I^2L) technology.

Several variations of partitioning and several different technological approaches have been applied to the horizontal and vertical circuits. These approaches include incorporation of horizontal and vertical oscillators on the same chip, the use of a 2X horizontal-oscillation frequency with I^2L countdown, synchronous switching vertical deflection (SSVD) using the horizontal system for drive, switch mode vertical deflection (SMVD), and CMOS experimental countdown circuits.

In general, the horizontal/vertical countdown-system approach appears to be preferred in new designs for the U.S. market as opposed to linear systems now using such types as the Philips TDA2593 horizontal circuit and the SGS-ATES TDA 1170 vertical circuit for the European market. The indications are that this area of design will not mature into a single system design approach for some time. The TDA2593 includes a double PLL design with a coincident detector and phase comparator that counters the common problem of RC horizontal-oscillator drift. Recent European horizontal-oscillator designs include a "sandcastle" generator that provides a two- or three-level chroma/luma blanking and gating pulse. The TDA1170 is a direct approach to linear vertical deflection and, in some product versions, provides direct yoke drive for small screen, 90° receivers.

Figure 3 illustrates a newer approach to horizontal-oscillator design that uses the CA3154 and CA3157 or CA3190 (depending on the system lines/frame rate) to provide a circuit with much greater frequency stability than previous circuits.[11] The CA3154 has a stable 504 kHz or 32X horizontal-frequency LC horizontal oscillator and AFC circuit. The 32X frequency rate has both cost and stability performance advantages. If preferred, a ceramic resonator can be used in place of the LC circuit for a hands-off prealigned system. The CA3157 and CA3190 are linear circuits that employ I^2L logic and counting circuits that divide the 32X horizontal frequency to provide the horizontal predrive pulse, vertical drive, and the vertical blanking pulse. The pulse outputs are based on precise counts of the 32X horizontal-oscillator output frequency. In addition, default mode circuits detect and determine reset requirements, detect and determine synchronous or asynchronous drive modes, and generate a direct-trigger vertical-oscillator drive in the case of nonstandard sync signals, such as those used in TV games and low-cost cameras.

The advantages offered by the countdown circuits have not been readily accepted by the world market in general, possibly for reasons other than those of a direct technical nature. For example, to accommodate functional partitioning requirements in all markets, which would mean satisfying some rapid design changes, would require a wide variety of circuits that would allow mix and match design options. However, at present only a limited number of countdown circuits are available, and a total receiver design-change cycle might be required to match one of the few circuits available with the existing receiver design.

The sandcastle function is normally

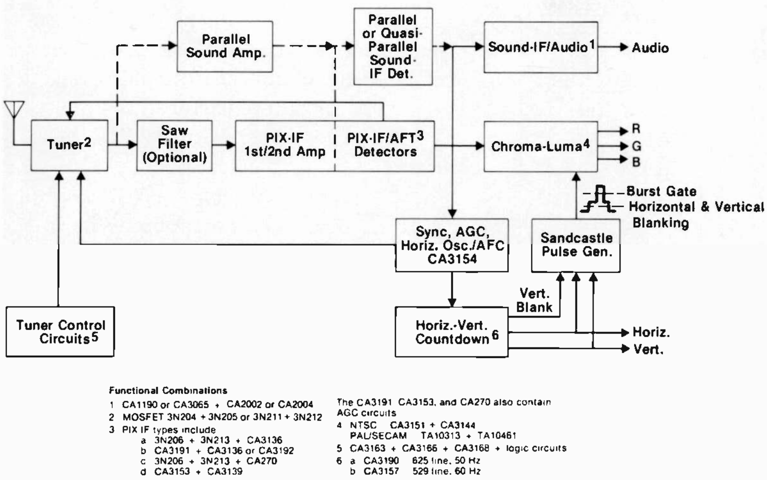


Fig. 3. Color-TV receiver IC complements for NTSC and PAL/SECAM systems.

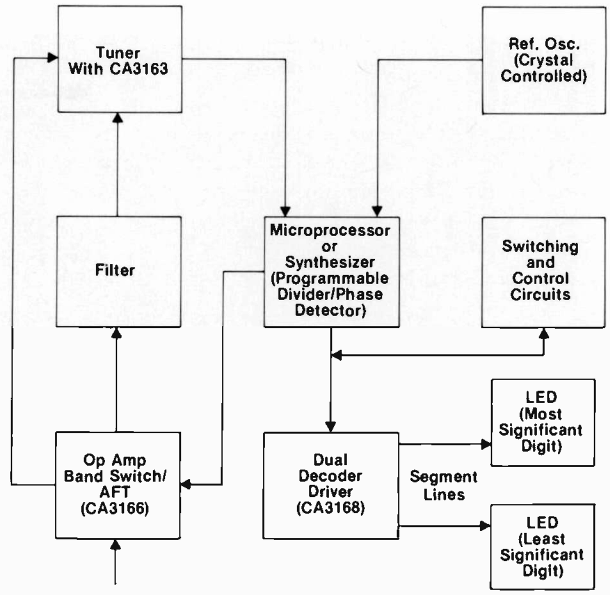


Fig. 4. Frequency synthesizer, digital tuning system.

derived from vertical and horizontal blanking pulses to provide retrace blanking and burst separation. Pedestal levels are normally low for the horizontal and vertical blanking function. The burst gate is at a higher voltage level and is used to perform the burst separation in the chroma circuit and keyed back-porch or black-level clamping in the luminance circuit. The use of the burst-gate function is a fairly common practice in Europe, but is not a standard. Becasue it is a function that can be readily designed into an IC, it is probable that this approach to blanking and gating will gain future acceptance in the U.S.

Tuner and control circuits

Attempts to integrate some functions of the UHF tuner have been made. However, the chances of achieving, through integration, an economic advantage over the dual-gate MOS (DMOS) transistors now used are unlikely. The use of ICs in the tuner would not eliminate the need for extensive trimming of the tuned circuits to align the bandpass circuits. Therefore, a tuner IC would provide only limited cost advantages in this application. The technology required to produce an IC with the frequency capability required in the VHF and UHF bands does exist. The CA3163 divide-by-64/256 prescaler was designed for use in a frequency synthesizer tuner system; the ECL process by which this device was fabricated makes it capable of a 3-gHz f_T, and permits it to operate into the low gigahertz frequency range. The CA3163 demonstrates best performance, including lowest matching losses, when located in the tuner next to the local oscillator.

Figure 4 illustrates how the CA3163 is used in a frequency-synthesizer tuning system. This system includes a programmable countdown circuit that further divides the channel frequency, which is compared to a crystal oscillator reference frequency in a phase comparator. The error signal is integrated in the CA3166 op-amp and fed to the tuner where it is used in varactor control of the local oscillator. The CA3166 also represents additional linear bipolar process capability as it combines a BiMOS op-amp, three logic-controlled bandswitch circuits, and an AFT disable switch using a CMOS transmission gate. The drive for the channel display is provided by a CA3168 dual 7-segment decoder driver. This IC is also a "mixed-technology" device, as it includes I^2L ROM decoder circuits. The advantages offered by the CA3163, CA3166 and CA3168 ICs are the result of technological achievements developed for the design of the synthesizer tuner system.[12]

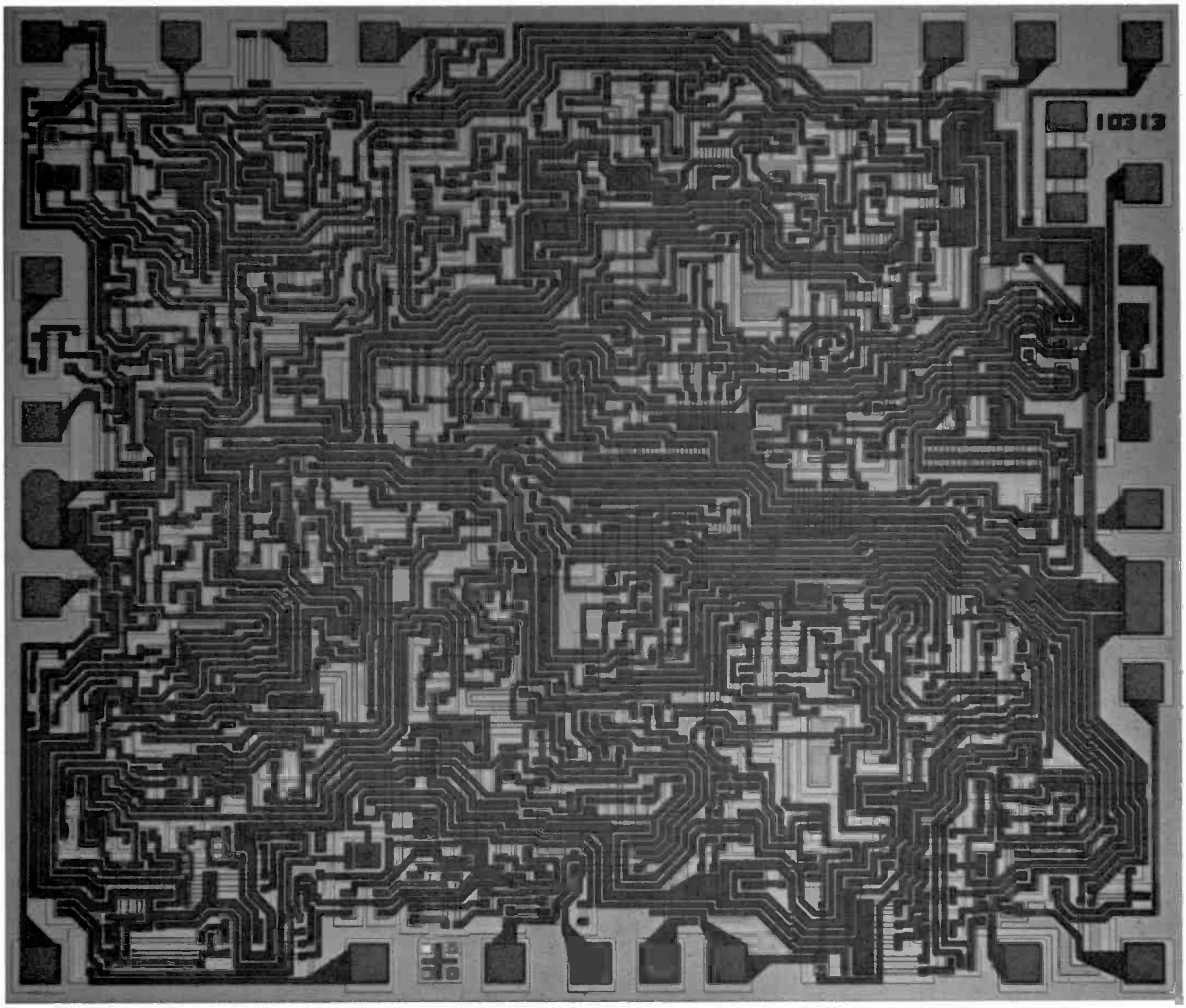
While the CA3163 is intended for use in TV-receiver circuits, it has many applications throughout the low-gigahertz frequency spectrum, i.e., up to 1.25 gHz. Of special interest are applications in the communications bands and CATV systems.

It should be noted that a frequency-synthesis system used for tuning control should not require an AFT circuit. This statement would be true in general if commercial practices did not permit deviation from the carrier frequencies. However, many closed circuit and other systems, such as CATV and games, do, indeed, frequently deviate from the standard channel frequencies by as much as 2 MHz, which is too wide a deviation to permit capture unless an AFT pull-in loop of wider range is added to the system. However, even when such a loop is present, the logic-control part of the synthesizer should be designed with a search routine to achieve the AFT lock. Otherwise, if the AFT bandwidth is greater than ±1 MHz, the AFT may tend to lock out on a carrier adjacent to the one desired.

Other tuning systems have been designed using voltage-synthesis techniques. In these types of systems the voltage needed to tune the varacter-controlled oscillator is stored in a memory as preset information. The preset mechanism may be as simple as a manual adjustment of a pot or as sophisticated as an A/D converter feeding data to a nonvolatile memory. The AFT circuit is also essential in systems of this type. For such systems, tuner interface requirements can be met by using the CA3166 and CA3168. The tuning-system designs for the European market are varied, as are the transmission systems. However, the voltage synthesizer tuning method has been generally preferred in Europe, as voltage synthesis circuits, in general, satisfy European requirements.

New design trends

From the designer's viewpoint, new features are most readily made available through new IC technology. Because of this new IC technology, long-standing practices of functional partitioning have



Fifth generation color-TV IC. The TA10313 PAL Chroma/Luma development circuit combines chroma processor, chroma demodulator, and luminance processor on one chip. An NTSC version is in development.

given way to new system techniques, such as those introduced by the CCD comb filter.[13]

The changes that have been most effective in improving receiver performance are feedback related, such as the PLL systems of the chroma, horizontal oscillator, and the tuning control systems. The combination of countdown and digital techniques has added new dimensions to overall IC design capabilities. Countdown from the horizontal to vertical frequency offers substantially improved vertical-deflection stability, and assumes hands-off operation of the vertical sync. Future possibilities include frequency countdown from chroma-to-horizontal-to-vertical.[14] Such systems have been proposed as solutions to the problem of better stability in very-large-screen systems.

Each new color-receiver design cycle offers a new opportunity and challenge that is now commonly based on the development of new ICs that coordinate the receiver design with new features and options that interface the receiver with or add to it new types of peripheral circuits or facilities. Current developments for which ICs offer both cost and performance advantages include:

- CCD comb filters/delay lines
- View data and teletex circuits
- Switching regulators
- Microprocessor controllers
- Vertical interval reference (VIR) circuits
- Picture-in-a-picture circuits[15]

It is beyond the scope of this paper to describe the potential for future growth of ICs in these particular areas. Future receiver designs may, possibly, include ghost-cancelling circuits and auto-switching circuits for the control of NTSC/PAL/SECAM standards.[16] Additionally, technological advances in the A/D and D/A area will present opportunities to overcome the current stability problems in multiple-cascaded gain stages and to improve signal linearity.

CCD comb-filter circuits will improve the picture quality of such systems by providing filter separation of the chroma and luma sidebands with little loss of picture detail while enhancing vertical detail and reducing cross-talk. Both luma and chroma delays are precisely matched by clocked delays referenced to the stability of the transmitted chroma subcarrier frequency.

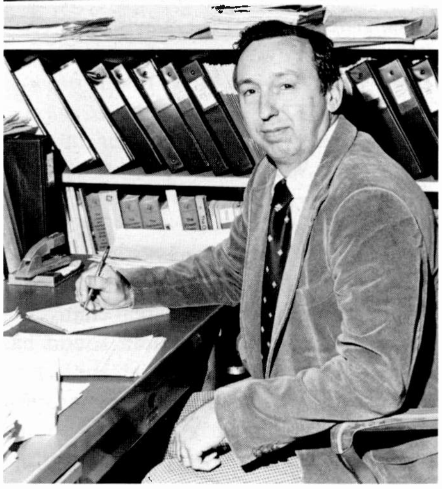
Teletext TV interface circuits using such CMOS types as the CD4053 and the CD4066 are available.[17] The feasibility for auto-black-levels has been demonstrated using commercially available IC types, such as the CA324 and the CA3081.[18] Although a multifeature type of microprocessor tuner-control circuit with remote control functions has been demonstrated using the 8-bit CDP1802 system, the industry trend has been to use only 4-bit circuits.[19]

Switching regulators are now available but are in only limited consumer-TV-receiver use. Vertical interval reference circuits have had only limited popularity because of irregularities in transmission of the VIR signal. The picture-in-a-picture, zoom and other concepts have been introduced to the market, but also appear to have only limited appeal. Multireception approaches, which can be complex and costly, can be matched by the available features of a video tape recorder. However, this area is open to new possibilities with technical advances in the video A/D and D/A converters and memory circuits.

It is anticipated that future color-TV receivers introduced in the consumer market will not only perform better, but will be available with a variety of new features and options made possible through a varied choice of design options. These options, and all new achievements in color-TV-receiver design will continue to be marked by major advances in solid-state IC technology.

References

1. R.L. Sanquini, "Linear ICs for Consumer Products," *The Electronic Eng.*, (June 1967).
2. L.A. Harwood, "A New Chroma Processing IC Using Sample-and-Hold Techniques," IEEE Trans. on Broadcast & TV Receivers, BTR-19, No. 2 (May 1973).
3. L.A. Harwood, "A Chrominance Demodulator IC with Dynamic Flesh Correction," IEEE Trans. on Consumer Electronics, Vol. CE22, No. 1 (Feb. 1976).
4. J.P. Bingham, M.N. Norman, R.L. Shanley, and B. Yorkanis, "A New Low-Level Luminance Processing System," IEEE Trans. on Consumer Electronics (May 1976).
5. L.A. Cochran, "The XL-100 ColorTrak System," *RCA Engineer*, Vol. 22, No. 1 (June July 1976).
6. L.A. Harwood, J. Hettiger, R.L. Shanley, E.J. Wittmann, "Chroma-Luma IC for NTSC Color TV Receiver," *RCA Engineer*, Vol. 25, No. 6 (Apr./May June, 1980), p. 16.
7. D.H. Pritchard and J.J. Gibson, "Worldwide Color TV Standards—Similarities and Differences," *RCA Engineer*, Vol. 26, No. 5 (Feb./Mar., 1980), p. 63.
8. W.H. Groenweg, "Sound Interference in Synchronous IF Demodulators," MRZ 202 (July 29, 1979).
9. CCIR The XIIIth Plenary Assembly, Geneva, 1974, Vol. XI (Television).
10. *RCA Engineer*, Vol. 16, No. 5, Articles on Microelectronics (Feb./Mar. 1971).
11. W.M. Austin, "A High Stability Sync-AGC and Horizontal-Vertical Countdown System for 525-Line Color Television Receiver Applications Using the RCA CA3154 and CA3157 Integrated Circuits," RCA-SSD Application note ICAN-6802.
12. B.W. Beyers, H. Blatter, J.B. George, J. Henderson, R. Rast, J. Tults, and C. Wine, "Frequency Synthesis Tuning Systems with Automatic Offset Tuning," *RCA Engineer*, Vol. 25, No. 1 (June/July 1979).
13. RCA-CE, Television Service Data, File 1979, C-7, CTC101.
14. K. Mohri, M. Shimano, T. Kuroyanagi, "Chroma Systems Trend in the Past & Future & Latest Chroma IC with Versatile Flexibility," IEEE Trans. on Consumer Electronics, Fall Conf. (1977).
15. M. Ullrich, M. Hegendorfer, "TV Receiver puts Two Pictures on Screen at Same Time," *Electronics* (Sept. 1, 1977).
16. S. Makino, *et al.*, "A Fully Automatic Ghost Canceller," IEEE Trans. on Consumer Electronics, Spring Conf. (1978).
17. W.H. Groeneweg, "An Application of an Integrated Single Chip Luminance and Chrominance Processor For PAL Color Receivers (TA10313)," Report No. MRZ-245 (Feb. 7, 1979).
18. W. Hinn, "A Simple Circuit for Automatic Background Color Balance," Report No. MRZ-253 (Oct. 30, 1979).
19. K. Karstad, "Microprocessor Adds Flexibility to Television Control System," *Electronics* (Nov. 22, 1979).



Wayne Austin began work in 1957 at RCA in the development of electron tubes for the consumer market. In the 1965 to 1968 time period he participated in advanced development work on solid-state devices for color TV. Until 1973 he worked in the Applications Engineering group for bipolar ICs in both industrial and consumer projects; during that year he became Applications Leader responsible for consumer bipolar IC applications.

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Dual dimension sound: quasi-stereo comes to television

For years color television has had to put up with monophonic sound, but all that is being changed by a new system that simulates the ambience of (true) stereo.

Abstract: *Dual Dimension Sound,™ one of the features in the latest generation RCA color television, is the marketing name for a unique quasi-stereophonic system that simulates the ambience of true stereo by generating two spectrally distinct sound channels from the monophonic audio source of the television receiver. Each sound channel output drives one of two separate full range loudspeakers located symmetrically about the television screen. This paper provides a summary of the characteristics and a brief history of synthetic stereo, and describes the development and present application of Dual Dimension Sound.*

Until recently, improvements in television sound systems were merely refinements of a system that has seen few real changes in nearly forty years. Television sound has always been monaural. The subject of stereo occasionally finds its way into discussions about improving television sound, but no standards have, as yet, been approved. Until such a time, the best alternative is synthetic or, quasi-stereo.

Methods for synthesizing quasi-stereophonic sound from monophonic sources are well known, but not until recent improvements in sound transmission quality, notably the new AT&T microwave transmission system linking the networks with local affiliates, were such methods seriously considered for use in television.

Reprint RE-25-6-7
Final manuscript received Jan. 17, 1980.

The technology necessary for changing the *concept* of TV sound systems is available, and by using it the RCA Consumer Electronics Division in Indianapolis has developed a new synthetic stereo system called Dual Dimension Sound, which is featured in the present top-of-the-line ColorTrak models.

The characteristics of quasi-stereo

In order to understand the concept of the quasi-stereophonic sound system, a discussion of the qualities of true stereophonic sound versus monophonic sound is an appropriate starting point. Two qualities distinguish true stereophony from single channel reproduction. The first quality, the sensation of *separation,* gives the listener the ability to selectively judge the locations of various sound sources, such as instruments in an orchestra. The second quality, the sensation of *presence,* is the feeling that the sounds seem to come from positions between and usually somewhat behind the speakers. The latter sensation gives the listener an impression of the size, acoustical character, and depth of the recording location. Since, in general, separation tends to contribute to the effect of presence, the term *ambience* is used to describe presence with the contributions due to separation included. Interestingly, in 1960 Lochner and Keet determined that ambience contributes more to the stereophonic effect than separation.[1]

It is ambience that the synthetic stereo system attempts to produce. Directional separation is less important, especially in systems designed for television use where a high degree of directionality might lead to confusing visual/aural imagery.

History of quasi-stereo

Quasi-stereo research was begun in 1954 by H. Lauridsen of the Danish National Broadcasting System.[2] Since then a number of schemes for generating quasi-stereo systems have been developed. In Lauridsen's experiment, a time-delayed (50 - 150 milliseconds) version of the monaural input signal was added to the monaural input signal to produce one channel and subtracted from the monaural input signal to produce the other channel. Subsequent analysis of Lauridsen's experiment by M. Schroeder of Bell Labs revealed that the channel outputs were complementary comb filter responses with a null-to-null frequency spacing of $1/T$, where T is the delay. In addition, the differential phase between the two output channels jumped discontinuously between $-\pi/2$ and $\pi/2$ at all frequencies that are integer multiples of $1/2T$.[3]

Schroeder developed experiments using linear phase comb filters and variable-phase all-pass filters to separate the amplitude and phase effects produced in Lauridsen's experiment in order to assess their relative contribution to the sensation of ambience. Schroeder concluded, at that time, that the strong quasi-stereo effect was missing in all experiments not involving strong spectral amplitude differences between the channels. Based on the findings of Loçhner and Keet[1] and his own further work, Schroeder later concluded[4] that there are all-pass filter configurations that produce strong quasi-stereo effects; however, his discovery that channel spectral intensity differences alone can produce the quasi-stereophonic sensation is the basis of the concept of Dual Dimension Sound.

The concept of dual dimension

Dual Dimension Sound is unique because of the simplicity of its method of complementary amplitude response generation. Complementary amplitude response is necessary to maintain a composite spectral output (i.e., sum of both output channels), which preserves the spectral balance of the original monaural source.

Schroeder had employed a bank of frequency-contiguous bandpass filters whose outputs were alternately selected (in the frequency domain) and combined to produce the complementary comb filter responses required. While this scheme was effective in producing the desired ambience, it was complicated, employing separate filter functions for each channel. Such a configuration would be prohibitively expensive for consumer product applications. The challenge in the design of Dual Dimension Sound, then, was the development of a circuit that would provide the desired quasi-stereophonic effect in a consistently manufacturable and cost-effective manner.

After deliberation, the basic concept of Dual Dimension Sound, as shown in Fig. 1, was devised. Note that the monaural input drives the input of a filter transfer function, $H(s)$. The output of $H(s)$ is fed to a power amplifier connected to a full range speaker to produce channel one. Channel one lacks certain portions of the total input spectrum because of the spectral selectivity of the filter function of $H(s)$. In order to obtain a composite output spectrum that preserves the spectral balance of the original monaural source, channel two is produced by taking the difference, via a differential power amplifier, between the output of $H(s)$ and an appropriately scaled version of the monaural input signal. In practice, the success of the difference amplifier in generating a frequency response complementary to channel one will be a function of the amplitude and phase characteristics of $H(s)$ relative to the input. This requires that $H(s)$ be selected so that at frequencies where the output of $H(s)$, hence channel one, is maximum, the inputs to the difference amplifier are equal in amplitude (the scaling network is adjusted to assure this) and phase. Consequently, reasonably complete cancellation occurs and there is no output from channel two.

Conversely, minimum spectral amplitude in $H(s)$ (and the output of channel one) will result in maximum spectral amplitude in the output of channel two, since the difference between the scaled monaural input to the difference amplifier (which is ideally constant in amplitude versus frequency) and the output of $H(s)$ will be greatest when the output of $H(s)$ is at a minimum, provided the amplitude variations are so large that they dominate the phase differences. Thus, through careful selection of nature of $H(s)$, only one filter function is required to generate two complementary channel frequency responses.

An important factor in the simplicity and feasibility of the Dual Dimension concept is the use of the differential power amplifier. Present integrated circuit technology makes extensive use of the differential amplifier in op-amps, and this technology has been expanded to make what are essentially power op-amps capable of delivering watts of power to a load. The availability of such devices makes it possible to generate complementary frequency responses and drive speakers in one operation. In addition, *dual* channel differential power amplifiers are now available, simplifying circuit designs and reducing cost.

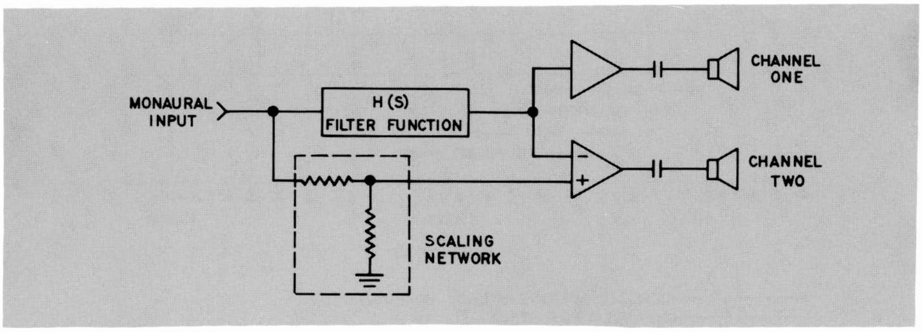


Fig. 1. Block diagram of the dual dimension sound concept.

The topology of $H(s)$

With the basic system concepts defined, the topology of $H(s)$ was the next major task. Initial designs centered on parallel one-stage transistor bandpass filters whose outputs were resistively added to form $H(s)$, as shown in Fig. 2a. This scheme was soon abandoned in favor of cascaded one-stage transistor bandstop filters, which required fewer parts (Fig. 2b). Further study led to the circuit shown in Fig. 3, in which two cascaded twin-tee notch filters were impedance scaled to eliminate buffer transistors. Elimination of active components in $H(s)$ improved reliability and reduced cost. Implicit in the impedance scaling scheme, however, was the need to provide a relatively high amplifier input impedance in order to minimize loading effects on the $H(s)$ output. In practice, the high input impedance required was obtained by feeding $H(s)$ to the positive input of the differential amplifier. This reversal of the differential amplifier input polarity was allowable, since the output magnitude will be the same for either polarity.

To see why no change in output magnitude occurs, assume a monaural input, e^{jwt}, and examine the magnitude of the difference amplifier output for the two cases of input polarity. The output of $H(s)$, one of the inputs to the difference amplifier, will be $H(w)e^{j(wt+\phi(w))}$, where $H(w)$ and $\phi(w)$ characterize the relative amplitude and phase of $H(s)$ respectively. The other input to the difference amplifier will simply be a resistively scaled version of the monaural input, Ke^{jwt}. Thus,

Case 1: $H(s) - \text{Mono}$:

$$= H(w)e^{j(wt+\phi(w))} - Ke^{jwt}$$
$$= e^{jwt}\,[H(w)e^{j\phi(w)} - K]$$
$$\therefore \; |e^{jwt}[H(w)e^{j\phi(w)} - K]|$$
$$= |e^{jwt}|\,|H(w)e^{j\phi(w)} - K|$$

Case 2: $\text{Mono} - H(s)$:

$$= Ke^{jwt} - H(w)e^{j(wt+\phi(w))}$$
$$= e^{jwt}\,[K - H(w)e^{j\phi(w)}]$$
$$\therefore \; |e^{jwt}\,[K - H(w)e^{j\phi(w)}]|$$
$$= |e^{jwt}|\,|-[H(w)e^{j\phi(w)} - K]|$$
$$= |e^{jwt}|\,|H(w)e^{j\phi(w)} - K|$$

— same result as Case 1

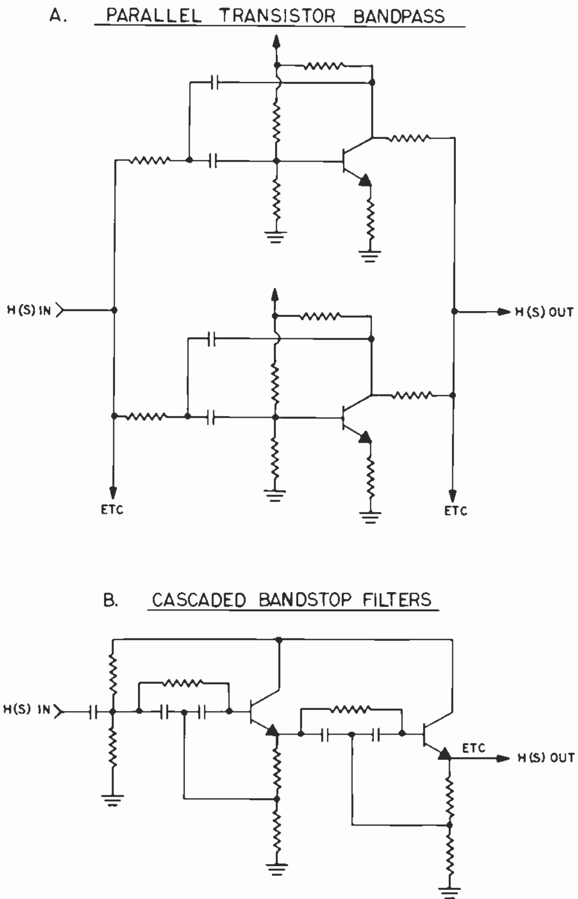


Fig. 2. Early topologies for H(s).

