60c JAN. 1967

Radio-Electronics™

TELEVISION • SERVICING • HIGH FIDELITY

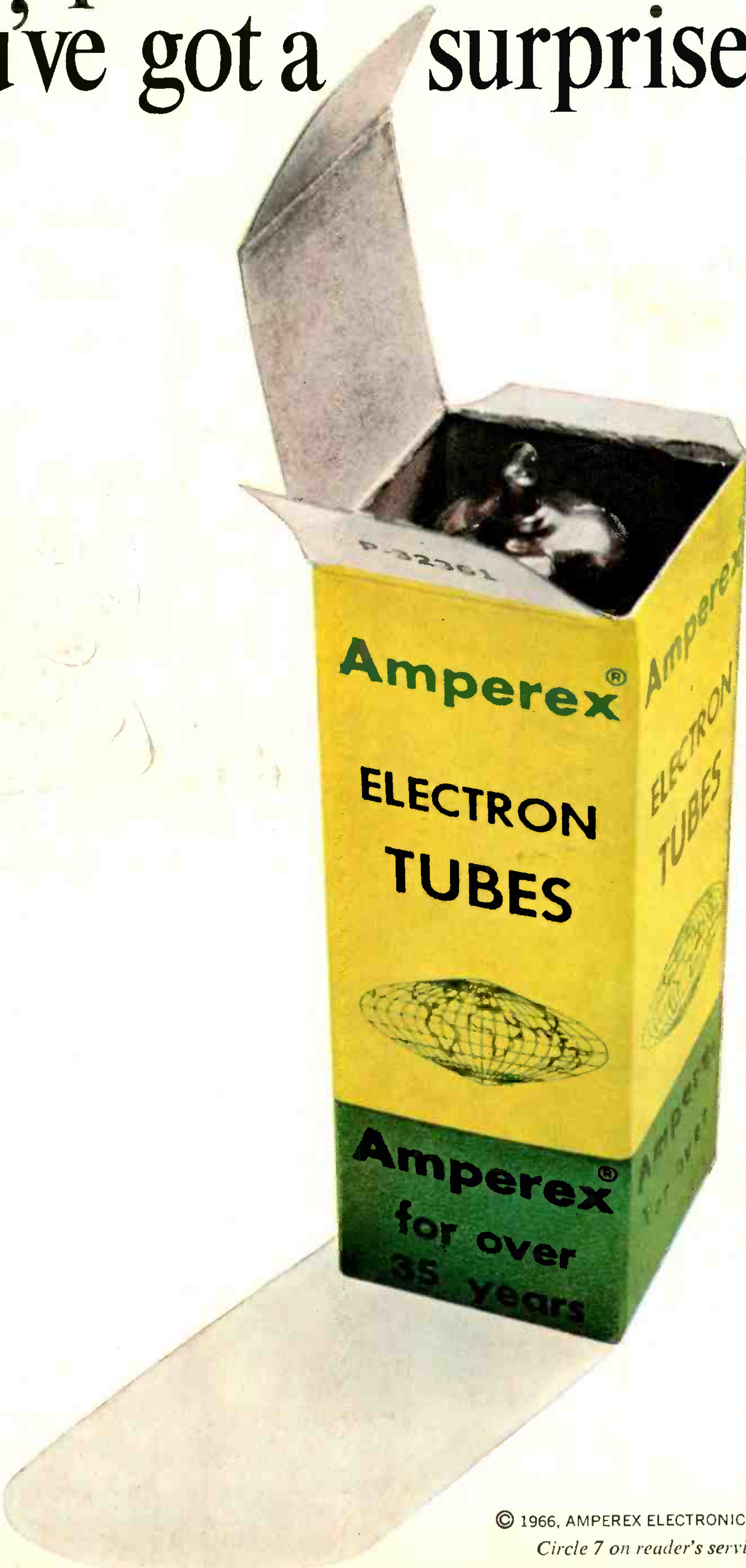
A GERNSBACK PUBLICATION
HUGO GERNSBACK, Editor-in-chief

4th annual color-tv issue

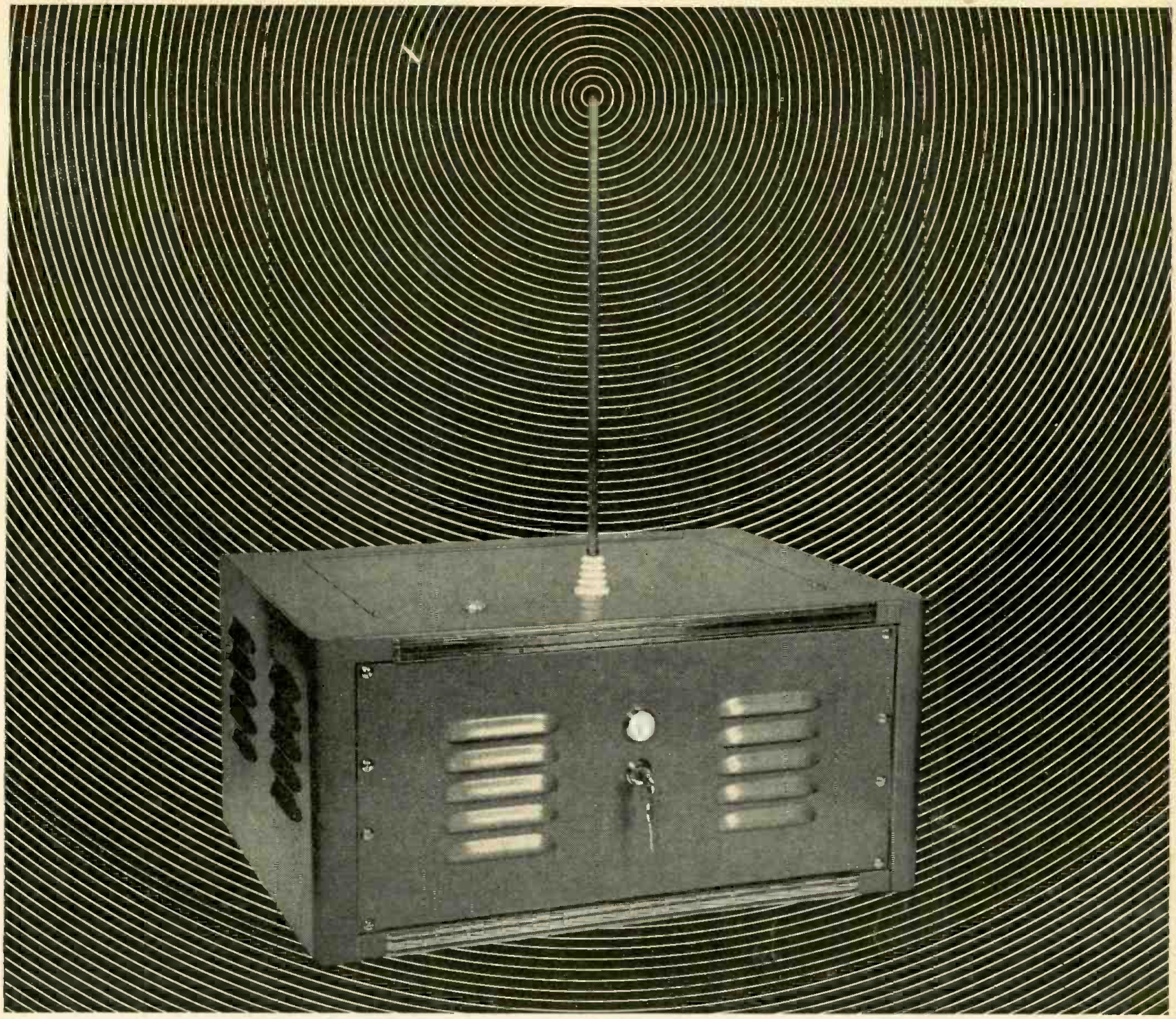
WITH DIRECTORY OF 1967 COLOR CIRCUITS

EASY COLOR SERVICING WITH ... COPE
3-D COLOR TV BY H...
PURITY AND CONVERGE...

If you think all replacement tubes are alike, you've got a surprise coming



Circle 7 on reader's service card



FROM THE EDITOR

What Price Color?

How often do you hear the question: I wonder what it really costs to own a color TV? Do you ever try to answer it? Have you often wondered yourself?

The question is one of today's most common. No more is there the barrier of "few programs." NBC is transmitting 100% of its network shows in color, and CBS and ABC aren't too far behind. Almost 15% of all television sets in use are color. You can hardly find anyone anywhere who isn't vitally interested in or curious about color television.

So, how much *does* it cost? There are two approaches to a valid answer. Let's look at the cold-cash-outlay approach first.

A new color receiver in the 25-inch class, which is becoming a popular size this season, retails for $500 to $900, depending on the cabinet and chassis. So, take $650 as a median price. An antenna, if one is needed, can add $25–100 to the investment. A typical cost, installed, is $55.

Then there's maintenance. Service charges vary so widely it's not easy to pin down a "typical" cost. However, there are fixed-cost annual service contracts, payable in advance; we can use one of them for a norm. One company's first-year contract sells for $47.

