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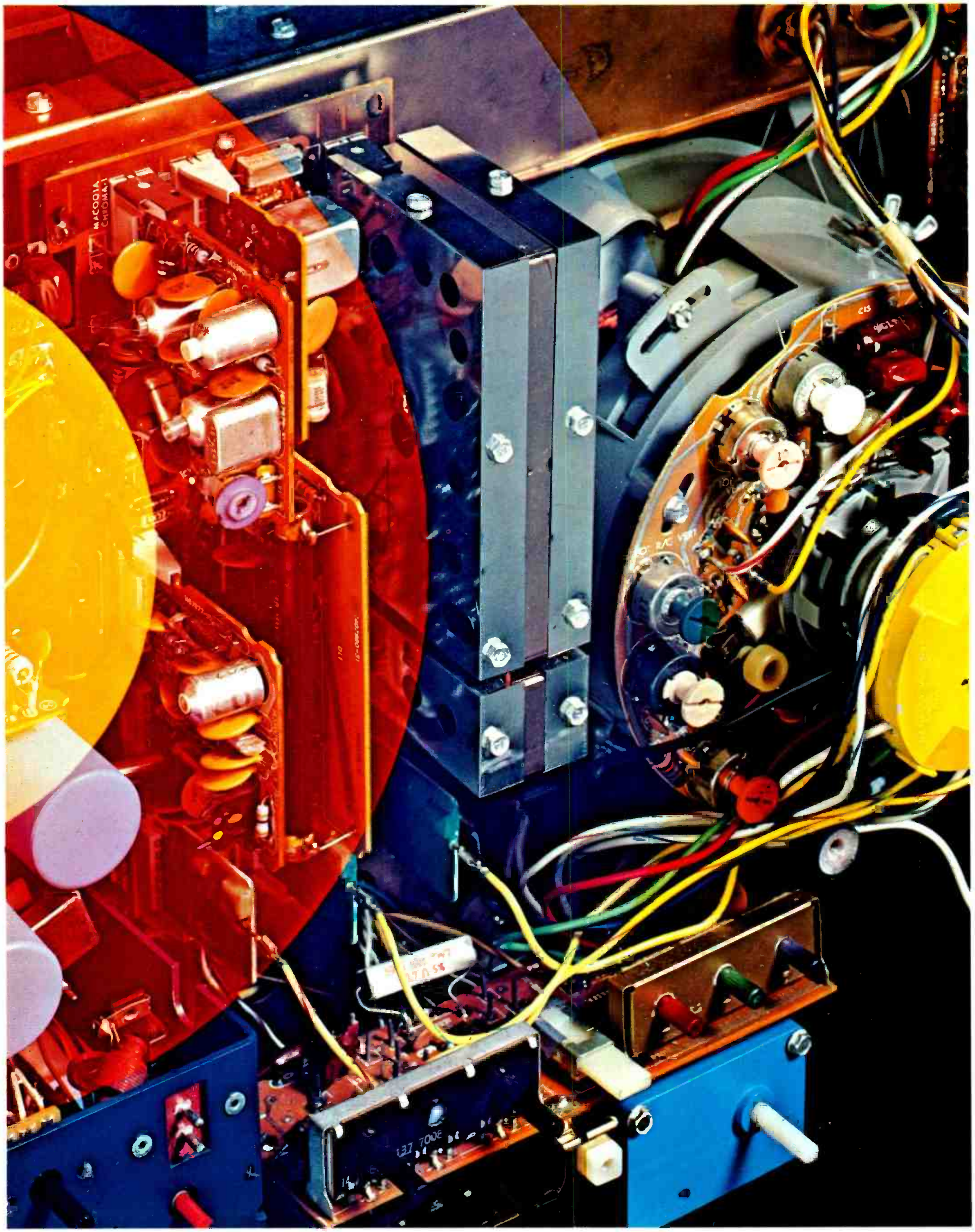

Challenge of consumer electronics engineering

"What's new and challenging in Consumer Electronics Engineering?" is a question often asked by engineers in other fields. The seventeen articles in this issue of the RCA Engineer speak for themselves but are only a partial answer to the question.

They are a partial answer because they illustrate the application of new technology but are silent as to the environment in which the technology is used. But as the technology has changed so has the environment.

- The world is now our market place, not only as an outlet for finished product but as a source of what goes into it. Our engineers and materials specialists now seek and test parts from suppliers world-wide.
- Inflation is a fact of life. Our engineers succeed in overcoming its effect on product costs. Nowhere is this better illustrated than comparing the number of components in RCA versus foreign designed products. Design ingenuity makes us the winner.
- Consumerism surrounds us with its demand for products which bring their owners fulfillment rather than frustration, and our engineers add reliability and hazard analysis to their collection of skills. We say design it so that it works well and, when necessary, can be repaired easily and quickly. We trade-off cost of design against cost of repair during warranty and seek the curve's minimum.

And so we have risen to the challenge of the environment as well as the technology.

We are proud of the accomplishments of the authors of these articles in this RCA Engineer. For the most part they are electrical engineers. But they would be the first to say that what they have done is possible only because of the creativity of our other specialists too—mechanical, chemical, and plastics engineers, physicists, and mathematicians.

We are proud also of the high level of interdivisional cooperation underlying these accomplishments. Particularly significant was the team approach with the Solid State Division in the application of monolithic technology in the products described in these articles.

What's new in Consumer Electronics Engineering? Everything. Everything except the pride and fulfillment our engineers experience by knowing that their work makes it possible to bring entertainment to countless millions of people.

M. H. Glauberman
Chief Engineer
Consumer Electronics Division
Indianapolis, Indiana

Our cover

. . . represents two significant breakthroughs in color television. The receiver shown is RCA's new all-solid-state, modular chassis—the CTC-49; this chassis and its several modules are described in several papers in this issue. The Accu-Color symbol superimposed over the photo represents our new system for color television, offering the most dependable, consistently accurate, and automatic color in RCA's history.

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• 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.

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Pride of Product

Most engineers are critical and introspective while proving in their new ideas, new circuits and new products; and engineers know also that even the best designed products and the most ingenious ideas can be modified, refined and improved.

Such traits characterize the professional, and the high degree of concentration in these areas of quality, performance and reliability often spells the difference between product success and failure. A proved-in, finished product that reflects the best collective efforts of the engineering community engenders a "pride of product" technically... an ingredient that can be extended beyond the working environment, to one's family, friends, community groups and professional associates. On these occasions, RCA engineers and scientists have the opportunity to represent the company and all its products.

Every member of the technical staff shares credit with his associates, in related activities, who design the RCA-built electronic systems for Apollo; the system analysts and programmers who conceive the software for RCA's fourth-generation computers; the scientists who are adapting the laser and the hologram for home use; the field engineers who keep the nation's early warning systems operating; and the designers and developers of RCA's new generation of color television receivers described in this issue.

Along with technical prominence and engineering leadership comes an equal share of responsibility for engineers to become the ambassadors of good will for all of the company's high-quality products and services. The combined effect of pride in product is a building of confidence in RCA's products and its future . . . fostered and advanced through the professional attitudes of RCA engineers and scientists.

In this issue of the RCA ENGINEER, the engineers of the Consumer Electronics Division describe, with justifiable pride, many of their recent developments and product designs. To meet the seemingly contradictory demands of the marketplace for high-quality performance, long life, and low cost, CED engineers have made dramatic advances in monolithic, integrated circuits, modular construction, compactness, performance, reliability, and safety. At the same time, CED engineers and their peers in other divisions are looking ahead with anticipated pride to consumer applications of laser and holography techniques, advanced video processing techniques, broader use of ceramic-thick-film technology, and further improvements in integrated circuit technology.

The quality products of the Consumer Electronics Division are some of the best known RCA products in the world . . . that reflect credit on technical and non-technical employees alike. Thus, by understanding the challenges and accomplishments of our engineering associates in CED, every engineer will be better equipped to represent RCA and his profession.

Future Issues

The next issue of the *RCA Engineer* features computer systems. Some of the topics to be discussed are:

RCA and the computer industry

Computer peripheral simulation

Semiconductor cooling packages

Computer-aided design

Computer power systems

Optical memories

Computer performance evaluation

Large core storage

Computer communication processor

Discussions of the following themes are planned for future issues.

Displays, optics, photochromics

Graphic systems

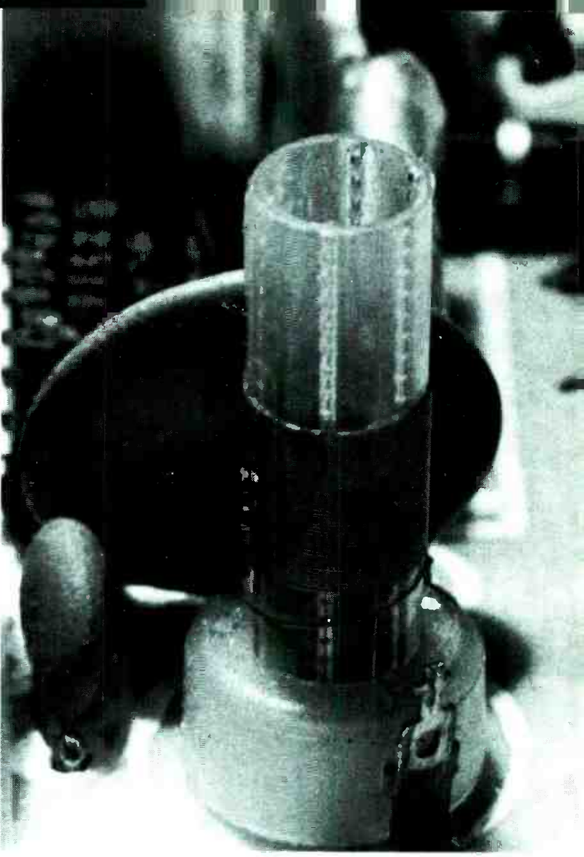
Systems programming developments

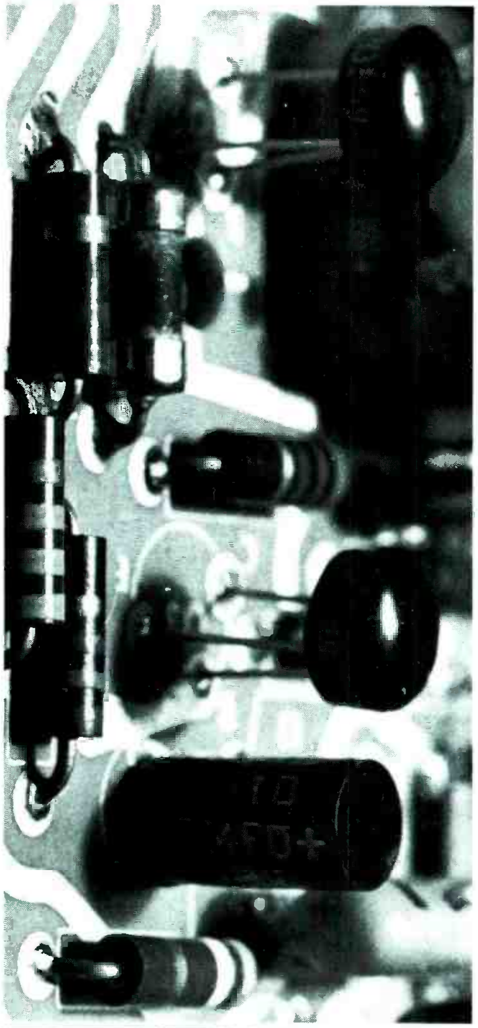
Computer peripherals

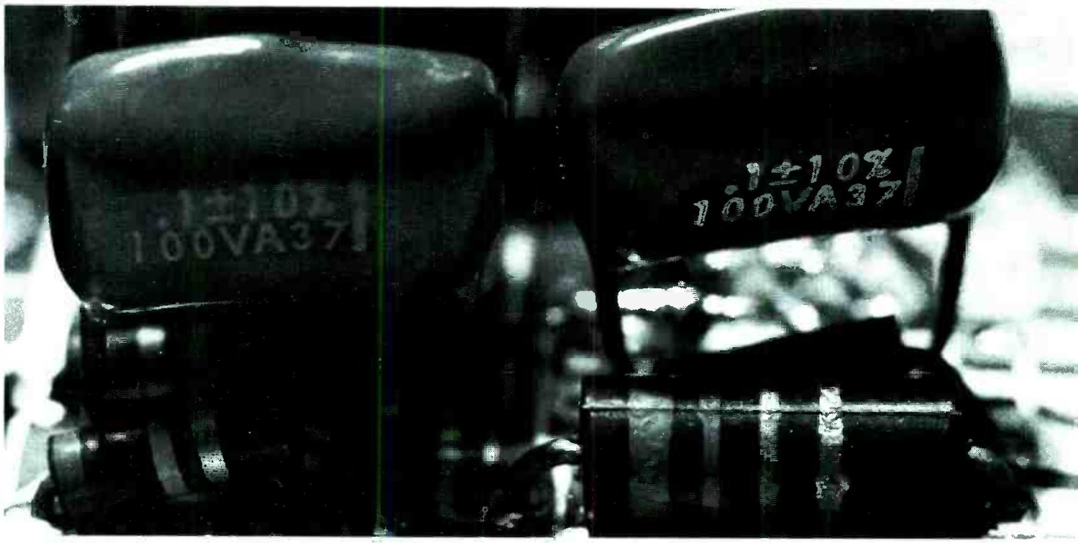
Advanced Technology Laboratories

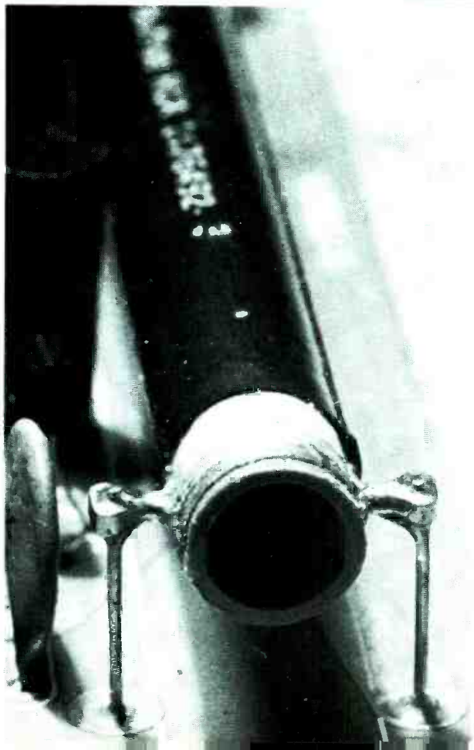
Mathematics for engineering

Video playback systems









The Engineer and the Corporation:

New-generation color-TV receiver

E. Lemke | J. A. Konkel

The design of an entirely new color-TV receiver represents an intriguing and unusual challenge to the design engineer. Using several new technical advances—e.g., thick-film ceramic circuits, high-component-density linear integrated circuits, wide-angle picture tube—the designers of the CTC-49 color television have been able to develop a product that should receive a high degree of customer acceptance for its performance, reliability, and ease of maintenance—yet a product that is opimitized for ease of manufacture and its ability to accept design changes without being completely redesigned. This design represents, perhaps, the greatest single departure from traditional circuitry and techniques in consumer electronics. The primary purpose has been to reduce the total circuitry into small, easily identifiable, independently aligned and, therefore, totally interchangeable functional modules.

THE FINAL DECISIONS as to which circuits should constitute an integral module and how many modules should be used was influenced by several imporant factors. As a first approximation, these factors can be classified as short-term and long-term goals.

Short-term goals define the extremes of physical size of the modules. Each module must be large enough to perform a minimum identifiable function, so that in case of failure, a defective unit can be identified based on certain exhibited performance deterioration, thus reducing some of the skills required in servicing. On the other extreme, the module should not become so large as to burden the customer with excessive replacement costs. In fact, user cost should be low enough, whenever possible, to preclude repair in favor of replacement. Additional module size limitations are imposed by such consideration as interaction among circuits, radiation, and capacitive limitations in high-gain high-frequency circuits.

Long-term goals, although somewhat more difficult to define beyond, say, a 3- to 5-year time cycle, certainly have to be included to allow potentially advantageous future developments to be included while retaining the same module-terminal arrangement and general form factors. Already, the parallel extensive development of specialized monolithic- and ceramic-circuit techniques within RCA have had significant influence in module function determination.

Technical description

The CTC-49 color television receiver meets these design goals with a total of eleven plug-in circuit modules. All modules are positioned in the chassis to face the back of the set and are easily and independently accessible. Except for the low-voltage power-supply module, all modules are plugged into phenolic master boards utilizing specially designed edge connectors.

The entire TV receiver can be divided into five distinctive assemblies:

1) The *tuner* assembly which contains the VHF and UHF tuners (both automatically fine tuned) and the primary customer controls—color, tint, brightness, on-off, volume, AFT defeat, and (continuously-variable) sharpness. The total assembly can be removed easily through plug connectors.
2) The complete *signal-processing* master board with its eight modules.
3) The *deflection* master board with its vertical and horizontal oscillator modules.
4) The *chassis proper*, on which the miscellaneous heavier components are assembled. These include the low voltage transformer, deflection output devices and their heat sinks, solid-state high-voltage quadrupler, and a small auxiliary circuit board containing kinescope set-up and the less-used customer controls—horizontal hold, vertical hold and contrast.
5) The *kinescope* itself with its deflection and convergence yokes, convergence-wave-shaping circuitry with its controls (purity and blue lateral), and degaussing shield and coil.

Several of the circuit innovations that represent important departures from previous receivers are described in the following paragraphs. Throughout the description, references are included to other papers in this issue that deal with specific module or circuit functions.

Tuner

The tuner assembly is quite similar to those used in previous solid-state chassis—employing a four-tuned-circuit, wafer-switch, VHF tuner with a MOS-FET RF amplifier, a cascode-type mixer, and automatic-fine-tuning (AFT)-controlled local oscillator. The

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received the BSEE with honors from the University of Minnesota in 1950. Mr. Konkel joined RCA in 1951 as an Engineering Trainee. He joined the Home Instruments Division following his training assignments, where he was engaged in IF, video, and chroma circuitry design for color television receivers. In 1960, as group leader, he became responsible for circuit design for color television receivers. Named to his present position in 1969, he is responsible for development of console and table model color television receivers. Mr. Konkel is a member of Eta Kappa Nu and Tau Beta Pi.

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received BSRE from Tri-State College in 1955 and joined RCA as a Corporate Specialized Engineering Trainee. He has been involved in various aspects of black-and-white and color-TV design and development. In 1965, he became Leader in color-TV design, and in 1969, he was promoted to Manager, where he has had project responsibility for design of wide-angle solid-state color receivers. He is a holder of numerous patents.

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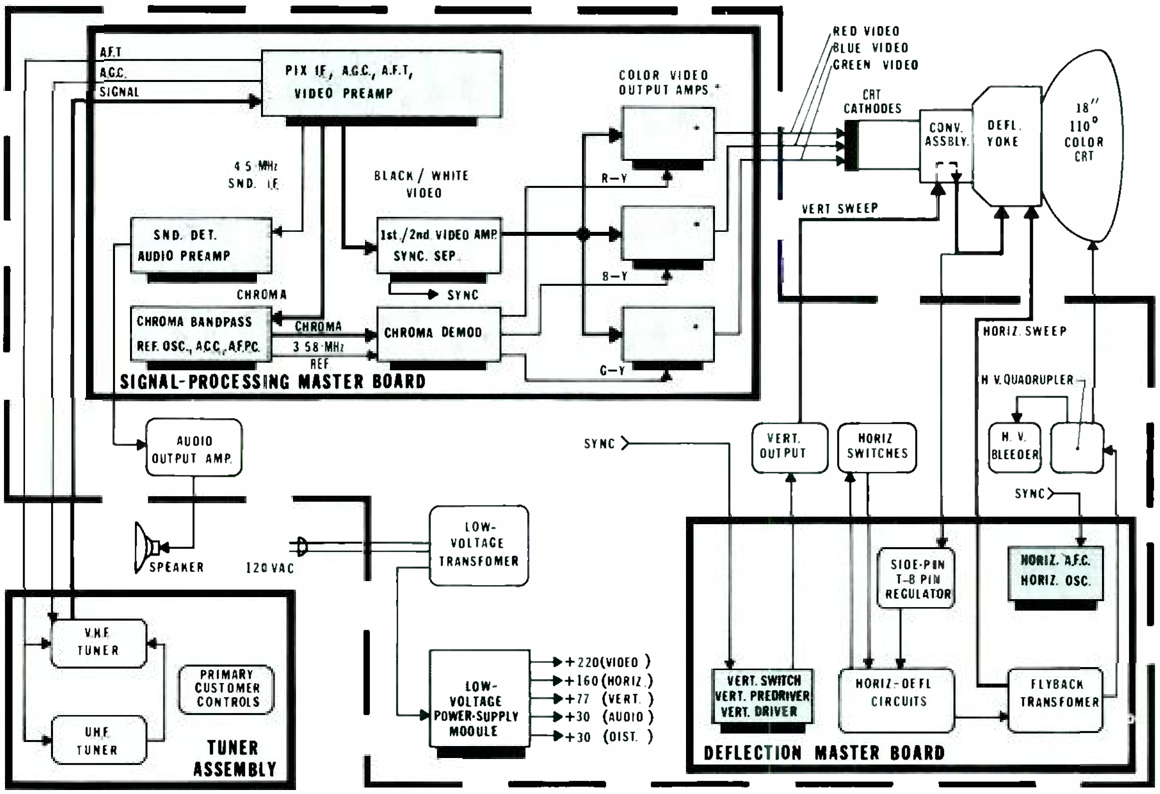

Fig. 1—Block diagram of the CTC-49 color television receiver; shaded blocks are modules.

most significant variation is elimination of the familiar "link circuit." In its place is a terminated coaxial line which interconnects the tuner and the IF amplifier. This coupling method makes the tuning of the mixer and the IF-amplifier input independent of each other and of the length of the interconnecting cable. This results in total interchangeability of the tuner and IF assemblies without requiring subsequent realignment of tuned circuits, as has been the case in the past.

Signal processing

The signal-processing assembly accounts for all the circuitry from the tuner output to the kinescope. Five monolithic integrated circuits are used, replacing a substantial amount of discrete components. The picture IF-AFT module is completely self contained, with the heart of the system being a new complex integrated circuit specifically designed for this purpose and used for the first time in TV receivers.[1,2] This IC performs the total amplification function of the picture-IF passband with outputs for the 4.5-MHz inter-carrier sound, low-level video, and color information. Another output provides reference for the automatic fine tuning (AFT) integrated circuit which is also contained on this module.

The video output from the IF module is fed into the video/sync module.[3] The functions of luminance delay, vertical and horizontal retrace blanking, control of contrast and control of video peaking are performed in the first video amplifier transistor. The second video amplifier is an emitter-follower stage which provides an impedance match between the first video amplifier and the three parallel-driven kine-drive modules.[3]

The tuned color input is fed into the first chroma module. As is the case of the picture-IF module, a specialized integrated circuit has been developed and used for the first time.[4] All active devices in this module are contained in this single IC which serves as a chroma-bandpass amplifier burst amplifier, and reference oscillator as well as automatic frequency and phase control (AFPC), automatic color control (ACC), color-level, control and burst blanking functions.

The 3.58-MHz output from the first chroma module is then fed to the second chroma module which contains the chroma-demodulator and color-difference-amplifier functions. Again, a new integrated circuit is utilized.[5]

So far, the functional description of chroma video system has borne at least some resemblance to circuits used in the past. The output of second chroma module, however, consists of three color-difference signals—*R-Y*, *B-Y* and *G-Y*—which are fed into three identical and corresponding kine-drive modules in which the matrixing of luminance and chrominance video is accomplished and the resultant output is used to drive the corresponding kinescope cathodes.[3] Thus, three medium power devices in parallel are used as compared to one high-power video-output device and three separate kinescope control-grid drivers.

The kinescope drive module represents the first RCA application of thickfilm ceramic-circuit technology in color receivers.[6] This allows bulk production of discrete components by chemical means directly on a ceramic substrate. Also, due to the good thermal characteristics of the ceramic, the transistors are bonded directly to the substrate and require no further heat sinks. The result is a package that is small, clean, and offers good long-term economic advantages.

The sound module is identical to one currently used in several other RCA color receivers.[7]

This then represents the entire signal-processing section; with minor discrete-component value changes, it can be used with any kinescope combination.

Deflection and kinescope

The deflection and kinescope assemblies represent another major advance in color-kinescope drive circuits. The CTC-49 is the first domestic receiver utilizing the new RCA 110° wide-angle-deflection kinescope as compared to the more common 90° deflection angle. This results in a substantially reduced depth in the instrument package, and for the first time, an 18-inch color receiver is available that closely resembles the slim appearance of comparable black-and-white television sets. The horizontal deflection circuitry itself bears close resemblance to that used in the CTC-40 chassis and operates on the same principles—except for modifications to provide for the substantially increased deflection-power and pincushion-distortion requirements.[8] Noteworthy is the utilization of a high-voltage multiplier which requires only one-fourth the voltage input to provide the kinescope high voltage requirements.

The vertical and convergence circuits represent substantial departure from previous practices, inasmuch as the normal vertical-output transformer has been eliminated through use of a complimentary-symmetry output circuit, similar to those used in high-quality, high-power, audio systems. The vertical convergence waveforms are clamped at deflection center resulting in substantial reduction in interaction of the individual waveform shaping controls.[9]

Conclusion

The CTC-49 represents a potential building block for future RCA sets and provides means for substantial standardization of RCA circuit modules. It indicates the expanded usage of analog monolithic circuits custom, tailored to unique color-TV needs. It also opens the door, and perhaps gives us a glimpse, of the future through such innovations as ceramic circuits, wide-angle deflection kinescopes, and high-density linear integrated circuits.

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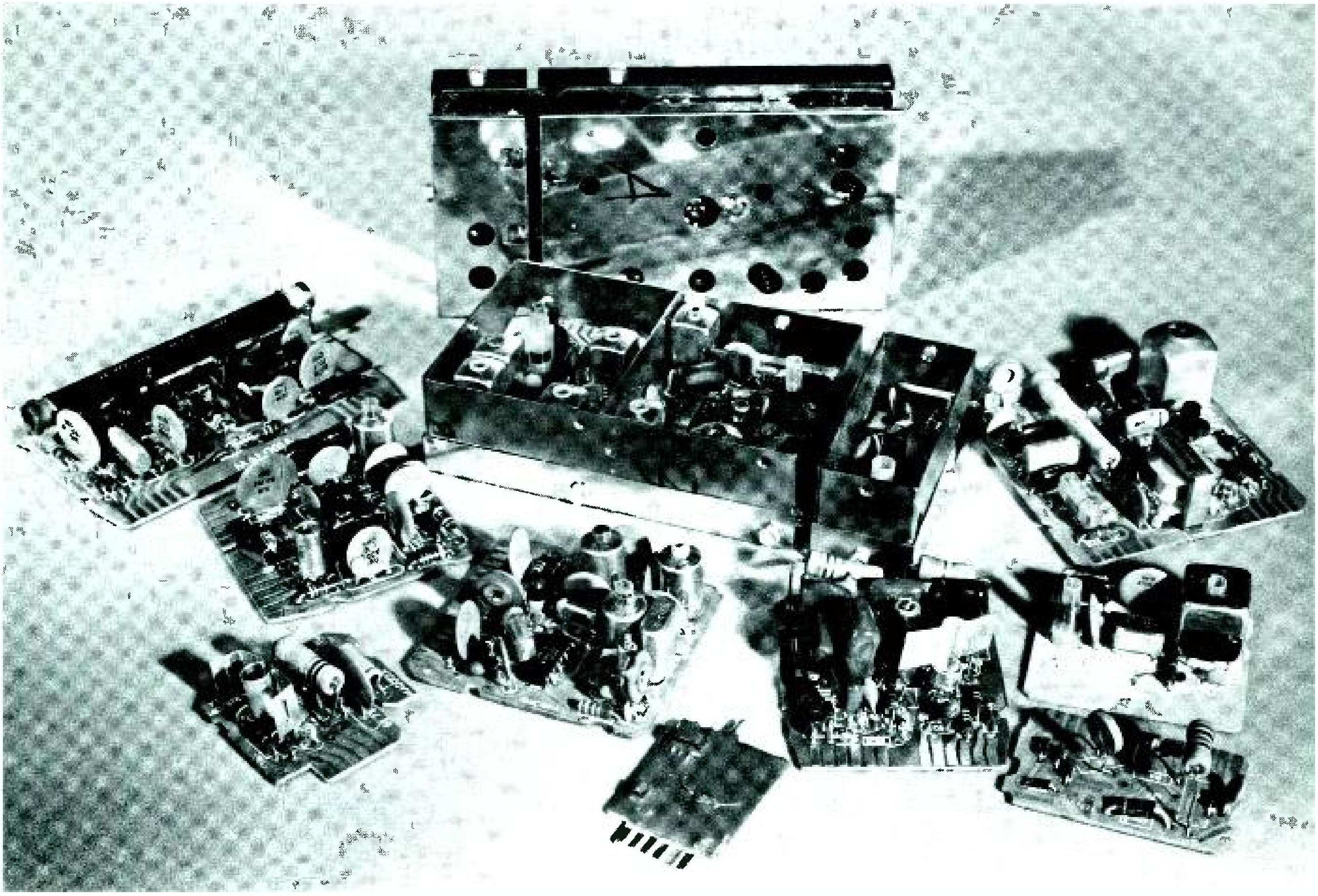

Fig. 2—The module complement for the CTC-49.

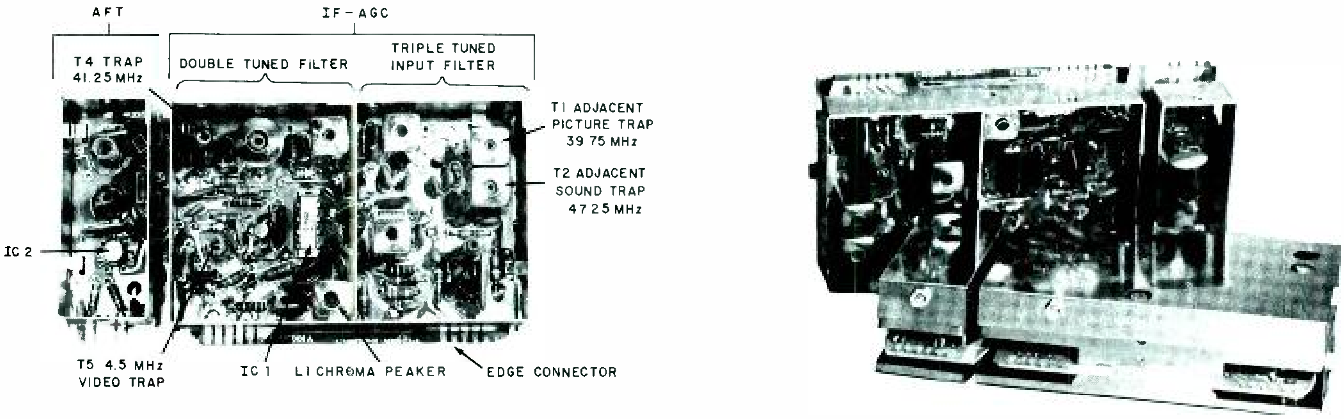

Fig. 1—Picture—IF and AFT module.

IF-AFT module for the CTC-49 color television receiver

D. Griepentrog

A new picture-intermediate-frequency (IF) amplifier and automatic gain control (AGC) system has been combined with an automatic fine tuning (AFT) circuit in module form for use in color television receivers. Emphasis has been placed on quality performance, independent of external circuitry.

THE IF-AFT MODULE described in this paper consists of two basic parts: the picture-IF section and the AFT section (Fig. 1). Each section enclosed in its own separate shield. All module components and both shields are mounted on a single printed-circuit board utilizing copper paths on both sides of the board and plated-thru holes. All connections to external circuitry are made through edge-connectors, facilitating ease of insertion and removal from the master board; the assembled module measures 6½×3⅜ ×1½ inches. A complete schematic is shown in Fig. 2; the performance of the module is summarized in Table I.

The picture-IF section consists of one integrated circuit (IC1) and two transistors. The function of transistor Q1 is to series regulate B+ for IC1 relative to a 12-volt zener reference in IC1 Transistor Q2 is an emitter follower providing both a low impedance video output source and isolation between the 4.5-MHz video trap (T5) and the chroma peaker (L7).

Table I—Performance summary.

Sensitivity	50 μV at module input (terminal 16) to produce minimum of 2-volts video output.
Selectivity	12-MHz maximum bandwidth at −50 dB. Attenuation at 35.25 MHz and 51.75 MHz is minimum of 60 dB.
Trapping	Adjacent picture (39.75 MHz) 60 dB minimum CO-sound (41.25 MHz) 46 dB minimum Adjacent sound (47.25 MHz) 60 dB minimum.
Response Shape	Symmetrical haystack with the chroma subcarrier (42.17 MHz) and the picture carrier (45.75 MHz) at 50%.
Video Output	6 volts p-p (85% carrier modulation) as maintained by the AGC system.
Gain Reduction	60 dB typical for input signal ranging from 50μV to 50 mV.
Chroma Output	1.2 volts p-p centered at 3.58 MHz.
AFT Range	Minimum of +700 kHz and −1.00 MHz pull-in range (effective IF bandwidth).

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received the BSEE from the Milwaukee School of Engineering in 1962. After graduation, he joined the Home Instruments Division of RCA and was involved with the application of solid state devices to color television receivers. He has worked in all phases of signal processing and has extensive experience in the design of frequency selective circuits. He is a member of the IEEE.

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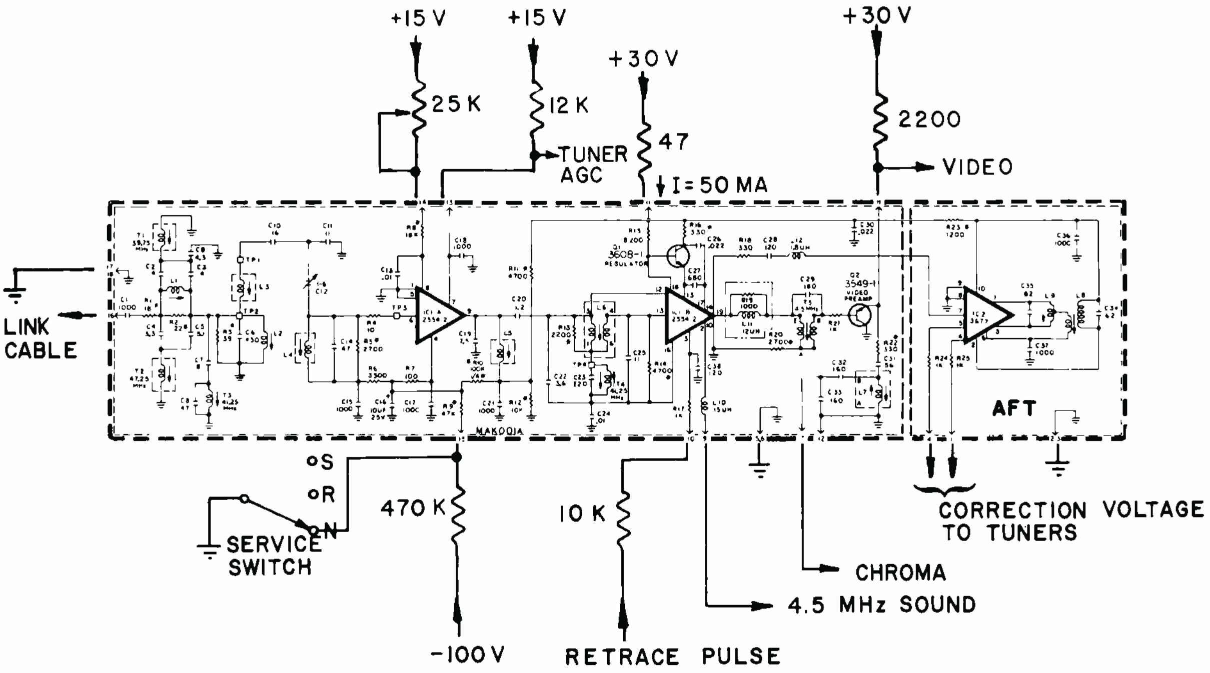


Fig. 2—Schematic diagram of IF and AFT module.

The integrated circuit IC1 is an IF amplifier, picture and sound carrier detecter, video preamplifier, noise-immune AGC circuit, and AGC-delay circuit. Five IF-bandpass and three IF-trap tuned circuits are used in addition to the 4.5-MHz trap and the chroma peaker.

The AFT section consists of one integrated circuit IC2 and two IF tuned circuits. A separate enclosing shield was required to prevent IF bandpass distortion and regeneration due to signal coupling from the AFT back into the IF section of the module.

Tuner-IF link circuit

A primary design objective was to make the IF-bandpass response independent of the tuner. This was necessary to insure the interchangeability of the tuner and the IF module. As a result, all IF-bandpass-response tuned circuits are located in the module. The tuner provides skirt selectivity only because the mixer output circuit has been designed for an essentially flat response between the IF frequencies of 41.67 and 46.25 MHz.

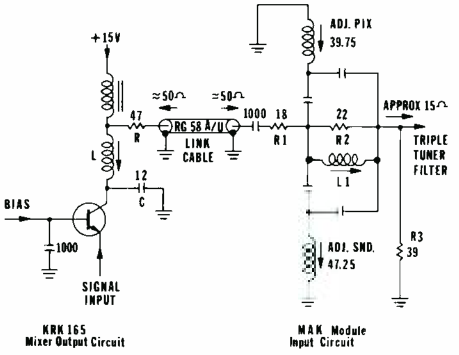


Fig. 3—Link circuit.

Fig. 3 shows the mixer output circuit of the KRK 165 VHF tuner. A low-Q, single-tuned circuit is used to couple signal from the output device to the 50-ohm link cable. The series connection of *R* (47 ohms), *L* and *C* provides the 50-ohm mixer output resistance for the link cable input termination since *L* and *C* are series resonant.

Link cable output termination is provided by the module. The input impedance of the module is nominally 50 ohms as provided by the series connection of R1 (18 ohms), R2 (22 ohms), and roughly 10 ohms due to R3 and the triple-tuned circuit (coils L2, L3, and L4). The inductive reactance of coil L1 is large compared to the resistance of R2 and therefore negligible. Thus, the link cable is terminated by its characteristic impedance at both ends over the range of frequency for which the mixer has a flat output.

IF filter circuits

The IF response is determined by the triple-tuned circuit with two traps preceding the integrated circuit and a double-tuned circuit with one trap between sections A and B.

In the triple-tuned circuit (Fig. 4), the two bridged-T traps are used to provide attenuation of the adjacent channel picture carrier and opposite adjacent channel sound carrier. A common bridged impedance consisting of parallel connected L1 and R2 is used. Adjustment of L1 for best null of the 47.25-MHz trap insures the desired 60 dB minimum attenuation.

The triple-tuned circuit provides, at center frequency, a source resistance to the integrated circuit of 800 ohms and a voltage gain of three from the module input to the integrated-circuit input (pin 6).

The first tuned circuit of the triple consists of L2 and C6 (Fig. 4). Capacitor C6 (430 pF) is series resonant with its lead inductance (0.006 μH) at 100 MHz and parallel resonant with coil L2 (0.024 μH) at 44 MHz. The third tuned circuit consists of coil L4 (0.27 μH) and capacitor C14 (47 pF). Coupling and voltage gain from L2 to L4 is provided by the second tuned circuit, coil L3 (1.8 μH) and capacitors C10, C11, and C12. The inductive reactance of L3 is 75 times larger than that of L2 to provide a certain amount of tuned-circuit isolation for ease of alignment.

This circuit provides protection against interference due to strong RF signal introduction between the tuner and the IF module. Parasitic resonances and couplings have been minimized to

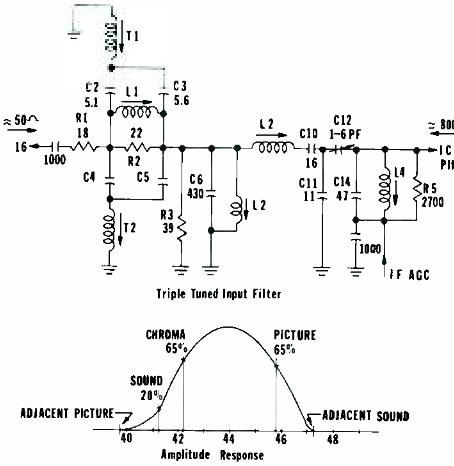


Fig. 4—Triple-tuned circuit and circuit response.

maintain high attenuation at frequencies far from IF resonance. The amplitude response is also shown in Fig. 4.

The double-tuned bandpass circuit (Fig. 5) with a bifilar-T trap at 41.25 MHz is similar to that used in the third IF stage of some color TV receivers. The sound and picture carriers are coupled into the IC at pin 12 to generate the 4.5-MHz sound-IF carrier. Trapping action removes the 41.25-MHz sound carrier at pin 13 of the IC to prevent formation of a 0.92 MHz beat with the chroma subcarrier at 42.17 MHz. The picture carrier and the chroma subcarrier entering at pin 13 are amplified, detected, and amplified again as video.

The two responses of the double-tuned circuit are shown in Fig. 5. Fig. 6a shows the overall picture-IF response from module input contact 16 to output contact 8.

Video trap

The detection of the sound and picture carriers will generate a large 4.5-MHz difference signal in video, if the sound carrier is not attenuated by the 41.25-MHz trap. This condition usually occurs only when AFT is disabled and the tuner oscillator is off frequency. A 4.5-MHz trap (T5 in Fig. 2) is included in the module to prevent interference in chroma and luminance.

Chroma peaker

The chroma peaker compensates for the slope of the video response as shown in Fig. 6b and 6c. The actual slope and the shape of the video response between 3.08 MHz and 4.08 MHz will vary from module to module because of component tolerance. Since an external peaker may not provide the correct resultant response, the peaker circuit was included in the module.

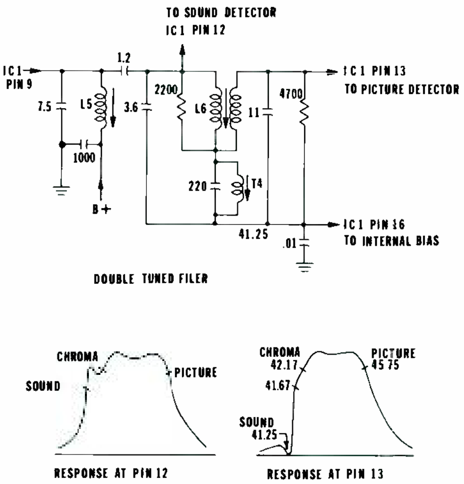


Fig. 5—Double-tuned filters and response.

The chroma peaker coil L7 uses two cores. One adjusts inductance to center the response at 3.58 MHz. The other core controls circuit Q with little effect on inductance to adjust chroma output level and bandwidth.

Automatic gain control

All AGC circuitry is included in IC1 except time constants, maximum-gain IF-bias components, and the AGC delay control. The delay adjustment is necessary for color TV receivers to minimize the "channel-6 beat" generated in the mixer.

A properly adjusted control will cause RF gain attenuation to begin at an input signal level of about 500 μV. Tuner AGC starting below 300 μV will result in a noisy picture for all input signal levels up to about 50 mV (see Fig. 7).

The AGC delay curve must be close to the noise curve not only to reduce "channel-6 beats" but also to reduce adjacent channel carrier crossmodulation in the mixer.

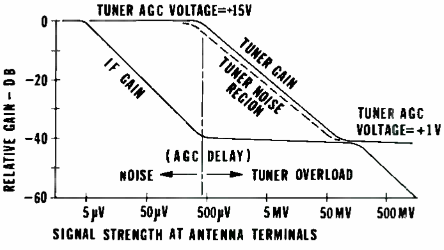
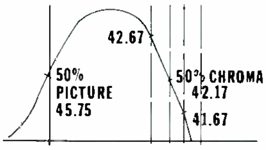
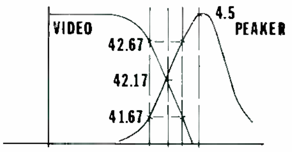


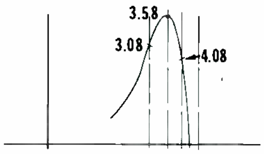
Fig. 7—Automatic gain control.



(a) Overall IF Response



(b) Overall Video and Peaker Response



(c) Overall Chroma Response

Fig. 6—Total picture—IF response.

Automatic fine tuning

The AFT circuitry in this module is similar to that used in a previous portable color-TV receiver (CTC-42) except for the manner in which input signal is provided.

The AFT signal source is IC1 (pin 14). The picture carrier source level is nominally 10 mV, located on the side of the steeply sloped IF response. A fixed tuned series peaker consisting of R18, C28, and L12, tuned with the input capacity of IC2 reduces the slope of the response at the IC2 input. The resultant AFT output correction voltage response is shown in Fig. 8.

Conclusion

The IF-AFT module is being produced for use in the CTC 49X chassis which uses a total of eleven plug-in modules. Performance and interchangeability is excellent. Receiver sensitivity typically ranges between 3 μV and 10 μV. Cost is about equal to the equivalent discrete system. Power consumption is low at about 1.5 watt (30 V, 50 mA).

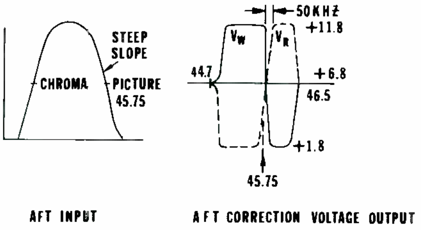


Fig. 8—Automatic fine tuning.

Sound system for the CTC-49 color TV

G. K. Sendelweck

The sound IF, detector, and amplifier for the CTC-49 color television receiver are incorporated into a single module board that can be used in several other receivers. Two features of this sound system are the use of an integrated circuit as the heart of the module and the application of an electronic attenuator circuit which eliminates electromechanical drive mechanisms for remote-control receivers.

THE MODULE CONCEPT in RCA color TV receivers was actually launched during the summer of 1969 with the introduction of the CTC-42, 16-inch portable receiver. This receiver incorporated the sound IF, audio detector, and audio preamp in an integrated circuit which was mounted on a plug-in module similar to the one used in the CTC-49. Presently, this module is being used in four different color-TV receivers and is scheduled for use in several more.

Since this was the first module to be used in RCA color TV's, some guidelines had to be established. Most important was interchangeability. The maximum number of components had to be mounted on the module, yet with sufficient flexibility to use the same module in several different chassis with various audio output and feedback systems. The second criterion was alignment: the module had to be capable of being aligned in a test fixture and maintain that alignment when plugged into the chassis. It must also be capable of being aligned in the chassis (i.e. in the customer's home) by a serviceman if the correct procedure is followed.

An integrated circuit—the RCA CA-3065, developed especially for this application by the Circuit Development Group in Somerville—is the heart of the sound system. In addition to the IC, the module requires only twelve components, thus making it one of the least complex modules in the color TV receiver (see Fig. 1).

Circuit operation

The CTC-49 sound system is shown in block diagram form in Fig. 2. The 4.5 MHz FM sound-IF is recovered by separate circuitry inside the pix-IF integrated circuit[1] and applied directly to the input of the sound system for processing. The input capacitor C1 was kept small enough so that variations in the output impedance of the pix-IF integrated circuit would have little effect on the tuning of the input transformer; T1 and C2 comprise a high-Q tuned circuit which resonates at 4.5 MHz and also provides impedance matching.

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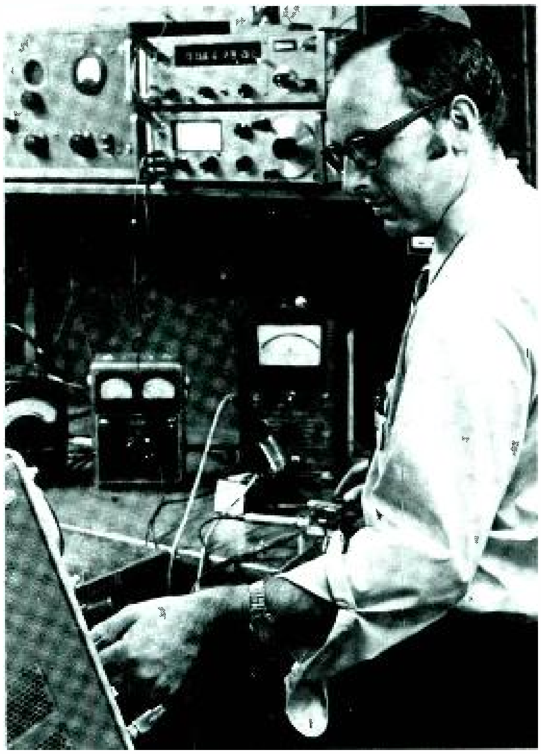

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received the BSEE with distinction from Purdue University in 1964. Following graduation, he joined the Color Television Design Group of the Home Instruments Division, Indianapolis, where he worked on convergence circuitry for color TV. He has since received the MSEE from Purdue and is presently employed in the development and design of TV sound systems. He holds two patents in the area of convergence circuitry and is a member of Tau Beta Pi.

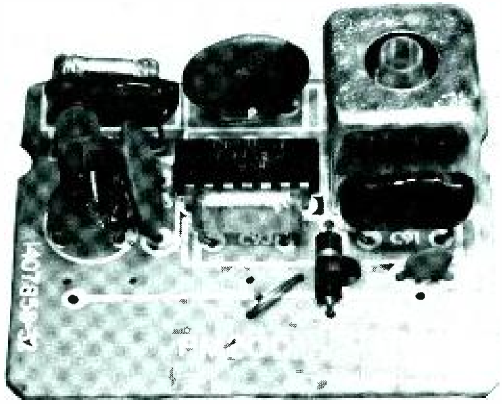

Fig. 1—Sound-IF, detector, amplifier module.

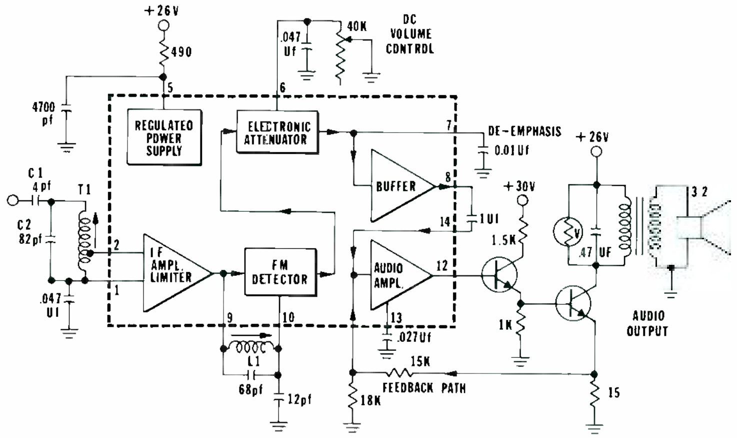

Fig. 2—Block diagram of the sound circuit.

The integrated circuit is quite complex as evidenced by its schematic diagram in Fig. 3. The IF-limiter section consists of three emitter-coupled stages, which function particularly well as limiters because each half of the differential amplifier is alternately cut off on the positive and negative half cycles of the input signal. Since the supply voltage is regulated, this allows symmetrical limiting without spurious phase modulation.[2]

The detector uses a frequency selective network and, unlike conventional discriminators, requires only a single coil for tuning. This results in a lower cost system which is considerably easier to tune than a conventional discriminator. The discriminator output is also high, being nominally 820 mV with an input signal deviation of 25 kHz.

Electronic attenuator

Probably the most unique feature of the integrated circuit is the electronic attenuator which allows the use of a single-wire volume control. The volume potentiometer is used as a rheostat and is part of a voltage divider circuit which changes the bias level on transistor Q6.

The resultant change in bias current in devices Q6 through Q10 will allow more or less of the audio current to pass through the load resistor R3, depending upon the volume control setting, providing more than 60 dB of volume-control action. The attenuator is balanced so that DC current through the load resistor does not change with volume control setting, thereby making the circuit virtually immune to noise from the volume potentiometer. Perhaps the most significant use of the DC feature occurs in remote-control receivers. Since it is possible to control the volume with a DC voltage connected directly to Pin 6 of the integrated circuit, the geared motor and motor relay previously used can be eliminated and replaced by a storage-capacitor/MOS type of remote system. The cost and reliability advantages of this type of system are readily apparent.

Audio section

The attenuator output is coupled by an emitter-follower buffer stage to the audio preamplifier which provides 20 dB of gain and operates into the base of an emitter follower driver transistor. The audio output stage is a fairly conventional transformer-coupled power amplifier which is capable of delivering 1.5 watts at less than 10% total harmonic distortion into a 3.2 ohm speaker. The capacitor across the transformer primary is used for high frequency rolloff while the voltage-dependent resistor (VDR) protects the output transistor from voltage spikes in case the speaker is disconnected. Overall feedback is used to stabilize the operating point and to decrease distortion.

Conclusion

The use of the electronic attenuator instead of a conventional volume control is a significant departure from previous sound systems. In addition, the detector on the CA3065 is one of the best single-coil detectors that the author has encountered in his work. Presently, several other device manufacturers are developing this type of IC, so the CA-3065 is well on its way to becoming an industry standard.

Acknowledgments

The author wishes to acknowledge the contributions of J. Avins and J. Craft of the Circuit Development Group in Somerville who were largely responsible for the development of the integrated circuit.

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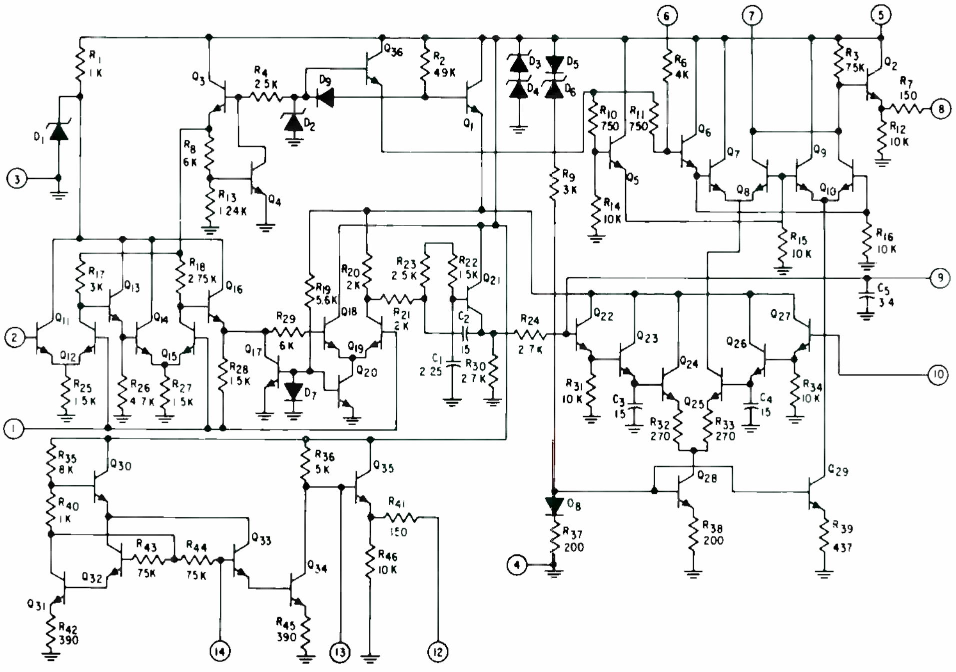
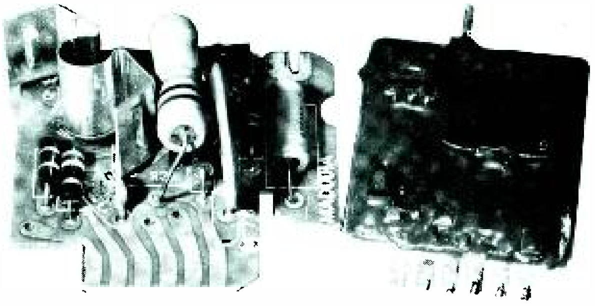
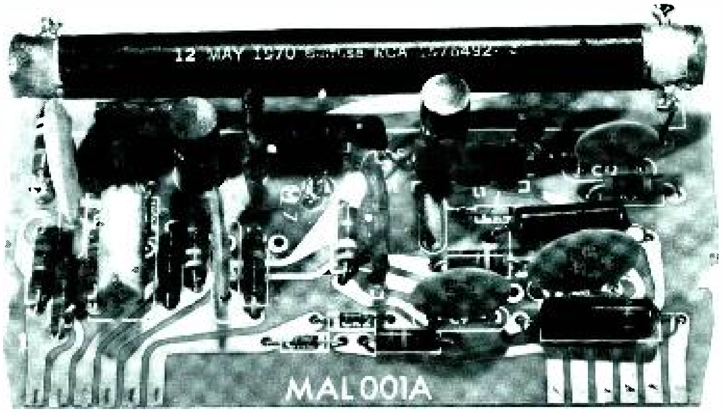


Fig. 3—Schematic diagram of the CA 3065 integrated circuit.





Luminance processing and kinescope driver modules for the CTC-49

D. H. Willis

This paper describes two modules used in the video system of the CTC-49 color television receiver. One module provides the video processing, luminance control, and sync separator functions; the other modules act as the kinescope driver. Both modules are plug-in types; the kinescope driver has been produced using both ceramic and phenolic printed-circuit boards (above, left); the luminance processing module (above, right) is available in phenolic-circuit-board form.

IN THE CTC-49 COLOR TELEVISION RECEIVER, the video envelope is detected and preamplified in the IF-AFT module, which is described in another paper in this issue.[1] The video is then fed to the video/sync module, which contains the first and second video amplifiers as well as the sync separator. The functions of luminance delay, vertical and horizontal retrace blanking, control of contrast, and control of video peaking are performed in the first video amplifier. Depending on the setting of the contrast control, the stage gain varies from about 0.3 to unity or slightly more. A shunt filter between the first and second video amplifiers attenuates 3.58-MHz video. The second video amplifier is an emitter-follower stage which provides an impedance match between the first video amplifier and the three parallel-driven kine-driver modules.