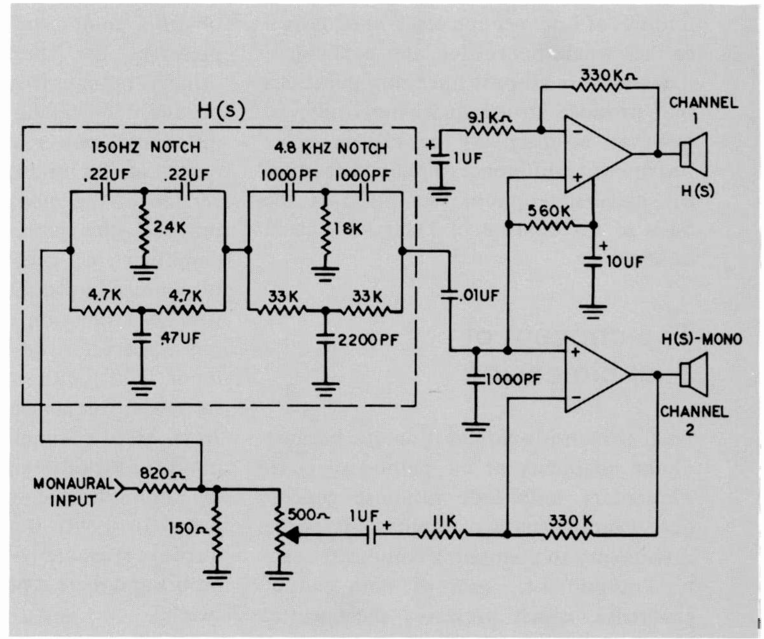


Fig. 3. Final dual dimension sound implementation.

The phase response of the output of the difference amplifier will differ by 180° in the two cases, but as previously mentioned, phase response is not a critical factor in determining the perceived ambience.

Selection of *H(s)* frequency response

The majority of television programming contains images of individuals who are singing or talking. Since no quasi-stereophonic system can determine the relative screen location of the images of the individuals, but may by its nature impart a degree of directionality to the sound, care must be taken to avoid the disquieting situation of an individual's image on one side of the television screen while the apparent source of his voice is on the opposite side. The problem is minimized in the Dual Dimension Sound system by selection of the notch frequencies so that make the human voice appears to emanate from the center of the television screen, while wideband background sound appears to emanate from throughout the televised image. Voices will appear centered when the loud speakers are reproducing them with equal intensity; thus, it is necessary to adjust the channel crossover frequencies (via channel notch frequency selection) to correspond to the frequency range where the voice response is, on the average, the greatest. Since the human voice varies tremendously as a function of speech and speaker, the solution to this problem was at best a compromise. However, research in the area of speech is extensive and some reasonable guidelines are established. Figure 4 shows the relative channel response of the circuit of Fig. 3 superimposed on a curve of idealized average intensity versus frequency of the human voice as described by French and Steinberg.[5] Notice that the crossover frequency of relative channel response at approximately 320 Hz is very near the peak of the voice intensity response curve. Therefore, a centering

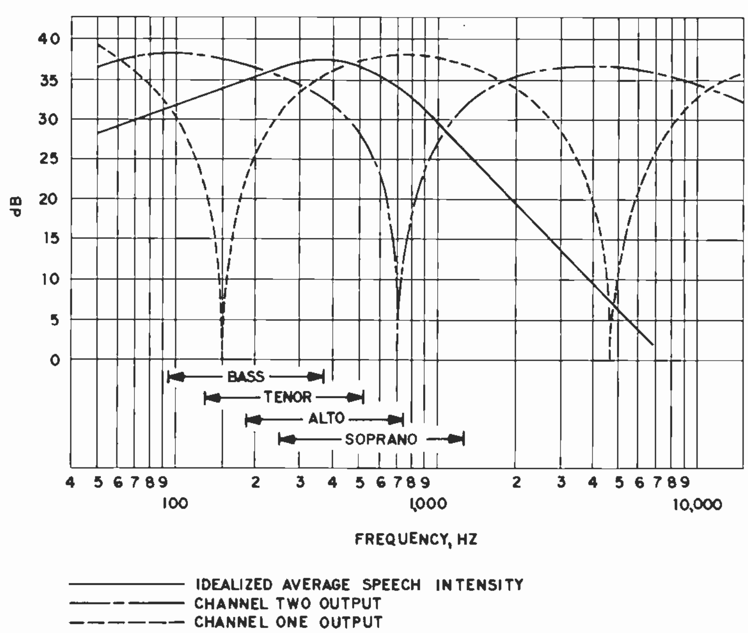
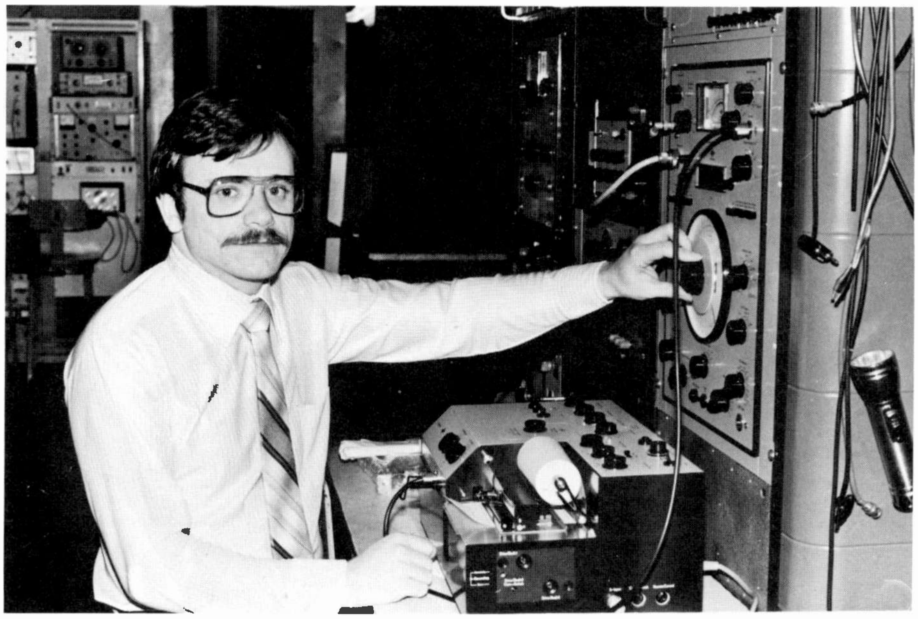


Fig. 4. Channel output responses.



Pat Griffis has worked for RCA since 1974 in a number of areas including design and implementation of automated production line test equipment, competitive analysis, and presently television design engineering. Mr. Griffis has recently been granted a patent on the Dual Dimension concept.

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effect will be apparent near the frequency at which the average human voice is producing the most power. The crossover frequency at approximately 1700 Hz coincides almost exactly with the mean value of what speech experts call the second formant, which is one of the most important vocal tract resonances in determining intelligibility of speech.

Perceived effect of dual dimension

The net result of selected spectral response might be best described by a typical example of two individuals talking to each other in the foreground of a busy office. The voices of the two speakers will tend to emanate from the center of the television screen while the background noise of typewriters, telephones, moving chairs, etc., will appear to emanate from throughout the televised image. Under such conditions, the viewer will have an increased sensation of being in the office (adding another dimension to viewing pleasure — hence, Dual Dimension) without receiving confusing auditory information about the relative location of the individuals in the scene.

The increased ambience of Dual Dimension Sound over conventional two-speaker monaural reproduction is readily demonstrable on the majority of program material. In order to show the advantages, a two-position switching scheme was developed to allow switching between conventional two-speaker monaural and Dual Dimension Sound. Such a switch is placed on the back of every ColorTrak receiver equipped with Dual Dimension Sound.

References

1. J.P. Lochner and W.V. Keet, "Stereophonic and Quasi-Stereophonic Reproduction," *J. Acoust. Soc. Am.*, Vol. 32, No. 2 (Mar. 1960), pp. 393-401.
2. H. Lauridsen, "Nogle forsog med for skellige former rum akustik gengivelse," *Ingenioren*, No. 47 (1954), p. 906.
3. M. Schroeder, "An Artificial Stereophonic Effect Obtained from a Single Audio Signal," *J. Audio Engineering Soc.*, Vol. 6 (Apr. 1958), pp. 74-79.
4. M. Schroeder, "Improved Quasi-Stereophony and 'Colorless' Artificial Reverberation," *J. Acoust. Soc. Am.*, Vol. 33, No. 8 (Aug. 1961), pp. 1061-1064.
5. N.R. French and J.C. Steinberg, "Factors Governing the Intelligibility of Speech Sound," *J. Acoust. Soc. Am.*, Vol. 19, No. 1 (Jan. 1947), p. 94, Fig. 2.

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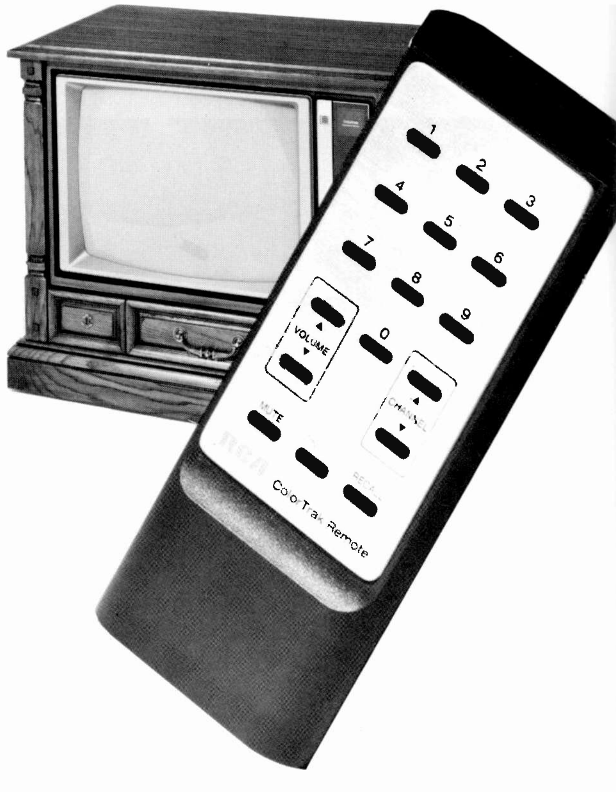
Infrared remote control for ColorTrak television receivers



A 64-function TV remote control? It's possible with the technology of the new IR scan remote system from Consumer Electronics.

Abstract: *Remote control in television has traditionally been accomplished using ultrasonic acoustic techniques. This established technology is now, because of economics, gradually being replaced by solid state alternatives. The new information carrier is infrared light transmitted by a Gallium Arsenide diode and received by a silicon photosensor. RCA Consumer Electronics has chosen to introduce infrared remote in a 17-function direct channel address remote control system for ColorTrak television receivers with Channelock tuning. This article presents the technical features of this new IR remote control system.*

Infrared remote systems for television were developed by the large European television manufacturers during the mid-1970s, and their research has resulted in the development of new components such as IR-emitting diodes, photosensors, and a variety of custom integrated circuits for encoding and decoding the transmitted data. The cost of these new solid state devices has gradually decreased as their use in European receivers has increased. Simultaneously, the hardware of the traditional ultrasonic acoustic remote control systems has increased in cost. Several U.S. and Japanese television manufacturers have recently introduced IR remote control systems. It is becoming increasingly clear that IR light will become the dominant means of remote television data transmission in the 1980s.

Reprint RE-25-6-8
Final manuscript received Jan. 17, 1980.

IR remote vs ultrasonic remote

All remote controls have a hand transmitter unit, a data link, and a receiver interface circuit. Acoustic remotes have evolved from purely analog devices into integrated digital devices. With this change, the number of control channels or functions has steadily increased. Function expansion is limited in acoustic systems by the characteristics of the audio environment in the television receiver and in the home. Two factors are important.

First, ultrasonic sound radiated mechanically from the television horizontal deflection system at harmonics of 15,734 Hz desensitizes the remote by providing in-band signals that "capture" the limiting preamplifier and the system frequency counter. Desired signals must be stronger than the interference. To achieve this, filters are used to reject the harmonics. A bandpass filter centered between the harmonics may be adequate, or in a larger system having a remote receiver bandwidth that includes the harmonics, expensive notch filters may be needed. System function expansion is, therefore, limited by filter complexity and cost.

The second environmental factor to consider is that pulse code modulation (PCM) for function expansion with narrow bandwidth is not practical with ultrasound. Ultrasound produces echos in the viewing room that continue after the hand transmitter is off or has changed frequency. This "echo effect" distorts the data and forces a long decode delay. The result is a remote control that feels unresponsive to the user who is trying to make fast digital calculator style entries.

The new IR system, however, allows function expansion using PCM. There is no significant echo delay with light. The present system permits 32 functions, and systems with 64 or more functions are technically feasible.

IR is better than ultrasound, but not perfect. Light travels in straight lines. Ideally, an IR remote transmitter should be pointed in the general direction of the receiver, with no obstructions in the light path. Wall and furniture reflections help to make IR aiming less critical, but ambient light is a problem. Room lighting, fires, and direct sunlight will desensitize an IR system.

The keyboard-scan remote frequency synthesis tuner

The present system combines the features of the "keyboard" and "scanning remote" systems described in the *RCA Engineer*, Vol. 25/1, June/July 1979. A block diagram of a complete system is shown in Fig. 1. Because the remote system and its ICs are totally new, three features not found in previous RCA ChanneLock tun-

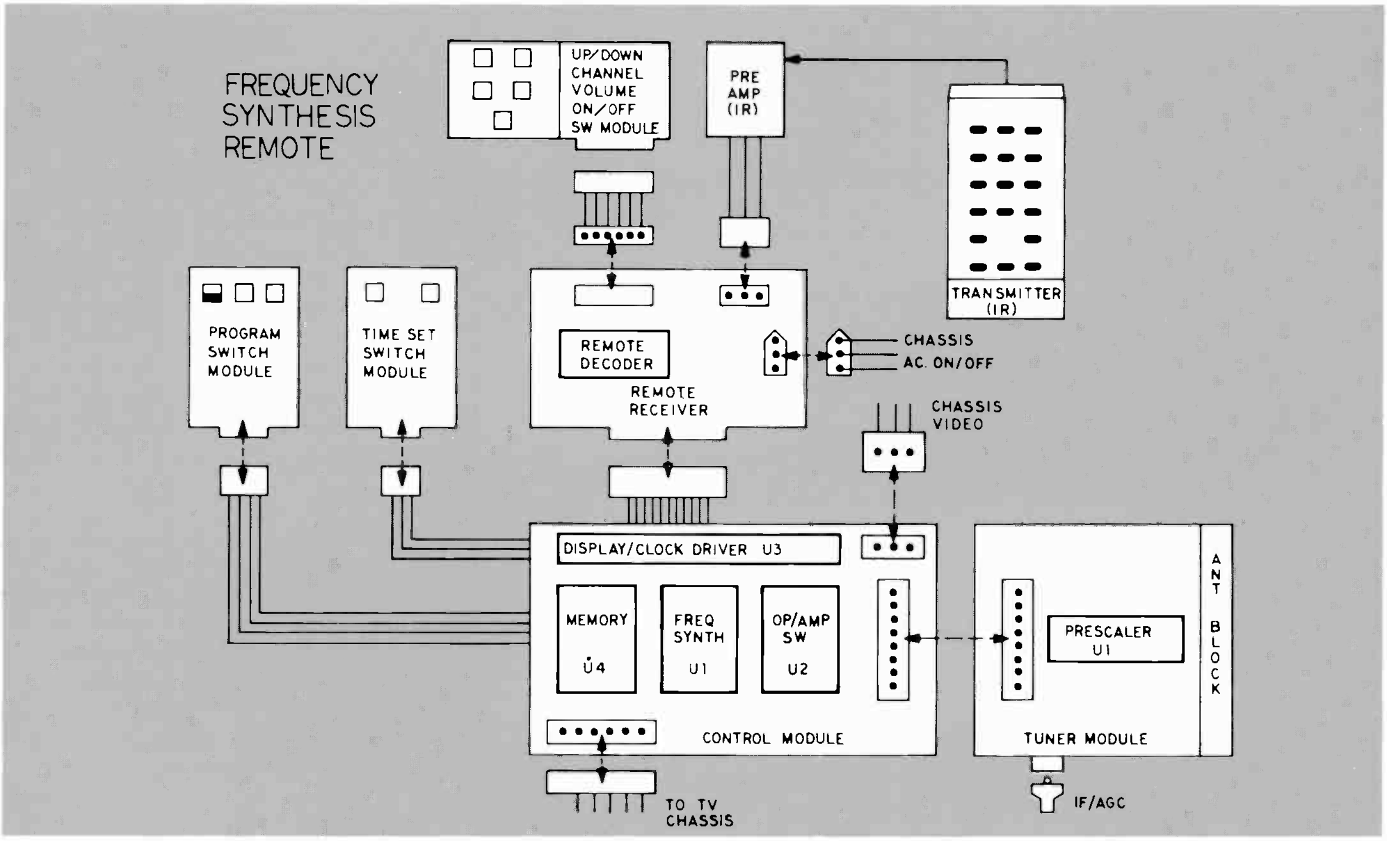


Fig. 1. Block diagram of scan remote system.

ing systems were able to be added. The first, *Toggle On/OFF,* allows the volume to remain preset at any level while the television is off. The second, *Audio Mute,* permits shut-down of the sound for interruptions such as telephone calls. Sound can be restored either with the mute button or with the volume up button. The third feature, *Display Recall,* brings the special on-screen data display into view so that the time and channel can be checked.

IR transmitter

The IR Transmitter, shown in Figs. 2 and 3, consists of an encoder IC, a ceraminator* oscillator, 17 control buttons, a battery, regulator driver circuits, and three IR-emitting diodes.

The encoder IC is a custom adaptation of an off-the-shelf PCM data transmission CMOS device. This IC generates a 40-kHz carrier modulated by a digital message consisting of 12 repeating "bit frame" patterns. This message, detailed in Fig. 4, contains synchronization and function identity information. Each of the 12-bit frames consists of three distinct intervals: the start interval, the data interval, and the mark interval. Each interval consists of 16, 48, and 64 carrier cycles respectively for a total time duration of 3.2 ms. Seven of the frames (1-6 and 12) have a fixed appearance and are used for system synchronization. Frames 7-11 carry the data in 5 bits for 32 possible codes. Seventeen of these codes are represented by the 17 control buttons of the system. When any button is held down, the message repeats. After 6.5 seconds, the message is stopped by a duration limiter counter. This circuit prevents accidental battery depletion if a button is held down for a long period of

*A ceraminator is a ceramic filter used as a resonator.

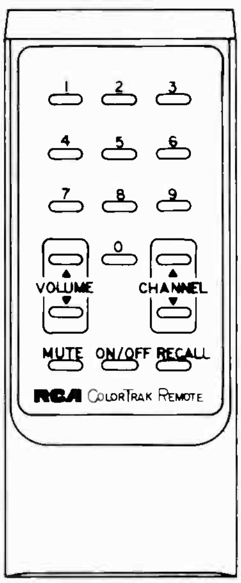


Fig. 2. 17-function IR transmitter.

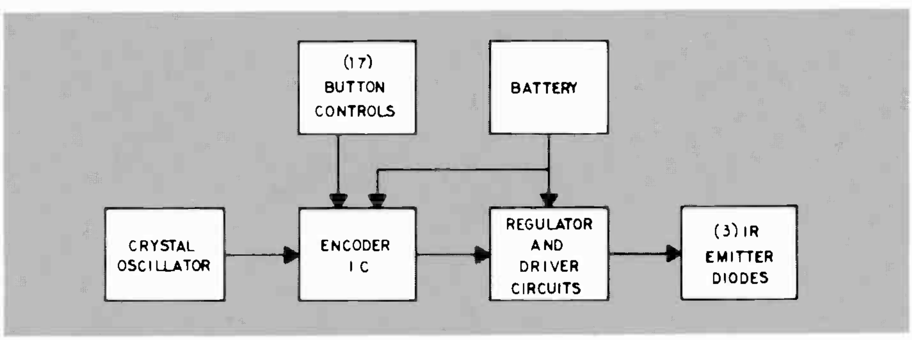


Fig. 3. Infrared transmitter block diagram.

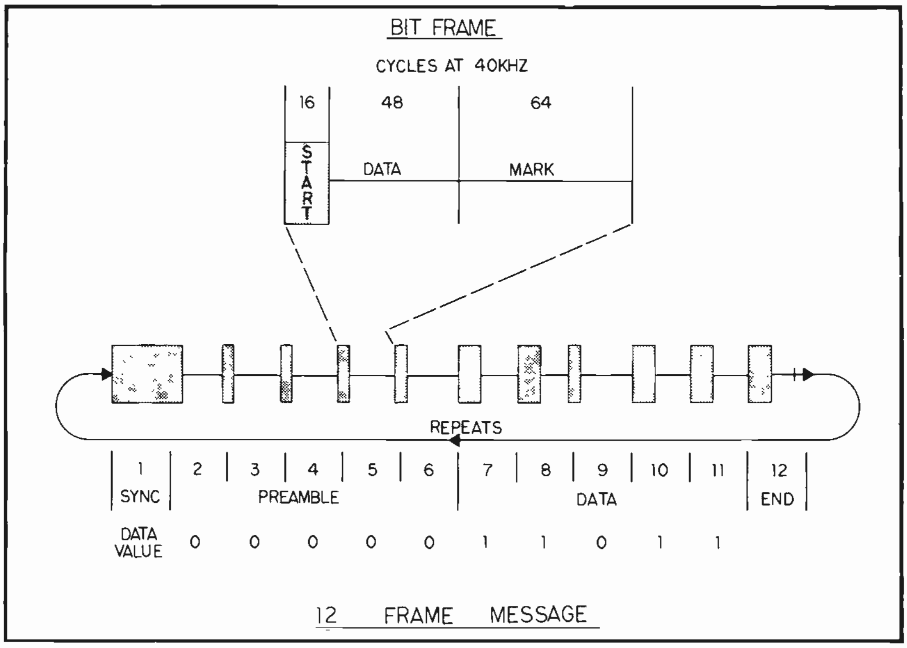


Fig. 4. Message format.

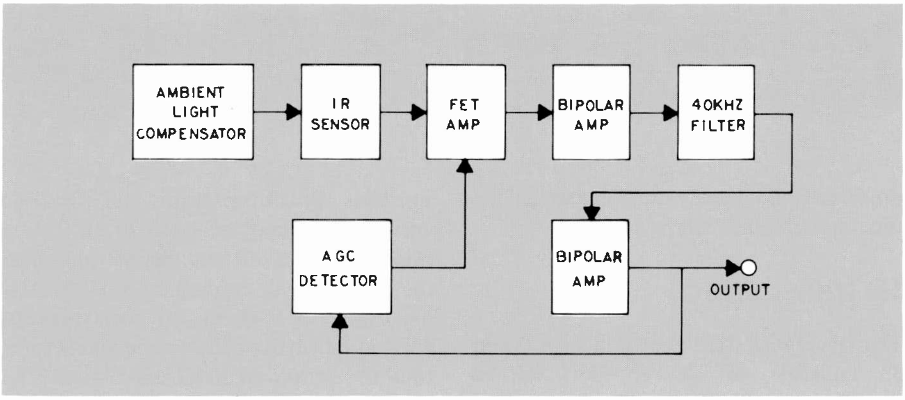


Fig. 5. Preamp block diagram.

time, as might happen if a book or other object were resting on a button.

The regulator driver circuits that couple the encoder IC to the IR-emitting diodes keep the drive to the diodes constant as the battery ages, and also extend battery life. The regulator is also important in preventing signals of an incorrect duty cycle from being transmitted, causing excessive power consumption. Additionally, the diodes are a-c coupled to prevent them from emitting if there is a component failure. Three diodes are used instead of one to widen the field of light distribution and to limit the power dissipation of each IR-emitting diode.

Preamp

The IR signal enters the receiver through a small window at the front of the preamplifier module. The preamplifier circuit, shown in Fig. 5, is basically a three-stage high-gain amplifier that features a low noise field effect transistor (FET) input device and two bipolar stages. A resonator is used in the second stage to peak the response for the 40-kHz carrier. The output is peak-to-peak detected to provide an automatic gain control (AGC) feedback voltage to the input FET. AGC reduces distortion for the strong signals generated when the transmitter is held close to the receiver. Each stage has a power supply decoupling filter to minimize the effect of power supply ripple.

Ambient IR light entering the preamplifier is handled by the ambient light compensator. When ambient IR light

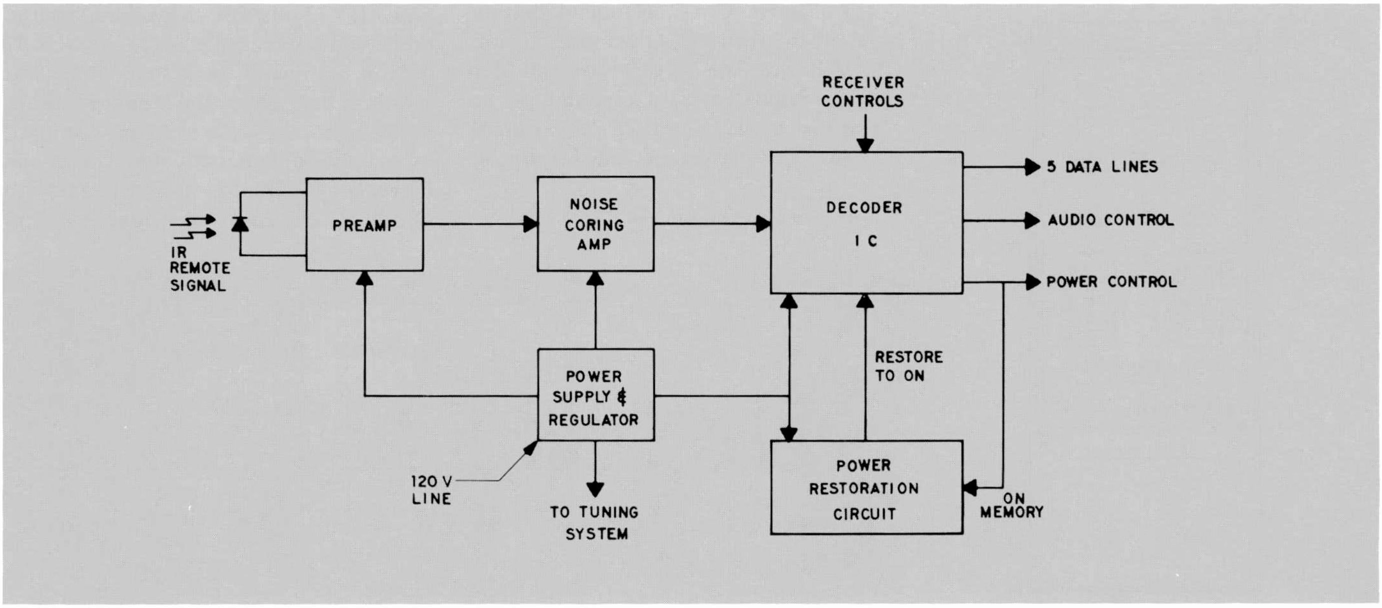


Fig. 6. Receiver module block diagram.

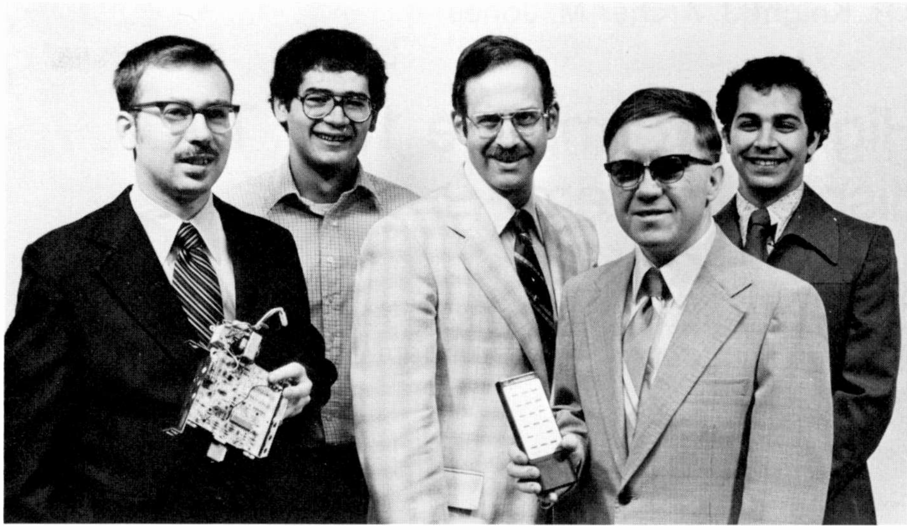
strikes the detector, the detector diode leakage increases to the point where the input signal is cut off. The compensator network establishes a leakage level where the effective input resistance of the FET amplifier is lowered and the ambient light sensitivity is diminished. This widens the system tolerance to ambient light changes.

Receiver module

The receiver module block diagram is shown in Fig. 6. The preamp output enters the receiver decoder IC through a noise coring network that passes voltages in excess of 1V peak-to-peak.

The decoder, also a custom adaptation of an off-the-shelf device, is a PMOS IC that contains circuits that automatically synchronize with the signal pattern and decode the data. The data signals are used to set the five data outputs, latch the on/off driver output, and control the analog audio output.

The remote receiver module also contains the standby power supply, regulator, and power dropout restoration system. The power supply and regulator are conventional. The restoration system was developed to compensate for the large standby power requirement of the decoder IC. It restores the receiver to "on" after a power dropout of up to five seconds. It does this by charging a capacitor while the receiver is on, and by using this stored energy to hold this "ON MEMORY" transistor on for up to five seconds during a total power loss. When power is restored, a detector circuit senses the voltage applied to the decoder IC. At the correct operating voltage, a "clear" command is sent to the power-up reset input of the IC. This sets the on/off output to off and triggers a pulse generator. The resulting pulse strobes the IC's toggle on/off input (provided the "ON MEMORY" transistor mentioned above is conductive). This toggle pulse restores the receiver to "on" only if it was previously on before the power dropout.



From the left are authors J.B. George, J. Wolford, D. Sakarya, H. Blatter and G. Tamer.

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Physical structure

The new IR preamp and receive modules are mechanically similar to the acoustic system modules they replace. This permits the new remote to be used with minor changes in existing TV cabinets. Only the power on/off button must be added to the receiver to make a complete working system.

Acknowledgment

The authors would like to acknowledge the valuable contributions of James Olsen, American Microsystems Incorporated and to the IR remote project. A special thanks to the many others who have helped bring this project to production and the marketplace.

P.R. Knight|J. Archer|M. Jones

High performance 100° TV display system

The ColorTrak performance goals for the new CE display system meant outdoing all competition in operating parameters.

Abstract: *A successful color television receiver design requires the synergism of many technologies. The final product represents the culmination of more than two years of dedicated design based on many years of steady progress. This paper describes the display system development of RCA's CTC 99 and CTC 101 chassis and covers: (1) picture tube selection; (2) deflection yoke design; and (3) circuit design.*

Competitive pressures in the market place demand that the attention of the RCA Display System's Group be directed toward "state of the art" development as well as improvements on past accomplishments. Smaller cabinets, improved picture quality, safety, reliability, automated assembly, low power consumption, and reasonable cost were some of the concerns that were addressed in setting goals for the display system on the CTC99/101 chassis.

Meeting those goals required selection of a new 100° color picture tube (CPT) that was designed and developed by the RCA Picture Tube Division (PTD), and design and development of a new 100° deflection yoke, and new deflection circuitry including an IC.

Each of these developments will be described with a discussion of engineering considerations and design trade-offs.

Reprint RE-25-6-9
Final manuscript received Jan. 17, 1980.