Adding up all these costs, you find an average initial investment of $752. That's the hard-dollar cost of owning a color-TV receiver, including the first year's maintenance. That's the amount a buyer must lay on the line or get from his bank or finance company.

In essence, this cold-cash approach answers the "How much?" question like this: For $752 you get a brand new, working, wood-and-guts color set, a color-oriented bunch of fancy aluminum called an antenna, and a year's freedom from service-cost worries. Not a very inviting answer, but an answer nevertheless.

Thank goodness there's another approach to the question—one that's both more attractive and more meaningful. This approach demands a little deeper thinking, however.

Start with the cold-cash figure I already gave you: $752. Consider then the expenses for the next two years, mostly for maintenance. Second- and third-year service contracts average $80 a year. Pretend the set will be thrown away after 3 years (it won't, but this way we avoid bothering about trade-in values). Overall cost, then, is $912 for 3 years. Averaged out, that's $304 a year, or $5.85 a week.

For the final answer to the question "What price color?", figure just what you can get for $5.85. Most families can find at least three good-quality color movies worth watching each week; cost to see—$5.85÷3=$1.95. Consider football, baseball, hockey, races, sports of all kinds; any real sports fan can find two or more of these contests any weekend, in color. Cost: $2.98 apiece. Color TV babysitting, at 2 hours each weekday and 4 hours on Saturday (forget Sunday), would cost 42¢ an hour.

A most interesting point about these color TV benefits is that none of them conflict with each other in time, and therefore they can all be spread over the cost of a single color set. Considering that, if the owner gets no more from his color receiver than these three services, the cost (computed wholly on a time basis) nets out to a startlingly small amount. To watch two movies—say, "Cleopatra" and perhaps "Bridge on the River Kwai"—will cost 38¢ each (with attendance unlimited). Two ball games—maybe Michigan State vs Notre Dame plus the Chicago Bears playing the St. Louis Cardinals—can be seen by as many people as the TV room will hold, for only 75¢ a game. Afternoon babysitting: 25¢ an hour. Throw in a few favorite soap operas, some daily quiz and game shows, an important documentary now and then, and a couple of early morning adult-education courses. You can easily build a case for the best entertainment bargain in any marketplace.

But no one looks at it that way, you protest. Why don't they? Those services are exactly what every color TV dollar is buying. Next time you hear someone ask "What does color TV really cost, now?"—tell them.

Forest H Belt

Radio-Electronics

January 1967 VOL. XXXVIII No. 1
Over 55 Years of Electronic Publishing

EDITORIAL

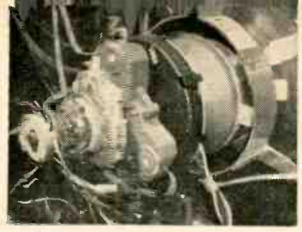
COLOR TELEVISION

TELEVISION

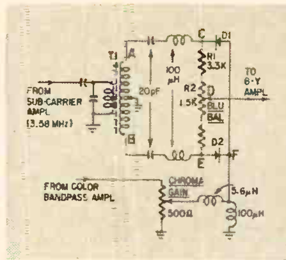
GENERAL

RADIO

THE DEPARTMENTS

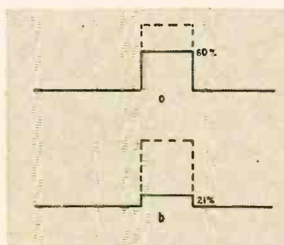


p 36—NEW CIRCUITS



p 53—CHROMA THEORY

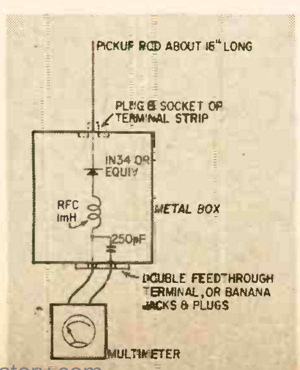
p 56—FIX COLOR FAST



p 59—GENERATING RGB

p 46—LASER PIX

p 44—CB TROUBLE HINTS



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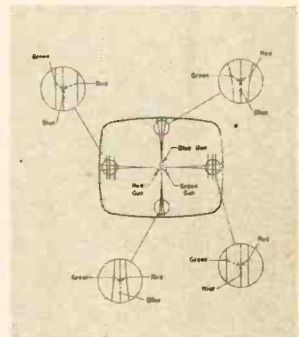
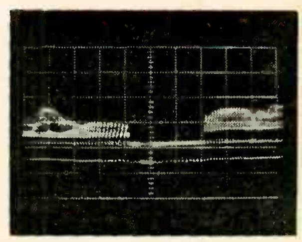
COLOR SCANNING



p 32—Two separate but related functions affect the image formed by a color CRT. Learn the how's and why's of purity and convergence action.

SCOPE TECHNIQUE



p 51—Service is easier when you use a triggered oscilloscope. It's different, and ideal for color.

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Institute of High Fidelity.
Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)

NEWS BRIEFS

VIDEO VISIT FROM VIETNAM

Television tape recordings were used recently to allow three US soldiers in Vietnam to "visit" with their families in Chicago. Low-cost CCTV-type video recorders were used to record the sight-and-sound messages in the battle zone. Then the tapes were flown back to the US and showed to the GIs' relatives. The photo shows a Chicago couple hearing their son.

The system, which was tested for possible regular use, was made possible by Ampex Corp., which donated two recording systems and several hundred reels of tape, and by Capital Cities Broadcasting, which assisted in financing the test. TV executive John Porterfield organized and produced the mission.

HUGO GERNSBACK HONORED BY WIRELESS PIONEERS

A recent gathering of the Antique Wireless Association, a group of amateur radio historians and collectors, paid tribute to pioneer publisher and radio manufacturer Hugo Gernsback. Among the exhibits of coherers, magnetic and electrolytic detectors, and early microphones, were many pieces of equipment manufactured by the Electro Importing Co., an early Gernsback enterprise. During the luncheon held in his honor, Mr. Gernsback addressed the group by means of a special tape recording. He stressed the need to preserve historical records and artifacts and spoke of his desire to see a museum devoted entirely to communication. Distinguished guests included: Elliott Sivowitch, assistant to curator, and Dr. Bernard Finn, curator of electricity, both of the Smithsonian Institute, and Frank Davis, curator, Ford Science Museum.

SLOW-MOTION TV REPLAY

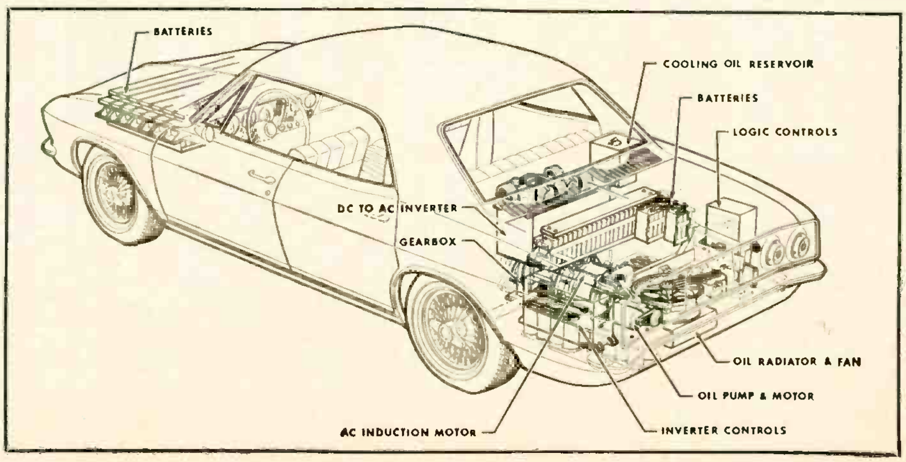
Baseball fans saw a further innovation in TV engineering used in last year's World Series. Interesting or tricky visual action was recorded and played back later in slow motion—electronically.

The technique made use of MVR Corp.'s VDR 250 Videodisc slow-motion recorder, which can record video signals on a magnetic disc. When replayed, action may be slowed or stopped completely, or it may be viewed at medium-slow motion as well as at normal speed. After recording, the machine can be cued for replay in less than half a second.

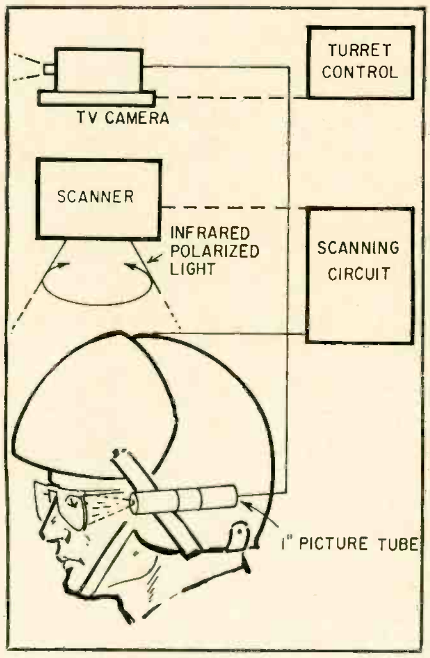
ELECTRIC-POWERED VEHICLES BEING TESTED

Research continues in attempts to develop a practical electric auto to meet today's needs. General Motors has installed silver-zinc battery packs, SCR's and specially designed ac motors in its experimental Electrovair II. Performance is reported similar to that of a gasoline-powered Corvair except for cruising range. The electric car must recharge its batteries every 40 to 80 miles, vs a range of 250–300 miles for gasoline-refill range of a standard car. A regular 1966 Corvair chassis is used, but Electrovair II weighs 800 pounds more than its gasoline-powered cousin.