The module that performs the functions of the chroma-bandpass amplifier, burst amplifier, reference oscillator, AFPC, AGC, color-level control, and burst blanking are described in another paper in this issue.[2]

Matrixing of luminance and chrominance video outside the kinescope offers several advantages, the most significant is that the load offered by the three kinescope cathodes may be divided equally among three moderately rated drivers instead of one relatively high-power device, and, of course, the three kine-control-grid drivers are eliminated. Three identical modules are used to drive the three kine cathodes. Insofar as the luminance signal is concerned, they are driven in parallel, but each is driven by its respective color-difference signal. In addition to an output amplifier, each module contains a bias regulator stage which stabilizes the DC operating point of the output amplifier by returning the output voltage to the same point during each horizontal-blanking interval.

Luminance processing circuits

The function of the video module, in addition to sync separation, is to introduce the proper luminance time delay, to add horizontal and vertical retrace blanking pulses, and to provide the amount of luminance power gain required to drive the kine driver modules. This module also contains the interfacing between the luminance channel and the contrast control, brightness control, brightness limiter, and the peaking control.

Approximately 7 volts peak-to-peak of luminance-sync signal is applied to terminal 1 of the video module (Fig. 1) from the IF module. This signal has essentially no attenuation of the higher frequency components out to 3 MHz. There is a deep 4.5 MHz trap in the IF module to remove the intercarrier sound signal from the luminance channel.

From terminal 1, the signal is sent directly to the sync separator circuit. A low-pass filter R2 and C5 provides transient response tailoring and noise bandwidth reduction. The C2-R3 clamping time constant is long enough to satisfactorily pass vertical sync without excessive sag under normal signal conditions. However, under aircraft interference conditions or in a threshold horizontal pull-in condition, low frequency modulation appears in

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the IF signal output. The C2-R3 time constant is too long to track the sync tip envelope of such a signal effectively and is therefore disabled under these conditions by CR1; C1 and R1 then provide the clamping time constant which is short enough to track the horizontal sync tip envelope while the adverse condition is present.

The luminance signal is first sent through the delay line. It is then applied to the base of Q3 which is the first video amplifier. The emitter circuit of Q3 includes the contrast control R4207 which varies the AC emitter degeneration of the stage. The collector load resistance for Q3 is the peaking control potentiometer R4209. With the peaking control maximum, the 15-volt supply is connected to module terminal 8 providing a transient response with large overshoots as a result of high frequency emphasis from emitter bypassing through L2, R10, C11, R7, and C12, L109, R123, and C112. With the peaking control minimum, terminal 2 is connected to terminal 1 reducing the emitter bypassing through R7 and C12 and loading the collector through C9, C12, and R7. These effects combine to reduce the overshoots in the collector signal by a substantial amount.

Retrace blanking pulses are added to the signal at the Q3 collector through diodes CR2 and CR304 which couple positive vertical and horizontal retrace pulses, respectively, to the collector during the retrace intervals. Diodes CR2 and CR304 are reverse biased during trace intervals insuring decoupling between the deflection and the luminance channel for these intervals. Diode CR3 functions to restrict the positive excursion of the retrace pulses to +15.7 volts assuring a level top to the pulses and a low output impedance for the stage during retrace intervals. This low output impedance aids the clamping action occuring in the DC restorer at the input to the second video stage.

The DC restorer for the second video stage input (C7, CR4, and R14) clamps the positive tip of the Q2 base waveform to the bias voltage on the CR4 cathode; the bias voltage is determined by the brightness control setting.

A simple emitter follower (Q4) provides current gain for driving the kine drive modules; Q4 is cut off during retrace intervals. The brightness control, R4202, is part of a voltage divider from B+ to ground through R4011, R4012, R199, R321, and Q302; Q302 is the brightness limiter and is normally biased into saturation by base current through R319. CR199 clamps the junction of R199 and R321 to the emitter of the luminance output stage as long as Q302 is saturated. This connection provides a controlled amount of luminance DC regeneration. Kinescope beam current passes through R319, R320, and R115 before being increased in potential by the high voltage multiplier. When this current exceeds 1.3 mA, there is no more base current available for Q302 so it comes out of saturation causing CR199 to become reversed biased. Thus, the clamp voltage on the CR4 cathode rises causing the second video stage to be biased further toward a cut-off condition in order to limit the beam current.

Switch S601 disconnects the luminance drive to the kine driver modules during the kine screen bias adjustments. Rheostats R333, R335, and R337 are used to adjust the gain of the red, green, and blue kine driver modules, respectively, to achieve gray-scale tracking with various kinescope-gun transconductances.

Kine driver

The CTC-49 employs a low-level matrix kine-driver system. In this type of system each respective color-difference signal (*R-Y*, *B-Y*, and *G-Y*) is added to a luminance signal (*Y*) at a low amplitude level to form the three color signals (red, green, and blue). These color signals are then amplified to a level suitable for application to the gun electrodes of a three-gun color kinescope. The module functions can thus be divided so as to have three identical kine drive modules, each receiving the same luminance signal and its own color difference signal, with each module output driving one of the three kine guns.

For the 18VANP22 110° kinescope, a grid-cathode bias (E_{gk}) of -140 volts was chosen as a threshold *on* condition, each gun conforming to this requirement by individual adjustment of its screen bias. Each kine driver module drives one kine-gun cathode within an operating range of +20 to +160 volts, with the kine-gun grids biased at +20 volts. If the maximum screen bias available is not sufficient to turn on one or more guns while biased with $E_{gk} = -140$ volts, the grids can be collectively biased more positively with the bias control.

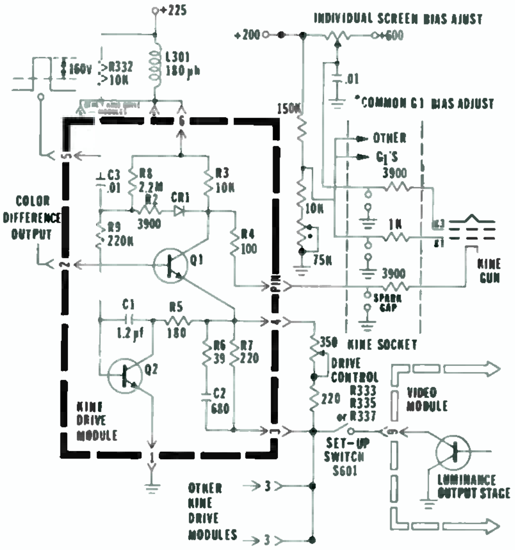

Fig. 1—Luminance processing module

In the basic kine driver stage (Fig. 2) Q1 operates in a fairly straightfor-

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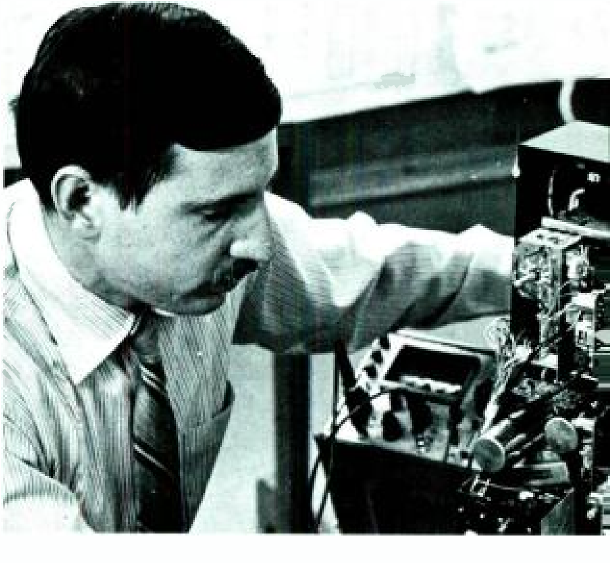

ward manner as a common-emitter amplifier for the color-difference signal and as a common-base amplifier for the luminance signal. The color difference signal, with an operating potential of approximately 5 volts, is applied to module terminal 2 and thus to the base of Q1.

Luminance signal voltage is applied to module terminal 3 and thus to the Q1 emitter resistance R_E=R7/(R_D+R16). Because the emitter voltage of Q1 fairly closely follows its base, the signal voltage across R_E is proportional to the color difference signal minus the luminance signal. If the color difference signal is $R-Y$ and the luminance signal is $-Y$, then the voltage across R_E is R. Therefore, since the voltage across R_E is proportional to the red signal, so also is the current through R_E and the collector current through Q1. This current produces an amplified $-R$ voltage at the collector of Q1 and at the red-kine cathode.

A difficult problem inherent in low-level matrix circuitry is providing, and maintaining, the proper bias voltage for the cathodes. The initial kine-cathode bias is subject to long-term and short-term drifts due to the leakage current of Q1, the base bias of Q1, the cut-in voltage of Q1, and the value of B+ on terminal 6. The bias of one kine cathode relative to the other two cathodes is particularly critical as relative drifts of two volts or more can be quite noticeable in the color content of the TV picture. The conventional approach to this problem involves additional potentiometers for initial bias adjustment and oversized heat sinks to keep device temperatures low. Such measures are not compatible with the modular circuit concept because module replacements should entail the barest minimum of subsequent chassis adjustments and large heat sinks do not fit easily onto modules. For these reasons, the automatic bias circuit was developed for the CTC-49 kine-driver modules.

Automatic bias circuit

In operation, the automatic bias circuit samples the voltage bias at the collector of Q1, compares this voltage to a reference, and adjusts the current bias of Q1 to correct the Q1 collector voltage bias if needed. Since the horizontal retrace time is the only interval during which the instantaneous voltage at the collector of Q1 is equal to the voltage bias of the collector, the collector voltage is sampled at this time. During the retrace interval, the retrace blanking circuit in the luminance channel drives terminal 3 to its most positive level, which is approximately equal to the emitter voltage of Q1, regardless of the scene, brightness control, etc. At this time, most of the current through Q1 is passing through R5, this current being a direct function of the collector voltage of Q2 Capacitor C1 acts as a Miller filter, so that the combination of C1 and Q2 appears as a large capacitance in parallel with a current generator. Thus, the collector of Q2 appears to R5 as though it were a DC voltage source, the magnitude of which is determined by the DC component of the waveform at the junction of R9 and C3 which provides DC base current to Q2 through R9. This action of Q2 is assured so long as Q2 is always conducting, which is the case except for very strong color-difference signals applied to terminal 2.

A horizontal-rate waveform (shown in Fig. 2 applied to module terminal 5) is completely AC coupled to the junction of R9 and CR1 by C3. Without conduction of CR1, DC current through R8 and R9 is sufficient to saturate Q2 because Q2 is a high-beta device. This conduction of Q2 causes a strong DC current through R5 and thus through Q1 causing the collector voltage of Q1 to drop. After the collector voltage of Q1 has been forced to drop sufficiently, CR1 will conduct on the positive tip of the horizontal-rate waveform, which occurs during the horizontal retrace interval, clamping the positive tip of the CR1 anode waveform to the collector voltage of Q1. Since the DC level of the horizontal-rate waveform is 160 volts below the peak positive level, the DC voltage at the anode of CR1 is 160 volts below the collector voltage of Q1 once clamping is established. As stated above it is this DC voltage that determines the DC current through Q2. The negative feedback bias loop has now been fully described. If the Q1 collector voltage drifts upward or downward from +160 volts, the DC level of the CR1 anode drifts upward or downward, respectively, from ground causing Q2 to conduct more heavily or turn off so as to bring the collector voltage back toward +160 volts. The loop gain of the circuit is about 20 so that if I_{CBO} of Q7 suddenly increases by 1mA, the automatic bias restricts the drop in collector voltage to 0.5 volts whereas it would drop 10 volts if the automatic bias circuit were not present. By correct choice of R8, the CR1 current can be adjusted to 1mA which provides about 10 volts of positive pulse at the collector of Q1 assuring a "blacker than black" condition during horizontal retrace.

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2. Cochran, L. and Harwood, L., "Chroma circuit design for the CTC-49," *this issue.*

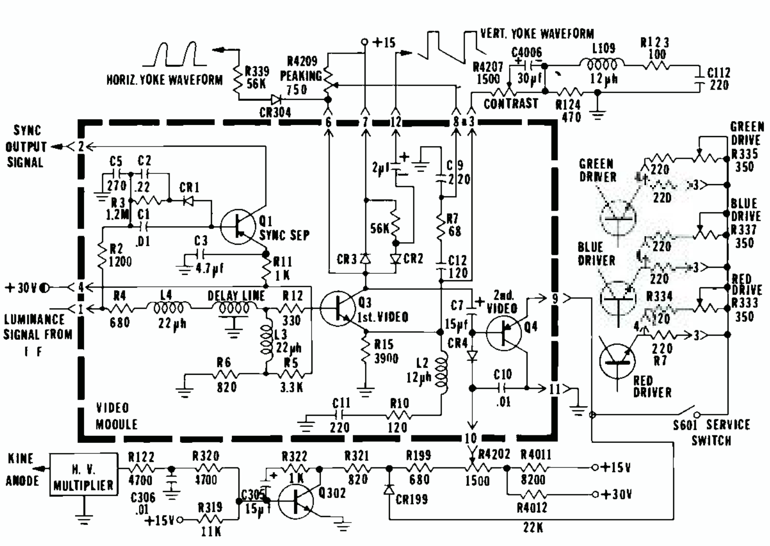
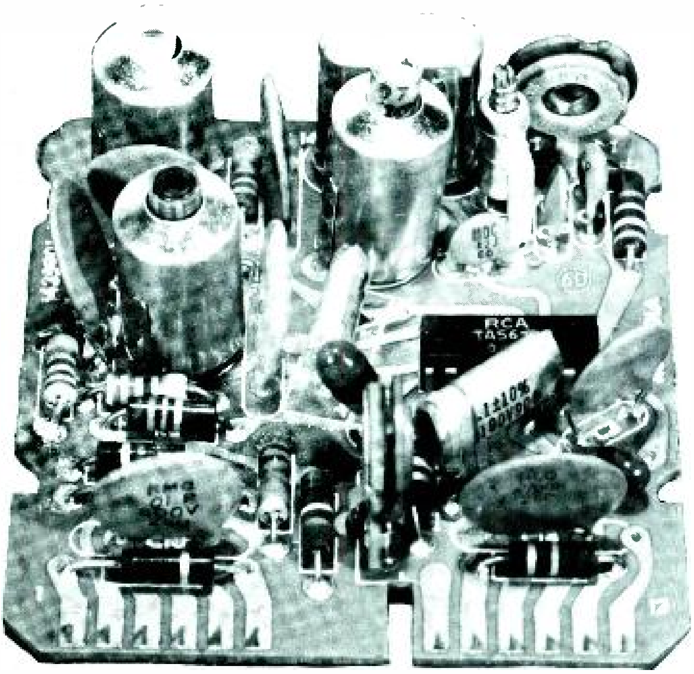
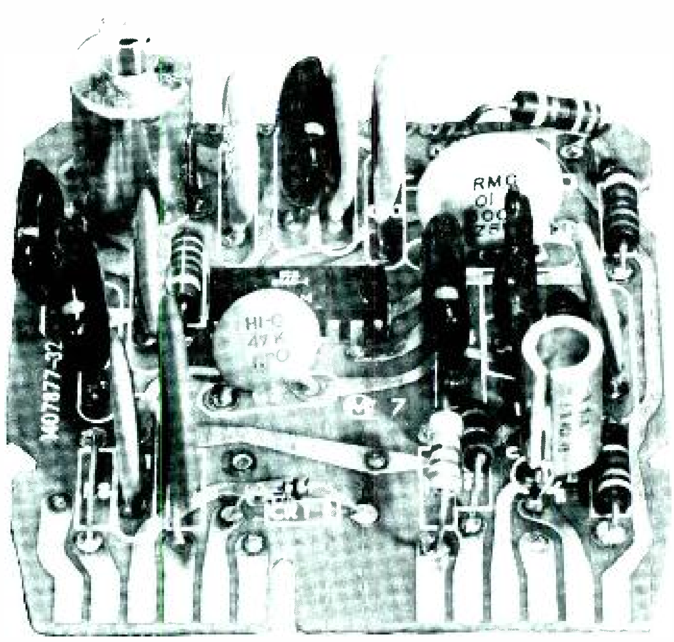


Fig. 2—Kinescope driver module





Chroma circuit design for the CTC-49

L. A. Harwood | L. A. Cochran

This paper describes a modular approach to color processing circuitry for color television receivers. Two silicon integrated circuits are described: the CA3066 chroma processor and the CA3067 chroma demodulator. These circuits were first introduced in RCA's new 110° deflection, 18-inch color TV receiver—the CTC-49.

COLOR PROCESSING CIRCUITS have traditionally occupied a large portion of the color television receiver due to the number of functions which they were required to perform With the advent of the integrated circuit, this is no longer the case. Modular construction, frequently used in military electronics, is now finding considerable attraction in consumer products, and coupled with integrated circuits, this technique has allowed the design of a compact and reliable color processing circuit. Table I compares the areas occupied by chroma-processing circuits in various RCA color chassis currently being produced.

The chroma circuitry in the CTC-49 was designed utilizing a pair of high performance integrated circuits—the CA3066 for processing and the CA3067 for demodulation. Two modules, each containing an integrated circuit, were used to achieve maximum design flexibility. Each module was designed so as to be aligned independently from the main chassis and from all other modules. Interconnections between modules were made at a low impedance level to insure interchangeability without realignment. All customer controls were designed to be DC operated to permit use with existing motorless remote control systems.

Table I—Area used for chroma processing circuitry in several RCA color TV receivers.

Chassis	*Approx. area (in²)*
CTC-49X	17.5
CTC-44	38.0
CTC-43	38.5
CTC-39	31.5

The primary function of a chroma processing circuit in a color television receiver is the restoration of the reference carrier and demodulation of the chrominance signal. A number of secondary functions such as; chroma and tint controls, killer, automatic chroma control (ACC), and other adjustments are also necessary for satisfactory operation. The various functions and their relationships are shown in block diagram form in Fig. 1. These functions are now performed by the CA3066 and CA3067 integrated circuits in conjunction with external components.

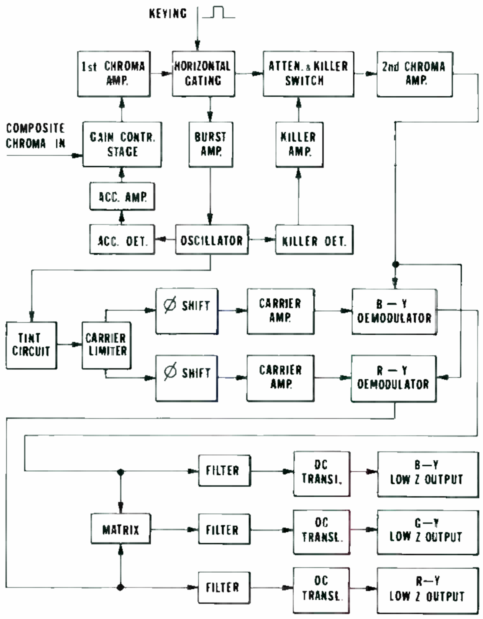


Fig. 1—Block diagram of the chroma section.

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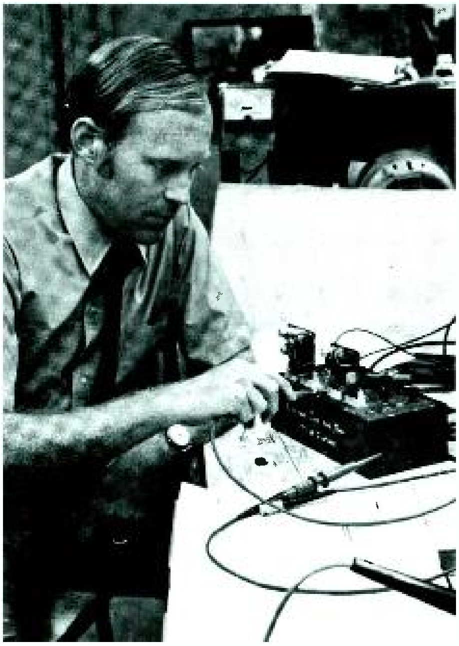

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joined RCA as a summer employee in June of 1962. He received the BSEE in January of 1963, and the MSEE in June of 1968 from Purdue University. Since joining RCA, Mr. Cochran has been a member of the Color Television Product Design Group of the Consumer Electronics Division. He has been responsible for the design and development of new color synchronizing circuits, demodulation systems, and many aspects of color signal processing circuitry. He has also been associated with the utilization of silicon integrated circuit technology in the design of color television receivers. Mr. Cochran is a member of Eta Kappa Nu and Tau Beta Pi.

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graduated from Munich Institute of Technology in 1949 with the BSEE and received the MSEE in 1959 from the University of Pennsylvania. Following engineering experience at Pilot Radio and Picatinny Arsenal, Mr. Harwood joined RCA in 1952 as an engineer in the Home Instruments Division and was engaged in the development and design of UHF and VHF tuners. From 1960 to 1963, he was a member of the Home Instruments Affiliated Research Laboratory in Princeton. Since 1964, he has been with the Consumer Electronics Division's integrated-circuit development group in Somerville, designing integrated circuits for television and radio receivers. He has been granted a number of patents in his field of work; he is a member of the IEEE.

The first chip, the CA3066, is 62 mils square and provides the circuitry for the gain controlled chroma amplifier, gating of the chroma and burst signals, DC-controlled chroma level adjustment, chroma-output stage, burst-amplifier stage, injection-locked oscillator driving the killer, and the AGC detectors, and killer and ACC amplifier stages.

The second chip, the CA3067, is 76 mils square and receives the reference carrier and the chrominance signal from the previously described circuit and delivers the three demodulated *R-Y*, *B-Y* and *G-Y* color difference signals to the kinescope driver module.[1] The tint phase-shift circuit, completely integrated, allows for a 100° angle adjustment by means of a customer-operated DC control. An amplitude limiter provides a constant amplitude carrier which drives two individually phase shifted demodulators. The chrominance signal, also applied to the demodulators, is demodulated and matrixed to produce the three color-difference signals.

Chroma I module—CA3066

First chroma amplifier

The composite chroma signal is derived from a low-impedance source located on a plug-in IF module.[2] High frequency roll off of chroma frequencies in the IF is compensated on the IF module. The chroma signal is applied to the first chroma amplifier consisting of transistor Q1 and the selective filter connected to terminal 16 (Fig. 2). This filter, is conjunction with the filter connected to terminal 15, provides the selectivity required by the chrominance signal. A low-Q core was added to L1 to provide flexibility in contouring of the frequency response. A current divider formed by devices F1Q2 controls the current flowing from the collector of Q1 to the tuned filter. The current divider is in the automatic chroma control (ACC) servo loop and maintains a constant chroma level at terminal 16. The signal is then applied to the second chroma amplifier Q3 and the burst amplifier Q6. Both stages are fed essentially in parallel by means of a signal translator formed by zener diode Z2, resistor divider R5 and R6, and the emitter follower F4.

Second chroma amplifier

The chroma signal, in its path to the second bandpass filter, is controlled by two current dividers formed by transistors F6Q4 and Q5F7. The first current divider is energized by the positive horizontal keying pulse applied to terminal 10 causing the second chroma-amplifier stage to be disabled during the burst interval. The second current divider, Q5F7, performs two functions:

1) It serves as an on-off switch when operated by the killer amplifiers Q12 and Q13. In the absence of a burst signal, Q13 conducts, and the base of the emitter follower F5 is at a low potential with respect to the base of transistor F8 causing transistor Q5 to be cut of.

2) The stage Q5F7 serves also as an attenuator when controlled by the variable potentiometer connected to terminal 15. Capacitor C102 places the base of transistor F5 at signal ground. The DC voltage at terminal 15 can be adjusted by the customer to set color saturation to a desirable level. The chroma signal, developed across the selective filter network at terminal 13, is translated to the output stage, F13, by the zener Z6 and resistor R33 network. The low impedance chroma at terminal 14 is ready to be applied to the demodulators.

Burst amplifier

The composite chroma signal, available at the emitter follower F4, is also supplied via resistor R7 to the burst amplifier Q6. The on-off, Q7F9, switch in the collector of Q6 passes the burst signal to the burst tank circuit at terminal 11, while the chroma signal returns to ground through the power supply terminal. The on-off switch is operated by the horizontal keying pulse applied to terminal 10. The function of the burst tank circuit is threefold:

1) It provides selectivity necessary for removing horizontal gating frequencies;

2) It provides some reactive impedance in the oscillator loop in order to satisfy phase shift criteria; and

3) It provides a voltage needed for neutralization of burst sidebands coupled through the crystal-holder capacitance.

The RC network connected to terminal 3 accurately sets the current in the burst transistor Q6 and provides a signal ground for its emitter.

Oscillator

The burst signal synchronizes the receiver and the transmitter by locking a locally generated carrier both in frequency and phase. The oscillator circuit developed for this function is of the injection type as employed in many presently used color receivers. The integration of this oscillator resulted in a very stable signal source with simple adjustments. Referring to Fig. 2, and 3, the oscillator consists of a linear amplifier followed by a limiter circuit and a crystal filter completing the feedback loop. The linear amplifier is formed by transistors Q9, Q10, and Q11 and resistors R18 through R22 connected to form a feedback amplifier.

This circuit has several desirable features important in this application. The feedback stabilizes the operating DC potential, which allows predictable set up of the killer and ACC detectors. Both detectors are directly coupled to this stage. The low input impedance at the input terminal provides a noncritical return path for the crystal filter.

The frequency of the oscillator is set primarily by the stable filter consisting of the crystal and tuning capacitor C106. The feedback amplifier responds linearly to applied signals, and the amplitude of the oscillator signal on terminal 8 increases proportionally to the applied burst signal. The limiter section consists of transistor Q8, the RC filter in the emitter of this transistor, and the collector load formed by the burst tank. The phase shift introduced in the limiter circuit is compensated in the burst tank circuit. The RC time constant is chosen so that this stage amplifies linearly for small signals; however, large signals are rectified, and the limiting which takes place mantains the oscillator output at a relatively constant level. The level at which the oscillator signal is limited is determined by the setting of potentiometer R106. The resulting voltage drop across the burst tank is coupled, through the crystal filter, to the input terminal of the linear amplifier section. Capacitor C105 filters harmonics of the oscillator waveform.

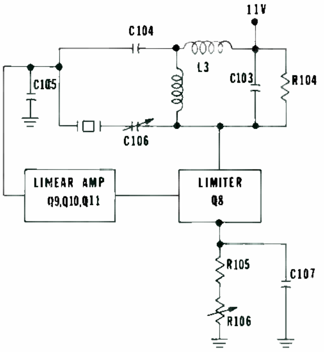

Fig. 3—3.58-MHz oscillator circuit.

The burst signal, amplified by Q6, also appears at the burst tank on terminal 11 where it excites the crystal and forces the oscillator into phase synchronization. The burst energy stored in the filter is amplified by the linear amplifier section of the oscillator. The increased CW amplitude, which depends on the amplitude of the injected burst signal, is detected by the killer and ACC detectors and used to supply these functions with information.

Automatic chroma control

The ACC detector consists of transistor Q14 and the RC circuit in the emitter of this transistor; the RC network integrates out the effects of loss of signal during the vertical interval. The oscillator peak signal is detected to provide optimum noise performance, and the DC component is used

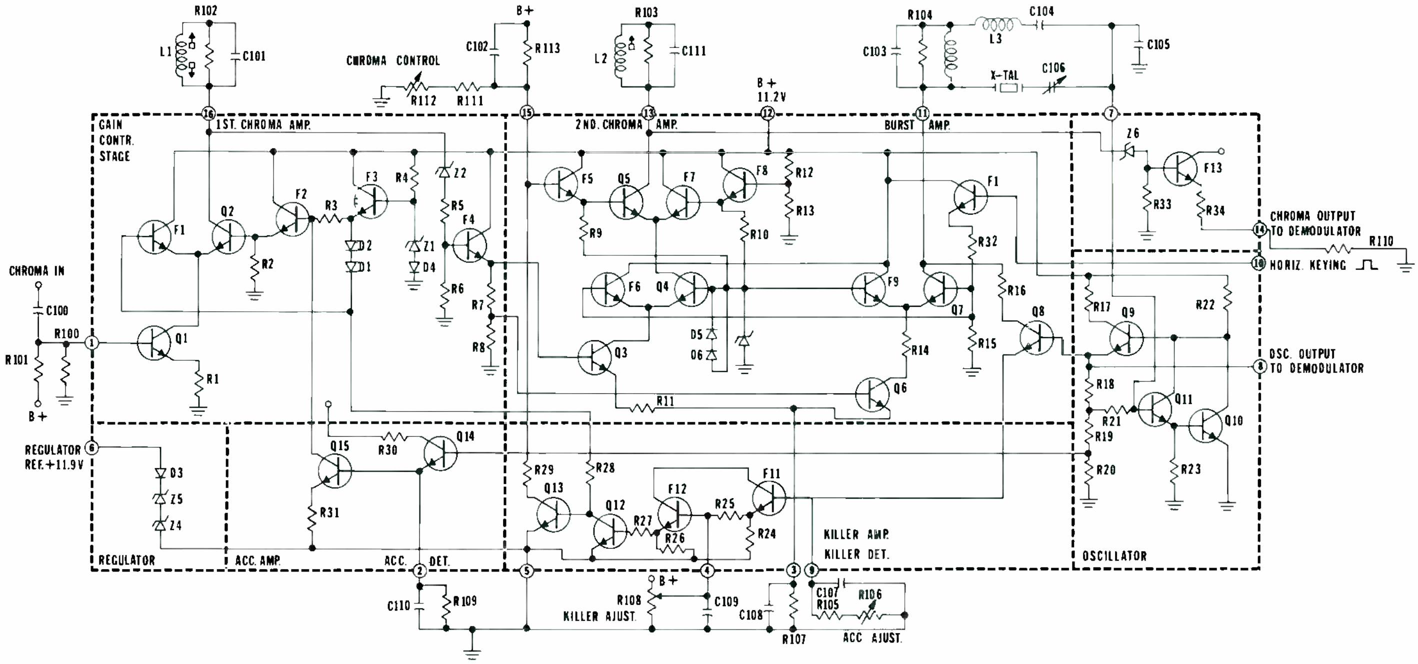

Fig. 2—Schematic diagram of the CA3066 chroma integrated circuit (Chroma I module).

to control the current in the ACC amplifier, Q15. In the absence of burst signal, the amplitude of the oscillator signal is adjusted so that transistor Q15 is cut off and the first chroma amplifier stage is at maximum gain. The voltage offset developed across diode D1 prevents the follower F1 from conducting. Diode D2 compensates the base-to-emitter offset of transistor F2. In the presence of a chroma signal, the rectified oscillator signal causes transistor Q15 to conduct thereby reducing the potential on the base of transistor F2. Through this action, transistor F1 is allowed to conduct, and the excess chroma signal is shunted to AC ground. The output signal from the first and second chroma stages remains essentially constant for relatively large chroma input-signal variations.

Killer circuit

The rectified oscillator signal from the limiter stage, Q8, provides the information necessary for the killer action. This DC information represents the average value of the signal existing in the oscillator loop due to the selected RC time constant of the detector; consequently, noise injected into the oscillator through the burst channel will be integrated and not coupled to the killer circuitry. In the presence of a burst signal, the amplitude of the oscillator signal increases and the corresponding rise in DC potential is translated to killer amplifiers Q12 and Q13.

The DC bias—translated through devices F11 and F12—is proportioned so that, in the absence of a burst signal, transistor Q12 is cutoff and transistor Q13 conducts. Threshold conduction of Q13 is adjusted by means of potentiometer R108 on terminal 4. Capacitor C109 filters AC information from the killer circuitry. The collector current in transistor Q15 reduces the potential on the base of transistor F5 to a level sufficient to disable the second chroma amplifier.

Chroma II—CA3067

The Chroma II module contains the CA3067 integrated circuit with associated external circuitry and a voltage regulator which is referenced to a zener supply located on the TA5625 (see Fig. 4). The series regulation circuit is connected as shown in Fig. 5. The zener reference is located on the TA5625 so that the biasing circuitry on this chip tracks the zener supply variations. The regulated supply is disabled if either chroma module is removed, insuring that no damage occurs to the integrated circuits.

The chroma and carrier signals are coupled to the TA5752 through appropriate coupling networks. The carrier signal is phase shifted and attenuated by R101 and C101 to establish correct nominal phase at a level that will not overload the tint control circuit. The chroma and reference carrier signals are processed in the TA5752 integrated circuit to produce three color-difference signals. A DC-controlled tint network permits the customer to correct the phase of the reference carrier.

Tint circuit

The operation of the tint network is based on a vector relationship as shown in Fig. 6. Vectors **A** and **B**, representing the instantaneous phase of the carriers, are added geometrically to produce a resultant vector **C**. Vectors **A** and **B** are displaced by a constant phase angle of 135°; however, the amplitude of the vector **A** is constant, while the amplitude of **B** can be varied in a continuous manner from zero to about twice the amplitude of **A**. Thus, the phase of the resultant vector **C** varies from 151.5° to 45° i.e., the phase variation is approximately 106.5°. The relatively small variation of the amplitude is inconsequential.

The reference carrier is applied to

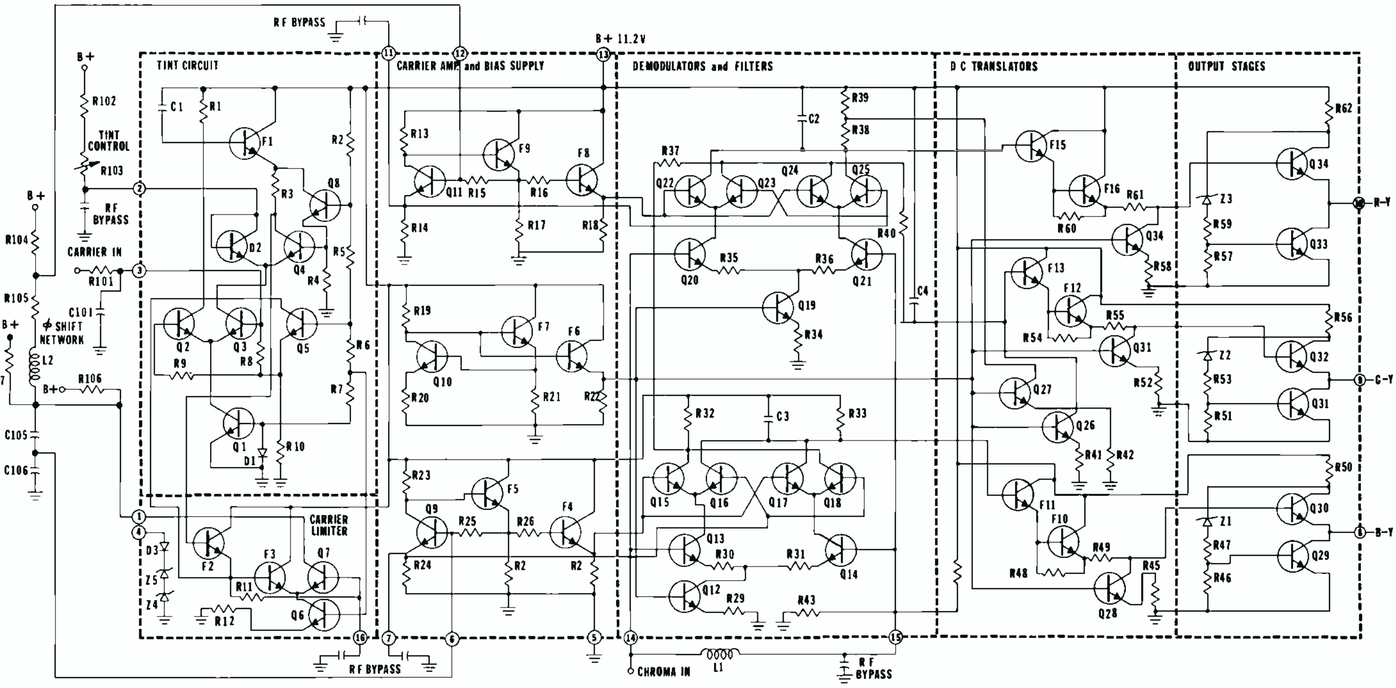

Fig. 4—Schematic diagram of the CA3067 chroma integrated circuit (Chroma II module).

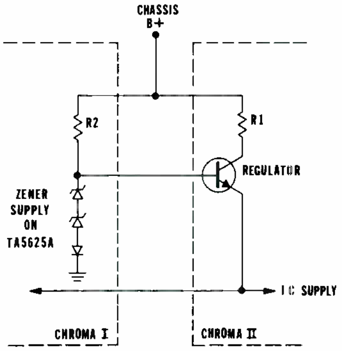

Fig. 5—Series regulator circuit for Chroma I and II modules.

terminal 3 (Fig. 4) which is the input of the differential stage formed by transistors Q2 and Q3. The R1-C1 network in the collector of Q2 phase-shifts the carrier signal by 45°. This signal is then added, at the collector of Q4, to the signal propagated along the path Q3 and Q4. The latter signal is 180° out of phase with the signal on terminal 3 and its amplitude can be varied by adjusting the impedance of diode D2. This diode shunts the reference carrier signal, and the diode impedance is a function of the customer-operated DC control current.

Carrier limiter and phase shift network

The reference carrier, which is controlled by the tint circuit, is applied to the limiter stage F3Q7 (Fig. 4) to remove amplitude variations. A tuned circuit in the collector of Q7 filters the harmonics of the current limiter carrier signal.

Separate reference carriers of approximately 90° phase difference are required for the *R-Y* and *B-Y* demodulators. The two reference signals are derived from the limiter tank circuit and the components of this circuit consisting of L2, R104, R105, C105, and C106 are chosen to provide two properly phase-shifted carrier signals of equal amplitude. Both signals are amplified by DC-coupled carrier amplifiers which provide stable reference bias potentials for the demodulators. Since both carrier amplifiers are identical, only one will be described. The amplifier for the *R-Y* carrier is formed by transistor F9 and Q11 and resistors R19, R14, R15, and R17. Resistors R13 and R14 are approximately equal in value; thus the DC potential at the emitter of the transistor F9 is approximately one half the supply potential. Using this low-impedance point for a reference voltage, the base of transistors Q22, Q23, Q24, and Q25 are biased from two symmetrical supplies formed by the R15-Q11 and R16-F8 follower circuits. This assures identical quiescent potentials for the demodulator transistor.

The amplification of the carrier signal, which is applied to terminal 12, is obtained in the Q11-R13 amplifier. This stage operates as a grounded-emitter amplifier since terminal 11 is bypassed for RF signals.

Demodulators

Two doubly balanced demodulators detect synchronously the chroma signal and produce three-color difference signals: *R-Y*, *B-Y* and *G-Y*.

In the *R-Y* demodulation, the chroma signal is applied to transistors Q20 and Q21 and passes through two pairs of alternately switched transistors Q22-Q23 and Q24-Q25. The switching signal is the previously described, properly phase-oriented reference carrier. The collectors of the switching transistors are connected so as to develop two signals: *R-Y* and its complement −*(R-Y)*.

Similarly, in the *B-Y* demodulator, the chroma signal is applied to transistors Q13 and Q14 and passes through the two pairs of switching transistors Q15-Q16 and Q17-Q18, and the output signals are *B-Y* and −*(B-Y)*.

The detected signals are processed in the following manner: The *R-Y* signal is developed across R38 in series with R39, filtered by C2, and translated to a low-output-impedance driver. The *B-Y* signal is developed across load resistor R33, filtered by C3, and translated to a corresponding driver circuit. The *G-Y* signal is obtained by matrixing the two complementary signals in the R32 and R37 resistor matrix. This signal is also applied to a low output impedance driver.

DC-translation and driver circuitry

Three identical driver stages are employed for the three color-difference signals. The drivers exhibit a very low output impedance achieved through DC-coupled feedback. Referring to the *R-Y* driver, the color difference signal, applied to the base of Q36, is available at the terminal 10. External loading, such as may be exerted by the output transistor, produces an error signal. This signal is propagated through the emitter collector path of Q36 to R62 and through zener Z3 and R59 to the base of Q35. The collector of this transistor is returned to terminal 10 thus completing the feedback path.

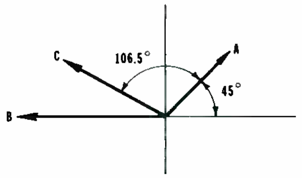

Fig. 6—Vector diagram of the phase relationships in the tint circuit.

The three driver circuits operate at equal and compensated DC potentials to facilitate DC coupling to output stages. The DC balance is achieved by means of current sources which shift the DC potentials. Thus, transistors Q27 and Q34 introduce DC drops on resistors R39 and R61, respectively, thereby maintaining the base potential of Q36 at a prescribed DC level. Similar compensation is achieved in the *B-Y* path by Q28 and by Q26 and Q31 in the *G-Y* channel.

Summary

The circuit module concept, combined with IC technology, has resulted in a significant step forward in the design of color television receivers. The developed chroma circuit is superior from a service, a manufacturability, and a design standpoint. As a result, the consumer benefits from a more reliable and easily serviced product, the manufacturer will be able to use more efficient production methods, and the designer will have the flexibility to improve his design without affecting the remainder of the color television receiver.

Acknowledgment

The authors acknowledge assistance and contributions made by E. J. Wittmann of Consumer Electronics Division, Somerville, N.J.

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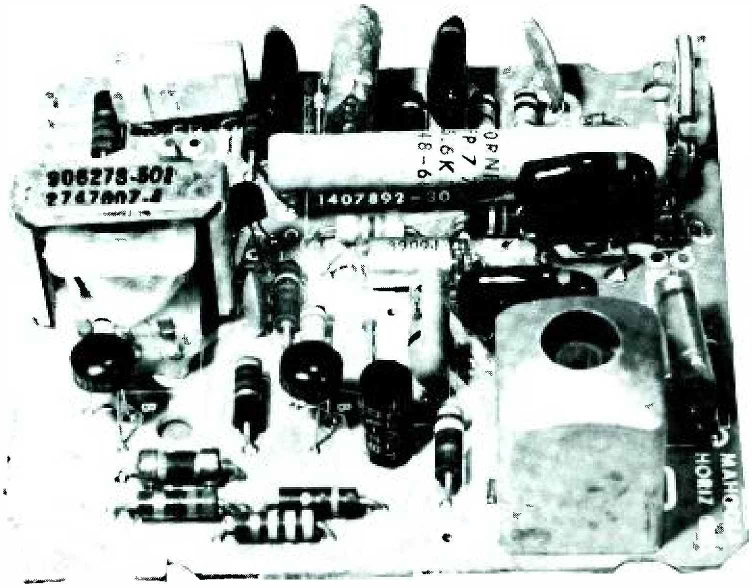

Horizontal AFC and oscillator for the CTC-49

J. K. Lin

This paper describes the horizontal AFC and oscillator circuits for the CTC-49 color television receiver which are contained in a single module. The associated horizontal deflection and high voltage circuits are describd in a companion paper in this issue.[1]

In general, the horizontal AFC and oscillator system for the CTC-49 is similar to the one used in the CTC-40. This circuit is chosen for its ability to provide a rectangular pulse with low output impedance and for its stability of frequency and pulse width despite variations of ambient temperature and line voltage. Some minor changes have been made to minimize the effects of excessive modulation on horizontal flyback pulse and the newer low gate impedance of commutating SCR. A block diagram of the system is shown in Fig. 1; the general performance characteristics are summarized in Table I.

Table I—Horizontal AFC and oscillator performance.

Pull-in Range:	15614 to 15887 Hz.
Hold-in Range:	15215 to 16199 Hz.
Frequency stability	
Versus line voltage (low to high line):	15703 to 15774 Hz.
Versus temperature (25 to 65° C):	±60 Hz.
Output pulse:	10 volts, peak to peak
Pulse width:	4.3 μs.
Stability of pulse width	
Versus line voltage:	<0.1 μs
Versus temperature:	<0.1 μs
Oscillator sensitivity:	2kHz/volt

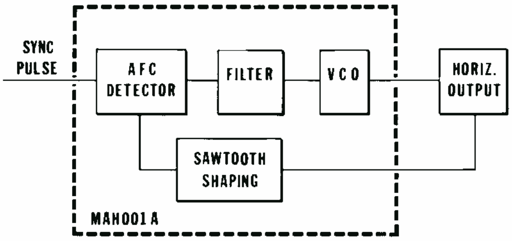

Fig. 1—Block diagram of horizontal AFC and oscillator system.

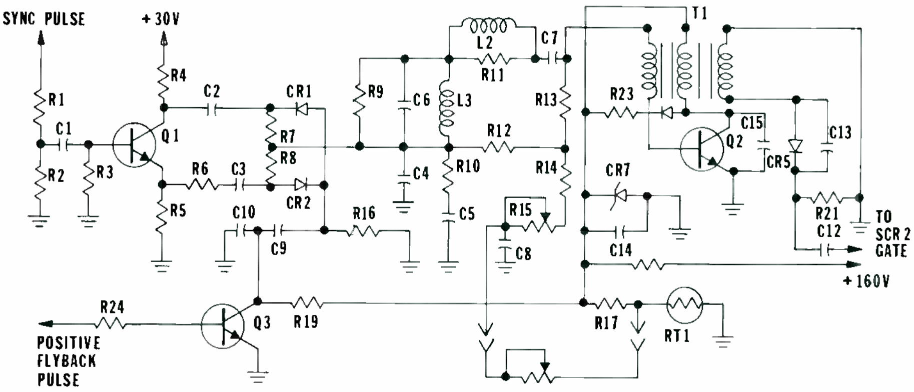

Fig. 2—Schematic diagram of horizontal AFC and oscillator system.

The horizontal oscillator is designed with a free-running frequency of 15,734 ± 60 Hz. The AFC circuitry associated with the sync pulse and horizontal flyback pulse is designed to hold the horizontal frequency to exactly 15,734 Hz. Fig. 2 is a schematic diagram of the entire horizontal AFC and oscillator circuit.

Horizontal AFC and filter

The positive sync pulse, separated from the composite video, is differentiated by capacitor C1 and resistor R3 and supplied to the base of transistor Q1 which acts as a phase splitter. A referenced sawtooth voltage is then compared with the negative- and positive-going sync pulses via a push-pull type detector. The sampled sawtooth voltage developed at the output of detector is filtered by a low-pass filter and supplied as a control voltage to the horizontal oscillator.

Reference sawtooth waveform

Due to the requirement for the side-pincushion correction with the 110°-deflection tube used in the CTC-49, the horizontal flyback pulses have more modulation than those on CTC-40 (90° deflection). The feedback of excessive modulation from horizontal output to the input of horizontal AFC (automatic frequency control) detector results in a center-line bend. To minimize this problem, an additional active device Q3 is used to form the AFPC (automatic frequency and phase control) reference voltage waveform. A positive going horizontal flyback pulse is fed in the base of transistor Q3 through resistor R24. During the trace time, capacitor C10 charges through resistor R19, creating the positive slope of the reference sawtooth. When the retrace time occurs, a positive-going flyback pulse causes transistor Q3 to conduct. Capacitor Q10 then discharges through transistor Q3.

Horizontal oscillator

A blocking oscillator incorporated with stabilization circuitry is employed here. A damping diode CR8 and resistor R23 have been added across the primary winding of oscillator transformer T1 to protect the oscillator transistor Q2 from the overshoot voltage at the collector of Q2. Because of the lower gate impedance of the commutating SCR, the oscillator transistor does not go into saturation immediately at turn on. This effect has been eliminated by choosing a higher current gain h_{FE} of the oscillator transistor Q2.

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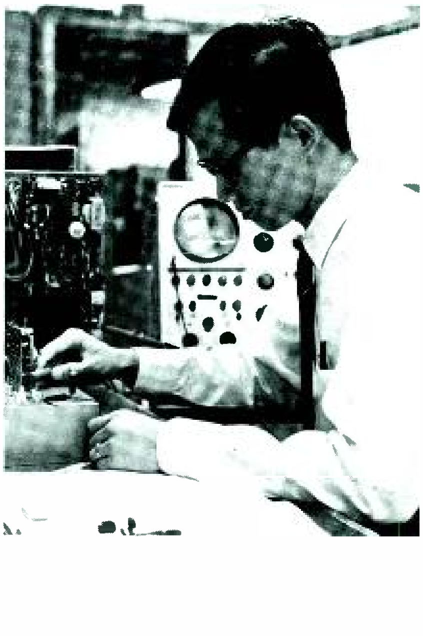

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Horizontal deflection and high-voltage circuitry for the CTC-49

R. J. Gries

This paper describes the horizontal deflection circuit and high-voltage system for the CTC-49 color television receiver. The associated horizontal AFC and oscillator are described in companion paper in this issue.[1]

The horizontal deflection circuit used in the CTC-49 color television receiver is very similar to that used in RCA's first solid-state instrument, the CTC-40. The CTC-49 uses the SCR circuit invented by Mr. W. Dietz, which is shown in schematic form in Fig. 1. This type of deflection circuit was selected since an SCR is the only consumer-type semiconductor commercially available that can handle the energy required to deflect the 110° kinescope. Since the SCR system has already been fully described,[2] only the differences will be discussed here.

Horizontal deflection

The CTC-49 requires about 5.2 millijoules of energy in the yoke for horizontal deflection; this compares with approximately 3.5 millijoules used in the CTC-40. The extra energy was achieved mainly by raising the current level in the circuit while maintaining the voltage constant because of the voltage-rating limitations on the SCR's and deflection diodes. This also explains why there are two capacitors in parallel several places on the schematic (Fig. 1); one capacitor is not able to carry the necessary current reliably because the capacitors available during development did not have sufficient area to dissipate the heat. Also, the deflection diodes were stud-mounted to the commutation-coil bracket, and the heat sink for the SCR's was greatly enlarged. It may be interesting to note here that the current flowing in the horizontal yoke winding is a 15-amp peak-to-peak sawtooth, and that an 18-amp peak current flows through the commutating SCR. The CTC-49 also uses a high-voltage quadrupler to develop the high voltage.

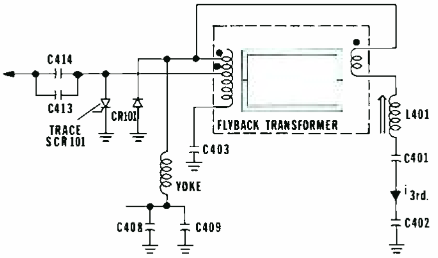

Fig. 2—Third harmonic circuit.

Third-harmonic tuning

Another difference between the CTC-40 and the CTC-49 is that the third-harmonic tuning is added to the retrace pulse by discrete-component circuits (Fig. 2). In the CTC-40, the leakage inductance and the stray capacity of the high voltage winding are tuned to the third harmonic of the retrace pulse. However, since the voltage pulse needed at the input of a high voltage quadrupler is about one-quarter of the voltage required when a single high-voltage rectifier is used, one-quarter of the turns on the high voltage winding are required. Thus, there is not enough leakage inductance and stray capacity to tune the high voltage winding in the CTC-49.

Although the third-harmonic tuning could not be built into the flyback, it was still needed to help turn off the

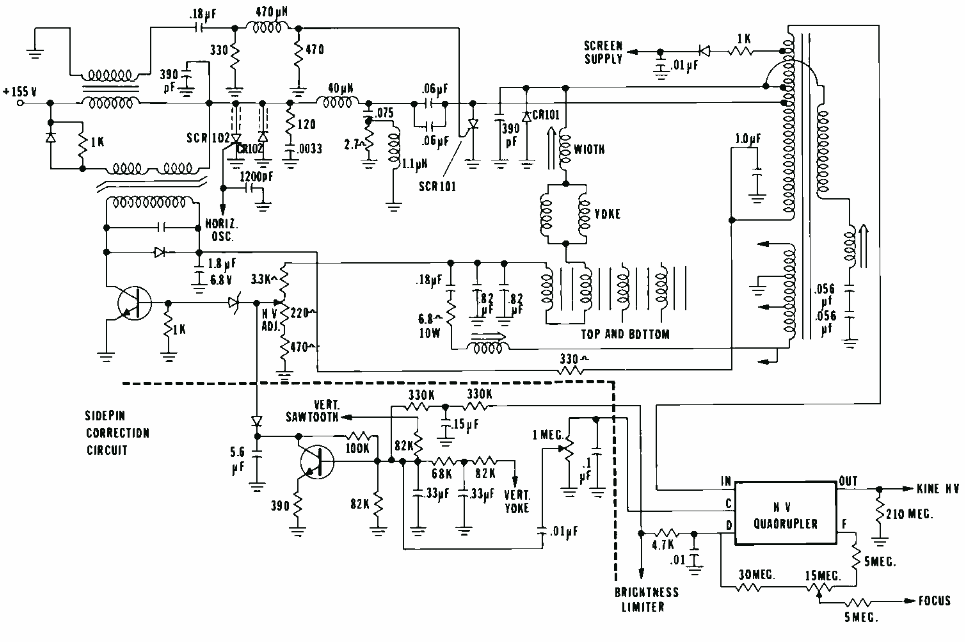

Fig. 1—Schematic diagram of horizontal deflection and side-pincushion correction circuit.

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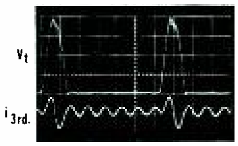

Fig. 3a—Third harmonic current.

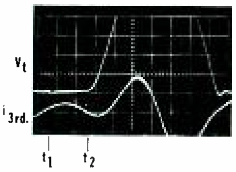

Fig. 3b—Current in the third harmonic circuit just before and during retrace.

trace SCR before retrace could occur. Third-harmonic tuning was also needed to reduce the operating voltage on the trace diode and trace SCR by approximately 20%. For these reasons, discrete components were required; however, most of the required inductance is built into the flyback by winding-bucking turns on the bottom leg of the flyback core. The rest of the circuit consists of two capacitors in series and a small tuning inductance.

The fact that the third-harmonic tuning reduces the voltage applied to the trace switch is well known and will not be discussed. The manner in which third harmonic tuning increases the allowed turn-off time for the trace SCR may be seen by referring to Fig. 2 and 3.

Prior to retrace, the commutation SCR is turned *on;* the commutation current turns the trace SCR *off* and the trace diode *on.* The amplitude of this commutation current determines the length of time that this diode conducts, which in turn determines the amount of time allowed for the trace SCR to turn *off*. The commutation current amplitude is determined by such considerations as the B+ voltage, the required energy to be stored in the yoke, the yoke impedance, the required retrace time, a compromise with the turn-off time of the commutation SCR, and the requirement that the trace diode not turn-off again immediately after the retrace period. By referring to Fig. 3b it may be seen that the third harmonic current is positive from t_1 to t_2 while the trace diode is conducting. Thus, there is a net increase in current from the anode to the cathode of CR 101 (Fig. 2) with the extra current flowing through the third-harmonic circuit back to ground. Although the current induced in the primary of the high-voltage transformer by the mutual inductance tends to cancel this increase in trace diode current, these windings are very loosely coupled, and the cancellation effect is not very large. Turn-off time was a constant consideration during the design of this system—even more so than in the CTC-40 because of the increased current in both SCR's.

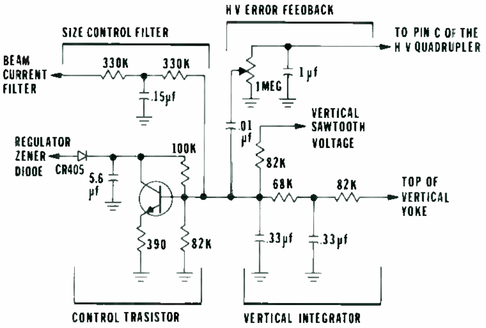

Fig. 4—Side-pincushion correction circuit.

Sidepin correction

Sidepin (side pincushion) correction is achieved differently in the CTC-49 than it was in the CTC-40 since much more sidepin correction is required for 110° kinescopes than is needed for the 90° tubes used with the CTC-40 chassis. The 110° tubes have about a 30-inch radius uncorrected, while the 90° tubes have approximately a 50-inch radius [curvature of outside vertical lines on an uncorrected kinescope as shown in Fig. 5]. The circuit used to correct for sidepin distortion is shown in Fig. 4. The regulator used in the CTC-49 is similar to that which was used in the CTC-40 and will not be described here.

The amount of scan and high voltage in the CTC-40 depends on the setting of the high-voltage adjustment potentiometer. The control transistor in the sidepin-correction circuit automatically changes this adjustment as far as the regulator transistor is concerned. When the control transistor is made more conductive, more of the feedback current flows through it; thus, less current can flow through the regulator zener diode, the regulator transistor, and the control winding of the regulator saturable reactor. As a result, more yoke current, scan width, and high voltage are produced. When the control transistor is made less conductive, just the opposite happens, and less scan width (yoke current) and high voltage are produced. Since the voltage at the cathode of the regulator zener diode drops to a very low voltage during the horizontal retrace, CR405 and the 5.6 μF capacitor are needed to keep the transistor turned *on* during this time and thus maintain a relatively high impedance across the output of the vertical integrator. As a result, to achieve sidepin correction, all that is needed is to make the control transistor have the correct collector current.

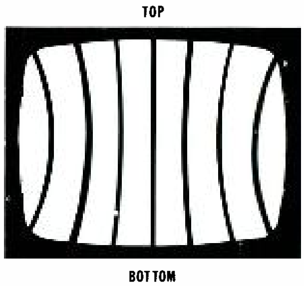

Fig. 5—Vertical lines in a raster with no sidepin correction.