Picture tube selection

At the beginning of the development cycle, a familiar issue was once again addressed. This concerned determining if there was a favorable alternative to the dot screen delta tube for a 25 V (25-inch viewable diagonal) color display. Ground rules stipulated that the display device would have to match or exceed delta tube picture quality. If so, advantages in the following areas would be sought: (1) reduce system cost, (2) provide new styling options, and (3) reduce power requirements.

Previous studies of this type had shown inline tubes with 29-mm neck diameter to be well suited for screen sizes up to 19 V. They required less deflection power than the previously standard 36-mm neck diameter delta system and made possible the use of self converging yokes. A self converging yoke eliminates the need for costly, energy consuming dynamic convergence correction circuitry which typically contains a combination of 12 or more variable resistors and inductors requiring tedious adjustment.

At the beginning of any previous 25 V development cycle, the resolution capability (spot size) required for large screen TV could not be achieved with known, practical, 29-mm inline gun assemblies. This was no longer the case when plans were being laid for CTC99/101 strategy which had benefit of new gun technology pioneered by Picture Tube Division in the form of its new High Potential-Bipotential Precision Inline (Hi-PI) gun. A number of 25 V experimental tubes were built with HiPI guns in order to make analytical measurements and side-by-side viewer tests to determine if inline technology had indeed reached the point where it could perform as well as delta in the 25 V size. These trials involved the David Sarnoff Research Labs at Princeton, the Picture Tube Division (PTD) at Lancaster, and the Consumer Electronics Division (CE) at Indianapolis. When the decision was made, which was based upon commercial as well as technical consideration, the HiPI inline was chosen.

Having settled upon the inline tube, new options were available with respect to deflection angle. Due to practical limitations relating to deflection power and edge convergence, 90° was the largest deflection angle ever to enjoy widespread use in a delta tube design. The inline tube presented new deflection options. Its smaller neck diameter translates into an inherently lower requirement for deflection power which made it practical to consider increasing the deflection angle. Also, the suitability of inline tubes for use with self-converging yokes indicated that dynamic convergence problems should not be a show stopper. A deflection angle increase does, however, mean that the yoke designer's task becomes more challenging as does the repeatability with which the yokes must be built and aligned with respect to the picture tube.

Further studies were made to assess the design trade-offs associated with 100° and 110° systems. Obviously, increasing de-

Fig. 1. Subjective evaluation of picture tube performance complements spot size measurements.

flection angle reduces overall tube length which provides new cabinet styling options and also improves center resolution by shortening the throw distance for the electron beams. On the negative side, the larger angle implies more deflection defocusing, an increase in deflection power, and a greater risk of problems associated with edge purity and edge convergence.

When all these factors were modeled, studied, and weighed, it was concluded that 100° was the appropriate step to take at this time. Development could now begin with a defined product, but difficulties still remained. Neither the tube nor the yoke which had been defined existed in a commercially useable form. Programs to develop the tube and the yoke in parallel were formulated with the handicap that the tube designer must have sample yokes before a tube can be completely designed, and the yoke engineer needs tube samples before he can finalize yoke design.

This interdependence is a typical problem in tube and yoke development and illustrates the need for CE and PTD to work closely together during the development cycle to ensure tube/yoke compatibility.

The deflection yoke

The CTC99/101 100° deflection yoke forms part of a system which required rethinking and re-evaluation of engineering design and manufacturing processes.

The whole deflection system was reviewed and formulated to produce higher reliability, better performance, low cost, and minimum power consumption. Picture tube arc protection requirements and good design practice led to the lowest usable peak voltage on the horizontal output transistor. Cost effective vertical circuit design produced an energy recovery system. The high yoke sensitivity needed to implement these circuits had not been met by any competitive products. The commitment to produce this sensitivity was made and met.

The yoke design group, led by J.K. Kratz, had already produced a very sensitive 90° design using a novel rear-tilt method to produce a mechanical adjustment of convergence. Low cost was met by saddle wound horizontal and toroidally wound vertical coils (an S/T yoke). Optimum convergence and cross-talk performance resulted after the vertical coil assembly received X (lateral), Y (vertical) and rotational adjustment with respect to the horizontal coils, followed by a glueing operation.

The 100° design concept was a logical extension of the 90° design and manufacturing technology. It was to be an S/T yoke built from a kit of subassemblies. The final product would not need further adjustment for convergence or cross-talk. No glue or wedges were to be used to hold the assemblies in proper alignment.

At this point, a brief illumination of some of the background to yoke design and performance may be helpful. The basic requirements which must receive attention in a deflection yoke design are impedance, sensitivity and adequate yoke-funnel clearance (pull-back). Attention to all three is necessary to produce an optimum match to the deflection circuitry and picture tube.

The interaction between impedance and sensitivity is an initial guide to the number of turns, selection of wire gauges and general shape of the ferrite core. Sensitivity increases with yoke length and reduced ferrite core diameter.

A successful design must optimize the use of its available volume. Ideally, the volume of the magnetic field should be no larger than that swept out by the beam bundle during deflection, but then the yoke would be inside the picture tube. Practical yokes generate a much larger field volume than this, and suffer inefficiency accordingly.

The commonly accepted figures of merit for yokes specify the stored energy in the horizontal coils, and the peak resistive power loss in the vertical coils, for a stated scan amplitude, final anode voltage and picture tube. The 100° yoke performance for edge to edge scan at 25 kv is:

Horizontal stored energy	$\frac{1}{2} L_H I^2_{pk} = 3.1\ mJ$
Vertical peak power	$R_V I^2_{pk} = 3.3\ W.$

Yoke pull-back is a distance measured along the tube Z-axis. It is an allowance made for picture tube manufacturing tolerances, and ensures that the scanning beams will properly illuminate each phosphor dot after passing through the shadow mask (color purity) while never striking the glass in the vicinity of the yoke. Pull-back requirements reduce yoke length and scanning sensitivity.

The yoke mounting and mechanical convergence assemblies must provide:

1. Some rotational motion to line up the deflection fields with the phosphor matrix;
2. Z-axis motion to set the yoke at the optimum purity point; and
3. Sufficient X, Y, Z and tilt adjustment to optimally position the yoke about the electron beams for convergence, absorb electron gun tilt and glass sealing errors; and absorb asymmetries in the yoke itself.

In the 100° yoke, particular attention was paid to reducing yoke asymmetry. The parts are designed and specified to produce a symmetrical unit.

The ferrite core was optimized by accurately grinding its front and rear surfaces and large outside diameter. The grind is specified to:

1. Maximize the core length for sensitivity;
2. Ensure front and rear faces are plane parallel and normal to the yoke *Z*-axis;
3. Reduce the out-of-round errors of the inside surface; and
4. Eliminate *Z*-axis tilt.

This process also improved the yield of usable cores.

The core is then fitted with plastic end caps in a special fixture which transfers the grinding accuracy to the next stage, the vertical coil production.

A major error that can occur in toroidally wound coils is failure to wind the coil about the true core axis. This causes a lack of mirror symmetry in each vertical coil. A new, simple winding machine core clamp was proposed, using the accuracy of the core-ring assembly to guarantee mirror symmetry. Voldemars Rage of the Machine Equipment Development Group turned the idea into metal.

The plastic end caps also have a shape that allows them to fit accurately to the horizontal coil insulator during final assembly. This integration of design and manufacturing processes has produced a yoke which meets all of its design goals.

Circuit design

Regulation against line voltage and load variations is accomplished with the proven XtendedLife regulator introduced in 1977 in the CTC85 chassis (see Fig. 3).[1] For optimum utilization of the horizontal output transistor a regulated supply of 123 volts is used; all other supplies are derived from the high voltage transformer (HVT). The combined effects of the regulator and the harmonic tuning characteristic of the HVT produce a 29.6-kv high voltage source with a low impedance of .1.5 megohms. Attention to detail has led to an overall receiver power consumption of typically 100 watts.

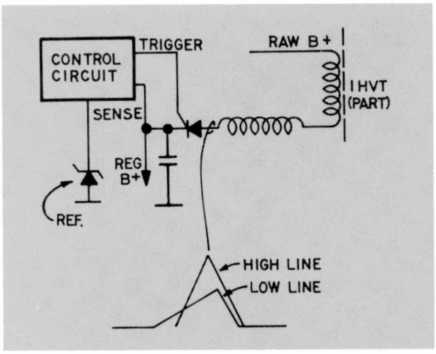


Fig. 3. Regulation against line voltage and load variations is accomplished with the proven XtendedLife regulator.

The "pincushion" correction method is unique in the USA and offers significant performance advantages over conventional systems. One hundred degrees deflection, with its inherently greater pin distortion and deflection energy requirements than 90°, demands more from the pincushion correction circuit. Pincushion distortion is the term used for the curvature of the raster sides caused by the center of deflection being forward of the center of curvature of the picture tube faceplate. The yoke current amplitude has to be modulated to compensate for this. Saturable reactor methods of modulating the horizontal deflection current at vertical rate also modulate the horizontal retrace time and, since normal practice is to derive high voltage from transformed and rectified retrace pulses, some modulation of the high voltage is typical. This leads to variations in the raster shape with brightness, but is small enough to be acceptable where the pincushion modulation is small. For 100°, this would not be the case. Furthermore, techniques that rely on the saturation characteristics of ferrite are inherently non-linear and variable.

The pincushion modulator used in the CTC99 and 101 chassis is, in effect, an auxiliary resonant retrace ramp generator that has its supply voltage, V3, controlled by a vertical rate parabola superimposed on an adjustable dc. It is this dc that provides for width adjustment and enables RCA to achieve the lowest overscan in the industry. This means, of course, that the viewer sees more of the transmitted picture. The circuit is further described by reference to the schematic shown in Fig. 4.

During horizontal trace, rectifiers CR401 and CR402 are held in conduction by the circuit loads across capacitor C405. This connects the secondary of T103 across C404 and, by transformer action, V3 appears in series with the horizontal yoke.

During retrace CR401/402 "switch off" and C406 completes the circuit via the 23-

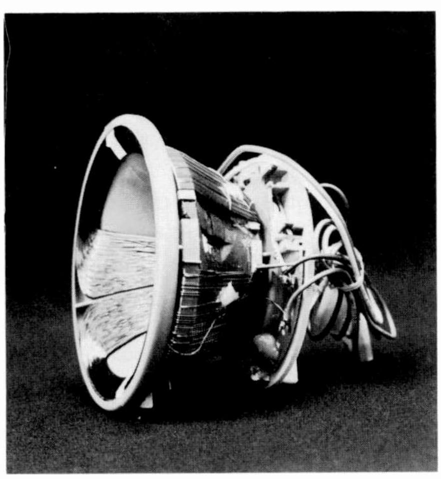


Fig. 2. The plastic end caps have a shape that allows them to fit accurately to the horizontal coil insulator during final assembly.

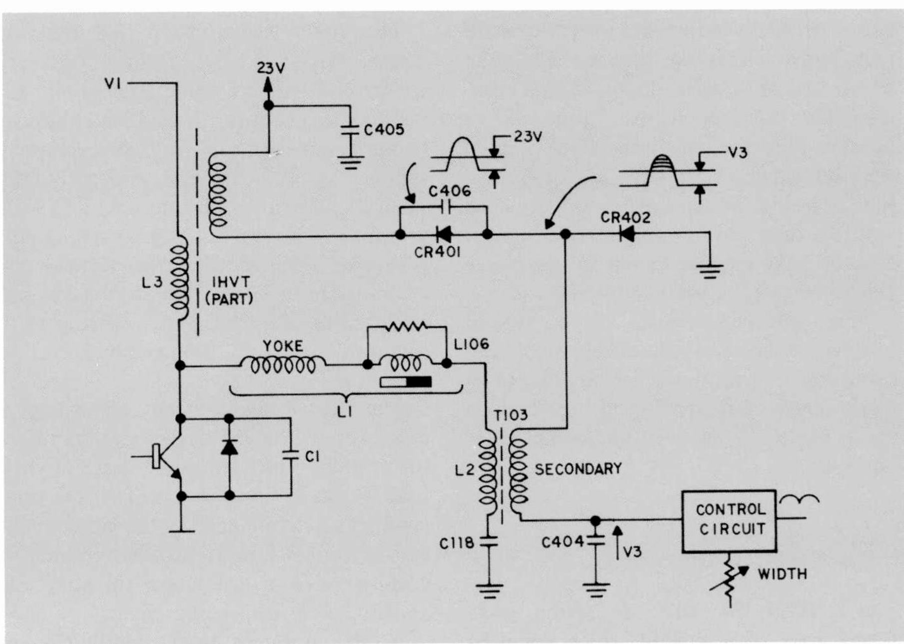


Fig. 4. The pincushion correction circuit modulates the deflection yoke current without modulating the high voltage.

volt HVT winding. Depending on $V3$, C406 presents an effective shunt capacitance to the horizontal deflection circuit. Since the effectiveness of T103 primary as an inductance also depends on $V3$, the two elements successfully maintain constant retrace time for horizontal scan. In the limit cases, where there is no control circuit loading, $V3$ is approximately 23 V so that there is no voltage across C406. At the same time, the yoke current is a minimum. If $V3$ is held at zero, then T103 primary has no voltage across it. The yoke current is a maximum and C406 is fully shunting the HVT winding. The condition for constant retrace time, neglecting HVT primary inductance, is:

$$C2 = C1\,[(V1)/(V2)]^2 \left\{[(L1+L2)/(L1)]-1\right\}$$

In order to make the highest performance deflection circuit possible, the yoke Q is lower than in other recent designs. During horizontal trace, the yoke current is a damped cissoidal wave of the form:

$$S(t) = A \exp{(jw-\sigma)t}$$

which results from the resonance (at approximately 6 kHz) of the yoke with the S correction capacitor; such a resonance is necessary to produce a linear scan. The exp $(-\sigma t)$ term, however, causes the left side to be stretched relative to the right and so a saturable inductor is used to correct for this. The characteristic of the linearity corrector is such that its inductance is constant and very low with current in one direction but increases proportional to current in the other direction.

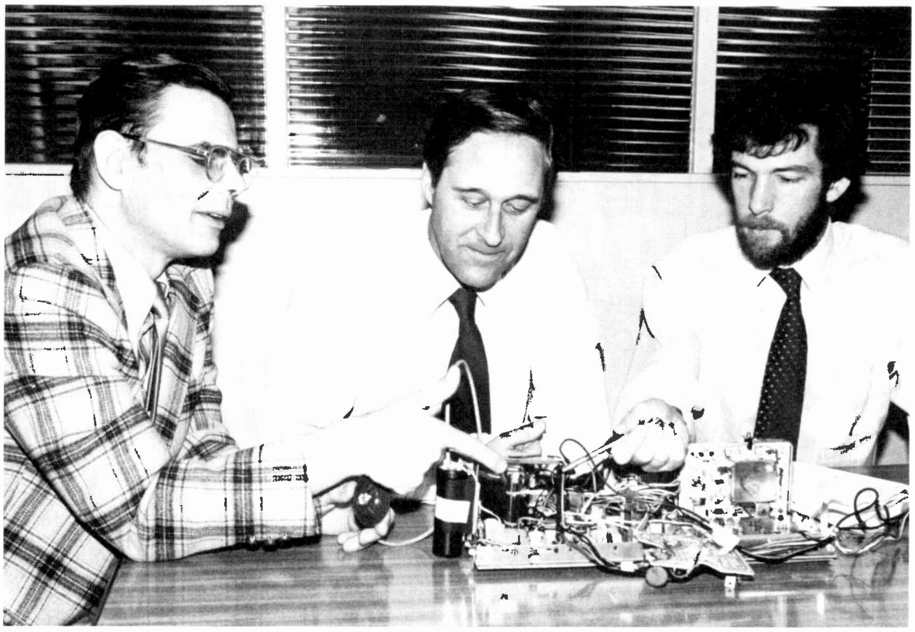
A centering circuit is also provided which, combined with diode modulator side pincushion correction, self correcting top and bottom pincushion (in the yoke), linearity correction, width adjustment and excellent high-voltage regulation, make for the best raster quality in the industry.

Vertical deflection performance complements the horizontal; apart from size adjustment all controls are unnecessary and have been eliminated. Vertical timing pulses are "counted-down" from the stable horizontal phase-locked loop to improve noise performance and ensure interlace. Power consumption of the entire vertical timebase is a mere 4 watts.

These accomplishments are examples of the design effort and engineering judgment that keeps RCA a leader in color television.

Reference

1. Wilmarth, P.C., "The XL-100 XtendedLife Chassis," *RCA Engineer*, pp. 76-79 (June July 1977).



Seated left to right are Mike Jones, John Archer and Peter Knight.

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Third-generation XL-100 XtendedLife chassis

Development of a new family of chassis promises benefits for RCA's XL-100 and ColorTrak television receivers.

Abstract: *The third-generation of XL-100 XtendedLife chassis marks a dramatic departure in packaging concepts. It was planned to be a safer, more reliable, more easily manufactured and serviced chassis to maintain or surpass the high standards of safety and performance set by its predecessors — at a substantial cost reduction.*

The introduction of the model FER450 19" television receiver in February, 1980, was the culmination of a tremendous two-year effort by the Consumer Electronics Division, in the first cooperative design between product design engineering and the new products lab: the CTC-107 family of chassis that will eventually replace all present chassis in the XL-100 line (Fig. 1). A major goal of this development effort was, of course, cost reduction. To maintain profits in such a highly competitive industry requires an ongoing effort to reduce manufacturing costs significantly enough to offset inflation. The real challenge, however, is to improve the final product while reducing its cost. In that light, the following goals were pursued in the development of the CTC-107 family of chassis:

1. Introduce new performance features into the XL-100 line.
2. Incorporate new circuit technology: a one chip chroma/luminance processor and an IF using a SAW filter, combined synchronous detector AFT/AGC IC.
3. Reduce size, weight, and material used in the chassis.
4. Standardize one basic board for all screen sizes and tuning systems.
5. Utilize the latest manufacturing techniques but remain compatible with techniques still in use.
6. Meet requirements for automatic test and alignment.
7. Incorporate more stringent safety and reliability standards.
8. Make improvements in serviceability over previous RCA chassis, which were already highly rated for serviceability.
9. Incorporate a new cost-effective remote system.

Performance improvements

The combination of luminance and chrominance circuitry into one 28-pin IC resulted in major improvements in picture quality. Previously, XL-100 TVs had automatic fleshtone correction, auto-color level adjustment, and the black level clamp. To these features were added: (1) A beam limiter circuit that decreases contrast rather than brightness to limit beam current. Hence, dark details are not lost during bright scenes. (2) A circuit that forces the color level to track with contrast. This virtually eliminates the need for the viewer to adjust the color control once it is set. Also added was an adjustable peaking

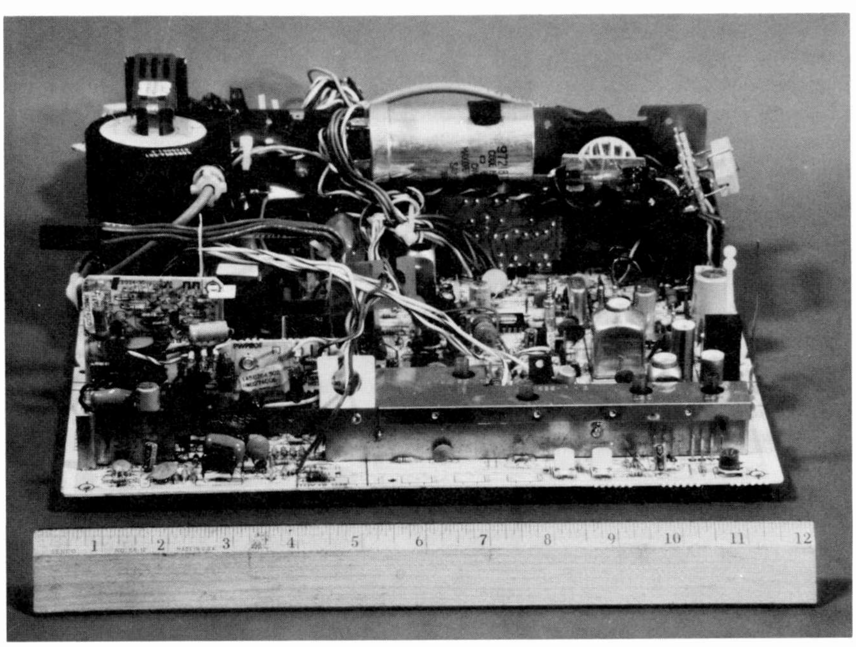

Fig. 1. The CTC108 chassis measures only 9½ x 11¾ inches.

Reprint RE-25-6-10
Final manuscript received January 15, 1980.

control that allows for optimal picture sharpness over a wide range of signal strengths. These signal processing features have greatly increased the picture quality in the price-leader models.

Another improvement is a low-power pin-correction circuit that keeps lines straighter around the edges of the screen. In fact, picture geometry in general has improved.

The new IF system features both positive and negative noise inverters that provide a clean sync signal to the horizontal and vertical oscillators, improving noise immunity. Vertical interlace has been improved, reducing vertical "jitter" in the picture. Horizontal oscillator stability and pull-in have so improved that the customer horizontal-hold control is unnecessary. Computerized automatic alignment assures consistent peak performance for every set. Even the speaker grills have been redesigned to provide high acoustical transparency. And, further performance improvements are being implemented in a version of this chassis which will be used in some ColorTrak models.

Circuits

Horizontal oscillator and output, as well as the horizontal output bias-regulated B+ supply circuit, are essentially the same as in previous recent RCA designs. An integrated high voltage transformer (IHVT) combines the flyback transformer and high-voltage tripler into one unit. Shutdown circuits provide both overcurrent and overvoltage protection.

The conventional vertical oscillator is coupled to a new vertical output design. This is a totem-pole arrangement, using only one predriver transistor. The bottom output transistor drives the base of the top output transistor through a diode switching arrangement during the first half of vertical scan, then directly drives the vertical yoke windings during the remainder of vertical scan. For retrace there is a resonant circuit that is much simpler than the switched vertical retrace circuit of previous designs. The result is reduced power consumption and the use of only one positive supply: eliminated is the dedicated negative supply used in previous vertical circuits.

In signal processing, a surface acoustic wave (SAW) filter/synchronous detector IF is employed. The SAW filter's input electrodes convert signal voltages to acoustic wave ripples on the surface of the ceramic substrate on which the electrode is deposited. The output electrodes are distorted by these waves and convert them to the processed output voltage. Geometry and spacing of the interdigitated electrodes are adjusted to produce the desired IF input bandpass response, replacing the conventional R-L-C discrete network. A single IC incorporates the amplification, AFT, and AGC functions and uses a filtered sample of the input pix carrier to synchronously detect the input signal. The SAW filter, combined with the one-chip synchronous detector system, affords performance comparable to previous systems, but has 50 fewer components and eight fewer alignments. The nine alignments that remain are simpler peaking or dc adjustments with less interaction.

The audio circuit is the same that has been used in all recent designs. Its heart is SSD's sound-plus-power audio IC. The luminance and chroma circuits have been fused via a new chroma-luma IC, which integrates the luminance channel (including beam limiter, black level clamp, and blanking circuits) with a chroma processor similar to that used previously. Luminance is matrixed with chrominance inside the IC, providing R-G-B outputs into the conventional picture-tube cathode-driver stages. The result is fewer parts and enhanced performance.

Size reduction

The size of the chassis and the material used to build it were reduced in several ways. The new chassis is entirely "hot" or non-line-isolated. Previous RCA chassis had only the regulator and horizontal output circuits "hot", and the rest of the chassis was isolated from the ac line or "cold". "Hot" and "cold" circuits that are physically adjacent required large spacings, wasting much board area. Also, components serving as hot-cold boundaries, such as the horizontal driver transformer, were larger to provide the proper isolation. Thus, going totally "hot", with only one ground system, saved considerable PC board area by permitting tighter copper spacings and smaller components.

The reduced component count, mainly due to the new SAW IF system and one-chip chroma-luma circuit, naturally reduced PC board size. Mounting many ac input-related components off the main board, also reduced its area, since these components are large and require large copper spacings to adjacent circuitry. Most of the regulator control circuit and the bias/drive/vertical height controls were mounted on stand-up PC boards to further reduce the size of the main board.

The amount of sheet metal has been greatly reduced, and that which remains serves many purposes. The SAW IF required far less shielding than previous IF circuits. An arm of this smaller shield is extended across the entire front of the chassis to strengthen the board and prevent warpage during solder. The rear apron, besides providing mechanical strength to the PC board as well as the flyback, also is used to mount the previously mentioned ac line-input components, anchor the stand-up bias/drive control board, mount and heatsink the horizontal output transistor, mount the vertical hold and peaking customer controls, support the service switch lever, and act as a ground plane. Even the two vertical-output transistor and regulator SCR heatsinks were used for other purposes. In fact, there is so little unused space, that it was difficult to find room for all the required labels!

Universal chassis

The CTC-107/108/109 chassis series represents a new level of standardization at Consumer Electronics. It started out at the most basic level — the individual component. The Components Liaison Group studied commonly used components — resistors, capacitors, transistors. They compared their parameters with suppliers' standard or most common component parameters and compiled a list of "preferred" parts that should be specified whenever possible. Thus, if the bulk of components used across the board are from the "preferred" group, savings can result from quantity buying and reduced handling.

As another means of standardization, all screen sizes use common tooling and form factor. The three chassis, CTC-107/108/109, look almost identical — indeed, of the 550 or so components used in the chassis, all but about 20 are common. The entire XL-100 line will eventually be replaced with these chassis: the CTC-107 for the 13-in., CTC-108 for the 17-in. and 19-in., and the CTC-109 for the 25-in. models.

Additionally, each chassis is fitted with all its various tuning systems at the final assembly plant. Previously, a dedicated chassis had to be built for each tuning system at the Taiwan and Juarez feeder plants. Now only the three basic chassis are produced at the feeder plants, and the

Bloomington receiver assembly plant then "plugs on" the appropriate tuning system and customer-control assembly that makes up a particular model (Fig. 2). This greatly reduces shipping, handling, and inventory costs and significantly increases scheduling flexibility.

Manufacture and test

With considerable effort, chassis were made more easily manufacturable. The chassis can be assembled at any of CED's three plants: Taiwan, Juarez, or the Bloomington lines. The chassis requires no pallet, but is itself sent down the production line. Off-line subassembly has been minimized; only the power cord assembly and the stand-up regulator and bias/drive controls cards are assembled separately. All other components, including the rear apron and IF shield, are assembled onto the main PC board on one continuous line. The picture tube socket PC board, which previously was assembled off-line, is physically connected to the main board through solder and test stations and is separated immediately prior to shipping from the feeder plant to the instrument assembly plant.

Most components are auto-insertable; special double sets of copper pads for ceramic disc capacitors allow for easy total hand-insertion also. Computer-generated copper patterns and solder-resist masks and the use of the in-line wave-soldering techniques improve solderability. There is less bridging and fewer touch-ups are necessary.

Chassis testing starts with a light-and-play check that weeds out gross failures. The chassis is then transferred to an automatic-test-equipment (ATE) test station. In less than a minute the chassis is completely aligned and tested. The ATE simulates actual operation under various conditions to check over 100 performance and reliability characteristics. The speed and accuracy of the ATE tester eliminate human error, allow much more consistent alignment and thorough testing than before, and greatly enhance the overall performance level.

TUNING SYSTEM:				CHASSIS INTERCONNECT JACKS	
ONE—KNOB VARACTOR	CHANNELOCK REMOTE	CHANNELOCK KEYBOARD	MECHANICAL TUNER		
X	*1	X	X	J101	ON/OFF
		X		J102	LAST CHANNEL MEMORY—KEYBOARD
X			X	J103	DIAL LIGHTS
X	*2	X	X	J104	DEGAUSS
	*2			J105	26V SUPPLY
	X			J106	REMOTE ON/OFF
X	X	X	X	J201	SPEAKER
X		X	X	J202	VOLUME
X	X	X	X	J301	I.F. INPUT
KEY	KEY	KEY	KEY	J302 KEY	TUNER CONTROL
X				J303	+185V DC SUPPLY
X	X	X	X	J401	YOKE
KEY	KEY	KEY	KEY	J701 KEY	CUSTOMER CONTROL *3 BRACKET

Fig. 2. The universal chassis interconnect system. Note J302 and J701 are keyed rows of pins which can accept differently keyed plugs to supply proper control signals to the various tuning systems and customer control arrangements used with the CTC107/108/109 chassis. ***1.** A jumper is plugged across J101 to connect ac line to the rectifier bridge continuously for remote sets. ***2.** A PC board is plugged onto J104 and J105 to provide degaussing on remote sets. ***3.** CTC107 chassis have customer controls mounted on chassis, do not have J701.

Safety and reliability

Safety, of course, is the prime concern in any design and must be built into the chassis. For example, copper was laid out for 3 volts per mil spacing, and two coats of solder resist are used to protect against arc tracking. Power resistors and other components that generate a significant amount of heat are elevated above the board. Redundance of paths carrying high horizontal yoke current provides arc protection should one path fail.

Review and testing by the Product Safety and Reliability Center was an ongoing process. Chassis went through numerous tests, among which were torturous altitude and humidity tests, life tests at elevated temperatures and line voltage, fault tests, salt mist tests, and picture tube arc tests using the Triggered Flashover Generator equipment and techniques developed by G. Forster at the RCA Zurich Labs. All weaknesses or failures discovered were analyzed and corrected.

Reliability, too, was considered. A more expensive but durable glass-laminate material is used for PC boards instead of convential phenolic material. Wide-narrow junctions in the copper pattern were tapered wherever possible to prevent hairline cracks. Components were derated to operate at less than their maximum ratings, even under worst case conditions, so they run cooler and last longer.

A major problem overcome was the mounting on the PC board of such a heavy component as the flyback transformer. In drop tests, boards broke because of the momentum of this massive component. In the new design, the flyback is mechanically supported by the rear apron (Fig. 3). The PC board slides into loose fitting rails in the cabinet and is also supported by the rear apron, which is anchored by two screws driven through the back cover. Thus, the PC board does not support the flyback at all, and drop testing has been very successful.

Serviceability

Many steps were taken to improve serviceability. The chassis layout chart inside the cabinet contains more information. Service test points are clearly identified on the PC board "roadmap," and alignment points are labeled. The board is marked and labeled according to circuit function, such as IF and sound, for quick location of problems (Fig. 4). Other labels provide additional servicing information.

The chassis slides out of the cabinet rails and tips up on its side so the bottom of the board is accessible. Since all auxiliary subassemblies plug-on, the chassis can be completely removed from the cabinet without tools and taken into the shop, if necessary. The SAW IF system is easier to align than previous circuits, another servicing plus.