Another experimental vehicle being tested by GM is Electrovan, a van truck using tanks of liquid hydrogen and oxygen as an electric fuel cell. Such a power source is still expensive and not yet practical.



HELICOPTERS USE NIGHT VIDEO



An infrared light source, a TV camera sensitive to infrared, and a special display system are being used by US helicopters in Vietnam. The apparatus enables flight personnel to see terrain in apparently total darkness.

No ordinary TV monitor is used. As the drawing shows, small CRT's are placed on each side of the pilot's head. Tube displays are picked up by glass in spectacles worn by the pilot. Thus he sees a TV picture of ground ahead of and below his plane, as well as being able to see normally through the plain lenses of the glasses.

continued on page 6

columbia stereo tape club

now offers you

any 5 stereo tapes free

if you begin membership by purchasing just one tape now, and agree to purchase as few as five additional selections in the next 12 months, from the more than 200 to be offered

JUST LOOK AT THE EXCITING STEREO TAPES on this page! Which ones would you like to add to your own collection? By joining the Columbia Stereo Tape Club now, you may have ANY FIVE of the magnificently recorded 4-track stereo tapes shown here — sold regularly by the Club for up to $46.75 — ALL FIVE FREE!

TO RECEIVE YOUR 5 PRE-RECORDED STEREO TAPES FREE — simply write in the numbers of the 5 tapes you wish in the coupon at the right. Then choose another tape as your first selection, for which you will be billed $7.95, plus a small mailing and handling charge. Also be sure to indicate the type of music in which you are mainly interested: Classical or Popular.

HOW THE CLUB OPERATES: Each month the Club's staff of music experts chooses a wide variety of outstanding selections. These selections are described in the entertaining and informative Club magazine which you receive free each month.

You may accept the monthly selection for the field of music in which you are primarily interested . . . or take any of the wide variety of other tapes offered by the Club . . . or take NO tape in any particular month.

After purchasing your first tape through this advertisement, your only membership obligation is to purchase 5 additional tapes from the more than 200 to be offered in the coming 12 months. Thereafter, you have no further obligation to buy any additional tapes . . . and you may discontinue your membership at any time.

FREE TAPES GIVEN REGULARLY. If you wish to continue as a member after fulfilling your enrollment agreement you will receive — FREE — a 4-track stereo tape of your choice for every two additional tapes you buy from the Club.

The tapes you want are mailed and billed to you at the regular Club price of $7.95 (occasional Original Cast recordings somewhat higher), plus a small mailing and handling charge.

SEND NO MONEY — Just mail the coupon today to receive your six stereo tapes and FREE take-up reel!

Note: All tapes offered by the Club must be played back on 4-track stereo equipment.

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Terre Haute, Indiana

2673. Also: On A Clear Day, All Or Nothing At All, etc.

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2217. Glittering performances of these two charming works

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2417. Also: Yesterday, Unchained Melody, 12 in all

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1530. Greater than ever... winner of 8 Academy Awards

2639. "The best musical score of '65." —Am. Record Guide

2676. A truly unique listening experience awaits you.

2159. Also: The Night We Called It A Day, etc.

2276. Also: Kansas City Star, In The Summertime, etc.

3432. Also: Come Running Back, Any Time, 7 more

2405. "Exciting, sensuous romanticism." —N. Y. Times

2346. Also: Once Upon a Time, Don't Wait Too Long, etc.

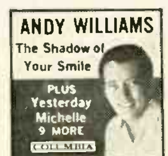
3559. Also: A Corner In The Sun, Homeward Bound, 8 more

2462. Also: We can Work It Out, Dance With Me, 8 more

2661. Also: Slow Walk, Jabo, Hooks, Fat Bag, 5 more

2485. Also: Walkin' My Baby Back Home, Unforgettable, etc.

2267. "Stunning, with staggering articulation."—High Fidelity



2460. Also: Try To Remember, A Taste Of Honey, etc.

2404. Also: Never Too Late, The Pawnbroker, Smile, etc.

2672. "The best musical of the season."—CBS News

FREE if you join now
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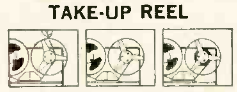

Just drop the end of the tape over the reel, start your recorder, and watch it thread itself! Unique Scotch® process automatically threads up tape of any thickness, releases freely on rewind.

SEND NO MONEY – JUST MAIL COUPON!

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Terre Haute, Indiana 47808

I accept your special offer and have written in the boxes at the right the numbers of my five FREE tapes. I've also indicated the number of my first selection, for which I'll be billed $7.95, plus a small mailing and handling charge. I will also receive my self-threading reel FREE!

My main musical interest is (check one):

☐ **CLASSICAL** ☐ **POPULAR**

I understand that I may select tapes from any field of music. I agree to purchase five additional selections from the more than 200 to be offered in the coming 12 months, at the regular Club price plus a small mailing and handling charge. Thereafter, if I decide to continue my membership, I am to receive a 4-track, pre-recorded tape of my choice FREE for every two additional selections I accept.

Print Name..
First Name Initial Last Name

Address..

City..

State.......................Zip Code..............

This offer is available only within the continental limits of the U.S. 49

SEND ME THESE 5 TAPES—FREE! (fill in numbers)

☐
☐
☐
☐
☐

ALSO SEND THIS TAPE AS MY FIRST SELECTION:

☐

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REMOTE-CONTROL BLACKBOARD

Closed-circuit TV can transmit an illustrated lecture from a college professor on campus to a class many miles away. Even though it's expensive, the new system, shown in the photos, makes illustrated lectures possible for about one-fourth the cost of CCTV. It uses ordinary telephone lines, and the class can talk back to the instructor for questions or comments. The lower photo shows a class watching the electronic blackboard to see what the instructor has written on the sending console.

At the instructor's position, an electronic pen is mechanically linked to two pots. As the teacher moves the pen on the transmitting-CRT face, the pots sense the position of the pen on X and Y coordinates. The pots' positions modulate tone transmitters which feed the telephone line.

At the receiving location, the recovered coordinate information deflects the beam of a special storage CRT. This image is then scanned by a small TV camera which feeds any desired number of CCTV monitors. The image on the storage tube may be erased when the instructor is finished with it.

Nearly any type of graphic material—handwriting, diagrams, formulas or sketches—may be used with the system, which was developed jointly by Purdue University and Sylvania Electric Products, Inc.

COMMERCIAL RADIO TO START IN BRITAIN

A new popular-music radio service with commercials will be started soon by the government of Great Britain. The new agency will be known as the Popular Music Authority (PMA) and will be financed entirely by advertising revenue.

This is in contrast with the prac-

continued on page 12

Radio-Electronics

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Available Under NEW GI BILL

If you served since January 31, 1955, or are in service, check GI line in postage-free card.

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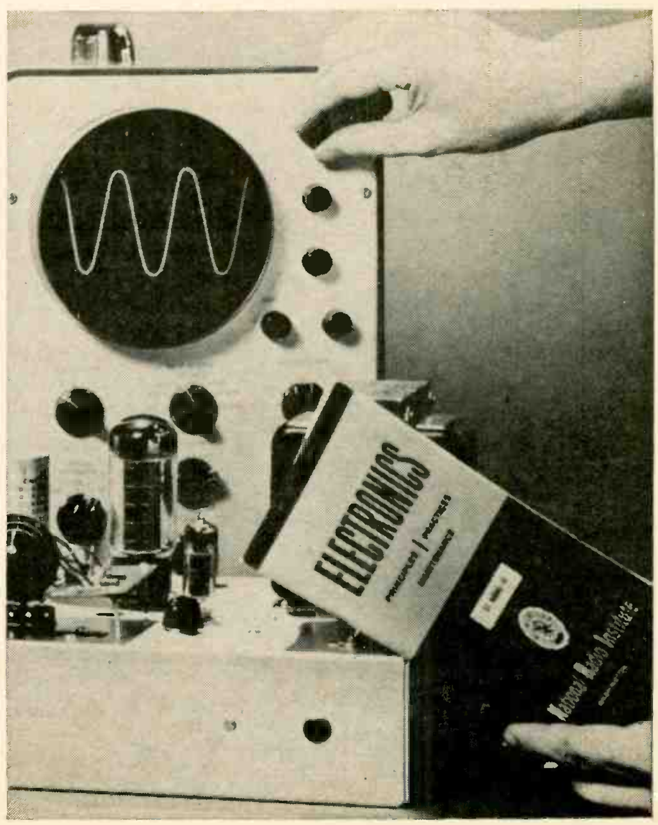

tice of the 44-year-old BBC, the government-controlled monopoly that has furnished Britons with commercial-free radio fare until now. PMA will broadcast on broadcast-band channels now used by BBC's Light Programme, one of three BBC services.