If sidepin correction were not used, vertical lines on the raster would appear as shown in Fig. 5; more scan is needed in the center and less at the top and bottom of the raster. Thus, a

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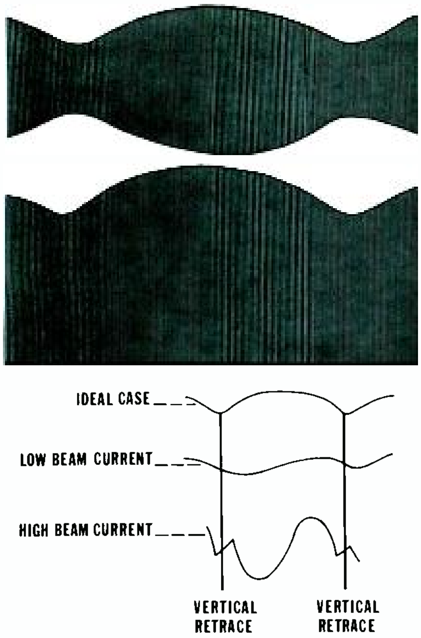

Fig. 6—a) Envelope of horizontal yoke current at a vertical rate; b) envelope of the horizontal retrace pulse at a vertical rate; c) high voltage AC or "ripple".

parabolic current is needed in the collector of the control transistor at the vertical scan rate (with maximum current occurring during the center of the vertical scan). The required parabolic voltage at the base of the control transistor is easily generated by integrating the voltage across the vertical yoke windings and the vertical sawtooth feedback voltage. This is done in the integrator. This works fine for low beam currents, but causes bends at high beam currents. The reason for this can be seen by referring to Fig. 6. If the yoke current and flyback pulse are varied at a vertical parabolic rate, the input to the high voltage quadrupler also is varied at this rate. However, the leakage inductance of the flyback transformer, time lag of the quadrupler, and the varying time constant of the kinescope (due to changing beam current) cause the "ripple" on the high voltage to be delayed and filtered.

The amount of the delay and filtering is strongly dependent upon the RC time constant of the kinescope where *C* is the kinescope capacitance and *R* is the equivalent kinescope resistance, which is determined by the high voltage divided by the beam current. Since the actual scan is directly proportional to the yoke current and inversely proportional to the square root of the high voltage, at high beam current, the top of the raster will be bent outwards while the bottom of the raster will be bent inwards (Fig. 6c). However, while the yoke current is close to being correct, the high voltage is actually lower than ideal at the top of the raster and higher than ideal at the bottom of the raster; this results in the exaggerated effect shown in Fig. 7. This effect can be overcome if a sample of the high-voltage AC portion is used as feedback to the control transistor. Since a high-voltage quadrupler is already being used, a sample of the high-voltage AC is relatively easy to obtain. Capacitors C5, C6, C7, and C8 usually are connected in series between the high voltage-output and the D terminal which is effectively ground potential. However, by disconnecting C5 from the D terminal and by bringing this lead out of the quadrupler (see Fig. 8), a high voltage coupling capacitor is created. This voltage is divided down by connecting a 0.1μF capacitor between point C on the quadrupler and ground. The capacitors inside the quadrupler are all 2000pF; the 0.1μF divider capacitor and the related components are shown in Fig. 4 as the HV-error feedback. Thus, at the top of the raster (at high beam currents) where high voltage is low and the scan width is too large, the negative portion of the high-voltage AC is fed back into the base of the control transistor which reduces its collector current. This causes the current in the regulator to increase, which in turn reduces the yoke current. At low beam current, the kinescope capacitance reduces the high voltage ripple to the point where the effect of this feedback voltage is negligible; thus, it does not affect the raster where it is already correct.

Fig. 4 also shows what is called a size-control filter. This is used to obtain a negative-going DC voltage which is proportional to the beam current. It does this by filtering the voltage which appears across the brightness limiter filter (beam current flows through this filter). Scan width is proportional to yoke current and inversely proportional to the square root of high voltage. Therefore as beam current increases, the high voltage tends to drop at a faster rate than two times the drop in yoke current. This is especially true when the B+ supply is regulated against load variations. This causes the raster size to tend to grow or "breathe" as beam current is increased. In the CTC-40, the effective impedance of the supply was adjusted by lowering the commutation inductance until yoke current tracked high voltage. However, lowering the commutation inductance reduces the allowed turn-off time for the commutation SCR; this is undesirable. Therefore, the regulator was used instead to also regulate raster size. As beam current increases the scan tends to increase. However, the output voltage of the size control filter goes negative, decreasing the collector current in the control transistor, increasing the current in the regulator zener diode and regulator transistor, and causing the yoke current and scan width to be reduced back to the desired values. This circuit also causes the high voltage to decrease further than it would have if feedback were not used. Thus, vertical-scan tracking is more difficult than if horizontal tracking were not used. While horizontal tracking can be made almost perfect with the method mentioned above, the CTC-49 is designed so that the horizontal and vertical scan change at approximately the same rate. Thus, the high voltage regulation is within performance limits even though a significant amount of size correction is used.

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2. Dietz, W. F. "An SCR Horizontal Deflection Generator,"*RCA Engineer,* (June/July, 1969), p. 56.

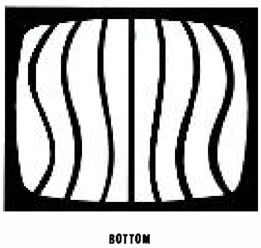


Fig. 7—High-brightness raster distortion with no correction.

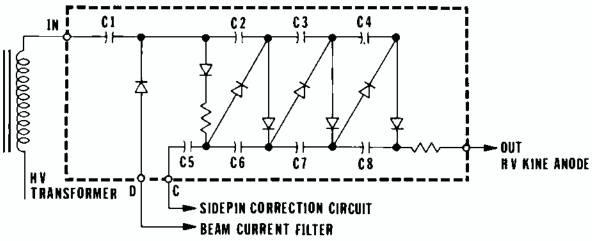
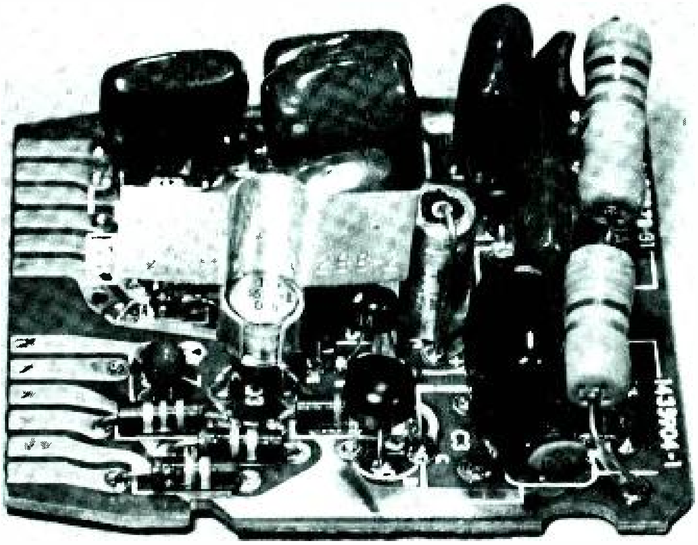


Fig. 8—High-voltage quadrupler.



Vertical deflection system for the CTC-49

L. E. Smith

This paper describes the design of the vertical deflection system for the CTC-49 color television receiver. This system is fully transistorized, transformerless, and utilizes a complementary-symmetry output circuit. A large amount of current feedback is used to reduce the undesirable effects of temperature, transistor Beta non-linearities, and normal component variations. Most of the circuitry is located on one 12-pin plug-in module. The two output transistors are located on a common heat sink with the trace and commutating SCR's used in the horizontal deflection circuit.

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received the BSEE from Purdue University in 1963. For three years, he worked on television display systems with General Electric. In May of 1966, he joined the Color Television group of RCA Home Instruments Division. He has been responsible for the design of solid-state vertical deflection systems, pincushion correction, convergence circuitry, and power supplies. Mr. Smith holds two patents.

THE VERTICAL DEFLECTION SYSTEM for the CTC-49 (110° kinescope) must provide the following:

A 60-Hz, 1.4-A, p-p sawtooth of current through a vertical yoke where $R_{yoke} = 7.75$ ohms and $L_{yoke} = 14.8$ mH; The retrace time shall be 0.7 ms. A 60-Hz, 1.5-A, p-p sawtooth of current through the vertical-rate-convergence circuitry, where $R_{conv.} = 5.5$ ohms.

A 60-Hz, 50-V, p-p pulse to be used for vertical blanking.

A 60-Hz 1.4-A, p-p sawtooth of current through the top and bottom pincushion correction circuitry where $R_{pin} = 1.18$, $L_{pin} = 1.7$ mH.

A 60-Hz, 0.4-V, p-p parabola to be used for side-pincushion correction.

A method of controlling the vertical yoke current, so that changes in ultor (high) and B+ voltages do not cause a change in raster height.

A block diagram of the system that satisfies these requirements is shown in Fig. 1.

Output stage

Most vertical systems use a transformer to couple the yoke to the

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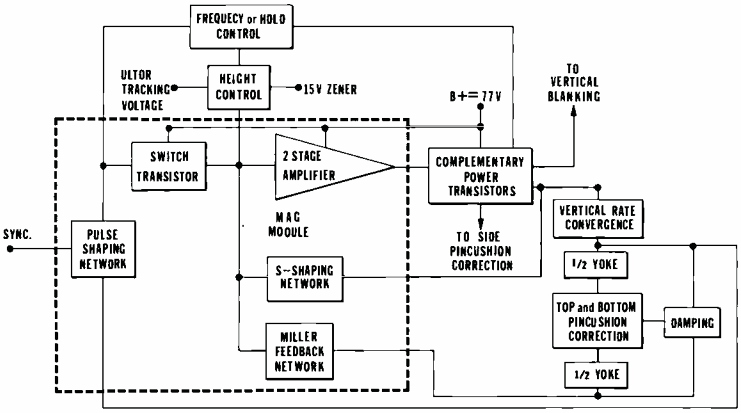


Fig. 1—Vertical deflection system block diagram.

power-output device. The CTC-49 uses two power transistors connected in complementary symmetry and a DC blocking capacitor to drive the yoke. The elimination of the vertical output transformer was important for several reasons. The vertical output transformer has an external magnetic field which causes a purity shift if located too close to the kinescope. With the reduced cabinet thickness of a 110° system, it is difficult to protect against purity shift. Also, a vertical output transformer is heavy and bulky which is not desirable for a portable design. As shown in Fig. 2, the complementary-symmetry output circuit utilizes one NPN transistor Q101, and one PNP transistor, Q102. Since, for a given power rating, NPN transistors are less expensive than PNP types, the circuit is designed so that the NPN dissipates more power and requires a higher V_{ceo} rating—resulting in a significant cost reduction. This would normally be the case in any complementary-symmetry circuit when the load is inductive, but by proper clamping and bootstrapping the difference in requirements can be increased. A bootstrapping capacitor, C11, and the proper choice of R16 and R17, forces V_1 to be nearly equal to the reverse breakdown voltage of CR4 during retrace. Zener diode CR4 is chosen such that its reverse breakdown voltage is less than minimum B+; this voltage determines the V_{ceo} of Q102. The V_{ceo} of Q101 is determined by maximum B+. Therefore, Q101 is a 90-V, 12-W device, and Q102 is a 70-V, 3-W device.

Another advantage of bootstrapping and clamping is that any change in B+, such as line or load variations, do not require C112 to be charged to some new blocking voltage. The problem with charging or discharging C112 is that the transient charging current flows through the yoke and the raster moves up or down momentarily. In a sense, Q101, in conjunction with CR4, acts as a series regulator during retrace.

Bootstrapping and clamping have one other advantage which is helpful in vertical deflection. The maximum peak-to-peak voltage swing across the yoke is reduced for a particular retrace time. This allows transistors with lower V_{ceo}'s and lower power supply voltages to be used.

Regarding the functions of the remaining components in this circuit (Fig. 2), CR104 is a bias diode used to reduce crossover distortion, and R221 is a 1.8-ohm resistor used to generate a voltage used in the frequency-control circuit. Resistor R427 keeps CR104 conducting and allows Q102 to clamp V_1 to the reverse breakdown voltage of CR4; Q102 also keeps V_1 from exceeding this breakdown voltage and Q101 keeps V_1 from dropping below the breakdown voltage during retrace. The driver is *off* during retrace.

Vertical-deflection module

Mounted on the vertical-deflection module are the high-gain amplifier, Miller feedback network, S-shaping network, and oscillator circuits.

The Miller integrator provides a linear sawtooth of current through the yoke. This current has to be modified because the center of deflection is not located at a distance from the kinescope faceplate equal to the radius of curvature of the kinescope faceplate. Two very objectionable effects are noticed: 1) the raster is stretched at the top and bottom; 2) pincushion distortion occurs. The 110° kinescope requires about 2 to 3 times as much pincushion and "S" correction as the 90° system. However, both of these corrections can be made in the same manner as in prior TV receivers except that the sawtooth must be increased in amplitude.

S-shaping

S-shaping, or modifying the yoke current to compensate for the stretch at the top and bottom of the raster, is done by generating a parabola of current and coupling this into the Miller integrator amplifier. The Miller circuit integrates this parabola and modifies the yoke current in the proper fashion for S-shaping. The parabola is generated by RC integration of the yoke voltage.

The DC voltage that is integrated to obtain the ramp of yoke current is coupled to the input of the Miller amplifier from the height control. The height voltage is a combination of a zener-referenced source plus a voltage which is proportional to the ultor voltage. The reason for this combination is that when ultor voltage changes, the raster size changes. However, a 10% change in ultor voltage causes a 5% change in raster size. By combining the voltage proportional to ultor voltage with a constant DC voltage, a height voltage is generated which does not change as much as ultor voltage. This system gives constant raster height.

The Miller feedback network is shown in Fig. 3. The feedback resistor R13 is in series with the vertical yoke; C7 is the Miller capacitor which couples the voltage across R13 to the amplifier. Diodes CR2 and CR3 are used to close the Miller loop quickly after retrace.

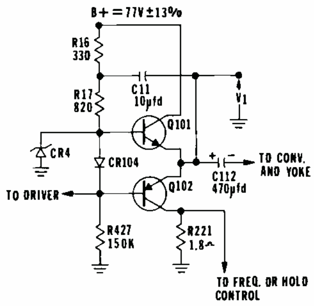


Fig. 2—Complementary-symmetry output circuit.

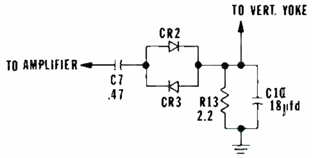


Fig. 3—Miller feedback network.

The voltage which appears across R13 is directly proportional to the current through the yoke (C10 is a high frequency bypass capacitor). Previous feedback systems sampled the voltage across the yoke instead of the current through the yoke. In this sampling system, the yoke voltage can be kept constant, but the yoke resistance changes with temperature, and causes the yoke current to change. Therefore, a thermistor is often needed in series with the yoke. With current feedback, the impedance of the yoke can change with temperature; yet yoke current does not change.

The switch transistor, in conjunction with the rest of the vertical circuit, works as an astable multivibrator. It free runs at 40 to 80 Hz, depending on the position of the hold control. Normal yoke-current variation and B+ changes have little effect on the free-running frequency. The circuit pulls-in to a sync frequency of 60 Hz when it is free-running at approximately 50 to 60 Hz. The hold control is needed because of component tolerances.

Top and bottom pincushion

Top and bottom pincushion correction is done in a conventional manner. An enlarged top and bottom pincushion transformer with fixed magnetic bias, a phase coil, amplitude control, and capacitor can make nearly straight horizontal lines at the top and bottom of the raster. Sinewave type correction appears to be quite satisfactory for an 18-inch 110° kinescope.

Convergence

Vertical-rate convergence currents are shaped somewhat like 60-Hz tilted parabolas. At the center of the raster, the current should be zero and stay at zero for various dynamic convergence adjustments. This allows a minimum of readjustment of static convergence. Fig. 4 demonstrates the basic idea of the new vertical convergence circuit which satisfies the above requirements. The convergence circuit is in series with the vertical yoke. Most of the yoke current goes through R1 and R2. However, the convergence coil does conduct through R1, D1, and D4 when I_{yoke} is positive, and through R2, D2, and D3 when I_{yoke} is negative. With the inductive impedance of the exciter windings, a nearly smooth parabolic current waveform can be obtained. Notice that a tilted parabola can be obtained by changing R1 or R2. Notice that I_{conv} is equal to zero at the center of the raster (when $I_{yoke} = 0$). Also notice that there is practically no interaction between $I_{peak\,(top)}$ and $I_{peak\,(bottom)}$. A complete convergence circuit schematic, including the horizontal rate convergence circuit is shown in Fig. 5.

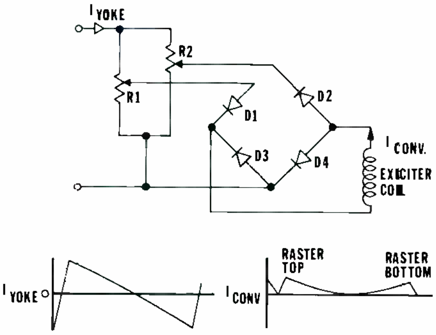


Fig. 4—Vertical-rate convergence circuit.

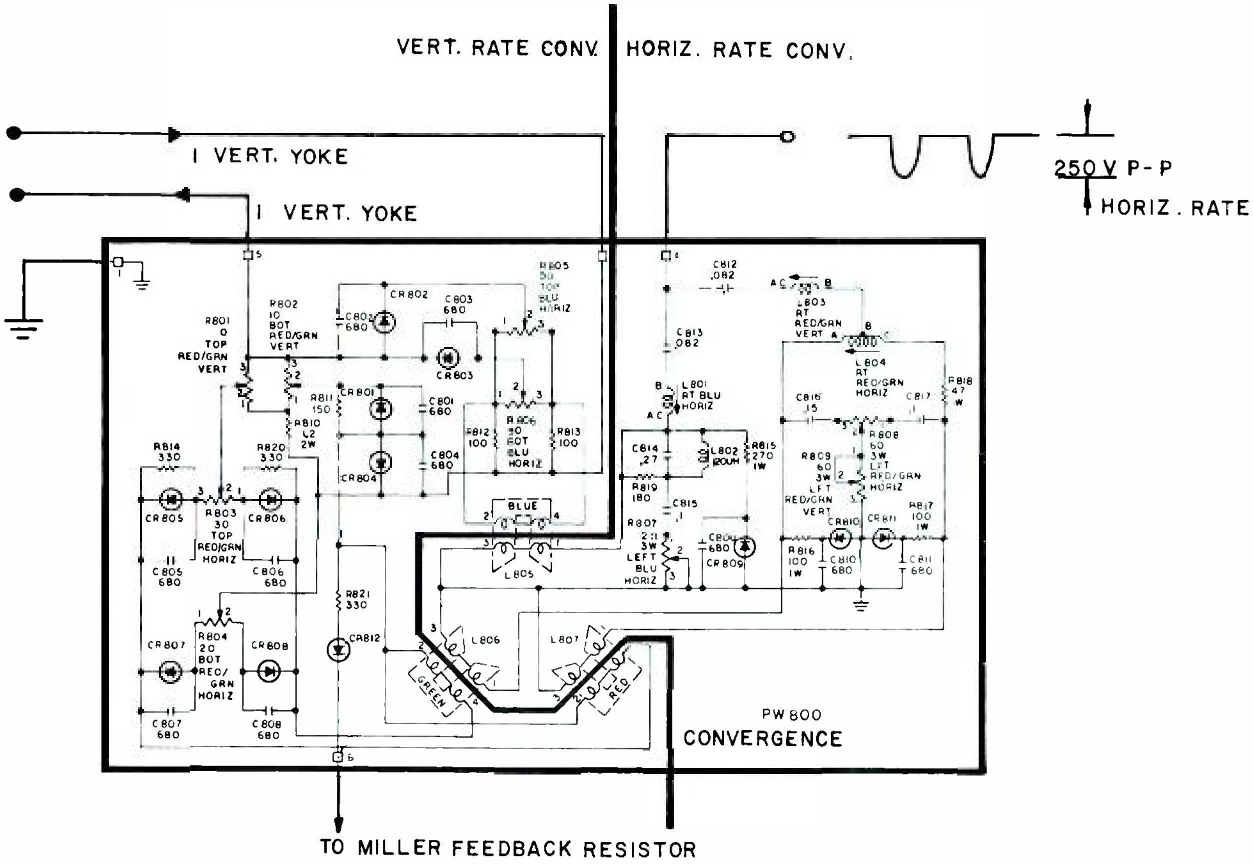
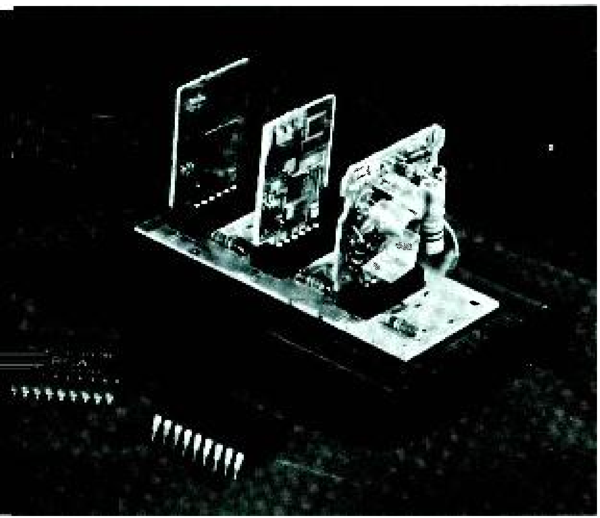


Fig. 5—Complete convergence circuit.



Kinescope driver modules mounted on standard mother board for the CTC-49 color TV. The module on the right has been produced using phenolic-circuit-board techniques; the center module demonstrates the combination of ceramic and silicon technologies; the module on the far left is a coated version of the center module. The modules are completely interchangeable.

Microelectronics in consumer products

W. H. Liederbach

The principal advantage of using microelectronics in consumer products is that such circuits can be manufactured at a lower cost, enabling RCA to remain competitive in a marketplace characterized by vigorous competition from abroad. However, several other side benefits accrue: 1) In-house personnel become very knowledgeable in all aspects of materials and design and, thus, are able to generate advanced competitive designs; 2) There is better control of product quality, and 3) Stylists have degrees of freedom which are not inhibited by the electronics. This paper describes RCA's ceramic integrated circuit facility that is presently manufacturing plug-in and soldered-in modules for several of the new generation of consumer products described in this issue.

MICROELECTRONICS TECHNOLOGY dates back to the 1940's when titanate ceramic substrates with printed resistors were first used to form RC combinations. But titanate ceramic was found to be structurally weak and have poor thermal properties. Nonetheless, it was a start which was the precursor of "Project Tinkertoy" of the early 1950's; this project compensated for some early limitations of microelectronics by designing a single-sized ceramic substrate capable of being machine fed. Steatite ceramic was used for the substrates, and although a good choice from an economic and experience point of view, it was also limited because of its marginal strength and poor thermal conductivity. The project began in the Washington Bureau of Standards and was carried out in further development by Kaiser Electronics and Paktron. The approach was further limited because silicon technology was not available, requiring the use of miniature vacuum tubes as active devices.

In the late 50's and early 60's RCA contributed a significant advance in microelectronics technology through the military "micromodule" program. The concept was based on miniature, standard-sized ceramic substrates made of alumina which provided exceptional structural strength and thermal conductivity. The program created a recognition in the industry that printed conductors, resistors, capacitors, etc. were germane to a low-cost manufacturing system. Major participation by most of the electronics industry during that period helped create upgraded alumnia ceramic, conductor inks, resistor inks, dielectric inks. encapsulation materials, printing and placement equipment, etc. The weakest part of the program was the need for attaching semi-conductor devices as cumbersome prepackaged devices.

It is to the credit of the IBM Corporation that they had the vision to consolidate all of the gains made in the technology to create, in the early 1960's, a fully manufacturable system of microelectronic modules, including highly sophisticated yet production-oriented flip-chip silicon devices. The success of this program is well known for digital applications.

Ceramic integrated circuits

In the early 1960's, RCA decided to exploit the same technology for linear and power applications in consumer electronics; these applications require a more diverse range of components than digital circuitry. A coordinated attack by the industry at large has filled this need with a new generation of materials and equipment. A completely viable microelectronics system—ceramic integrated circuits—has evolved which joins the best of silicon and ceramic technologies and offers significant benefits for consumer electronic products.

The Consumer Electronics Division is using microelectronics in its products mainly because of the potential for manufacturing circuits at a lower cost,

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and the additional measure of in-house control over quality and reliability provided. Additionally, in-house processing allows us to develop a broad knowledge of materials, processing, and circuit design parameters—resulting in more intelligent design; enhanced response time, and increased innovation. Plug-in functional modules also reduce servicing costs—on the production line as well as in the home. As a side benefit, highly stylized designs will be possible because of the reduced space requirements.

To establish this capability in ceramic integrated circuits five basic materials technologies had to be developed: alumina ceramics, titanate ceramics, noble metals (e.g., *Ag*, *Pd*, *Au*, *Ru*, *Rh*), silicon, and organic resins for environmental protection.

Alumina

In the alumina ceramic area, we have chosen to manufacture an 85% alumina instead of the classical 96% alumina. An 85% alumina is a very practical compromise of cost and desirable finished properties. It is processed at a lower temperature (1500° vs. 1650°C.) with lower resultant stress on the kiln and refractories. Involvement in alumina ceramic technology creates a base for contribution beyond circuit substrates into multilevel ceramic packaging, tuner substrates for high-frequency low-loss application, trim potentiometers, and ceramic interconnection boards in place of copper-clad phenolic.

Titanate

Products relating to research in titanate ceramics include printed capacitors in the 1 to 5000 pF range, discrete capacitors in the 0.01 to 0.5 μF range, frequency filters, and phonograph pickups.

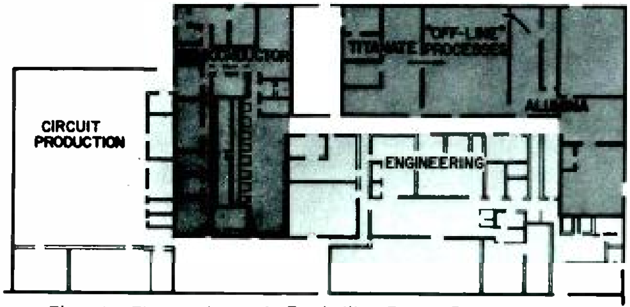

Fig. 1—Floor plan of Rockville Road Plant—85,000 square feet.

Noble metals

Noble metal metallurgy is required to provide the conductors, resistors, capacitor electrodes, solder terminals, and printed inductors.

Silicon

Silicon technology has historically been the key to success in microelectronics. This continues to be true in consumer electronics for transistors and diodes and multiple-device silicon chips. The silicon IC chips are in use now as soldered-in prepackaged devices. Beam-lead chips on ceramic will probably be the next logical step followed by a flip-chip "poor man's IC". It will probably be an eight to twelve bump [solder connection] device maximally designed as part of a functional module encompassing the best virtues of silicon and ceramic technology.

Organic resins

Encapsulation of the modules varies as to whether it is a solder-in module, dual in-line module, or a plug-in module. We are presently using polycarbonate plastic boxes for our solder-in module with a flexible epoxy fill. This provides a nonflammable, self-extinguishing package. Plug-in modules are flow coated on one side with the same flexible epoxy used in our solder-in modules. Evolution in the encapsulation area will be toward transfer molding.

RCA facilities

The organization for bringing the ceramic integrated circuit technology into fruition involves research and development labs, a sample lab (1 to 100 pieces) and engineering pilot lab (1000 to 5000 pieces), equipment development, computer facilities (for engineering studies, environmental and stress data, and process control), production,

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received the BS in Ceramic Engineering from Iowa State University in 1948. He was employed by the E. I. DuPont Co. from 1948 to 1955 and the Centralab Division of Globe-Union from 1955-1958 before joining RCA in the Semiconductor Division at Somerville, N.J. in 1958. His work since 1958 has been microelectronics with emphasis on packaging systems. Materials, packaging, and systems contributions include multilevel ceramic packages, noble metal metalizers, hermetic ceramic packages for semiconductors, reliability studies on silver migration and whisher growth, ultrasonic cleaning technology, and high-speed low-cost module systems for consumer applications. Mr. Liederbach was chairman and Co-Founder of the Indiana Section of The American Ceramic Society in 1965, and Vice-Chairman of the Charter Indiana Section of ISHM in 1969. He was conferred the Title of Fellow in the ACS in 1968 and passed state exams for Registered Professional Engineer in 1969. He is a Member of American Ceramic Society, National Institute of Ceramic Engineers, Pi Kappa Phi Social Fraternity, Tau Beta Pi, Knight of St. Patrick, and Keramos Honorary.

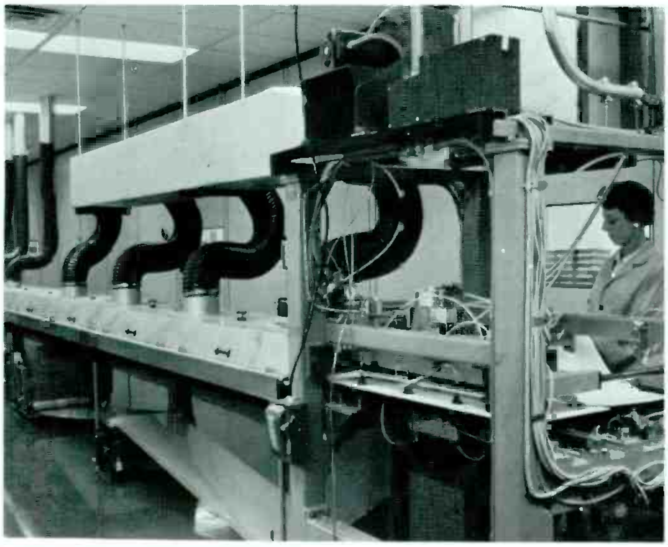

Fig. 2—Alumina casting machine.

Fig. 3—Laminating and punching of alumina parts.

Fig. 6—Front end of screening machine—"magazine feed."

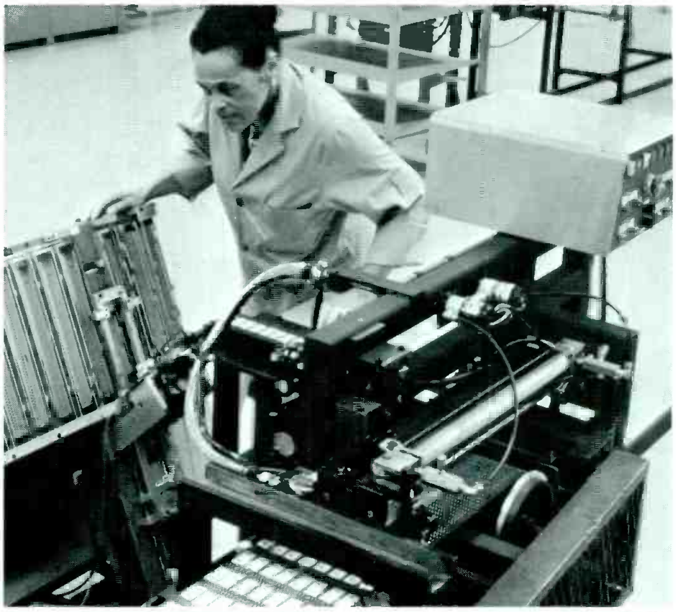

Fig. 7—Back end of screen and fire system—"back into magazines."

Fig. 8—Manufacturing process control—probes and computers.

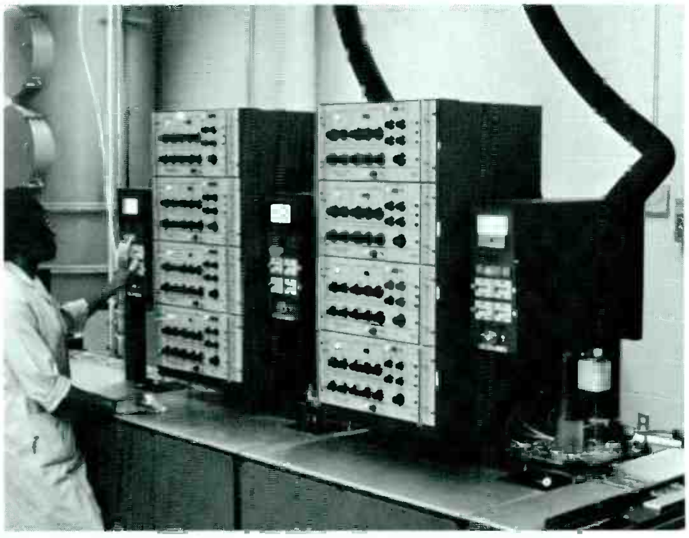

Fig. 10—Resistor adjust—amenable to change using lasers.

and quality control. This organization exists at the Consumer Electronic Division's Rockville Road Plant which has 85,000 square feet of floor space (Fig. 1) devoted to this technology.

Raw material storage and ball mill processing are part of the system (Fig. 2) with very efficient casting machines used for forming all-alumina and titanate sheets at casting speeds up to 24 inches a minute in 8- and 16-inch-wide belts. The dried alumina or titanate sheets (Fig. 3) are laminated, and the parts are punched out with carbide tools for firing—in gas-fired kilns for alumina and electric kilns for titanates.

A TV set is classically a three-level packaging system, comprising a mother board, plug-in daughter boards and solder-in components. To meet this need we have created two standard sizes (Fig. 4) of alumina substrates:

Size 1 for solder-in modules—1.4×0.75×0.025 inch.
Size 2 for plug-in modules—1.4×2.0×0.050 inch.

Of major significance is the 1.4 inch width which provides a common dimension for "railroad tracks" going through our magazine-oriented manufacturing system. Modules made to date with this philosophy include a nine-lead solder-in module, an 18-lead dual-in-line solder-in module, and one version of plug-in module.

Screen printed capacitors are used for values below 5,000 pF Multilayer capacitors (Fig. 5) are used for values up to 0.5 μF. A standard size of 0.175" × 0.125" is used with the thickness parameter offering a degree of freedom. The thickness of dielectric and the dielectric constant can be changed for capacitance and voltage design flexibility. Tantalum chip capacitors will be used up to and including 50 μF.

All discrete components such as chip capacitors, silicon devices, and lead frames are reflow solder attached using screen-printed solder cream.

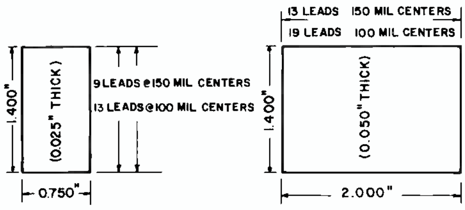

Fig. 4—Standard package sizes for high-speed magazine manufacturing via the "railroad-tracks" system.

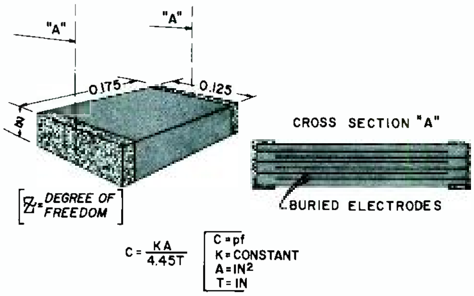

Fig. 5—Multilayer capacitor structure.

The ceramic area is what we describe as our "off-line" facility. It is backed up in raw material process control with a laboratory containing equipment for differential thermal analysis, thermal gravimetric analyses, and particle-size measurements.

The "on-line" facility includes all those items of production that are sequential, such as the printing and placing steps. The selection of two standard sizes with a common dimension of 1.4 inch allows a manufacturing system with magazine feed features (Fig. 6). The loaded magazines act as the dispenser to the first screen print station (Fig. 7). At the end of this print and dry station, the ceramic wafers are automatically re-inserted into magazines for the next operation. All of this occurs at a rate of 1 to 2 seconds per piece. Three belt furnaces are used for firing 1) metallizing layers at 850°C, 2) screen-printed capacitors at 1050°C, and 3) screen printed resistors at 740°C. At the discharge end of both capacitor and resistor belt furnaces, automatic probing and feeding data to a computer memory occurs for on-line process control (Fig. 8). The control mechanism is the belt speed of the furnace which is the variable employed in the time-temperature firing sequence. Changes in belt speed are dictated by the program written into the computer system for achieving target values of printed components. In the resistor system, for example, the 8000 series of DuPont resistor inks are used which have the same resistivity-firing temperature slope (Fig. 9) so that when more than one resistivity per-circuit is employed, the values will all track together. For values of resistors that require tolerances better than ±15%, an abrasion system (Fig. 10) of adjustment is in use which should be replaced, eventually, by a laser device. Our transport system was designed with this in mind several years before laser adjusting became practical.

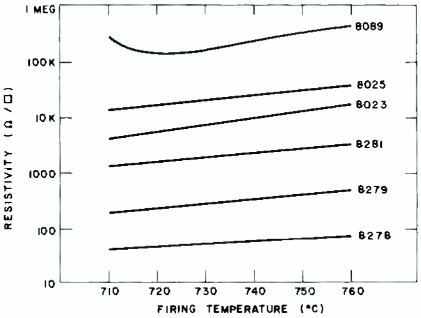

Fig. 9—Resistor inks (series 8000) resistivity vs. belt speed.

A computer center serves the ceramic integrated circuit facility in three ways:

1) For control process described;
2) For the accumulation and analysis of environmental stress data; and
3) For engineering studies.

All circuits are 100% checked with automatic testers.

An important facet of the system is an engineering pilot area where every circuit is run in quantities of 1000 to 5000 circuits so that it can be debugged and the manufacturing specifications established. In support of development and production, the analytical services lab is equipped with X-ray, metallurgical microscopy, surface analysis, ink rheology, tensile testing, and other chemical and physical laboratory equipment.

Conclusions

There is no doubt that microelectronics as a technology will continue to evolve as it has for the past 20 years. However, for the technology to move ahead, standardization in the industry must take place. This is necessary to facilitate mechanical handling and to establish second sourcing without which major markets can never be established. This need for standardization is complicated because there has already been considerable investment in phenolic-circuit-board technology, making it is impossible to introduce traumatic changes in assembly procedures. Change must be evolutionary.

Further developments will include dynamic circuit adjustment with lasers, multiple bump "poor man's IC's", printed coils with printed ferrites, and printed electronic tuners—all with military reliability at consumer prices.

Advances in integration of color television receivers

J. Avins

In 1965 RCA pioneered the first use of monolithic silicon integrated circuits in television receivers in the intercarrier-sound 4.5-MHz FM amplifier-limiter-detector subsystem. Since then much progress has been made in applying integrated circuits to the signal processing functions in a color television receiver; for example RCA's new CTC-49 solid-state color TV receiver uses six monolithic silicon circuits.[1] In bringing about this result, a team effort which effectively utilized the engineering resources of the Consumer Electronics and Solid State Divisions has played a key role.

IT WAS LOGICAL, back in 1964, to select the intercarrier-sound function as a test vehicle for examining the viability of integrated circuits in TV receivers. The reasons for choosing this particular part of the receiver were that it presented a complex functional block with an input signal at one frequency (4.5 MHz) and an output signal at another frequency (audio) and in between a substantial amount of signal-processing—IF amplification, limiting, FM detection, and audio amplification. This large number of functions was favorable to making the integrated-circuit approach competitive in cost with discrete technology. An additional factor was the improved performance obtainable because of the removal of any limitation on the number of active devices.

The approach followed in the intercarrier-sound function has proved applicable to several other parts of the television receiver with the result that substantially all the signal-processing functions in a color television receiver have now been integrated:

1) The complete picture (and sound) IF system (RCA CA3068)[2,4]
2) The automatic-fine-tuning function (RCA CA3064)[2,4]
3) The complete chroma amplification and color synchronization circuits (RCA 3066)[6]
4) The color demodulation and tint control (RCA 3067)[6]
5) The intercarrier sound function (RCA CA3065)
6) The horizontal oscillator and AFPC (RCA TA 5627)[3]
7) The remote control receiver function (RCA CA3035)

Each of these integrated circuits stands on its own as a separate and relatively complete function (Fig. 1). In general, the integrated-circuit partitioning follows the signal and control paths, with the interfaces determined by several factors—including the number of external pins required for a given grouping of functions, the chip size (which influences yield and cost), chip dissipation, and adaptability to modular design. Where possible, feedback problems are eliminated by partitioning so that input and output signals are at different frequencies.

Picture- and sound-IF channel

Prior attempts at monolithic integration in the picture-IF amplifier have been limited to the integration of one or two IF stages, the assumption implicit in this approach being that the feedback problems are so formidable as to preclude the possibility of integrating the complete IF amplifier which requires a gain of the order of 70 dB at 45 MHz. In the RCA approach, this problem has been overcome by integrating the video-detector system as well as the complete IF amplifier on the same chip, and by providing untuned internal coupling between the high-level IF amplifier stages and the video detector. In this way, the output of the chip is at video frequency, and high level IF signals are never brought out to an external pin connection so the external feedback problem is eliminated. The complete IF system (Fig. 2) was integrated on a 65×67 sq mil monolithic chip.

Primary motivation in the partitioning of the system was the desire to keep the high-level 45-MHz signals confined to the tiny chip area to avoid feedback and stray coupling problems. To accomplish this, the gain normally provided by the second and third IF stages is provided by a broadband amplifier which is directly coupled to the linear video detector and to the video preamplifier. The output level at terminal 19 is 7 volts p-p of video, sync negative. The input level to the second video-IF stage (at terminal 13) is 10 mV; input to the first IF is 100 μV.

The chip layout allows for the introduction of selectivity as required. The interface between the first and second IF stages is brought out to separate pins so that a selective filter can be introduced. Additional selectivity can be provided in the coupling link between the mixer output and the first IF stage input. Further flexibility exists for the distribution of selectivity—

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received the AB with honors in math and physics from Columbia College and the MSEE from Polytechnic Institute of Brooklyn. Prior to 1941, he was engaged in the design of radio test equipment. From 1941 to 1946, he served as an officer in the Signal Corps. In 1946, he joined the Industry Service Laboratory, RCA Laboratories, where he was engaged in research and development of FM and TV receivers. From 1955 to 1956 he was Manager of the RCA Industry Service Laboratory in Zurich. Rejoining RCA Laboratories in 1957, he served as Manager of the Research Applications Laboratory and the Consumer Electronics Division Affiliated Laboratory. Since 1964, he has been on the staff of the Chief Engineer, Consumer Electronics Division, responsible for the development of integrated circuits for TV and radio receivers. Mr. Avins is a member of Phi Beta Kappa, a fellow of the IEEE, a past chairman of the IEEE receivers committee, a member of the Administrative Committee of the Broadcast and Television Receivers Group, and chairman of its standards subcommittee. In 1971, he was co-recipient of the David Sarnoff Outstanding Achievement Team Award in Engineering for his leadership in the development of integrated circuits for use in television receivers.

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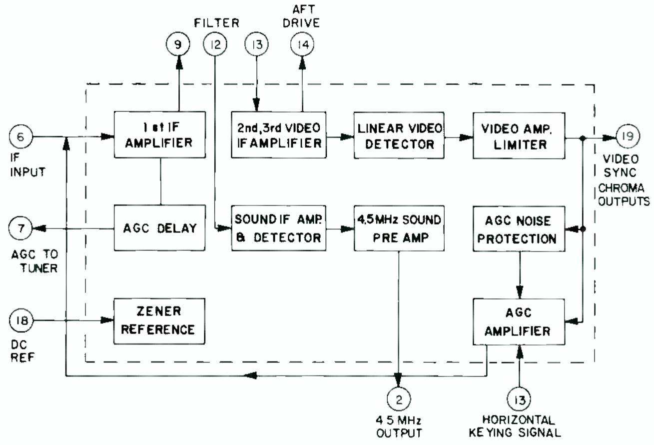

Fig. 1—Complete integration scheme for the CTC-49 color television receiver; shaded blocks are integrated circuits.

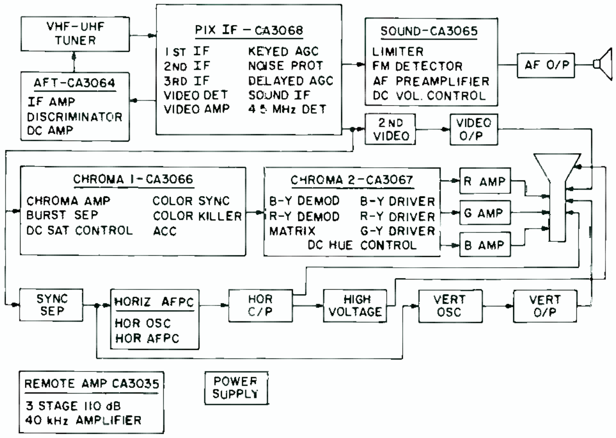

Fig. 2—Complete picture and sound color television IF system (CA 3068).

ranging from broadbanding of the mixer output to provide complete tuner interchangeability, to the insertion of two tuned circuits in the mixer output followed by a transmission line and a single- or double-tuned transformer preceding the integrated circuit.

In addition to the basic problem of stability, which was solved by placing the detector on the chip, a number of special problems required solution:

1) Maintenance of white level in the face of direct coupling to the wideband resistance-coupled second and third IF amplifier stage
2) Provision for the sound take-off despite the inaccessibility of the second and third IF stages,
3) Provision for driving the automatic-frequency-control discriminator without bringing out the high-level IF signal, and
4) Maintenance of stability despite possible parasitic internal couplings in the chip as well as in the leads of the package.

The solutions to these problems are described in the following paragraphs. In a conventional discrete IF amplifier, white level (minimum carrier amplitude) is identified by the fact that the diode detector is easily referred to either ground or a known DC potential, since the detector is driven through a transformer with low DC resistance. In the integrated system of Fig. 2, the problem of DC white-level uncertainty is solved by using a "dummy detector". The output of the active detector is combined with the dummy detector output in a differential network which is insensitive to the actual DC level at the output of the third IF stage to which the detector is coupled.

The sound problem is solved by taking off the 41.25-MHz carrier at a point in the filter network between the first and second IF stages and providing an additional gain stage to bring up the 41.25-MHz and 45.75-MHz signal levels so that they can be detected on the chip to produce the desired 4.5-MHz intercarrier beat. The filter network is designed to boost the 41.25-MHz component at terminal 12 while attenuating the 41.25-MHz component at terminal 13, so that the generation of undesired 920-kHz beat components between the picture and sound channel in the wideband amplifier driving the detector is prevented. The single detector thus functions to produce both demodulated luminance and chrominance components.

Automatic fine tuning (AFT) presented a special problem since the drive to the AFT circuit is normally taken from the high-level last IF stage which is not available externally in the integrated-circuit approach. This problem was solved by taking the AFT drive from a buffer terminal at the input to the second IF stage (where the level is low enough not to cause feedback or instability) and by designing a high-sensitivity AFT integrated circuit which requires only 10-mV drive to produce the required AFT control voltage.

Automatic gain control (AGC) is included on the integrated circuit because it functionally belongs with the IF amplifier; the AGC is driven from the video preamplifier in the chip, and the delay information is derived from the first IF stage which is also on the chip. The keyed AGC maintains sync peak level accurately in the output of the video preamplifier; further, the noise immunity inherent in clipping close to the sync peak level is enhanced by circuitry on the chip which prevents AGC setup in the presence of impulse noise.

The AGC is applied to the first IF stage to provide more than 40 dB of AGC range in a cascode configuration which maintains the passband. Tuner delay information is taken from this stage.

In this brief description, the motivation behind the integration of the IF and related functions has been indicated. Detailed papers in this issue describe the design and application of this monolithic IF system.[2, 4, 5]

Other subsystems

Substantial strides have been made in designing monolithic integrated circuits to perform the low-level signal processing functions required in a color television receiver. In particular, the pivotal role performed by integration of the picture and sound IF amplifier and the related detector, video, and AGC functions on a single chip is apparent in making possible a logical partitioning of the receiver circuitry.

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Monolithic IC for automatic horizontal frequency and phase control of TV receivers

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A monolithic integrated circuit embodying the horizontal oscillator, automatic frequency and phase control (AFPC), and buffer for driving the horizontal deflection circuit in color TV receivers is described. Through the use of a dual-mode system with balanced sample-and-hold phase comparators, the need for the conventional horizontal hold control is eliminated. The integrated circuit lends itself to the design of a compact horizontal oscillator AFPC module.

AUTOMATIC PHASE CONTROL SYSTEMS are used exclusively to synchronize TV-line-scanning deflection with the horizontal sync pulses transmitted as part of the composite video signal. By comparing the phase of a voltage-controlled oscillator (VCO) to the phase of the incoming signal and by controlling the oscillator from the filtered output of the phase comparator, the VCO is locked to the average frequency of the incoming signal. The phase transfer function of this system, or closed-loop response, is particularly sensitive to the design of the low-pass filter or compensation network. Ideally, a long integration time or narrow noise bandwidth is desirable to minimize picture disturbances from thermal and impulse noise sources. Narrowing this bandwidth has the adverse effect of lowering the system loop gain for the beat notes produced by the AFPC phase comparator when the picture is out of sync, decreasing the pull-in range and increasing the pull-in time. Oscillator drift can become a major part or exceed a pull-in range that is too narrow. The choice of system parameters thus becomes a compromise between pull-in range and noise performance.

In the integrated-circuit approach shown in Fig. 1, a dual-mode system is combined with a stable sinewave oscillator to eliminate the horizontal hold control, and improve noise performance without compromising pull-in range. When the system is operating in sync, the sync input at terminal 12 and the flyback pulse at terminal 11 occur at nearly the same time. Sensing this alignment, the coincidence gate operates the mode switch to disable phase comparator B. In this configuration, the IC operates as a conventional horizontal AFPC system with the exception that the low-pass filter has been chosen so that the noise bandwidth gives an equivalent pull-in range of ±20Hz. This bandwidth is a practical limit determined by timing instabilities due to such sources as trigger level uncertainties in the receiver's horizontal deflection circuitry. As in conventional systems, the relative phase of the integrated flyback pulse and sync input is determined by phase comparator A, creating an error

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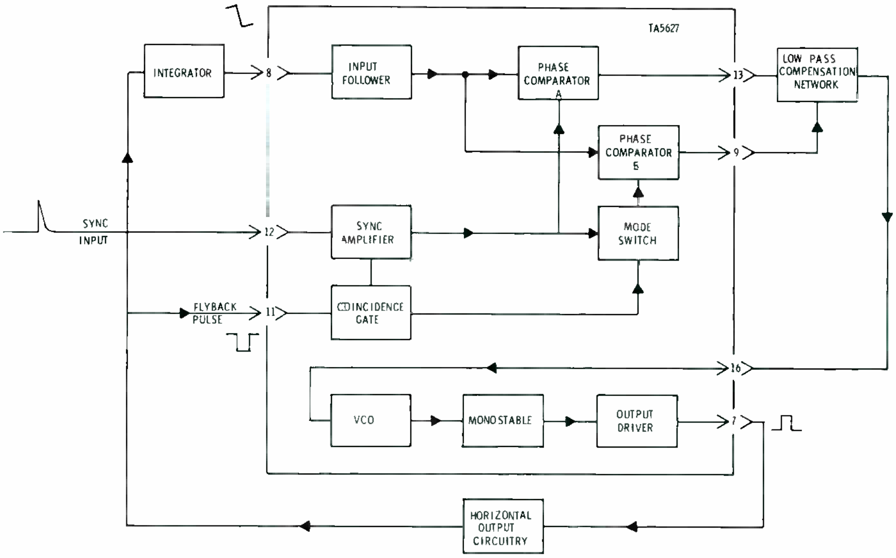

Fig. 1—Block diagram of TA5627 horizontal APC system.

signal which is filtered to control the frequency of the vco. The vco output is wave shaped to drive the horizontal output circuitry, which in turn generates the flyback pulse.

Switching channels or a noise burst may cause the system to lose phase lock. Two possible situations can now exist. Either the horizontal oscillator may have drifted beyond the 20-Hz pull-in range so that conventional pull-in is impossible; or if the oscillator is within this bandwidth, the pull-in time will be unduly slowed by the relatively long time constants inherent in the compensation network. Loss of phase lock will be detected by the coincidence gate operating the mode switch to enable phase comparator B. Comparator B bypasses a portion of the low-pass filter, increasing the system bandwidth and increasing the pull-in range to ±450Hz. After acquiring phase lock, phase comparator B is disabled.

Typical system characteristics measured in a complete receiver are tabulated below (T_p is the pull-in time to acquire phase lock).

Strong signal conditions
  Maximum pull-in range:
    15,078 to 16,411 Hz,
    −656 to +677 Hz
  Pull-in range, $T_p = \frac{1}{3}$ s:
    15,273 to 16,187 Hz,
    −461 to +453 Hz
  Hold-in range:
    14,973 to 16,423 Hz,
    −761 to +689 Hz
  Phase Lock:
    $t = 1.1\ \mu s$ *for* $\Delta f = 914$ Hz

Weak signal conditions
  Maximum pull-in range:
    15,086 to 16,380 Hz,
    −648 to +646 Hz
  Pull-in range, $T_p = \frac{1}{3}$ s:
    15,275 to 16,190 Hz,
    −459 to +456 Hz
Very weak signal conditions
(Picture is barely discernable against noise.)
  Maximum pull-in range:
    15,349 to 16,123 Hz,
    −385 to +389 Hz
  Pull-in range, $T_p = \frac{1}{3}$ s:
    15,450 to 16,091 Hz,
    −284 to +257 Hz
Single mode
The pull-in mode is disabled by connecting a 2.3-volt power supply to the base of F4 (Fig. 2).
  Maximum pull-in range, $T_p = \frac{1}{3}$ s:
  15,717 to 15,753 Hz,
  −17 to +19 Hz
Horizontal Hold Control
  Not required.

The integrated circuit schematic is shown in Fig. 2. The following sections comprise the circuit and design considerations.

Phase comparator

The phase comparator consists of a keyed follower driven by an input follower. A DC-biasing dummy balances the offsets of these two stages. A sawtooth generated by integrating the flyback pulse feeds input follower Q11-Q12-Z4. Feedback holds the collector current of Q11 essentially constant preventing variation in offset with the sawtooth voltage excursion. Keyed follower Q13-Q14-Q15-Z5 is switched by the sync driver Q2. Diodes Q13 and Q14$_A$ turn the pseudo-complementary gate *off* symmetrically by slowing the switching rate at the high-impedance base of Q14$_B$ to a rate determined by the low-impedance collector of Q14$_B$. The keyed follower, in combination with the compensation network, forms an efficient sample-and-hold comparator. Base-to-emitter offsets of Q11 and Q14$_B$ are matched by the offsets of Q8 and Q9, respectively. Transistors F1, Q1, and F2 interface with the positive sync pulses found in the NPN solid-state receiver environment. The Q8-Q9-Q10-Z3 combination is the DC dummy used to bias the vco. Reference supply Q19-F12 is used to bias the phase comparator and the DC dummy.

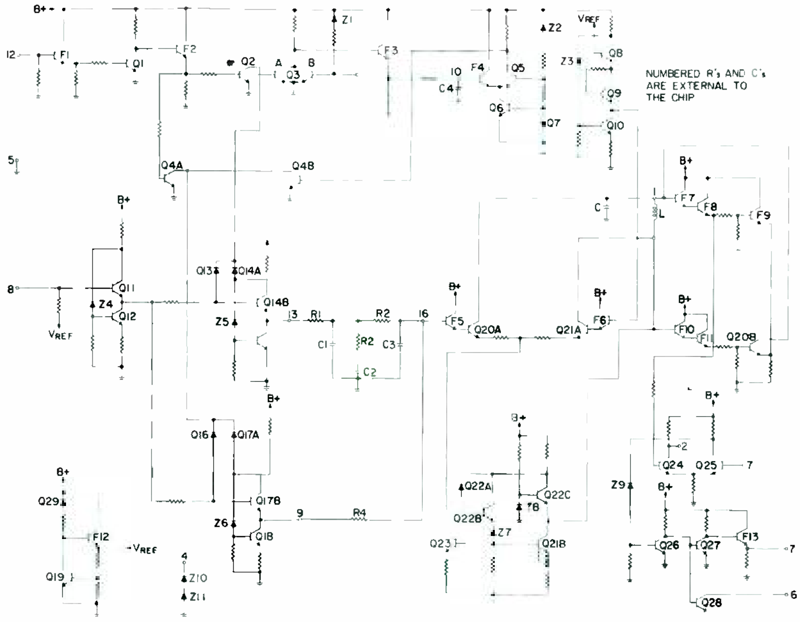

Fig. 2—Schematic diagram of TA5627 horizontal AFPC system.

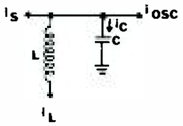

Fig. 3—VCO tank circuit.

Compensation network and mode switching

Phase-lock open-loop responses differ substantially from the analagous responses of frequency-lock loops or feedback amplifiers. Due to the integrating effect of the phase comparator, the open-loop phase characteristic starts from 90° and the gain characteristic rolls off inversely proportional to frequency. Compensation networks are necessary to make the loop stable and optimize the pull-in performance. The loop is usually designed to be slightly underdamped taking advantage of the small amount of overshoot to reduce pull-in time.

Since compensation network R1-R2-C1-C2 is driven by a follower that is on only during the sync pulses, the average series resistance is equivalently twelve times R1; R3-C3 is an additional section effective in the pull-in mode. Capacitors C1, C2, and C3 provide storage for the sample-and-hold-type comparator. Wide frequency deviation pull-in is accomplished by keying *on* follower Q16-Q17-Q18-Z6 creating a parallel path around the R1-R2-C1-C2 compensation network.

Gate $Q3_A$-$Q3_B$ detects coincidence between the sync and the negative flyback pulses at terminal 11 to key the Q16-Q17-Q18-Z6 follower *off* or *on* when the sync and flyback pulses are in or out of synchronism, respectively. The gated pulses are averaged by F3-R11-C4 to become the mode switching control voltage. Amplified F4-Q5 compares this voltage with a reference and switches $Q4_B$.

Voltage controlled oscillator

Automatic phase control (APC) perpormance in a noisy environment is intimately tied to the stability of the VCO. As the input signal-to-noise ratio becomes degraded, the pull-in range is reduced and a point is reached where pull-in is precluded by oscillator frequency offset. An enlarged pull-in range is not the solution for an unstable oscillator since the pull-in threshold suffers.

The *LC* sinewave oscillator F7-F8-F9-F10-F11-$Q20_B$-L-C5 is a differential amplifier with its input at terminal 1 connected to the in-phase output at the collector of $Q20_B$. The DC oscillator bias is supplied through $Q22_C$.