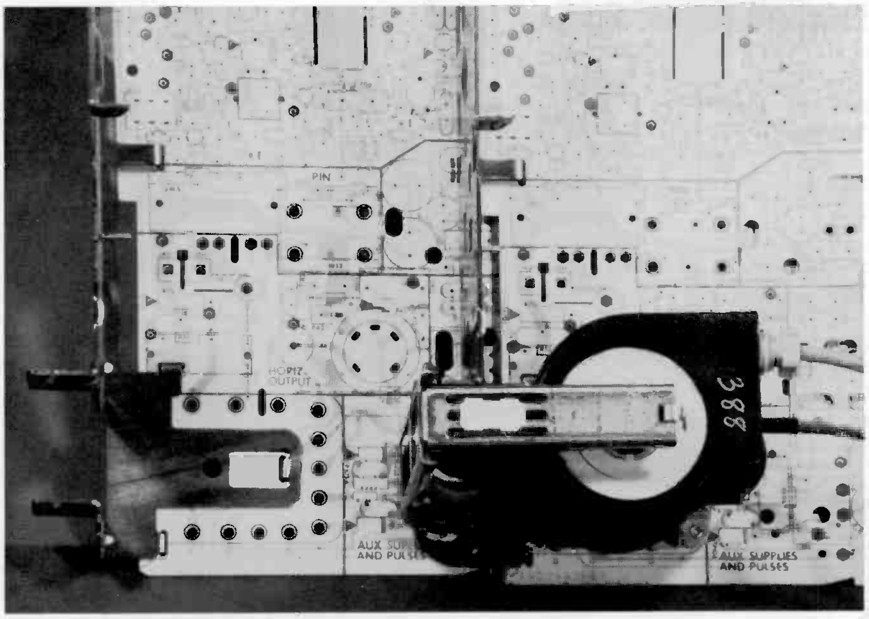

Fig. 3. The flyback transformer is electrically connected to PC board but, as can be seen in the view with flyback removed at left, it is mechanically supported by the rear apron.

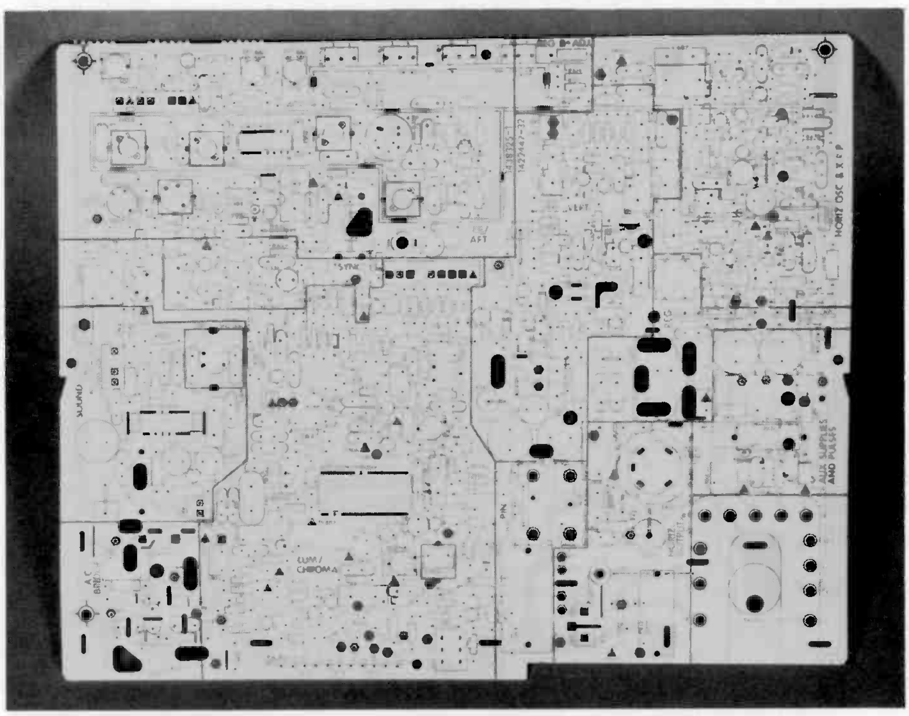

Fig. 4. The top of the bare board is replete with assembly and service information.

Remote system

The one-board approach was also applied to the remote system. The preamp and control modules were combined into one board, and the sheet metal frame stripped away (Fig. 5a). The remote board slides into rails molded into the cabinet. The remote board cables are all plug-in so that no special chassis is needed for remote.

A new scheme for controlling on/off function eliminated the step-down transformer and rectifier circuit (which powered the remote board in the "off" mode) and the relay, which provided the on-off function in previous designs. The main power supply bridge is now left on continuously, and its +150V dc output supplies power to the remote board through a simple dropping resistor arrangement. A transistor switch in the remote board turns the receiver on and off. The switch enables and disables the regulator control oscillator, which turns on or off the B+ to the horizontal output stage. Since all other supplies are derived from auxiliary windings in the flyback, removing the input pulse to the flyback effectively turns the set off (Fig. 5b).

Only one problem remained: normally, when ac is turned on, current passes through the field-neutralizing coil surrounding the picture tube until the thermistor in series with the coil heats up and opens the circuit, thus degaussing the picture tube. If the ac line is always connected to the rectifier bridge and a dc voltage turned on and off further upstream, auto-degaussing becomes a problem. The desire to maintain a common chassis for all tuning systems caused more complications.

The problem was solved by using a small PC board that plugged onto four bead-chain terminals on the main board; two terminals which the degauss coil cable plugged onto on non-remote sets and two terminals that picked up the set's 26V dc supply and ground. The 26-V supply actuated a relay in series with one side of the degauss coil (the degauss cable now plugging to the small board). When the chassis was turned off, the 26-V supply dropped out, opened the relay, and disconnected ac from the degaussing coil. This allowed the thermistor to cool and permitted degaussing when the set was again turned on.

The relay handled degaussing current and was considerably smaller and less costly than the relay that had to handle total set current in the old system. This proved to be very cost-effective, especially so since production schedules call for an

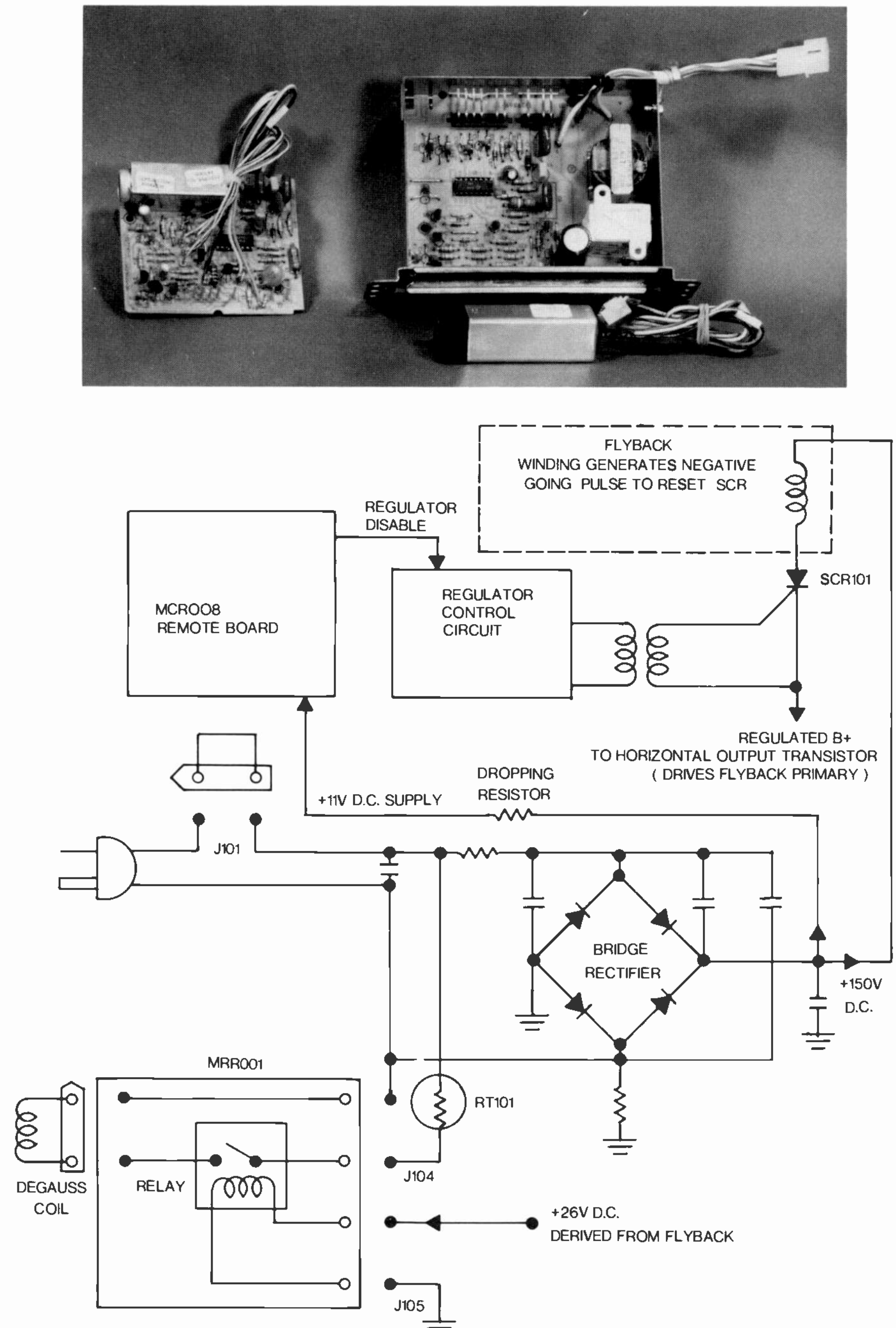

Fig. 5. Top: Size comparison of unitized MCR008 remote board (left) with the two units it replaces. Bottom: Cost effective remote turn-on circuit: ac bridge is on continuously; remote board turns regulated B+ on/off; degaussing is achieved using relay on MRR001 module.

increasing percentage of remote sets to keep up with consumer demand.

Conclusion

The CTC-107/108/109 chassis has dramatically reduced weight and material. With its excellent performance, it also has the most cost-effective design in RCA's history. The cabinets designed to house these chassis are also smaller. The CTC-108 instrument with ChanneLock keyboard tuning system has broken the 50 pound barrier for 19-inch receivers—weighs only 48 pounds. The 13-inch CTC-107 receiver is over 25 percent smaller. Of course console cabinets housing the CTC-109 chassis continue to follow conventional furniture designs.

Safety, reliability, and serviceability were of prime importance in the development of this chassis. New circuitry, notably the SAW filter IF and one chip chroma-luma system have joined time-proven circuits to boost performance while cutting size. And, a new cost-effective remote system provides an advantage in this growing market.

As for the future, plans are already underway to upgrade performance further in this extremely flexible chassis for use in some ColorTrak models.

And a deflection LSI has been designed to integrate the vertical and horizontal oscillators and regulator functions, allowing further improvements in upcoming chassis. So, it is with pride that we announce RCA's small color chassis design has a big future ahead of it!

Acknowledgment

The author wishes to thank P.C. Wilmarth for his guidance as Project Manager of the CTC-107/108/109 chassis.

References

1. Wilmarth, P.C.:"The XL-100 XtendedLife Chassis," *RCA Engineer*, Vol. 23, No. 1 (June/July 1977).
2. Giger, R.J., *The CTC 108 Training Manual*, RCA Corporation, Consumer Electronics Technical Training, Indianapolis, Ind.

John Nicholson joined RCA Consumer Electronics as a Resident Engineer in Bloomington, Ind., upon graduation from Purdue University in 1976. His responsibilities included follow-up of design-related factory problems for the CTC85/86/89/90 chassis and later for the CTC93 chassis. He transferred to the Indianapolis Project Engineering Group in 1978, where he took on his present assignment as systems design engineer for the CTC107/108/109 chassis.

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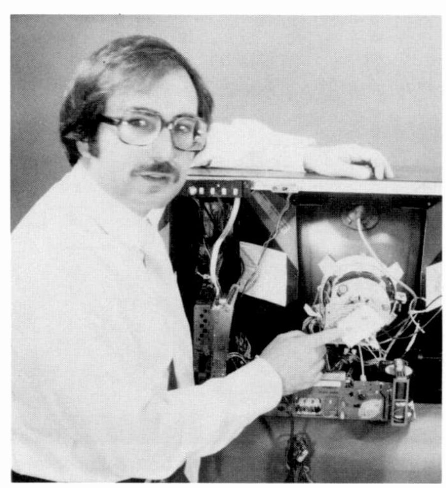

R.P. Filips

Why serviceability?

Serviceability, like performance, quality, reliability and safety, must be designed into a product.

Abstract: *Serviceability is now a prime consideration in the design of television receivers and video tape recorders. The procedures and the systems described are based on objectives aimed at bringing about improvements in the design which will ultimately reduce service costs. This is because less labor is used to repair a serviceable product. This paper describes the primary responsibilities of the Serviceability Committee and the ISCET evaluation and rating systems.*

Serviceability, in its broadest sense, means exactly what the word says—how *serviceable* is a product? Can it be fixed? Not all consumer products are serviceable, of course. Many have had serviceability designed out. These are usually (though not always) small, low-cost items that a user simply replace when necessary. More expensive products, however, must be serviceable. In fact, the serviceability of consumer products often seems to increase as a direct function of cost.

Just saying that a product is serviceable does not mean much. How many of us have opened up a supposedly user-serviceable product and had springs and gears disappear into every dark place in the room? There are degrees of serviceability, and the objective of any manufacturer of consumer goods should be to make its products as serviceable as possible.

Why is serviceability desirable?

Cost reduction is probably the most immediate benefit of serviceability. A serviceable product reduces repair costs, both for the consumer and for RCA. RCA sees savings if a product must be repaired during the warranty period, and the customer saves on repairs after the warranty period has expired.

A second benefit of serviceability, no less important than the first, is goodwill. A serviceable product generates dealer, Servicenter, and customer goodwill, and this type of word-of-mouth praise often results in increased sales.

Serviceability is a major design consideration of Consumer Electronics, primarily because a serviceable product reduces the cost of the RCA labor warranty. Assemblies and components can be replaced in less time and at a lower labor rate when they are accessible and easy to remove. Accessibility is a very important design parameter, especially in areas where high-stress components such as fuses, power-supply rectifiers, and output devices are used. An example of poor accessibility is a fuse located under a subassembly which has to be removed before the fuse can be replaced. Normally, fuses and associated parts are replaced in the customer's home at the minimum service charge. If major disassembly is required, the product will be taken to the service shop at twice the cost or more. The labor rate doubles because of component inaccessibility.

Objectives for serviceability

Serviceability, like safety, performance, and reliability, must be designed into a product. It must be a prime consideration from conception of the product until the day it is boxed for delivery to the customer. Consumer Electronics Engineering Procedure ENG-230 requires that ease of service for finished television instruments will be an important factor in instrument design. In order to accomplish this objective, formal serviceability reviews of instrument design occur as a routine part of the product development cycle. These reviews are conducted by the RCA Serviceability Committee. Once the instrument reaches the production stage, reviews and ratings are made by independent service technicians from the National Electronic Service Dealers Association (NESDA) and the International Society of Certified Electronics Technicians (ISCET).

The RCA Serviceability Committee

The primary responsibility of the RCA Serviceability Committee is to evaluate the serviceability of an instrument during its design and preproduction stages. Instruments are reviewed during the following stages of development:

- Original concept
- Engineering prototype
- Pilot model production
- Preproduction
- Production

The committee has three permanent members:

- Manager, Product Support (Chairman)
- Manager, Product Safety (Co-chairman)
- Manager, Technical Services (Canada)

Representatives of the following activities

Reprint RE-25-6-11
Final manuscript received May 10, 1979.

participate as required by the subject matter of a particular meeting:

- Cost analysis
- Design Engineering
- Distributor & Special Products Division
- Field Service Engineers
- Manufacturing Engineering
- Manufacturing Technology
- Product Assurance
- Product Planning
- RCA Service Company
- Warranty Programs

Serviceability evaluation procedure

Prior to each serviceability evaluation meeting, Product Support puts together a check list of serviceability features. This list is based on inputs from distributors, dealers, and Servicenters. An ISCET serviceability check list is also used as an evaluation tool during these meetings. During the meeting, the instrument is evaluated and rated on the ISCET Rating Form (Table I). This form lists 83 different requirements that must be met to receive the maximum serviceability rating.

Table I. ISCET serviceability rating data—RCA 19-inch color television receiver—CTC88AC chassis.

Section	*Poss. Points*	*Points by team member* 1.	2.	3.	4.	5.	6.	*Avg.*
A. Back removal	80	60	60	60	60	60	60	60.
B. Product identification	70	65	70	57	60	60	70	63.67
C. Control access. & ident.	85	83	83	83	83	83	83	83.
D. Accessibility for service & component ident.	325	295	290	258	295	285	290	285.5
E. Chassis & subassembly removal & handling	120* N/A	120	120	120	120	120	120	120.
F. Bench servicing	110	110	110	98	110	110	110	108.
G. Performance of service	270	270	270	218	260	270	270	259.67
Discretionary points + or −	(±50)	+5	+14	+23	+20	+21	+10	+15.49
Individual totals		1008	1017	917	1008	1009	1013	
Total Possible Points	*1060*	*Total points earned (team average)*						*995.33*

Serviceable point rating total.......................... 995.33

Percentage $\frac{995.33}{1060} \times 100 =$ 93.90%

Serviceability grade.. Excellent

NESDA/ISCET serviceability committee

As part of RCA's total serviceability program, the services of the NESDA and ISCET are used to inspect and rate a production instrument of each new chassis design from a standpoint of serviceability at the time of introduction to our distributors. These inspections are conducted on a voluntary basis using the services of a crew of ISCET technicians. This has proven to be valuable to RCA, to the independent service technician, and to the customer.

ISCET evaluation

After the instrument is completely developed, a production sample is submitted (at the time of introduction to CE distributors) to ISCET for an official serviceability rating. Prior to evaluating the product, the ISCET inspection team is asked to attend a technical training program on the instrument they are inspecting. This familiarizes them with the product and its serviceability features. After ISCET completes its inspection of the instrument, any serviceability rating discrepancies are reviewed with representatives of the RCA Serviceability Committee. In addition to this review, an official serviceability evaluation report is submitted to RCA covering all discrepancies and comments. The information in this report is used to improve future instruments. As an example of the effectiveness of the Serviceability Committee, RCA received the highest NESDA/ISCET serviceability rating in the industry to date.

As stated earlier, the immediate benefit of improved serviceability is reduced repair cost. There are, however, some long-range benefits. As often happens when an industry is genuinely concerned with improving a product, the strict RCA serviceability evaluations of its instruments will probably result in substantial improvements in product reliability and efficiency. For example, it may not be too long before instruments have built-in test equipment for identification of faulty components or modules. Hard-wired modules that can be easily be removed from the set in the customer's home with a soldering iron will improve serviceability. Improvements such as these are not far away. As RCA improves the serviceability of its sets, the rest of the industry will follow. The biggest winner will be the customer.

Rudy Filips, Manager of Service Support for the Consumer Electronics Div. has held his present position since 1975. He had previously been Manager of the Consumer Acceptance Laboratory for RCA Purchasing Company, NV, in Japan, from September, 1966 through March 1975, and a Field Service Engineer for the Consumer Electronics Div. from February, 1954 through August, 1966.

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The impact of regulatory requirements on TV design

To those in the television business it sometimes seems as though this is '1984,' and that somewhere there is a Ministry of Television Regulations whose business is harrassment. It may be, however, that those regulations are necessary after all.

Fig. 1. Fortunately not all the regulations in one year's *Federal Register* apply to TV receivers.

Abstract: *The controls necessary for transmitters are matched by a multitude of governmental regulations which directly affect the TV receiver industry. Technical specifications, safety, advertising and manufacturing are the areas of main impact; the first three of these are summarized here.*

It often seems that regulations, particularly Federal regulations, are symptoms of bureaucratic involvement in matters that are better left to the operation of the free market place. This article shows the pervasiveness of regulations, some of which add appreciably to the cost of TV receivers. But without some form of control the whole television industry would be chaotic. Many people oppose what they believe to be excessive regulation, but support regulations they consider reasonable. The question of when regulation stops being necessary will never be resolved. If we review just a few of the many aspects of safe, efficient, high-quality television reception, it soon becomes clear that a great deal of regulation is needed. In context of TV reception, we in the industry must assume that electricity is available in every home, or in almost every home, without appreciable failures or surges, and that it is supplied at about 120V and at a precise frequency of 60 Hz. We assume that the wiring in the home will be safe, the outlets will be standard, and that the cost of the electricity is reasonable. We assume that the television signals received are of the standard type, that the transmitters operate on their assigned frequencies, and that the signals are received from a constant direction with a constant field strength.

Obviously, transmissions must be subject to control and regulation, for it is easy to imagine our confusion if transmitters used different standards or, in the interests of competition, intentionally jammed each other. Receivers, essentially passive devices, are less obviously suited to government control.

There are at least four broad areas in which controls affect the receiver design and manufacturing business: technical specification, safety, advertising, and manufacturing. The regulations for manufacture are so extensive that they will not be considered here. Energy consumption has, in the past, been closely connected with advertising, so they are grouped together here. Power consumption is, however, now becoming a regulated technical specification.

Technical specifications

If a TV viewer's picture were interfered with by a neighbor's too powerful CB transmitter, he would complain. Not surprisingly, the neighbor with the CB is entitled to protection from interfering radiation from the TV set.

The Federal Communications Commision (FCC) has the task of regulating the amount of permissible radio frequency interference that comes from the local oscillator and from any circuits in which varying currents flow. For example, the sweep circuits are specifically mentioned in the FCC regulations, and specific limits are given for radio noise conducted into the power line. The smallest permissible free space radiation from TV receivers must be between 25 and 70 MHz and no more than 32 microvolts/meter at 100 feet from the receiver.

New specifications for test sites were proposed by the FCC in 1977 and are currently being discussed. We developed TEM cells (essentially large metal boxes simulating a transmission line and containing material that absorbs RF radiation) to test the susceptibility of our products to emanations from legal transmitters.

Other FCC regulations are designed to ensure that the UHF channels (14 through 83) are available to the public (Table I). Some years ago it was realized that the TV system would never expand into the UHF range unless broadcasters were assured of a viewing public equipped with UHF receivers. Viewers would not buy UHF-equipped receivers unless UHF broadcasts

Reprint RE-25-6-12
Final manuscript received March 11, 1980

were available. If given the choice, they would buy the less expensive VHF-only sets, and set manufacturers would not add UHF tuners to their models unless there was a customer demand. The FCC, therefore, ruled that sets sold in this country must possess a UHF capability comparable in performance to that of VHF. The following requirements have been added since that first ruling:

1. If a VHF antenna is provided, a UHF antenna must also be provided.
2. If the VHF antenna is connected at the factory, the UHF antenna must also be connected.
3. The UHF tuner noise figure shall be no more than 14 dB. This figure will probably decrease in the future. The measurement and statistical sampling techniques are spelled out in detail.
4. The picture sensitivity for UHF shall not be more than 8 dB worse than that for the VHF channels.
5. UHF and VHF tuning systems shall provide about the same degree of tuning accuracy with about the same expenditure of time and effort. This means, for example, that if the VHF channels are detented, the UHF channels must also be detented. If the VHF dial is illuminated, the UHF dial must also be illuminated.

Receivers must be certified by the FCC to ensure that they meet these and other requirements. For new models there is now an FCC Identifier number that identifies the manufacturer or trade name, the place of manufacture, and the particular model family group. You will see these FCC ID labels appearing on new sets.

RCA has well over a hundred new models every year, and is approaching a hundred families. For each family a group of documents is supplied to the FCC (Fig. 1). These include photographs, circuit diagrams, radiation measurements, and noise figure measurements. Throughout the production run for a particular tuner type the noise figures for sample sets must be measured, and the running averages and statistical distributions calculated. If the calculated number derived from these becomes higher than 14 dB, corrective action must be taken. A summary of the calculated data is sent to the FCC in an Annual Report.

Safety

The Federal agency primarily concerned is the Consumer Product Safety Commission (CPSC) which was established by Congress to protect the public against "unreasonable risks of injury" from consumer products. The Commission is responsible for over 10,000 products in about 370 product categories.

Television receivers have an excellent safety record. At one time a television receiver safety standard had been proposed, and tests were performed by the Commission's Bureau of Engineering and Sciences and by an independent contractor. Televisions fared so well that in July, 1979, the CPSC concluded that the industry was manufacturing safe sets and terminated the proceedings aimed towards a mandatory standard.

The Bureau of Radiological Health of the Department of Health and Human Services enforces regulations on x-radiation, infra-red and other emissions from TV sets. The x-radiation limit is 0.5 mR/hour at 5 cm from any point on the external surface of the receiver, and this is to be measured at supply voltages up to 130 VRMS. Tests are run with component or circuit failures that will cause maximum x-radiation emissions, and with all user and service controls adjusted to provide maximum emissions. Labels must be affixed to finished sets to warn of any failure, improper adjustment, or replacement that could cause excessive radiation.

Extensive records must be kept by manufacturers, and summaries of these must be sent to the BRH every year. Also, every model must be certified before it can be sold. This includes submission of detailed descriptions of the circuit test methods and measurements. The BRH regularly inspects the test and manufacturing facilities.

RCA and other manufacturers go to considerable effort to make their sets safe. RCA sets not only satisfy the Underwriters Laboratory standards and tests, they surpass them in many respects.

Testing is performed throughout the design phase and during initial production in the Safety and Reliability Center in Indianapolis. This includes tests on circuits, components and materials, and complete receivers. Tables III and IV give some of the requirements.

Table I. Regulatory agencies, departments and organizations.

CPSC —	Consumer Product Safety Commission
CSA —	Canadian Standards Association
DOC/BFC —	Department of Commerce/ Bureau of Foreign Commerce
DOC/ITA/OEA —	Department of Commerce/ International Trade Administration/ Office of Export Administration
DOC/PTO —	Department of Commerce/ Patent and Trademark Offices
DOE/OCSE —	Department of Energy/ Office of Conservation & Solar Energy
DOT/CS —	Department of the Treasury/ Customs Service
FCC —	Federal Communications Commission
FTC —	Federal Trade Commission
HHS/BRH —	Department of Health and Human Services/ Bureau of Radiological Health
UL —	Underwriters Laboratories, Inc.

Table II. FCC requirements.

A. EM Radiation

1. Into the power line
2. Into free space

B. UHF/VHF Comparability

1. Noise Factor
2. Sensitivity
3. Tuning ease
4. Receiver features

C. Possible Future Requirements

1. Selectivity
2. Intermodulation and crossmodulation
3. New transmitter frequency allocations

Advertising and power consumption

The engineering content of advertising aimed at the general public often appears trivial, but in fact there are numerous claims which require engineering substantiation. If these claims are inaccurate there may be a loss of consumer confidence, and penalties may be imposed by the Federal Trade Commission. The FTC Act, Section 5, says, "unfair or deceptive acts or practices in commerce are hereby declared unlawful." Case law further says that "it is an unfair practice in violation of Section 5 of the FTC Act to make a claim for a product without having a reasonable basis for making the claim. Whether or not the claim is true and the product performs as advertised, has no bearing on the violation." So not only must the claims be true but they must also be supported before an ad runs. Proving a claim is true after the ad campaign runs is not good enough.

Not only does newspaper, magazine and television advertising demand accuracy, but point-of-sale advertising, catalog sheets, hang-tags and product training bulletins carry the potential for liability if adequate substantiation is not available.

Table III. Safety requirements (CPSC/UL/CSA).

1. Double protection against electrical shock
2. Fire retardant, self-extinguishing components, circuit boards and cabinets
3. Implosion safety
4. Avoidance of mechanical hazards

Table IV. BRH safety requirements.

X-radiation limit: 0.5 mR/hour

Tests Required:

- Customers' controls misadjusted
- Service controls misadjusted
- Component tolerance limits
- Worst case failure consequences
- Life tests
- Service fail-safe
- Considerable documentation
- Etc.

For instance, a hang-tag that gives a power consumption figure must be backed by measurements of a sufficient number of sets, measured in a precisely defined manner.

As a further example, claims of improved reliability require statistical support. This is not normally available at the start of a production run, so we can only advertise "designed for improved reliability," however confident we are in the improved design, until statistical support becomes available.

The FTC had considered requiring that sets carry a large label giving the expected annual energy consumption compared with that of other sets. This program, being implemented for many consumer products, now excludes TV sets, largely through the efforts of the EIA's Consumer Electronics Group, because their power consumption is relatively low. The manufacturers have a strong interest in reducing power consumption because it means lower temperatures and greater reliability. Also, the record shows the tremendous power reduction of TV receivers since the days of tube sets.

Current RCA color sets use from about 69 to 113 watts depending on the model. At an electricity cost of 4.97 cents/kWh, and with a viewing time of 2200 hours per annum (both government supplied figures), the annual running costs of a TV are about $7.50 to $14.00. The latter figure includes the energy consumption of the remote control receiver while the set is off.

The Office of Conservation and Solar Energy in the Department of Energy is at present gathering information from manufacturers and others on the trends in energy consumption. It is possible that EIA may be able to help obtain exemption here as well. The Energy Policy and Conservation Act, as amended, requires the Department of Energy to prescribe energy efficiency standards by November, 1981. The DOE will probably propose final standards that are to be achieved by November, 1986. Intermediate standards are also likely to be proposed. Whatever these final standards are, they will vary with screen size.

The tentatively determined maximum technologically feasible energy efficiency for color TV receivers is 125 kWh/year, which corresponds to 57W if there is zero stand-by power consumption. The equivalents for B/W sets are 50 kWh/year and 23W.

Authors Clyde Hoyt and Francis Holt.

Clyde Hoyt was involved in the technical development and design of the first commercial television receivers (such as 638TS). He has been active in CE engineering and management to the present time. Mr. Hoyt is currently Manager of Product Safety and External Technical Relations.

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Conclusion

Regulations are increasing both in number and in effect. No mention has been made of the laws of individual states, controls on imports and exports, and the numerous regulations which control the work environment of the engineers and others.

The authors would like to thank Ed Evans, Gil Hermeling, Fred Korzekwa, Ken Lockhart, Lu Thomas, RCA's Law Department and many others whose work is essential to RCA's satisfying the requirements of the regulatory agencies.

J.J. Nigborowicz

Competitive Product Analysis: its effects on CE

Monitoring the progress of the TV industry keeps RCA in the forefront of the competition.

Abstract: *Competitive Product Analysis is a small group in the Consumer Electronics Engineering Department whose function is to provide meaningful information on how RCA TV design compares with the rest of the industry. The group also acts as an engineering design aid in evaluating RCA performance during the design cycle. This paper provides some insight into the duties and analytical procedures of the Competitive Product Analysis group and into other involved areas of Consumer Electronics.*

Competitive Product Analysis is an organization that has close ties with Engineering, Product Planning, Cost Analysis, Manufacturing and Reliability. It serves as a tool to aid RCA Consumer Electronics (CE) in designing and building the best television on the market. The television industry is a very competitive business. Every year it becomes increasingly more important to design a more competitive, cost-effective receiver with improved performance without sacrificing manufacturability, reliability or safety. As each year's design cycle progresses, Competitive Product Analysis serves as Consumer Electronics' eyes on the world, searching for and evaluating new ideas brought to the television industry by its competitors.

Reprint RE-25-6-13
Final manuscript received Jan. 21, 1980.

RCA versus the competition

One of the main duties of Competitive Product Analysis is to coordinate an "RCA vs. the Competition" report. A decision is made through the Competitive Analysis Committee (which is composed of members from various parts of the Consumer Electronics organization) as to which competitor or competitor's receivers should be evaluated. The decision could be based upon cursory observations of performance, cost-effectiveness, component count or just the competitor's reputation or advertising policy. Once the decision has been made, Competitive Product Analysis orders and expedites procurement of the required television receivers for analysis.