Chief reason behind the decision was the nagging existence of "pirate" stations which operate transmitters from offshore ships or abandoned gun forts on reefs, selling time and broadcasting modern popular music. These stations are to be outlawed.

The new radio service has a precedent, however—the 12-year-old ITA (Independent Television Authority). BBC television is commercial-free, like its radio service, but ITA carries advertising on its channel.

MORE SHORTWAVE BROADCASTING

For the first time in 4 years, conditions have opened up on the 11-meter shortwave band. Signals are being received on the 25–26-MHz international frequencies, due to increased sunspot activity. Not only will overseas broadcasts be available for SWL's, the 27-MHz Citizens band will undoubtedly be plagued by skip interference.

FM listeners in the New York City vicinity can hear Radio Peking, Radio Moscow and Radio Havana without a shortwave receiver. New York's WRFM (105.1 MHz) tapes English-language news and comments from these three Iron-Curtain SW stations for playback to their audience. The excerpts are heard intermittently from 8 to 11 pm nightly. WNYW, WRFM's SW affiliate, returns the courtesy by broadcasting features about the US to its overseas listeners at the same time.

HANDWRITTEN NUMBERS

Most information-processing devices can recognize only printed numerals. IBM's 1287 can read handwriting—at least the numbers from 1 to 10, and the letters C, S, T, X and Z. Now being offered for lease or sale, the machine will be useful for coding sales slips and bank deposits, and for many similar applications. The five letters were selected for their ease of recognition.

NOBEL PRIZE TO SCIENTIST

The Nobel Prize for physics has been awarded to Dr. Alfred Kastler, a French scientist. Dr. Kastler's experiments, which began in 1949, produced knowledge of energy levels inside the atom. His work has been called basic to the development of the laser.

NO-CONTACT SWITCH

Eliminating moving parts and contacts, a new switch developed in England is not affected by oil or dirt deposits. The device works when a piece of metal is inserted in a magnetic field between two gaps. Interrupting the field triggers a circuit which can be used to control any on–off function. Power required for the switch is 27 mW; maximum switching speed is 100 operations per second. The encapsulated switch measures 2⅜ x 1⅜ inches and will operate up to 113°F. END

CORRECTION

There is an error in Fig. 3 of the article "Solid-State and Hi-Z Too" on page 48 of the November issue. As the circuit is drawn, R2 is shorted out. You can correct this on your diagram by deleting the horizontal line from the junction of C1 and R2 to the gate of Q1. This places R2 in series with the gate and C1 just as it is in Fig. 1.

Our thanks to Dr. Kurt J. Schulz of Gary, Ind. for calling this to our attention. END

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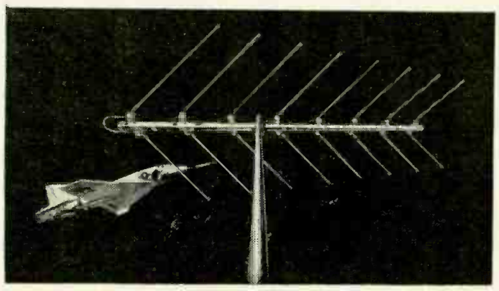
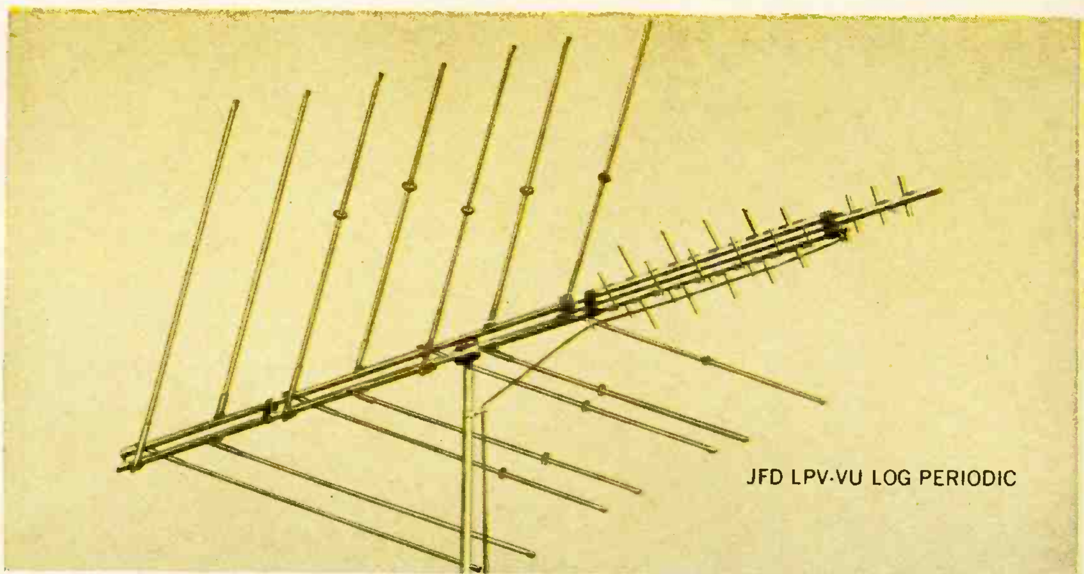
assault on perfec



Back in 1962, we invented a new kind of TV antenna.



Licensed under one or more of U.S. patents 2,958,081; 2,985,879; 3,011,168; 3,108,280; 3,150,376; 3,210,767, RE. 25,740 and additional patents pending in U.S.A. and Canada. Produced by JFD Electronics Co. under exclusive license from the University of Illinois Foundation.

14

Circle 14 on reader's service card

tion: PERFECTION CONQUERED

We did not improve on an old antenna. We started from scratch to design a new one. *Really new.*

It wasn't easy. And it wasn't cheap. But it worked like mad.

We called it the LPV Log Periodic. Its performance caught our competitors with their charts down. But it wasn't long before they came up with LPV copies in every way—except in performance.

Meanwhile back at the JFD labs in Champaign, Illinois, our scientists and engineers continued their "assault on perfection." In 1963, they again shattered antenna precedent by coming up with the *first* combination VHF/UHF/FM log periodic antenna, the LPV-VU. Instead of three different antennas, installers now needed only *one* LPV-VU and *one* downlead.

Our competitors scoffed at the idea. They said it couldn't be done. Until the "eye-popping" results started to roll in. Then there was a mad scramble for the LPV-VU bandwagon.

These "me-too" antennas looked like the LPV-VU Log Periodic. Sounded like it, too. But their charms were skin-deep.

Only the JFD LPV-VU delivered deluxe 82-channel log periodic performance. Because only the JFD LPV-VU followed the genuine patented log periodic concept of the University of Illinois Antenna Research Laboratories. Thanks to the protection of eleven different LPV-VU U.S. patents issued and pending—more than those of any other antenna.

You would think by now our Research and Development people in Champaign would leave well enough alone. But no. These "Young Turks" have gone and done it again. This time it's a new all-band log periodic design—the LPV-CL Color Laser. (Must be that "assault on perfection" bug they've still got up their polinear recorder.)

Why did we call it the Color Laser?

Well, engineers tell us that laser light beams with their tremendous bandwidth capacity are the communications carrier of the future. And we believe that our new VHF/UHF/FM Color Laser with its extreme bandwidth, among other unique characteristics, is the antenna of the future—only it's available to you *now*. How does the Color Laser deliver unsurpassed natural color, black and white across 82 channels, and FM, too?