In the VCO control circuit, Q22-$Q21_B$-Z7, the current in the upper transistor is kept essentially constant so that all current variations occur in the lower transistor. Any AC current into the low-impedance junction of the emitter of $Q22_C$ and collector of $Q21_B$ is confined to the lower device. The junction of the emitter of $Q22_C$ and collector of $Q21_B$ is connected to the lower end of the coil, thereby sampling the tank quadrature current. The full alternating component of the coil current flows in $Q21_B$. One quarter of this current flows in Q23 which feeds splitter F5-F6 $Q20_A$-$Q21_A$. The differential voltage on the bases of F5 and F6 determine the quadrature current at the top of the tank and the frequency of the oscillator.

Some new circuit concepts are introduced in the VCO design and a more detailed explanation follows. In Fig. 3, the VCO tank schematic, i_{osc} is the oscillator current supplying tank losses and is in phase with the tank voltage v_t. The splitter current, i_s, coil current i_L, and capacitor current i_c, are all in quadrature with the tank voltage. It can be shown that:

$$\frac{\textit{oscillator frequency}}{\textit{resonant LC frequency}}=\frac{\omega_0}{\omega_{LC}}=[f(\alpha)]^{1/2}$$

where the current splitter ratio $\alpha=i_{20A}/(i_{20A}+_{21A})$ and $f(\alpha)=(i_s+i_L)/i_L$.

Using the diode equation, it can be further shown that for the splitter

$$\alpha=\frac{1}{1+\exp(-qv_D/KT)}$$

where v_D is the differential voltage applied to the splitter bases.

Referring to Fig. 4, the VCO schematic and summing the current at the bottom of the coil:

$$i=i_L-(1-\alpha)i/4 \text{ or } i=4i_L/(5-\alpha)$$
$$i_S+i_L=\alpha i/4+i_L=i_L5/(5-\alpha)$$
$$f(\alpha)=(i_S+i_L)/i_L=5/(5-\alpha)$$

and finally, the oscillator control characteristic:

$$\frac{\omega_0}{\omega_{LC}}=\left(\frac{5}{5-\alpha}\right)^{1/2}$$

$$=\left(\frac{5+5\exp(-qv_D/KT)}{4+5\exp(-qv_D/KT)}\right)^{1/2}$$

$$\cong 1.05+\frac{0.029\,q}{KT}v_D$$

Output circuit

A 6-μs pulse is generated by emitter-coupled monostable multivibrator Q24-25. Devices Q26-Q27-F13 comprise the output driver, while Q28 is a multi-emitter sink to discharge an external coupling capacitor providing negative bias for driving SCR deflection systems; Q28 can also be used to discharge the base of an external driver transistor in transistor deflection systems.

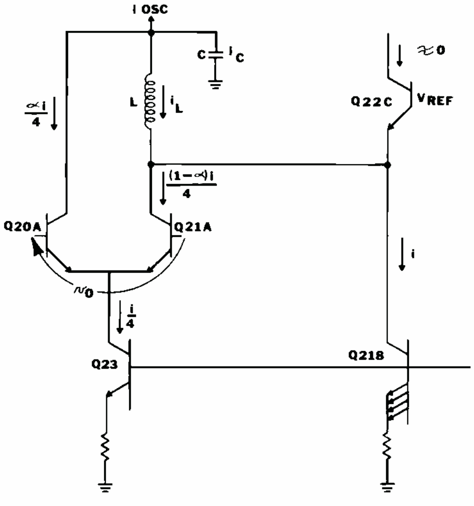

Fig. 4—VCO schematic diagram.

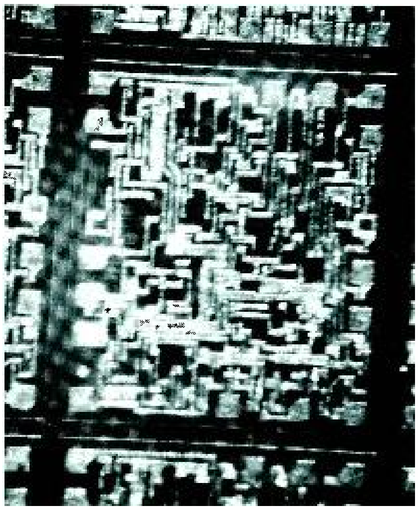

Fig. 5—Final chip layout.

Video-IF and AFT integrated circuits

J. R. Harford

This paper describes a monolithic integrated circuit (type CA3068) which has been developed to perform the video-IF and related functions in color television receivers. To accommodate the low available signal levels (large video-IF signals exist only internal to the integrated circuit and do not appear on the external signal leads), a companion integrated circuit (type CA3064) has been developed. Integrated-circuit designs allow greater use of active devices and tightly matched components but limit the dissipation and number of external terminals. Therefore, some novel design approached had to be used to provide all the necessary functions within the system constraints.

THE VIDEO-IF INTEGRATED CIRCUIT (RCA type CA3068) supplies signals to the tuner, sound, chroma, video, and sync circuits contributing significantly to the total quality of the TV set. Therefore, as much of the design effort was devoted to secondary functions, such as impulse-noise performance and airplane flutter, as to the fundamental functions, such as gain and distortion. The result is an integrated circuit suitable for use in a high quality color or black-and-white TV receiver. A block diagram of the integrated circuit is shown in Fig. 1. The first-IF amplifier achieves 40 dB of voltage gain, and employs a dual-mode cascode amplifier. The dual-mode circuit enables performance to be optimized for weak and strong signal conditions. The automatic gain control (AGC) delay circuit senses the gain of the first IF stage and reduces the tuner gain for strong signals, preventing tuner and IF overload. The combined gain of the second- and third-video-IF stages is also about 40 dB and features feedback techniques to provide an untuned low-impedance signal to the detector, and a buffered output to the automatic fine tuning (AFT) circuit. The linear video detector is a transistor detector, specially biased for optimum linearity. The transistor detector is directly connected to the third-IF stage, and to achieve satisfactory video dynamic range, the video-amplifier limiter must cancel the quiescent DC level from the detector. This is done with a differential circuit which provides large dynamic range and excellent video limiting characteristics. The AGC system is a relatively simple high-gain circuit which requires no external adjustments for video-detector level setting. A novel AGC impulse-noise-protection circuit effectively reduces the gain of the AGC circuit during noisy conditions, and it does not require the bulky external capacitor normally associated with such circuits, thus freeing two external terminals for other uses. The sound-IF amplifier and detector are straight-forward, while the 4.5-MHz sound preamplifier features a low-*Q* filter to peak the desired 4.5-MHz signal. A zener reference is supplied for use where an accurate DC component on the video signal is required.

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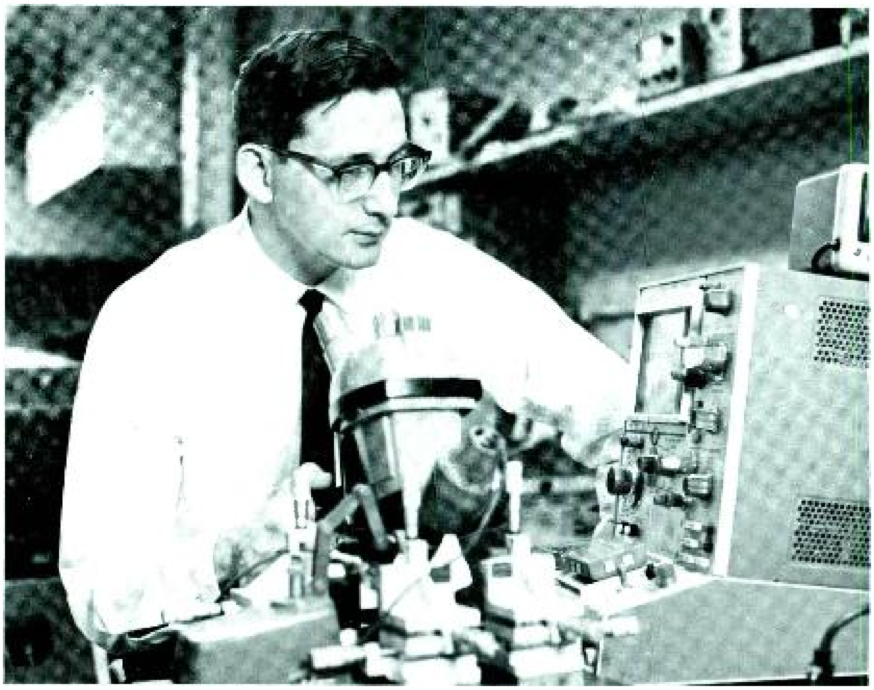

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received the BEE from Union College, Schenectady, New York, in 1958. He joined RCA in 1966 at Somerville as an engineer in the Integrated Circuit Development group of Consumer Electronics Division where he has contributed to the design of several television-oriented integrated-circuit subsystems, and has had project responsibility for the RCA CA3068 picture-IF integrated circuit. Previous experience was gained at Aircraft Radio Corporation in the design of air navigation aids, including a VHF solid state AM transmitter, and an electric gyro amplifier. Mr. Harford also has project responsibility for the B-15A "Omni" converter and the 105A transponder system. At Bendix Corporation, York Division, Mr. Harford designed microwave components including solid state transmitters, phase shifters, and circulators spanning the frequency range from 100 MHz to 35 GHz. Mr. Harford has two patents issued and several others pending.

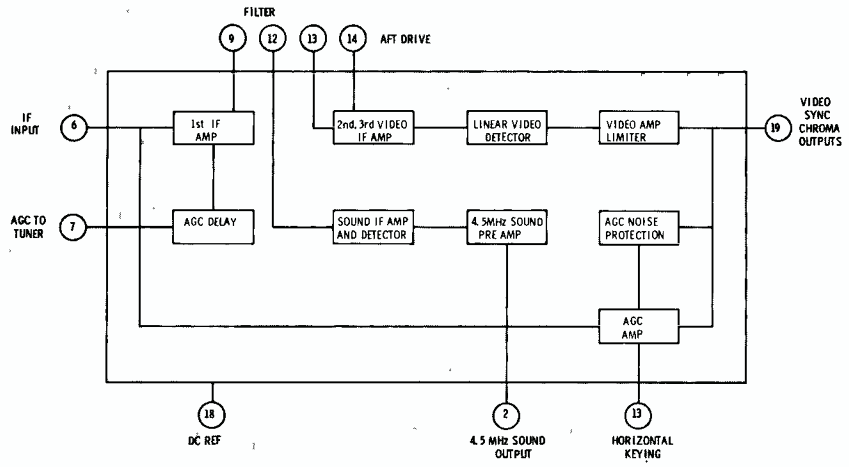


Fig. 1—Block diagram of the type CA3068 integrated IF circuit for color and black-and-white television receivers.

The automatic fine tuning (AFT) integrated circuit (shown in block diagram form in Fig. 2) features a high-gain cascode circuit to operate directly from the CA3068, and an AGC circuit which minimizes performance variations due to normal video signals.

IF system—type CA3068

First-IF stage

The first-IF stage has been designed with 40-dB gain, resulting in 100 μV (at 85% A.M.) system sensitivity for a 4-volt peak-to-peak video output. Since previous high-performance IF designs range in sensitivity from 100 μV to 300 μV (85% A.M.), for a 2-volt p-p output, the high gain should make the circuit universally acceptable. Dual signal paths are provided: a high-gain low-noise path for weak signals and a low-gain degenerated path for strong signals—the signal being steered along the proper path by the AGC circuit. The resulting circuit has a modified cut-off characteristic which improves the signal handling capability over a non-degenerated stage, and also enhances the delayed-AGC characteristic. The reverse (G_m)-AGC-control mode was chosen for its low power requirements, its precisely known gain-versus-I_c characteristic, and its high and stable input and output impedance parameters. The single-ended cascode configuration was chosen to achieve high gain and excellent input-output isolation.

As shown in Fig. 3, $Q6_A$ and Q7 form a conventional cascode circuit and are the primary amplifiers for weak signals. The geometry of these devices is optimized for high gain (G_m) and low noise. Transistors F2 and F3 raise the circuit input impedance to a value much greater than that of any practical tuned circuit, thus assuring the stability of the tuned circuit over the entire gain-control range. As the signal increases and the gain of $Q6_A$-Q7 is decreased by AGC action, a signal level is reached where the gain of $Q6_A$-Q7 is the same as the gain of the degenerated stage Q2-$Q6_B$. At this signal level, the circuit transfers to the modified cut-off characteristic. Since Q2 is a degenerated transistor due to the resistor R5 in its emitter, this device can handle larger signals before input distortion occurs, thus extending the AGC range of this circuit compared with conventional reverse-AGC bipolar transistors.

Delayed AGC

The delayed-AGC circuit senses the input signal to the tuner. When this signal reaches a satisfactory $(S+N)/N$, the circuit applies AGC to the tuner. The circuit must assure that a minimum IF-gain reduction takes place while the tuner RF stage is being gain reduced, to assure freedom from undesired "beats" in the picture due to mixer or IF overload. As shown in Fig. 4, Q5 is connected to "sense" the current, hence the gain of the cascode. As stated previously, a very accurate relationship exists between the gain of the cascode circuit, and its collector current (I_c). An external adjustable current is applied to the collector of Q5 through terminal 8. This current is such that at maximum gain (hence maximum cascode current), Q5 is in saturation. At reduced gain, the bias on the base of Q5 reduces due to AGC action. At some value of gain reduction, as determined by the delay-adjust bias, Q5 comes out of saturation and turns on F5; F5 then applies bias to the AGC circuit to compensate for reduced AGC-loop gain which occurs when the cascode transfers to its modified cut-off characteristic. F5 also turns on Q4 forming a high gain amplifier which applies delayed-AGC to the tuner. Only negative-going delayed AGC is provided since no terminals could be taken from the other functions to provide both output polarities. Since polarity inversion only takes one inexpensive discrete transistor, this is only a minor consideration.

Second and third IF

The second and third IF stages are combined in a feedback amplifier (Fig. 5) which amplifies the signal from the cascode stage to 1 volt RMS. By virtue of the feedback, a low output impedance of 500 ohms is achieved, which contributes to the excellent detected signal linearity of the system. The feedback also extends the 3-dB frequency response beyond 70 MHz. A separate output is taken from Q8 to provide a low-impedance signal to drive a high-gain AFT circuit, such as the CA3064.

As shown in Fig. 5, Q9 is an emitter-degenerated amplifier, with feedback

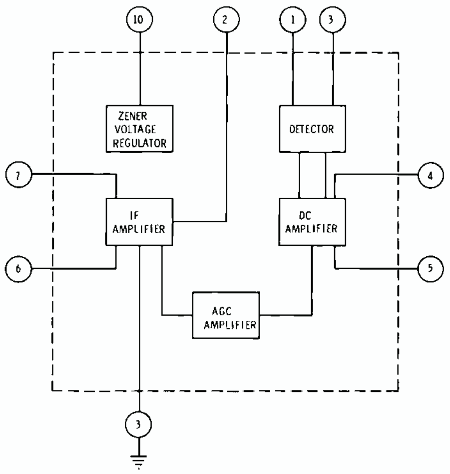


Fig. 2—Block diagram of the CA3064 integrated AGC circuit.

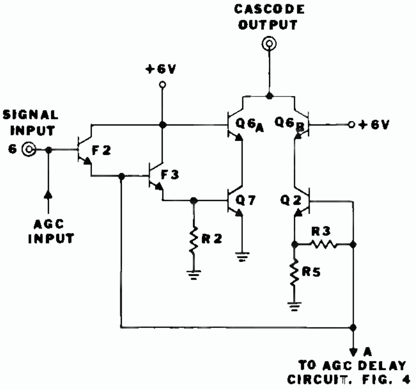


Fig. 3—Basic cascode circuit.

also applied to its collector via R59 and F7. This collector feedback modifies the collector impedance seen by Q9—hence its gain. The tuned circuits are buffered from chip-to-chip impedance variations by Q8, and DC biasing and impedance buffering are provided by Q23. Fixed-gain amplifier, Q10, supplies the power required to drive the linear peak detector.

Linear peak detector

The linear detector must detect the chroma subcarrier without introducing differential phase errors as a function of the video signal and must detect the video signal with a minimum of amplitude distortion. Two principles have been used to achieve the desired results. First, the detector is driven from a low-impedance untuned source. In many conventional transistor receivers, the detector is driven from a high-impedance double-tuned unequal-*Q* transformer. Any detector impedance variations due to normal video excursions can cause noticeable phase shift, hence considerable emphasis has been placed on linear detection to minimize these phase shifts which can cause color distortions. The untuned low-impedance drive circuit provides a near-optimum detector driving condition. Second, the detector is biased in such a manner as to provide detector linearity comparable to an unbiased point contact diode driven with *twice* the signal. The result is a detector circuit whose characteristics enable much lower third-IF power to be used than ever before in a quality instrument.

The detector transistor, F9 (Fig. 6), is accurately biased to a low current by F8, Q11, and R20. Transistor F8 is, in turn, biased to the same potential as the detector, F9, by the low-pass filter, R19-C3. This low-pass filter allows DC biasing while preventing F8 from detecting the IF signal. Transistor Q11 is also used to render the bias currents in F9 and F8 independent of the DC component at their respective bases. The conventional detector time constant, R20 and C4, is chosen for optimum detector efficiency and desired video bandwidth.

Video amplifier

The video amplifier also serves as an impulse-noise limiter for the video signal and the sync circuits. Since limited power is available to perform the many functions noted, the dynamic range of the video and third-IF signals is necessarily restricted. This leads naturally to a limiting type of system for impulse noise protection, as opposed to noise-inversion techniques which require excessive dynamic range and more external components to assure proper detection of the impulse noise. Since the detector is directly connected to the video amplifier, the video amplifier must also cancel the DC level at the detector to provide maximum video dynamic range and reference the detected signal to ground potential. A unique differential circuit has been developed which has excellent characteristics for this application.

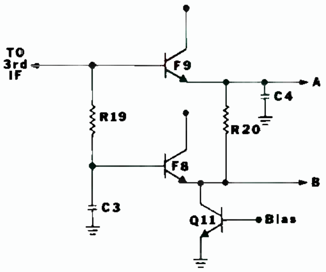


Fig. 6—Linear peak detector.

Low-pass filters R23-C5 and R21-C7 (Fig. 7) reject the 45-MHz signals present, while allowing the video components to pass. Transistors Q12 and F10 are impedance buffers. In the absence of a signal, points *C* and *D* are at the same potential, while R25 and R27 are essentially the same value. Diode-connected transistor D3 has the same geometry as Q13. By virtue of the diode equation, then, the current in Q13 is the same as the current in D3. Since the available currents are the same, no current is available for D2, and Q14 is cut off. In the presence of a detected signal, the voltage at points *D* and *C* remains fixed. The resulting excess current in R27 is now shunted into D2, and Q14 conducts. Thus, in the absence of a signal, Q14 is cut off and the video output voltage is a maximum near the B+ supply. In the presence of a detected signal, Q14 can saturate result-

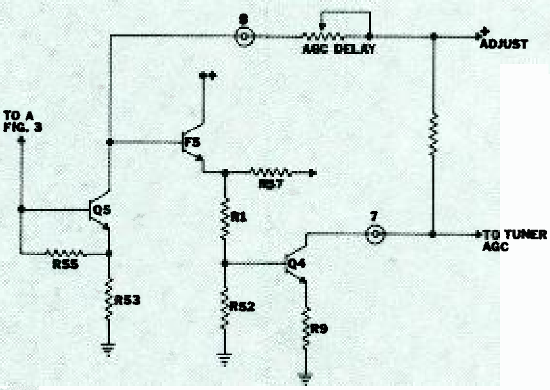


Fig. 4—Delayed AGC circuit.

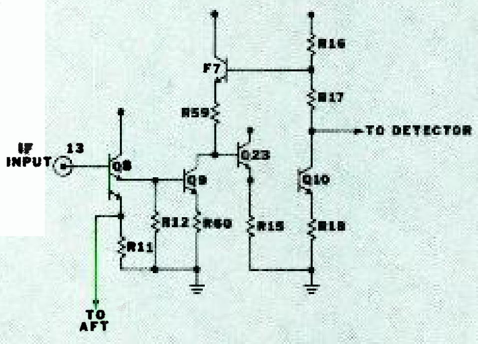


Fig. 5—Second and third IF are combined in a feedback amplifier circuit.

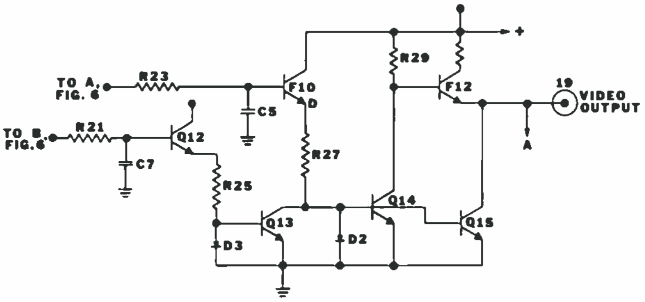


Fig. 7—Video amplifier and limiter.

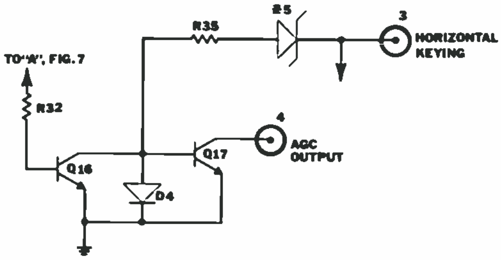


Fig. 8—AGC circuit.

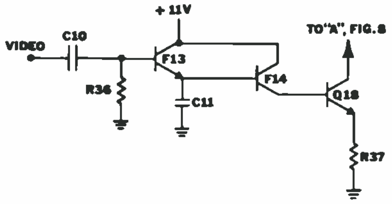


Fig. 9—AGC noise protection.

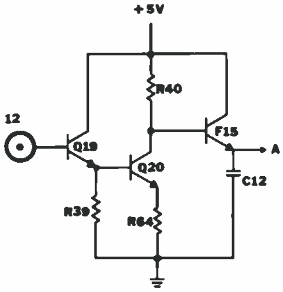


Fig. 10—Intercarrier sound amplifier and detector.

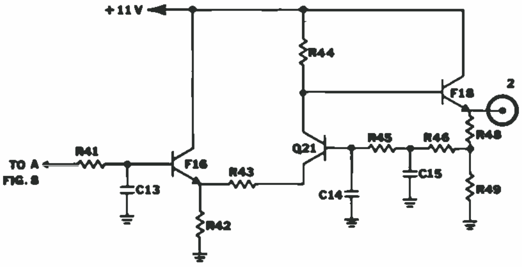


Fig. 11—4.5 MHz sound preamplifier.

ing in a video output voltage of ground potential. It is this ground potential which is used as the clipping level in the presence of impulse noise. F12 is an impedance buffer, and Q15 enhances the fall time of the circuit. Wherever they appear, resistors in the collectors of emitter followers are generally placed there for short-circuit or impulse-noise protection.

Automatic gain control

The AGC circuit is a switching-type circuit, keyed by the horizontal deflection system for the conventional keyed-AGC improvement in impulse-noise performance and for reduced AGC loop gain during the vertical sync interval. No adjustments are required for the AGC, since sync tip level is set very accurately to 0.8 volt above ground by this circuit.

As shown in Fig. 8, R32 is a current-limiting and filtering resistor connected to the video output. When the video signal falls below about 0.8 volt, Q16 starts switching *off* and allows current to flow into D4, turning on Q17—the discharge transistor for the AGC circuit; this removes charge from the AGC-filter and bias network. Positive horizontal keying pulses are supplied to D4 through Z5; Z5 is used to develop a 5-volt offset voltage which prevents false AGC action during the normal ringing which occurs on the horizontal pulse. Current limiting resistor, R35, protects the IC from excessive dissipation.

AGC noise protection

High-performance TV receivers require AGC noise protection to prevent the picture from "washing out" or "setting up" on impulse noise. Since objectionable impulse noise has the characteristics of very high amplitude and high frequency components, a circuit which senses this information and reduces the AGC-amplifier gain accordingly has been developed. This circuit is free from "lock-out" yet requires no additional terminals or external components. This is accomplished by C10 (Fig. 9) which will only allow high frequencies and not a DC component to pass from the video system to the AGC system.

Video signals are fed into the high-pass filter, C10-R36, and the resulting high frequency signals are peak detected by F13-C11. If the detected signal is great enough to overcome the offset potential of F14 and Q18 (about 1.4 volts peak), Q18 turns on and "hogs" current from the horizontal keying circuit resulting in reduced AGC loop gain—thus preventing AGC system "set-up."

Sound-IF subcarrier

The sound IF subcarrier (41.25 MHz) is trapped out of the video-IF system —preventing beat interference problems due to the sound subcarrier interacting with the chroma subcarrier. To recover the 4.5-MHz intercarrier sound signal, a separate IF amplifier and detector is required. Since the detection level is lower than in conventional sets, a 4.5-MHz preamplifier is also included, to provide compatible signal levels with existing sound-IF circuits.

The sound-IF detector circuit is shown in Fig. 10. This circuit consists of a single-stage amplifier, Q20, with impedance buffer Q19 driving the peak detector, F15. The only special consideration here is in the bandwidth of the amplifier, Q20, where low capacitance geometry was used.

Intercarrier sound preamplifier

The 4.5-MHz signal passes through the low-pass filter, R41-C13 (Fig. 11), which removes the video-IF signals. The remaining signals are then amplified by the degenerated differential amplifier, F16-Q21. Negative feedback is applied to the base of Q21 through a filter network, which boosts the gain of the amplifier at 4.5 MHz, while maintaining low DC gain. It is important to maintain low DC gain since this circuit receives its bias in an open-loop manner from the main video-IF amplifier.

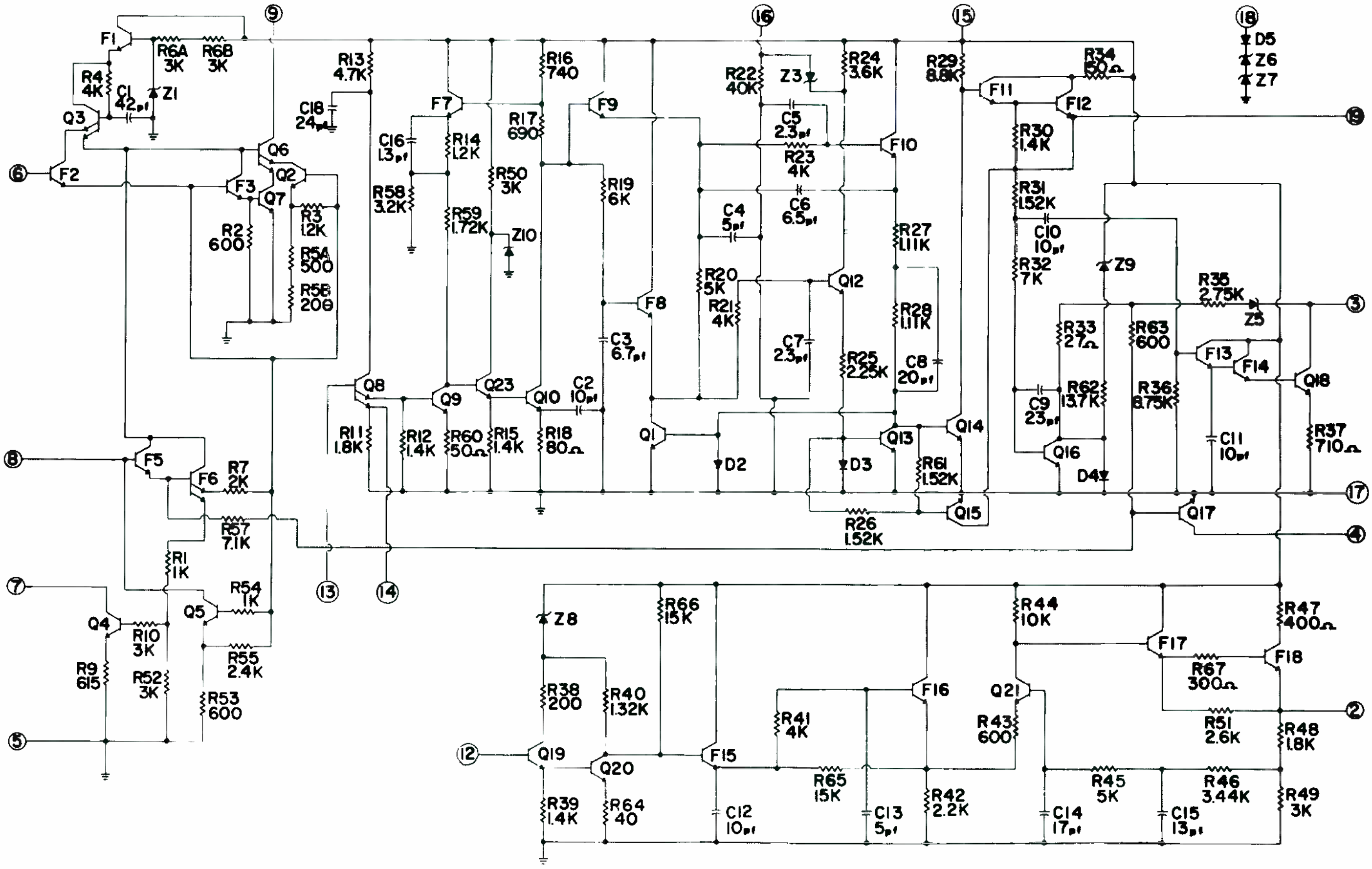


Fig. 12—Schematic diagram for the type CA3068 integrated IF amplifier. The entire circuit is contained on a single monothlitic silicon IC that measures 65 x 67 sq. miles.

Internal reference voltage

An internal zener diode reference is available which can be used to provide excellent DC stability. Alternately, the circuit can be powered from an 11.5-volt 30-mA externally-regulated supply. The low-voltage low-power single voltage requirement makes this integrated circuit readily adaptable to battery-powered TV receivers as well as conventionally powered TV receivers.

Applications

The complete schematic of the CA-3068 (shown in Fig. 12) demonstrates the complexity that can be achieved in a monolithic IC that measures only 65×67 sq. mils using standard high volume IC process. The use of this integrated circuit in the high-performance CTC-46 and CTC-49 color receivers and their scheduled use in the high-performance KCS-186 black-and-white receivers demonstrate the acceptance of this IC as a competitive component.

AFT circuit—type CA3064

The CA3064 AFT circuit was designed specifically for use with the CA3068 integrated circuit. Its high-gain characteristic (only an 18-mV peak signal is required to drive it to full output) makes the circuit very versatile, leading to its early introduction in the CTC-42. This circuit differs from its predecessors primarily in its sensitivity characteristic, and only a brief description of the circuit will be made.

The IF amplifier (Fig. 13) is the familiar cascode circuit Q1-Q3, with Q2 acting as an impedance buffer. Transistors Q4 and Q5 provide "dummy" biasing for the amplifier. The detector is a high-efficiency differential peak detector consisting of Q7-C1, and Q13-C2; Q8 and Q12 provide sharply defined pull-in characteristics as seen on the swept-system response. The DC amplifier is the familiar differential amplifier configuration consisting of Q9, Q11, Q10 and D4. The AGC amplifier, Q6, senses the detected signal at the emitters of Q9 and Q11 and reduces the gain for the signal peaks and for airplane-flutter conditions resulting in improved performance.

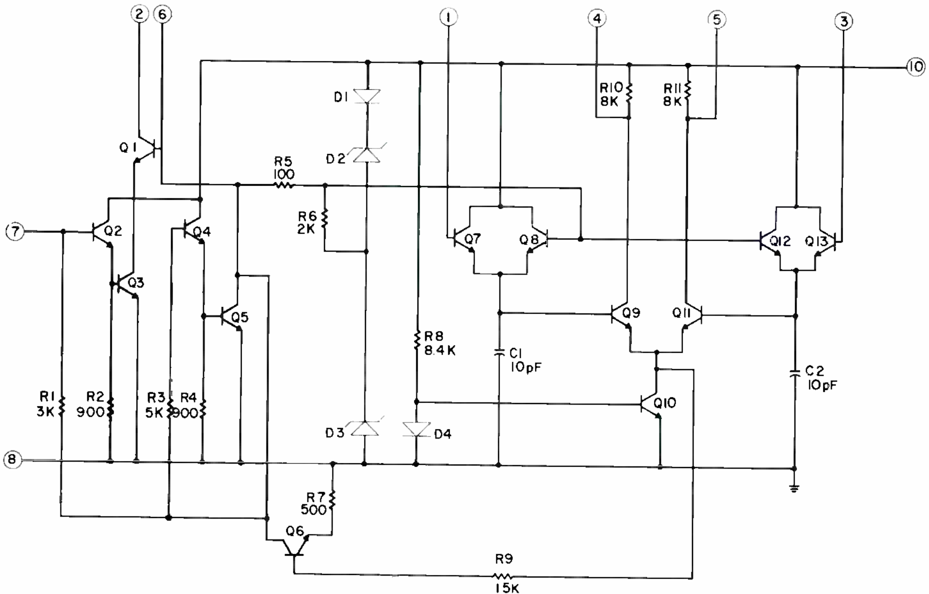
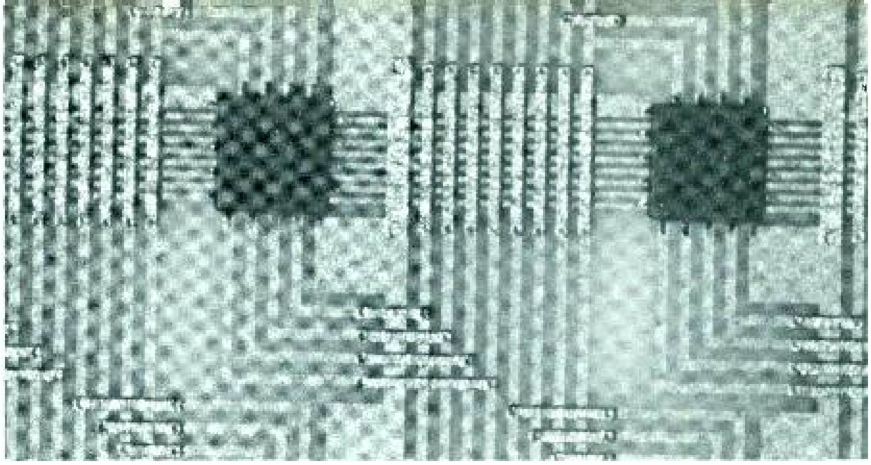


Fig. 13—Schematic diagram for the type CA3064 integrated AFT circuit.



Beam-lead technology—a status report

W. Greig | J. Banfield | R. R. Soden

Because beam-lead technology is a relatively new area of microcircuitry, this paper reviews the progress made in the field to date. Such items as processing steps, manufacturing techniques, film deposition, chip separation, and bonding are covered. Beam-lead devices have already found acceptance in computer assemblies, and more uses and applications are being discovered. Because of their high reliability and integrity, such devices are becoming more commonplace.

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received the BS in physics from Fordham University in 1953. Mr. Greig joined RCA Electronic Components in 1953 as a specialized trainee. After completion of his training program, he was assigned permanently to the Semiconductor Department. He was called to military service from 1954 to 1956. He has been active in the development of diffusion techniques for both germanium and silicon. He was responsible in particular for development of the phosphorus oxychloride, boron nitride, and doped-oxide diffusion techniques for silicon. He has been involved in the application to device fabrication of various technologies, such as sputtering, vacuum evaporation and chemical vapor deposition. He has also been engaged in development of advanced assembly techniques which have included the early development of ultrasonic wire bonding, fabrication and assembly of flip-chips, and development of the beam-lead technology. It is the latter area where he has been most active having participated in the Safeguard Program as well as the earlier development work. He is presently responsible for development of thin-film technology as it applies to advanced packaging techniques. Mr. Greig has had one patent issued and has several patents pending. He has also authored or co-authored several technical papers. He is a member of the American Vacuum Society.

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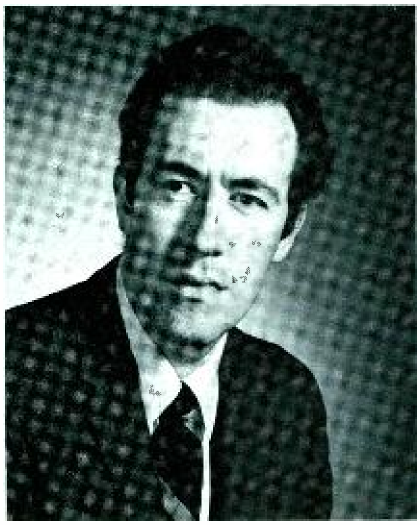
received the BS in physics from Fordham University in 1965. He worked at Philips Laboratory in Briarcliff Manor, New York, for three years before coming to RCA. At Philips, he worked on the deposition of thin films by sputtering. At RCA, he has been responsible for the thin film lab in the Advanced Materials and Processes group. He has done extensive work on the beam-lead metal system and associated processing. He is presently an Engineer in the Advanced Materials and Processes Lab involved in multilevel interconnections and dielectric sputtering. He has two patents pending and is a member of the American Vacuum Society.



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received the AB in Chemistry in 1961 from Rutgers University and the MS in Metallurgy in 1967 from Stevens Institute of Technology. From 1956 to 1961, Mr. Soden worked for Bell Telephone Laboratories. From 1962 to 1963, he was with the Isomet Corporation, where he worked on the research, development, and production of laser crystals. With Bell Laboratories from 1963 to 1968, where he did research on high-purity metal single crystals. Mr. Soden joined RCA's Solid State Division in 1969 where he was a project leader on ROM and LSI technologies. He is presently project leader responsible for metallization technology. Mr. Soden has eleven patents issued and has published extensively.

THE FABRICATION of discrete and monolithic integrated-circuit chips, highly reliable and hermetically passivated, is the end result of direct application of the planar-process technology and the more recently developed beam-lead technology. The planar process involves the combination of oxidation, solid-state diffusion, and photochemical process techniques to form devices of various configurations that have desired electrical properties. Beam-lead technology involves the utilization of a passivation layer and a multilayered, metallized, interconnecting system of unique design which is metallurgically sound, highly corrosion-resistant, and readily bondable for attachment to a suitable substrate or package.

The use of beam leads significantly reduces assembly costs and improves reliability as compared to the wire bonding method. The reliability factor, which is dominant in beam-lead technology, is optimized by use of proper materials in the fabrication processes. Current technology uses silicon nitride as the passivating or sealing layer and *PtSi-Ti-Pt-Au* as the metal system for interconnections and lead attachment.

Beam-lead processing and techniques

In the strictest sense, beam-lead technology encompasses a passivating layer, a multilayered metal system, and uniquely-designed metallization. The metallization consists of a layered structure of platinum silicide, titanium, platinum, and gold (*PtSi-Ti-Pt-Au*). The metallized pattern and subsequent processing are designed to yield a chip in which the attaching leads extend over the edges of the chip. Fig. 1 shows typical wafers and illustrates the difference between a standard or conventionally-metallized pattern (in which final lead attachment is accomplished by wire bonding) and the beam-lead metallization. In the beam-lead method, Fig. 1b, the metallized pattern is brought out into the grid. Subsequent processing involves removal of the silicon and the oxide in the grid to leave the beams cantilevered over the edges of the chip and available for easy attachment to a package or substrate. The term beam-lead is derived from the description of the cantilevered

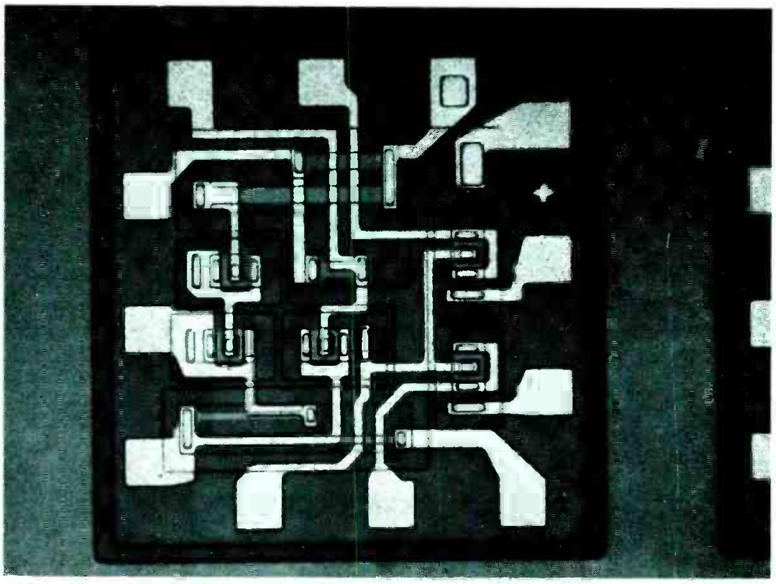
Fig. 1a—Method of metallization for wire bonding.

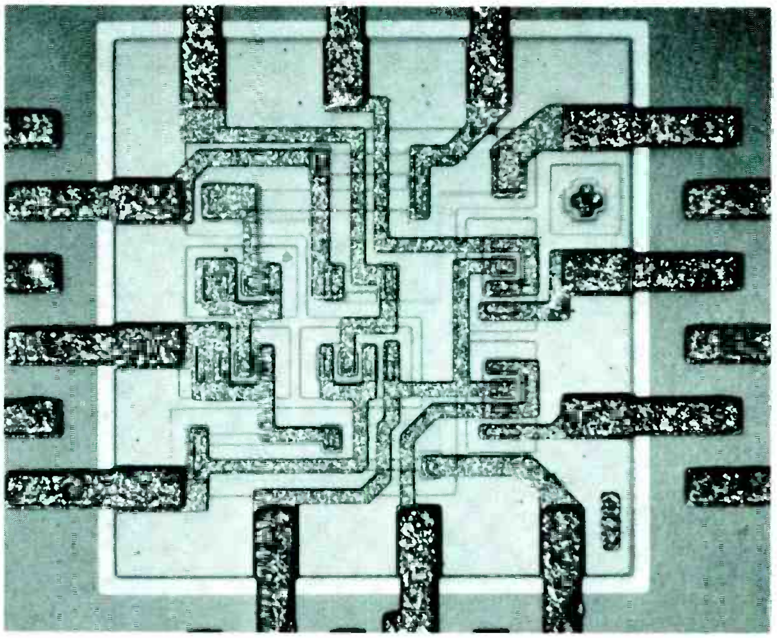
Fig. 1b—Method of metallization for beam-lead bonding.

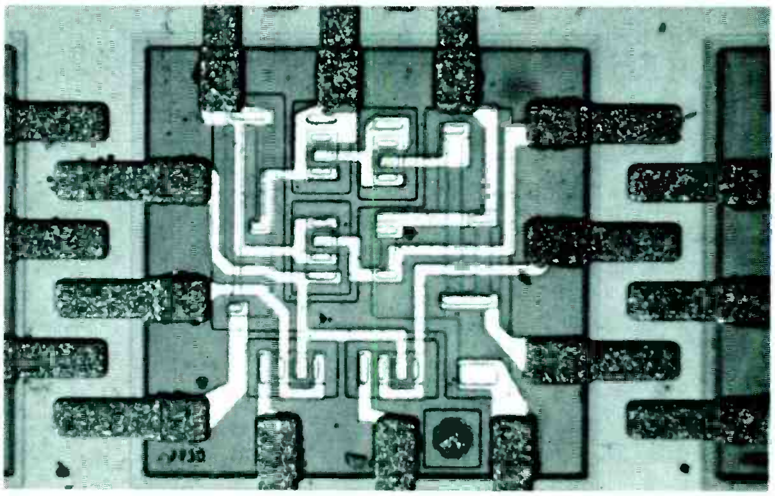
Fig. 2—Metallization system using aluminum with beams of *Ti-Au*.

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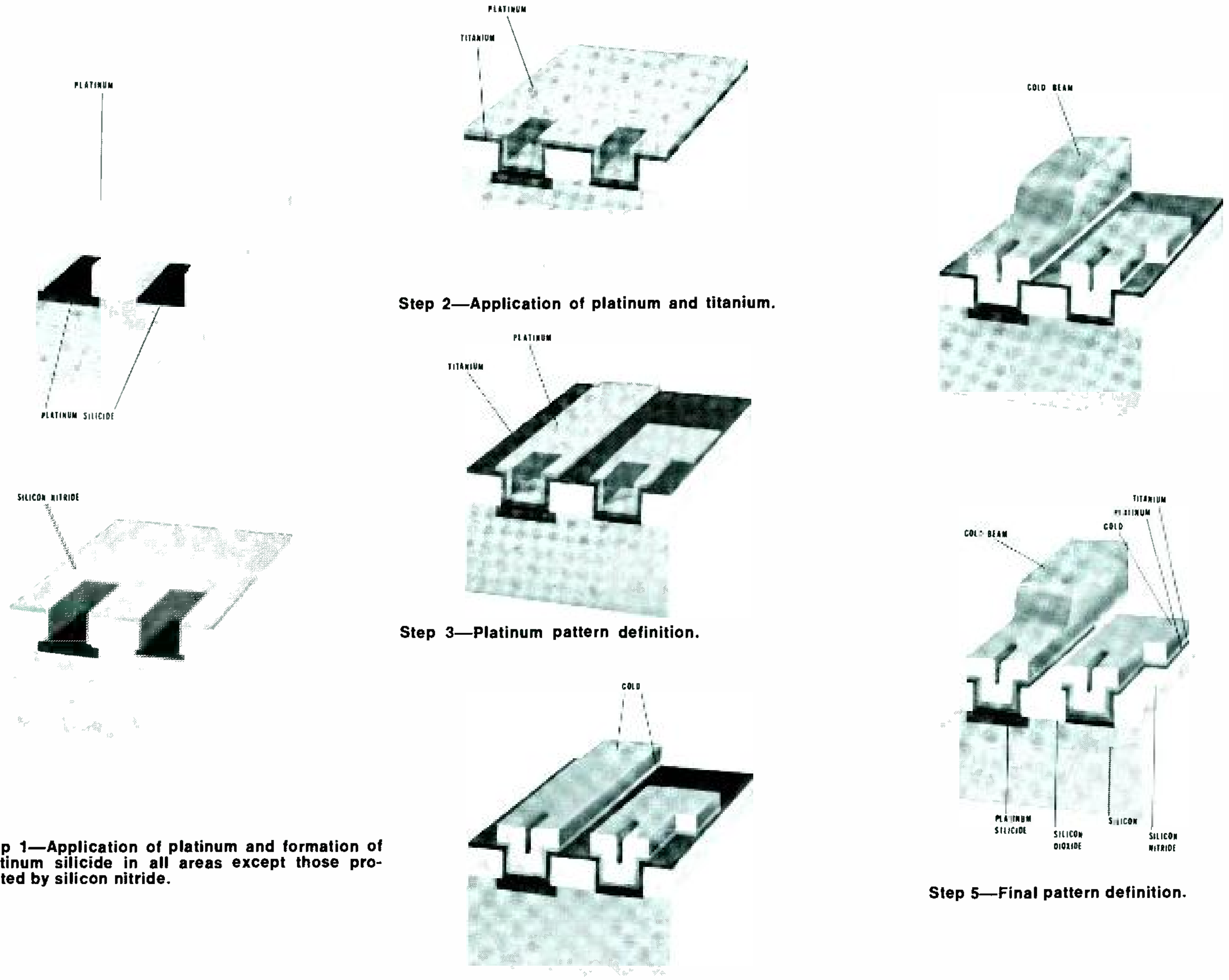


Step 1—Application of platinum and formation of platinum silicide in all areas except those protected by silicon nitride.

Step 2—Application of platinum and titanium.

Step 3—Platinum pattern definition.

Step 4—Gold electroplating.

Step 5—Final pattern definition.

Fig. 3—Process steps in forming contacts and interconnections.

structure and has evolved as a generic term identifying any device having connections designed with an extended beam for ready attachment to a substrate package of similar configuration.

Beam lead connotes the unique connection scheme only, and implies neither chip hermeticity nor the use of any particular metal or combination of metals. The beam-lead circuit in Fig. 2 is similar to that in Fig. 1b, but has a metallization system consisting of aluminum with beams of *Ti-Au*. Although the device shown in Fig. 2 is identical in electrical properties and operation to that of Fig. 1b, it is not hermetic in chip form.

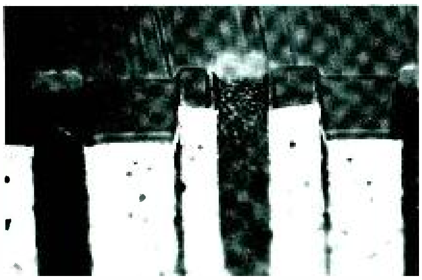


Fig. 4—Photomicrograph of an angle lap of sputtered *Pt* and *PtSi*.

The beam-lead process actually complements the well-established silicon planar technology and consists of the following processes: a) dielectric deposition, b) contact opening, c) deposition and formation of contacts and interconnections, d) chip separation, and e) beam-lead bonding.

Dielectric deposition

The silicon nitride (Si_3N_4), which functions as the sealant or passivating layer, is deposited over the surface of a silicon wafer upon completion of all the diffusions and oxidations needed to prepare the device. This layer is formed by introducing silane and ammonia (together with nitrogen as a carrier gas) into a reaction tube in which the silicon wafers are heated to approximately 800°C. Techniques such as radiotracer analysis and etch rate studies are employed to provide quantitative as well as qualitative data on passivation properties of the film; i.e., its ability to act as an effective barrier against ionic contamination.

Fig. 5—Photomicrograph of an angle lap of a finished metallized device.

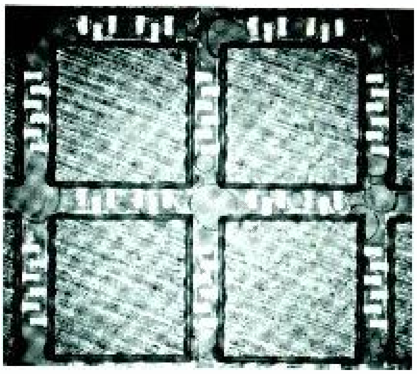


Fig. 6—Separated chips.

Contact openings

Because of the slow etch rate of silicon nitride, normal photoengraving techniques cannot be used to open contacts. When buffered hydrofluoric acid is used as an etchant, etch rates are typically 1000 angstroms per minute for thermally-grown silicon dioxide and 10 angstroms per minute for silicon nitride. Silicon nitride on the other hand is etchable in hot phosphoric acid, while SiO_2 is not. Because of this solubility difference, a process is employed which makes use of a deposited and defined SiO_2 layer as an etch mask to permit selective removal of Si_3N_4 in the contact areas.

Deposition of contact and interconnections

Titanium, platinum, and gold are the basic metals used for the beam-lead contacts and interconnections. The *Ti* and *Pt* are deposited by sputtering, rather than by the more conventional thermal-evaporation technique used extensively in the microelectronics industry. The gold is electrodeposited.

The sequence of steps for deposition of contacts and interconnections is shown schematically in Fig. 3, and is described as follows:

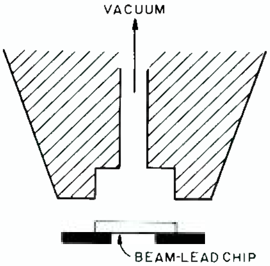
Step 1—With contact windows opened, a thickness of appoximately 500 angstroms of *Pt* is sputter-deposited over the surface of the wafer. The wafer is then heated to 650°C, either in a vacuum chamber or in a muffle furnace in an argon atmosphere, to form platinum silicide in the contact areas. In the areas protected with silicon nitride, the platinum is unreacted and must be removed by chemical etching in aqua regia.

Step 2—*Ti* and *Pt* are sputter-deposited sequentially, each to a thickness of approximately 1500 angstroms.

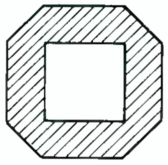
Step 3—The platinum is defined by photoresist and chemical etching to leave a wafer having a continuous layer of *Ti* and the interconnection pattern etched in *Pt*.

Step 4—The *Ti* layer is then coated with another photoresist layer and, with the continuous *Ti* film used as a conducting layer and the photoresist as a plating mask, gold is electroplated on the *Pt* to a thickness of approximately 2 to 3 micrometers.

Step 5—A further photoresist step defines the beams, and gold is electroplated to a thickness of 12 to 15 micrometers. The *Ti* layer is chemically etched to complete the metallization.



(a) CROSS-SECTION



(b) BOTTOM VIEW

Fig. 7—Beam-lead bonding tool.

The metallurgy of the structured metals system is extremely sound. The *PtSi* used for contact to the silicon is stable, and forms a low-resistance contact. The *PtSi* is formed by a solid-phase reaction and therefore is not prone to the "spiking" frequently encountered with aluminum. The system is easily controlled: its thickness is determined by the thickness of the deposited *Pt* and to a lesser degree by the sintering temperature. Fig. 4 is a photomicrograph of an angled cross-section of a wafer following *Pt* deposition and sintering. Relative thicknesses of the *Pt* and *PtSi* are apparent.

Titanium, because of its high affinity for oxygen, reacts readily with *PtSi*, SiO_2, and Si_3N_4, and therefore provides excellent adherence. The platinum layer is used as a barrier to prevent the top layer of gold from coming in contact with either the *Ti* or the silicon at high temperatures and causing deterioration of the interconnections or degradation of the device characteristics. The choice of *Au* as the outer metal provides the desired standards of high conductivity and corrosion resistance; in addition, gold is readily bondable to a wide variety of substrates and materials. Fig. 5 is a photo-

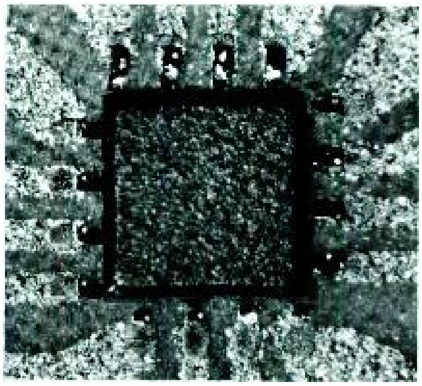


Fig. 8—Photomicrograph of a typical beam-lead-bonded chip on a metallized ceramic header.

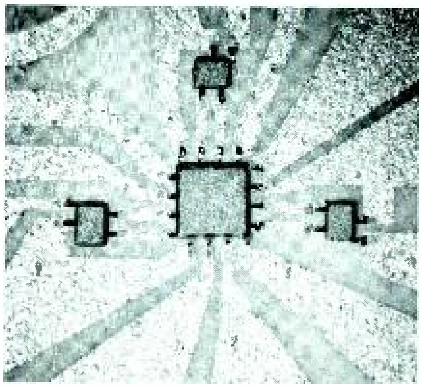


Fig. 9—Typical electronic component assembly.

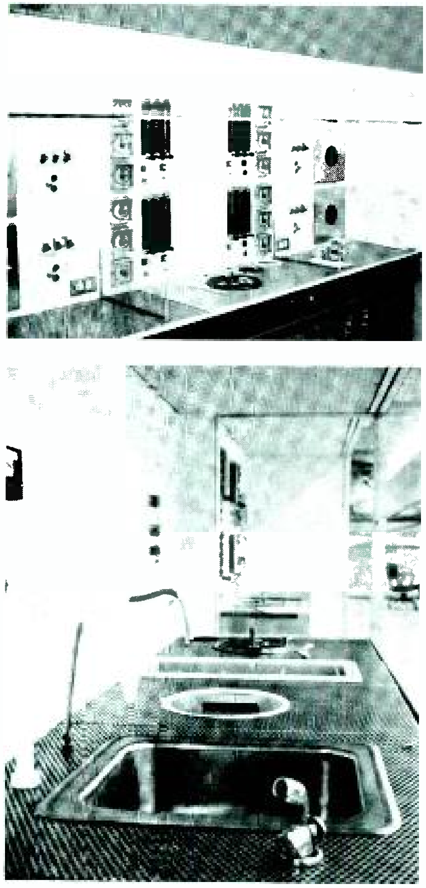


Fig. 10—(top) Typical diffusion station and (bottom) chemical cleaning station.

micrograph of an angled cross-section through the active regions of an actual device; the photo clearly shows the layered structure described.

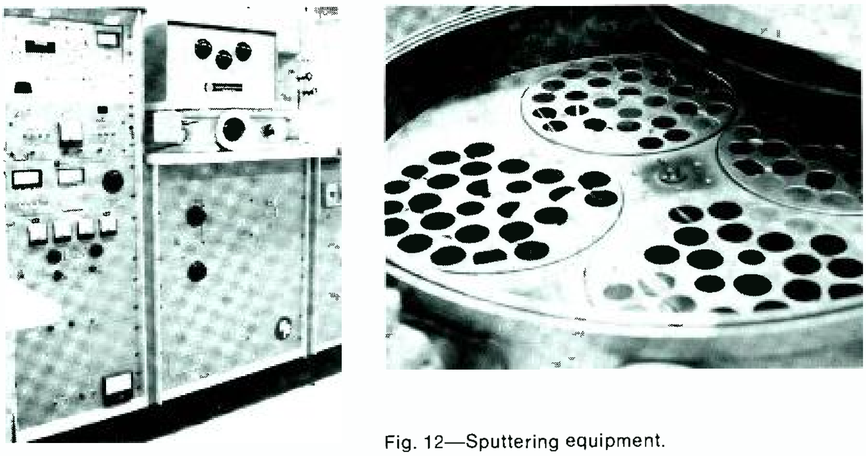


Fig. 12—Sputtering equipment.

Chip separation

After completion of all the metallization steps, the process of separating the chips begins. In the beam-lead process, this separation involves removal of the silicon from the "streets" or grids between the chips. The complete process includes a precision backgrinding or backlapping, a front-to-back alignment, and a chemical etch to remove the silicon from the grid. Fig. 6 shows a section of a wafer following chip separation. Removal of the chips for bonding following electrical testing can be accomplished in several ways. With respect to chip separation, if (100)-axis crystal is used, etchants such as potassium hydroxide can be employed to provide a highly selective and precisely controlled high-yield etching process. This type of anisotropic etch also permits fabrication of air-isolated integrated circuits with closely spaced components. This latter feature is accomplished without any additional processing steps, requiring only a change in the final chip separation photomask.

Beam-lead bonding

The actual beam-lead bonding is performed in such a manner that the labor involved is completely independent of the number of beams to be bonded, which is quite unlike the wire-bonding process. Because all beams are bonded in a single operation, the number of beams per chip to be bonded is immaterial. Although the cost saving realized from the use of beam leads is rather small on discrete-device chips because of the additional processing required, the savings are significant in the case of large-scale integration, medium-scale integration, or conventional integrated circuits in which the number of bonds increases with increasing complexity.