Upon arrival, the television receivers are measured for performance. Many standard tests such as transient analysis, color edge distortion, ac input power, audio power and distortion, high voltage regulation, raster distortions and many others are performed and the results stored in a computer for future reference. This affords CE quick and easy access to competitive performance information when additional product comparisons are required. With the aid of a Tektronix Digital Processing Oscilloscope, processed oscilloscope waveforms can be stored in the computer's memory, thus recording the characteristics of the receiver under test.

Along with the performance evaluation, circuit evaluation is an important part of the study. By examining circuit configurations, IC partitioning and various component parts count, the effectiveness of the manufacturer's performance/cost tradeoffs can be compared. Also, circuit ideas which appear to be clever can be further analyzed and evaluated for their merit.

Another important part of a complete competitive product analysis is a detailed cost estimate of the instrument. Here, the television under evaluation is delivered to Cost Analysis where it is disassembled and completely costed out. Since there is no way to really know another manufacturer's actual expenses in manufacturing a receiver, the analysis is performed as if the particular chassis design was being built by RCA. With this in mind, the cost of the components are designated to be RCA costs for similar parts with RCA sourcing. The results do not necessarily yield the competitor's actual cost, but serve as useful comparisons to the cost effectiveness of an RCA design. The cost study is partitioned into various circuits such as the tuner, IF, chroma, luminance, audio, power and deflection. In this way, a cost comparison can be made circuit by circuit. When major differences are found, further investigation is needed to determine the reasoning behind that design approach.

While the time consuming cost analysis is being carried out, an identical television receiver is sent to Manufacturing and Reliability for their comments. The Manufacturing group examines the

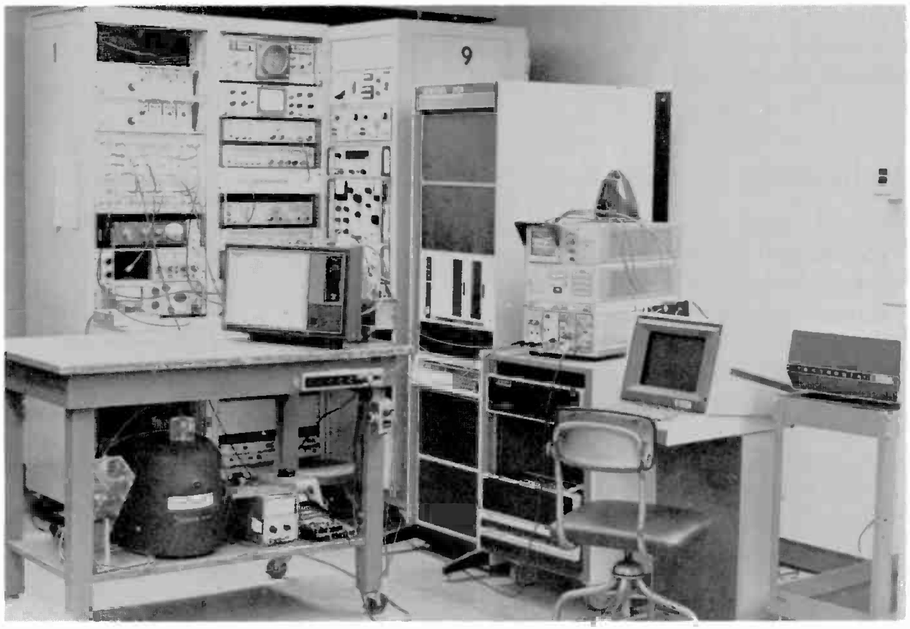


Fig. 1. Competitive Analysis computer-aided test setup.

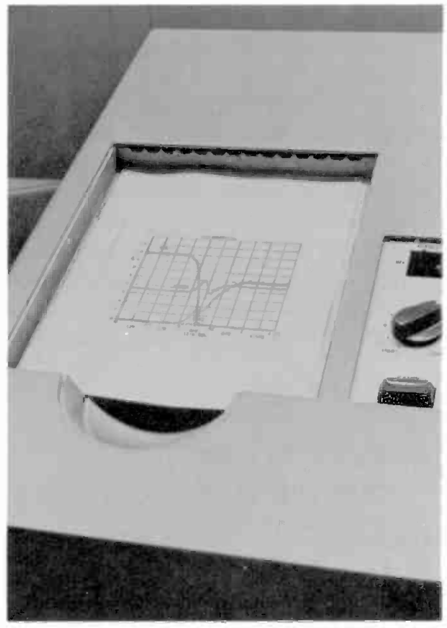


Fig. 3. Typical hard copy printout of measurement waveforms.

Fig. 2. The digital processing oscilloscope with PDP 11/34 computer.

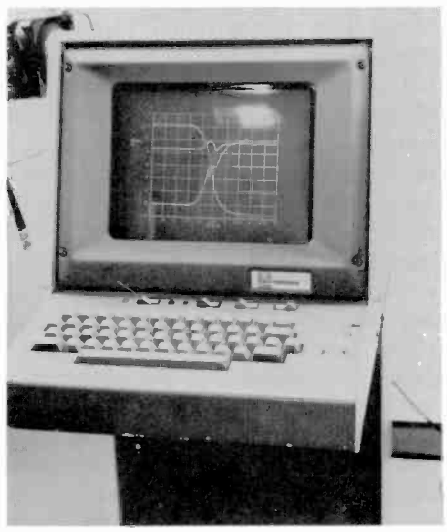


Fig. 4. CRT graphics terminal displaying averaged color transition waveforms.

product under evaluation for any new and effective assembly techniques. Primary emphasis is directed towards circuit board assembly. The components are examined for ease of automatic component insertion and solderability. The receiver is graded on chassis and instrument assembly. The Reliability group also has its turn at evaluating the competitive receiver in its area of expertise. The results could indicate problem areas of the competition or RCA which could require some attention.

With such a detailed comparison of "RCA vs. the Competition," the differences in features, performance, cost, manufacturability and reliability are spelled out. This information is useful in determining what areas of TV design need more attention.

Analysis of specific items

Full competitive evaluations are not the only assignments for Competitive Product Analysis. There are times when the complete chassis is not of particular interest. Instead, there may be a specific circuit which requires attention. The interest may be in the tuning system, remote control circuitry, signal processing circuitry or the power and deflection area. No matter what area is slated for analysis, the first step is the same: the set must be obtained for evaluation. If the circuit is new, the next step is familiarization with the design. Always, a performance evaluation of the area of interest is required. Often, if a specific type of design expertise is required, such as with tuners, aid is enlisted from the ranks of Design Engineering. From there, the analysis can go in one of two directions. The design engineer can perform all necessary tests and report the results. The other option allows the design engineer to share his knowledge and suggest useful tests and methods for completing the evaluation. Upon completion of the testing, all interested parties have access to the performance information. Usually, innovative circuits are not only examined for performance, but also for cost. If this is the case, the circuitry along with all available schematics and explanations are sent to Cost Analysis for its inputs. Such feedback could indicate potential areas for a more cost-effective design in RCA products.

Analysis in the market place

Frequently, it is advisable to examine RCA's posture in the market place. Whether the new RCA introductions are top-of-the-line or leader product, it is helpful to observe how they stack up against the available competition. This type of evaluation is what the consumer might actually see if faced with all the competition in one room. This analysis does not employ expensive test equipment, but rather only the trained eyes of the observers. Such an evaluation can be handled in two ways. The sets can be left in their out-of-the-box condition or each instrument can be adjusted according to factory specifications for optimum performance. In most cases, the latter is preferable. With all instruments operating simultaneously and displaying the same video signals, the observers can obtain a very good indication of the performance differences between the sets. A variety of test signals can offer some indication of each set's performance under most types of signal conditions. Also, the observers can get a feel for the different features offered on various receivers and the accessability of the customer controls. This type of evaluation will quickly let one know which television receivers just do not measure up. Often, such an evaluation is performed in the design stages so any indicated design changes can be implemented to help ensure a competitive edge.

Schematic analysis

Not all tasks of Competitive Product Analysis deal with the actual competitive product. Much of the efforts are devoted to information gathering. Efforts are constantly directed towards obtaining the most recent schematics available on any television receiver which might be of interest. These include not only schematics of U.S. and Japanese sets sold in the United States, but also domestic Japanese and European schematics. Many times new circuit ideas will be tried out in the foreign country before being introduced to the United States.

Besides the constant hunt for schematics, it is important to keep on top of new innovative product introductions. These are important because they do have some effect on where the schematic hunts are focused. Not only is Engineering interested in knowing what new ideas are brought to the television industry, but also in determining if any manufacturer has introduced a new idea. This is a different type of research for Competitive Product Analysis. Competitive schematics are searched to determine if someone else has already implemented a new idea. Advanced circuit diagrams might indicate the presence of some type of hidden problem not previously foreseen, thus eliminating a potential future factory problem.

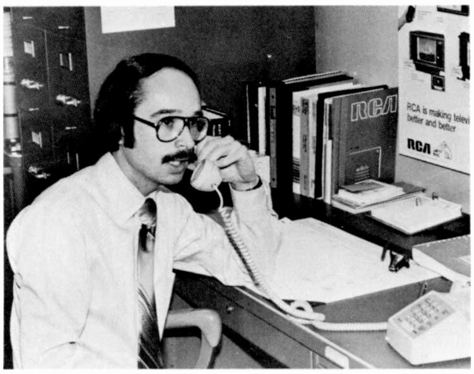
Analysis for design

Competitive Product Analysis is also used as an aid in the design cycle of RCA television receivers. With the use of the Digital Processing Oscilloscope and the PDP 11/34 computer for automatic testing, many samples of various design iterations can be measured quickly and the results stored in memory for future evaluation. Also, statistical analysis can be performed on the stored data to yield some indication of design deviations, thus helping to optimize some design parameters.

At this time, there are several automatic tests typically performed in the design cycle. The system is expanding continuously to offer more design aids to the engineering group.

Conclusion

Competitive Product Analysis does have an effect on CE. There are many television manufacturers with many good ideas. Each day, it becomes increasingly critical to monitor the progress of the rest of the industry to support our intentions of equaling or surpassing the competition.



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Resident Engineering

Resident Engineering groups at Consumer Electronics manufacturing plants provide a crucial liaison with Design Engineering in Indianapolis.

Abstract: *Design and Manufacturing must keep in close touch if a complicated product is to be made in large numbers. Resident Engineering fills the liaison function and provides engineering representation at each of the manufacturing plants. Some problems which arise in sample building and in production are referred back to the design engineers at CE headquarters; others are dealt with on the spot.*

When dealing with very high production volume, problems of communication between the Design Engineer and the manufacturing facility become especially acute. As many as 50,000 television receivers may be produced at the RCA Consumer Electronics Plant in Bloomington in one week, and at these volumes, a minor recurring problem quickly becomes a major problem. In order to keep the Design Engineering Group free to perform its intended function, a Group designated as Resident Engineering was formed. As the name indicates, this group resides at the manufacturing site. The engineers in this group are designated Liaison Engineers because of their role as primary technical communications link between Design and Manufacturing. They also must link between Resident Engineering Functions in C.E. Plants in Bloomington, Prescott, Juarez, and Taiwan. Resident Engineering is expected to provide timely technical advice to Manufacturing and Quality Control on incoming parts and on all steps of assembly, test, packing, and final shipping.

A document known as Engineering Change Notice (ECN) is the official communication from Design Engineering of changes in drawings. Every drawing change requires an ECN. Resident Engineering is responsible for reviewing each ECN for its impact upon the manufacturing operation. The Liaison Engineer will notify the factory if special action is required as a result of the ECN. The Engineer will check for factory documents that may be superseded. He will often make samples to evaluate the effect of such changes on test, assembly, and the finished product. The electrical and mechanical Liaison Engineers must be as familiar as possible with their area of responsiblity. If a potential problem can be identified before production is begun, a definite money savings can result. For example, an assembly that looks good on paper may be impractical at production line speed.

A major portion of Resident Engineering work is analyzing problems that occur in production. These problems may be caused by some part of the manufacturing operation, or defective parts, or they may have a direct design connection. When, in the judgment of the Resident Group, a problem may be design-related, action must be requested of Design Engineering. Coordination is established between the Project Engineer in Indianapolis Design Engineering and his counterpart in Resident Engineering. A joint analysis of the problem is undertaken and a resolution worked out. The resolution may be a specification change, a circuit change, a new or modified part added. It is important, at this stage, that immediate action take place. An ECN takes time to process, so a document known as a Factory Notice (FN) is initiated at the Plant. The FN is used by Resident Engineering for plant-wide communication. Information is transmitted on specification changes, part changes, trial runs, and general information. The FN is used any time that fast, wide distribution of engineering information is needed. The FN is intended to be temporary and is superseded by permanent document changes as soon as possible.

Resident Engineering obtains samples from Design Engineering for the Factory. These samples are used by Manufacturing and Manufacturing Engineering as assembly guides. Prior to turning these samples over to the Factory, Resident

Reprint RE-25-6-14
Final manuscript received April 15, 1980.

Engineering will check them against every single document existing on that item. Every screw, resistor, capacitor, and wire will be checked. All assembly drawings, schematics, part lists, and supporting paper will be checked for correct information. When all questions are resolved and all parts are correct or explained, the sample will be given to the Factory. There are always problems in starting a new model, and if paperwork errors and misunderstandings can be resolved early, the process will flow smoothly.

When starting a new television model, RCA goes through two manufacturing sample programs. The first is known as the pilot. This is basically a proof of the design, and these sets are used primarily for life testing and engineering experiments. The second sample program is known as pre-production. This is a final chance to check all Manufacturing and Engineering systems before production starts. Resident Engineering is involved in both programs. A sample of both builds will be checked for performance problems. These samples are also checked against all paperwork for deviations. Observations of problems and deviations from specification are forwarded to Design Engineering. Resident Engineering will assist Manufacturing in building the samples. This often involves staying on the line to assist in assembly and to answer test questions as they occur. Especially important is the early life testing. This is often where problems can be detected and eliminated. For this reason, Resident Engineering troubleshoots all pilot life test failures.

One pre-production sample is designated a release sample. This sample is checked for performance, appearance, lead dress, packing, and tags. It represents exactly what production will be like. Indianapolis Engineering will give the final "go" for production based upon this sample.

As noted earlier, Resident Engineering is a technical adviser to all functions of the operation. Basically, this involves answering questions about different aspects of the television operation. Often there are questions and differences of opinion over specifications. To resolve questions, Resident Engineering conducts tests and oversees or advises on experiments. This is to ensure that a final product or some sub-assembly or component conforms to specifications.

Resident Engineering evaluates the results of shipping tests on pilot, pre-production, and production instruments. Any instrument that fails these tests is analyzed to determine if the failure was due to defective materials or workmanship. In the case of defective materials, the vendors of sister plants are notified; or, if necessary, a Factory Notice is issued instructing the factory as to the rework procedure. If the failure is not related to materials or workmanship, a modification is made to the design to correct or prevent the failure.

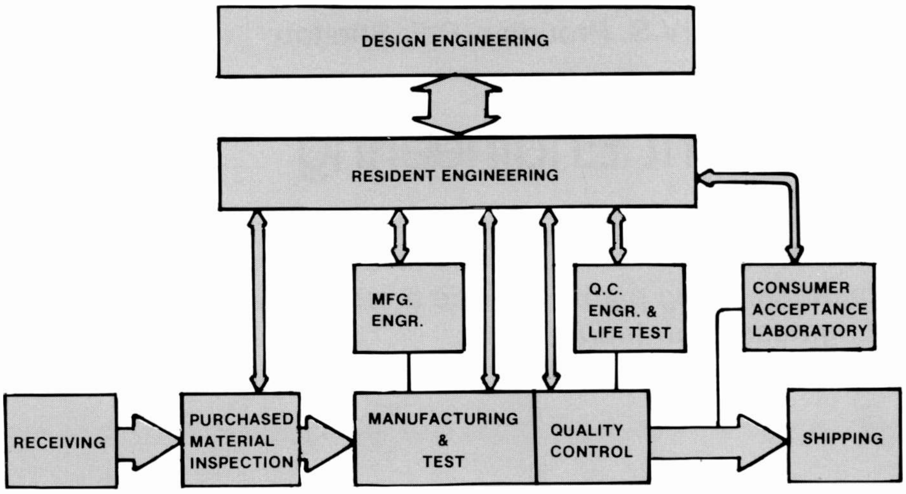

Fig. 1. Resident Engineering is midway between Design and Manufacturing.

All components and sub-assemblies used in the manufacturing assembly operation must go through several levels of approval. First, the vendor submits samples to the Design function for Engineering (E) approval. Once E approval is granted, samples are submitted to the Factory for Manufacturing (M) approval. The M approval form is issued by Resident Engineering based upon information provided by the Quality Control inspection. In those cases where a sub-assembly is a chassis made in a feeder plant, Resident Engineering does most of the testing and inspection. The Quality Control inspection of other items results in a work sheet that lists discrepancies in the part and any test that was specified but not performed. A test might not be performed due to insufficient time or lack of equipment. The Liaison Engineer must decide if the test can be omitted. He must also decide whether a particular discrepancy can be temporarily accepted or whether it justifies rejection. He may request help from Indianapolis Engineering Laboratories in obtaining measured standards. These standards can be used to calibrate the equipment for the plants.

Once components and sub-assemblies pass the E and M levels, they are approved for production. Resident Engineering may still be involved if production shipments have discrepancies. Quality Control will issue a Material Discrepancy Report (MDR) to report material failing some print specification. The Liaison Engineer must look at each MDR for its impact upon the final product. He may request additional test or samples. These investigations may result in the parts being used as is, or they may be rejected or reworked until acceptable. Sometimes parts pass all inspections and still cause problems in production. In these cases, the Liaison Engineer may recommend a rework and added specifications for the drawing.

There are times when a material substitution must be made. The correct material may not have been received, or may have been defective. Whatever the reason, if the needed material is not available, Resident Engineering must keep production moving by finding a substitute part. This may involve searching through records to find an equivalent part. In all cases, the specifications of the replacement must be carefully checked. Also, records must be checked to ensure that all applications are investigated, and if there is any possibility of a safety hazard, then Design Engineering must make the final approval.

One important advisory function is on Regulatory Agency Requirements. Resident Engineering must be well aware of U.L. requirements and the regulations of several government agencies. With help of Indianapolis Engineering, Resident Engineering is the technical link between Design Engineering and the Manufacturing facility. They will review Design documentation for problems and impact upon production. They will provide analysis of design-related problems. Resident Engineering will provide coordination for design prototypes and manufactured samples. Resident Engineering is the technical advisor to the Factories' various sections on all items relating to the product. An engineer in the Resident Group must have well-rounded general technical knowledge. He needs to be a good problem solver, with good deductive reasoning ability. He must have the ability to deal with details. Finally, the engineer must have the ability to deal with people who are all turning to him as the man with the answer.

Left to right, George Proudian, Dave Bump, Bob Shelton, Marv Norman, and Brian Pollack.

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Marv Norman joined RCA Consumer Electronics Division in 1964 as an engineer in the home office. He is presently employed as a Resident Engineer in the Bloomington plant. His previous articles in the *RCA Engineer* involved: The remote amplifier IC; and the ColorTrak television features.

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RCA Taiwan Ltd.

The Chinese environment and oriental life style of Taoyuan, Taiwan, are reflected in RCAT.

Abstract: *RCA Consumer Electronics began operations in Taiwan in 1969 with approximately 250 employees producing quite unfamiliar products. Today, the mature RCA-Taiwan plant totals approximately* 6000 employees producing all *RCA black and white TV receivers and several major color TV components. This article is an overview of the philosophy, development and maturation of RCA Taiwan, including its product lines, employee life style, and engineering organization.*

The television receiver is one of the most complex yet familiar consumer electronic products made today. The manufacturing strategy for the production of RCA color receivers involves the utilization of "feeder" plants to supply subassemblies for the Bloomington, Indiana final assembly plant and the Prescott, Ontario final assembly plant. One of these feeder plants is RCA Taiwan (RCAT). In addition to providing sub-assemblies for color televisions, RCAT has full responsibility for RCA black and white receivers from co-development, with the black and white engineering group in Indianapolis, of the instrument design to the finished product ready for distribution. RCAT also has a Solid State operation.

The history of RCA Taiwan

Consumer Electronics began its operations in Taoyuan, Taiwan (RCAT) in August of 1969 when it was allocated 10,000 square feet of manufacturing space in the Memory Products building. One hundred black and white TV receiver kits were prepared in the U.S. and sent to RCAT as training aids for the initial personnel. The sets were built and tested over and over again until the basic skills were developed.

In January of 1970, the first black and white TV receiver line was installed to produce finished instruments. Later that year, facilities were added for the manufacture of the yokes and high voltage transformers that would be used on the instruments assembled there. The high-technology manufacturing challenge extended to vendors in the area, who had as much to learn as those in the plant.

RCAT became an integrated VHF tuner manufacturing facility in 1971 when it began manufacturing tuner assemblies from the bare wafer through to the finished tuner. Prior to this, all tuners were purchased as completed units. As a part of this new experience, the first engineering "E" approvals for the VHF tuner components were issued.

The Computer Division of Memory Products closed out its activities in 1972, providing an additional 100,000 square feet of manufacturing space for Consumer Electronics. The additional space was used for Color Modules and Hybrid Color Boards. By this time, RCAT was producing most of the black and white receivers for RCA.

In 1973, a satellite plant was established in San Hsia, a small town about 18 miles from Taoyuan. The San Hsia satellite plant assembled components on the printed circuit boards for the Taoyuan plant. During this period of product and facility expansion, the engineering group had matured to the point that they were able to tool and "E" approve their first TV cabinet.

A major step in the development of RCAT took place in 1974 when the Indianapolis design engineering group designed a cabinet and overall black and white instrument while the chassis circuit design took place in Taiwan. The first Taiwan-designed sets went into production in 1975. At the same time, RCAT was given responsibility for producing the Signal Package Subassembly for color receivers. The San Hsia satellite plant was closed and two new satellite plants were established at Hsin Chu, about thirty miles south of Taoyuan, to assemble parts to printed circuit boards.

Electronic tuners were integrated into RCAT in 1976, followed in 1977 by more complex color receiver modules and subassembly support and integrated high voltage transformers. These new products brought new technologies and presented a real challenge to the mature and capable manufacturing facility. Also, the RCAT engineering group designed a new low-cost black and white chassis, a significant step in keeping that product line viable. In addition to responsibility for black and white electronics, the overall design of cabinets and instruments was shifted to RCAT.

The now mature RCAT operation is producing all RCA black and white TV receivers. This includes chassis, yokes and high voltage transformers, all RCA tuners, both black and white and color, and color receiver subassemblies and modules. The skills to produce this product mix is finely tuned with support groups in Materials,

Reprint RE-25-6-15
Final manuscript received March 11, 1980.

Fig. 1. Numerically controlled yoke winding for black and white TV receivers.

Fig. 2. RCA black and white TV receivers assembly line.

Fig. 3. Black and white TV receivers being packed for worldwide distribution.

Fig. 4. Color receiver chassis assembly was introduced in RCAT in 1977.

Purchasing, Finance, Plant Engineering and Industrial Relations. Quality and Consumer Acceptance Labs meticulously verify quality for world-wide distribution of the products.

The life style at RCAT

When RCA set up its operation in Taiwan, it did not attempt to change the culture or life style of the Chinese employees. Instead, the company designed and instituted programs that were compatible with Chinese culture and life style. This was only one of the challenges that faced the four representatives sent by RCA to begin the Consumer Electronics efforts in Taiwan in 1969. One of the original four, Loren Wolter, continues today as the President of RCA Taiwan Ltd. From a beginning of approximately 250 employees, RCAT has grown to a Consumer Electronics employment level of five Americans and approximately 6,000 Chinese. Of these, approximately 80 percent are female.

The cultural life style in Taiwan requires that an employer take a paternal attitude toward its employees. The obligations of the employer go begond the work place. A small-town-type environment must be created. RCAT has eight dormitories that house 2,500 of the female employees and the remaining 3,500 employees commute to work on sixty-five company-operated buses. Additionally, the plant complex contains a bank, post office, small shops, a library, and classrooms for various cultural programs such as sewing, flower arranging and exercise. The day shift employees work a 9.6 hour day, five days per week, while the evening shift works 7 hours, six days per week.

The RCAT engineering staff

The logistics and responsibilities of RCAT require a fairly extensive engineering organization and staff. There are approximately 100 engineers divided into three basic departments; Engineering, Manufacturing Engineering, and Quality Control Engineering. Each of these three departments has many responsibilities. The following is a brief description to the function and overall contribution of each group.

The engineering department

This department consists of five groups: Design, Components, Resident, Mechanical and Product Safety. The design engineering group began in 1975 and is subdivided into a signal group, deflection group and system and audio group. The design engineers have total responsibility for the black and white receiver design.

The components engineering group began in 1969 and is responsible for "E" approvals, vendor and home office liaison,

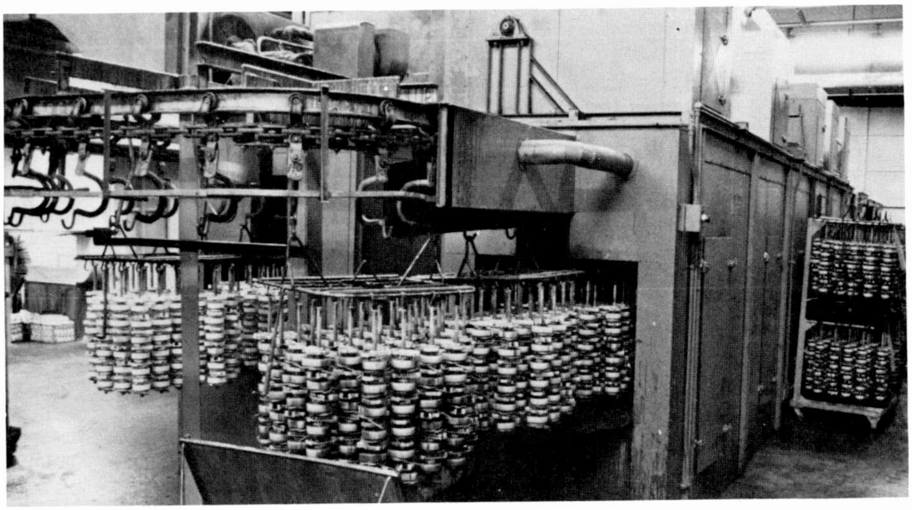

Fig. 5. Black and white TV receiver integrated high voltage transformers going into the curing oven.

and various engineering administration activities.

Resident engineering was an original function in RCAT. It began by feeding back the information on a problem to Indianapolis for a solution. It has evolved into a problem-solving group, feeding back information on the solution to Indianapolis.

The mechanical engineering group has responsibility for the non-electrical design of the black and white product, including E approvals for mechanical parts. This includes cabinets, packaging, support construction, and new model mock-ups. The objective of the product safety group is to insure that the black and white and color product meets the regulations of DHEW, FCC, UL, CSA and Home Office safety engineering requirements.

The manufacturing engineering department

This department has four groups: Process, Test, Industrial, and Mechanical. The process engineering group has responsibility for the development of detailed manufacturing processes, the resolution of daily line problems, and the development of line and work place layouts. The test engineering group operates the signal room, develops test processes, maintains test equipment, and the development and construction of computerized automatic test equipment (ATE) for RCAT.

The industrial engineering group is responsible for work factor analysis of time and motion study and the development of rates and allowances. Additionally, they conduct skills training programs and manage the technical library. The mechanical engineering group in the manufacturing engineering department operates a small machine shop for basic spare parts and simple fixtures, and supports other departments.

The quality control department

This department has four groups: Purchase Material Inspection, In-Process Control, Quality Control Engineering, and the Consumer Acceptance Laboratory. The quality control engineering group is involved with the establishment and control of tracking systems design and statistical analysis of data. They also conduct correlation studies, reliability testing, and proposed new product acceptable quality levels.

Conclusion

This article has provided a brief history of RCAT, a taste of the life style of this Chinese facility, and an overview of the engineering organization and staff that make the plant functional. With the decade of the seventies having provided an opportunity for this remote facility to mature into a significant contributor in the Consumer Electronics manufacturing strategy, RCAT looks forward to the even greater challenges of the eighties.

Acknowledgment

The authors would like to acknowledge the valuable editorial assistance of E.J. Byrum and J.A. Gross.

Back row, left to right, P.Y. Chiang, M. Chang, P. Kuo, P. Yuan, R. Chen, and W. Lee. Seated, left to right, E.J. Byrum, L. Wolter, T.T. Chang

T.T. Chang is Manager of Plant Quality Control. He joined RCAT CE Engineering in 1968.

Robert Chen is Manager of Manufacturing Engineering. He joined RCAT CE Engineering in 1970.

P.Y. Chiang is Manager of Mechanical Engineering. He joined RCAT CE Engineering in 1972.

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Mike Chang is Manager of Components, CE Engineering. He joined RCAT CE Engineering in 1969.

Peter Kuo is Manager of Resident Engineering. He joined RCAT CE Engineering in 1972.

Loren Wolter, one of the original four expatriots, is today the President of RCA Taiwan, Ltd. He joined RCA in 1959.

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Microcomputer applications in non-electronic testing

In the mechanical world, automatic test is still an emerging technology. Utilizing a background of 20 years' electronic testing experience, however, the application of computers to the demands of monitoring, testing and controlling machinery is expanding rapidly. Once the reliability and lead-time problems of microprocessor systems in an automotive environment are solved, writes Ward's Auto World, "it will be Buck Rogers all the way to the 21st century."

Abstract: *The author summarizes the prospects for automatic test equipment in mechanical applications. Emphasizing the speed with which computer and microprocessor technology has developed, especially along the paths of miniaturization and cost reduction, the discussion brings out the large savings in time and money which are emerging in systems of hand-held ATE. The author stresses the application of these equipments to vehicle engines and accessories, pointing out that, at costs far below those of conventional instruments, simplified test equipment (STE) can perform a wide variety of both mechanical and electrical tests. Specific tests are described, such as those for compression balance, timing, and engine power, and illustrations provide examples of test data. This rapidly developing technology, says the author, can bring an end to the costly and inefficient "diagnosis by replacement" approach so prevalent in the military.*

Changing microcomputer technology

It is interesting to look back to the time, only 20 years ago, when we programmed automatic test equipment by punching holes in Remington Rand cards. Design of airborne computers still incorporated vacuum tubes, and the integrated circuit was just being invented.

In the early 1960s, we at RCA were building what may have been the first microcomputer, the AM 3210 (Fig. 1). This small computer was constructed from micromodules the company had developed for the Army. These micromodules were made from miniaturized parts which would fit into a 3/8-inch cube, or module, to make up gates, flip-flops and drivers. The modules were then assembled in egg-crate structures and stacked to make a 2/3-cubic foot computer, for use in an advanced stellar inertial guidance system being developed by the Air Force. These computers cost a quarter of a million dollars each in 1961 dollars (when gasoline was selling as low as 15 cents a gallon in Texas) so even the Air Force winced at the thought of paying for them.