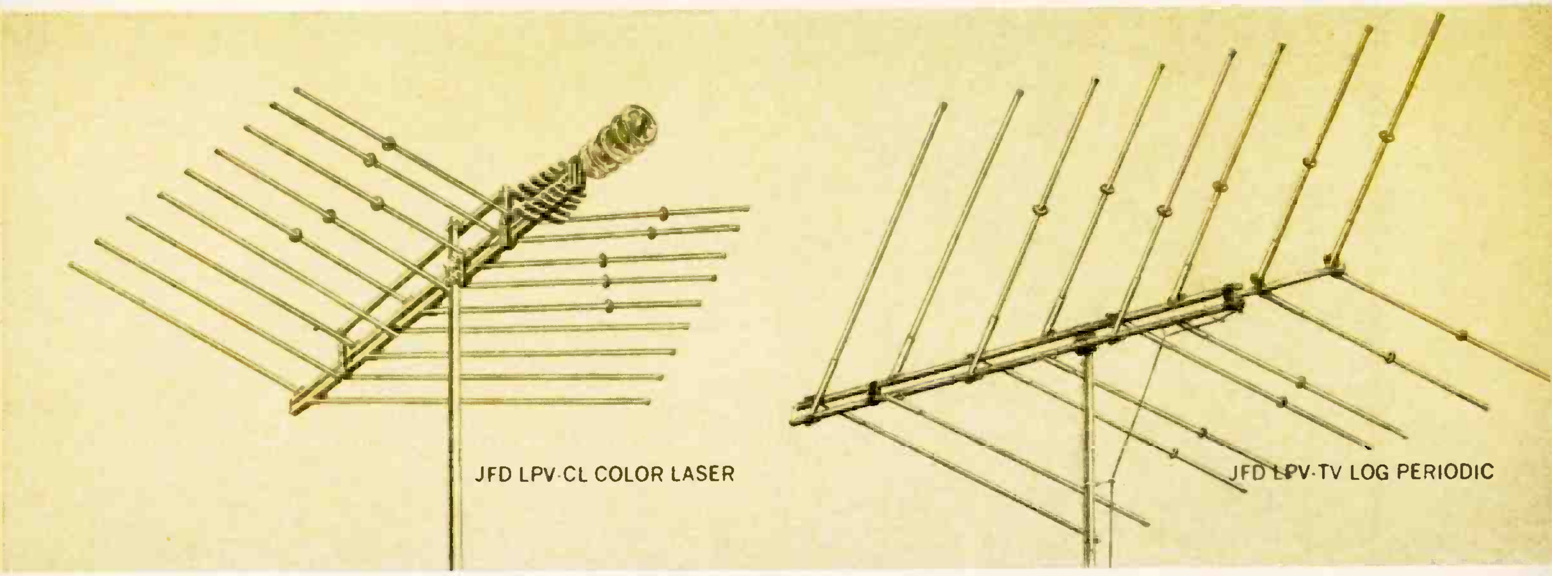
Three reasons: (1) *Patented *VHF "cap-electronic" Log Periodic V Design,* (2) *a new broad band UHF "zoned" trapezoid driver,* (3) *a new disc-on-rod UHF director system.* And there are patents issued and pending on all three.

We've also spun off the LPV "cap-electronic" Log Periodic section of the Color Laser. It forms the heart of a great new VHF antenna series we've named the LPV-TV.

This "assault on perfection" of ours involved a complete new mechanical design, as well. Results: "fast-lok" element brackets, "hot" twin booms (no lossy harnesses or transformers), new super-strength double U-bolt profiles, high reliability cylindrical capacitors, plus our electrically conductive gold alodized aluminum.

If you're the breed of professional contract installer or self-servicing appliance dealer who *never* settles for less than the best, we have a suggestion. Use a JFD LPV-CL Color Laser or LPV-TV Color Log Periodic on your next installation. See what it feels like to install the *best* of all in performance and customer satisfaction.

You will also see why our research and development people have now changed their watchword from "assault on perfection" to "perfection *conquered*".



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Correspondence

BEGINNERS' CLUB

Dear Editor:

The British Amateur Electronics Club was formed recently for the benefit of all who are interested in electronics as a hobby.

I think it would be of considerable interest to our members to exchange ideas with electronic enthusiasts in the USA and, also, I hope they would like to hear from us.

CYRIL BOGOD

26 Forrest Road
Penarth,
Glam:
Great Britain

SLIPS!!

Dear Editor:

In my letter "Hertz Not New" in the November issue, I have apparently been edited into making an incorrect statement. In the original letter, I said: ". . . 'pico' took 40 years to get into general use. It was first . . . referred to in the *US Signal Corps Manual* in 1921 . . . and was actually adopted (and later abandoned) by *QST* in 1926." In the magazine the letter reads: "Hertz was first referred to . . ."

The term *hertz* was not used in the *Manual* in 1921. Just to make sure, I got the ancient work down, and found that it was already using the Americanism "cycles." (In some problems and explanations, "cycles per second" was spelled out.) Radio frequencies were invariably converted to wavelength and expressed in meters, and only in describing the Alexanderson alternator was a frequency as high as "200,000 cycles" mentioned.

ERIC LESLIE

New York, N. Y.

LADDER LINGO ✓

Dear Editor:

About the problem on the resistance of an infinite ladder network, which appeared in "What's Your EQ?" in the June issue. This has an interesting sidelight, especially for electronics men interested in mathematics.

The answer, $\frac{-1+\sqrt{5}}{2}$, is equal to the reciprocal of "tau" (also called "phi"), which appears many times over in geometric design, architecture, and art, as well as in mathematics. Evidently we may now add electronics to the list.

Briefly stated, tau is the ratio of length to width (aspect ratio) of a rectangle, the semiperimeter of which bears the same ratio to its length, as its length bears to its width. Tau is approximately equal to 1.618034.

A curious property of tau is that it is the only positive number which becomes its own reciprocal by subtracting 1 from it. In view of the ladder network problem this means that if you add a single 1-ohm resistor in series with the input, the new network has a resistance equal to tau, or $\frac{1+\sqrt{5}}{2}$. A little manipulation will verify that this is the reciprocal of the original expression above.

Another interesting aspect of tau, which for the astute observer will tie it in directly with the ladder network problem, is the following alternate way of expressing it:

$$\tau = 1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \dots}}}$$

[*Tau or phi—it's Greek to me.—Editor*]

MILTON BADT, JR.

APO, N.Y.

GOOD OLD DAYS

Dear Editor:

Like thousands of radio engineers and amateurs, I received my greatest inspiration from Hugo Gernsback's vari-

continued on page 22

16

Join "THE TROUBLESHOOTERS"

They get paid top salaries for keeping today's electronic world running

Suddenly the whole world is going electronic! And behind the microwave towers, push-button phones, computers, mobile radio, television equipment, guided missiles, etc., stand THE TROUBLESHOOTERS —the men needed to inspect, install, and service these modern miracles. They enjoy their work, and get well paid for it. Here's how you can join their privileged ranks— without having to quit your job or go to college in order to get the necessary training.

JUST THINK HOW MUCH in demand you would be if you could prevent a TV station from going off the air by repairing a transmitter...keep a whole assembly line moving by fixing automated production controls...prevent a bank, an airline, or your government from making serious mistakes by repairing a computer.

Today, whole industries depend on electronics. When breakdowns or emergencies occur, someone has got to move in, take over, and keep things running. That calls for one of a new breed of technicians—The Troubleshooters.

Because they prevent expensive mistakes or delays, they get top pay—and a title to match. At Xerox and Philco, they're called Technical Representatives. At IBM they're Customer Engineers. In radio or TV, they're the Broadcast Engineers.

What do you need to break into the ranks of The Troubleshooters? You might think you need a college diploma, but you don't. What you need is know-how—the kind a good TV serviceman has—only lots more.

Think With Your Head, Not Your Hands

The serviceman, you see, "thinks with his hands." He learns his trade by taking apart and putting together, and often can only fix things he's already familiar with.

But as one of The Troubleshooters, you may be called upon to service complicated equipment that you've never seen before or *can't* take apart. This means you have to be able to take things apart "in your head." You have to know enough electronics to understand the engineering specs, read the wiring diagrams, and calculate how a circuit should test at any given point.

Now learning all this can be much simpler than you think. In fact, you can master it without setting foot in a classroom and without giving up your job!

AUTO-PROGRAMMED™ Lessons Show You How

For over 30 years, the Cleveland Institute of Electronics has specialized in teaching electronics at home. We've developed special techniques that make learning easy, even if you've had trouble studying before.

For one thing, our AUTO-PROGRAMMED™ lessons build your knowledge as you'd build a brick wall—one brick at a time. Each piece rests securely on the one that came before it.

In addition, our instruction is personal. When your teacher goes over your assignment, no one else competes for his attention. You are the only person in his class. He not only grades your work, he analyzes it to make sure you are thinking correctly. And he returns it the day it's received so that you can read his comments and corrections while everything is fresh in your mind.

Always Up-To-Date

To keep up with the latest developments, our courses are constantly being revised. This year CIE students are getting new lessons in Laser Theory and Application, Microminiaturization, Single Sideband Techniques, Pulse Theory and Application, and Boolean Algebra.

In addition, there is complete material on the latest troubleshooting techniques including Tandem System, Localizing through Bracketing, Equal Likelihood and Half-Split Division, and In-circuit Transistor Checking. There are special lessons on servicing two-way mobile equipment, a lucrative field in which many of our students have set up their own businesses.

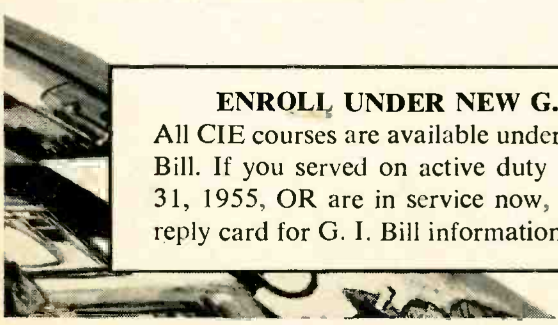
Your FCC License—or Your Money Back!

Two-way mobile work and many other types of troubleshooting call for a Government FCC License, and our training is designed to get it for you. But even if your work doesn't require a license, it's a good idea to get one. Your FCC License will be accepted anywhere as proof of good electronics training.