The actual bonding of the beam leads to a metallized package or substrate is performed by a thermocompression technique. As shown in Fig. 7, the chip itself is not contacted by the beam-lead bonding tool during the bonding operation; therefore, no stress is introduced. In addition, when the bonding tool is heated to a temperature of approximately 300°C, little heat is transferred to the chip itself. The bond integrity of the beam-lead bonding operation is readily evaluated by both visual and mechanical inspection, and any faulty bonds can be rebonded. Another feature of the beam-lead bonding is that chips can be completely removed and new chips bonded in place, which is highly desirable in multi-chip hybrid circuits. Fig. 8 shows a microphotograph of a typical beam-lead-bonded chip on a metallized ceramic header.

Present facilities

Fig. 9 shows a typical beam-lead integrated-circuit. This assembly, commonly referred to as a hybrid integrated circuit, consists of individual active and passive device chips interconnected by a metallized pattern on a common substrate. Strict in-process controls and extensive environmental, mechanical, and electrical testing are

Fig. 11—Modular in-line concept.

Fig. 13—Beam-lead bonder.

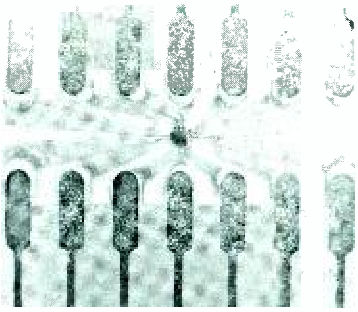


Fig. 14—Typical device bonded on ceramic substrate.

used in the manufacture of beam-lead devices to assure the highest level of reliability.

The actual manufacturing facility for such devices, located in Somerville, N.J., is of the latest design and uses laminar flow equipment extensively in all processing areas. The plant equipment, utilizing modular design, is arranged to complement product flow. A typical diffusion station and a chemical cleaning station are shown in Fig. 10. Fig. 11 illustrates the modular in-line concept utilizing laminar flow equipment. Pass-throughs are provided between modules to ease the flow of the work from station to station. Fig. 12 shows the sputtering equipment and an inside view of the apparatus, while Fig. 13 shows a beam-lead bonder.

Samples of beam-lead devices can be subjected to a series of tests to establish their integrity and reliability, including deliberate contamination with sodium chloride followed by a 300°C heat treatment in forming gas with a bias voltage applied to the devices. A 300°C reverse-bias check can also be included as part of the final testing. This type of testing results in devices of extremely high electrical, mechanical, and structural reliability.

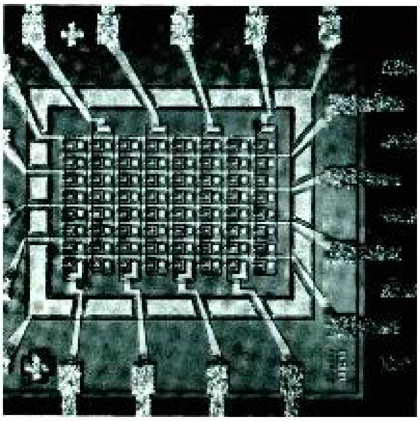


Fig. 15—Developmental 64-bit read-only memory.

Applications of beam-lead technology

The use of beam-lead technology has been extended to a wide variety of applications. For example, several integrated circuits have been redesigned for beam-lead fabrication, and an increasing number of developmental circuits are being designed with beam-lead structure. Fig. 14 shows one of the devices bonded to a ceramic substrate package.

The assembly methods and the reliability of beam-lead technology are important factors which make the technology readily adaptable to large-scale integration, either for monolithic single chips with multiple leads, or for hybrid multi-chips. For example, a read-only-memory (ROM) array has been designed and developed which utilizes the beam-lead technology exclusively.

The ROM array consists of an *X—Y* bipolar array and includes a fusible link as part of the interconnection pattern. The fusible link is constructed so that it is field-alterable; i.e., the memory can be set by the user by "blowing" the appropriate fuse or fuses within the array. A photomicrograph of a developmental 64-bit ROM with a fusible link is shown in Fig. 15. The fusible-link process has been developed so that the fuse material is an integral part of the interconnections and thus provides a high level of reproducibility and reliability. This approach also provides a great deal of flexibility and is compatible with either approach to large-scale integration. For example, a multi-chip array has been developed utilizing the beam lead 64-bit ROM and a thin-film-on-ceramic interconnection technology. This latter technology makes use of techniques such as the "micro-bridges" or "beam cross-overs" as well as "cross-unders." Both techniques are illustrated in the Fig. 16. The "beam cross-over" requires additional processing; however, the cross-under results from the beam-lead bonding process. Upon being bonded, beam-lead chips will lift from the substrate and thus permit lines to run under the chips.

Beam-lead technology also appears to be adaptable to multilevel metallization in monolithic large-scale integration where the reliability and metallurgical integrity of interconnections are prime considerations.

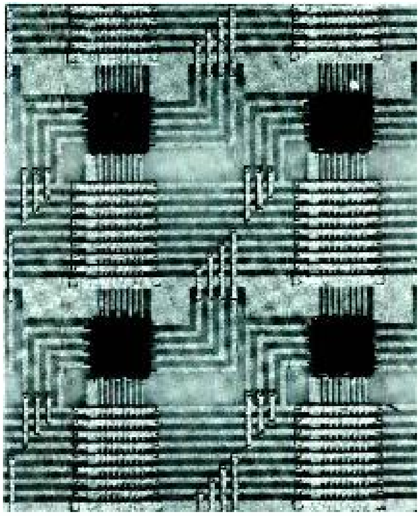


Fig. 16—Multi-chip array with thin-film-on-ceramic interconnections.

Fig. 17 shows a high-speed memory utilizing multilevel metallization which has been experimentally produced by beam-lead technology. Several other programs investigating further applications of beam-lead technology are under way. Additional work is directed not only toward the extension of the technology, but also to the areas of process improvement and development.

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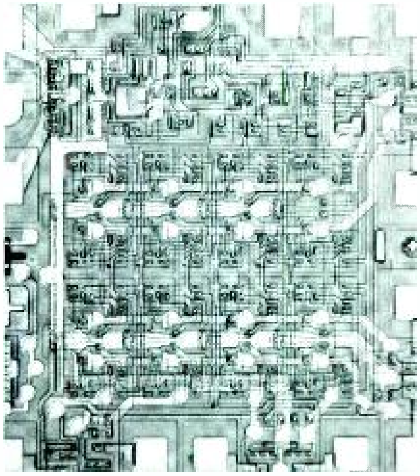


Fig. 17—Experimental 16-bit high speed lead processing.

Seven RCA men elected IEEE Fellows

The seven RCA men cited herein have been honored for their professional achievements by being elected Fellows of the Institute of Electrical and Electronics Engineers. This recognition is extended each year by the IEEE to those who have made outstanding contributions to the field of electronics.

Editor's note: In addition to these seven recipients, three recent past RCA employees received the grade of Fellow from IEEE: David K. Barton, formerly with Missile and Surface Radar Div., "for contributions to precision tracking radar and radar systems engineering"; Dr. Murray A. Lampert, formerly with RCA Laboratories, "for contributions in the understanding of injected currents in insulators and semiconductors"; Dr. Richard B. Marsten, formerly with Astro-Electronics Div. "for contributions to the development of radar and communications satellite systems."

Eugene D. Becken . . . for contributions to management of engineering and to the use of computers in international communications.

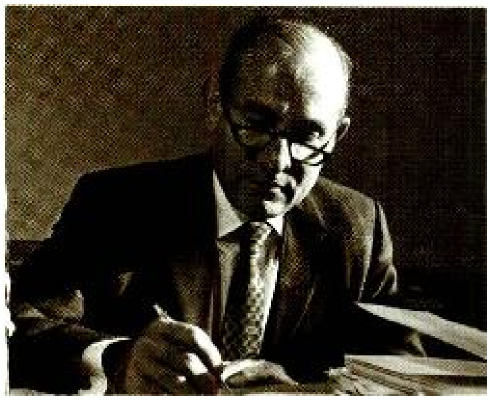
Eugene D. Becken, Executive Vice President, Operations. RCA Global Communications, Inc., New York, N. Y., received the BSEE from the University of North Dakota and the MSEE from the University of Minnesota. In 1952, he received the MS in Business and Engineering on a Sloan Fellowship at M.I.T. Mr. Becken joined RCA Communications in 1935 as Transmitting Engineer at the Rocky Point transmitting station. The following year he was transferred to the New York headquarters where he held a number of operating and engineering positions He became Plant Operations Engineer in 1948 and Assistant Vice President in 1953 He was elected Vice President, Operations Engineering in 1959, Vice President and Chief Engineer in 1960, Vice President, System Operations in 1968, and Executive Vice President, Operations in 1970. Recently, he has been very active in RCA Global Communications, Inc. automation programs which include the provision and operation of computers for message and circuit switching systems for international message traffic and telex services. Mr Becken is a registered Professional Engineer in New York and a member of the Society of Sloan Fellows of M.I.T., Newcomen Society of North America, Bankers Club of America, RCA Institutes Board of Technical Advisors, American Association for the Advancement of Science, New York Academy of Sciences, Armed Forces Communications and Electronics Association, and Commerce and Industry Association of New York, Inc. He has been Chairman and member of the Radio Communications and Space Communications Committees and a member of Communications Committee of the IEEE. He has published several technical papers and is a contributor to the *Communication System Engineering Handbook and the Encyclopedia of Science and Technology.*

Loren F. Jones, III . . . for contributions to AM and TV broadcast engineering, air navigation, computers, and evaluations of new technology.

Loren F. Jones, formerly Director, Education Services, Cherry Hill, N. J. (now retired and serving as a consultant) graduated from Washington University and attended the Graduate School of Business of Stanford University. Soon after joining RCA in 1930, he undertook engineering assignments in several European countries. On his return to Camden, New Jersey, he was active in broadcast and associated fields. During 1937—1938, Mr. Jones was in Russia heading an RCA team on a TV project. During World War II, Mr. Jones represented RCA in the marketing and coordinating of government research and development projects. He served as chairman of the Direction Finder Committee and as a member of the Communications and Radar Divisions of the Office of Scientific Research and Development, for which he was awarded the Presidential Certificate of Merit. He was a member of the Scientific Advisory Board of the United States Air Force. In 1951, he originated and organized the New Products Division of RCA. As a result of one of the programs of that division, RCA established Electronic Data Processing as a new business. Mr. Jones became Marketing Manager of that business. Later he became Manager, Engineering, New Business Programs, and finally Director, Educational Development. Mr. Jones is a member of Sigma Xi, and the Franklin Institute. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics.

Thomas M. Gluyas . . . for technical leadership in the development and design of television transmitters and radar equipment.

Thomas M. Gluyas, Jr., Administrator, Transmitting Equipment, Systems Engineering, Communications Systems Division, Camden, N. J., received the BSEE from Pennsylvania State University in 1935 where he was president of the IRE student branch and a member of Eta Kappa Nu. After working on television research at the Philco Radio and Television Corp., he joined RCA in 1941. During World War II, Mr. Gluyas was the responsible engineer in the design of a series of aircraft search radar antennas. After the war, he was a senior engineer in the design of the first television transmitter produced in quantity in the United States. Mr. Gluyas was responsible for the development of the first experimental UHF-TV transmitter in the United States, paving the way for opening of the UHF band to commercial television broadcasting. He also developed TV transmitter circuits necessary to enable color broadcasting. Mr. Gluyas has held engineering management positions in charge of development and design of military airborne fire control radar, airborne television and infra-red systems, commercial broadcast studio products, audio equipment, and broadcast transmitters. He is a member of Eta Kappa Nu. He was chairman of IRE 15.6 and EIA TR4.1 committees on standards for television broadcast transmitters. He has published technical papers relating to color television broadcasting equipment and techniques, and he has been issued 20 U. S. patents in the fields of radar and television transmitters and antennas.

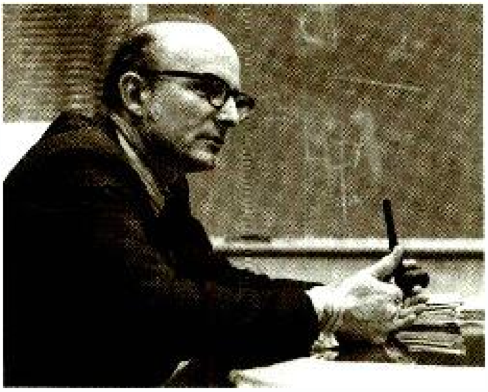


Rabah A. Shahbender . . . for contributions to magnetic and ultrasonic devices and computer memories.

Rabah A. Shahbender, Head, Digital Device Research, Digital Systems Research Laboratory, RCA Laboratories, Princeton, N. J., received the BEE from Cairo University, Cairo, Egypt, in 1946. He received the MSEE from Washington University, St. Louis, Mo., in 1949 and the Ph.D. in Electrical Engineering from the University of Illinois in 1951. From 1946 to 1948, he was employed by the Anglo-Egyptian Oilfields Ltd and undertook work in seismic exploration. From 1951 to 1955, Dr. Shahbender was on the staff of Honeywell, Brown Instruments Division, Phila., Penna., where he conducted research in the behavior of nonlinear closed-loop systems. He joined RCA in Camden, N. J., in 1955, and worked in the areas of adaptive systems, nonlinear filters, electron-beam devices, ultrasonic devices, and airborne fire control systems. Dr. Shahbender transferred to RCA Laboratories, Princeton, N. J., in 1959 and has been active in the area of high-speed digital memory systems. He is presently Head of the Digital Device Research in the Digital Systems Research Laboratory. Dr. Shahbender received the AFIPS Best Paper Award in 1963, IR-100 Awards in 1964 and 1969, and RCA Laboratories Achievement Awards in 1960 and 1963. From 1960 to 1966, he was Chairman of the Department of Electronic Physics, at La Salle College, Evening Division, Phila., Pa. Dr. Shahbender is a member of Sigma Xi, and Eta Kappa Nu, and a Fellow of the University of Illinois. He has published a number of papers relating to his work, and holds several U. S. Patents.

Dr. James Vollmer . . . for contributions to radiation, physics, and quantum electronics, for applied research, and for leadership in engineering education.

Dr. James Vollmer, Manager, Advanced Technology Laboratories, Camden, N. J., received the BS in General Science at Union College in 1945, and the MA and Ph.D. in Physics at Temple University in 1951 and 1956, respectively. His research interests, publications, and patents cover a wide variety of fields, ranging from infrared properties of materials to plasma physics to quantum electronics. His professional experience includes, in order, five years of teaching at Temple University, eight years of supervising a research group at Honeywell, Inc., and twelve years of research and development supervision at RCA. Currently, Dr. Vollmer is Manager of RCA's Advanced Technology Laboratories, a group of 130 engineers and physicists charged with translating the recent advances of basic research into useful techniques and devices. Typical areas of effort are electro-optics, optics, lasers, holography, sensors, microwave physics, microsonics, thermal management, advanced recording techniques, pattern recognition, LSI-hybrid circuit techniques, semiconductor device characterization, and computer systems, analysis, and techniques. Dr. Vollmer is a Fellow of the AAAS and a member of the American Physical Society. His honors include membership in Phi Beta Kappa, Sigma Xi, Sigma Pi Sigma, and Eta Kappa Nu. He is currently listed in American Men of Science, Who's Who in the East, and Leaders in American Science.



Donald J. Parker . . . for contributions to the field of electro-optical engineering.

Donald J. Parker, Chief Engineer, Government Communications Systems, Communications Systems Division, Camden, N. J., received the BS in Optics from the University of Rochester in 1950 and joined the Applied Research department of RCA. His early experience included electro-optical engineering on color television broadcast, recording, and projection equipment; radar—IR scan and track equipment; television aerial reconnaissance; and high resolution radar recording. He became supervisor of the Optics Group in 1954 and Manager of Applied Physics in 1957. As Manager of Applied Physics and later (1963) Manager of Applied Research, he directed engineering development and design in electro-optics, electrostatic printing, superconductivity, molecular resonance, and plasma physics. He was responsible for the initiation of state of the art developments in laser communications and detection, ultra-wideband video recorders, automatic speech recognition, thermo-electric cooling and power generation, and a wide scope of applied research work in computers including circuits, memory, packaging, software and design automation. Mr. Parker also directed the product design of a family of classified special purpose computers later produced in large volume, as well as the advanced product design of classified sophisticated electro-mechanical systems and communications systems. Mr. Parker was appointed Chief Engineer of Government Communications Systems in September 1968. He is responsible for engineering efforts covering a broad scope of advanced techniques, systems design, and product engineering. Mr. Parker is a member of the American Physical Society, the Optical Society of America, and the Society of Motion Picture and Television Engineers.

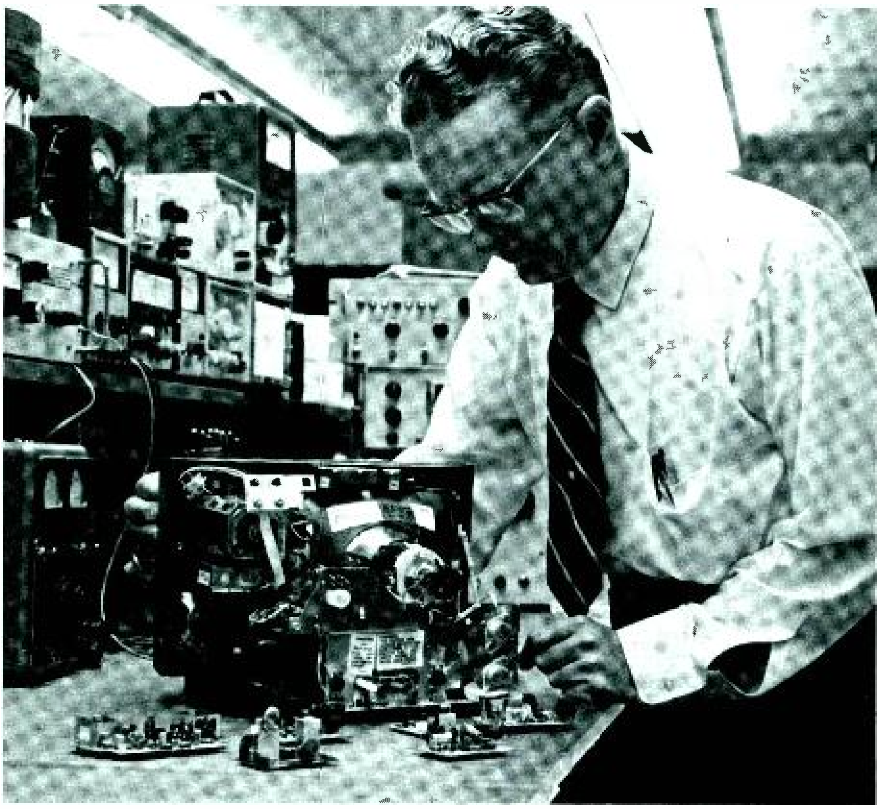
C. Price Smith . . . for contributions to the processing and fabrication techniques for large-scale manufacture of shadow-mask color television picture tubes.

C. Price Smith, Manager, Power and Electro-Optic Products, Industrial Tube Division, Lancaster, Pa. received the BSEE from the University of Missouri in 1942. Mr. Smith joined RCA in Harrison, N. J., in 1942 as a production engineer and transferred to the newly-established RCA plant in Lancaster, Pa., in 1943. He became Group Supervisor in the Tube Development activity and, in 1948, was made Manager of the Development Shop. In 1954, Mr. Smith was named Manager, Black and White Kinescope Engineering, Marion, Indiana; that same year, he became Manager, Color Kinescope Engineering, Lancaster. From 1955 to 1961, he was Manager, Engineering of all picture tubes. From 1961 to 1963, he was on special assignments for the Executive Vice President, Research and Engineering. He was appointed Director, Process Research and Development Laboratory, Princeton in 1963, and was named Director, Consumer Electronics Research Lab. in 1966. In 1968, Mr. Smith was named Manager, Conversion Tube Operations, Lancaster Plant and in February, 1970, he was promoted to his present position in which he is also responsible for operations services for all activities at the Lancaster Plant. Mr. Smith holds a number of important U. S. Patents. In 1952, he was cited in an RCA Victor Award of Merit for contributions to the development of metal kinescopes. He is a registered professional engineer, and an advanced class radio amateur. He is President, Lancaster Chapter, Society for Advancement of Management; and a Member, IEEE committee on Manufacturing Technologies, Penn State Science Advisory Committee, American Association for Advancement of Science, University Club, and Sigma Pi Sigma.

A modular system for consumer electronics

L. P. Thomas

Pre-aligned and pretested modular "black box" functions are the building blocks of the consumer electronics system described in this paper. Flexibility of design, ease of manufacture and test, and consumer demands—including serviceability, reliability, and styling—were paramount considerations in development of the system. Naturally, profit optimization is also a strong motive implicit in all these considerations.



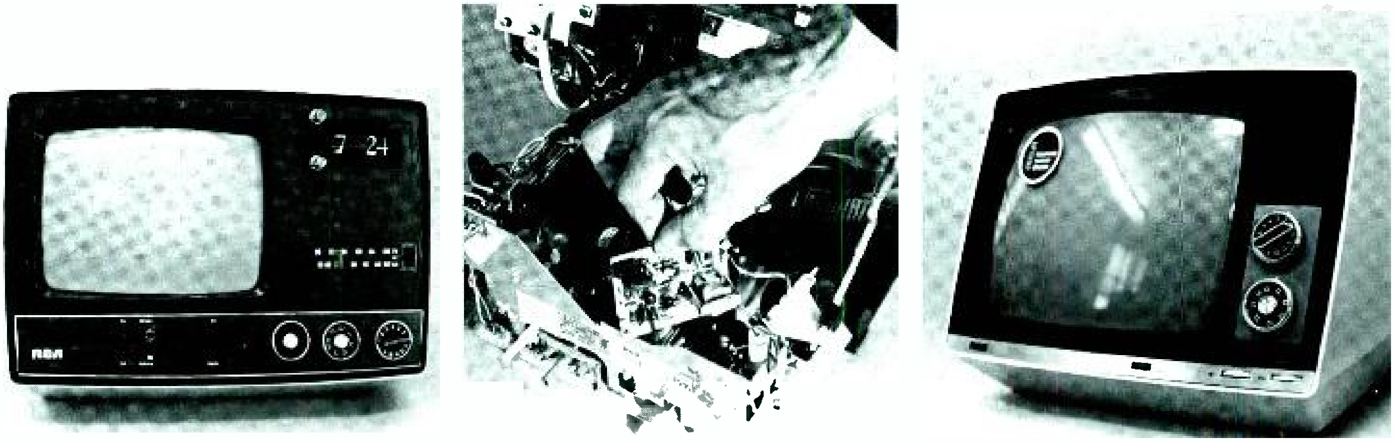
L. P. Thomas, Manager
Advanced Product Development
Black and White Television Engineering
Consumer Electronics Division
Indianapolis, Indiana
received the BSEE from Clemson University in 1947. He has since taken courses in Business Administration at the Wharton School of the University of Pennsylvania. He joined RCA televison engineering in 1947 and became responsible for the design and development of video-sync-separator, AGC, and noise-cancellation circuitry for black-and-white television receivers. He has also designed remote control circuits and automatic contrast and brightness control circuits and other items related to the television field. He has 23 issued patents, plus patents pending, and has written a number of technical articles and lectures. He is a senior member of the IEEE.

CONSUMER ELECTRONIC PRODUCTS have traditionally followed conservative design and packaging philosophies while incorporating, within that framework, technological advancements as rapidly as possible. In today's marketing-oriented business environment, traditional techniques are no longer responsive enough to maintain RCA's historical prominence. Therefore, a new and more viable concept has been initiated to help insure RCA's future position of leadership in the market place. This concept may best be described as "a modular system for consumer electronics".

The costs associated with this system are based on the total costs of doing business, rather than cost optimization in any one department. For example, if the solder department were to use a lower-cost "rosin-joint-special" material to make its internal budget look good, the few thousand dollars saved in an inferior solder could conceivably cost the company millions. A slight increase in material content to reduce factory, warranty, engineering, and other costs is one of the major concepts of this system.

Why the modular approach?

New market possibilities are opened by our ability to adapt already tooled instruments to other uses; the modular approach provides the flexibility necessary to change models without waiting for the "annual changeover." Thus, new technology or new market requirements can be incorporated without traumatic instrument redesign. For example, the hybrid-type KCS-176



Three different production instruments using identical tuners, picture IF modules, sound modules, and video modules. Left is the 9-inch KCS-176 packaged with an AM/FM radio and digital clock; center is the 9-inch KCS-185; right is the 12-inch KCS-177.

modular television was recently redesigned as an AC/DC portable (Fig. 1); the time for this project was substantially less than previously required —due mainly to the modular approach.

In addition, the availability of skilled troubleshooters to the consumer as well as to the factory is an obvious problem alleviated, to some degree, by the modular system. Factory rejects which, for some conventional production sets, could be measured in acre-feet are just as unacceptable as an out-of-service TV measured in time units of weeks by the consumer. In addition, the cost of a repair call resulting in a "shop job" and the cost of repairing instruments by the acre foot are both rather disturbing to the people involved.

Engineering

Design objectives

One design objective is to keep the number of connections to each module to an absolute minimum; a further objective is to avoid splitting up functions on different modules. For example, if the IF malfunctions, it should not be necessary to change three different modules to find out which one is defective. Economics and circuit limitations do not always permit completely separate functions for each module; however, this is attempted in so far as practical.

Complete interchangeability of any given module as well as standardization of modules between different instruments are additional objectives. The modules are designed as self-contained "black boxes" such that discrete-component, integrated-circuit, or ceramic-circuit technologies can be used interchangeably to perform the same function. This feature allows the rapid introduction of new technology as it becomes available.

Standardized, interchangable modules can also save many hours of valuable engineering time. Using traditional construction methods, identical IF circuits on printed boards having different form factors (to accommodate various kinescope sizes) have often resulted in considerable engineering effort. However with the modular concept, the same picture-IF module has already been used in three different televisions.

Design concept

The design objectives have been fulfilled by a system that uses prealigned, pretested, standardized black-box-type modules, with low-impedance input and output connections. The IF module is a good example. The input link circuit is designed such that no additional alignment or touch up is required, regardless of the tuner used. The output of the IF module is low-impedance video that can be fed to various functions on the mother board in a relatively noncritical manner. Thus, the IF module, as well as all other modules, are at least as interchangeable as standard nuts and bolts. The sound-IF module is another good example. Its input is 4.5 MHz, and its output is audio. This module, which contains a dual-in-line integrated circuit, is used in four different instruments and is planned for several others.

The video module provides a good example of the utilization of different technologies within one module without the necessity of retooling an entire instrument, or having to wait for a complete model changeover. This module can be manufactured with discrete components or ceramic circuits. The discrete and ceramic circuit versions would be completely interchangeable. The cost comparison of two different technologies can also be readily made. In addition, only the latest versions need to be stocked as replacements parts.

The 9-inch KCS 176, 12-inch KCS 177 and 9-inch KCS 185 all use identical tuners, picture IF-modules, sound-IF modules, and video modules. Nevertheless, the mother board in the KCS 185 is substantially different from previous instruments.

The instruments are designed such that only the low-failure-rate passive components are mounted on the mother board. All chassis transistors are on modules, or are mounted in sockets on heat sinks.

Many of these advances increase the material cost of the receiver. The connector development in black-and-white TV, for example, cost approximately one cent per contact. The total area of printed-circuit board material used in production increased slightly.

Merchandising

The modular approach offers several advantages to the merchandising activity. Existing modules can be used with new and different kinescopes or styling innovations. As mentioned previously, the use of existing modules also reduces the time required to introduce new models. Existing models can also be adapted to special uses if a special demand arises; whereas, conventionally built instruments, may not be adaptable for the quantities involved in an acceptable time span.

There are other interesting possibilities as modules are used in larger numbers of instruments. If the total annual market could be predicted more accurately than the market for specific models, the factory could be scheduled to build the total module requirements without regard to specific models. The sales plan could be flexible enough to increase or decrease various individual models with a constant supply of common modules. Further, if too many modules were built in any one model year, they could be used in those future models that use the identical module or could be sold as replacement parts.

Manufacturing

Each time a new model is started in the factory, there is some loss in production before the line can be operated at rate. The number of rejects is usually higher during start up than after a line has been running. The first instrument to use the modular approach had a minimum of start up and reject problems compared to conventionally designed instruments.

Let us assume that cold solder joints, broken and defective parts, etc. are uniformly distributed throughout an instrument. One defect in a conventionally built instrument necessitates the entire instrument being sent for troubleshooting; production decreases and reject stores increase. However, defective modules can be easily replaced. The flexibility of changing modules can be shown statistically (and in practice) to put more instruments in finished goods—with a given reject rate. Faults are not uniformly distributed throughout an instrument, but the illustration is valid.

Also, a defect in the IF or tuner section in a conventionally built instrument requires considerable effort and expense to repair, if the defect occurs late in the production cycle. In a modular receiver, a tuner or IF module can be replaced without the necessity of sending the entire instrument to the alignment position a second time. In addition, a defect in a module is easier and less costly to repair than the same defect in an assembled instrument.

Progressive alignment is one of the efficient methods of aligning television receivers in mass production. This technique requires an operator to connect an assortment of leads to each instrument as it progresses down a conveyer line. After the leads are connected, the operator aligns the instrument and then removes the assortment of required leads. An appreciable time of the entire procedure is consumed in connecting and disconnecting leads. A socket performs the connections in a module, with the consequent savings in time.

The amount of skill required to repair a module is an important consideration in the factory. The number of parts on a module is relatively small. A troubleshooter learns the possible faults rather rapidly and can accurately diagnose the defect. The same defect in an instrument, as a practical matter, is more difficult to diagnose and repair, due to the interaction with other circuits and the sheer number of parts in a complete instrument. Also, modules isolate faults to a particular area in the manufacturing process. A specific example could be a blank raster on a newly-wired television instrument caused by an open IF coil. In a conventionally built instrument, the same kinescope appearance could be caused by the tuner, AGC circuit, power supply, or video amplifier. The same fault in a module just wired is already confined to the module under test.

Testing

The investment in factory test equipment is another consideration. Automation of a modular approach versus automatic testing and assembly of a conventionally built instrument must be considered. The entire subject of automation is too complex to go into detail in this article. However, experience has indicated there is less need for expensive test instrumentation in the modular instrument.

Warranty

Warranty includes labor as well as parts for certain time periods. The expense of replacing a soldered-in component in a repair shop is considerable. The most expensive module for black-and-white receivers can be discarded at a lower cost than would be required if a single carbon resistor were to be replaced in a service shop. Modules are as easily replaced as a tube in most instances. Also, the risks of damaging other parts in a repair shop is less when plugging in a replacement module.

Serviceability

A large user of television receivers such as a school or motel could keep several spare modules on hand for rapid service. The ability of a serviceman or dealer to replace modules without the use of test equipment is a major advantage. Considering the expense of time and skill, the advantage of area troubleshooting with modules as opposed to exact part trouble shooting should be obvious.

The possibility of a "drug store" type module tester can be considered as modules are more widely used. The serviceman or service center then need only stock the latest version of a particular module.

The consumer

The consumer desires quick service. Replacement of a plug-in module is a very rapid means of effecting a repair. The consumer who can replace tubes can also replace modules.

Summary

The "black box" concept of plug-in, pre-aligned, and pretested modular functions in consumer products has demonstrated its usefulness as well as considerable promise for the future. Actually, this concept has been applied in several RCA black-and-white television receivers in production over the past year. Factory construction experience on similar models (built conventionally and with modules) demonstrates the validity of the factory cost assumptions. Although the concept may be improved with additional engineering development, the present marketing flexibility inherent in this concept is extensive.

Design trends in solid-state black-and-white television

J. C. Peer

The design of all-solid-state black-and-white receivers in recent years has been characterized by three major trends: 1) the modular concept, 2) greater emphasis on reliability and safety, and 3) development of two basic chassis types. These design approaches, coupled with several significant circuit innovations, have produced a new line of black-and-white sets that meet higher performance, safety, and reliability criteria and, at the same time, offer the consumer a wider range of model types and styles.

THE MARKETS for RCA solid-state black-and-white televisions have been expanding rapidly in recent years. One of the necessary ingredients of this success has been a new engineering design approach, which is characterized by three major trends:

1) Applications of the module concept,
2) Greater emphasis on set reliability and safety, and
3) Evolution of a basic large-screen chassis and a basic small-screen chassis.

In addition, these major trends which affect the whole chassis design, there are noteworthy individual circuit design trends, including:

1) Added tuner complexity with "compatible UHF and VHF tuning ease,
2) High-performance video-IF integrated circuit.
3) Improved vertical circuit,
4) Improved horizontal oscillator, and
5) Solid-state high-voltage rectifiers in all sets.

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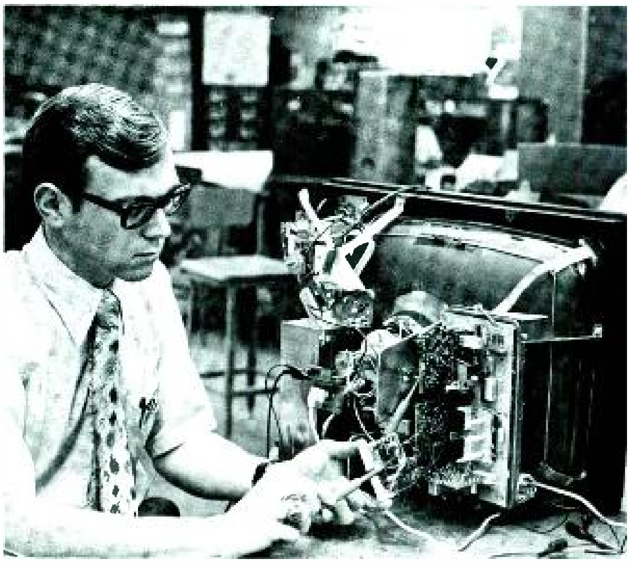
received the BSEE in June 1967 and the MSEE in January 1971 from Purdue University. Since then, he has worked in the black-and-white TV Engineering group at the Consumer Electronics Division. His main work has been in sold-state design.



Modular concept

The basic idea of the modular concept is to build each major circuit function on a small separate plug-in module. An entire set consists of five or six replaceable modules which plug into sockets on the main or "mother" printed-circuit board. The small added cost of sockets and extra printed-circuit board material is well offset by the advantages of: 1) easier factory troubleshooting and fewer line rejects, 2) faster repair in the field, 3) common modules used in several sets, and 4) added design flexibility. The module concept is described more fully in another paper in this issue.[1]

The block diagram in Fig 1 shows how extensively modules are used in our KCS-185 solid-state nine-inch instrument. All six modules are independent of each other and the mother board. Any module may be replaced in the field or the factory in a matter of minutes, with no alignment necessary except adjustment of a few customer controls. In our large-screen sets, only five modules are currently planned because the audio output circuitry is too small to warrant a separate module.

Reliability and safety

Naturally reliability and safety of all our consumer products are very important. All new solid-state black-and-white instruments carry a one-year warranty on both parts and labor, and every effort is being made to continue to produce the most reliable instruments in the field. In addition, special emphasis is placed to safety-related aspects of the design to help insure dependable performance. As always,

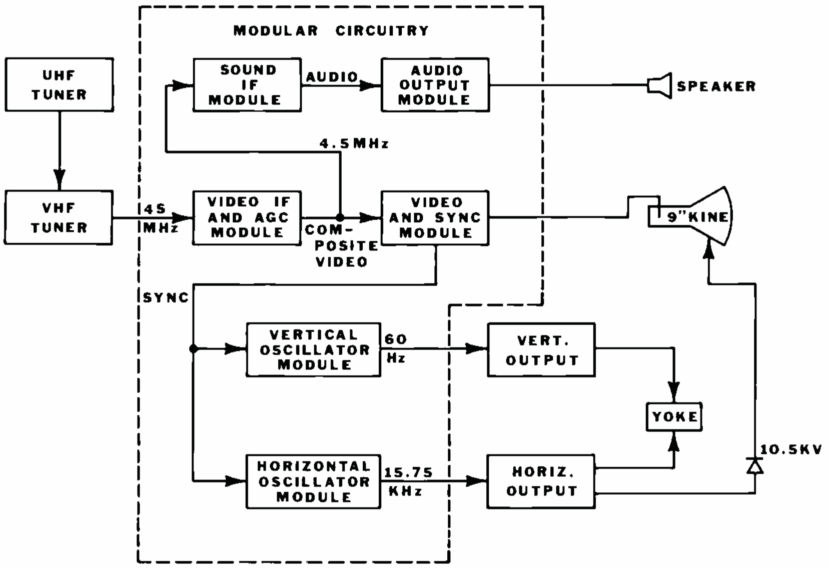


Fig. 1—KCS-185 modular chassis.

the circuit designs are made as conservative as possible consistent with stringent performance standards and reasonable cost. Given a conservative design in which a transistor is well within its safe operating area, the solid-state device should outlast most passive components. Consequently, more emphasis is being placed on the reliability of some passive components, such as capacitors and switches which must withstand heavy stresses every time the instrument is turned on. In addition to carefully studying the reliability of individual components, considerable effort is being expended in examining the instrument as a system to remove safety hazards that might occur as a result of catastrophic failure of any single component.

Safe x-ray radiation levels of the instrument are also important. The replacement of tube high voltage rectifiers with solid-state devices has eliminated one source of x-ray radiation. To further insure that this radiation remains at safe levels, limiting circuits are being used to insure that high voltage remains at predetermined levels even if there is a catastrophic failure in horizontal output circuitry. Kinescope arcover presents a special reliability problem in solid-state sets because of the susceptibility of transistors to voltage and current transients. The circuitry in our solid state instruments is designed to withstand higher voltage arcs than the set can possibly generate.

Two basic chassis

Another design trend is the evolution of a basic chassis for 16-, 19-, and 21-inch sets and another basic chassis for 7- and 9-inch sets with overlap in the 12-inch screen size. The main determining factor here is power.

In the large-screen sets, economics require a transformless "off the line" power supply providing a B+ of 140 volts DC. The audio, video, and horizontal output stages operate from 140 volts; the vertical output requires from 15 to 25 volts; and the small-signal circuits use 12 volts. In these "off the line" sets, the low-voltage supplies are conveniently derived from the flyback transformer which reduces power dissipation and makes power-supply filtering easier. Of course, the 140-volt supply became practical with the development of 1400-volt horizontal output transistors.

The advantages of transformerless "off the line" operation disappear in small-screen sets because the power and high voltage requirements are lower. These sets can be run with a 12-volt supply from a power transformer. By adding a power-supply regulator, AC/DC operation (as well as constant picture size) can be offered. The audio, vertical, and horizontal output stages use the regulated 12-volt supply, but the video output still requires a 100- to 150-volt supply derived from the flyback transformer.

Most of the small-signal circuitry is common to both large and small sets. The video-IF, sound IF, and video-output modules are already used in several sets including hybrid chassis. The particular small-signal module used is mainly determined by performance requirements and not chassis size.

Our design goal, especially in the large-screen chassis, is to develop a "standard" mother board and a flexible set of modules that can be packaged into several cabinet styles and with several screen sizes. Performance can be tailored for the exact screen size and desired specifications by varying the modules and using different components and/or printed circuit patterns on the same mother board. Hopefully, this goal will increase standardization and decrease design time for new sets.

Individual circuit trends

Added tuner complexity with "compatible UHF and VHF ease"

Present transistorized VHF tuners generally have four tuned circuits with a common-base or common-emitter RF input stage and with a cascode mixer. Most UHF tuners use a passive tuned input circuit with a transistor oscillator and diode mixer. During UHF reception, the VHF tuner doubles as an IF amplifier.

The recent F.C.C. requirement to provide compatible tuning ease for both UHF and VHF reception will change the present system of detented-VHF and continuous-UHF tuning. Either more complex mechanical displays will be used with the present transistor tuners to provide detented tuning on both UHF and VHF reception or varactor tuners will be employed for continuous tuning through the UHF and both the VHF bands.

Undoubtedly, both systems will be tried. The transistor tuners have proven themselves in the field, but their mechanical switching requires mounting directly behind the tuning controls which is usually near the front of the cabinet. The varactor tuners, although more expensive, allow more styling flexibility because they require only a control voltage and, therefore, can be mounted away from the tuning controls.

High performance video-IF integrated circuit

RCA's video-IF integrated circuit is scheduled for our new 19-inch solid-state instrument. The inclusion of the AGC circuitry in the chip itself helped make this circuit economical for black-and-white television. This chip is used in RCA deluxe models now, and, eventually, will appear in all solid-state instruments. This chip's advantages and design problems are described in another paper in this issue.[2]

Improved vertical circuit

An inherently linear vertical amplifier circuit has been developed and is currently used in the CTC 40-color receiver and all solid-state black-and-white instruments. Fig 2 is the basic block diagram. The vertical oscillator is a switch controlling the class-A DC amplifier. The amplifier is connected as a Miller integrater by C1, which samples the yoke's sawtooth current. The large AC feedback through C1 insures a good current sawtooth. With S-shaping added in the feedback loop, linearity of 2% or better is obtainable which has allowed elimination of the vertical linearity control. However, it is the linearity clamp transistor which makes the circuit practical by quickly biasing the amplifier into linear operation as soon as the vertical trace begins. Once the amplifier is in class-A operation, the linearity is insured.

Another advantage of this closed-loop system is its immunity to component variations. This repeatability is ideal for mass production and does not require tight components tolerances.

Improved horizontal oscillator..

Another design innovation is the improved horizontal oscillator using just one capacitor and no coils (refer to the block diagram in Fig. 3). The output of the differential amplifier controls the two states of transistor switch Q1. In one state, the switch presents a high trip voltage to input 2 of the differential amplifier and charges C1 toward B+. In the other state, switch Q1 presents a low trip voltage at input 2 and discharges C1 toward ground. Assume the first state of switch Q1. When the differential amplifier senses that C1 has charged to the high trip point, the amplifier actuates switch Q1. Now Q1 starts discharging, and the low-trip-point, voltage is applied to input 2. When C1 discharges to the low trip point, the differential amplifier flips switch Q1 back to its original state to repeat the cycle. Automatic frequency control (AFC) is added by varying the low trip point.

The differential amplifier and a few inexpensive glass resistors provide good frequency stability with temperature and supply voltage variations. The oscillator's self-starting characteristic is inherent, and its horizontal hold control is a simple potentiometer. By contrast, the previous multivibrator oscillator required a separate starting circuit as well as a thermistor and sinewave horizontal hold coil for frequency stability. However, the sinewave coil also introduced bothersome magnetic pick-up problems.

Thus, at about the same cost as the old circuit, the improved oscillator provides good stability, no starting circuit, and no magnetic pick-up problems. In addition, the new circuit can more readily be built as a ceramic or integrated circuit in the future.

Solid-state high voltage rectifier in all sets

Over the last several years, more reliable selenium and silicon high voltage rectifiers have been marketed at more favorable prices. They are now used in all solid-state sets as well as most tube chassis.

One arc of a tube-type high-voltage rectifier in a solid-state set will destroy the horizontal output transistor on the primary of the flyback transformer. Thus, tube rectifiers require elaborate protection circuitry. The solid-state high-voltage rectifiers do not have this problem.

Solid-state high-voltage doublers and triplers are also available now. The use of these devices requires less high voltage from the flyback transformer which allows smaller and less expensive flybacks. Assuming the doublers and triplers are reliable, they will probably be used in black-and-white televisions when they become cost competitive with the larger flyback-type single-stack rectifier combination now in use.

Conclusion

RCA is marketing more solid-state black-and-white sets. By broad application of the modular concept and greater emphasis on reliability and safety, RCA will quickly establish a reputation for reliable operation and quick repair in all their solid-state instruments. The use of modular construction and two basic chassis should reduce manufacturing problems. There is a continuous engineering effort to improve the performance and/or cost of individual circuits. As improvements are developed, the modular concept will enable us to more quickly design the new circuits into our production solid-state instruments.

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1. Thomas, L. P., "A Modular System for Consumer Electronics," *this issue.*
2. Muttcrspaugh, M. W., "Modular video IF systems for monochrome TV," *this issue.*

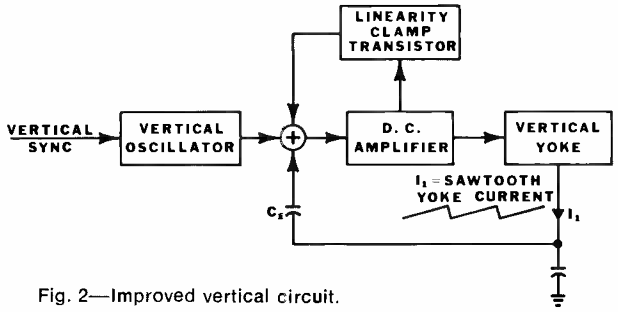

Fig. 2—Improved vertical circuit.

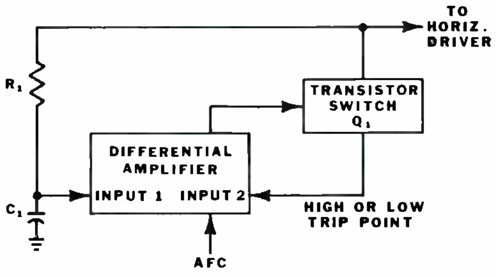

Fig. 3—Improved horizontal oscillator.

Modular video-IF systems for monochrome TV

M. W. Muterspaugh

The advantages of modular construction in consumer electronic products have been discussed in several papers in this issue.[1] The design of the IF module presented in this paper illustrates these advantages. The module, which uses the RCA type CA3068 integrated circuit,[2] is currently being used on several black-and-white television receivers produced by the Consumer Electronics Division.

Most hybrid and solid-state black-and-white television sets built by RCA use modular construction. Pre-aligned and pretested modules have reduced production troubleshooting and simplified field servicing. Integrated circuits are naturally adaptable to such construction. At present, all modular chassis use a common sound module encompassing a 4.5-MHz IF strip, discriminator, and audio preamplifier in a single RCA integrated circuit. A new RCA integrated circuit, presently in production, is being used in a video-IF module which includes a high-gain 45-MHz IF amplifier, gated-ACC system, video driver, and separate 4.5-MHz sound takeoff amplifier.

Design Goals

Interchangability

Factory production and field servicing both benefit if modules are interchangeable without realignment and, preferably, without readjustment. The tuner provides a double-tuned transformer output matched to a 75-ohm link cable. The IF strip must then provide a good wideband match to this cable, or any mismatch will detune the tuner output transformer. The tuner and IF module alignment must be held to close tolerance since errors will not be corrected by an overall instrument alignment.

Few adjustments

Elimination of excessive alignment adjustments saves labor as well as parts cost. In a discrete system, an extra tuned circuit is usually required. The first stage must be broadband due to impedance changes and detuning when automatic gain control (AGC) is applied. Double-tuned circuits are usually difficult to align when only a minimum number of devices is used and each must be coupled for maximum gain. In designing the IC, extra stages can be included to produce high gain and high impedance to minimize loading of the filter circuits.

Adaptable to several models

It is advantageous to use the same module in several chassis, saving tooling and production setup time. Since the same basic integrated circuit is also used for RCA color, similar savings are realized in the production of the integrated circuit itself.

Portability

It is desirable to use a 12-volt supply and provide means of regulating this supply. Thus, the module can be used with a battery pack in a small set.

Size and number of external components

Small size is necessary in a nine-inch set and often helpful in a larger one. However, complex coils or transformers can offset the size advantage of the integrated circuit. It must use small, easily produced, external components

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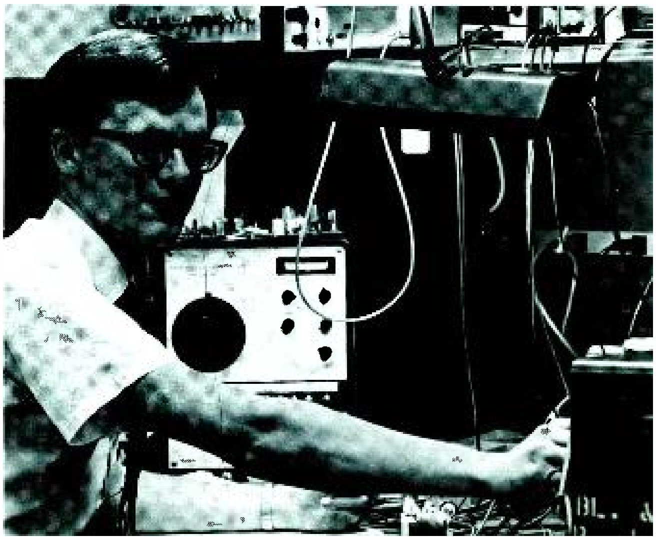


—and as few of these components as possible.

Interference protection

Harmonics generated in the IF and video detector can cause interference on Channels 6 and 8. All 45-MHz currents must be well isolated to prevent interference on UHF channels.

Cost

Cost is always a major consideration in the highly competitive industry that television has become. Cost savings can be realized in several ways. The integrated circuit must incorporate several related functions and not merely the high-frequency IF devices. For example, the AGC system for a solid-state IF strip is costly requiring three to four transistors. A video driver can be included to drive the high power output device directly. The 4.5-MHz sound must be derived without excessive amplitude modulation and of sufficient amplitude to feed the sound IF.

Design

The IF system shown in Fig. 1 was developed in response to these design goals. Specific design features are described in the paragraphs that follow.

Filters

The selectivity is provided in two sections: the input single-tuned circuit and trap, and the double-tuned interstage circuit.

A resistive pad is used to terminate the link cable and isolate the cable from the high-Q input circuit. The bridged-T trap circuit is used to give maximum attenuation to an adjacent-channel sound carrier that might be present. Precision components achieve a good null at 47.25 MHz without the use of extra nulling adjustments. The input coil is actually two coils: a small air-core spring, and a shielded adjustable coil. This circuit is nearly the equivalent of a tapped coil and provides the inductive load needed to minimize the effect of the trap on the passband. This configuration is realized using miniature, high-Q coils. The circuit Q is controlled by R_5 and the resistive input network to give a 3-dB bandwidth of 3.0 MHz, centered at 44.25 MHz. Losses in the input circuit are also adjusted to center the signal levels within the IF-AGC and dynamic ranges.

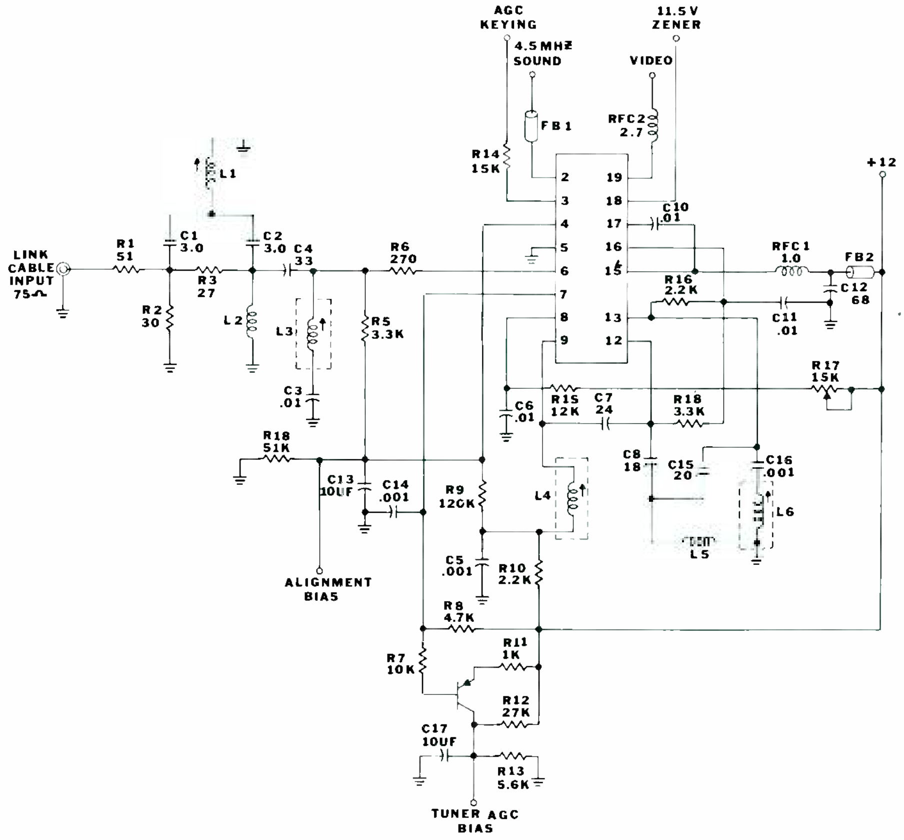


Fig. 1—IF amplifier schematic diagram.

The "T equivalent" circuit is used for interstage coupling to realize a precision, miniature double-tuned transformer. Magnetically coupled transformers at this frequency are difficult to manufacture and are physically large. The mutual element is an air-core spring winding which is accurately controlled by physical dimensions. In addition, this coil may be "knifed" to provide simple and effective coupling adjustment if needed. The circuit Q's are each set at 21 and are controlled by R16 and R18 which also feed bias for the broadband amplifier and sound channels, respectively. The ratio of C7 to C8 is adjusted to drive the sound channel with a proper signal level. The spring coil is then set for critical coupling producing a 3.0-MHz bandwidth. This is not the optimum Butterworth filter but is chosen to give proper relationships of the various IF signals. Picture carrier at 45.75 MHz is set at 50% (depending on the fine tuning) to give proper reception of the vestigial sideband. Color subcarrier at 42.17 MHz is placed low on the response since the resulting beat frequencies with 45.75 MHz and 41.25 MHz can produce annoying patterns on the screen. Sound at 41.25 MHz is placed fairly low, between 5 and 10%, to produce an adequate sound-IF signal at 4.5 MHz (the heterodyne of 45.75 and 41.25 MHz) and yet keep intermodulation low. In addition, there is a printed "gimmick" capacitor between the interstage and input circuit. This provides a controlled regeneration at maximum gain, causing the double-tune to broaden and enhance picture and sound carriers at very weak signal levels. Overall sensitivity of the IF is approximately 150μV for full video output.

In general, each section of the filter is being used to best advantage since extra components inside the integrated circuit serve to isolate the tuned circuits from the stages that have AGC applied.

AGC system

The AGC system is almost completely contained in the integrated circuit. A single transistor is used externally to supply AGC voltage to the tuner RF stage, and this may be included in later versions of the IC. The keying pulse

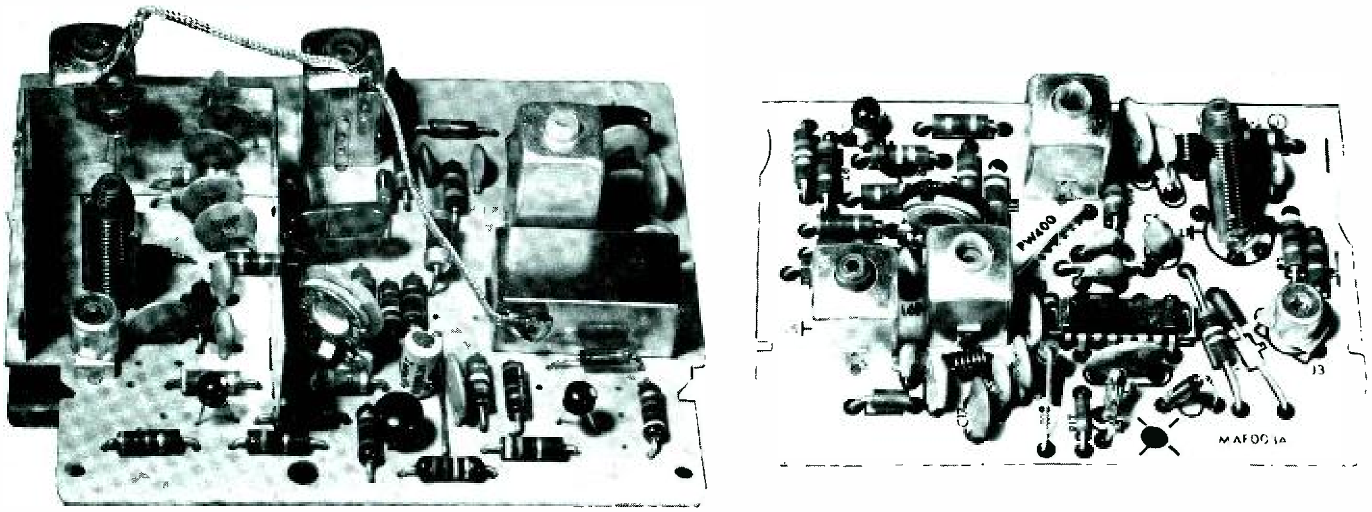


Fig. 2—Integrated-circuit and discrete-component IF-amplifier modules. Note the size reduction with the integrated version.

is fed in through a series resistance, the current controlling the amount of keyed-AGC versus average AGC. Time constants are externally variable by C13 and C17. Noise immunity is good, and airplane flutter rejection is excellent. The integration of the AGC function is a real cost savings since discrete systems use three to four transistors, precision components, and often a threshold control for the AGC gate. A delay or "noise" control is still necessary to adjust the ratio of AGC attenuation between the tuner and IF strip, but this can be set during alignment in a test fixture and need not be made in each individual instrument.

Other features

The video output signal is high (7 volts peak-to-peak) at a low impedance suitable for driving the output device directly. This has also eliminated the video bias control.

The sound channel provides a 4.5-MHz output suitable for use with the integrated circuit sound module in present use. The separate detector and amplifier help prevent intermodulation beats with the color subcarrier and excessive AM modulation of the 4.5-MHz sound carrier. This is especially important with the high-level video output and the relatively low supply voltage.

A zener diode reference is provided on a separate pin within the IC. A similar discrete component would be expensive.

Special considerations

As in any high gain system, the ground pattern and layout are very critical. Stray couplings and common ground impedances must be minimized in the printed board if stable operation and consistent results are to be obtained. The basing of the IC is very important.