By 1970, however, Control Data Corporation was making a computer 1/27th the size, for $45,000. This CDC 469 computer (Fig. 2) was used by RCA in ATE/ICE, the first automatic test system developed by the Army for the testing of internal combustion engines. Microcomputer technology development was beginning to accelerate. Only five years later RCA designed a computer which cost $230, for use in the first hand-held automatic test system for internal combustion engines. This computer (Fig. 3) contains an RCA 1802 microprocessor, ROMs, RAMs, decoders and I/O ports, on a six-layer printed board.

Today, one can pick up almost any trade journal and find advertisements for computers, only slightly bigger than the micromodule, for $2 or $3 each (Fig. 4). Twenty years ago we put one gate in a module. Now, we can put in 3,000, and the experts predict that that figure will rise to 100 million.

Decreasing hardware costs and increasing computational power have led to ever more and broader applications, with software's share rising, at times, to above 80 percent of total system cost. *Business Week* pointed out, in March of 1979, that "by the mid-1980s, complete mini-computer-sized systems will be fabricated on a single chip. A user may spend $150,-000 on software to run a $10 device." In view of these developments, we are taking a much more careful look at hardware-software tradeoffs, and hardware ways to save software costs — a complete reversal of the trend of ten years earlier. A recent

Reprint RE-25-6-16
Final manuscript received Oct. 26, 1979.
This article is based on his keynote speech at the ATE Seminar held in Danvers, Mass. on June 4, 1979.

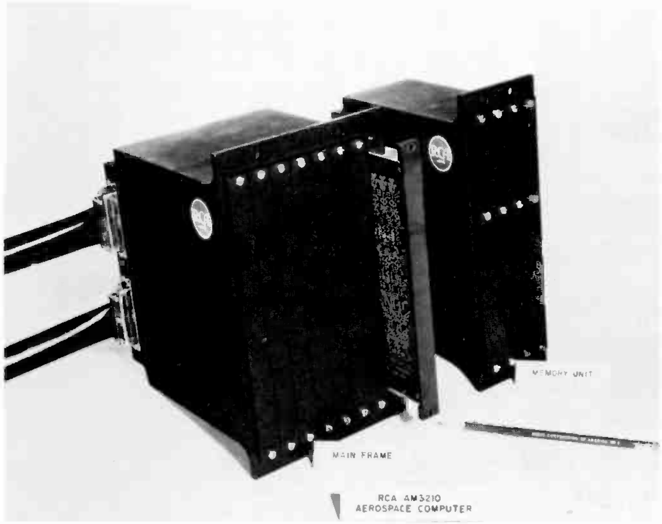

Fig. 1. The AM 3210, possibly the first microcomputer, was designed by RCA in the early 1960s.

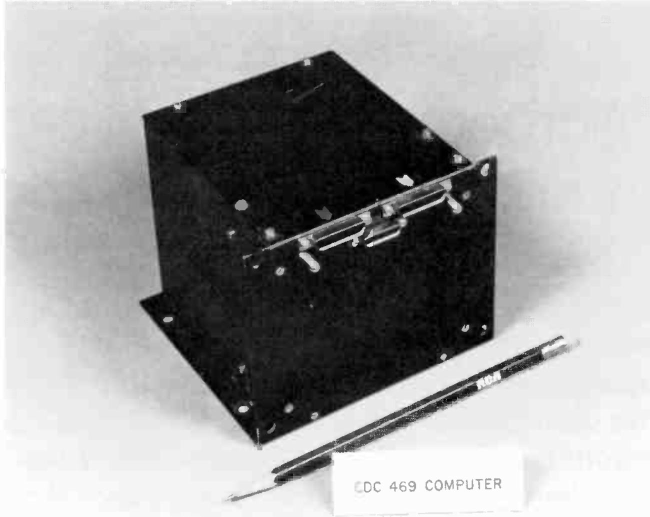

Fig. 2. The CDC 469 computer, used in the ATE/ICE program.

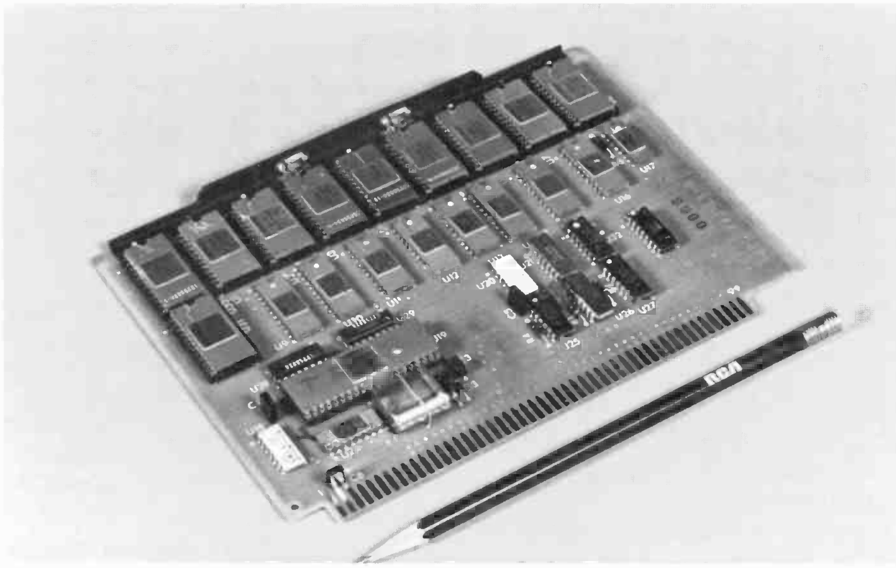

Fig. 3. The RCA 1802 Simplified Test Equipment Computer, heart of the first hand-held automatic test system for internal combustion engines.

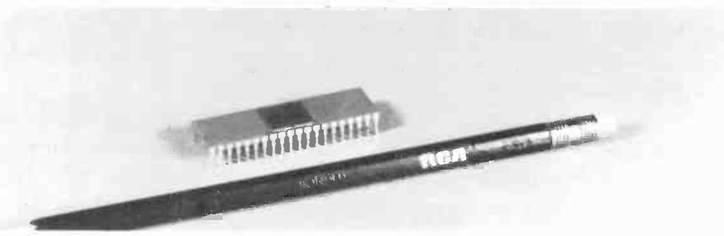

Fig. 4. The National COP 400, an example of the current crop of small, inexpensive computers.

article by M.J. Gilbert in this journal[1] provided an example of one extreme in the decreased use of software, describing a computer-controlled automatic tester used at Automated Systems that executes 64,000 tests in one-quarter of a second and has only *one* programmed instruction.

Non-electronic testing

Non-electronic testing represents a very narrow portion of a broad spectrum of computer applications, ranging from information-oriented computer processing on one end to the measurement and control of physical processes, on the other. It is an emerging technology which requires a whole new and innovative look at the way we test and analyze the performance of machinery, new techniques that depend on electrical and computer, as well as mechanical, technology. Non-electronic testing involves the merging of three engineering disciplines: mechanical, electrical, and computer science. This does not mean that each practitioner in this field must be proficient in all three areas of knowledge, but there certainly must be a basis for mutual understanding, and some sharing of concepts. Typically, mechanical engineers who work in this environment seek out formal training in electrical engineering or computer science. It is not unusual to find a mechanical engineer programming digital filter designs to facilitate engine timing analysis on a starter voltage waveform, or an electrical engineer taking a course in internal combustion engine design.

For five years, engineers at RCA Automated Systems have been applying microcomputer-based technology to simplify the testing and monitoring of gasoline, diesel and turbine engines and engine accessories. Hand-held automatic test equipment, served by kilobytes of memory, has replaced existing test equipment one hundred times its size, and tests which took hours, sometimes days, to perform are being completed in seconds. Compression balance is measured by analysis of the vehicle battery voltage, horsepower is determined by use of the vehicle ignition instead of a dynamometer, and a failing battery is detected by starter current analysis.

A good introduction to the subject of non-electronic applications of automatic test equipment can be obtained by considering the variety of non-electronic test systems that Automated Systems has been working on.

- *ATSJEA*, or Automatic Test System for Jet Engine Accessories is a multicomputer, multiprogrammed system that tests jet engine fuel controls, which are hydromechanical computers (Fig. 5). The system has a computer room, a power room and multiple test stands, with each test stand as large as a small bedroom. It has a program computer which will run up to 40 test stands from different stages in the same program, or from 40 different programs, at the same time. It also has one or more control computers to maintain the programmed environment for each group of four test stands. Future systems like this will be stand-alone, each test stand with its own microprocessor control system. Jet engine fuel controls will be electronic, operating under microprocessor control.
- *ATE/ICE* (Automatic Test Equipment for Internal Combustion Engines) was an early automatic test system for field maintenance of internal combustion engines (Fig. 6). ATE/ICE used the CDC 469 computer and contained tape cassettes which interactively walked a mechanic through vehicle diagnostic procedures.
- *Non-Contact* test equipment (Fig. 7) uses the microprocessor for deep engine diagnostics by analyzing harmonic signals in the vehicle exhaust stream. Similar testing has been run at the engine's oil filter and air inlets.
- *VMS* (Vehicle Monitoring System, Fig. 8) is the largest microprocessor-based monitoring system developed at RCA to date. It has 32,000 words of memory on two 5x7 printed boards and a full-fledged real-time multitasking operating system. The vehicle monitor unit was developed to study the use, abuse, and maintenance of vehicles, and resides in a vehicle for up to a month, scanning, processing and managing data from over thirty transducers and eight modes of vehicle operation. Repair information can be entered into the data entry unit by the mechanic. The data retrieval unit facilitates self-test, program loading and data retrieval for computer analysis.
- *STE*, the Simplified Test Equipment system, represents the way of the future in field testing, especially in non-electronic testing. It has excited both the generals and the GIs. STE (Fig. 9) is less than one-half cubic foot in size and weighs ten pounds. It is simple to use, has only four switches and a display, and can perform hundreds of tests. It comes with a transducer kit and cables, and can be used in a diagnostic connector mode or in a transducer kit mode. (All future Army vehicles will have diagnostic connectors.) The set can be produced in quantity for less than the cost of a conventional CRT ignition analyzer, and can be programmed to execute tests normally requiring equipment many times its cost. It can perform complex tests, and read out in mechanics' units. It can autorange, scan for max points, interleave functions, dynamically compensate for signal biases, tell if it's being incorrectly used and say so. STE can perform *mechanical* tests: speed, power, pressure, temperature, balance, level, and flow — and *electrical* tests: voltage, current, and resistance.

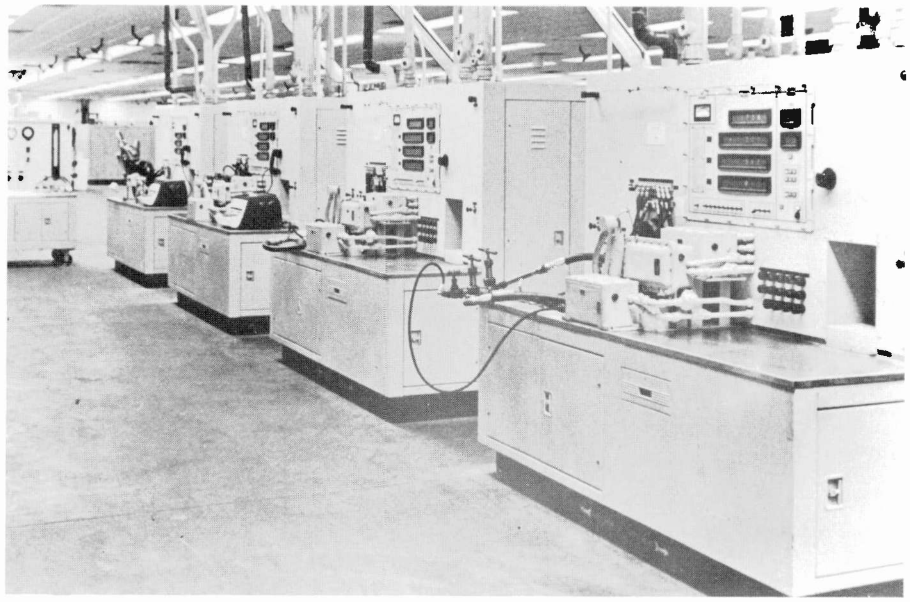

Fig. 5. ATSJEA computer room and test stands, comprising a system for testing jet engine fuel controls.

STE is a conservative design. The hardware has only four boards and contains only the bare essentials, with expansion space for memory and signal conditioning. Self-teaching and automatic features minimize the problems GIs typically have with interpolating readings on gauges, selecting scales, and connecting equipment up. Fourteen uniquely

Fig. 6. Automatic Test Equipment/Internal Combustion Engines, shown in operation on Army vehicles.

Fig. 7. Non-contact testing: analyzing harmonics in the exhaust stream.

defined test interfaces enable the testing of 14 generic classes of vehicles, such as spark ignition, small diesel, large diesel, turbine-equipped, etc. A resistive code differentiates one vehicle type from another, allowing software to execute a different set of tests at each interface. Some of the interfaces are electrically oriented, others are mechanical. By moving the vehicle test meter (VTM) from one diagnostic connector to another, a different set of tests and conversion constants is brought into play.

The need for non-electronic testing

Experience shows that on complex equipment, 60 to 90 percent of the mean-time-to-repair is spent determining the cause and location of a malfunction. In the automotive area the practice has been, and still is, to diagnose by replacement, generally by rote, on a hit-or-miss basis, until the symptoms have been alleviated. This is an expensive process.

In the 1960s a group in the Army, called the Brown Board, sought to find out more about the high cost of fleet maintenance. It found that maintenance cost came to approximately one-third of the vehicle replacement value *each year*. Moreover, it was found that 40 percent of the components in the scrap pile were good, and of the 40 percent, 89 percent were either engines or engine accessories. The waste involved is shown in the following examples:

- 57 percent of the scrapped carburetors were good
- 46 percent of the replaced electrical parts were good
- 20 percent of the engines were in good or excellent condition.

Currently employed test equipment is 40 years old. It is very difficult to use with present technical manuals. The high incidence of replacement of good components, noted above, indicates that this test equipment is not effective. In armored vehicles, in particular, restricted access is a problem, and the time needed to obtain access for test purposes is often equal to time to replace. Equipment and procedures are not adapted to the organizational mechanic's real-life problems.

The Army needed test capability of a kind that would *avoid diagnosis by replacement*. It needed a *simplified test equipment interface* to gain accessibility. Required was a *small, lightweight, dependable* unit that could be taken into the field under battle conditions.

Developing non-electronic test equipment

Developing practical requirements is probably the most important single factor in the success of non-electronic test equipment. To promote this on STE, the GI, the Tank Automotive Research Command, and RCA worked together continually, throughout the program. The focus was always on the field user, with freedom allowed to adjust the requirements as necessary, in whatever way feasible, to meet the user's needs. The task group was allowed to write the specification. The approach used was strikingly similar to that advocated by Ken Schoman during an IEEE software engineering lecture series held at Burlington in spring, 1979: (1) don't constrain your design, (2) understand the real problem, and (3) select the best approach.

Developing non-electronic test software

Fig. 8. Vehicle Monitoring System hardware, boasting 32,000-word memory, aids study of vehicle use, abuse, and maintenance.

Fig. 9. Simplified Test Equipment (STE/ICE) is small and easy to use, yet performs hundreds of mechanical and electrical tests.

is both an analytical and an empirical process. Computer models provide effective tools to study machinery characteristics and to design new test techniques. The model considers physical configuration, mechanical and thermal dynamics, fluid flow, electrical system, injection system, etc. Outputs from the math model (Fig. 10) effectively illustrate machinery dynamics under fault conditions.

Tests written in FORTRAN can be exhaustively verified on the computer before they are ever coded in the language of the tester. Inserting faults in engines, for example, is difficult and time-consuming, sometimes taking several days, and has to be redone every time an algorithm is changed. On the model, in contrast, it is only a matter of changing an input parameter at the terminal.

In real life, however, the waveforms have a high noise and harmonic content, sometimes completely masking the data of interest. If it were not for the model, many factors in developing test technology would have been completely overlooked. Knowing what to look for, we can design so as to process the data by hardware or software, whichever is best in the given case. Data is acquired on analog tape, verified on a plotter, reduced and stored on disk for use in further algorithm refinement. Over 1,500 vehicle data runs are currently on file at Automated Systems. We can make an algorithm change, and, overnight, check it against every vehicle and fault on file. This is important when you consider that some of these vehicles are as far away as San Jose, California, and it takes several days to baseline a vehicle and insert the faults.

Typical non-electronic testing algorithms

The illustration in Fig. 11 presents an actual plot of battery voltage at various stages of amplification, filtering, and processing, before the data is ready for analysis. Engine compression balance is tested in this fashion from battery voltage alone. When the starter is engaged, battery voltage falls rapidly, and the cranking ripples are evident. Sometimes they are only one-tenth of a volt. Hardware and software filtering and processing are necessary to bring out the useful features. After processing, we can see distinct compression peaks (Fig. 11). STE/ICE calculates the percent compression unbalance from these peaks and displays it to the operator in units specified by the vehicle manufacturer.

Timing is a measure of the dynamic relationship of the ignition primary waveform (points-opening signal) and the starter voltage peak. The test was run with the engine cranking and the ignition inhibited. The starter voltage signal is fed through a low-pass filter and digitized. The digitized starter voltage data is then further processed by a recursive digital filtering algorithm to smooth out higher-frequency variations caused by the rotating commutator bars of the starter. The timing angle calculation (in degrees) compensates for two major effects: speed variations (varying torque loads), and phase shift of current peak (eddy current electromagnetic phenomenon).

The ignition engine power test is interesting because of the ingenious way it uses the vehicle's frictional forces to measure the vehicle's power. The graph in Fig. 12 shows typical torque curves for a four-cylinder jeep engine. Indicated torque is the total power the engine produces. Frictional torque is the power lost to friction in the engine, accessories, etc. Brake torque is the remaining usable power. When running a power test, igni-

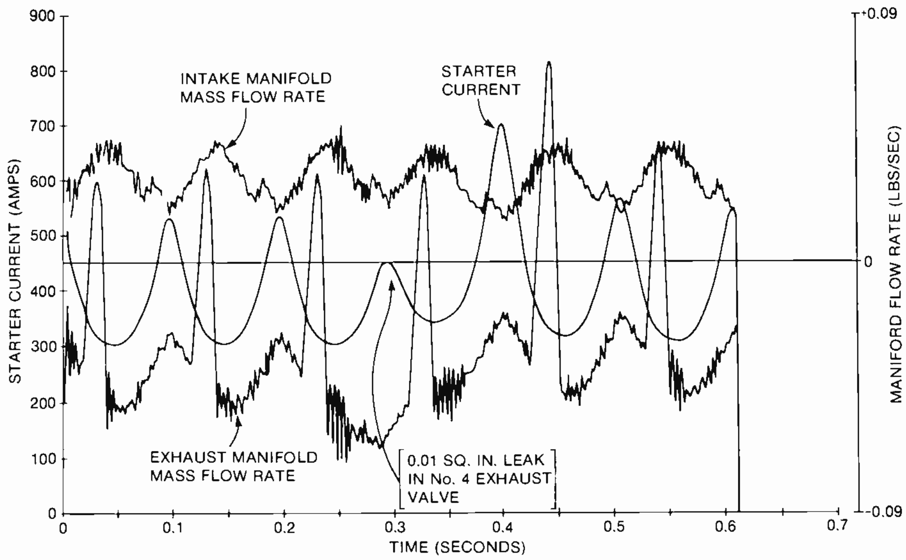

Fig. 10. Mathematically-modeled cranking engine waveforms.

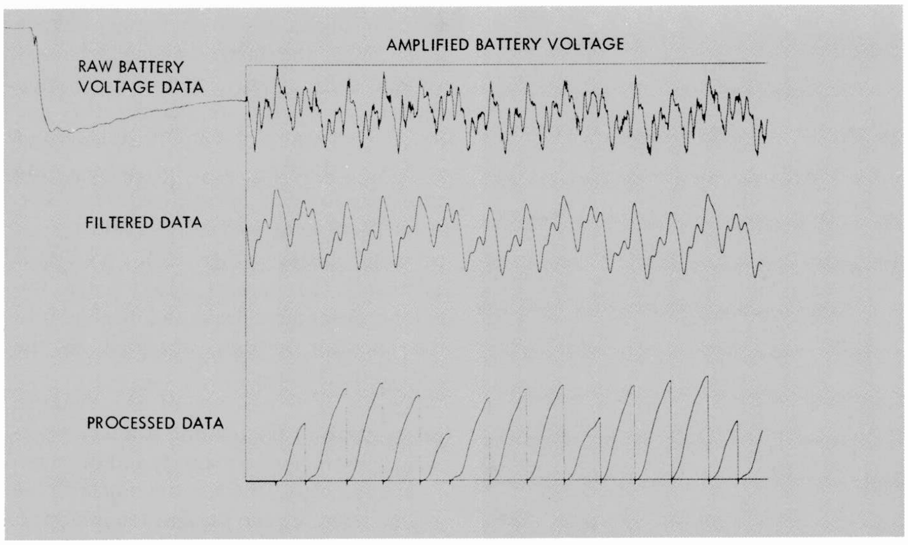

Fig. 11. Battery voltage plot at various stages of processing, data which enables testing of engine compression balance from battery voltage alone.

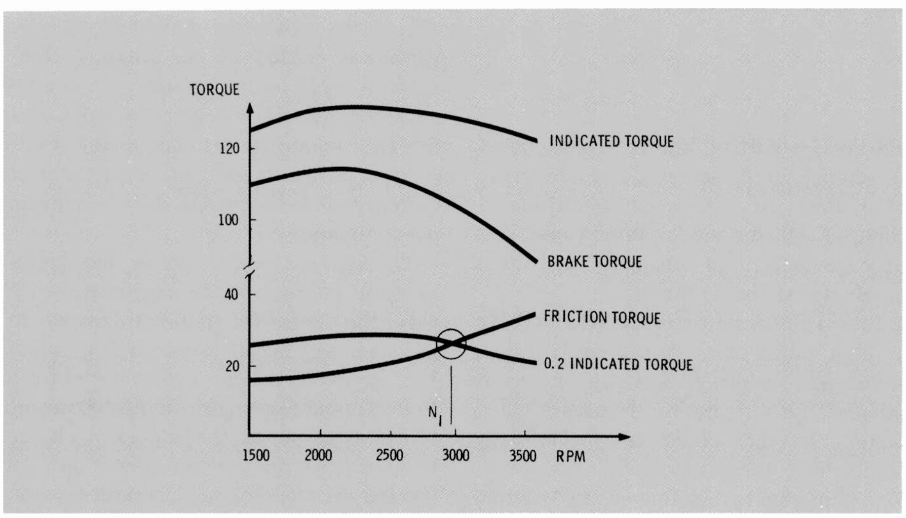

Fig. 12. Typical torque curves for 4-cylinder jeep engine. STE/ICE ingeniously uses vehicle's frictional forces to measure its power.

tion firing is interrupted until equilibrium is reached between the total power generated by the engine and the power lost to friction in the engine and accessories. In the jeep, the interrupt ratio is four out of five. Full IHP is then five times the FHP, and BHP is IHP minus FHP. When a test is run this way, it is run at wide-open throttle, giving full fuel and full air flow.

The test is started from idle by depressing the accelerator to the floor. At 3600 r/min, the tester automatically inhibits firing until an equilibrium condition is reached between the power being generated (indicated hp) and the frictional forces (frictional hp) in the engine. In a four-cylinder engine, this point is reached by firing one out of every five plugs, in firing order. After stabilizing, the ignition interrupter is shut off, allowing the engine to accelerate above equilibrium, where it is cut completely. The deceleration is measured as the equilibrium speed point is passed.

Frictional horsepower is then computed from the rotational moment of inertia (a vehicle constant) and the deceleration rate. Horsepower is displayed in percent of rated power. Previously, it was necessary to remove the engine or drive the vehicle on a dynamometer, to acquire the same information.

Starter waveforms as seen at the battery (Fig. 13) can be used to extend the range of a current probe, check the condition of a battery, check its charge, or check the starter current. For example, if we measure the voltage at the starter current peak and the rate of change of battery internal

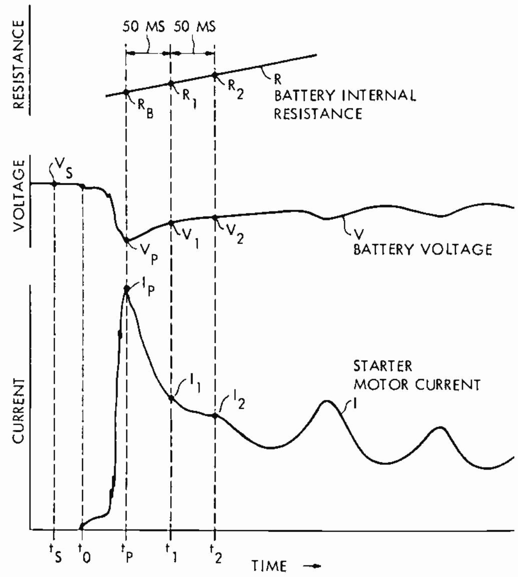

Fig. 13. STE/ICE starter waveform analysis provides a check of starter current, battery condition and charge, and can extend the range of a current probe.

Fig. 14. Simplified Test Equipment for the Army's XM1 tank contains 190,000 bytes of memory and has expansion capability.

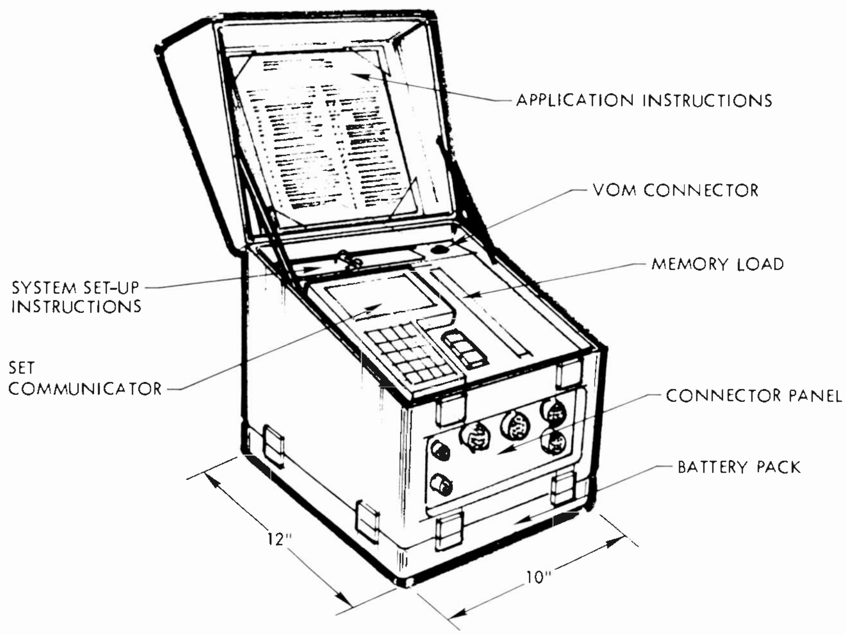

Fig. 15. Artist's conception of the microprocessor ATE of the future, which will service all new organizational combat and tactical vehicles.

resistance (by Ohm's law), we can compute the current peak beyond the range of the current probe. The internal battery resistance is a measure of the percent charge in a battery, and the battery resistance slope is a measure of the ampere-hours capacity of the battery.

New microcomputer applications in non-electronic testing

RCA is currently expanding the simplified test equipment capability to the complete vehicle and to the XM1 tank. Testing will encompass engine, transmission, electrical turret control, stabilization, and fire control systems. Three RCA 1802 microprocessors are used in the STE/XM1 system (Fig. 14), currently under development for the Chrysler Corporation. STE/SM1 contains 190,000 bytes of memory, with expansion capability.

A new microprocessor ATE is in the definition stage (Fig. 15). This test system combines all features previously mentioned, including plug-in solid state memory, two-way multiplexing and distributed computing, and interactive hand-held communication. Systems like this will service all new organizational combat and tactical vehicles.

On-board monitoring and prognostic systems that use new types of distributed microprocessor architecture and new machinery testing technology for engines, pumps, compressors, hydraulics, etc., are currently being studied and developed at RCA. This work will optimize machinery performance, alert operators of impending dangers, and feed larger data-base computers for control of total systems. In these future systems, maintenance will be scheduled by prognostic methods using trending and geriometric techniques. In this way, machinery will be kept in a maximum state of readiness without the need for "scheduled" maintenance.

Reference

1. M.J. Gilbert, "Automatic ROM Tester," *RCA Engineer*, Vol. 25, No. 3 (Oct./Nov. 1979), p. 67.

Henry Fischer, Manager of Design Engineering, Automated Systems, Burlington, joined RCA in 1959. Among his earlier responsibilities at RCA, he had charge of systems application and self-test programming of the Automatic Programmed Checkout Equipment for the Atlas missile. In later assignments, he was responsible for studies and design of a micro-modularized, general purpose aerospace computer. Managerially involved in RCA test equipment development for the U.S. Army since 1963, Mr. Fischer has had leadership responsibilities in the EQUATE program and in the ATE/ICE vehicle diagnosis system. Most recently, he was responsible for the development of the 32,000-byte RCA 1802 microprocessor-based vehicle monitoring system, and of production hardware and diagnostic firmware for the STE/ICE vehicle test system.

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G.J. Giering|K.S. Mango

Manufacturing attributes performance summary — MAPS

The MAPS report reduces the internal scrap and rework costs at the source and reduces field failures and warranty usages.

Abstract: *The MAPS report, discussed in this paper, assures that scrap, rework and warranty costs have adequate visibility. The actual cost of a product is compared to the theoretical cost by product grouping, by processing areas, and by the responsible manufacturing engineer. The MAPS report, in reality, works on a close to zero defect manufacturing quality cost comparison. By comparing the actual cost versus theoretical cost, built-in standards for manufacturing inefficiencies do not mask the magnitude of potential quality cost improvement.*

The ability of a manufacturing organization to control and improve yields, quality, and costs is highly dependent on timely application of management attention and organizational priorities to the proper areas of opportunity. The ability to make timely and proper priority choices depends on accurate and timely communication of operating performance at all levels of the organization.

The Electro-Optics and Devices (EOD) plant produces several hundred different tube types simultaneously. Quantities vary from a few units per month with unit costs of over $1,000 to types running at thousands of units per month at unit costs of less than $10. Technologies and disciplines involved cover a wide range of materials and processing skills. Managing such a complex operation places a severe burden on everyone involved. Quick recognition of developing problems, identifying opportunities, and tracking daily performance can be a monumental task. Success depends on performance feedback to every level of the organization from line worker to manager. Performance feedback must be at a level of detail appropriate to the needs of each level and each skill specialty.

It was this need that led to the creation of the manufacturing attributes performance summary (MAPS). The first objective was to satisfy the need of engineering to identify the amount, source, and cost of reject product. Supervision used the same detail report to identify operator training and control needs. Summary reports enabled management to track performance, spot trends, forecast, and to deploy assets. The MAPS system that has evolved has become a valuable and integral part of the information system that has resulted in steady manufacturing performance improvements.

Reprint RE-25-6-17
Final manuscript received Oct. 15, 1979.