And no wonder. The licensing exam is so tough that two out of three non-CIE men who take it fail. But CIE training is so effective that 9 out of 10 of our graduates pass...on their very first try. That's why we can offer this warranty with confidence: *If you complete one of our license preparation courses, you'll get your license—or your money back.*

Mail Card for 2 Free Books

Want to know more? Mail the postage-paid reply card bound here. We'll send our 40-page catalog describing our courses and the latest opportunities in Electronics. We'll also send a special book on how to get a Commercial FCC License. Both are free. If the card is missing, just send us your name and address.



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ous "wireless" activities in the years prior to World War I.

I am enclosing an early photograph of my first wireless station. This picture brings back many fond memories, including falling to sleep almost every night with an Electro Importing Co. catalog in my hand. It was my "bible."

WILLIAM W. HARPER

W6TQ

Pasadena, Cal.

SAD DAY FOR COLOR TV

Dear Editor:

I want to express my sympathy to the bereaved families of the customers, dealers, and technicians who read the article "Is Color A TV-Man Job?" in the September 1966 issue (page 78). I do hope a few escaped the fate predicted by the blurb which ran directly under the headline:

> "Customers, dealers, technicians all still have serious doubts about color television. This article should lay many of them to rest."

RICHARD H. DORF

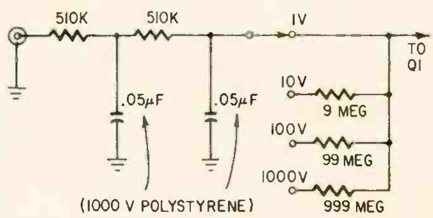
New York, N.Y.

[*And the industry already with a shortage of service technicians! Unforgivable.—Editor.*]

MORE HELP ON PMDVM

Dear Editor:

The "Poor Man's Digital Voltmeter" I built from the article in the August 1966 issue suffers errors due to stray or superimposed ac components at 60 Hz (or multiples thereof, depending on exact phase relation to the chopper timing). A filter (see diagram) having a time constant of about 100,000 μsec (.1 sec) will remove these errors but will limit the lowest range to 1 volt full scale.



PLACE SHIELD AROUND FILTER, ATTENUATOR, Q1 AND C1.

A better solution would be to provide chopper drive at about 6,000 Hz. Total filter resistance could then be reduced to 10K to restore the lower ranges, but more extensive shielding would probably be needed to reduce stray coupling. The unit could then be operated on a built-in battery.

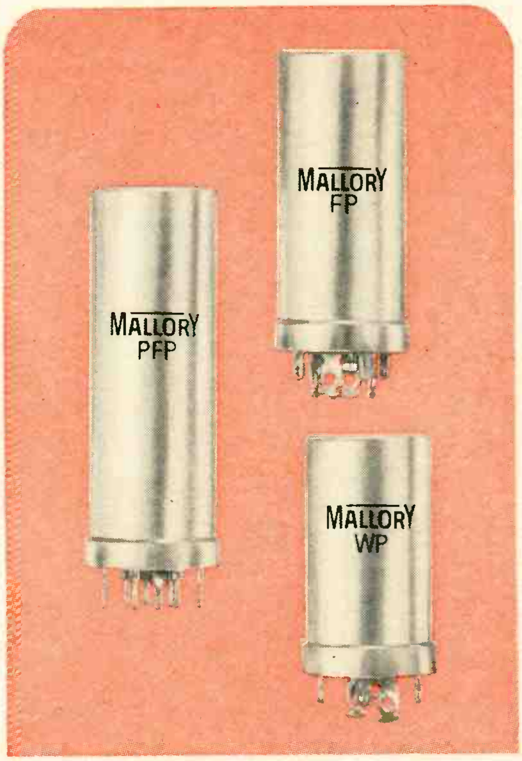
BRUCE R. RILEY

Cocoa Beach, Fla.

END

MALLORY **Tips for Technicians**

Choosing electrolytic capacitors for color TV



When you need to replace an electrolytic capacitor in a color television, it pays to select the best. Your customer has a lot of dough invested in his color set, and he won't settle for less than top performance. And his eye can see sub-standard performance in color that would go unnoticed in black-and-white.

Color TV is tough on electrolytics. Ambient temperatures run hotter, because of the greater number of tubes and resistors inside crowded cabinets. Ripple currents are higher, so the capacitor has to do a better job of getting rid of internally generated heat. Voltage ratings are higher, too; most electrolytics in color TV are 400 volts or higher.

It's no surprise that leading color TV makers are pretty darn particular about the electrolytics that they use as original equipment. They demand a true high-voltage, high-temperature, high ripple capacitor . . . not one that's simply made to sell at bottom price. And meeting these demands is the way Mallory got to be the top supplier of electrolytics for color TV. We're the guys who pioneered the 85°C capacitor, who have consistently increased ripple current capacity, and who have the reputation of leadership in high voltage ratings.

Here's our tip of the month. To save yourself time, get a copy of our new cross reference, "Exact Replacement Metal Can Electrolytic Capacitors for Color TV". It lists the original part number and the catalog number of the corresponding Mallory replacement for 38 leading color TV manufacturers. To save yourself costly call backs, use only the best . . . and that's one of the Mallory FP-WP series, made to original equipment specs. To get everything you need for color TV service, see your Mallory distributor. He stocks Mallory power resistors, circuit breakers, carbon and wire-wound controls and Discap® ceramic capacitors.

For a copy of the Color TV cross reference, ask your Mallory Distributor, or write to Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

Circle 18 on reader's service card

SERVICE CLINIC

By JACK DARR Service Editor

In the Shop . . . With Jack

WE'VE HAD BOOST VOLTAGE FOR A LONG time, and in spite of an incautious statement by a certain Clinic Conductor a while back, it is even used in some transistor TV sets, as a cheap source of higher voltage for certain applications. It's easy enough to get boost—simply charge a capacitor with the energy from the flyback pulse during retrace time. If we return this capacitor's negative terminal to B+ instead of ground, the capacitor-stored voltage is added to the B supply. This means we've boosted the B+ voltage. Some schematics use the symbol B++ for boost.

However, the design engineers weren't content to leave the boost alone. They found they needed higher voltages, especially for some of the newer color CRT's. So, they boosted the boost and called it boosted-boost. In doing it, they simply repeated themselves (as I just did!) How? By using a tap on the flyback to provide a 500-volt pulse which is rectified and used to charge a capacitor. This capacitor is returned to B+ +, and its charge is added to the boost. The result of all this hanky-panky is a monster voltage called B+++. Fig. 1 shows a basic RCA circuit, used in the CTC15 and CTC16 series, a good example of B+++.

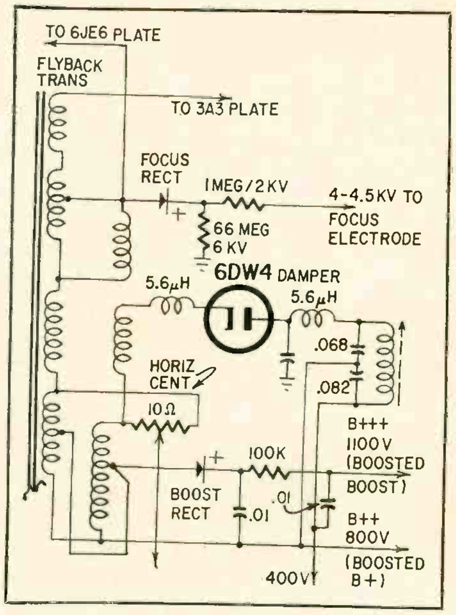


Fig. 1—Development of the boosted-boost.

The important point about boosted-boost circuits is that they use special rectifiers. Usually, such a rectifier is a very-high-voltage silicon unit, consisting of many tiny silicon-diode pills in series. If diodes are stacked in series, the voltage rating is multiplied by the number of diodes, while the current rating stays the same. A stack of ten 100-volt diodes would be good for 1,000 volts, and so on. The diodes are usually packed in a long, thin tube, with axial leads.

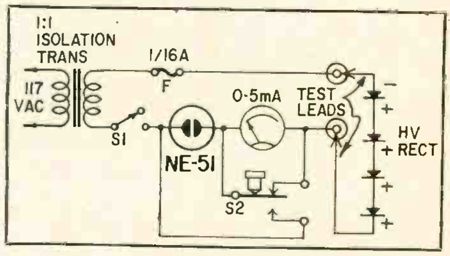


Fig. 2—One focus-rectifier test circuit.

The B+++ rectifier isn't so bad—it actually boosts the boost by only about 300–400 volts. However, the same type of rectifier is used to produce focus voltage, in the range of 3 to 5 kV or more. A typical focus rectifier might be about 2½ inches long, and about half the size of a lead pencil, with a rating of 5.5 kV peak. It'll have about 9 jillion wee silicon diodes in it. The current rating of these focus rectifiers is down in the microampere range, since focus current is small.

The problem is testing the things. The average 1.5-volt ohmmeter battery won't tell you a heck of a lot about these diodes, since it won't cause enough forward bias to make them conduct. Even good diodes simply read open both ways, which tells us nothing. Focus voltage is low, but we don't know why—not yet.

General Electric has come up with a test circuit for focus rectifiers (Fig.