Interference from the 45-MHz high-level signals and its harmonics is prevented by careful bypassing and filtering. A 2.7-μH choke, self-resonant at the fourth harmonic, is used in the video output lead. The sound output contains a ferrite bead. The B+ supply must be bypassed to give a low-impedance source for the video driver stages and also provide a great deal of high-frequency filtering. The 1.0-μH choke is made very lossy to prevent resonance with C10. A high frequency filter, especially for harmonics of 45 MHz, is made of the ferrite bead and C12.

The IC has advantages in this area in confining most harmonic currents to the small area of the chip and then shielding the IC package.

Conclusion

The size and component reduction of the integrated-circuit module compared to the discrete component module it replaces is shown in Fig. 2. The IC module has one less tuned interstage circuit, and the double-tuned interstage is more easily aligned. The video bias adjustment, which was on the instrument chassis, has been eliminated. The AGC gate circuit, which was on another module in the discrete system, has been included on the new IF module—producing size and cost reductions in several areas.

The integrated circuit has become a very practical device for television, especially when used with a modular chassis construction using prealignment and testing. The performance is first-rate at a cost of the most simple discrete-component system.

References

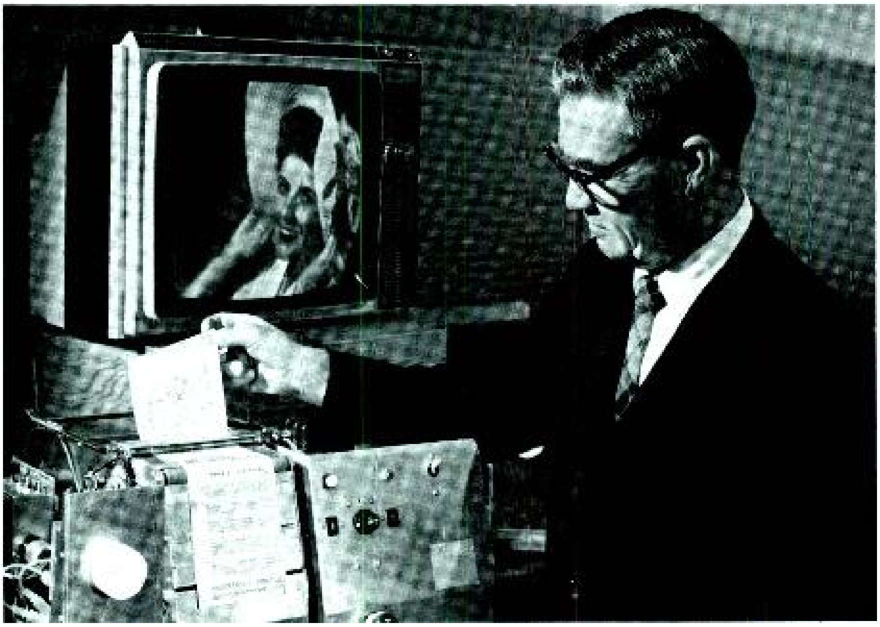
1. *See, for example,* Thomas, L. P., "A Modular System for Consumer Electronics," *in this issue.*
2. Harford, J. R., "Video-IF and AFT integrated circuits for television receivers," *this issue.*

Homefax—a consumer information system

W. D. Houghton

The Homefax concept of producing, in the home, printed copies of information coordinated with a particular television broadcast would undoubtedly enhance television programming services. So, to demonstrate the concept, RCA Laboratories has developed the various elements required for such a system, including an in-home-type electronic printer to produce panels of hard copy on Electrofax paper.

HOMEFAX, a new concept in home information services developed by the RCA Laboratories, utilizes existing television channels to provide additional information compatibly with, and in support of, regular television programming. In operation, separately identified panels of information are transmitted to the home for display either as still pictures on the TV screen or as printed copy from an electronic printer. To achieve compatibility with regular television programming, the Homefax signals are multiplexed into the vertical blanking interval of the standard television signal at a scan-line-per-field rate. Different panels of information are selected for display by the use of specially coded signals. For TV display, the received signals—which are stored as



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Final manuscript received June 1, 1970

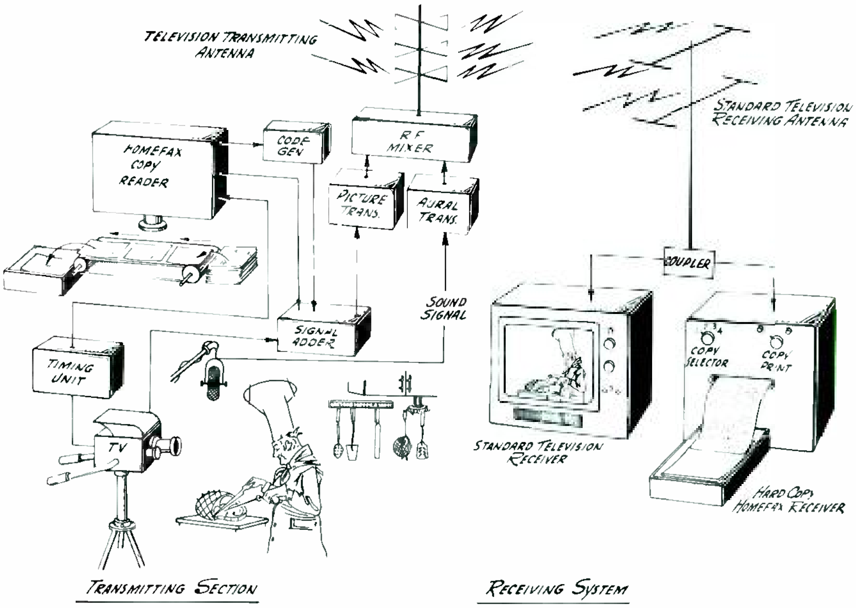

Fig. 1—Major components of a complete TV-coordinated Homefax system.

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RCA Laboratories
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has been associated with RCA for more than 30 years. Mr Houghton was instrumental in the development of time division multiplex systems for RCA communications and took an active part in the early research on the RCA compatible color television system. He headed a team that developed the first experimental video tape system to record color television signals for broadcast over a television station. Presently his group is engaged in research on home information systems. One of these systems is the subject of this paper. Mr. Houghton holds over forty U.S. patents in the fields of time division, color television, video tape recording, and communication systems. He has delivered papers at the National Convention of the IEEE on time division multiplex system research and has co-authored several papers on both time division multiplex and video tape recording systems. He also delivered a paper on Homefax at the 1970 Fall Technical Conference of the Society of Motion Picture and Television Engineers. Mr. Houghton is a member of the Princeton Section of the IEEE where he has held the positions of Treasurer, Vice Chairman, and Chairman, and he is active at the National IEEE Convention as a member of the Information Committee. He is also a member of the American Academy for the Advancement of Science and Sigma Xi.

complete TV frames in an electronic memory—are recalled repetitively at standard TV-field rates to form a video signal that represents a still picture. For hard copy, the received signals activate the Homefax electronic printer to produce panels of printed and graphic material built up at a scan-line-per-field rate.

Some examples of how these hard-copy panels could be coordinated with the television program are: athlete line-ups for reference during sports telecasts; cooking recipes produced during cooking programs; cut-outs or coloring sheets to accompany children's programs; and examination or homework sheets accompanying educational broadcasts.

Homefax concept

As a basis for the discussion that follows, consider a televised cooking program where the printed copy output is a series of recipes. As shown in Fig. 1, the television camera is focused on the chef, who is preparing a meal, while the copy-reading camera scans the various recipes passing in front of the lens. The scanning is accomplished in the same manner as in conventional television but the scan rate is one scan line for each frame of the televised picture. As the different recipes advance under the camera, a special code generator produces signals that identify their content. This identification signal permits the viewer to select any or all of the recipes being transmitted. A common timing unit synchronizes the code generator with the copy-reading camera to permit both the code and information signals to be multiplexed into the vertical blanking interval of the program signal produced by the studio camera. The composite signal consisting of the *program* plus the *code* plus the *information* is coupled to a standard television picture transmitter. A microphone and an aural transmitter, together with an RF signal mixer, completes the transmitting part of the system.

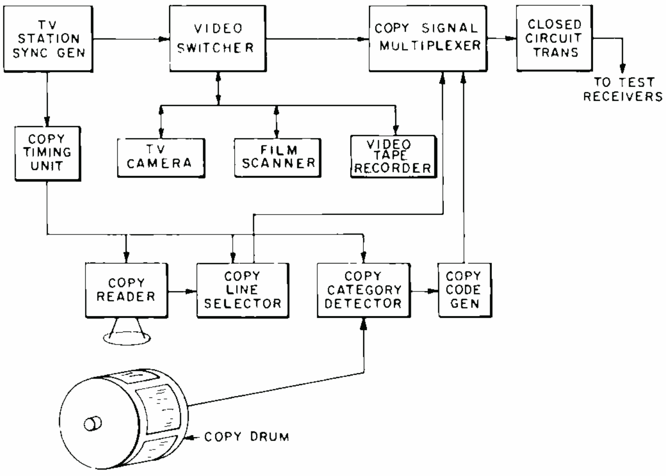


Fig. 3—Laboratory test terminal block diagram.

The received signals are applied to a television receiver and a Homefax receiver through a conventional multiset coupler from a standard TV antenna. The signals are compatible with both color and black-and-white television. Included in the Homefax receiver—besides the conventional RF, IF and video circuitry—are special code selecting networks and electronic controls for the fast-acting electronic printer.

VBI Homefax channel

To make the Homefax signals compatible with regular television program signals, so that the television network can provide a signal path into the home, the unused horizontal spaces that occur during the vertical blanking interval (VBI) of a television signal are used. As shown in Fig. 2, the first three spaces of the vertical blanking interval contain equalizing pulses, while the next three spaces contain the wide vertical synchronizing pulses. The following three synchronizing spaces contain another set of equalizing pulses. Thus, the first nine horizontal spaces in the vertical blanking interval are used for the vertical synchronizing, while the next eleven spaces contain no signal; some of these spaces are used for the transmission of Homefax information.

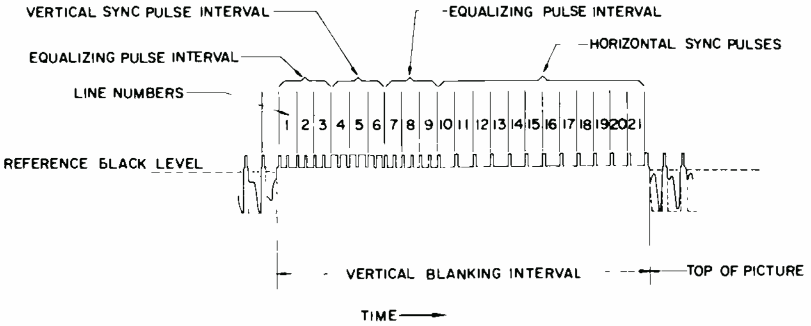


Fig. 2—Horizontal time spaces that comprise the vertical blanking interval.

These eleven spaces were provided in the original television signal specifications to allow the electron beam in the receiver picture tube to return to the top of the screen to start a new vertical scan.

Early TV sets used DC restoration techniques to maintain reduced return-scan-line visibility. However, since the visibility was a function of the background controls, and accurate settings were rarely obtained by the viewer, the modern trend in receiver design is to incorporate vertical-retrace-blanking circuits that bias the electron beam off while it is being deflected to the top of the screen. This type of vertical retrace blanking not only eliminates return-scan-line visibility, but it also makes possible the insertion of modulation in some of the spaces of the vertical blanking interval.

In the Homefax system described in this paper, one of the unused spaces in each vertical blanking interval is used as a communications channel to send successive television-type scan lines from the copy-reading camera. Thus, the added information is coupled to the home receiver at a scan-line-per-field rate over existing television distribution facilities.

When one VBI space in each field is used to carry one horizontal TV scan, then 360 complete 600-scan-line messages can be transmitted every hour.

If only three VBI spaces were used for Homefax signals, then over 1000 messages per hour could be transmitted along with the regular television program, and no additional video bandwidth, radio frequency spectrum, or transmission power is needed for the additional information.

Laboratory test system

Transmitting system

The signal generating and multiplexing equipment required to test the technical feasibility of the Homefax concept are shown in Fig. 3. The station sync generator, video switcher, film scanner, video-tape recorder, TV camera, and video tape recorder can be found in most well-equipped television program originating facilities. The copy timing unit, copy reader, copy drum, copy line selector, copy category detector, and copy code generator, together with the copy signal multiplexer, however, had to be developed for the laboratory system.

The copy timing unit is a modified RCA-TG-3 synchronizing pulse generator that locks in with the station sync generator through a phase-slipping network that permits the center scan lines in the odd and even fields to coincide with a particular space in the vertical blanking interval of the video signals produced by the primary program source.

The copy reader is a modified RCA TK-22 television camera that is focused on the copy fastened to a rotating drum. The copy drum was designed to accomodate two copy panels; a cam mechanism triggers the copy category detector to produce the appropriate copy identification signal in the code generator.

The rotational speed of the copy drum was made variable so that tests could be conducted to determine the optimum value. Nominally, the speed was adjusted so a complete copy panel could be scanned in ten seconds. Since the copy line selector selects only the center line of the video frame from the copy-reading camera, only the line appearing at the top of the drum (as it rotates in front of the lens) has to be in focus.

The copy code generator contains circuits that produce bursts of six different frequencies in two halves of a single VBI space, giving a total selection capability of 36 possible messages. In the laboratory system, a separate VBI space was used for the code to provide flexibility for the proposed tests. However, it is possible to produce a large-capacity code in the form of short bursts that precede the copy information in the same VBI space.

The selected lines from the copy selector together with the code from the code generator are multiplexed into the video signal from the video switcher by a special signal combiner network. The multiplexed signal is coupled to a standard closed-circuit transmitter for distribution to the television and Homefax receivers.

Laboratory Homefax receiver

The RF, IF, 2nd detector, video amplifier, sync separator, and horizontal deflection circuits in the Homefax receiver (Fig. 4) are basically the same as those in most standard television receivers. The copy code selector, the copy line gate, and the high-voltage generator, together with the thin-window cathode-ray tube, paper-transport mechanism and electrofax toning unit had to be developed.

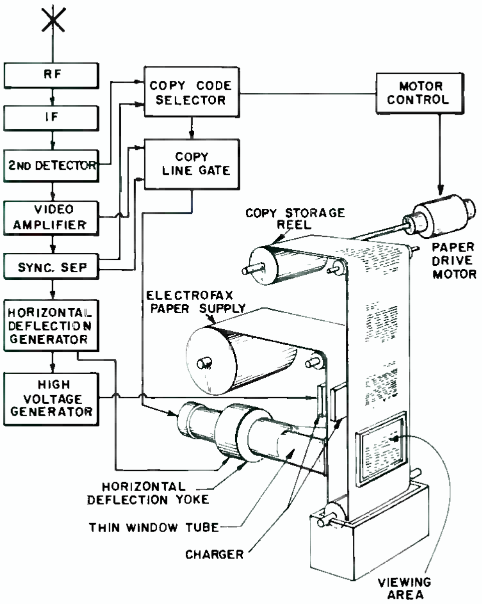


Fig. 4—Homefax receiver—block diagram.

In the stand-by condition, the RF, IF, 2nd detector, video amplifier, sync separator, and horizontal-deflection circuit are made operative. When the receiver is tuned to an active television channel, the video signal appears at the output of the video amplifier while the horizontal deflection locks to the received synchronizing pulses produced by the sync separator. The copy selector is preset to recognize a particular code. When this code appears in the appropriate VBI space in the received video, operational signals are coupled to the printer drive motor control and the copy-line gate. The drive motor moves the paper from the supply reel to the storage reel, and the copy-line gate connects the control electrode of the thin-window cathode ray tube to the information signal appearing in a predetermined space in the vertical blanking interval. Thus, when the code selector receives the proper code, the electron gun in the printing tube is connected to the copy signal for the duration of one horizontal scan for each successive blanking interval. The copy signal intensity

Bob Sanford of RCA Laboratories with author checking Homefax printers prior to Field tests.

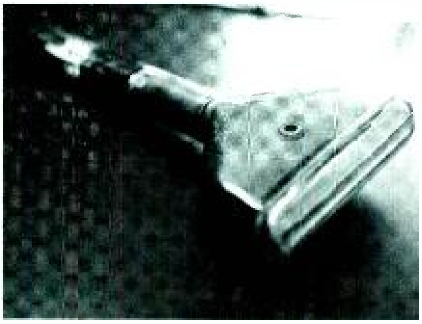


Fig. 5—Thin-window cathode ray tube.

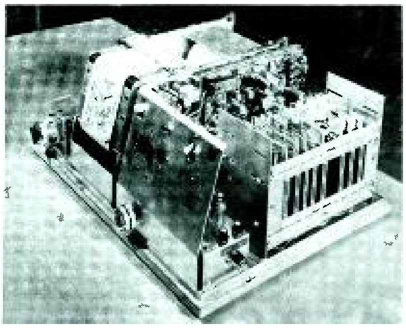


Fig. 6—Homefax receiver and electronic printer.

modulates the electron beam in the thin-window tube.

As the Electrofax paper is drawn from the supply reel to the storage reel, it passes first a charging unit that bathes the paper in an ion field, charging the zinc oxide surface to saturation. When the charged paper passes in front of the thin-window tube, the light from the phosphor screen discharges the zinc oxide coating in a pattern corresponding to the light variations. The "exposed" paper then passes through a liquid reversal toning unit that deposits black toner particles in the areas that were discharged by the light. As the paper is drawn from the toning unit, the volatile toner carrier dries quickly leaving a permanent copy of the selected information on the Electrofax paper.

A viewing window permits immediate observation of the printed-copy panel as it passes onto the storage reel. When the complete message is transmitted, the code signal ceases, and the printer motor and copy-line gate in the receiver are automatically shut off, while the remainder of the circuitry returns to a stand-by condition awaiting the arrival of another preselected cole signal in the chosen VBI space.

Thin-window cathode-ray tube

The thin-window cathode-ray tube, which exposes the Electrofax paper, was invented by Roger Olden,[1] a former member of the RCA Laboratories, now retired. Although the original metal-funnel tube, which used mica for the thin window, had the potential of exposing the Electrofax paper at the necessary scanning rates, further development was necessary to make it satisfactory for Homefax use. The required developments were:

Dennis Dorsey of RCA Laboratories at control point of field tests.

1) An all-glass tube containing a glass thin window to reduce the manufacturing costs;
2) A bulb design that would permit mass production;
3) A match between the spectral response of the Electrofax paper and the spectral characteristics of the thin-window tube phosphor; and
4) A controlled spot size that would permit resolving at least 100 lines per inch on a window 4 inches long and 1/10 inch wide.

A number of these tubes (Fig. 5) were produced by Electronic Components in Lancaster, Pa., for use in Homefax system tests.

System tests

By the mid 1960's, most of the units that required research and development were built, and a complete Homefax signal generating facility was set up in the laboratory. Also several experimental receivers (Fig. 6) were constructed to operate with the laboratory signal source.

For approximately one year, tests were conducted on the system, and modifications and improvements were incorporated to establish satisfactory operation. Since test results proved technical feasibility in a laboratory environment, plans were made to initiate a series of on-the-air tests, using the commercial television broadcast facilities of WNBC-TV in New York City, to obtain operational data.

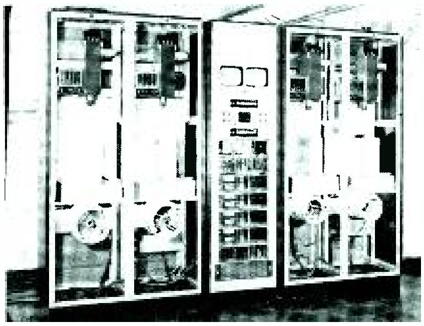
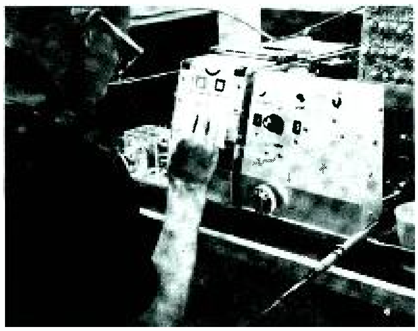


Fig. 7—Experimental Homefax terminal developed for NBC.



Bill Bruce (also of RCA Laboratories) recording information on received copy during field tests.

Before interconnecting with the television system at NBC, a more elaborate and ruggedized copy-reading and signal-multiplexing equipment had to be constructed. Fig. 7 shows the Homefax terminal that was constructed by the Broadcast group in Camden, New Jersey. This equipment contains four copy-reading cameras that scan eight copy panels to provide information signals for four VBI spaces. For test purposes, the identification code unit was designed to insert the codes in any one of the unused VBI spaces. Also included at the request of NBC operations personnel, was a remote switching capability that permits the equipment to be operated from the television master-control center. Another feature incorporated in the equipment is an automatic fail-safe arrangement that would completely remove the Homefax signals from the transmitted video should unlocked timing or any other malfunction occur.

Field test

The five racks of equipment were set up in a special room at NBC in the RCA Building in New York City, and video signals originating in one of the NBC studios were sent from the television master control to the Homefax unit, where code and information signals were added. The composite video signal from the Homefax signal adder was then sent back to TV master control over coax cables installed for this purpose. Since all signals were coupled through master control, NBC operating personnel had complete control of all signals being sent to the Channel 4 WNBC-TV television transmitter located in the Empire State Building.

Fig. 8—Homefax mobile unit ready for travel.

Twenty Homefax receivers were constructed at the Home Instruments Division in Indianapolis, Indiana, for distribution in the New York, Connecticut, Pennsylvania and New Jersey receiving locations.

A mobile receiving unit, shown in its ready-for-travel condition in Fig. 8, was constructed to provide flexibility in the choice of receiving sites. Fig. 9 is an interior view of the mobile unit showing the black-and-white television receiver, the color receiver, two Homefax receivers and an oscilloscope, plus miscellaneous test equipment. A telephone was included to provide communications to the Homefax test control center at RCA Laboratories in Princeton.

Fig. 10 is an exterior view of the mobile unit, setup to receive signals picked up by the rotatible television antenna atop the 40 foot telescoping mast.

Test results

A series of test transmissions were conducted from June 29, 1967 through November 3, 1967, with receiving locations at Farmingdale, L.I., Princeton, N.J., New York City, N.Y., Norwalk, Conn., Harrison, N.J., Lumberton, N.J., Langhorne, Pa., Asbury Park, N.J., Lakewood, N.J., Moorestown, N.J., Suffern, N.Y., Livingston, N.Y. and Kingston, N.Y. The Kingston tests included a CATV system to receive the distant signals from New York City.

Although these tests proved the technical feasibility of the system, they also exposed some areas needing innovation and improvement. Research is continuing on improved coding, synchronization systems, and electronic printers. As with any new idea, the problems determining whether or not a profitable business can be established are indeed complicated and are outside the scope of this paper.

Fig. 9—Interior of Homefax mobile unit.

Acknowledgements

The author acknowledges the assistance given by the following people: R. F. Sanford (RCA Laboratories) who developed the all glass thin window cathode ray tube together with L. Grove and D. Harsch (EC Lancaster); E. Giaimo, G. Lozier, and H. Wielicki (RCA Laboratories) who developed the reversal toning system for the printer; K. Bahrs, R. W. Bruce, C. Carroll, E. P. Cecelski, D. P. Dorsey, M. Leedom, S. Naroff and R. F. Sanford (RCA Laboratories) who developed the first laboratory printer and transmitting terminal; K. Lockhart (CES, Indianapolis), who was responsible for the construction of the field test printers; M. Forbes, W. Hingston, H. Wilson (CSD Camden), who were responsible for the construction of the transmitting equipment taken to NBC; R. E. Morey (RCA Laboratories), who was responsible for outfitting the mobile test unit; D. P. Dorsey (RCA Laboratories), who organized and carried out the field test series; and H. F. Olsen (RCA Laboratories), whose support throughout the entire project was most valuable.

In addition to the above, the author recognizes the assistance given by Arnold Hohl (RCA Service Company) and the various service company branch managers who made their facilities available to us during the field test series. Also to Lyn Thomas (RCA Laboratories), who organized and filed the vast amount of data obtained from the field tests.

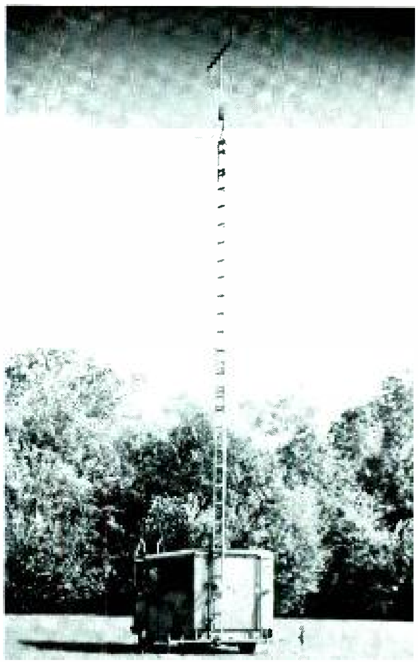
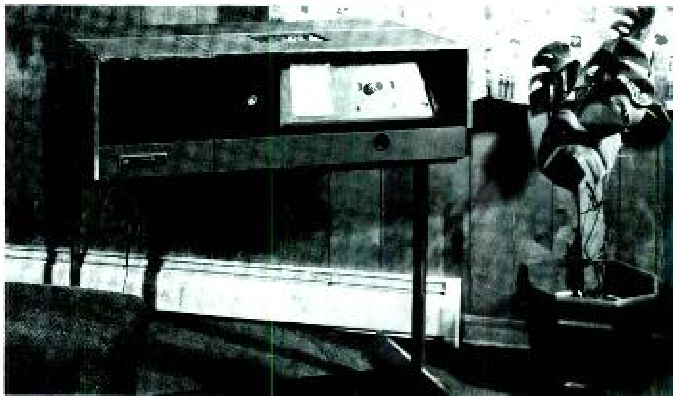


Fig. 10—Mobile unit in the antenna erected.

Reference

1. Olden, Roger, "The Role of the Mechanical Engineer at RCA Laboratories," Vol. 9, No. 6, *RCA Engineer* (April-May 1964).



Homefax printer in a sample "home-unit" with its companion 9-inch television receiver.

Single-vidicon color camera for home use

C. D. Boltz | J. H. Wharton

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

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

History

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

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

Color encoding system

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

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

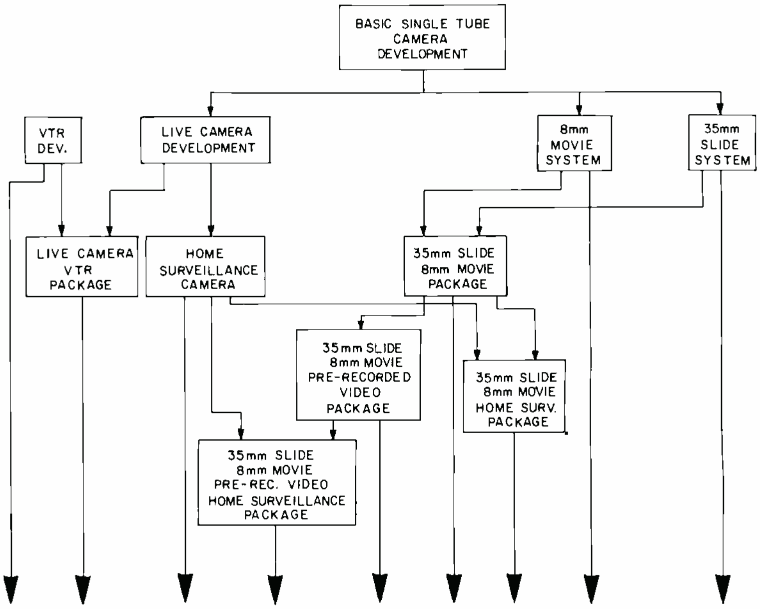


Fig. 1—Potential product evolution.

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

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

Developmental problems

It was recognized early that the color camera system being developed presented many unique problems. Two of the most significant problems previously mentioned are those of providing a completely automatic, "hands off" system and of providing the device at a selling price compatible with consumer products. The low price aspect of the development almost automatically ruled out any design which required the extensive use of high-quality optics. For this reason major emphasis was placed on the development of a vidicon with encoding stripes included as a built-in feature. This eliminates the need for optics of a quality necessary to image the high spatial frequency of the encoding filters on the vidicon photoconductor. Through the cooperative effort of Electronic Components at Lancaster, Pennsylvania, a program was initiated to develop appropriate filters and the techniques for fabricating them into the vidicon. This effort is discussed in greater detail in the section entitled "Spectraplex Development."

The extreme light sensitivity of the vidicon makes it possible, in principle, to provide a live color camera capable of operation in normal room light (approximately 50 lm/ft^2 scene illumination). It is desirable to preserve this feature. One problem which arises in this regard is the elimination of luminance-to-color crosstalk. As with NTSC, there are certain luminance signals within a scene which cause the color sensing circuits to respond since they do not know if a 3.5 MHz or a 5-MHz signal is actually caused by encoding filter action or by scene content. The most effective way of avoiding this problem is to slightly defocus the scene ahead of the encoding filters such that spatial frequencies equivalent to color carriers are attenuated. Because of picture vertical resolution requirements, it is desirable to defocus only in the horizontal plane. An astigmatic lens can be used for this purpose; however, for the consumer, it provides a focusing problem because there are now two points at which the image can be focused, only one of which is correct. A vertical grating of opaque and clear stripes which diffracts the light and effectively provides a "notch" spatial filter can also be used where ample scene illumination is available. It does, however, reduce

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

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

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

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

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

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

Colorimetry

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

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

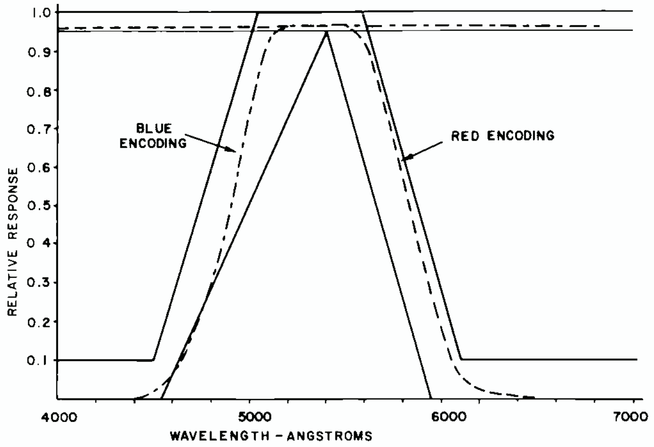

Fig. 2—Encoding filter spectral response.

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

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

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

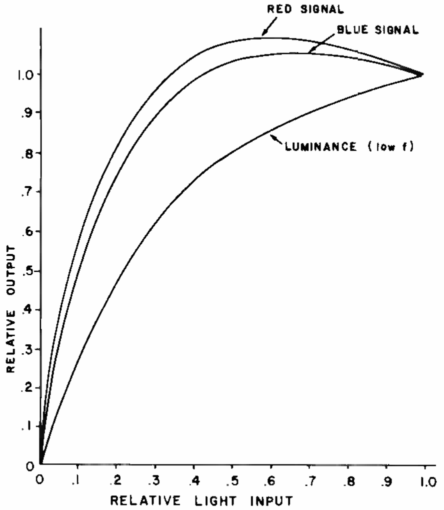

Fig. 3—Typical vidicon signal transfer characteristics as seen by camera encoding-decoding system.

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

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

It is the variation in gamma with luminance level that causes the greatest problem. Since the color signals are generated as increments of the vidicon transfer characteristic, the changing gamma causes a marked difference between the transfer characteristic of the color signals and the luminance signal. The solution to this problem was to cause the gain of the color channels to be controlled as a function of luminance. This solution provides a good grey-scale tracking and does not deteriorate color *S/N* ratio.

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

The input data for the program contains the following information:

1) The date of the particular run.
2) Description of the run.
3) Type of illuminant incident on the color bar slide and its spectral distribution.
4) Description of the color bar slide and the spectral transmission characteristic of each of the bars.
5) Vidicon data and its spectral response characteristic.
6) Red-encoding filter spectral transmission characteristic.
7) Blue-encoding filter spectral transmission characteristic.

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

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

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

Choice of camera tube

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

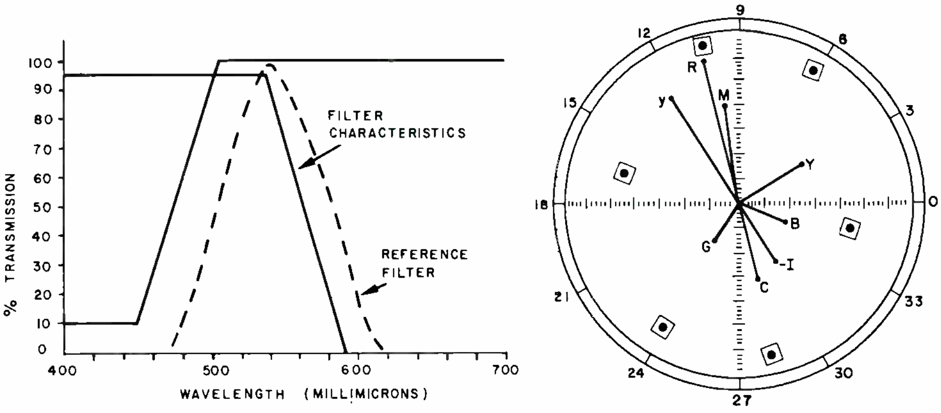

Fig. 4—Typical useful output information derived from a computer run. At left are the filter transmission characteristics; at right is a typical vectorscope display. Typical noise figures relative to base systems using the reference filter are: red S/N=+0.22dB; blue S/N=2.86dB; red crosstalk figure of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

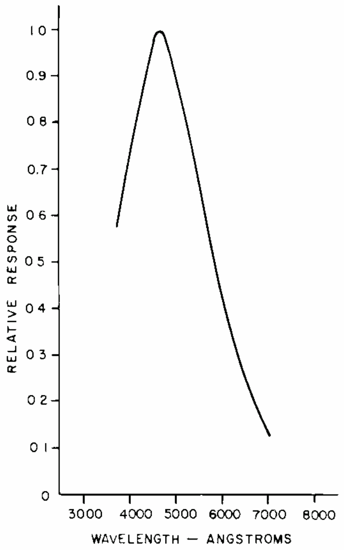

Fig. 5—Desirable vidicon spectral response.

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

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

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

Gamma correction

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

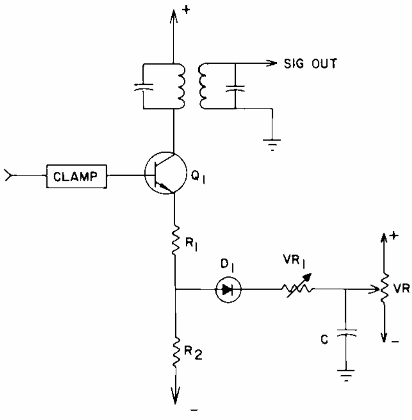

Fig. 6—Color gamma correction circuit.

Vidicon focus and deflection

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

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

For a home instrument, a low-cost solution to generation of the vidicon high voltage would be to use a flyback-type of high-voltage supply. To maintain focus, very good regulation of the vidicon electrode voltages is required. In addition, scan amplitude must be kept constant to maintain the carrier frequencies in the center of the passband; otherwise color smearing and even loss of carrier amplitude can result. Horizontal scan linearity also must be good, and it was decided that a total variation due to nonlinearities and scan amplitude changes of ±2% was probably acceptable. Coupled with this, the vidicon voltages must be controlled to better than ½%.

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

Otto Schade at the Harrison, N.J., plant showed us a vidicon focus and deflection assembly that solved the electron optic problems and would be most suitable for a striped filter camera. Unfortunately, the power requirements were too high for a home instrument.

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

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

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

Spectraplex development

Spectraplex was the name given by Lancaster to vidicons with integral-color stripe filters, with the goal being a low-cost color camera tube. Dichroic filters were initially made in two parts on very thin glass cemented together. The thickness of glass restricts the maximum lens opening. In fact, about one *f*-stop is required for each mil of glass between the filters. As we had the potential of a color camera that would make good pictures in much lower light levels than a movie camera, the *f*-stop restriction could only be a temporary measure. The second stage was the formation of an integral faceplate. The faceplate had first one dichroic deposited, then etched to produce stripes. This was followed by the other set of dichroic stripes, a conductive coating, and the photoconductor. There was a great deal of interchange between the materials processing group at Lancaster and Indianapolis with regard to these faceplates. Faceplates would be sent to us for evaluation at the dichroic filter stage, returned to Lancaster for application of the TIC coating, further evaluation here, back to Lancaster to have the photoconductor added and be made up into vidicons, which were again returned to us for test. Much new knowledge was gained from this cooperative process.

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

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

Signal-to-noise

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

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

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

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

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

Automatic target control

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

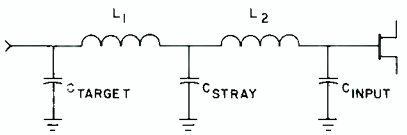

Fig. 7—Preamplifier input network.

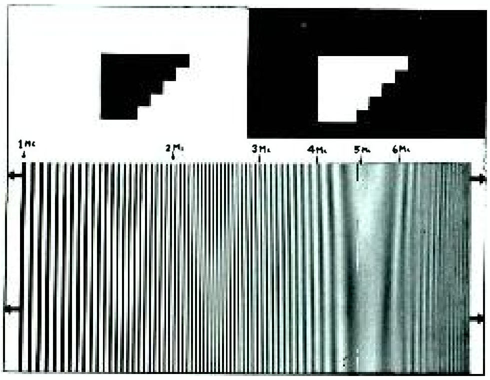

Fig. 8—Video sweep test chart.

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

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

Live camera

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

Slide and home movie player

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

Current status

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

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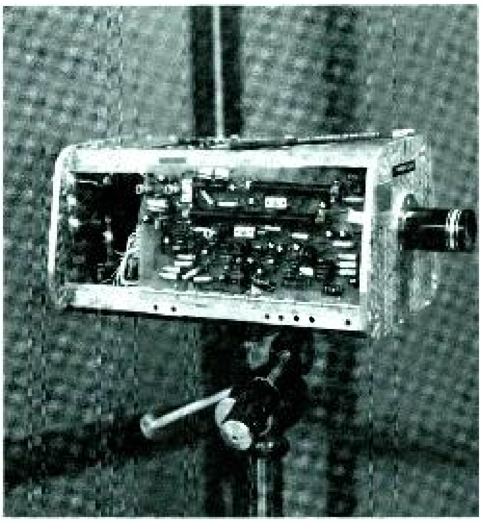


Fig. 9—Live camera prototype package.

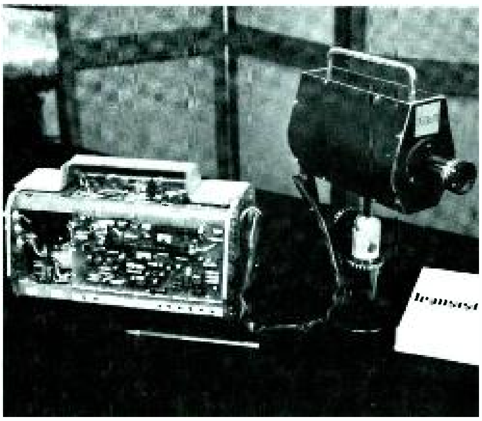


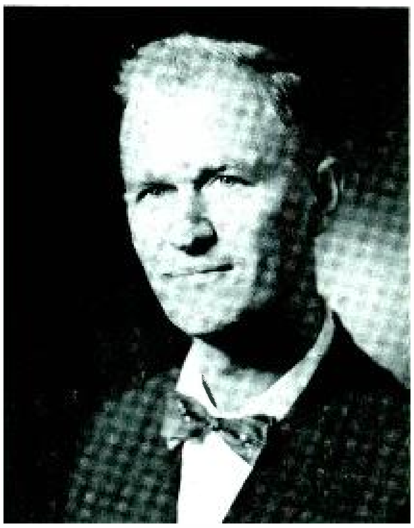
Fig. 10—Two package version.

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

Simplified video processing techniques

J. O. Schroeder | D. R. Patterson

The availability of modern semiconductor devices, including integrated circuits, makes it practical to achieve a high degree of simplification in the design of television circuitry for black-level setting and blanking insertion. In this paper, some generalized concepts of video processing are discussed, and illustrative circuits are shown using bipolar, MOSFET, and IC devices. An extremely simple video line/processing amplifier is described in detail to fully illustrate the principles involved in a practical situation.



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was first employed in Link Radio Corporation's Receiver/Transmitter Test Department from 1940 to 1944. During the next two years with the Navy, he served at the Naval Research Labs. in radio and radar system maintenance. Mr. Schroeder rejoined Link Radio as design engineer and later became project engineer in charge of mobile and fixed-station FM equipment. He designed and supervised the installation of what is believed to be the first 12-jump FM radio-repeater system, which extended from Santiago, Chile to Havana, Cuba. In 1950, he became Assistant Chief Engineer with Muzak's transcription studios, where he was instrumental in developing special electronic equipment for high-quality magnetic tape and disc master recordings. From 1951 to 1959, as Senior Design Engineer with the NBC Development Lab., Mr. Schroeder developed many original equipment designs for color TV broadcasting. From 1959 to 1961, he was Project Engineer with the Daven Company's Broadcast and Government Equipment section. After joining the David Sarnoff Research Center in 1961 as a Member of the Technical Staff, he was instrumental in developing circuitry for use in RCA's commercial line of FM-stereo receivers He received the 1962 David Sarnoff Outstanding Achievement Award for unique circuitry in this area. Later, he was active in work done on single-gun color TV systems. His current responsibilities include widely diversified pulse and video circuitry for infrared camera systems. Mr. Schroeder has been granted six U.S. patents covering novel circuitry for amplification, demodulation, and switching.

TODAY many different types of communications systems use various video processing techniques. Many of these are highly specialized, however, and this paper will only discuss processing as it relates to television video signals and, more specifically, the reinsertion of "black-level" after the signal has passed through amplifiers in which this component has been lost.

Outlined in this paper, are a few simple techniques for accomplishing the desired objectives, taking advantage of active components which are readily available today. All of these techniques are variations of the basic scheme which will be presented.

The old way

Not too many years ago, in the days of the vacuum tube, video processing was often accomplished by the typical circuit illustrated in Fig. 1a. There were variations on this circuit but, in general, circuits of this type were used for black-level setting and blanking insertion. In theory it performed well, but in practice its performance ranged from good to poor, depending on the stability of certain critical resistors, the quality of the diodes, and the stability of the plate current of the vacuum tube with age, heater voltage, and other variables. One obvious disadvantage of this classic approach is the presence of the diodes in the video signal path. To preserve linearity in the "black" portion of the video signal, it is necessary to make the plate load resistor, R, large so as to provide a "constant current" drive source for the diodes. As a result, the DC gain of

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attended Trenton Technical Institute in Trenton, New Jersey and received a diploma in Electronic Technology in 1962. He has completed three years at Drexel University in a continuing program leading to the BSEE. He joined RCA Laboratories in 1962 as a Research Technician in the Conversion Devices Laboratory where his duties included system design, mechanical packaging, and construction of special purpose television test equipment and closed-circuit camera systems. In 1969, Mr. Patterson joined the Semiconductor Device Research Laboratories of the RCA Laboratories with similar responsibilities.

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the pentode amplifier is very high and the circuit is susceptible to drifts in black level arising out of very small drifts in the potential(s) of the tube elements. Nevertheless, since vacuum tubes make relatively poor switches, there was no alternative to using diodes to do the switching.

The new way

Today, the designer has at his fingertips numerous active devices which would have staggered the imagination only a few short years ago. The availability of these devices makes it possible to accomplish the desired goals with precision and circuit simplicity.

All of the circuits to be discussed are based on the concept outlined in Fig. 1b. The raw input signal is fed to an emitter-follower or an IC amplifier with a high degree of overall negative feedback. Either one of these provides a building block which has high input impedance, low output impedance, and very stable DC output voltage. Depending upon whether artificial or true black-level insertion is to be achieved, the signal input may be either RC coupled as shown, or DC set through the use of a keyed clamp or DC restorer.

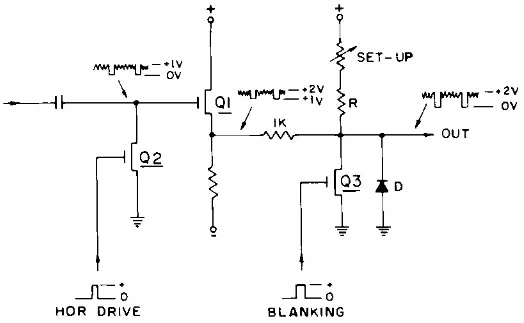


Fig. 2—Processing with MOSFETs.

The stable DC level upon which the video signal is riding at the output of the emitter-follower (or IC) is then shifted through the use of a simple resistor network so that this level is in the vicinity of + 2 volts. The output impedance of the circuit is raised to 1000 ohms with a series resistor, and a switch which is driven by the kinescope blanking pulse shorts the signal to ground during the blanking period. The output signal appears here with re-inserted DC levels as shown in Fig. 1b. Note that this simple scheme possesses the excellent linearity of the emitter-follower or IC negative feedback amplifier and the important further advantage that the output signal is firmly *shorted* to ground during the blanking period which corresponds to picture "black". No extraneous signals such as noise, deflection transients, clamp spikes, or the like can appear in the output during blanking time.

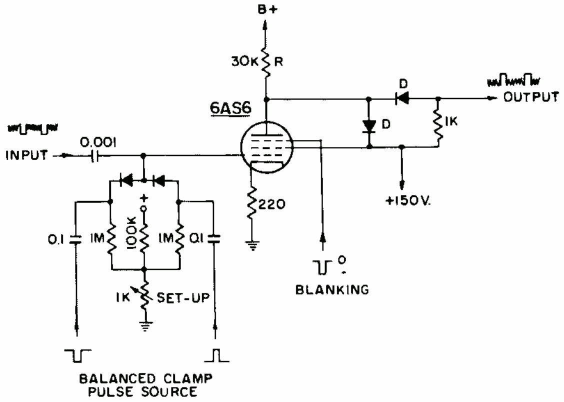


Fig. 1a—Typical vacuum tube circuit.

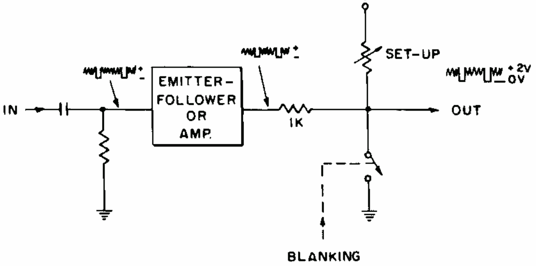


Fig. 1b—Simplified video processing concept.

Use of MOSFETS

Field effect transistors of either the insulated-gate or junction type lend themselves extremely well to the scheme outlined above, because of their high input resistance and their excellent switching capabilities.

Fig. 2 is an example of an extremely simple circuit which achieves true black-level reinsertion. The input signal is applied to the gate of source-follower, Q1, a depletion-mode device. Transistor Q2, an enhancement-mode device, performs the clamping function. During picture time, when the gate of Q2 is at ground potential, its source-drain resistance is extremely high. During the clamping interval the positive gate pulse causes the transistor to switch to its "on" condition and this resistance drops to about 100 ohms. Truely ideal clamping is achieved if the impedance of the input signal source is low.

The signal at the source of Q1 follows the gate input with a DC offset of about one volt, as indicated on Fig. 2. To achieve blanking insertion, this signal, with its black-level clamped at +1 volt, is applied to transistor Q3 through a 1000-ohm series resistor. Transistor Q3, like Q2, is an enhancement-mode switching type MOS which is "off" when its gate is at ground potential and switches to a very low resistance state when its gate is driven

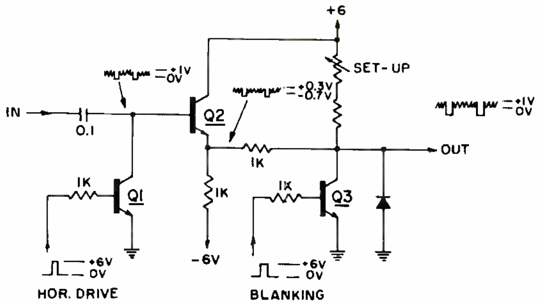
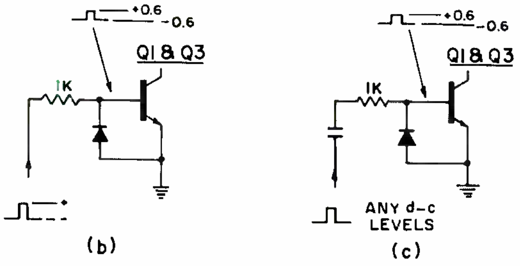


Fig. 3a—Processing with bipolar transistors.



Figs. 3b and 3c—Alternate pulse coupling schemes.

positive. This switching action results in the output signal shown on the drawing, where black-level is at ground and the "set-up" or pedestal upon which the white signal components ride is at a positive potential determined by the position of the set-up control. Since resistor R is large compared to 1000 ohms it causes negligible attenuation of the signal during picture time. The diode connected across Q3 prevents black spikes in the picture from "punching" below black-level. This could cause sync instability in conventional television systems. Ideally, the diode should be a germanium type so that these negative spikes are caught and limited at a few tenths of one volt below zero.

Use of bipolar transistors

Conventional bipolar transistors are also well suited for use with this processing scheme and a typical example is shown in the circuit of Fig. 3a. In general, it is quite similar to the MOS circuit shown and described above. A few points of difference are worthy of mention, however.

First, there will be some base current flowing in emitter-follower Q2 and this current will tend to change the charge on the input coupling capacitor during line time. To prevent clamp problems, it is necessary to observe the following precautions:

1) Use a high-beta, low-leakage transistor for Q2.
2) Use a larger value of input coupling capacitor, typically 0.1 μF for standard TV rates.
3) Use enough base drive into Q1 so that it behaves as an ideal zero-resistance switch during "on" time.
4) Drive Q2 from a very low impedance signal source.

If these rules are observed, the charge leak-off of the coupling capacitor will be minimized and easily restored by the low clamp switch and driving impedances. Of course, if true black-level reinsertion is not required, Q1 can be replaced by a 1000-ohm resistor. In this case, the input coupling capacitor is chosen to provide the required low-frequency response and the precautions mentioned above are not necessary.

Note also, that the use of bipolar transistors places certain restrictions on the input signal wave-shape. Typical black-and-white television signals are fine, but waveforms having information which extends both above and below "black" level can cause trouble if the negative excursion exceeds 0.6 volts. Since the base of the clamping transistor, Q1, is at ground potential during picture time, conduction will occur in the base-collector junction whenever the instantaneous collector voltage drops to a negative voltage which exceeds the contact potential, roughly −0.6 volts. This conduction will result in streaking and other undesirable effects in the picture. There is a simple way to avoid this difficulty, however, and this is shown in Fig. 3b. If the switching transistors, Q1 and Q3, are driven from a pulse source which swings both plus and minus, and clamp diodes are added from their bases to ground, the base voltage during the picture interval will be clamped at −0.6 volts. This means that the collector voltage has to drop to about −1.2 volts before unwanted conduction occurs. If two clamp diodes are used in series, a negative swing of −1.8 volts can be tolerated. As an alternative, the diodes may be omitted entirely if the base line of the driving pulse is firmly established at some negative potential, such as −3 volts, for example. This would allow the video to swing down to about −3.6 volts. However, care must be taken to see that the emitter-base reverse breakdown voltage is never approached during turn-on or under other transient conditions.

Still another possibility is the use of clamp diodes in conjunction with capacitive coupling from the pulse source to the base. This technique is illustrated in Fig. 3c.

Complete bipolar amplifier

An example of how the techniques discussed above were put to practical use is shown in Fig. 4. This processing amplifier, although originally designed for a rather specific purpose which called for "artificial" black-level insertion, has found widespread use for other applications because of its simplicity, versatility, and stable performance. If it is operated without drive pulses, it serves as a video line amplifier with a maximum gain of about 5, a bandwidth exceeding 6 MHz, and good linear output capabilities exceeding 1 volt peak-to-peak into 75 ohms. Either polarity of video input signal may be accommodated, as long as the output signal is "whites positive." Sync may be added to the output signal if it is applied to the sync input connector. Finally, if blanking pulses are applied to the blanking pulse input connector, black-level insertion is achieved.

An RCA CA-3001 integrated-circuit video amplifier is used as the input stage. Although no overall negative feedback is used, it possesses the DC output level stability and the low out-

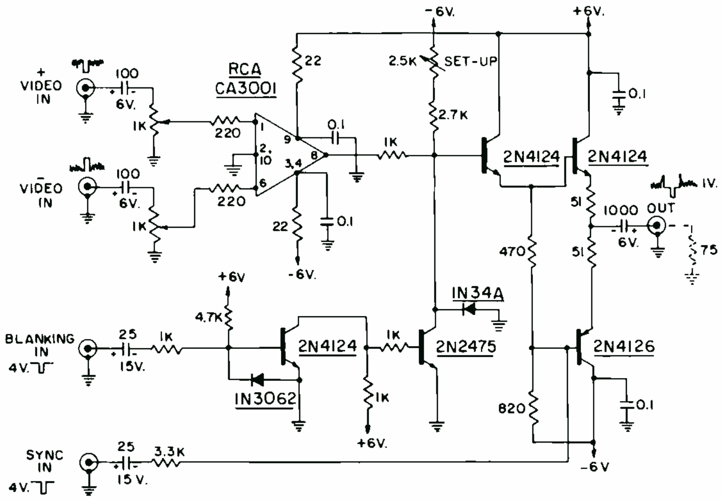


Fig. 4—Complete bipolar amplifier circuit.

put impedance desired. The actual DC level at the output of the IC (pin 8) is about + 2.7 volts. This level is shifted downward to about +1 volt by the 1000-ohm output resistor and the 2.7-kilohm resistor and set-up potentiometer which are returned to the minus supply. The input blanking pulse, which is negative 4 volts according to convention, is inverted and limited by the 2N4124 pulse input transistor. It is then applied to the 2N2475 switching transistor which shorts the signal at its collector to ground during the blanking interval, providing the pedestal.

The processed signal is fed to a pair of complementary emitter-follower output transistors through an emitter-follower driver stage to provide the 75-ohm drive capability with good linearity and frequency response. Composite sync is added to the video signal at the base of the 2N4126 output transistor. If a potentiometer is used to terminate the sync pulse input connector the amplitude of added sync may be varied from zero to whatever maximum limit may be desired, as determined by the value of the 3.3-hilohm limit resistor. The amplifier draws about 30 mA from a supply of plus and minus 6 volts.

One big virtue of an "artificial" black-level system such as this one is that clamp streaking and noise intermodulation effects are completely absent, even with raw input video which contains large-amplitude extraneous signals in the blanking interval and/or a large white pedestal upon which is superimposed a low-amplitude picture signal. This is illustrated by the oscillogram shown in Fig. 5a. The input to the amplifier consisted of a 100kHz sine wave running continuously. Standard television sync and blanking pulses were applied to the pulse input connectors. The photo shows the excellent switching capabilities of the system and its ability to provide a perfectly clean blanking interval, without chewing up the desired signal component, even though the input signal contains large-amplitude excursions during the blanking interval. This capability is useful in certain tyes of television systems which do not produce the ideal "textbook" video signal waveforms that one would like to present to the processing amplifier.

The remaining oscillograms in Fig. 5 show the output of the amplifier under typical television signal conditions, the input signal consisting of the raw video from a vidicon camera preamplifier. The "glitches" which are present in Figure 5e are not caused by the processing amplifier. They were present on the incoming sync signal, the only one available when the photos were taken.

Conclusion

Thanks to the excellent switching characteristics and stability of modern semiconductor devices, the circuit designer has a wide choice of methods to achieve processing of a video signal. One general concept of processing has been presented and the implementation of this concept illustrated, using both MOS devices and conventional bipolar transistors.

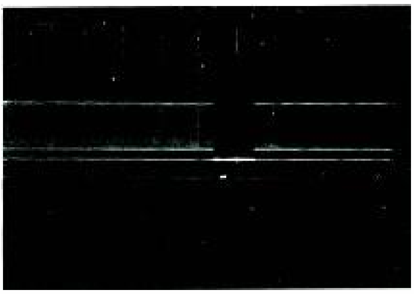


Fig. 5a—Amplifier output (input is 100-kHz sine wave).

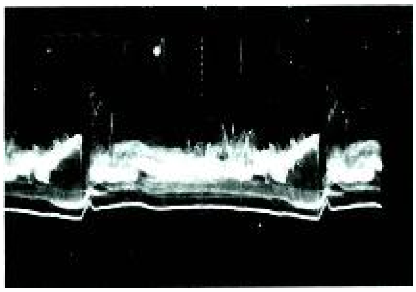


Fig. 5b—Raw video input (vertical sweep rate).

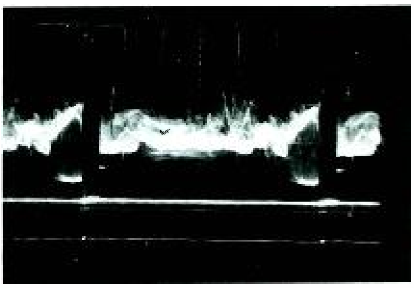


Fig. 5c—Processed video output (vertical sweep rate).

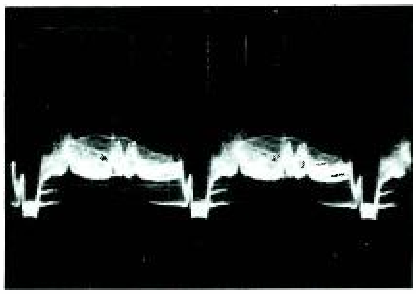


Fig. 5d—Raw video input (horizontal sweep rate).

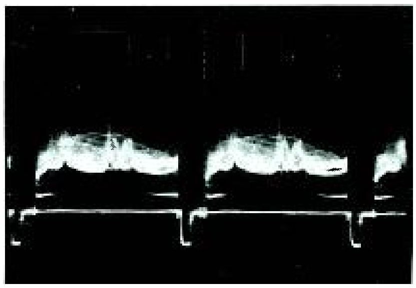


Fig. 5e—Processed video output (horizontal sweep rate).