Overview

The prime objective of the MAPS system is to provide timely and accurate performance feedback to the appropriate levels of the manufacturing chain. MAPS was developed in Lancaster and operates on the Corporate Time Sharing Computer of Telecommunications And Computer Services (TACS) located in Cherry Hill, New Jersey. It consists of conversational interactive APL work spaces which are accessed by telephone lines from Lancaster, Pa.

The system is totally product counting, sorting, and reporting. This is accomplished by an algorithm of APL functions designed to evaluate attribute data collected at key in-process skill centers. Performance can be judged by percent defective data statistical comparison to established attribute process capabilities, theoretical dollar losses and material variances.

The series of reports selectively generated by MAPS is uniquely organized to present an overview of the accumulated data as well as the detail required to plan for improved performance. As applied to Lancaster's Electro-Optics manufacturing departments, these reports permit a quick, current, accurate assessment of performance for:

1. The factory operation as a whole;
2. The product lines within the factory;
3. The subproduct lines; and
4. The individual subtypes within the subproduct lines.

MAPS summary

A typical summary report (Table I) supplies the reader with an accumulation of data organized to reflect overall factory operations. The line entries, which appear in the body of the report as subproducts, result from separate reports that will be discussed later. The subproduct reports contain the detail necessary to generate the overview presented in the summary. Performance of the product lines appears as subtotals and the data for the entire factory are represented by the bottom line grand total.

With some study, this summary report

Table I. MAPS time period summary. See glossary below for a commentary on the table headings.

Report	*Gross Qty*	*Gross Rej*	*Gross %*	*PBAR %*	*Stat*	*Salv*	*Qual Rej*	*Net Good*	*Net %*	*Theo Loss*	*Mat Var*	*T-Loss / Net*
Sub 2	932	305	32.7	32.7	IC	179	98	708	24.0	20261	3369	28.62
Sub 5	3343	1481	44.3	39.5	HI	1149	279	2732	18.3	14492	(71)	5.30
Sub 1	1103	488	44.2	35.4	HI	215	86	744	32.5	13135	(1332)	17.65
Sub 7	2978	683	22.9	30.9	LO	354	50	2599	12.7	11548	6999	4.44
Sub 6	4863	749	15.4	18.0	LO	241	10	4345	10.7	7972	3829	1.83
Sub 4	8193	3076	37.5	33.2	HI	2553	558	7112	13.2	4497	(319)	.63
Sub 3	64	44	68.8	30.0	HI			20	68.8	1277	(1025)	63.87
Sub 8	2252	102	4.5	8.0	LO	159		2309	(2.5)	(1292)	13173	(.56)
Prodline 1	23728	6928	29.2	28.4	IC	4850	1081	20569	13.3	71891	24623	3.50
Sub 11	1362	259	19.0	22.0	IC			1103	19.0	26733	(12373)	24.24
Sub 10	292	87	29.8	38.0	IC	10		215	26.4	22697	1922	105.57
Sub 14	131	33	25.2	14.6	HI			98	25.2	9819	(4587)	100.19
Sub 12	245	84	34.3	31.6	IC	48		209	14.7	5002	1702	23.94
Sub 13	184	9	4.9	16.8	LO	1		176	4.3	1778	1089	10.10
Sub 15	98	3	3.1	3.5	IC			95	3.1	1221	967	12.85
Prodline 2	2312	475	20.5	23.4	LO	59		1896	18.0	67250	(11280)	35.47
Factory	26040	7403	28.4	27.9	IC	4909	1081	22465	13.7	139141	13343	6.19

reveals immediate information pertinent to the various levels of management. For example, the operations manager can determine the status of performance at each or all levels of the organization by comparing current yields (gross and net percent) with the established capabilities (PBAR). The statistical analysis (Stat), in fact, highlights significant shifts in performance. Consistent with significant shifts will be the impact on theoretical dollar losses (Theo Loss) and changes in material variances (Mat Var) which ultimately reflect the efficiency of the factory operation.

As used in Electro-Optics at Lancaster, this summary report focuses attention where it is needed, brings pressure to bear down the chain of responsibility, and then becomes the tool to measure the effectiveness of the attention it invoked.

The product line manager, meanwhile, views the report in terms of his product line responsibilities, where the contribution of each of the subproduct lines must be evaluated. The subproduct lines are ranked by theoretical losses and indicate potential targets for cost reduction through improved manufacturing methods. Equally important to the product line manager are the yield calculations and material variance figures — the measure of efficiency for the specific product line compared to standard costs.

Product line 1, overall, appears to be in reasonably good shape—performance is in control, the net yield is respectable, material variance is positive. In truth, however, four of the eight subproduct lines are statistically out-of-control high (HI) and show negative material variances. While the figures are not proportionately alarming, attention is called for.

Product line 2 shows a different set of circumstances. The overall yield has improved significantly (LO) with only one of the subproduct lines in statistical difficulty; yet, the material variance stands at minus $11,000. Clearly, the data are wrong unless the established capability exceeds the standard scrap allowance. Indeed, this is the case. Subproduct line 11 was previously called to attention and became the subject

Glossary of report columns

Table I: MAPS Summary

Report — Designates a subproduct line grouping of subtypes.
Gross Quantity — The total number of units produced within the subgroup.
Gross Reject — The total number of rejects found in the Gross Quantity.
Gross % — Initial percent rejects.
PBAR %—Established historical average percent defective for all the subtypes included in the subgroup.
Statistic — Statistical comparison of actual performance and established capability. HI signifies statistically higher than capability. IC signifies in-control; LO signifies statistically lower than capability.
Salvage — Total number of units tested OK after rework.
Quality Rejects — Total number of defectives rejected at pre-ship test.
Net Good — Total shippable units.
Net % — Final percentage rejects.
Theoretical Loss — Theoretical cost of net rejects.
Material Variance — Cost of net rejects factored by allowable shrinkage.
Theoretical Loss per Net — Theoretical loss. Net good.

Table II: Subproduct Line Report*

Rejects — Designates specific cause for reject.

Figure 1: Theoretical Loss Report

Subtype — Identifies a specific subtype.
Subreport — Identifies the subproduct line.
Skill Center — Identifies processing center responsible for the theoretical losses.
Theoretical Loss — Losses associated with the specific subtype within designated skill center.

*Most column headings agree exactly with MAPS report except for the reject columns.

Table II. Results from subproduct line 14. See glossary on p. 69 for comments on the table headings.

Subproduct line 14—total from start to end time period.

Sub-Type	*Gross Qty*	*Gross Rej*	*Gross %*	*PBAR %*	*Stat*	*Salv*	*Qual Rej*	*Net Good*	*Net %*	*Theo Loss*	*Mat Var*
Type 1	6	2	33.3	8.6	IC			4	33.3	542	(350)
Type 2	85	13	15.3	16.6	IC			72	15.3	3990	(90)
Type 3	40	18	45.0	11.2	HI			22	45.0	5287	(4147)
Total	131	33	25.2	14.6	HI			98	25.2	9819	(4587)

Subproduct line 14—skill center A from start to end time period.

Sub-Type	*Gross Qty*	*Gross Rej*	*Gross %*	*PBAR %*	*Stat*	*Rejects A1*	*A2*	*A7*	*Salv*	*Qual Rej*	*Net Good*	*Net %*	*Theo Loss*
Type 1	6			.6	IC						6		
Type 2	85	2	2.4	1.1	IC	1		1			83	2.4	614
Type 3	40	3	7.5	.6	HI		3				37	7.5	881
Total	131	5	3.8	.9	HI	1	3	1			126	3.8	1495

Subproduct line 14—skill center B from start to end time period.

Sub-Type	*Gross Qty*	*Gross Rej*	*Gross %*	*PBAR %*	*Stat*	*Rej B3*	*Salv*	*Qual Rej*	*Net Good*	*Net %*	*Theo Loss*
Type 1	6	1	16.7	2.9	IC	1			5	16.7	271
Type 2	85			5.4	IC				85		
Type 3	40	11	27.5	2.4	HI	11			29	27.5	3231
Total	131	12	9.2	4.3	IC	12			119	9.2	3502

Subproduct line 14—skill center D from start to end time period.

Sub-Type	*Gross Qty*	*Gross Rej*	*Gross %*	*PBAR %*	*Stat*	*Rej D2*	*Salv*	*Qual Rej*	*Net Good*	*Net %*	*Theo Loss*
Type 1	6			.1	IC				6		
Type 2	85	8	9.4	.1	HI	8			77	9.4	2456
Type 3	40	4	10.0	.1	HI	4			36	10.0	1175
Total	131	12	9.2	.1	HI	12			119	9.2	3630

of priority programs to close the gap between actual performance and capability. The excessive variance was expected and the summary report measures the effectiveness of improvement programs. On the other hand, subproduct line 14 has had a shift in performance and attention is required.

Subproduct line report

The questions that arise from shifts in performance cannot be answered directly from the MAPS summary report. Which particular tube types contribute negatively to the subproduct line results? What is the nature of the problem? Where should effort be directed in order to remedy the situation? The results from subproduct line 14 (Table II) will serve as a good example to demonstrate MAPS' ability to answer these important questions.

Subproduct line 14 is composed of subtypes 1, 2, and 3. The sum of activity by subtype is first displayed. The accumulated results are exactly as reported in the MAPS summary report and the same appraisal techniques apply to this report. The performance of the subproduct line is most heavily influenced by the performance of subtype 3.

To ascertain the nature of the problem, MAPS, as planned, provides a capsule of information for the major skill centers that process these subtypes. In this case, subtype 3 is out-of-control high (HI) in three skill centers. (Centers not relevant to this discussion have been omitted in Table II.) Not one, but rather three distinct problems related to three separate skill centers have been uncovered.

To narrow the search even further, the "Rejects" columns in the skill center capsules disclose the specific defects which caused the subtypes to be rejected. It now becomes a management decision to rearrange priorities, if the magnitude of the problem warrants. At Electro-Optics, the subproduct lines under the domain of a product line manager are controlled by type engineers who must then interface with the technical personnel within the skill centers to resolve the problems.

Figure 1 displays, in ranked order, the subtypes which account for 80 percent of the total "bucket scrap." The theoretical losses are measured against 100 percent yield, as opposed to variances and statistics which are used to judge performance against established standards.

The prime use of the product and subproduct line reports is to emphasize

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problems resulting from a change in performance. The theoretical loss report identifies the major contributors to losses regardless of present state of the art. This report serves to assist management in longer range objectives and programs directed toward finding the "bucket of gold" which could be obscured by the other reports.

System support and credibility

The utilization of the reports is proportional to their credibility. Credibility is dependent on supplying accurate information on schedule. Both of these factors are dependent on the diligence and knowledge of each contributor in the support chain. Computer software assures proper sorting, accumulation, and calculations using the supplied inputs. Programs can be written to challenge input errors within predetermined boundaries; however, accuracy rests primarily in the hands of the system support personnel. With proper training and sufficient experience, a "This can't be right" syndrome develops and many errors are challenged and corrected before they become part of the reports. While the ability to question input data must be developed by each contributor, this ability must be highly developed particularly by the individuals that input the data directly to the computer.

Theoretical Loss Report

Sub Type	*Sub Report*	*Theo Loss*	*Skill Center*
S123	Sub10	12086	T
V004	Sub11	10739	B
123A	Sub5	6515	E
•	•	•	•
•	•	•	•
•	•	•	•
Type3	Sub14	3231	B*
•	•	•	•
•	•	•	•
Type2	Sub14	2456	B*
•	•	•	•
•	•	•	•
•	•	•	•
etc.	etc.	etc.	etc.

*Relative position of sub types cited in narrative.

Fig. 1. The subtypes which account for 80 percent of the total "bucket scrap" are displayed in ranked order in this theoretical loss report. See glossary on p. 69.

The final check and balance, in Electro-Optics, rests on the shoulders of the in-process quality control technicians assigned to the individual product lines. They are intimately familiar with MAPS, production records, product schedules and flow. Any suspect data are investigated prior to input and the reports are audited prior to issue. The results are better than 95 percent accuracy and virtually unchallenged credibility.

Conclusion

Quality and reliability assurance (Q&RA) has a responsibility to assure that quality costs are continuously under management scrutiny and control. In this regard, there are several different categories of quality costs. Internal and external failure costs are two of the largest categories. These costs may be better known as scrap, rework and warranty costs.

It is the responsibility of the quality and reliability organization to assure that these costs have adequate visibility. The MAPS report performs this function. The actual cost of product is compared to the theoretical cost by product grouping, by processing areas, and by the responsible manufacturing engineer. The theoretical cost, by definition, is the cost of making a product with approximately zero material scrap and 90 percent labor efficiency. Therefore, the MAPS report, in reality, works on a close to zero defect manufacturing quality cost comparison. By comparing the actual cost versus theoretical cost, built-in standards for manufacturing inefficiencies do not mask the magnitude of potential quality cost improvement.

A very significant part of the report is that the costs are ranked in a Pareto type of analysis. The Pareto principle is that a small percentage of the defect items will contribute a large percentage of the total loss. The report ranks by item the major loss areas accounting for 80 percent of the total loss. This ranking gives management a useful tool to properly define cost effective priorities.

The proper assessment of internal failure costs is important because high internal failure costs have a direct correlation with field product failures and their associated failure costs. High percentages of internal failures, with associated scrap and rework, mean increased field failures and customer dissatisfaction. This is due to the fact that 100 percent screening of product at the end of the line is not 100 percent efficient. Most screens at best are 90 percent efficient. Therefore, if a screen must remove, for example, 30 percent defective product, approximately 3.0 percent would pass through the screen and be received by the customer. Not only does this mean that the customer would get an objectionable percentage of defective product, but screening costs become excessive. A properly-run quality system must be dedicated to reducing the internal scrap and rework costs at the source. In the final analysis, this is the most cost effective and profitable way to run an operation and, at the same time, have customers who are satisfied with the product quality and reliability.

The MAPS report, as attested to by manufacturing management, has certainly helped in analyzing, reducing and controlling internal failure costs. Field failures and warranty usages have also been reduced with implementation of the MAPS program.

Dates and Deadlines

Upcoming meetings

Ed. Note: Meetings are listed chronologically. Listed after the meeting title (in bold type) are the sponsor(s), the location, and the person to contact for more information.

JUL 13-18, 1980—**Power Engineering Society Summer Meeting** (PE) Radisson Hotel, Minneapolis, MN **Prog Info:** John M. Thorson, Jr., Control Data Corp. HQA032, P.O. Box "O", Minneapolis, MN 55440, (612) 853-6079

AUG 12-15, 1980—**Joint Automatic Control Conference** (CS ASME, AIAA, ISA) Sheraton Place, San Francisco, CA **Prog Info:** Prof. David Hullender, Dept. of ME, Univ. of Texas, Arlington, TX 76010, (817) 273-2561

AUG 18-22, 1980—**Intersociety Energy Conversion Engineering Conference (IECEC)** (IEEE, ED, AES, AIChE, ASME, SAE, AIAA, ACS) Olympic Hotel, Seattle, Washington **Prog Info:** Sidney W. Silverman, 19630 Marine View Drive, SW, Seattle, Washington 98166, (206) 773-2457

AUG 26-29, 1980—**Parallel Processing** (IEEE, C) Boyne Highlands, Harbor Springs, MI **Prog Info:** T. Feng, Dept. of Computer Science, Wright State University, Dayton, OH 45385, (513) 873-2498

SEP 8-10, 1980—**Engineering in the Ocean Environment (Oceans) '80** IEEE COE MTS) Olympic Hotel, Seattle, Washington **Prog Info:** Dr. Stanley R. Murphy, Dire. of Div. of Marine Resources, Univ. of Washington, Seattle, Washington 98105, (206) 543-6600

SEP 16-18,1980—**Weatern Electronic Show and Convention (WESCON)** (IEEE L.A. & SFPAC Councils, ERA Northern & Southern CA Chapters) Anaheim, Convention Center, Anaheim, CA **Prog Info:** F.T. Anerews, Jr., Bell Labs, Whippany, NJ 07981, (201) 386-2460

SEP 17-19, 1980—**30th Annual Broadcast Symposium** (BCCE) The Washington Hotel, Washington, D.C. **Prog Info:** Robert A. O'Connor, CBS TV Network, 51 W. 52nd St., N.Y., NY 10019, (212) 975-3791

SEP 22-28, 1980—**COMPCON Fall '80** (C) Capitol Hilton, Washington, DC **Prog Info:** Harry Hayman, COMPCON Fall, P.O. Box 639, Silver Spring, MD 20901, (301) 439-7007

SEP 23-25, 1980—**ESMO-80** (IEEE, PE) The Sheraton O'Hare, Chicago, IL **Prog Info:** A.A. Chase, Tech. Program Chairman, c/o Northeast Utilities Service Co., P.O. Box 270, Hartford, CT 06101, (203) 666-6911, ext. 5305

SEP 27-28, 1980—**Frontiers of Engineering in Health Care** (IEEE, EMB) Washington Hilton Hotel, Washington, D.C. **Prog Info:** L.E. Ostrander, PhD., Center for Biomedical Engineering, Rensselaer Polytechnic Inst., Troy, NY 12181, (518) 270-6548

SEP 29-OCT 3, 1980—**Industry Applications Society Annual Meeting** (IA) Stouffer's Inn, Cincinnati, OH **Prog Info:** William L. Wachs, 4701 Marburg Ave., Cincinnati, OH 45209, (513) 841-8477

OCT 1-3, 1980—**Circuits and Computers, Intl. Conf. (ICCC)** (IEEE, CAS, Reg 1, Mid-Hudson Sect., C) The Rye Town Hilton Inn, Port Chester, NY 10543 **Prog Info:** Dr. NB Guy Rabbat, IBM Corp., D/818, B/300-45A, Hopewell Junction, NY 12533, (914) 897-8126 (business); (914) 297-5315 (home)

OCT 1-3, 1980—**21st Foundations of Computer Science Annual Symposium** (IEEE C) Lake Placid, N.Y. **Prog Info:** Prof. Ronald V. Book, Dept. of Math & Comp Science, Univ. of Calif., Santa Barbara, CA 93106, (805) 961-2778/2171

OCT 1-3, 1980—**Fault Tolerant Computing Systems (FTCS 10)** (IEEE C) Kyoto, Japan **Prog Info:** Prof. John Meyer, Dept. Elec. & Computer Engineering, Univ. of Michigan, Ann Arbor, MI 48109, (313) 763-0037

OCT 5-8, 1980—**Electronic and Aerospace Systems Convention (EASCON)** (AES, Wash. Sec.) Stouffer's Inn, Washington, D.C. **Prog Info:** Mr. Robert S. Cooper, V.P., Satellite Business Systems, 8003 W. Park Drive, McLean, VA 22102, (703) 827-2000

OCT 6-7, 1980—**Local Computer Networks Fifth Conference** (IEEE C) Minneapolis, MN **Prog Info:** Dr. Abe Franck, UCC, Univ. of Minnesota, 227 Experimental Engr., 208 Union Street, SE, Minneapolis, MN 55455

OCT 7-9, 1980—**Electromagnetic Compatability Symp.** (IEEE EMC) Baltimore Hilton, Baltimore, MD **Prog Info:** Paul Newhouse, IIT Research Institute, ECAC/North Severn, Annapolis, MD 21401, (301) 267-2453

OCT 15-17, 1980—**Canadian Communications and Power Conf.** (Reg. 7, Montreal Section) Montreal, P.Q., Canada **Prog Info:** George Armitage, IEEE Canada Office, 7061 Yonge Street, Thornhill, Ontario, Canada, L3T 2A6, (416) 881-1930

NOV 2-5, 1980—**Computer Applications in Medical Care** (IEEE C, EMB, Washington Section, GWU Med. School, SOC. Intern. Med., MUMPS User Group, Med. College of Va.) Capital Hilton Hotel, Washington, D.C. **Prog Info:** Harry Hayman, P.O. Box 639, Silver Spring, MD 20901, (301) 439-7007

NOV 3-5, 1980—**Automatic Support Systems for Advanced Maintainability (AUTOTESTCON)** (IEEE, AES, IM, Washington Sect., AIAM) Sheraton Park Hotel, Washington, D.C. **Prog Info:** M. Myles, Chairman, AUTOTESCON, Suite 901, 1735 Jefferson Davis Highway, Arlington, VA 22202, (202) 692-3148

NOV 6-8, 1980—**MIDCON Electronic Show & Convention** (IEEE, Region 4 & IEEE Chicago & Dallas Sections, ERA Mid-USA Council, ERA Chicago & SW Chapters) Dallas Convention Center, Dallas, TX **Prog Info:** Dale Litherland, Electronic Conventions, Inc., 999 N. Sepulveda Blvd., El Segundo, CA 90245, (213) 772-2965

NOV 11-13, 1980—**Cherry Hill Test Conference** (IEEE C, Phila. Section) Phila., PA **Prog Info:** Joseph B. Tomei, Program Chairman, Sperry-Univac, P.O. Box 245, Chalfont, PA 18914, (215) 542-5070

NOV 12-14, 1980—**Engineering Management Conference** (IEEE EM, Boston Sect.) Colonial-Hilton Inn, Wakefield, MA **Prog Info:** Mr. Palo Pierce, P.O. Box 361, Acton, MA 01720, (617) 263-3577

NOV 30-DEC 3, 1980—**Thirteenth Annual Workshop on Microprogramming** (IEEE, C) Broadmoor Hotel, Colorado Springs, CO **Prog Info:** Harry Hayman, P.O. Box 639, Silver Spring, MD 20901, (301) 439-7007

NOV. 30-Dec. 4, 1980—**National Telecommunications Conference** (IEEE AES, COM, GRS, Houston Sect.) Shamrock Hilton, Houston, TX **Prog Info:** Dr. Harb. S. Hayre, General Chairman, Univ. of Houston, EE Dept., Houston, TX 77004, (713) 749-4503/4534

DEC 1-4, 1980—**Pattern Recognition** (C) Konover Hotel, Miami Beach, FL **Prog Info:** Harry Hayman, 5th Pattern Recognition, P.O. Box 639, Silver Spring, MD 20901, (301) 439-7007

DEC 1-5, 1980—**Symposium on Distributed Data Aquisition, Computing and Control** (IEEE C) Miami Beach, FL **Prog Info:** Harry Hayman, P.O. Box 639, Silver Spring, MD 20901, (301) 439-7007

DEC 8-10, 1980—**Int'l. Electron Devices Meeting** (IEEE ED) Washington Hilton Hotel, Washington, D.C. **Prog Info:** Melissa Widerkehr, Courtesy Associates, 1629 - K

St., NW, Washington, DC 20006, (202) 296-8100

DEC 9-11, 1980—**Position Location and Navigation Symposium (Plans '80)** IEEE AES) Atlantic City, NJ **Prog Info:** Mr. Edward Yannuzzi, Naval Air Development Center, Deputy Director, Command Projects, Code 10, Warminster, PA 18974

DEC 10-12, 1980—**Decision & Control** (CS) Albuquerque Inn, Albuquerque, NM **Prog Info:** Prof. P.R. Belanger, Dept. of Elec. Engineering, McGill Univ., 3480 University St., Montreal, P.Q. H3A 2A7, Canada

JAN 27-29, 1981—**Reliability & Maintainability Symposium** (IEEE R, ASQC, AIAA, AIIE, ASME) Philadelphia Marriott, Phila., PA **Prog Info:** K. Greene, OUSD (R&E)—DMSSO, Two Skyline Place, 5403 Leesburg Pike, Falls Church, VA 22041

FEB (no publication scheduled)—**Aerospace and Electronic Systems Winter Conv. (WINCON)** (AES, Los Angeles Council) **Prog Info:** Henry Oman, Meetings Coordinator (AES), Boeing Aerospace Co., Box 3999, Seattle, WA 98124, (206) 773-8962

FEB 18-20, 1981—**Intl. Solid State Circuits Conference** (IEEE SSC, Council New York Sect.) Hyatt Hotel, New York, NY **Prog Info:** J.A.A. Raper, Chm., General Electric Co., P.O. Box 1122, Syracuse, NY 13201; Inform., contact: Lewis Winner, 301 Almeria Ave., Coral Gables, FL 33134, (305) 446-8193

FEB 21-26, 1981—**COMPCON Spring '81** (C) **Prog Info:** Harry Hayman, P.O. Box 639, Silver Spring, MD 20901, (301) 439-7007

MAR 9-12, 1981—**Software Engineering 5th Int'l. Conf.** (IEEE C) Town & Country Hotel, San Diego, CA **Prog Info:** Harry Hayman, Software Engineering, P.O. Box 639, Silver Spring, MD 20901, (301) 439-7007

MAR 30-APR 1, 1981—**IEEE Int'l. Conference on Acoustics, Speech and Signal Processing** (ASSP) Sheraton-Atlanta Hotel, Atlanta, GA **Prog Info:** Prof. Ronald W. Schafer, Dept. of Elec. Engr., Georgia Institute of Tech. Atlanta, GA 30332, (404) 894-2917

APR 7-9, 1981—**ELECTRO** (IEEE Reg. 1, CEN, New Eng. Councils & IEEE METSAC Sect., ERA, New Eng. & New York Chapters) Coliseum & Sheraton Center, New York, NY **Prog Info:** Dale Litherland, Electronic Conventions Inc., 999 N. Sepulveda Blvd., El Segundo, CA 90245, (213) 772-2965

APR 13-15, 1981—**Technological Policy Conference** (IEEE TAB/USAB) Hyatt Regency Washington, 400 New Jersey Ave., NW, Washington, DC **Prog Info:** Mr. Leo C. Fanning, IEEE USAB Office, 2029 K St., NW, Washington, DC 20006, (202) 785-0017

MAY 4-7, 1981—**Offshore Technology Conference** (IEEE COE, MTS, AIME) Houston, TX **Prog Info:** Offshore Technology Conference, 6200 Central Expressway, Dallas, TX 75206, (214) 361-6604

MAY 19-21, 1981—**National Aerospace & Electronics Conf.** (IEEE AES, Dayton Sect.) Dayton Convention Ctr., Datyon, Ohio **Prog Info:** NAECON, 140 E. Monument Ave., Dayton, Ohio 45402, (513) 223-6266

MAY 19-21, 1981—**Intl. Telecommunications Energy Conference (INTELEC)** IEEE COM, IEE, IERE) Royal Lancaster Hotel, London, Eng. **Prog Info:** Secretariat—INTELEC '81, IEE Conference Dept., Savoy Place, London, WC2ROBL, England or Mr. I.G. White, British Post Office, Rm 107, Leith House, 47/57 Gresham St., London EC2V 5JL, U.K.

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Advanced Technology Laboratories

G.J. Ammon

Wideband optical disc data recorder systems—IEEE Section Mtg., Univ. of Penna., Phila., Pa. (1/15/80)

A.F. Cornish

A microprocessor architecture for digital signal processing—IEEE Workshop on Microprocessors in Military and Industrial Systems, Johns Hopkins Univ. Applied Physics Lab., Laurel, Md., *Proceedings* (1/15-16/80)

R.F. Kenville

Digital data storage on optical discs and information display—IGC Conf., Outlook for Optical and Video Disc Systems and Applications, Miami, Fl. (2/20-22/80)

Automated Systems

L. Arlan

Electro-optic products and systems—IEEE, Southeastern Massachusetts Univ. (2/27/80)

L. Arlan|M.J. Cantella
T.J. Dudziak|M.J. Krayewsky

High resolution computer-controlled television system for hybrid circuit inspection—Optics in Metrology and Quality Assurance, Los Angeles, Ca. (2/4/80)

M.J. Cantella|J.J. Klein, *et al.*

Thin diode platinum silicide IR CCD focal plane—Society of Photo-Optical Instrumentation Engineers Symposium, Los Angeles, Ca. (2/4/80)

N.L. Laschever

Productivity, competition and innovation—Editorial for the *IEEE Reflector* (2/80)

N.L. Laschever

Proposed policy on engineering technology—Editorial for the *IEEE Reflector* (1/80)

Broadcast Systems

R.M. Unetich|D.D. Harbert

Automatic power level control and VSWR protection of modern television transmitters—IEE Conference, London, England (3/24/80)

Laboratories

R. Amantea

An approximate closed-form model for simulating thyristor forward-blocking characteristics—*IEEE Transactions on Electron Devices*, Vol. ED-26, No. 11 (11/79)

I. Balberg

A study of the electronic structure of a-SI:H by tunneling—*J. of Non-Crystalline Solids* 35 & 36 (1980) 605-610

D. Botez|F.W. Spong|M. Ettenberg

High-power constricted double-heterojunction AlGaAs diode lasers for optical recording—*Appl. Phys. Lett.* 36(1) (1/1/80)

R.S. Crandall

Electronic transport in bandgap states of hydrogenated amorphous silicon—*J. of Non-Crystalline Solids* 35 & 36 (1980) 381-386

R.V. D'Aiello|P.H. Robinson|D. Richman

Epitaxial solar cells on titanium-doped silicon substrates—*J. of Electronic Materials*, Vol. 9, No. 2 (1980)

J.G. Endriz|S.A. Keneman|C.A. Catanese

Feedback multiplier flat-panel television: I—system design—*IEEE Transactions on Electron Devices*, Vol. ED-26, No. 9, (9/79)

J.J. Hanak

Stacked solar cells of amorphous silicon—*J. of Non-Crystalline Solids* 35 & 36 (1980) 755-759

M.L. Hitchman

A consideration of the effect of the thermal boundary layer on CVD growth rates—*Journal of Crystal Growth 48*, pp. 394-402 (1980)

M.L. Hitchman|M.T. Gale|J.R. Sandercock

Calibration standards for surface profile monitors—*J. Phys. E: Sci. Instrum.*, Vol. 13 (1980)

M.L. Hitchman|J.M. Hale

Some considerations of the steady-state and transient behaviour of membrane-covered dissolved oxygen detectors—*J. Electroanal. Chem.* 107 pp. 281-294 (1980)

M.A. Lampert

Fate of the Coulomb singularity in nonlinear Poisson-Boltzmann theory: The point charge as an electrically invisible object—*Physical Review A*, Vol. 21, No. 1 (1/80)

C.W. Magee, *et al.*

Depth distributions of low energy deuterium implanted into silicon as determined by SIMS—*Nuclear Instruments and Methods* 168, pp. 383-387 (1980)

J.I. Pankove, *et al.*

Optical absorption by gap states in hydrogenated amorphous silicon—*J. of Non-Crystalline Solids* 35 & 36 (1980) 459-462

J.I. Pankove|C.P. Wu

Photoluminescence from hydrogenated ion-implanted crystalline silicon—*Appl. Phys. Lett.* 35(12) (12/15/79)

D.H. Pritchard|J.J. Gibson

Worldwide color television standards—similarities and differences—*SMPTE Journal*, Vol. 89 (2/80)

J.R. Sandercock

Light scattering from surface and bulk thermal magnons in iron and nickel—*J. Appl. Phys.* 50(11) (11/79)

R.S. Stepleman|N.D. Winarsky

Adaptive numerical differentiation—*Mathematics of Computation*, Vol. 33, No. 148, pp. 1257-1264 (10/79)

T. Takahashi|O. Yamada

Luminescence of terbium-activated alkali rare earth metaphosphate glasses—*J. of the Electrochemical Society*, Vol. 126, No. 12 (12/79)

M.L. Tarng|J.I. Pankove

Passivation of p-n junction in crystalline silicon by amorphour silicon—*IEEE Transactions on Electron Devices*, Vol. ED-26, No. 11 (11/79)

M. Toda|S. Osaka

Large area electronically controllable light shutter array using PVF2 bimorph vanes—*Ferroelectrics*, Vol. 23, pp. 121-124 (1980)

Missile and Surface Radar

J.A. Bauer

Hybrid status at RCA—Ceramics and Hybrid Technology in the 80s, IEEE Computer Packaging Society meeting, IEEE Headquarters, New York (3/27/80)

J.A. Bauer|R.F. Kolc

Applications growth of chip carriers—NEPCON WEST, Anaheim, Ca., *Proceedings* (2/28/80)

F.J. Buckley

Management of real-time programming—Drexel University Engineering Course (3/80)

F.J. Buckley

Software quality assurance management—Computers in the 1980s Conference, Los Angeles, Ca., (3/80)

J.E. Friedman

MSR—a miniprofile—*TREND*, Vol. 19, No. 10 (2/80)

R.F. Kolc

Computerized thick film printer—DoD Hybrid Microelectronics Planning Conf., San Diego, CA (1/80)

L.C. Pickus

Conducted IEEE Professional Communication Society Technically-Write workshop, Dobbs Ferry, N.Y. (2/21-22/80)

R.L. Schelhorn

Comparitive evaluation of thin film and thick film hybrid circuit fabrication techniques—Keystone ISHM Meeting, Cherry Hill, N.J. (3/80)

A. Schwarzmann

Performance of the porcelain-metal substrate at microwaves—*IEEE Transactions on Components, Hybrids, and Manufacturing Technology*, Vol. CHMT-2, No. 4 (12/79)

M. Weisbein

Software quality assurance—Software Quality Development Seminar, AED (2/5/80)

RCA Ltd.