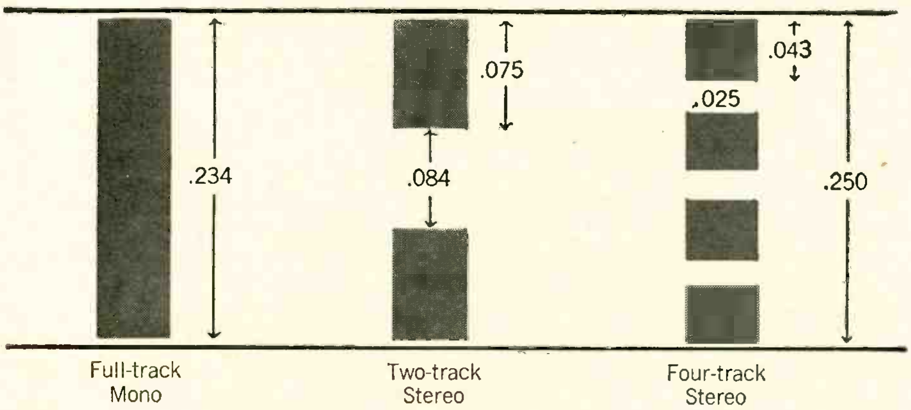
This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 154 West 14th Street, New York 10011.

Some plain talk from Kodak about tape:

The big squeeze—Multitrack Stereo

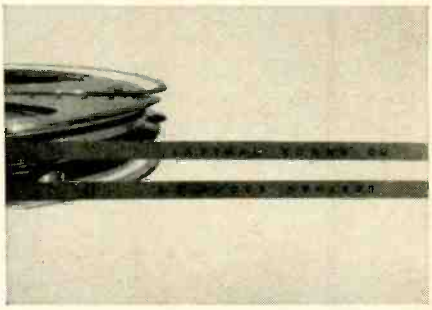
Remember the college fad a few years back—how many brawny brutes could be squeezed into a little car built for plain folks? For a while, it looked like a somewhat similar situation was about to take place in the tape-recording field—first monaural, then 2-track, then 4-track, and now even 8-track recording. Even though these developments continue at a fast clip, 4-track stereo is still the name of the game as far as high-fidelity applications are concerned. And very nice it sounds, too, thanks to the precision built into modern heads. But you do have to watch yourself. Having double the information on a given length of tape means everything has to be just so—including the tape you use.



4-track star. The first thing to worry about in considering a tape for 4-track stereo is output. As you can see in the chart above, adequate separation must be maintained between each track to prevent cross-talk. And as the actual width of the recorded tracks drops down, the output per channel on the tape drops in proportion.

Thus, to make the most of what you can record, you need a tape with a high-powered oxide layer—one that's going to give you a high output with a good signal-to-noise ratio. KODAK Sound Recording Tape, Type 34A, fills the bill—gives you 125% more undistorted output than conventional general-purpose tapes. You get practically the same per-channel output on 4-track stereo with Type 34A that the other tapes would give you on 2-track! But there's more to recommend the use of Kodak tape.

Staying on the right track. Because everything gets smaller in proportion when you go to 4-track, dimensional precision becomes that much more important. Take a tape that suffers from a case of drunken slitting. (That's when the edges of the tape snake back and forth even though the width is constant.) It's not hard to see how this tape isn't going to "track" straight past the head. A slight case of this and you get alternating fluctuations in output on both channels. If the condition is bad enough, a poorly slit tape can cause your heads to drop out the signals completely, even pick up the signals on the tracks going the other way. Horrors! Lucky for you, you have nothing to worry about with Kodak tapes. We keep our tolerance to .001 inches. That's twice as close as industry standards. To make your life even easier, we also backprint all our tapes so you can always tell



whether a reel has been wound "head" or "tail" first. Simply note which comes first off the supply reel, the "E" of "EASTMAN" or the "O" of "CO"... and note it on the reel.

Kodak tapes—on DUROL and Polyester Bases—are available at most electronic, camera, and department stores. To get the most out of your tape system, send for free, 24-page "Plain Talk" booklet which covers the major aspects of tape performance.

EASTMAN KODAK COMPANY, Rochester, N.Y.

Circle 20 on reader's service card

2). They apply the 117-volt ac line to the stack and measure current. You can do this without the isolation transformer, but watch out—the rectifiers will be hot with respect to ground. With this circuit, spring-loaded switch S2 shorts out the meter, until the neon bulb tells us that the rectifier is not shorted completely. (One of those "unlikely but always possible" things.) When the switch is pushed, the neon lamp is shorted, and the meter reads the dc output.

For focus rectifiers, a reading above 0.5 mA is considered good. Anything less should be viewed with suspicion. For B+++ rectifiers, which have lower voltage ratings but carry a higher current, the lowest reading should be 1 mA.

Motorola also has a test for B+++ rectifiers, as shown in Fig. 3. This uses a 45-volt battery or power supply, and a vtvm. The 1-meg resistor is used as a diode load, and keeps us from being fooled by rectifiers with too-high internal resistance. With the diode hooked up in the forward direction, the reading will be almost full supply voltage, and practically zero in the other direction.

If you have an ohmmeter with a very high resistance range, say X1 meg, it will give you an idea of the condition of these rectifiers. The bad one will probably read open in both directions. Good ones will read a pretty high resistance forward, but the back resistance should read infinity. This test isn't too reliable, due to the low voltage; the output-current test is better. Don't forget that you can always use the oldest test in the book—try a new part!

If the slide-rule jockeys keep bootstrapping their way up the boost-voltage scale, we might have some interesting problems a few years from now. You might hear something like this:

"Hey, Bill, what's the matter with that set?"

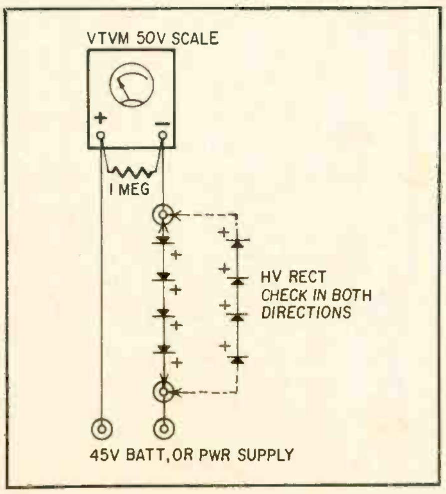


Fig. 3—Another way to test HV diodes.

"Don't know yet. My B+++ seems okay, but my B++++++ is about 2,000 volts too low!"

Color worms

I'm having trouble getting the color to tune properly, or hold, in a Zenith 29CJ20 color set. Good signal, all tubes check okay. If I tune into the "worms," I can hold color fairly well. But if I back up to get rid of the beat, color pops in and out. Tuner trouble, do you think?—K. W., Troy, N.Y.

Not necessarily. This is an alignment problem, in my experience. Try this: Tune for the best color, disregarding the worms. Check the setting of the traps—A5, A6 and A7—in the input of the video i.f. If one of these is even slightly off, it will cause your trouble. Watch the picture in the mirror, and *very carefully* move each trap, but not over a half-turn. If you're lucky, you won't have to make a full sweep alignment. The 39.75-MHz trap (A7) is the most critical.

Automatic degaussers in metal cabinets

I'd like to install an automatic degausser, the kit made by Colman Electronics, in an RCA CTC11 color chassis. I note in your January 1965 issue that RCA uses auto-degaussing on all models except those in the metal cabinet. Is a degausser practical in a metal cabinet?—C. J., Los Angeles, Calif.

Yes. The only reason the auto-degausser was left out, as far as I know, is that the metal-cabinet model is the lowest-priced in the line. The degaussing circuit should certainly work just as well in metal cabinets as in wood, and they all use the same chassis.

Intermittent red

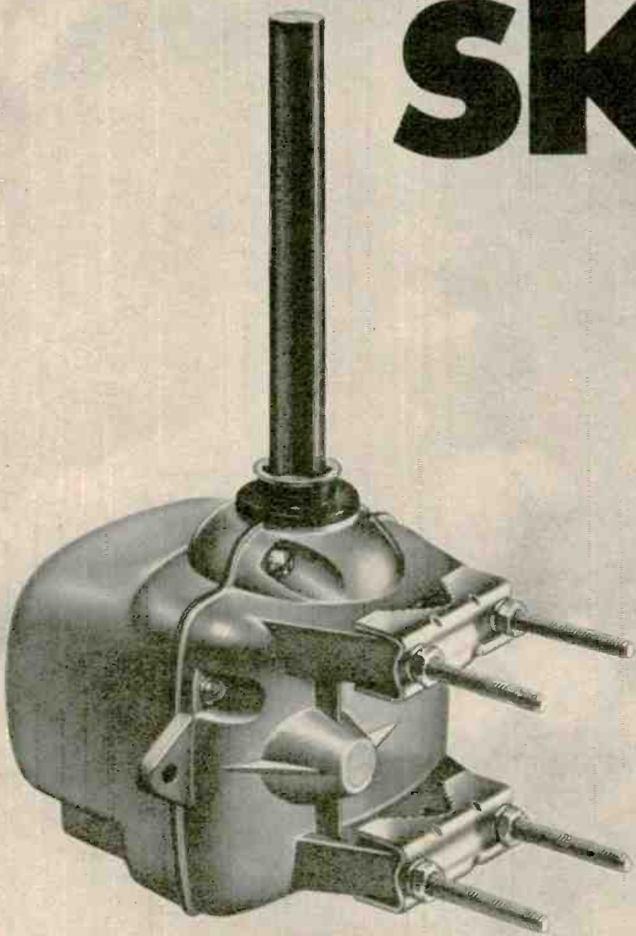
In an RCA CTC15 color chassis, the red signal cuts on and off. I can tap the 6GU7 red amplifier tube and affect the red signal, but replacing the tube doesn't help. Sometimes, tapping the other (G—Y/B—Y) tube seems to have an affect. Any helpful ideas?—L. T., Provo, Utah

For one thing, I'd cross my fingers and check the picture tube. However, this sounds more like PC-board trouble. Take both demodulators out and clean the sockets very carefully, and make sure the contacts are tight. Then, resolder *all* contacts around both sockets, just for luck; this may cure the trouble.