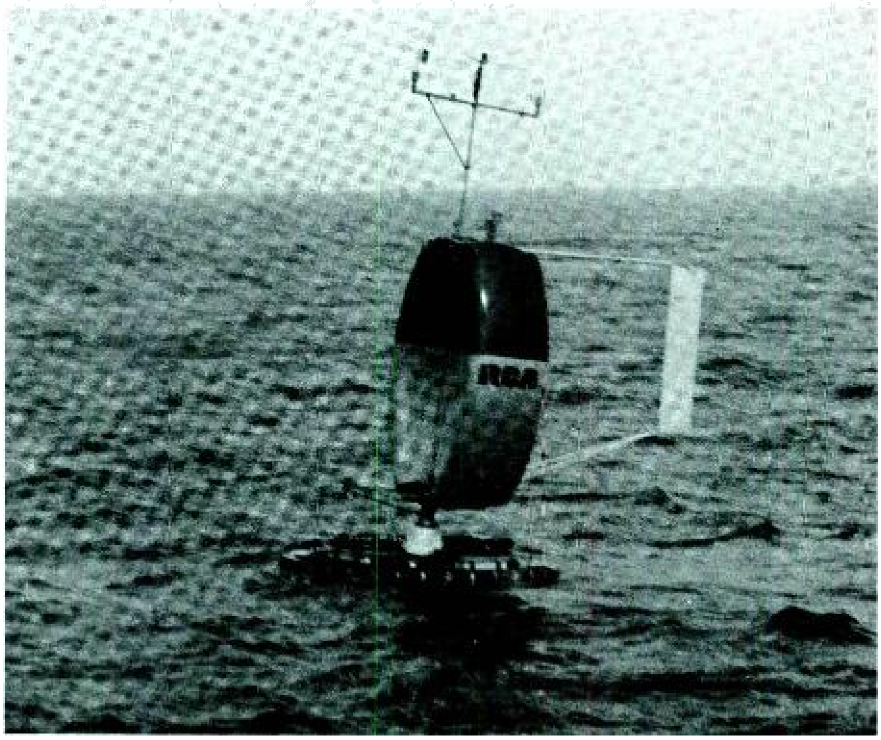


Fig. 1—SKAMP afloat.

SKAMP—a station keeping and mobile platform

E. W. Schlieben

SKAMP, or Station Keeping And Mobile Platform, is an unmanned, self-navigating boat potentially capable of self-deployment to any ocean area or station. Some of the considerations that led to the present boat configuration are discussed and the prototype is described. Data are given for the sail characteristics, indicating that it resembles a conventional sail. A brief account is given of the experience gained to date from sea trials. In conclusion, some operational and economic aspects of this type of boat are discussed. The operational flexibility and the economy of this unique type of boat are high-lighted.

A BUOY is defined as a "distinctively shaped and marked float—anchored to mark a channel, anchorage, navigation hazard, etc., or to provide a mooring place away from the shore." In recent years the word "buoy" has been used also to designate moored instrumented surface or subsurface platforms.

SKAMP is not moored and, therefore, is not a buoy. It is instead an unmanned, self-propelled, self-navigating boat that can move from place to place, and can take up a station or progress from one station to another. In the station-keeping mode, it can perform like a buoy. And in the transit mode it can perform as an instrumented boat.

This paper contains a rationale for the

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holds the BSME with major in Aeronautical Engineering from NYU and has had further training in market planning and development, management methods, and financial planning and operations. Before assuming his present assignment, Mr. Schlieben was administrator of Independent Research, the Manager of Long Range Planning and Special Projects at AED. He was also Director of Research Engineering for the Electro-Optical Division of the Perkin-Elmer Corporation; Director of Product Planning for the Electronic Systems Division of Sylvania Electronic Products; Superintendent of the Control and Guidance Division of the Johnsville, Pa. Naval Air Development Center; Vice President in Charge of Engineering of York Research Corporation; Senior Project Engineer of G. and A. Aircraft Corporation (Pitcairn Autogiro Company); and a Senior Stress Analyst for the Glenn L. Martin Company. He also was owner of the Low and Preston Company and an Editor of *Product Engineering* magazine. Mr. Schlieben holds patents in various fields, among which are those of aircraft, oceanography, computers, industrial processes, and commercial devices. He is an Associate Fellow of the Institute of the Aerospace & Aeronautical Sciences and a member of the National Industrial Security Association and of the National Oceanographic Association.

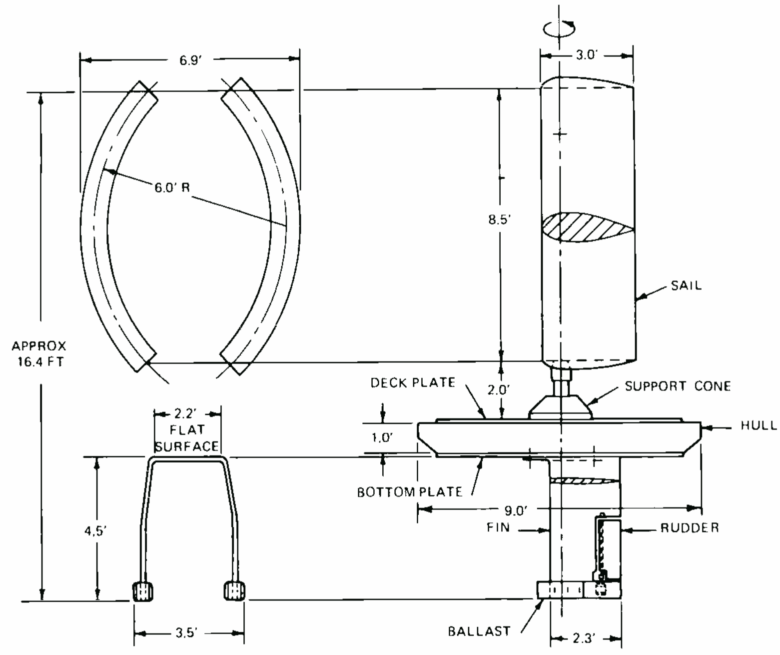


Fig. 2—SKAMP structural configuration.

SKAMP concept, a description of the prototype boat, a status report on the current program, and a discussion of the economics of SKAMP systems.

Rationale

Although buoys are cost-effective for many measurement needs, compared to manned aircraft and ships, persistent mooring system difficulties, handling problems, and systems operational problems have contributed to delays in the deployment of networks. There are, of course, other considerations of an economic, political, and utilitarian nature, that have hampered buoy use.

The two most troublesome aspects of buoy systems are the awkwardness of the mooring system and the rigid logistics support required to implant and retrieve buoys on the high seas.

It seemed prudent to examine other possible solutions. Why not, for example, consider a self-navigating, self-propelled platform, thus avoiding the need for tender vessels and mooring systems.

It quickly became apparent that any platform capable of precise self-navigation anywhere on the high seas must make use of satellite navigation information, and must therefore be equipped with a satellite navigation receiver and a computer for determining position fixes, computing on-board steering commands, etc. Further, because power is a precious commodity on an ocean platform intended for long-term operation, the propulsion system capable of driving the platform over long distances must be extremely efficient or must draw on externally available sources. Finally, the navigational and propulsion equipments must exhibit high reliability with mean failure times of at least a year.

Two arts are combined in the SKAMP concept—a new one and an old one. The use of LSI arrays in linear and digital electronics and low-powered, highly reliable COS/MOS integrated digital circuits, are having a profound effect on the size, volume, power requirements and reliability of new electronics equipment. Such subsystems as the navigation receiver and computer can now be developed specifically for unattended operation on remotely located platforms. Power requirements have been reduced from 1200 watts to 12 watts. The new electronics art therefore strongly underpins the SKAMP concept and gives it viability.

The old art is reflected in the use of sails for propulsion. For the expenditure of a small amount of power to operate sail and rudder hydraulic servo controls, a SKAMP vessel can use wind derived propulsion power up to several hundred times greater than the on-board power consumed.

But, although the power gain realized by the use of sails is high, it was recognized that cloth sails are impractical for an unmanned platform. Further, it was known that experimental attempts to use rigid wing-like sails had been less than successful because of abrupt stall problems and other difficulties.

Therefore, a new type of rigid sail was developed, combining the desirable aerodynamic characteristics of cloth-sail propulsion systems with the inherent ruggedness and simplicity of operation of rigid sails. Thus a 7000-year-old art has been updated and incorporated in an advanced vehicle system.

The prototype

So much for the preamble.

Figs. 1 through 4 show the third prototype SKAMP, currently being used for performance evaluations. [Fig. 1 shows a later model of SKAMP; thus, the difference in appearance.]

The boat comprises a rigid sail made of cambered wing-like sails; a buoyant, elastic, foam hull bounded by deck and bottom plates; a center body; and underwater fins with rudders.

The sails are made of reinforced plastic skins and are foam filled. They ex-

Fig. 3—SKAMP fin and rudder detail.

Fig. 4—SKAMP prototype configuration.

hibit the aerodynamic characteristics of cloth sails and are tolerant to normal rapid changes in wind direction without developing excessive variations or loss in propulsion force.

The hull is a discus shape made of a closed-cell elastomer-foam body clamped between upper deck and bottom plates. The foam provides most of the buoyant force. The deck plate is cut out and the foam body contains recesses to elastically support the equipment containers. The hull is elastically connected to the center body through compliant ring gaskets.

The hull configuration and materials used result in an unusually compliant structure capable of withstanding wave pounding and heave, surge, and sway loading imposed through wave action. In addition, the elastic-hull connection to the center body acts as a low-pass filter, blocking high-frequency hull pitch and roll motions normally shared by the center body. In low-frequency waves, the hull and center body follow the local wave slopes. In a short choppy sea, the hull and center body are effectively decoupled. Masts and antennas are deflected only a few degrees from the vertical and appear to be mounted on a much larger hull.

The underwater fins and rudders are made of reinforced plastic. The fins have a cambered span to improve low-speed operation. The rudders are protected from direct impact loads by the fins. The twin-fin configuration permits one to suspend sensor strings on a cable aligned with the vertical axis of rotation of the platform. The rudders and sail are rotated by hydraulic actuators.

The sail is made of two cambered span wings, comprising thick symmetrical airfoils. The thick sections were chosen to provide reserve buoyancy in the event of a knockdown. In fact, the boat can recover from a 180° roll.

The aerodynamic characteristics of the sail, tested at several Reynolds Numbers, are shown in Figs. 5, 6, and 7. These tests were undertaken by the

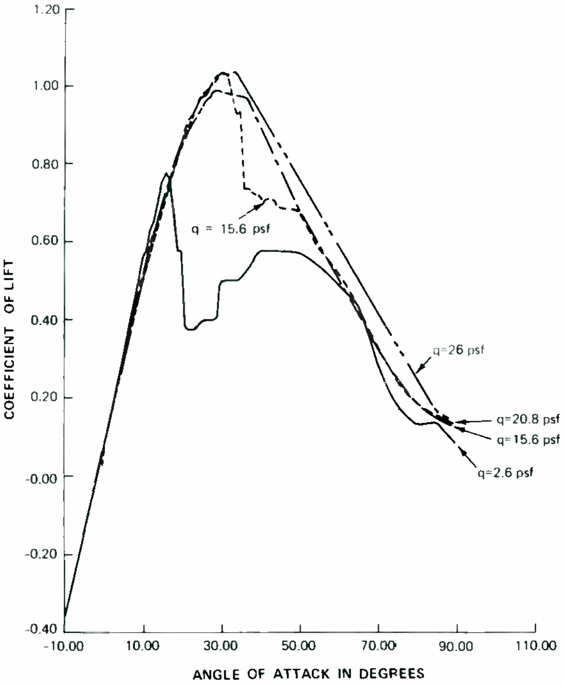


Fig. 5—Sail, support cone, and hull; lift coefficient versus angle of attack.

Department of Aerospace and Mechanical Sciences of Princeton University as part of a broader research program.

The lift and drag characteristics of the SKAMP prototype sail, including mast and deck drag, are similar to typical clothsail systems:

> The maximum lift occurs at approximately 30°.
> High lift coefficients (above 0.8 C_L max.) are realized over an angle of attack ranging from approximately 15 to 40°.
> The maximum lift-to-drag ratio, L/D, is approximately 4.5.

Although the prototype SKAMP sail compares favorably with good clothsail performance, maximum lift and L/D can be increased through the use of thinner airfoils, higher aspect-ratio wings, and wing-camber shaping. However, because hull and fin L/D ratios are typically low for all boats, the gain from sail improvements in sailing performance is not too significant for most SKAMP applications. Significant improvements in performance can be obtained, if desired, through sail *and* hull optimization.

Fig. 8 shows a characteristic set of calculated performance curves for a SKAMP-type vehicle; V_S and V_T are SKAMP speed and true wind-speed, respectively, and a is the sail angle of attack. These curves do not describe the prototype performance and are not valid beyond a Froude number of 0.3, because they do not account for wave-making drag. They are principally of interest in depicting the pattern of sailing speeds along selected courses.

One may end the brief description of the prototype boat by pointing out that SKAMP sailing performance can be tailored to the mission. For short sailing distances and long stays on station, sailing performance is secondary to other considerations. For long distances and limited station keeping, it is desirable to emphasize sailing performance.

Current status

To date, three SKAMP prototypes have been tested to evaluate sailing performance, directional stability, and seaworthiness. These tests have been conducted in winds up to 40 mi/h during sailing trials and up to 60 mi/h at rest. Early tests revealed some directional instability due to the limited rotational damping of the round hull. Later tests were quite satisfactory after hull rotational dampers were added. In general, the SKAMP prototypes have sailed and handled well. "Ghosting" or very-low-wind sailing performance shows that SKAMP can hold course even when the wind approaches a calm. There have been no structural failures.

In the current series of tests being conducted under U.S. Navy auspices in the Atlantic and Pacific oceans, the objective is to extend test experience in heavy seas and to develop operational procedures. In the tests under way, the prototype is locally commanded, based on position information obtained by visual observation or radar tracking, and telemetered wind and boat-speed data.

Another planned SKAMP configuration incorporates a satellite navigation subsystem. The station-keeping doctrine employed is to dead reckon between satellite fixes and to reset sail and rudder settings so as to return to station at time intervals that are a function of distance off station.

On the basis of several sea trials of the SKAMP prototypes, the evidence points to the conclusion that a stable unmanned sailboat, with the potential for operation in rough seas for long periods, is technically and practically feasible. Indeed, at this point in time, it is more comforting to contemplate the prospect of realizing an unmanned boat capable of long-term operation than to dwell on the performance of some of the subsystems. Problems remain to be solved in both the power supply and the sensor subsystem.

A number of missions for which SKAMP configurations are being developed require long-term power in the range from a few watts to several hundred. Unfortunately, there are no available off-the-shelf power supplies or power conditioning systems. Power-supply subsystems must be developed for each new application. Further, reliability data is not available for the more promising fuel cells, thermoelec-

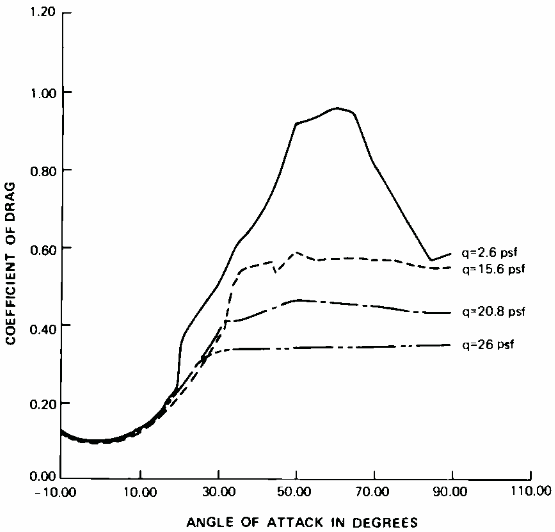


Fig. 6—Sail, support cone, and hull; drag coefficient versus angle of attack.

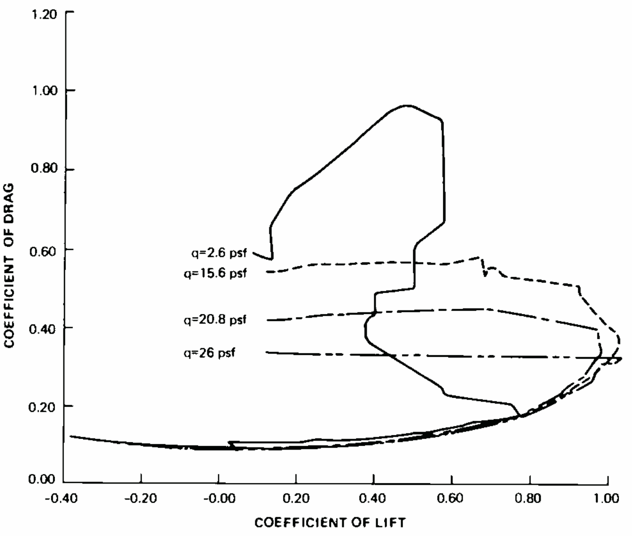


Fig. 7—Sail, support cone, and hull; drag coefficient versus lift coefficient.

tric generators, and solar-cell power supplies. There is not enough accumulated experience available on which to base long-term performance predictions. At the present time, we are developing a solar-cell power supply. This program draws heavily on the Astro-Electronics Division's experience in space technology.

In the sensor domain, it is clearly evident that existing electromechanical wind indicators, anemometers, and water-current meters are inadequate. They are not capable of long-term unattended use and abuse on the high seas on a Skamp-type platform. Rugged solid-state sensors are badly needed. Their development should be strongly supported by all user groups.

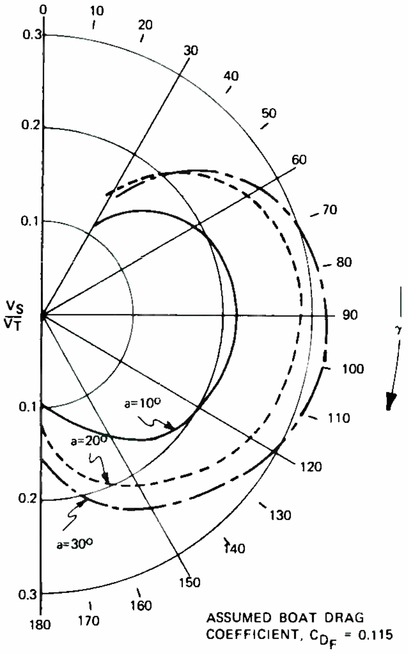
The pacing technologies therefore, in the Skamp program, are those supporting long-term, economical power sources, and atmospheric and oceanographic sensors.

The electronics subsystems can be brought to any desired level of reliability through proper design, parts selection, choice of manufacturing processes and environmental testing. Witness the performance of spacecraft electronics in meteorological satellites and in communications satellites, some of which have been operating continuously for several years.

Operations and economics

Mobile platforms differ markedly in capability and performance from moored fixed platforms. Each has an operational domain that overlaps the other. Both can be used gainfully in the service of those who have a need to place instruments at sea. Point and synoptic measurements are required by many groups engaged in ocean-related activities. Fixed buoys or Skamp's can provide fixed platform capability and Skamp-type boats can provide moving platform capability.

Mobile, unmanned, instrumented platforms—equipped with rocketsondes, and winches for lowering instrument capsules—can perform synoptic measurements in three dimensions. Operating as buoys or as transiting boats, will allow measurements in highly resolved geographical coordinates.



ASSUMED BOAT DRAG COEFFICIENT, C_{D_F} = 0.115

Fig. 8—SKAMP characteristic performance.

The economic and operational virtues of wind-driven self-navigating ocean platforms are many. Such platforms require little logistics support and minimize recurring costs.

A typical Skamp sea-based network would be based at a depot chosen to place it at a reasonable distance from the furthest Skamp station or patrol area. Skamp's would be serviced, repaired, and maintained in readiness at the depot. When one or a group of boats are deployed, it is necessary only to put them in the water and tow them to open water, using readily available tugs, range boats, or work boats. Once in open water, they can be cut loose and allowed to proceed on their own to their respective assigned stations or their patrol areas.

Recovery operations are carried out in a similar fashion. Skamp's would be programmed to abandon station (or sweep area) after a set time and proceed to an offshore rendezvous area where they can be located and then towed back to the depot.

Because of their mobility, it also is possible to consider shorter tours of duty on station than would be economically feasible for moored, nonmobile platforms. By adopting a "bucket brigade" doctrine of operation, Skamp's may be rotated as often as usage experience dictates. If, for example, system mean-time-between-failure for an experimental network indicates a high survival probability for six months, then a four- or five-month tour of duty may be decided upon—to be extended as system reliability grows.

On station, mobile platforms may be used in a flexible manner. As data from a network is analyzed, the need may arise to change the network configuration to increase geographical density in areas of special interest. This can be accomplished easily by commanding new station locations.

Finally, single Skamp's or a small group of three or four can be dispatched to distant stations for special investigations, when it would not be feasible or economical to commit a buoy tender to transport fixed moored platforms.

If one considers the gross economic aspects attaching to the use of Skamp-type platforms, it is evident that ship-tender logistic support costs are greatly reduced. This is a recurring operational cost and can be a substantial part of the lifetime costs of a fixed, moored, ocean-platform system.

Another significant recurring cost avoided in a mobile platform is that for mooring systems. Replacement, warehousing, and handling costs cited by others, on a one-year replacement schedule, are substantial.

The sail and sail-servo cost and the electronic tether system cost are one-time, non-recurring costs. New low-powered satellite navigation systems will be produced in quantity in the near future, at a cost comparable to a deep-ocean mooring system for fixed platforms.

In most networks, it is anticipated that Skamp equipment and operations costs will be one-third to less than one-half the costs of a fixed, moored-platform system.

The Skamp concept, which first received moral support from the U. S. Navy, is currently being evaluated by the Meteorological Division of the Naval Air Systems Command and by others. Rough-sea experience is being accumulated, as well as experience in transit and station keeping operations.

Mechanical design of a portable air traffic control tower

W. H. Neve | W. D. Ogle | M. J. Sheedy

This paper describes the mechanical design, development and testing of a portable Air Traffic Control Tower, AN/TSW-7. The design was particularly challenging in that the equipment shelter walls consisted of approximately 50% glass, yet had to survive the rigorous environmental and mechanical testing of MIL-STD-810A, 18-inch drops to concrete, the Aberdeen Proving Ground Munson Road Course, and railroad humping at 9 miles per hour.

In the development of equipment shelters and cargo pallets, several requirements greatly influence the design: environmental, service, transportability, weight, and configuration. The goal in the design of the AN/TSW-7 was to satisfy these requirements and at the same time maintain an optimum strength-to-weight ratio to capitalize on \$200/pound weight incentive. Specifically, some of the requirements are as follows:

1) Operating temperature, −40°F to +125°F;
2) Non-operating temperature, −80°F to +160°F;
3) Altitude, operating 10,000 ft., non-operating 50,000 ft.;
4) 10-day humidity per MIL-STD-810A;
5) Munson road test on an M35 truck and XM-720 transporter;
6) 18-inch flat and rotational drops to concrete;
7) Railroad Hump at 9 miles per hour;
8) Fording and rain testing per MIL-S-55286 and MIL-S-52059;
9) Shock and vibration per MIL-STD-810A; and
10) Winds 100 knots operating, 130 knots non-operating.

System description

The complete system configuration in its operational mode is shown in Fig. 1. The system consists of an equipment shelter, a cargo pallet, a power generator (60 or 400 Hz), a UHF/VHF communication antenna, a radio direction finder antenna, a wind measuring set, and dolly transporters which can be mounted to the pallet or shelter for transport.

The shelter is a modified S-141 shelter and meets all the requirements of MIL-S-52059. Its modification includes the addition of glass panels and jacks to elevate it to 4 ft above the ground. Stairs and a platform are provided for shelter entry in this mode. The bottom of the shelter and pallet is equipped with longitudinal skids to permit tow-

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ing and fork-lifting. The cargo pallet is equipped with jacks to elevate the environmental control unit (ECU) so that the air ducts between the ECU and the shelter approximate a straight line. The antennas are integral units which are capable of autonomous deployment; identical items such as ground anchors, winches, guy wires, etc. are utilized in different areas.

Shelter internal configuration

The shelter configuration is approximately 8 ft wide, 8 ft high, and 12 ft long and weighs 4000 pounds. The upper half consists mainly of nine sheets of laminated glass.

Internal to the shelter are racks and consoles with solid-state radios, landline telephones, meteorological equipment, and other hardware used to maintain a complete and up-to-date visual flight rules (VFR) capability comparable to that of any large airport. Located in the forward part of the shelter is a rack and console system which consists of one basic console frame supported by, and tied to, four radio and filter racks (Fig. 2). On the floor at the rear of the shelter are located a power supply rack, a power distribution panel, radio direction finder equipment, and a storage rack. Attached to the ceiling above the console are 16 speakers, a digital clock, and two light guns. Fixed to the ceiling at the rear of the shelter is a system block diagram and a high frequency radio mount. All this equipments, except the power distribution panels, are of modular construction and can be plugged in and out of the system for ease of maintenance or replacement. Each of three control panels on the console—the local, the data and the ground control—folds down to enable connector disengagement. Strip lights of variable intensity are located at both sides of each of the control panels. These lights are supplemented at each control position by gooseneck lamps. All the modules on each of the control panels are equipped with captive hardware and are easily removable; all similar equipments on each panel are interchangeable. A desk writing surface is provided at each operator position, equipped with a plastic snap-out section under which procedural maps may be placed.

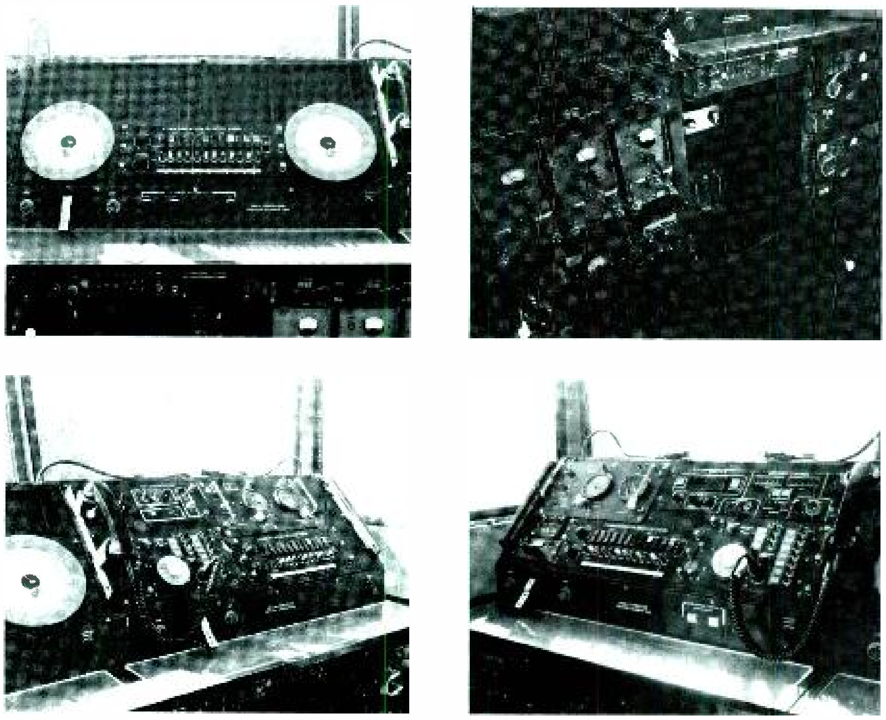


Fig. 2—Shelter internal configuration.

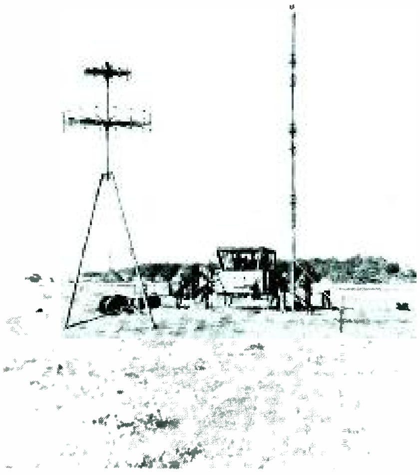


Fig. 1—Operational configuration.

Cargo pallet configuration

The basic pallet configuration is shown in Fig. 3. Aluminum hat section members are attached to the pallet surface via stainless screws into flat head riv-nuts. The riv-nut heads recess into counterbored holes on the bottom of the hat section flanges.

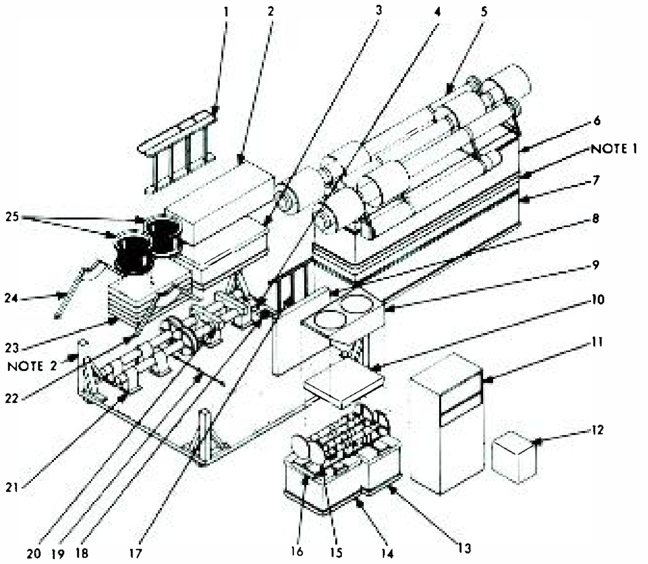
All the equipment, except the ECU is secured to the pallet with straps (not shown). The central cases contain the radio direction finder antenna. The top case is provided with aluminum frames to support the communication antenna mast sections. When all equipments are assembled in place, one set of lifting slings is used to secure the load, with an additional set used in railroad transport.

Preliminary development and test

Two approaches to the structural design were considered: one where most equipments would be mounted in rack systems which in turn would be shock-isolated from the shelter, and the other where all equipments would be hard-mounted to an isolated shelter. Since a significant weight savings could be realized if it were possible to isolate the rack structure, the first approach was investigated.

Information on previously employed shelters equipped with aluminum crushable skids, which had been gathered from various sources, indicated that a shock-pulse magnitude in the order of 30 to 40 g could be expected. Isolators were selected which would attenuate their pulse to approximately 20 g, the design limit of the equipments to be isolated. A sway space of 1.0 inch was required and available.

The opportunity to substantiate the backup information gathered and the subsequent design that evolved from this information presented itself via



Legend

1. Stairway
2. Wind mast transit bag
3. AN/TSW-7 tool kit
4. Center-of-gravity diagram
5. Communication antenna mast modules (consisting of three UHF-VHF modules, two mast base modules, an obstruction light module, and a gin pole)
6. DF antenna assembly transit case No. 2
7. DF antenna assembly transit case No. 1
8. Platform and handrail
9. ECU plenum
10. Anchor transit bag
11. ECU
12. Battery pack
13. Auxiliary generator transit case
14. Cable transit case
15. Pallet jacks
16. Pallet jack frame
17. Ladder
18. Loading diagram
19. Shelter grounding stake
20. Tool kit frames
21. Shelter jacks
22. Communication antenna erection support
23. Communication antenna transit bags (5)
24. Communication antenna erection support
25. ECU ducts and attached adapter flanges

Fig. 3—Transit position of equipment on pallet.

the contract for the AN/TSW-7. One requirement in that contract was that the shelter had to be qualified at the drop and railroad hump tests at both the component level and the system level.

A deliverable shelter was fabricated and installed with a complete rack-console shock-isolated structure, a mock-up speaker support structure, and lead ballast to simulate the remainder of the equipment weight. Mounted to the rack and console and ceiling speaker structures were dummy loads of the same weight and distribution as the deliverable equipments. The shelter system was instrumented inside and out with a total of 12 accelerometers. Figs. 4 and 5 show the shelter instrumentation distribution. The accelerometer outputs were recorded on an electro-magnetic galvanometer contained in a direct readout oscillograph. The shock levels of the drop and hump tests are available, and Tables I and II of this document contain the results.

One 18-inch flat drop and four rotational drop tests were conducted at Craig Systems in Lawrence, Mass. Test results indicated that the shelter, with crushable aluminum skids, received a shock pulse of 80 g at one point on the outside and up to 70 g at various points on the inside. This loading was twice as high as was expected, and an analysis indicated that it would be impossible to attenuate the pulses to safe levels within the sway space available. A decision was made at this point to consider the second option, which was to hard-mount everything inside the shelter and change the aluminum skids to elastomer skids.

Final mechanical configuration

Skids

As was pointed out previously, the aluminum crushable skids on the shelter, during an 18-inch flat drop to concrete, transmitted a shock pulse of approximately 70 g to the rack isolators. This was a greater pulse than could be attenuated to safe levels within the space limits available. Beyond this, the equipments that originally had to be isolated, such as ceiling-mounted speakers and the DF set, would certainly be destroyed by such a shock. Therefore, the crushable skids had to be replaced with skids that would transmit no more than 20 g to the shelter in an 18 inch drop to concrete. A skid was developed which provided the necessary isolation. Some characteristics of the skid are:

1) Payload range—500 to 14,000 lb;
2) Deflection—30% initial load height;
3) Damping—considered excellent; and
4) Weight—31 lb each (3 used on shelter, 2 used on pallet).

The skid design meets the following test requirements:

1) 18-inch flat and rotational drop—maximum 20 g shock pulse transmitted to interior of shelter;
2) Towing and bearing—per MIL-S-55286; and
3) Vibration—per MIL-STD-167.

The first use of this particular elastomer skid design was on the AN/TSW-7, and it greatly contributed to the successful passing of all shock tests.

Shelter internal structural configuration

The final rack-console structural configuration differs somewhat from that used to support the dummy loads during the preliminary shock tests. The bottom of the racks had to be altered to facilitate the change from a shock isolation mounting system to a hard mounting system. A realistic look at the floor construction (Fig. 6) indicates that it is, by itself, not well suited to carry the side loads induced by the rail hump test.

If **R** is to react **L**, then a combined bending and shear stress will exist on the fastener as well as a tensile stress due to torquing the fastener. The total stress will fail the fasteners unless an extremely large number of them are used to share the load.

If **R′** reacts **L**, then the assumption must be that the 0.04-inch thick floor skin will carry the side loads without buckling; this it will not do.

In the final design, structural members were used at the top and bottom of the

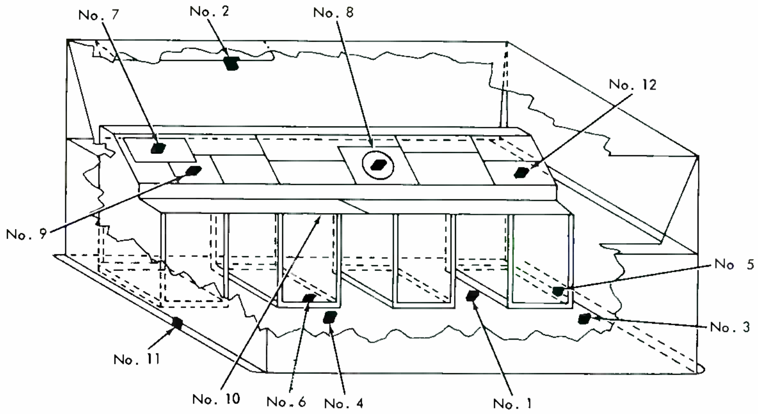


Fig. 4—Accelerometer orientations and directions for drop shock tests.

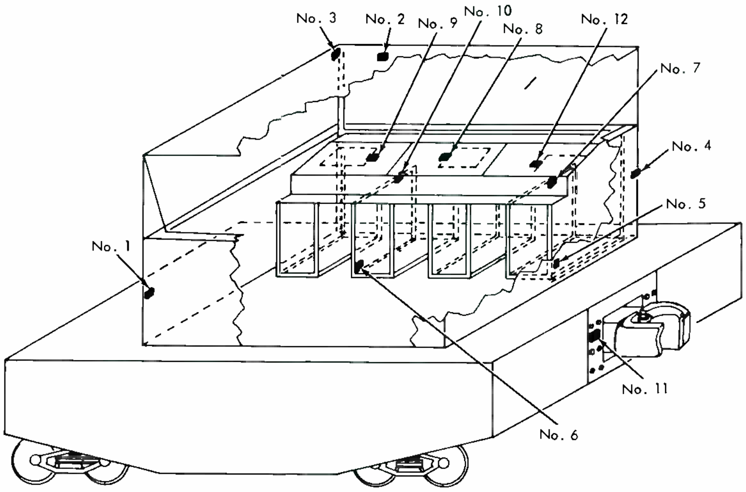


Fig. 5—Accelerometer orientations and directions for railroad hump tests.

Table I—TSW-7 shock test data.

	Drop No. 1 (flat)		Drop No. 2 (rotational)		Drop No. 3 (left-to-right)		Drop No. 4 (rear-to-front)*		Drop No. 5 (front-to-rear)	
Channel No.	Peak g	Time (ms)	Peak g	Time (ms)	Peak g	Time (ms)	Peak g	Time (ms)	Peak g	Time (ms)
1	35	5	15	3	—	—	—	—	8	5
2	60	20	32	14	20	18	—	—	50	10
3	70	15	10	3	30	18	—	—	50	8
4	—	—	25	5	35	20	—	—	40	6
5	37	24	4	11 (Hz)	55	20	—	—	22	25
6	15	5	22	46	8	60	—	—	22	25
7	22	20	25	45	7	10	—	—	27	25
8	53	47	50	20	23	60	—	—	40	45
9	26	47	25	40	6	50	—	—	31	35
10	12	10	22	45	10	50	—	—	20	40
11	80	10	25	20	10	15	—	—	20	5
12	25	55	10	32	25	40	—	—	30	40

*Loss Of Power Prior to Drop No. 4

Table II—TSW-7 hump test data (flat-bed car with shelter impacted with coal car traveling at 9 mi/h for all hump tests).

	Hump No. 1		Hump No. 2		Hump No. 3		Hump No. 4	
Channel No.	Peak g	Time (ms)	Peak g	Time (ms)	Peak g	Time (ms)	Peak g	Time (ms)
1	—	—	—	—	—	—	—	—
2	—	—	21	60	10	60	15	70
3	—	—	15	70	10	60	15	70
4	—	—	19	65	12	60	17	40
5	—	—	22	72	12	90	16	90
6	—	—	22	40	18	90	27	90
7	—	—	17	80	18	85	28	70
8	—	—	27	72	23	90	36	82
9	—	—	27	72	18	90	21	80
10	—	—	17	72	15	80	20	80
11	—	—	30	12	40	14	62	10
12	—	—	22	70	20	80	25	70

rack system which carried the rail hump loads to the shelter side walls with the floor serving only to position the lower rack structural ties. Two top-hat sections, running almost the entire length of the shelter and spaced a distance apart equal to the depth of the racks, are fixed to the shelter floor structural members which run normal to them. These top-hat sections were sized by the drop test loads in that the vertical webs had to be adequate to resist buckling. The size chosen to resist buckling proved more than adequate to carry the shear loads introduced during the rail hump tests. The rack structure is fixed to the top-hat section via bolts which carry into the hat sections the loads imposed by the drop tests. Pins are used to carry rail-hump-induced shear loads from the racks to the top hats.

The top-hat sections at the bottom of the racks serve to collect part of the rail-hump shear and carry it to the side walls as tension or compression. The remaining shear is collected at the top of the racks by members which also run the full length of the rack configuration.

These members and also those at the bottom of the racks terminate at each end at structural members which fix the rack-console system to both side walls. The upper members, of which the console itself is considered a part, were sized using the assumption that they would react the applied shear as tension from the wall opposite the side that was hit rather than compression against the side that was hit.

Pallet structural configuration

The equipment on the pallet was designed to withstand a 20 g shock pulse. This maximum level is ascertained in drop test by employing elastomer skids as discussed previously. During the preliminary design phase, a standard MIL-D-27295A pallet was considered. However, this was abandoned since it was designed to carry 8500 lb, a

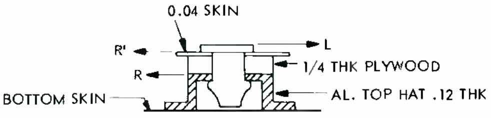


Fig. 6—Floor construction.

much heavier load than required for AN/TSW-7 which is 3000 lb. A new design could be made which would be tailored to the equipment.

Designing for the hump test presented more of a problem than the shelter in that there were no end walls to transfer the loading. Mechanical constraints were considered but their sizing became out of proportion.

The final design, which proved successful, was to provide aluminum hat sections on the pallet floor which would act as shear carrying members and as additional pallet stiffeners. The shear was carried from the hat sections to the pallet floor via counterbored holes on the back of the hat sections interfacing with the heads of riv-nuts. Holes were made in the hat sections to interface with studs on the equipment cases. The load was then secured to the pallet with nylon straps which tie to the stanchions, and a lifting sling which ties to lifting rings at the pallet sides. The nylon straps were able to give under impact offering some shock absorption features not available when employing metal restraints.

Environmental control system

The following design requirements had to be met for environmental control internal to the AN/TSW-7 shelter:

1) Maintain +70°F in the shelter ambient with an outside ambient of −40°F;
2) Maintain +80°F in the shelter with an outside ambient of +125°F;
3) Melt 2 inches radial ice from the shelter glass while attaining requirement 1) above;
4) Limit the noise input to the shelter which could not exceed curve NC-45 of MIL-STD-803-A-2; and
5) Limit excessive condensation on the glass and equipment.

The final design of the environmental control system was derived as a result of past experience, analysis, and product development. Considerable knowledge and data were gianed from the earlier AN/TSW-6 program—predecessor to the AN/TSW-7. The AN/TSW-6 shelter employed electrically heated glass for defrosting and a one-point source was used for air distribution throughout the shelter. Diffusers are used in the AN/TSW-7 to defrost the glass, and there is a complete circumferential air distribution system. The advantages of the new design are as follows:

1) Electromagnetic interference problems caused by thermostat switching prevalent with electrically heated glass) are eliminated;
2) Positive control of defrosting is provided (e.g., all flow can be directed to front glass pieces if desired);
3) Basic cost of glass is less expensive than electrically heated glass;
4) The new circumferential air plenum provides more uniform air flow, enhancing human comfort.

Other salient factors of the final design are described with reference to the basic design requirement.

The noise and vibration requirement was met by mounting the ECU to the pallet and directing air flow via flexible air ducts. To supplement the sound-absorbing characteristic of the air duct, the shelter air plenum was lined with acoustically absorptive material.

Condensation in the shelter was reduced by the introduction of air ducts and by the remote location of the ECU from the shelter. This eliminates the "raining effect" of the ECU into the shelter, which would occur had the ECU been mounted directly to the shelter wall. Moisture from the ECU tends to condense in the ducts. The ducts act as traps which tend to condense moisture into the ducts before it enters the shelter.

The temperature requirements were met by selection of an ECU which could provide the necessary heating and cooling capacity. The ECU was a model AF/32-C-24 for 60-Hz operation or AF/32C-25 for 400-Hz operation. This selection provided a minimum of 28,600 BTU/hr in heating and a nominal of 36,000 BTU/hr in cooling.

Legend for Figs. 7 & 8

1. Obstruction light module
2. UHF-VHF antenna module
3. Mast long guy
4. Mast sling
5. UHF-VHF antenna module
6. UHF-VHF antenna module
7. Winch extension rope
8. Anchor
9. Gin-pole guy
10. Mast short guy (with clip)
10A. Mast short guy (with ring)
11. Gin pole
12. Winch rope
13. Winch
14. Anchor
15. Mast short guy (with clip)
16. Base mounting plate
17. Lower mast base module
18. Base mounting plate guy
19. Upper mast base module
20. Electrical cables
21. Gin pole guy
22. Mast short guy (with clip)
23. Anchor
24. Mast short guy (with clip)
25. Mast long guy
26. Mast sling
27. Small mast erection support
28. Anchor
29. Mast short guy (with ring)

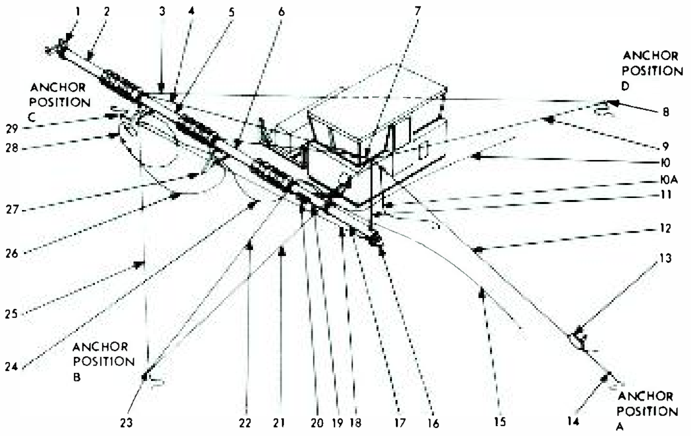


Fig. 7—Communications antenna before erection.

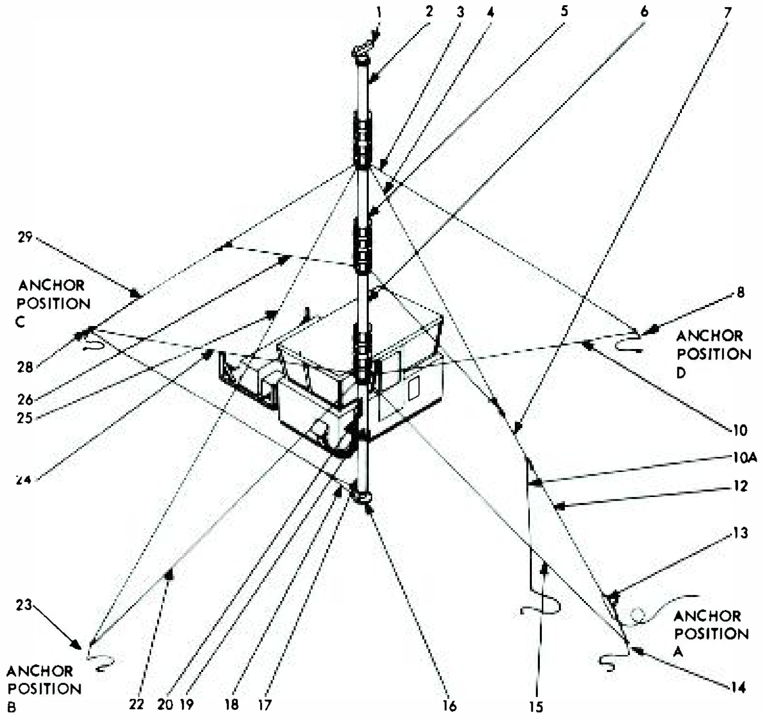


Fig. 8—Communications antenna after erection.

Deployment conditions

The following requirements had to be met as deployment requirements for the AN/TSW-7 systems:

1) Erection and teardown of the system under adverse field conditions, including high winds, heavy rains, etc.
2) Set-up and operation within one hour after arrival at a site utilizing no special tools other than those found in the Standard Military Tool Kit.

The fully operational system configuration is depicted in Fig. 1. The system in its transit mode is depicted in Fig. 3. Many factors contribute to the successful meeting of the deployment requirements. The following basic concepts were employed in the AN/TSW-7:

1) Antenna guying concept
2) Commonality of equipment
3) Quick release devices
4) Captive hardware
5) Plug-in sections
6) Systematic stacking arrangement

Antenna guying concept—The antennas—UHF/VHF comm. (42 ft high) and RDF (26 ft high)—are elevated using a basic gin-pole method as depicted in Figs. 7 and 8. During field conditions, a pulley had to be added to the top and bottom attachments for the winching side to prevent uncontrollable oscillations induced by the winching action. Two sets of guys are employed for the comm. antenna which are necessary under conditions of 130-knot winds. For system use, a common removable grip hoist winch is employed. Dual lines and attachments are provided at the winching pulley of both the RDF and comm. antennas to facilitate winch removal.

Commonality of equipment—Wherever possible, identical equipment is employed to serve a similar function. Arrowhead anchors are used throughout the system for all soil and environmental conditions. The same winch is used for antenna erection. Identical guy lines, attachments, and pulleys are used for erecting the antenna equipment and anchors. Identical hardware for similar applications is used on equipment panels, drawers, ducts and consoles throughout the system.

Quick-release attachment devices—Hold-down nylon straps that secure the palletized load are provided with a quick-release mechanism. Other nylon straps provided for the shelter and pallet in transit are of the NAS quick-release type. As an example of the time savings resulting from the use of quick-release devices employing nylon straps, the ECU redesigned to employ these devices resulted in an assembly time savings of 15 minutes.

Captive hardware—Captive hardware is provided in all normally removable equipments. Quarter-turn fasteners and Southco captive studs are employed extensively. The RDF antenna and comm. antenna both employ quick-release pins.

Plug-in sections—The RDF antenna is provided with plug-in dipole arms which snap in and out readily to facilitate assembly. The arms also plug into polyethylene foam sockets in their designated transit case for immediate accessibility.

Systematic stacking arrangements—The pallet is loaded for transit on an equipment first-need basis. The tool box, which is needed for disassembly, is the first equipment disassembled and therefore is readily accessible. The UHF/VHF comm. antenna, which is the first unit to be erected, is topmost on the palletized load. Other equipments are stacked and available as needed in the scheme of assembly.

Transportability

The AN/TSW-7, in its transit configuration, can be transported in the following ways:

1) Rail
2) M-35 truck
3) Fixed-wing aircraft (C-130A)
4) Demountable dolly set (XM-720)
5) Rotary-winged aircraft

To meet the requirements for Munson Road testing and the lifting and towing-eye tests of MIL-S-52059, it was necessary to add a compression bar across the shelter door. This bar is readily removable for shelter entry. Analyses also proved that it was necessary to add compression bars across the pallet stanchions to meet the conditions of Munson Road testing.

Two sets of lifting slings are provided for helicopter lift and towing. These slings are also used to secure the pallet load in transit and railroad humping. In addition, for Munson road testing on an M-35 truck, the slings secure the shelter and pallet.

The capability of the shelter and pallet to be loaded into a C-130 aircraft has been demonstrated analytically. A maximum weight requirement was levied by specification of 5000 lb per unit or 10,000 lb total. The final weight of the shelter is 4120 lb and 3540 lb for the pallet for a total of 7660 lb.

Final mechanical tests

During the summer and fall of 1969, the AN/TSW-7 systems successfully passed the following tests:

1) Low temperature;
2) High temperature;
3) Altitude;
4) ECU performance and ice melting;
5) Fungus;
6) Watertightness;
7) Sand and dust;
8) Salt fog;
9) Winds;
10) Snow;
11) Rail hump;
12) Drop;
13) Munson road;
14) Humidity;
15) Leveling;
16) Center of gravity;
17) Assembly and disassembly; and
18) Helio deployment.

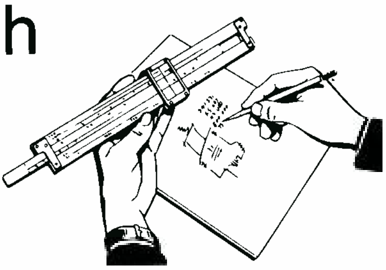
The successful completion of this testing resulted in a contract for an additional twenty-one systems.

Summary

The following salient factors are recommendations in the design of systems similar to the AN/TSW-7:

1) Design for 18-inch drops to concrete hardmount equipment inside the shelter and shock-mount the shelter outside by using elastomer skids;
2) Provide compression bars across the shelter door and on the sides of the pallet for transit;
3) Provide a pulley arrangement for the antenna winching cables for erection;
4) Locate the ECU remote from the shelter for operation;
5) Employ pre-stretched nylon straps to secure equipment;
6) Employ a diffuser system to defrost glass (this system is generally more efficient than heated glass);
7) Employ flathead riv-nut heads to carry most shear loads produced by pallet railroad hump testing; and
8) In basic shelter-wall construction, the thermal barrier should be on the outside rather than inside.

Engineering and Research Notes



Brief Technical Papers
of Current Interest

Square-wave frequency doubler or quadrupler

Gordon F. Rogers, Manager
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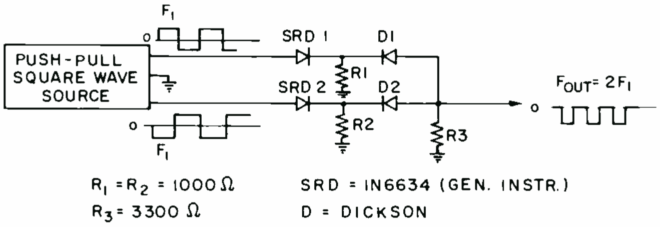

Fig. 1—Frequency doubler.

The square-wave frequency-doubling circuit employs two step-recovery diodes (SRD1 and SRD2 Fig. 1) and two conventional fast-switching diodes (D1 and D2). The step-recovery-diodes are selected with a life-time which is long compared to the sum of the time durations of 1) an applied forward conduction pulse and 2) an immediately following reverse conduction pulse. For such a diode, the product of forward current and forward conduction time is substantially equal to the product of reverse current and reverse conduction time.

The switching diodes D1 and D2 are coupled to a common output load R3 and to their respective step-recovery diodes, SRD1 and SRD2. The step-recovery diodes conduct alternately in their forward direction on opposite half cycles of push-pull square waves supplied from a source at a frequency F1. The switching diodes D1, D2 each conduct only during a portion of the applied square waves immediately following forward conduction of the associated step-recovery diode (SRD1 or SRD2). The switching diode current flows through the respective step-recovery-diode in the reverse direction. Resistors R1 and R2 are equal. The reverse current of each step-recovery-diode is selected as twice the amplitude of its forward current by selection of the value of R3. The reverse current of each step-recovery-diode (and therefore the forward current of the associated switching diode) flows for one-quarter of each cycle of the square wave. The currents of diodes D1 and D2 are combined in output load resistor R3 such that square waves are produced across the output resistor R3 having a frequency F_2 twice that of the input frequency F_1.

Additional doubling circuits of this type may be cascaded to provide output signals at frequencies 2^n times the input signal frequency, where n is the number of cascaded doublers.

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Square-wave frequency multiplier employing inductors or capacitors as storage elements

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In the circuit shown in Fig. 1, transistor Q1 is driven into saturation as the applied square-wave input swings positive. At the same time, Q3 is cut off. The current in inductance L1 increases substantially linearly at a rate determined primarily by the regulated voltage V_2. At the end of each positive half cycle of the square wave, transistor Q1 is turned off and the voltage across L1 reverses polarity. The main regulated supply voltage (such as +30 volts) and the resistor divider R1-R2 are selected with respect to the voltage V_2 so that the voltage across L1 during this interval is substantially twice the voltage (and of opposite polarity) as compared to the preceding interval. Transistor Q2 is turned on to saturation conduction as its base rises sufficiently positive with respect to its emitter. The current in L1 declines to zero in one-half the time interval required to increase to its peak value, and transistor Q2 then turns off (i.e., transistor Q2 conducts during one-half the negative half of the input square wave or for one-quarter cycle). The collector current of Q2 passes through a load RL to produce an output voltage pulse. While transistor Q2 conducts, transistor Q3 is supplied with positive base input and also conducts to store energy in L2. In a manner similar to that described previously, L2 discharges through Q4 (thus producing a current in RL) during the first half of the next succeeding positive input to Q1. A square wave of twice the frequency of the input square waves is produced across RL.

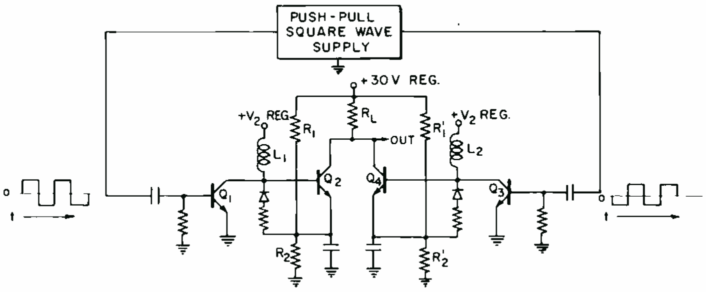

Fig. 1—Frequency multiplier.

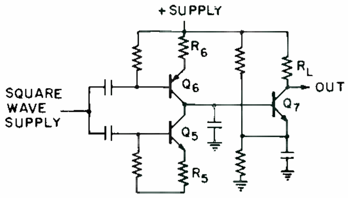

Fig. 2—Frequency doubler using capacitive storage.

Half of a square-wave frequency doubler circuit employing a capacitive storage element is shown in Fig. 2. A mirror image of the illustrated circuit coupled to load resistor RL is also required to provide the desired frequency doubling. In Fig. 2, transistors Q5 and Q6 are operated as switched current sources with emitter resistor R5 twice the value of emitter resistor R6 so that, when conducting, the current of transistor Q5 is one-half that of transistor Q6. During each positive half cycle of the input square wave, transistor Q5 conducts to reduce the voltage across capacitor C with respect to ground. During each negative half cycle, transistor Q6 conducts to increase the voltage across capacitor C during the first half of the negative half cycle. During the latter half of that half cycle, transistor Q7 is turned on to produce an output across load resistor RL. The second half of the circuit (not shown) produces conduction in a similar manner through resistor RL but displaced in time by an amount such that the frequency of the output square wave is twice that of the input square waves.

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Logic-circuit carrier-generation for 90° colorplexer system

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A technique is described for developing an accurate 90° relationship between carriers of the same frequency. The circuitry is useful, for example, in a signal encoding device which provides NTSC-type chroma signals. A block diagram of the system is shown in Fig. 1. The 14.32-MHz output of the oscillator is applied to a squaring circuit which serves to limit the oscillator signal, thus providing a square wave at the output. The square wave is applied to the input of a bistable multivibrator (FF #1). The bistable multivibrator thus provides two signals at half the frequency of the signal applied to the inputs. Each of these signals is 180° out of phase with the other as shown in Fig. 2. The signals are respectively applied to separate bistable multivibrators, designated as FF #2 and FF #3. The bistable multivibrators, as triggered by the output signals from the bistable multivibrator 12, produce two square waves at a frequency of 3.58 MHz. This frequency is the chrominance sub-carrier frequency. The output waveforms of the multivibrators are filtered via suitable low-pass filters to provide, at the respective filter outputs, two distinct phases of the chrominance subcarrier signal, each of which is 90° out of phase with the other. The wave shapes at the outputs of the various circuits are shown in Fig. 2.