R.J. McIntyre|P. Webb

Silicon detectors for fibre applications in the 1 to 1.15 μm range—CLEOS/ICF Conference, San Diego, Ca. (2/26-28/80)

P. Webb

Large area detectors with enhanced quantum efficiency in the 1.0 to 1.15 μm range—CLEOS/ICF Conference, San Diego, CA (2/26-28/80)

Solid State Division

Z.F. Chang

Application of ASCR in 40-kHz sine-wave converter—IEEE International Telecommunications Energy Conference, Washington, D.C. (11/27/79)

Patents

Commercial Communications Systems

Adam, K.C.

Analog-to-digital circuit with adjustable sensitivity—4189714

Bendell, S.L.

Video image tube highlight suppression circuit—4190865

Colgan, Jr., J.J.

Image Pickup assembly—4191936

Dischert, R.A.|Thorpe, L.J.

Remote control system for a television camera—4190863

Dischert, R.A.

Remote iris control for television cameras—4190864

Dischert, R.A.|Thorpe, L.J.

System for connecting a plurality of video sending television apparatus—4191971

Ovnick, Jr., J.L.

CATV block converter—4191966

Consumer Electronics

Hicks, J.E.

Switching regulator for television deflection circuit with improved ultor voltage regulation—4190791

Government Communications Systems

Springer, J.F.|Kaplan, D.H.

Switch matrix for data transfers—4191941 (assigned to U.S. government)

Laboratories

Bell, A.E.|Bartolini, R.A.|
Shahbender, R.A.|Williams, B.F.

Record playback apparatus and information record therefor—4189735

Bell, A.E.|Bartolini, R.A.

Recorder and antireflective record blank having an optically passive transparent layer—4195312 (assigned to U.S. government)

Bell, A.E.|Bartolini, R.A.

Antireflective information record having an optically passive transparent layer—4195313 (assigned to U.S. government)

Davidson, E.B.

Water based photoresist—4194912

Ettenberg, M.|Kressel, H.

Two-way single fiber optical communication system—4195269

Goel, J.

Method of making a field effect transistor—4194285

Hartmann, J.C.|Maxemchuk, N.F.

Bidirectional digital position encoder—4194184

Hawrylo, F.Z.

Ohmic contact for P type indium phosphide—4195303 (assigned to U.S. government)

Kleinknecht, H.P.

Optically measuring the carrier concentration in a semiconductor—4188123

Levine, P.A.|Sauer, D.J.

Low noise CCD input circuit—4191895

Sauer, D.J.|Levine, P.A.

Low noise CCD input circuit—4191896

Sechi, F.N.

Microwave FET power circuit—4189682 (assigned to U.S. government)

Sechi, F.N.|Camisa, R.L.

Microwave FET power oscillator—4189688

Spong, F.W.

Recording methods for a multilayer optical record—4190843

Sterzer, F.

Apparatus and method for Hyperthermia treatment—4190053

Tams, 3rd, F.J.

Processing rack—4191295

Valachovic, J.

Method and apparatus for determining focus conditions—4189746

White, H.E.|Petri, R.J.

Digital phase synchronizing system—4191975

Missile and Surface Radar

McCurdy, R.J.

Sampling method and apparatuses—4188583

Picture Tube Division

D'Amato, R.J.|Nolan, R.A.

Color picture tube having improved corrugated apertured mask and method of making same—4187443

D'Amato, R.J.|Stone, R.P.

Color picture tube having improved corrugated mask—4195248

Kimbrough, L.B.|Vanrenssen, M.

Apparatus for applying sealing material to a cathode-ray tube—4194463

Ottos, J.G.

Apparatus and method for automatically aligning a multibeam electron gun assembly with a cathode-ray tube bulb—4189814

Vanrenssen, M.

Apparatus and method for determining deviation of mask-to-faceplate spacing in a cathode-ray tube—4190936

RCA Limited (Montreal)

Fjarlie, E.J.

Spectrometer—4193691

SelectaVision

Allen, J.A.|Torrington, L.A.

Video disc player having unitary record handling platform construction—4191380

Christopher, T.J.|Tretter, L.L.

Video processing system including comb filters—4195309

Stave, F.R.

Apparatus for facilitating carriage return in video disc player—4191381

Solid State Division

Checki, Jr., A.D.

Semiconductor device package—4190735

Dietz, W.F.

Deflection circuit—4193018

Dingwall, A.G.

Circuitry with unbalanced long-tailed-pair connections of FETs—4188588

Dingwall, A.G.

Memory organization—4189782

Kaplan, L.A.

RC oscillator—4188593

Engineering News and Highlights

Luther appointed to new CCSD post

Arch C. Luther has been appointed to the new post of Division Vice President, Engineering, at RCA Commercial Communications Systems Division. It was announced by **J. Edgar Hill,** Division Vice President and General Manager. Previously Chief Engineer for the division, Mr. Luther will continue to supervise and coordinate engineering activities in the Division's four business units: Avionics Systems, Broadcast Systems, Cablevision Systems, and Mobile Communications Systems.

Mr. Luther has been involved in the design and development of RCA commercial electronics equipment since 1950. He joined the company that year after graduation from the Massachusetts Institute of Technology with a bachelor's degree in electrical engineering. He has been instrumental in the design of advanced equipment for broadcasting, including the industry's first all-solid-state video tape recorder, introduced by RCA in 1961, and the first video tape cartridge recorder, introduced in 1969.

In 1975, Mr. Luther won the David Sarnoff Award for Outstanding Technical Achievement, RCA's top technical honor, for his "many contributions enhancing RCA's reputation as a leading supplier of television systems."

During his RCA career, Mr. Luther has been awarded more than 30 patents. He is active in the Institute of Electrical and Electronics Engineers, and received the IEEE Fellow Award in 1974.

He received the 1969 Fellow Award of the Society of Motion Picture and Television Engineers, and in 1973, won its David Sarnoff Gold Medal for major contributions to magnetic video recording technology.

Staff Announcements

Consumer Electronics Division

James R. Smith, Manager, Division Quality Assurance, announces the appointment of **Robert L. Pletcher,** Manager, Consumer Acceptance Laboratory, VideoDisc Player. Mr. Pletcher will report to the Manager, Division Quality Assurance.

Laboratories

Kerns H. Powers, Staff Vice President, Communications Research, announces the organization as follows: **Bernard J. Lechner** continues as Director, Video Systems Research Laboratory; **Joseph H. Scott** is appointed Staff Engineer; **Fred Sterzer** continues as Director, Microwave Technology Center; and **Daniel A. Walters** continues as Director, Communication Systems Research Laboratory.

Henry Kressel, Staff Vice President, Solid State Technology, announces the organization as follows: **Larry J. French** as Director, Custom LSI Laboratory and Photomask Technology. (Mr. French will report to the Staff Vice President, Solid State Technology, RCA Laboratories. With regard to the management of Photomask Technology, Mr. French will receive business direction from the Division Vice President, Integrated Circuits, Solid State Division.) **Bernard Hershenov** continues as Director, Solid State Devices Laboratory; **Israel H. Kalish** continues as Manager, Integrated Circuit Design and Process Development (SSTC); **Louis S. Napoli** continues as Staff Scientist; **David E. O'Connor** is appointed Director, Integrated Circuit Technology Research Laboratory; and **William C. Schneider** continues as Manager, Special Projects and Products (SSTC).

David E. O'Connor, Director, Integrated Circuit Technology Research Laboratory, announces the organization as follows: **Norman Goldsmith** continues as Head, Lithography & IC Processing; **Gary W. Hughes** is appointed Head, IC Design & Testing; **Walter F. Kosonocky** continues as Fellow, Technical Staff; **Paul K. Weimer** continues as Fellow, Technical Staff; **David E. O'Connor** continues as Acting, Memory Technology; and **George L. Schnable** continues as Head, Device Physics & Reliability.

Larry J. French, Director, Custom LSI Laboratory and Photomask Technology, announces the organization as follows: **Philip K. Baltzer** continues as Head, LSI Systems and Applications; **John W. Gaylord** continues as Manager, Process Monitoring and Control; **David S. Jacobson** is appointed Manager, Custom LSI Products; **Walter F. Lawrence** is appointed Manager, Photomask Technology and Operations; and **Lawrence M. Rosenberg** continues as Manager, Design Automation.

David S. Jacobson, Manager, Custom LSI Products, announces the organization as follows: **Richard H. Bergman** is appointed Manager, Custom LSI Design, Test and Applications; **David S. Jacobson,** Acting, Production Engineering; **David A. Woronka** is appointed Administrator, Technical Contracts; and **Evan P. Zlock** is appointed Manager, Custom LSI Production and Product Control.

Picture Tube Division

Stanley S. Stefanski, Division Vice President, Manufacturing, announces the organization as follows: **Bernard D. Brumley,** Manager, Marion Plant; **John S. Ignar,** Manager, Scranton Plant; **John R. Moss,** Manager, Midland Plant; **Thomas I. Peters,** Director, Component Manufacturing; and **Stanley S. Stefanski,** Acting, Operations Planning and Control.

Thomas I. Peters, Director, Component Manufacturing, announces the organization as follows: **John M. Fanale,** Director, Glass Operations; **Joseph W. Himelick,** Director, Operations—RCA Borinquen, Inc. & RCA del Caribe, Inc., **Richard H. Hynicka,** Manager, Lancaster Manufacturing Operations; **Thomas I. Peters,** Acting, Component Manufacturing Engineering Coordination; and **David O. Price,** Manager, Materials.

Stanley S. Stefanski, Division Vice President, Manufacturing, announces the organization of Operations Planning and Control as follows: **Richard C. Allen,** Manager, Technical Contracts Support and Services—Manufacturing; **John K. Breneman,** Manager, Operations Planning; **Walter D. Hoskinson,** Manager, Product Coordination and Control; and **Stanley S. Stefanski,** Acting, Tube Manufacturing Engineering Coordination.

Record Division

James M. Frische, Manager, Indianapolis Plant, announces the appointment of **Ananthanarayan Devarajan,** as Manager, Engineering.

Research & Engineering

Howard Rosenthal, Staff Vice President, Engineering, announces the appointment of **John D. Bowker** as Director, RCA Frequency Bureau.

"SelectaVision" VideoDisc Operations

Jay J. Brandinger, Division Vice President, "SelectaVision" VideoDisc Operations, announces the organization as follows: **Harry Anderson,** Division Vice President, Player Manufacturing; **H. Nelson Crooks,** Director, Technical Liaison; **Arthur W. Hoeck,** Director, Business Planning; **Charles R. Horton,** Manager, European Systems Development; **Franklin R. Levine,** Director, Product Assurance; **Robert K. Lorch,** Director, Finance; **Robert C. McHenry,** Director, Industrial Relations; **James L. Miller,** Director, Systems and Test Engineering; **Harry Weisberg,** Division Vice President, Disc Operations; and **Willard M. Workman,** Director, Player Engineering.

Solid State Division

Richard L. Sanquini, Director, Memory, Microprocessor and Timekeeping Operations, announces the appointment of **Michael S. Fisher** as Manager, Large Scale Integration (LSI) Product Marketing and Applications Engineering.

Michael S. Fisher, Manager, Large Scale Integration Product Marketing and Applications Engineering, announces the organization as follows: **Edward C. Crossley,** Leader Technical Staff—LSI Applications Engineering (Auto/Custom); **Michael S. Fisher,** Acting Manager, Automotive Product Marketing; **Julius S. Lempner,** Manager, Memory, Microprocessor Component Product Marketing; **Joseph P. Paradise,** Leader Technical Staff, LSI Applications Engineering Memory and Microprocessor Components; and **Rein E. Rist,** Manager, Timekeeping Product Marketing.

Heshmat Khajezadeh, Director, Bipolar and MOS Logic Operations, announces the appointment of **Alfredo S. Sheng** as Manager, Bipolar and MOS Logic Engineering.

Alfredo S. Sheng, Manager, Bipolar and MOS Logic Engineering, announces the organization as follows: **Charles Engelberg,** Leader Technical Staff, Testing; **Alfredo S. Sheng,** Acting, Product Development; **Bruno J. Walmsley,** Manager, Applications; and **George J. Waas,** Manager, Design.

John P. McCarthy, Director, Government and Hi-Reliability Operations, announces the appointment of **Norman C. Turner** as Manager, Trident and Hi-Reliability Operations, Somerville.

Promotions

Government Systems Division

Mark Burmeister, from Manager, PRICE Marketing and Operations, to Director, PRICE Systems.

Picture Tube Division

Fred Sheperd, from Associate Member, Technical Staff, to Member, Technical Staff.

Louis J. DiMattio, from Engineering Leader, Product Development, to Manager, Product Engineering.

Distributor and Special Products

Craig Elderkin, from Manager, Sound Product Development, to Chief Engineer.

William J. Bachman, from Senior Member, Technical Staff, to Manager, Mechanical Engineering and Development.

Licensed engineers

When you receive a professional license, send your name, PE number and state in which registered, RCA division, location, and telephone number to *RCA Engineer*, Bldg. 204-2, RCA Cherry Hill, N.J. New listings (and corrections or changes to previous listings) will be published in each issue.

Laboratories

P.T.S. Lin, NJ 19144
NY 054853

Professional activities

Kressel elected to National Academy of Engineering

Dr. Henry Kressel, Staff Vice President, Solid State Technology, RCA Laboratories, Princeton, is one of 82 engineers recently elected to membership in the U.S. National Academy of Engineering. The NAE cited Dr. Kressel for "pioneering research in opto-electronics devices with specific emphasis on semiconductor lasers."

Election to the Academy is the highest professional distinction that can be conferred on an engineer and honors those who have made important contributions to engineering theory and practice or who have demonstrated unusual accomplishments in the pioneering of new and developing fields of technology.

Dr. Kressel started work for the RCA Semiconductor Division in 1959, and in 1963 was awarded a David Sarnoff Fellowship to pursue his doctoral studies. In 1966 he joined RCA Laboratories, and in 1969, became Head of the Semiconductor Devices Research Group. In 1977 he was appointed Director of the Materials and Processing Research Laboratory, the position he held prior to his appointment as a Staff Vice President in 1979.

Goodwin recognized by American Defense Preparedness Association

William V. Goodwin, Division Vice President and General Manager, RCA Missile and Surface Radar, has recently received the 1980 Harvey C. Knowles award of the American Defense Preparedness Association. He was cited for having made "a major technical contribution to our national armament progress" and for his leadership and technical direction of the radar-based, computer-controlled AEGIS fleet defense system which RCA designed and is building for the U.S. Navy. He was described as the architect of RCA's mission in predecessor programs through the mid-1960s, and then as Prime System Contractor for the AEGIS Program beginning in 1969 when the Navy contract was awarded.

Mr. Goodwin has been with RCA since 1949 except for the 1954-59 period when he was associated with the Bendix Missile Division. He rejoined RCA in 1959 as Manager of Advanced Projects at the Missile and Surface Radar operation. Four years later, he was appointed Manager of Navy Air Defense Programs and in 1967, was named Manager, Marketing Department. Mr. Goodwin was advanced to Division Vice President and Program Manager AEGIS Department in 1970 and promoted to his present position in August 1978.

Belohoubek receives microwave award

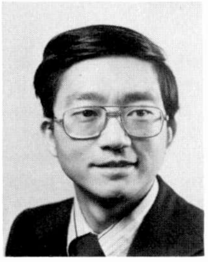
Erwin F. Belohoubek, Head, Microwave Circuits Technology, recently received the 1980 Microwave Application Award from the IEEE Microwave Theory and Techniques Society. Dr. Belohoubek was cited "for pioneering the concepts and practical implementations of internal matching of microwave transistors."

NJIT Achievement award to Kosonocky

Dr. Walter F. Kosonocky was among five New Jersey Institute of Technology alumni recently honored for distinctive achievements in civic and professional leadership and service. Dr. Kosonocky, a 1955 graduate of NJIT, is a Fellow of RCA Laboratories and has been associated with RCA since 1955.

technical excellence

Astro-Electronics presents two Engineering Excellence Awards



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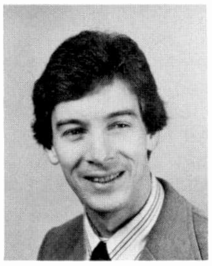


Voorhees

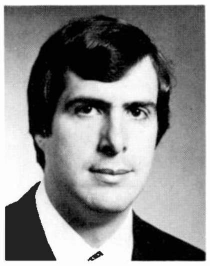
Two engineers at Astro-Electronics have won Engineering Excellence Awards for their major contributions to space technology in 1979.

Dr. David Fei Hon Chu and **Carl Voorhees** received the awards "in recognition of dedicated outstanding effort in their contributions to a modal vibration test program for the Block 5D-2 meteorological satellite."

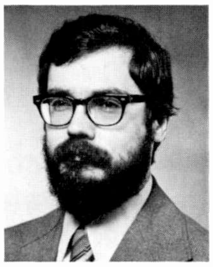
Dr. Chu was responsible for theoretical analysis and computer programming for the Block 5D-2. This included finite element modeling of the test configuration spacecraft, and computer programming of the computations to check the orthogonality of modes.

Mr. Voorhees was responsible for the test equipment and test operation of the Block 5D-2 spacecraft. He supervised model makers in building up the test configuration on a seismic pad in the vibration laboratory. In addition, he coordinated the integration of electronic gear to form a total system for vibrating the spacecraft and recording its data.

First Quarter 1980 Technical Excellence Award Winners announced by MSR

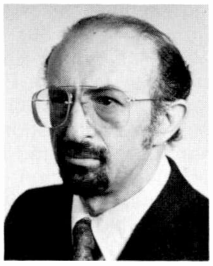


Costello



Povilonis

Stachejko



Staiman

CETEC's review of the first quarter 1980 Technical Excellence Award nominations has been completed, with four winners selected. Brief summaries of the citations are given below.

D.O. Costello — for the hardware design and firmware development of the array control logic unit, which is part of the signal processor for the Crossbow-S Generic Radar. His innovative design, applying an embedded bit-slice microprocessor for radar control, enhances RCA's business position in the application of distributed processors to radar systems.

A.J. Povilonis — for his contribution to the overall system design and computer software architecture of the Crossbow-S Generic Radar. He combined radar system knowledge, software expertise, and a perceptive analysis of tri-service customer requirements to develop a minicomputer-based design for simulation of both phased-array and dish-antenna radars.

V. Stachejko — for his development of a capacitive tuning iris for the phase shifters that will be used in each AN/SPY-1A antenna array. His novel, sophisticated design will simplify production and effectively eliminate rejection of phase shifters for insertion phase deficiencies. The result is a significant cost-saving potential for each AEGIS ship.

D. Staiman — for his work in modifying and extending the basic theory and techniques used in developing MSR's near-field antenna testing facility. Of special significance was his original work in concepting an inverse Fourier transform function, which permits data taken in the array measurement plane to be transformed to the aperture plane for use in establishing phase alignment of the waveguide beamformer networks.

Luedicke and Reisner named Fellows of the Technical Staff at RCA Laboratories

Dr. Eduard Luedicke, Advanced Systems Research Laboratory, and **Dr. John H. Reisner,** VideoDisc Systems Research Laboratory, have been appointed Fellows of the Technical Staff of RCA Laboratories. The designation of Fellow is comparable to the same title used by universities and virtually all technical societies, and is given in recognition of a record of sustained technical contribution in the past and of anticipated continued technical contribution in the future.

Authors and Inventors honored at MSR

Eighty-two members of Missile and Surface Radar and Government Systems Division Staff were honored during National Engineers Week at an Authors' Reception in Moorestown, N.J. Hosted by Bernie Matulis, Chief Engineer, the reception was to honor those who have enhanced their technical reputations as well as RCA's, both through papers presented and published and through patent awards received in 1979.

In congratulating the honorees, Mr. Matulis referred to the impressive listing of papers and patents contributed by members of the Moorestown facility. "Your effort represents a real contribution to the technical community during 1979. Just as important, however, is the effect of your work in building your personal professional reputation as well as RCA's. My sincere congratulations."

Those honored are as follows:

S.L. Abbott
K. Abend
E.M. Allen
R.D. Bachinsky
J.A. Bauer
H.B. Boardman
B.F. Bogner
D.F. Bowman
F.J. Buckley
M.W. Buckley
L.L. Coulter
J.A. Di Ciurcio
R.C. Durham
F.A. Eble
S. Fazzolari
D. Fennessy
G.R. Field
W.R. Fink
B.A. Francis
F.R. Freiman
J.E. Friedman
D.M. Fuerle
B.P. Gaffney
J.B. Galpin
I.E. Goldstein
S.J. Goliaszewski
J. Golub
H.B. Gould
T.G. Greene
H.M. Halpern
J. Haness
W.A. Harmening
S.L. Hazen
D.J. Herman
A.G. Hopper
M.C. Johnson
P.R. Kalata
R.A. Kasmar
R.D. Kemp
R.E. Killion
N.R. Landry
A. Leder
P. Levi
E.G. Lurcott
L.W. Martinson
S.I. Newburg
F.E. Oliveto
R.E. Park
O.L. Patterson
W.T. Patton
R.P. Perry
L.C. Pickus
J.R. Platt
M.H. Plofker
C.E. Profera
D.L. Pruitt
R.J. Rader
R.J. Renfrow
N.A. Ricciardi
E.W. Richards, Jr.
E.E. Roberts, Jr.
G.J. Rogers
M.I. Rozansky
R.L. Schelhorn
C.T. Schilsky
D.P. Schnorr
A. Schwarzmann
R.M. Scudder
T.M. Shelton
S.M. Sherman
D. Shore
V. Stachejko
D. Staiman
S.A. Steele
G.W. Suhy
J.T. Threston
H. Urkowitz
A.L. Warren
R.B. Webb
M.L. Weisbein
F.W. Widmann
L.H. Yorinks

ATL honors Authors, Speakers and Inventors

On April 28, Advanced Technology Laboratories (ATL) held its annual informal reception in Camden to honor 34 members of its staff who made important professional contributions during the past year.

Fred E. Shashoua, Director of ATL, congratulated the honorees and thanked them for their accomplishments: "During 1979, you found the time, in an already busy professional career and personal life, to write papers, prepare technical presentations, and conceive inventions. These activities have increased the store of knowledge, improved your professional stature, and enhanced RCA's competitive position."

The honorees included:

G.J. Ammon
K.B. Barnes
A. Boornard
P.J. Coyle
S.L. Corsover
M.S. Crouthamel
L.D. Elliott
A. Feller
D.A. Gandolfo
A.P. Gilson
F.J. Goodman
W.F. Heagerty
W.A. Helbig
D.G. Herzog
J.L. Hudson
K.C. Hudson
G.W. Hunka
R.F. Kenville
D.S. Kent
W.F. Meeker
B.M. McCarthy
T.D. Michaelis
L.D. Moore
A.L. Nelson
J.I. Pridgen
R.L. Pryor
C.W. Reno
J.R. Richards
A.B. Sally
B.W. Siryj
M.W. Stebnisky
R.J. Tarzaiski
J.R. Tower
J.J. Welsh

GCS honors Authors, Speakers and Inventors

Government Communications Systems (GCS) held its annual reception for authors, speakers and inventors on May 1 in Camden, J.V. Fayer, Chief Engineer, was the host. Eighty-six members of GCS were honored at the reception:

R.W. Allen
H. Barton, Jr.
O.E. Bessette
A.L. Black
O.D. Black
D.C. Bowen
R.H. Brader
J. Bradshaw
J. Branch
S.S. Brokl
D.C. Bussard
M.G. Caracappa
R.H.G. Chan
L.J. Chapman
J.A. Clanton
J.A. Cocci
B.L. Compton
S.L. Corsover
A.T. Crowley
J.W. Daniel, Jr.
D.W. Diehl
E. DiRusso
L.W. Dobbins
J.H. Everhart
R.J. Flint
P. Greene
J.S. Griffin
K. Hamburg
D. Hampel
L.V. Hedlund
C.R. Henter
D.G. Herzog
R.E. Holston
J.H. Hoover, Jr.
K.C. Hudson
C. Humphries
D. Imbesi
A. Jackson, III
E. Jellinek
A. Kaplan
D.H. Kaplan
G. Katz
J.W. Kaufman
J.R. Khalifa
E. Lachocki
N. Macina
G.E. Mackiw
M.R. Mann
F.M. McDonnell
K.E. McGuire
J.F. McSparren
C.A. Michel
C.A. Miedzius
D.A. Miller
D.H. Montgomery
P.F. Muraco
E.J. Nossen
S. Nossen
J.R. Orr
M. Packer
P. Pierson
D. Poitras
K. Prost
F.L. Putzrath
R.J. Ragucci
R. Richter
M.H. Riddle
J. Rothweiler
E.J. Sass
H.M. Schwartz
D. Sheby
D. Sherwood
J. Shukal
R.L. Sims
J. Springer
K.D. Stacy
E.R. Starner
C.R. Thompson
E.A. Timar
S.R. Tomkiel
D. Troxel
V.F. Volertas
D.M. Ward
J.L. Waring
D.B. Wolfe
J. Zlogar

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Reliability

Research Management

Research

RCA Business Operations

RCA Plants

RCA Laboratories

RCA Service Company

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Television Receiver, Remote Control

Television Receivers

Television Signals

Television Standards

Television Transmitters

Television Audio

Television, Cable

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Video Recording

X-ray Measurement

X-ray Shielding

Zurich

Author Index

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Contact your Editorial Representative, at the extensions listed here, to schedule technical papers and announce your professional activities.

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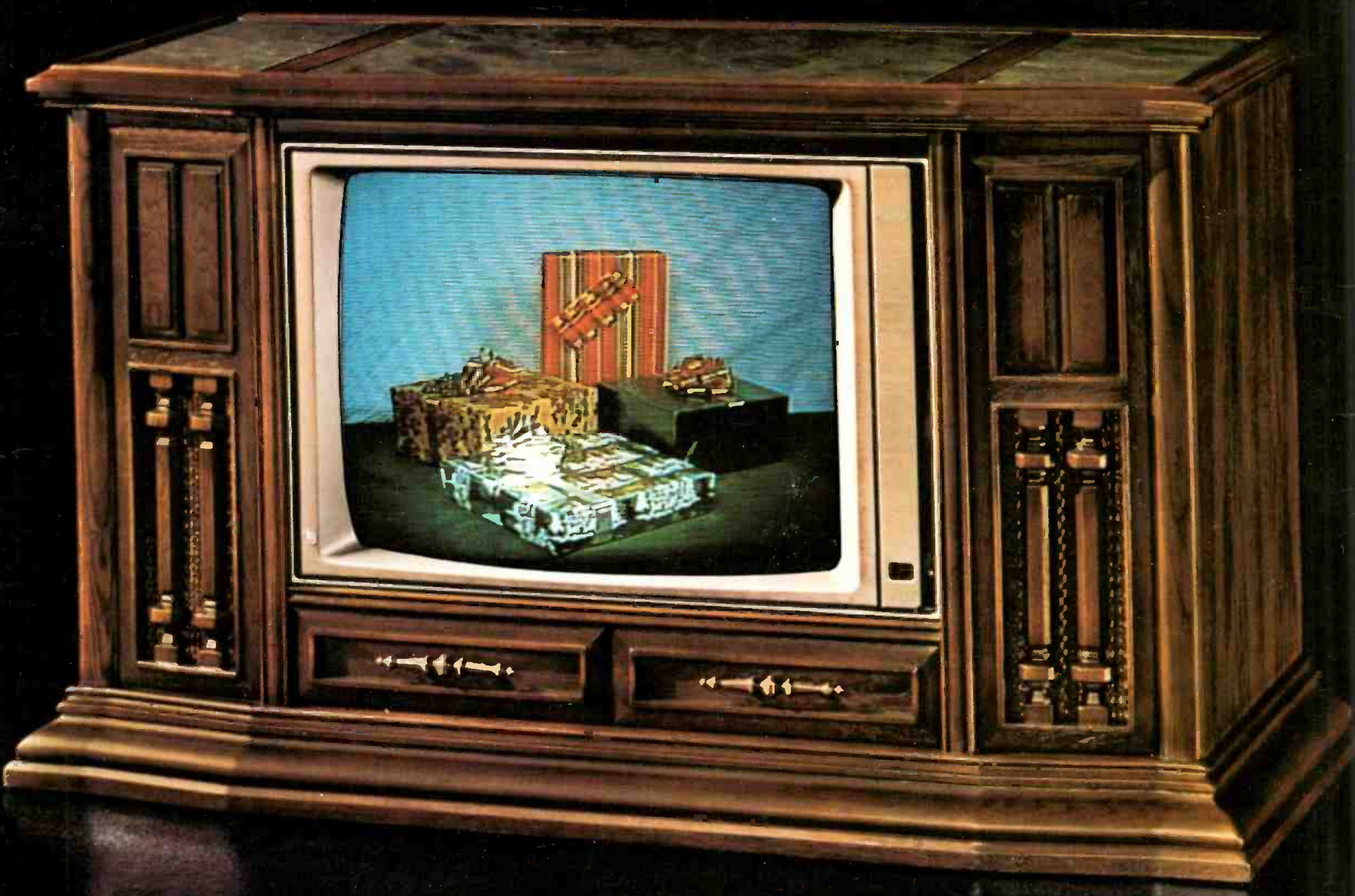
RCA Limited

BOB McINTYRE Ste Anne de Bellevue (514) 457-9000

On the front cover, we show one of RCA's top-of-the-line color television receivers, incorporating CCD comb filter Detail Processing circuitry. Here is the same video image but without the benefit of this circuit. For further information, see pages 6-15.



RCA Engineer

A technical journal published by
Corporate Research and Engineering
"by and for the RCA engineer"

Printed in the U.S.A. Form No. RE-25-6