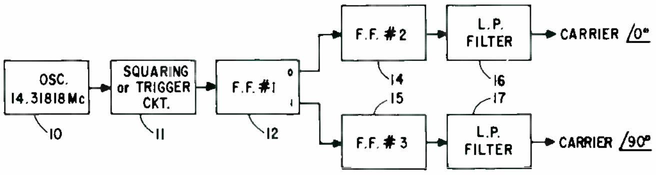

Fig. 1—System block diagram.

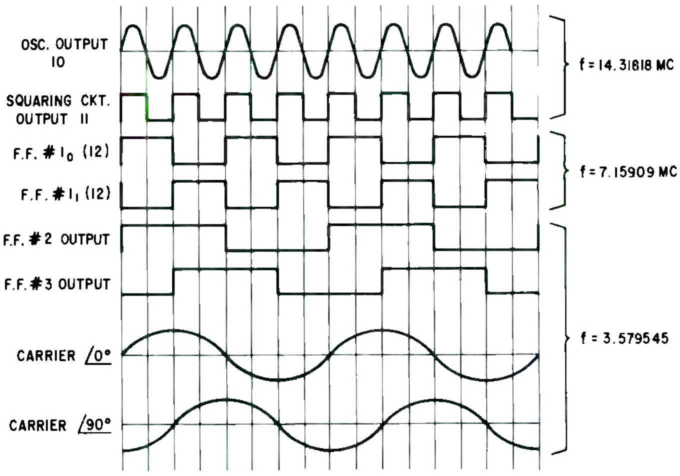

Fig. 2—System Waveforms.

Reprint RE-16-5-23 | Final manuscript received December 10, 1970.

Directory of RCA licensed professional engineers

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Editor's note: Since this list was compiled, several division names have been changed. The new division names are as follows:

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DCSD	Communications Systems Division (Government)
EC, Somerville	Solid State Division
CSD	Systems Development Division

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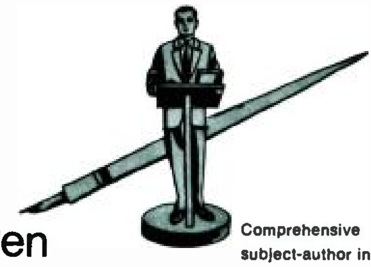

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STABLE GUNN DOMAINS Including Diffusion, Simplified Theory for—M. A. Lampert, R. A. Sunshine (Labs, Pr) *J. of Applied Physics*, Vol. 41, No 11; 11/70

SPACECRAFT INSTRUMENTATION

INFRARED SENSING in Meteorological Satellites, Applications of—A. Aronson (AED, Pr) IEEE Northeast Electronics Research and Engineering Mtg. (NEREM 70) *NEREM* 70 Record Boston Mass.; 11/4-6/70

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SUPERCONDUCTIVITY

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TELEVISION BROADCASTING

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TELEVISION EQUIPMENT

IMAGE STABILIZATION, Open Loop TV—J. Dubbury (ASD, Burl) Boston Chapter AES Group Mtg., IEEE; 11/10/70

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Subject listed opposite each author's name indicates where complete citation to his paper may be found in the subject index. An author may have more than one paper for each subject category.

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Patents Granted

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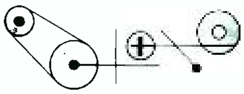

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Computer Systems Division

Computer Memory Addressing—A Prieto (CSD, Palm Beach) U.S. Pat. 3,551,898; December 29, 1970

Tape Level Sensor—J. P. Watson (CSD, Palm Beach) U.S. Pat. 3.550,828; December 29, 1970

Bi-Directional Shift Register—J. E. Croy (CSD, Cherry Hill) U.S. Pat. 3,555,433; January 12, 1971

Recording Transducer Selection Limiter—E. L. Nelson (CSD, Pal Beach) U.S. Pat. 3.555.518; January 12, 1971

Dead Track Handling—J. Agin (CSD, Marlboro) U.S. Pat. 3,518,625; June 30, 1970

Consumer Electronics Division

Automatic Record Changer—J. A. Tourtellot (CED, Ind) U.S. Pat. 3,545,767; December 8, 1970

Compensated VHF-UHF Automatic Gain Control Delay System—W. L. Lehmann, J. C. Marsh (CED. Ind) U.S. Pat. 3,548,-315; December 15, 1970

UHF-VHF Tuner With U-Shaped Strip Balanced Transmission Line—D. J. Carlson (CED, Ind) U.S. Pat. 3,551,819; December 29, 1970

Picture Projection with Sound—D. R. Andrews (CED, Ind) U.S. Pat. 3,554,637; January 12, 1971

Kinescope Bias Tracking Circuits—D. R. Griepentrog (CED, Ind) U.S. Pat. 3,555,-175; January 12, 1971

Plural Operating Mode Automatic Gain Control System—D. F. Griepentrog (CED, Ind) U.S. Pat. 3.555,162; January 12, 1971

Automatic Degaussing Circuit for TV Having Voltage Doubler Power Supply—J. K. Allen (CED, Ind) U.S. Pat. 3,555,343; January 12, 1971

Astro-Electronics Division

Expandable Metal Structure Meking by Etching—H. J. Sheetz, R. T. Molloy (AED, Hstn) U.S. Pat. 3,546,075; December 8, 1970

Electromagnetic and Aviation Systems Division

Multiple Channel Display System—W. A. Helbig, W. L. Ross (EASD, Van Nuys) U.S. Pat. 3.555.520; January 12, 1971

Electronic Components

Current Mode Switching Circuit—E. K. C. Yu (EC, Som) U.S. Pat. 3.549,900; December 22, 1970

Non-Destructive Read-Out Memory Cell—A. K. Rapp (EC, Som) U.S. Pat. 3.549,-904; December 22, 1970

Variable Threshold Level Field Effect Memory Device—J. H Scott, Jr. (EC, Som) U.S Pat. 3,549.911; December 22, 1970

Complementary Semiconductor Matrix Arrays for Low Power Dissipation Logic Application—R. W. Ahrons (EC. Som) U.S. Pat. 3.550.089; December 22, 1970

Capacitor Discharge Ignition Circuit—M. S. Fisher (EC, Som) U.S. Pat. 3.546,528; December 8, 1970

Transistor High Current Switching and Inverter Circuits—D. M. Baugher (EC, Som) Pat. 3,546,627; December 8, 1970

Charge Storage Device with PN Junction Diode Array Target Having Semiconductor Contact Pads—E. F. Cave, F. C. Duigon (EC, Som) U.S. Pat. 3,548,233; December 15, 1970

Lead Assembly Structure for Semiconductor Devices—S. L. Starger (EC, Som) U.S. Pat. 3,553,828; January 12, 1971

Electronic Components

Method of making Photo-emissive electron tubes—R. M. Matheson, F. A. Helvy (EC, Lanc) U.S. Pat. 3,536,526; December 7, 1970

Method for making cathode assembly for electron tube—P. L. Nestleroth, W. H. Silvers (EC, Lanc) U.S. Pat. 3,535,757; December 7, 1970

Method of evacuating and sealing a glass envelope containing a photoconductive device—A. D. Eyster, J. F. Heagy (EC, Lanc) U.S. Pat. 3,536,462; December 7, 1970

Method for preparing cathode—A. Month (EC, Lanc) U.S. Pat. 3,536,526; December 7, 1960

Metallization of Titanate Wafers—W. H Liederbach, L. Pessel (EC, Som) U.S. Pat. 3,554,637; January 12, 1971

Self-Correcting Shift Counter—R W. Ahrons (EC, Som) U.S. Pat. 3,555,249; January 12, 1971

Electrical Circuits—A. L. Limber (EC, Som) U.S. Pat. 3,555,309; January 12, 1971

Graphic Systems Division

Programmed Method for Manipulating Electronic Fonts in Electronic Photocomposition Systems—P. E. Justus, T. A. Korn (GSD. Dayton) U.S. Pat. 3,546,681; December 8, 1970

Government Communications Systems Division

High Voltage Wide Band Amplifier—L. P. Dague (GCS, Camden) U.S. Pat. 3,546,-611; December 8, 1970

Low Power, High Stability Digital Frequency Synthesizer—E. D. Menkes (GCS, Camden) U.S. Pat. 3,546,618; December 8, 1970

Vertical and Horizontal Aperture Equalization—R. A. Dischert, W. J. Cosgrove, R. R. Brooks (GCS, Camden) U.S. Pat. 3,546,372; December 8, 1970

Burst Flag Generator—J. F. Monoahan (GCS, Camden) U.S. Pat. 3,546,602; December 8, 1970

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Thyristor Control Circuit Using D.C. Controllable Triggering Means—W. R. Walters (GCS, Camden) U.S. Pat. 3,551,787; December 29, 1970

Laboratories

Electrophotographic Method and Apparatus—R. G Olden (Labs, Pr) U.S. Pat. 3.549,251; December 22, 1970

Input and Output Emitter-Follower CML Circuitry—H. R Beelitz (Labs, Pr) U.S. Pat. 3.549,899; December 22, 1970

Photochromic Memory in Which Memory Memory Location is Selectively Heated During Write Cycle—G. A. Alphonse, A. Akselrad (Labs, Pr) U.S. Pat. 3.550,096; December 22, 1970

Transfer System for Cryogenic Liquids—A. Harel (Labs, Pr) U.S. Pat. 3,529,429; September 22, 1970

Semiconductor Laser Logic Apparatus—R. H. Cornely (Labs, Pr) U.S. Pat. 3,546,-495; December 8, 1970

Sequential Information Hologram Record—D. L. Greenaway, H. J. Gerritsen (Labs, Pr) U.S. Pat. 3,545,834; December 8, 1970

Tunable Microstrip Band Pass Filter Utilizing Syromagnetic Material at the Junction of Two Conductive Loops—C. P. Wen (Labs, Pr) U.S. Pat. 3,546,637; December 8, 1970

Process of Thermoplastic Deformation Imaging—N. E. Wolff (Labs, Pr) U.S. Pat. 3,547,628; December 15, 1970

Dark Trace Cathode Ray Tube with Photochromic Imege Screen—Z. J. Kiss (Labs, Pr) U.S. Pat. 3,548,236; December 15, 1970

Control of Optical Properties of Materials with Liquid Crystals—G. H. Heilmeier (Labs, Pr) U.S. Pat. 3.551,026; December 29, 1970

Alternating Current Driven Load Circuit—L. A. Zanoni (Labs, Pr) U.S. Pat. 3.551,-689; December 29, 1970

Clock Logic Circuits—J. R. Burns, J. J. Gibson (Labs, Pr) U.S. Pat. 3,551,693; December 29, 1970

Oscillating Voltage Range Indicator—G. W. Gray (Labs, Pr) U.S. Pat. 3,551,696; December 29, 1970

Semiconductor Laser Having High Power Output and Reduced Threshold—H. Nelson (Labs, Pr) U.S. Pat. 3,551,842; December 29, 1970

Process for Manufacturing Microminiature Electrical Component Mounting Assemblies—M. Caulton, R. D. Destefano, S. P. Knight (Labs, Pr) U.S. Pat. 3,554,-821; January 12, 1971

Professional Meetings

Dates and Deadlines

Be sure deadlines are met—consult your Technical Publications Administrator or your Editorial Representative for the lead time necessary to obtain RCA approvals (and government approvals, if applicable) Remember, abstracts and manuscripts must be so approved BEFORE sending them to the meeting committee

Calls For Papers

AUG. 17, 18, and 19, 1971: **High Frequency Generation and Amplification—Devices and Applications,** Cornell University, Ithaca, New York, School of Electrical Engineering, Cornell University, The office of Naval Research In cooperation with: IEEE, Circuit Theory Group, Electron Devices Group, Microwave Theory and Techniques Group. **Deadline info: (abst) 5/1/71 three copies single spaced to:** Professor Lester F. Eastman. Program Chairman. School of Electrical Engineering, Cornell University, Phillips Hall. Ithaca, New York 14850.

AUG. 23-28, 1971: **European Microwave Conference,** Royal Inst. of Tech., Stockholm, Sweden, G-MTT, Region 8, Swedish Acad. of Engrg. Sci. IEE, et al. **Deadline info: (syn) 3/1/71 (abst) 7/15/71 to:** H. Steyskal, Euripean Microwave Conf., Fac 23. 104 50 Stockholm 80, Sweden.

AUG. 24-27, 1971: **Western Electronic Show & Convention,** San Francisco Hilton & Cow Palace, San Francisco. Calif., Region 6, WEMA, **Deadline info: (session proposals) 3/1/71 to:** WESCON Office, 3600 Wilshire Blvd., Los Angeles, Calif. 90005.

SEPT. 6-10, 1971: **London International Symp. on Network Theory,** City Univ., London, England, G-CT, IEEE UKRI Section, IEE, IERE, City Univ. coop. **Deadline info: (papers) 3/10/71 to:** G. S. Brayshaw. City Univ., St. John St., London E. C. 1 England.

SEPT. 7-10, 1971: **Conference on "Displays,"** Univ. of Loughborough, Loughborough, England, IEE, IEEE UKRI Section IERE et al. **Deadline info: (syn) 12/14/70 (papers) 4/1/71 to:** IEE, Savoy Place, London W.C. 2 England.

SEPT. 14-16, 1971: **Int'l Conf. on Engineering in the Ocean Environment,** Town & Country Hotel, San Diego, Calif., Oceanography Coordinating Comm. & San Diego Section. **Deadline info: (abst) 3/30/71 to:** Maurice Nelles, Bissett-Berman Corp., 3939 Ruffin Rd., San Diego, Calif. 92123.

SEPT. 19-23, 1971: **Joint Power Generation Technical Conference,** Chase Park Plaza Hotel. St. Louis. Missouri. IEEE Power Engrg. Society, ASME, ASCE participating. **Deadline info: (ms) 5/7/71 to:** R. L. Coit, Westinghouse Elec. Corp., Lester P. O., Philadelphia, Penna. 11913.

SEPT. 21-23, 1971: **Conference on Infra-Red Techniques,** Univ. of Reading. Reading. England, IERE, IEEE UKRI Section. IEE, Inst. of Phys. & Phys. Society. **Deadline info: (syn) 1/31/71 (papers) 4/30/71 to:** IERE. 8-9 Bedford Square, London W. C. 1 England.

SEPT. 27-30, 1971: **IEEE Power Engineering Society Tech. Conf. on Underground Distribution,** Cobo Hall & Hotel Pontchartrain, Detroit, Michigan, IEEE Power Engrg. Society. **Deadline info: (papers) 3/1/71 (abst) 9/30/70 to:** B. E. Smith, Virginia Elec. & Power Co., POB 1194, Richmond, Va. 23209.

OCT. 18-22, 1971: **Region 8 Convention (EUROCON),** Palais de Beaulieu, Lausanne. Switzerland. **Deadline info: (abst/sum) 4/1/71** to: Andreas Rannestad, Norwegian Def. Res. Est.. POB 25, N. 2007 Kjeller, Norway.

OCT. 25-29, 1971: **Jt. National Conference on Major Systems,** Disneyland Hotel. Anaheim, Calif., G-SMC, ORSA. **Deadline info: (abst) 1/1/71 (papers) 6/15/71 *to:*** F. J. Mullin, MS R3/2054, TRW, 1 Space Park, Redondo Beach, Calif. 90278.

NOV. 3-5, 1971: **Northeast Electronics Research & Engineering Meeting,** Sheraton Boston Hotel, War Mem. Aud., Boston, Mass. New England Sections. **Deadline info: 7/2/71 to:** IEEE Boston Office, 31 Channing St., Newton, Mass. 02158.

DEC. 7-9, 1971: **Vehicular Technology Conference,** Sheraton-Cadillac Hotel, Detroit, Michigan, G-VT. **Deadline info:** IEEE, 345 East 47th Street. New York, N.Y. 10017.

JAN. 30-FEB. 4, 1972: **IEEE Power Engineering Society Winter Meeting,** Statler Hilton Hotel. New York. N.Y., IEEE Power Engrg. Society. **Deadline info: (papers) 9/15/71 to:** IEEE, 345 East 47th Street, New York, N.Y. 10017.

APRIL 11-13, 1972: **Conf. on Industrial Measurement & Control by Radiation Techniques,** Univ. of Surrey. Guildford, Surrey, England. IEE. IERE. IPPS. IMC, IEEE, UKRI Section et al. **Deadline info: (syn) 6/21/71 (ms) 11/8/71 to:** IEE, Savoy Place, London W.C. 2 England.

JUNE 12-17. 1972: **1972 (5th) Congress of the International Federation of Automatic Control,** Paris. France. **Deadline info: (abst) 3/1/71 (ms) 7/15/71 to:** submit abstracts and pepers through AACC by sending them to one of the following individuals, any of whom can provide further information: **Applications:** Dr. Winston L. Nelson, Bell Telephone Labs., Inc.. Whippany, New Jersey 07981; **Bio Systems:** Dr. Ken Bischoff, School of Chemical Engineering, Cornell Univ., Ithaca, New York 14850; **Components:** Prof. George A. Etzweiler, Electrical Engineering Dept., Pennsylvania Stale University. University Park, Penna. 16802; **Education:** Prof. Stephen J. Kahne, Electrical Engineering Dept., University of Minnesota. Minneapolis, Minnesota 55455; **Space:** Dr. John A. Aseltine, 1617 Via Zurita, Palos Verdes Estates, California 90274; **Systems:** Prof. Herman R. Weed, Electrical Engineering Dept., Ohio State University. Columbus, Ohio 43210; **Theory:** Dr. Bernard Friedland, Singer-General Precision, Inc.. 1150 McBridge Avenue, Little Falls, New Jersey 07424.

AUG. 21-26, 1972: **13th International Congress of Theoretical and Applied Mechanics,** Moscow State University, Moscow. USSR. **Deadline info: (sum) 3/15/72 to:** Prof. G. K. Mikhailov, Leningradskii Prospekt 7, Moscow A-40.

Meetings

MARCH 1-3, 1971: **Int'l Symposium on Fault Tolerant Computing,** Huntington Sheraton Hotel, Pasadena, Calif., IEEE Computer Society. Jet Prop. Labs. of Cal. Tech. **Prog info:** W. C. Carter, IBM Research Ctr., Yorktown Heights, N.Y. 10598.

MARCH 1-3, 1971: **Particle Accelerator Conference,** Pick Congress Holel, Chicago, Illinois, G-NS, NBS et al. **Prog info:** L. C Teng, National Accelerator Lab.. Box 500, Batavia, Illinois 60510.

MARCH 10-12, 1971: **AIAA 6th Aerodynamic Testing Conference,** Albuquerque, N. Mex. **Prog info:** AIAA, 1290 Ave. of the Americas, New York, N.Y. 10019.

MARCH 15-17, 1971: **AIAA Space Shuttle Development Testing and Operations Conlerence,** Phoenix, Ariz. **Prog info:** AIAA, 1290 Ave. of the Americas. New York, N.Y. 10019.

MARCH 22-25, 1971: **IEEE International Convention & Exhibition,** Coliseum & N.Y. Hilton Hotel. New York. N.Y. **Prog info:** J. H. Schumacher, IEEE, 345 E. 47th St., New York, N.Y. 10017.

MARCH 31-APRIL 2, 1971: **Reliability Physics Symposium,** Stardust Hotel, Las Vegas. Nev., G-R. **Prog info:** O. D. Trapp, Fairchild Semiconductor. 464 Ellis St., Mountain View. Calif. 94040.

APRIL 5-6, 1971: **Southeastern Symposium on System Theory,** Georgia Inst. of Tech., Atlanta, Georgia, IEEE Computer Society, G-AC, Georgia Tech. **Prog info:** C. O. Alford, School of EE. Georgia Institute of Tech.. Atlanta, Ga. 30332.

APRIL 5-6, 1971: **Rubber & Plastics Ind, Technical Conference,** Holiday Inn, Akron, Ohio. G-IGA, Akron Section. **Prog info:** Chet Blumenauer, Uniroyal Inc., 154 Grove St., Chicopee Falls, Mass. 01021.

APRIL 7-10, 1971: **USNC/URSI-IEEE Spring Meeting,** Statler Hilton Hotel, Washington, D.C.. USNC/URSI, 6 IEEE Groups cooperating. **Prog info: IEEE**, 345 East 47th Street, New York. N.Y. 10017.

APRIL 12-15, 1971: **National Telemetering Conference,** Washington Hilton Hotel, Washington. D.C., G-AES, G- Com-Tech. **Prog info:** H. B. Riblet, Johns Hopkins Univ., 8621 Georgia Ave., Silver Spring, Md. 20910.

APRIL 13-15, 1971: **Conference on Frontiers in Education,** Quality Hotel Central, Atlanta, Georgia. G-Education, G-MMS. ASEE. Atlanta Section. **Prog info:** W. L. Hughes. Oklahoma State Univ., Stillwater, Oklahoma 74074.

APRIL 13-15, 1971: **Symposium on Applications of Walsh Functions,** Naval Research Lab., Washington, D.C., G-EMC participating, NRL, Univ. of Maryland. **Prog info:** H. F. Harmuth, Dept. of EE, Univ. of Maryland, College Park, Md. 20742.

APRIL 13-16, 1971: **International Magnetics Conference,** Denver Hilton Hotel, Denver, Colorado. G-MAG. **Prog info:** Geoffrey Bate. IBM Corp., Boulder, Colorado 80302.

APRIL 19-20, 1971: **Power Conditioning Specialists Conference.** Jet Propulsion Lab., Pasadena, Calif., G-AES. **Prog info:** IEEE, 345 East 47th Street, New York, N.Y. 10017.

APRIL 19-21, 1971: **AIAA/ASME 12th Structures, Structural Dynamics, and Materials Conference,** Anaheim, Calif. **Prog info:** AIAA, 1290 Ave. of the Americas, New York, N.Y. 10019.

APRIL 19-21, 1971: **Off-Shore Technology Conference,** Astrohall, Houston, Texas, TAB Oceanography Coordinating Committee et al. **Prog info:** H. S. Field, Geophysical Res. Corp., 136 Mohawk Blvd., Tulsa, Oklahoma 74106.

APRIL 19-22, 1971: **Israel Convention of Electrical & Electronics Engineers,** Tel-Aviv Fair Grounds & Sheraton Hotel, Tel-Aviv, Israel. IEEE Israel Section et al. **Prog info:** IEEE, 345 East 47th Street, New York, N.Y. 10017.

APRIL 20-21, 1971: **Electric Process Heating in Industry Technical Conference,** Pfister Hotel. Milwaukee, Wisconsin, G-IGA, Milwaukee Section **Prog info:** Fred Pyecroft, Phila. Elec. Co., 211 S. Broad St., Phila., Penna. 19105.

APRIL 21-23, 1971: **AAS/AIAA Variable Geometry of Expandable Structures Conference,** Anaheim, Calif. **Prog info:** AIAA, 1290 Ave. of the Americas, New York, N.Y. 10019.

APRIL 24-29, 1971: **73rd Annual Meeting & Exposition,** Conrad Hilton Hotel, Chicago, Ill. **Prog info:** The American Ceramic Society, Inc., 4055 North High St., Columbus, Ohio 43214.

APRIL 26-28, 1971: **Region III Technical Convention,** Univ. of Virginia. Charlottesville, Virginia, Region III. **Prog info:** E. W Hutton. General Elec. Co, Waynesboro. Va. 22980.

APRIL 26-28. 1971: **AIAA 6th Thermophysics Conference,** Tullahoma. Tenn. **Prog info:** AIAA, 1290 Ave of the Americas. New York, N.Y. 10019.

APRIL 26-28, 1971: **Conf. on the Management of Transmission & Distribution Systems,** London, England, IEE, IEEE UKRI Section. **Prog. info:** IEE, Savoy Place, London, W.C. 2 England.

APRIL 26-28, 1971: **Region III Technical Convention,** Univ. of Virginia, Charlottesville, Virginia. Region III. **Prog info:** E. W. Hutton. General Elec. Co.. Waynesboro, Va. 22980.

APRIL 26-29, 1971: **ASME/AIAA Habitability in Space Stations Meeting,** Houston. Texas. **Prog info:** AIAA, 1290 Ave of the Americas, New York, N.Y. 10019.

APRIL 28-30, 1971: **Southwestern IEEE Conference & Exhibition,** Rice Hotel, Albert Thomas Conv. Ctr., Houston, Texas, SWIEEECO, Houston Section. **Prog info:** D. R. Williams, Dept. of EE, Univ. of Houston, Houston, Texas 77004.

MAY 3-6, 1971: **Ind. & Comm. Power Sys. & Elec. Space Heating & Air Conditioning Jt. Technical Conference,** Detroit Hilton Hotel. Detroit, Michigan. G-IGA, S. E. **Prog info:** T. L. Schaller, Allen-Bradley Co., 1491 N. Harding St., Indianapolis, Indiana 46207.

MAY 4-5, 1971: **Appliance Technical Conference,** Sheraton Chicago Hotel, Chicago, Illinois, G-IGA, Chicago Section. **Prog info:** Vic Petchul, Dana Chase Pub. Inc. York St. at Park Ave., Elmhurst, Ill. 60126.

MAY 10-12, 1971: **Electronic Components Conference,** Statler Hilton Hotel, Washington. D.C.. G-PMP. EIA. **Prog info:** E. Moss, Mallory Capacitor Co., 3029 E. Washington St., Indianapolis, Ind. 46206.

MAY 10-12. 1971: **AIAA Joint Strategic Missile Sciences Meeting** (Classified Secret), U.S. Naval Academy. Annapolis, Maryland. **Prog info:** General Chairman, Dr. Richard Hartunian, Aerospace Corp., 1111 Mill Street, San Bernardino, Calif. 92408.

MAY 11-13, 1971: **Sixth Region Technical Conference,** Woodlake Hotel, Sacramento, Cal., Region 6, Sacramento Sect. **Prog info:** Ronald Soohoo. Univ. of Calif., Dept. of EE, Davis. Calif. 95616.

MAY 12-14, 1971: **Electron, Ion, and Laser Beam Technology Conf.,** Univ. of Colorado, Boulder, Colorado, G-ED. AVS et al. **Prog info:** IEEE, 345 East 47th Street, New York, N.Y. 10017.

MAY 16-20, 1971: **International Microwave Symposium,** Marriott Twin Bridges Motor Hotel, Washington. D.C., G-MTT. **Prog info:** R. V. Garver, Harry Diamond Labs, Conn. & Van Ness St.. Washington, D.C. 20438.

MAY 17-19, 1971: **Aerospace Electronics Conference,** Sheraton Dayton Hotel, Dayton, Ohio, G-AES, Dayton Section. **Prog info:** IEEE Dayton Office, 124 E. Monument Ave., Dayton, Ohio 45402.

MAY 17-20, 1971: **Spring Joint Computer Conference,** Convention Ctr, Atlantic City, New Jersey, IEEE Computer Society, AFIPS. **Prog info:** AFIPS Hdqs., 210 Summit Ave., Montvale, New Jersey 07645.

MAY 24-26, 1971: **IEEE Power Engineering Society Power Industry Computer Applications Conference,** Statler Hilton Hotel, Boston, Mass., IEEE Power Engrg. Society. **Prog info:** P. L. Dandeno, Hydro Elec. Pwr. Comm. of Ontario, 620 University Ave., Toronto. Ont. Canada.

MAY 25-27, 1971: **AIAA 1st Annual Urban Technology Meeting and Technical Display: "Cities—1976",** New York Coliseum, New York, N.Y. **Prog info:** Dr. Herbert Fox, Chairman, New York Section AIAA, Chairman, Dept. of Aero/Mech Technology. New York Institute of Technology, Old Westbury, N.Y.

JUNE 1-3, 1971: **Electrical & Electronic Measurement & Test Instrument Conference (EEMTIC),** Skyline Hotel, Ottawa, Ontario, Canada, G-IM, Ottawa Section. **Prog info:** F L. Hermach, B-162 Metrology Bldg, NBS, Washington, D.C. 20234.

JUNE 2-4, 1971: **Conference on Laser Engineering & Applications,** Washington Hilton Hotel, Washington. D.C., IEEE Quantum Elec. Council, OSA. **Prog info:** D. E. Caddes, Sylvania Elec. Sys., Electro-Optics Organ., Mountain View, Calif.

JUNE 7-8, 1971: **Chicago Spring Conf. on Broadcast & TV Receivers,** Marriott Motor Hotel, Chicago, Illinois, G-BTR, Chicago Section. **Prog info:** Donald Ruby. Zenith Radio Corp., 6001 W. Dickens Ave., Chicago, Ill. 60639.

JUNE 7-8, 1971: **Symposium on Applications of Ferro-electrics,** IBM Res. Ctr.. Yorktown Hgts. N.Y. & Holiday Inn, White Plains, N.Y., G-SU. **Prog info:** L. E. Cross, Penn. State Univ., State College, Penna. 16802.

JUNE 8-10, 1971: **Conference on Aerospace Antennas,** London, England, IEE, IERE. IEEE UKRI Section. **Prog info:** IEE, 2 Savoy Place, London W.C. 2 England.

JUNE 14-16, 1971; **International Conference on Communications,** Queen Elizabeth Hotel, Montreal, Quebec, Canada, G-Com Tech. Montreal Section. **Prog info:** W C. Benger. Northern Elec. Co. Ltd.. POB 3511, Station C., Ottawa 3, Ontario, Canada.

JUNE 14-18, 1971: **AIAA 7th Propulsion Joint Specialist Conference,** Salt Lake City. Utah. **Prog info:** AIAA, 1290 Ave. ol the Americas. New York, N.Y. 10019.

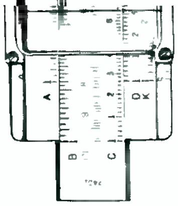
JUNE 21-23, 1971: **AIAA 4th Fluid and Plasma Dynamics Conference,** Cabana Hyatt House, Palo Alto, Calif. **Prog info:** Arnold Goldburg, Head, Flight Sciences Laboratories, P.O. Box 3981, Seattle, Washington 98124.

JUNE 27-JULY 1, 1971: **Design Automation Workshop,** Shelburne Hotel, Atlantic City, New Jersey, IEEE Computer Society, ACM, SHARE. **Prog info:** R. B. Hitchcock, Sr., IBM, Box 218, Yorkstown Hgts., N.Y. 10598.

JULY 5-8, 1971: **8th International Shock Tube Symposium,** London, England. **Prog info:** AIAA. 1290 Ave. of the Americas, New York, N.Y. 10019.

Call for Educational Exhibits

AUG. 25-27, 1971: **1971 IEEE International Geoscience Electronics Symposium,** Washington, D.C., Geoscience Electronics Group of the IEEE. **Deadline info:** Individuals and companies are invited to submit a comprehensive description of exhibits demonstrating Geoscience Electronics Hardware no later than 1 April 1971. Any supporting information, such as illustrations, can be submitted with the description to aid the committee in making their selection to: Mr. Charles F Getman, Exhibits Chairman, 1971 IEEE International Geoscience Electronics Symposium, U.S. Naval Oceanographic Office, Engineering Services Division, Washington, D.C. 20390.



Engineering News and Highlights

A. N. Curtiss

N. L. Laschever

F. H. Krantz

A. N. Curtiss to Retire

Arthur N. Curtiss, Staff Vice President, Administration Research, and Engineering is retiring after 40 years with RCA. Mr. Curtiss was appointed Staff Vice President, Administration, RCA Laboratories in 1961. He is also a Director of RCA Research Laboratories, Inc., RCA's research facility in Japan. Mr. Curtiss joined RCA in 1930. He held a succession of engineering positions at Camden, N.J. and Indianapolis, Ind. In 1950, Mr. Curtiss was named Plant Manager of RCA's then newly established manufacturing facility at Los Angeles; in 1956, became General Manager. Mr. Curtiss received the BSEE from the University of Pittsburgh in 1927. He did graduate work in Engineering at the University of Pittsburgh, University of Pennsylvania, and Purdue University, and in Business Administration at UCLA. The recipient of an RCA Award of Merit in 1955, Mr. Curtiss has written a number of technical articles on radio, audio, and radar; and he has been issued four U.S. patents. He is a Fellow of the IEEE and holds membership in many professional, industrial, and educational associations. He is a Registered Professional Engineer in New Jersey.

Paul Bennett Retires

Paul R. Bennett of Communications Systems Division, Meadowlands, Pa., has retired after 32 years with RCA. Mr. Bennett attended Bliss Electrical School and Rensselaer Polytechnic Institute from 1927 to 1931. In 1939, he joined RCA's International Division in Buenos Aires, Argentina, as Chief Engineer. In late 1943, Mr. Bennett engaged in defense work at Camden, N.J. until 1945. He then was responsible for design of a Home Instrument line for the RCA International Division. In 1955, he transferred to Domestic Radio and Phonograph Engineering and later became Manager of Product Design. During this period, he served as Editorial Representative on the *RCA Engineer*. In 1960, he transferred to RCA Mobile Engineering in Canonsburg and later to Meadowlands. In 1967, he transferred to the Base Station and Systems Design Group.

Laschever is named Chief Engineer, Aerospace Systems Division

J. R. McCallister, Division Vice President and General Manager, Aerospace Systems Division, recently named **Norman L. Laschever,** Chief Engineer, Aerospace Systems Division. Mr. Laschever replaces **Fred Krantz** who was recently appointed to the post of Division Vice President and General Manager, Electromagnetic and Aviation Systems Division.

Mr. Laschever received the BSEE from Massachusetts Institute of Technology in 1940 and the MSEE from Northeastern University in 1970.

From 1946 to 1955, Mr. Laschever was employed by the United States Air Force at Wright Patterson Air Force Base, Ohio, with responsibility for USAF fighter and helicopter Doppler navigation programs and design of advanced communication equipment. From 1955 to 1962, he was associated with the Laboratory for Electronics, first as Manager of the Navigation Laboratory and, later, as Manager of the Technical Staff Office. He also served as Assistant Director of Research Engineering. In January 1962, Mr. Laschever joined RCA as a member of the Chief Engineer's Technical Staff and then was made Manager of RF Engineering, Aerospace Systems Division, with responsibility for the radar and electronic warfare (EW) product lines of ASD. Mr. Laschever is a member of Eta Kappa Nu and a Senior Member of IEEE.

P. R. Bennett

Krantz is new Division VP for EASD

Irving K. Kessler, Executive Vice President, Government and Commercial Systems, has appointed **Frederick H. Krantz,** Division Vice President and General Manager, Electromagnetic and Aviation Systems Division.

Mr. Krantz received the BSEE from Drexel Institute, Philadelphia, and the MSEE from the University of Pennsylvania. Mr. Krantz joined RCA in January 1968 as Manager of the Command and Control Program Management Office at ASD. In January, 1969, he was appointed Chief Engineer, Aerospace Systems Division. Before joining RCA, Mr. Krantz was associated with IBM, Burroughs Corp., and Leeds and Northrup Co. He is a member of the IEEE and holds several U.S. Patents.

Harry R. Wege Engineering Library Opened

The Harry R. Wege Engineering Library of the Missile and Surface Radar Division was recently opened. The library is named in honor of Harry R. Wege, a former RCA Vice President, whose 43 years of service to RCA included the founding of the Moorestown plant. The Library, maintained by the Engineering Department, will service personnel engaged in the design of radar and associated electronic equipment. However, personnel working in various major disciplines, including business administration, will also find useful materials.

More metrics

Mr. McKee's article on "Metrication" which appeared in the Dec. 1970, Jan. 1971 issue of the *RCA Engineer* sparked a great deal of reader interest. One letter, from Mr. H. R. L. Lamont, Director, European Technical Relations, pointed out that an interesting handbook is available to anyone who wants more information on metrication. The book, *International System of Units* (SI), National Bureau of Standards Special Publication No. 330, can be obtained from the Superintendent of Documents, Washington, D.C., 20402; the price is 50 cents.

Staff Announcements

Computer Systems

RCA's Information Systems operations has undergone a major realignment; it will now be known as RCA Computer Systems. The changes entail the consolidation of management, financial, administrative, and planning functions of the operation divisions which formerly comprised the company's Information Systems group and the formation of two new divisions, a new staff group and a new manufacturing organization.

The newly structured organization consists of five operating divisions—Data Processing, Systems Development, Graphic Systems, Memory Products and Magnetic Products. In addition, it has a Computer Systems Staff group and a Systems Manufacturing organization.

The Computer Systems organization is headed by **L. E. Donegan, Jr.**, who on January 6 was elected Vice President and General Manager, Computer Systems, by the RCA Board of Directors.

Mr. Donegan announced these management assignments in the Computer Systems organization, all of whom will report to him:

Joseph W. Rooney is President of the newly formed Data Processing Division. Mr. Rooney was Division Vice President, Marketing, of the former Computer Systems Division.

V. Orville Wright is President of the newly formed Systems Development Division. He was Division Vice President, Government Marketing, for the former Computer Systems Division.

John R. Lenox is Division Vice President, Systems Manufacturing. He was Division Vice President, Manufacturing, for the former RCA Computer Systems Division.

W. William Acker, is Division Vice President, Computer Systems Staff. He also is acting General Manager of the Graphic Systems Division. Mr. Acker was previously Division Vice President, Finance and Administration, of the former Computer Systems Division.

H. H. Jones is Division Vice President and General Manager, Magnetic Products Division. The unit manufactures computer tapes and magnetic discs as well as a variety of audio and video magnetic tapes in plants in Indianapolis, Ind., and Bryn Mawr, Wales. Mr. Jones was Division Vice President, Finance, for the former RCA Information Systems.

Steven P. Marcy continues as Division Vice President and General Manager of the Memory Products Division. The unit designs and manufactures computer memories for RCA and a number of other computer manufacturers. It is headquartered in Needham, Mass.

M. William Friis continues as Manager, News and Information, RCA Computer Systems.

Data Processing Division

Joseph W. Rooney, President, Data Processing Division has announced the organization of Data Processing as follows: **James P. Boyle,** Division Vice President, Northeastern Region; **John B. Burke,** Manager, Personnel; **Michael E. Heisley,** Division Vice President, Western Region; **John A. Hunter,** Administrator, Marketing Projects; **Howard W. Johnson;** Division Vice President, Field Engineering; **Paul H. McNamara,** Division Vice President, Central Region; **Larry E. Reeder,** Division Vice President, Data Processing Administration and Planning; **Joseph W. Rooney,** Acting Division Vice President, Government Marketing; **Joseph W. Rooney,** Acting Division Vice President, Marketing Operations; **Walter G. Cleveland,** Manager, Industry Marketing; **Robert J. Goethals,** Division Vice President, Advertising and Sales Promotion; **E. Allen Henson,** Division Vice President, Conversion Programs; **James N. Landon,** Division Vice President, Marketing Programs; **Loren R. Watts,** Division Vice President, Eastern Region.

Corporate Engineering Services

A. Robert Trudel, Director, Corporate Engineering Services, has appointed **Avrel Mason** Staff Advisor, Corporate Engineering Services.

Professional Activities

Astro-Electronics Division

G. Barna has been appointed Chairman of the American Institute of Aeronautics and Astronautics Technical Committee on Sensors.

Consumer Electronics

William H. Liederbach, Manager, Ceramic Circuit Engineering, has been elected chairman of the Indiana Section of the International Society for Hybrid Microelectronics. Mr. Liederbach is also Program Chairman for the 1971 International Hybrid Microelectronics Symposium to be held in Chicago, October 11-13, 1971. The title of the symposium is "One World of Microelectronics" (abstract deadline is March 1, 1971). Mr. Liederbach is also a member of the planning committee for the "Midwest Electronics Materials Symposium" to be held at Notre Dame University on June 4, 1971. The symposium is co-sponsored by the Indiana and Michigan Sections of the American Ceramic Society and the Indiana Chapter of the International Society for Hybrid Microelectronics.

Patents and Licensing

Dr. George H. Brown, Executive Vice President, recently spoke at Young Engineer's Night at the Engineers Club of Philadelphia. The topic of Dr. Brown's speech was "Engineers: What Can You Do for Society."

Missile and Surface Radar Division

Merrill W. Buckley, Jr., Administrator, Planning and Management, recently addressed two Philadelphia Sections of the IEEE at the University of Pennsylvania. Mr. Buckley's speech dealt with "Using Modern Systems Analysis and the Computer for Business Planning and Management Problem Solving."

Degree granted

Piero G. Ruffinengo, of the Aviation Equipment Department, Electromagnetic and Aviation Systems Division, has been awarded the MS in Operations Research/Large Scale Engineering Systems by the UCLA School of Engineering.

Continuing Engineering Education

BTSS Course

An elementary course in RCA's Basic Time Sharing System (BTSS) was recently presented at RCA Laboratories by **R. J. Beshinske.** The twenty-seven-hour course included sessions on introduction to computers, the Basic Time Sharing System, Fortran PI programming language, and /E, the test editor. The course was video taped and will be reshown in 1971 as soon as the course notes are complete.

Continuing engineering education course presentation

In response to numerous inquiries concerning RCA's Continuing Engineering Education Program, a two-day "open house" presentation of sample CEE tapes and instructional materials was held at the RCA Laboratories during December. More than 130 of those who attended expressed an interest in one or more of the available courses, and the most popular of these will be selected as the initial course offerings at the Laboratories.

H. C. Horton, Manager of Consumer Electronics Technical Services, receives a plaque from L. M. Krugman, Vice Chairman, IEEE, Central Indiana. The award cited RCA Consumer Electronics contributions to the advancement of Engineering education for the second consecutive year.

Promotions

Missile and Surface Radar Division

J. Ervin from Ldr., Engrg. Sys. Proj. to Mgr., Advanced Production Engrg. (R. V. Donato, Advanced Production, Moorestown)

M. G. Herold from "A" Engineer to Ldr., Des. & Dev. Engrs. (M. Korsen, Information Processing Equipment, Moorestown)

D. Herman from "A" Engr. to Ldr., Engrg. Sys. Projects (J. C. Volpe, MFAR Software Interface, Moorestown)

D. E. Simon from Member Prog. Mgmt. Staff to Mgr., Div. Program (J. M. Seligman, Lightweight Tactical Systems Programs, Moorestown)

D. L. Williams from Member Prog. Mgmt. Staff to Mgr., Long-Range Planning (H. G. Stewart, Advanced Planning, Moorestown)

Electromagnetic and Aviation Systems Division

S. Ehrlich from Sr. Mbr., D&D Engrg. Staff to Ldr., D&D Engrg. Staff (J. MacFarlane, Van Nuys)

Astro-Electronics Division

P. Holtzman from Engr. to Mgr., Signal Processes & Digital Engineering (J. Baumunk, Hightstown)

W. Lindorfer from Sr. Engr. to Mgr., Spacecraft Preliminary Design (M. Cohen, Hightstown)

A. Martz from Sr. Engr. to Mgr., Sys. Engrng. (E. Walthall, Hightstown)

P. Nekrasov from Sr. Engr. to Mgr., Space Power (E. Goldberg, Hightstown)

Solid State Division

H. A. Hansen from Mgr. Quality & Reliability Assurance to Mgr., Mfg. & Prod. Engrg. (H. A. Uhl, Integrated Circuits—Assembly & Test, Findlay)

R. C. Reutter from Engrg. Ldr., Mfg. to Mgr., Mfg. & Prod. Engrg. (H. A. Uhl, Integrated Circuits—Wafer Prep, Findlay)

J. D. Young from Engr., to Engrg. Ldr., Mfg. (R. E. Davey, Signal Discrete Products, Findlay)

Electronic Components

M. M. Bell from Mgr. Mech'l. & Elec'tl. Eqpt. Design to Mgr. Equip. Design and Development (J. T. Cimorelli, Harrison)

W. F. Blydenburgh from Engr., Equipment Develop. to Engrg. Ldr., Equipment Develop. (M. M. Bell, Harrison)

J. J. Carroll from Mgr., Q&RA-Power Devices to Mgr., Q&RA (Mgr., Quality & Reliability Assurance—Industrial Tube Division, Lancaster)

R. A. Jeuch from Engr., Prod. Develop. to Engrg. Ldr., Prod. Develop. (Mgr., Regular Power & Laser Operations, Lancaster)

C. A. Mannon from Engr., Mfg. to Engrg. Ldr., Mfg. (Mgr., Q&RA—ITD, Lancaster)

D. C. Reed from Adm., Q & R Sys. Engrg. to Mgr., Q & R Sys. Engrg. (Mgr., Quality and Reliability Assurance—Industrial Tube Division, Lancaster)

R. H. Zachariason from Mgr., Chemical & Physical Lab., to Mgr., Color Product Engrg. (Mgr., Engrg. Dept.. Lancaster)

RCA Service Company

D. W. Dunkle from Engr. to Mgr., Facilities (E. J. Lauden, Andros Ranges, AUTEC Project, Bahamas)

R. A. Hughes from Engr. to Mgr., Range Support (L. R. Whitehead, Operations AUTEC Project Andros Island Bahamas)

M. R. Peddicord from Sys. Service Engr. to Ldr., Sys. Service Engrs. (H. Chadderton, Computer Systems Oper., Washington)

Computer Systems Division

J. C. Mayer from Principle Member, Tech. Staff to Ldr., Technical Staff (D. F. Wright, Marlboro)

J. M. Murray from Engrg. Design Coordinator to Ldr., Design Automation Processing (S. J. Pelish, Marlboro)

T. J. Piacenza from Engrg. Design Coordinator to Ldr., Design Automation Processing (S. J. Pelish, Marlboro)

G. Steele from Principle Member, Technical Staff to Ldr., Technical Staff (C. C. Eckel, Marlboro)

C. V. Tateosian from Mgr. Engrg. Admin. (Peripheral Engrg.) to Mgr., Engrg. Services (Design Automation) (J. W. Haney, Marlboro and Palm Beach Gardens)

E. J. West from Principle Member, Tech. Staff to Engrg. Scientists, Tech. Staff (C. C. Eckel, Marlboro)

David C. Crosby honored by Army for outstanding civilian service

One of the highest honors granted by the U.S. Army to a civilian was awarded today to **David C. Crosby,** Manager of Quality -Improvement for RCA, Camden, N.J.

At a ceremony in the Pentagon, Mr. Crosby was presented with the Army's Outstanding Civilian Service Award for his exceptional contributions to the Army Zero Defects Program. Lt. General John M. Wright, Comptroller of the Army, made the presentation.

The award is given only to civilians not employed by the Army and ranks second to the rarely bestowed Decoration for Distinguished Civilian Service.

Awards

Aerospace Systems Division

Ernest A. LeBlanc of RF Engineering, has been selected as Engineer of the Month for November for his work on the IGW Acoubuoy, Spikesid, and Command Microphone programs.

Dr. W. Roger L. Thomas of Electro-Optics and Controls Engineering has been selected as Engineer of the Month for December 1970 for his leadership in the newly developing technology of thin-film infrared monolithic solid-state arrays and their application to remote sensing.

The team of **Ronald P. LeBlond, James B. Lynch, Paul M. MacLean, A. Richard Miles, Ricardo B. Simonelli, Theodore Singer,** and **Amy C. Spear** from Systems Design Support was selected for a Team Award for November for its work on the first LCSS Master File for the Army Missile Command. The LCSS Master File is the first phase of a Product Assurance Information System (PAIS) for LCSS which will provide the Army with a means of monitoring LCSS performance on a continuous and timely basis to assess operational readiness of weapons systems, identify problem areas, and initiate effective corrective action.

The team of **Kenneth R. Andrews, Raymond T. Boyle, A. Joseph Burwell, Priscilla T. Harding, John F. MacQuilken, Herbert W. Silverman,** and **Martin M. Wienshienk** from Data Systems Development Engineering has been selected for a Team Award for December 1970 for its performance on the Factory Test Automation (FTA) Program. The FTA is a system in which the in-plant Spectra 70/45 is used to control an Analog Test Set in the factory.

Communication Systems Division

Michael H. Riddle of Recording Equipment Operation, Government Communications Systems, has received a Technical Excellence Award. Mr. Riddle recognizing his many contributions to the AN/GSH-32 Video Disc Recorder program. Mr. Riddle was instrumental both in acquiring this program and carrying it to a successful conclusion.

Electronic Components

Edward E. Bliss has been selected for an Engineering Recognition Award for the year ending December 1970. His achievements include design improvements of the Microwave Integrated Circuit jammer module. His technical excellence is demonstrated by his use of the computer to calculate, from measured data, the adjustments necessary to obtain phase reproducibility.

Richard J. Rodrick has been selected for an Engineering Recognition Award for the year ending December 1970. His technical accomplishments include the resolution of the heat transfer problem with the 4070/71 oscillator/amplifier in the APX-72 military transponder, and the electrical optimization of the amplifier cavity for increased efficiency.

RCA Personnel Help Counsel Jobless Engineers

Recent figures show that approximately 2,000 of the 5,000 Delaware Valley engineers and scientists affected by the massive job layoffs in the nation's aerospace industry are still without jobs.

RCA engineers and executives, in conjunction with the American Institute of Aeronautics and Astronautics and the U.S. Department of Labor, are participating a no-charge series, "Workshops on Professional Employment."

During January and February, two workshops (three sessions each) were held at the RCA Moorestown Plant; other workshops have been conducted in several Delaware Valley Plants.

The workshops are aimed at assisting unemployed engineers and scientists, regardless of prior affiliation or discipline, to find employment in comparable positions.

Thomas G. Greene, Administrator, Publications and Presentations, and Chairman of the Greater Philadelphia Section AIAA and the workshop committee, said 80 persons signed up for the first program held at RCA.

At each session, counselors work with small groups of five or six engineers to provide constructive suggestions and advice.

Representatives from the local office of the N.J. Training and Employment services spoke at each of the sessions. The following RCA Moorestown personnel acted as counsellors: **George S. Black,** Leader, D&D Engineering; **Richard E. Gorkes,** Manager, Engineering Adm, **Thomas G. Greene,** Administrator, Publications and Presentations; **Donald J. Iannettoni,** Administrator, G&CS Employment and Benefits; **Martin Korsen,** Manager, Product Design; **Stanley J. Macko, Administrator,** Technical Projects Coordination; **Dr. Thomas Martin,** Leader, Systems Engineering; **William Miles,** Human Resource Analyst; **Jerry K. Milligan, Manager,** Resources Services; **Bernard Orzechowski,** Principal Member of Engineering Staff; **William S. Perecinic,** Manager, Product Design; **William T. Strenger,** Administrator, Laboratory Coordinator; **Dr. Todd T. Reboul;** Staff Technical Advisor; **Sidney Robinson,** Administrator, Value Engineering; and **Barry Tuft,** Personnel Training.

T. G Greene

Newly appointed Editorial Representatives for Consumer Electronics Division, Indianapolis. Left to right are: (seated) E. E. Janson, W. H. Liederbach, R. J. Buth, C. W. Hoyt; (standing) F. R. Holt, J. Stark, R. C. Graham.

New Editorial Board at Consumer Electronics

Clyde Hoyt, Technical Publications Administrator and Chairman of the Editorial Board. Consumer Electronics Division, Indianapolis, Ind., has announced several new Editorial Representative appointments; these are **R. Buth,** Engineering; **F. Holt,** Advanced Development; **E. Janson,** Black and White TV Engineering; **W. Liederbach,** Ceramic circuits Engineering; and **J. Stark,** Color TV Engineering. **R. C. Graham,** remains as Editorial Representative for Radio Engineering.

Mr. Hoyt, as Technical Publications Administrator, is responsible for review and approval of technical papers; for coordinating the technical reporting program; and for promoting the preparation of papers for the *RCA Engineer* and other journals, both internal and external.

The Editorial Representatives are responsible for planning and processing articles for the *RCA Engineer*, and for supporting the corporate-wide technical papers and reports program.

Clyde W. Hoyt is a graduate of Morningside College and Iowa State University in Arts and Electrical Engineering. He has been actively engaged in many phases of Consumer Electronics Engineering; his work in television dates back to the introduction of the 630TS in 1946. In recent years he has been active in Consumer Electronics Staff and Managerial positions.

Ronald J. Buth received the BSEE from Evansville University in 1960 and the Doctor of Jurisprudence from Indiana University in 1967. Before joining RCA, he was employed by the Department of the Navy and was engaged in the design and manufacture of defense electronic systems. He also spent a period of time working for the Bendix Corporation in their Patent Law Department. In 1969, he joined RCA as a staff member in Engineering Administration. He is a member of the Indiana Bar as well as the Indiana and American Bar Associations.

Robert C. Graham received the BSEE from West Virginia University in 1958 and joined RCA as a specialized trainee. In 1960, he was appointed Engineering Group Leader responsible for product design of transistor receivers. He is now an Engineering Group Leader working in the Procured Products Department, responsible for procurement evaluation and approval of foreign consumer products.

Francis R. Holt received the BSc in Mathematics and Physics in 1941 and 1942 from London University. From 1942 to 1945 he worked on radar and countermeasures circuitry at RAE and TRE, England. He was also involved in technical intelligence work in the Royal Air Force. From 1946 to 1956, he was with the British Atomic Energy Department. From 1956 to 1958, he was with Philco Corporation, Leeds & Northrup, and the University of Pennsylvania. He then joined the RCA Laboratories at Princeton. Most of his work there was related to consumer electronics, and in 1966 he moved to Indianapolis to join the advanced development team.

E. E. Janson received the BSEE degree in 1962 from Michigan State University. Following graduation, he joined Consumer Electronics and was assigned to the design and development of television video, sync, AGC, and noise-immunity circuits. He is now a Group Leader in Black and White TV Engineering, responsible for audio, IF, and tuner design and development.

William H. Liederbach received the BS in Ceramic Engineering from Iowa State University in 1948. He was employed by the E. I. DuPont Co. from 1948 to 1955 and the Centra-lab Division of Globe-Union from 1955-1958 before joining RCA in the Semiconductor Division at Somerville, N.J. in 1958. He is presently Manager of Ceramic Circuits Engineering.

John Stark, Jr. received the BSEE in 1950 from the University of Wisconsin. After graduation, he joined RCA as an engineer in training. In 1951, he joined the Color Product Development group of Home Instruments, in Camden. In March 1961, he was named Leader, Color TV; in 1969 he was promoted to Manager, Color TV Engineering.

Editorial Representatives

The Editorial Representative in your group is the one you should contact in scheduling technical papers and announcements of your professional activities.

Government and Commercial Systems	
Aerospace Systems Division	Engineering, Burlington, Mass.
Electromagnetic and Aviation Systems Division	Engineering, Van Nuys, Calif. Engineering, West Los Angeles, Calif.
Astro-Electronics Division	Engineering, Princeton, N.J. Advanced Development and Research, Princeton, N.J.
Missile & Surface Radar Division	Engineering, Moorestown, N.J.
Government Engineering	Advanced Technology Laboratories, Camden, N.J. Defense Microelectronics, Somerville, N.J. Advanced Technology Laboratories, Camden, N.J. Central Engineering, Camden, N.J.
Government Plans and Systems Development	Engineering Information and Communications, Camden, N.J.
Communications Systems Division	
Commercial Systems	Chairman, Editorial Board, Camden, N.J. Mobile Communications Engineering, Meadow Lands, Pa. Professional Electronic Systems, Burbank, Calif. Studio, Recording, & Scientic Equip. Engineering, Camden, N.J. Broadcast Transmitter & Antenna Eng., Gibbsboro, N.J.
Industrial and Automation Systems	Engineering, Plymouth, Mich.
Government Communications Systems	Engineering, Camden, N.J.
Computer Systems	
Systems Development Division	Palm Beach Product Laboratory, Palm Beach Gardens, Fla. Marlboro Product Laboratory, Marlboro, Mass. Systems Programming Product Laboratory, Palo Alto, Cal. Systems Programming Product Laboratory, Riverton, N.J.
Data Processing Division	Service Dept., Cherry Hill, N.J.
Magnetic Products Division	Development, Indianapolis, Ind.
Memory Products Division	Engineering, Needham, Mass.
Graphic Systems Division	Engineering, Dayton, N.J.
Research and Engineering	
Laboratories	Research, Princeton, N.J.
Electronic Components	Chairman, Editorial Board, Harrison, N.J.
Receiving Tube Division	Receiving Tube Operations, Woodbridge, N.J. Receiving Tube Operations, Cincinnati, Ohio
Television Picture Tube Division	Television Picture Tube Operations, Marion, Ind. Television Picture Tube Operations, Lancaster, Pa.
Industrial Tube Division	Industrial Tube Operations, Lancaster, Pa. Microwave Tube Operations, Harrison, N.J.
Technical Programs	Engineering, Harrison, N.J.
Solid State Division	Solid State Power Device Engrg., Somerville, N.J. Semiconductor and Conversion Tube Operations, Mountaintop, Pa. Semiconductor Operations, Findlay, Ohio Solid State Signal Device Engrg., Somerville, N.J.
Consumer Electronics Division	Chairman, Editorial Board, Indianapolis, Ind. Engineering, Indianapolis, Ind. Radio Engineering, Indianapolis, Ind. Advanced Development, Indianapolis, Ind. Black and White TV Engineering, Indianapolis, Ind. Ceramic Circuits Engineering, Rockville, Ind. Color TV Engineering, Indianapolis, Ind.
Services	
RCA Service Company	Consumer Products Service Dept., Cherry Hill, N.J. Consumer Products Administration, Cherry Hill, N.J. Tech. Products, Adm. & Tech. Support, Cherry Hill, N.J. Missile Test Project, Cape Kennedy, Fla.
RCA Global Communications, Inc.	RCA Global Communications, Inc., New York, N.Y.
National Broadcasting Company, Inc.	Staff Eng., New York, N.Y.
RCA Records	Record Eng., Indianapolis, Ind.
RCA International Division	New York, N.Y.
RCA Ltd.	Research & Eng., Montreal, Canada
Patents and Licensing	Staff Services, Princeton, N.J.

*** Technical Publication Administrators listed above are responsible for review and approval of papers and presentations.**

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