In this chassis, by the way, red and blue are amplified in the same 6GU7 tube; green is handled by a section of the horizontal blanker tube. So, check the tube first, then all supply-voltage connections. END

Circle 22 on reader's service card➤

Help stamp out green sky



CDE's Skyline Series Rotor Helps Give The Truest Urban/Suburban Color TV Reception!

Green sky, purple people and brown water... help your customers avoid these with CDE's Skyline series rotor. It's the most rugged lightweight on the market... the first rotor system designed specifically for metro-suburban areas.

It's *dependable*... because of a weatherproof die-cast housing. *Better-performing*... because of a high-torque motor with heavy wormgear drive. *Longer-lasting*... because of heavier-than-average construction throughout.

And see the built-in antenna mounting mast? It's there to prevent mistakes: the Skyline series can *only* be fitted to antennas it can control.

Available in both automatic and manual forms, the Skyline series rotor means the very best in color and black and white TV reception. Goes great with FM rigs, too!

CDE CORNELL-DUBILIER


We're looking for the men who want these well paid jobs!
And RCA Home Training can help you qualify
Just mail card today for details

Thousands of well paid jobs for men skilled in electronics are unfilled now

RCA INSTITUTES CAN TRAIN YOU —AT HOME—AND HELP YOU QUALIFY FOR JOBS LIKE THESE!

Every Sunday—and most week days —you will find *The New York Times, The Houston Chronicle, The Los Angeles Times* and many, many other newspapers cram-full of ads like these. Actively seeking qualified men for jobs in electronics and related fields.

Many of the men who *could* qualify for these jobs—well paid jobs—that is, men with the aptitude and native interest to enjoy a career in electronics—are handicapped because for one reason or another they have not had the opportunity to train themselves for jobs like these.

NOW—THANKS TO RCA INSTITUTES HOME STUDY— YOU CAN TRAIN FOR A CAREER IN ELECTRONICS

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PURITY AND CONVERGENCE

A penetrating study of the exact how's and why's of color-tube action from the point of view of two interrelated sweep-circuit functions

By W. D. MURPHY and R. L. CARR*

MANY PEOPLE IN THE ELECTRONICS field—technicians, hams, engineers, hobbyists—know something of the operation, adjustment and repair of the color TV receiver. Most of these persons are fairly knowledgeable about front ends, i.f.'s, agc, sound section, sweep circuits, etc. But there is still confusion in the minds of some regarding the relationship between purity and convergence. Why? Perhaps because both purity and convergence assemblies are on the neck of the CRT, because both must be adjusted during setup, and because both appear to interact with one another.

Purity and convergence in a color receiver are like the sparkplugs and carburetor in a gasoline engine, in one important respect: Each is an example of A and B interaction. Sparkplugs and carburetors perform different jobs, but they are interrelated. The sparkplugs ignite the mixture of air and gasoline which the carburetor produces. If either is defective or misadjusted, the engine won't work properly. Fouled plugs may require carburetor adjustment to keep the engine running. Conversely, improper gas mixture (defective carburetor) may lead to poor sparkplug life.

In a color receiver, both purity and convergence are necessary for the CRT to display a proper picture. The two perform completely different jobs, but they are interrelated because each affects the picture on the screen.

Color-picture-tube construction

You know, of course, how the three-gun tube works: Three electron beams excite red, blue and green phosphors on the screen by passing through holes in the shadow mask. Although all three beams may pass through the same hole, they do so at different angles, thus striking three phosphor dots of three different colors. Thus the color picture is formed. In order for each beam to hit its respective dot, the position of the dots with respect to the holes in the shadow mask must be precisely established.

Fig. 1 shows how phosphor dots are put on the screen of a color CRT. First, the inner surface of the faceplate is covered with a mixture of single-color phosphor and light-sensitive "photoresist" material. Then the shadow mask is inserted into its precisely located mounting assembly within the faceplate (see insert). Next, the faceplate and shadow mask assembly is mounted on an "exposure" table (as shown). Finally, ultraviolet light is used to fix the phosphor dots to their permanent positions.

The ultraviolet (UV) lamp is placed under the faceplate at the position where the yoke will be when the CRT is in a receiver. A concentrator lens above the lamp forms the UV light into a point source. Further above, a corrector lens makes a small change in the angle of light striking the screen edges. (This is needed to correct for certain yoke characteristics which will be discussed later.)

As you can see in Fig. 1, only UV light which passes through the shadow-mask holes strikes the phosphor layer. Where this happens, the phosphor is hardened and secured to the faceplate. Since the UV light passes through every hole in the shadow mask, a dot of one color is formed for every shadow-mask hole. The unexposed phosphor is then washed away, and the process is repeated for the two other colors. Each time the phosphor color is changed, the point source and lens system are repositioned, to correspond with the position of each electron gun in the finished tube. Since the UV light passes through the shadow mask at a different angle for each of the three colors, the sets of colored dots are positioned differently on the faceplate.

After the faceplate has been sealed to the CRT envelope, the three electron guns are precisely placed within the neck of the tube. This insures that the three electron beams will start from the exact points at which the UV light was located when forming the color dots.

Purity

The process we've described is reversed when the color CRT is installed in a receiver and displays a picture. The electron guns emit beams which excite the phosphor dots; the dots, in turn, emit colored light visible to the viewer's eye.

Sometimes, when the color picture isn't correct, we say the purity is at fault. What do we mean? A simple definition of purity is: Nothing but red on the screen when only the red gun is turned on, and the same for the green or the blue guns.

Each electron gun (a point source) in a color CRT is installed in the same place the UV light (also a point source) was, with respect to the screen. Then, when the red gun is turned on, for instance, it lights red dots. This is true *only* because the "red" electrons pass through the shadow-mask holes at "red" angles. If the red gun is aimed correctly, the red electrons go through the shadow mask at the wrong angle and hit the wrong phosphor dots. This causes impurity.

The color picture tube forms a picture line by line and dot by dot with the point-source electron beam. It is fairly easy to align the gun so the beam produces correct purity at screen center. But—what about at the edges of the picture?

Fig. 2 shows how the deflection yoke bends the electron beam to cover the sides and edges of the picture. From the faceplate's point of view, it appears as if the deflected beam had actually originated from a point within the yoke itself. The location of this *apparent deflection point* is determined by the yoke. Fig. 2 also illustrates that the deflection point is actually shifted *by the yoke* along the tube axis as the angle of deflection changes. This is a characteristic of the yoke. Near the edges of the screen, where the deflection angle is greatest, this point is much closer to the faceplate. If there were no corrections built into the tube to compensate for the yoke, it would be impossible to achieve overall purity. The exposure table of Fig. 1 has a large correction lens between the UV lamp and the faceplate. This correction lens is designed to match typical yoke characteristics, since the length, winding shape, field uniformity, etc. deter-

*Sylvania Electric Products, Inc.

INTERACTION

mine how the electron beams will bend when they pass through the yoke.

In addition to the yoke, one other component controls purity. That is the rotatable, adjustable-strength *purity magnet* on the neck of the picture tube. Precise gun alignment during manufacture isn't always possible, and the purity magnet is used to fine-align the guns.

An important, but often overlooked, function of the purity magnet is to compensate for the effects of the earth's magnetic field. This field bends the electron-beam paths, causing impurity. The amount of this impurity depends on where the receiver is and how much iron or steel is near it.

Alignment instructions for a color receiver usually state that the purity magnet should be adjusted to obtain good center-screen purity only, with the yoke deliberately moved back toward the convergence assembly. This procedure should be followed so that, for the initial purity adjustment, the *only* possible area of the screen capable of correct purity is the very center. Then the purity magnet is adjusted so the electron beam is properly aimed for screen center.

Purity adjustments are usually made with only the red gun operating, since a red screen shows up impurities more glaringly than a blue or green screen. Once the red beam has been properly positioned, the other two will normally be correct. Should there be small errors in gun alignment, the purity magnet and yoke can be used for compromise purity of all three fields. Moreover, since any slight impurity will be *most* noticeable on a black-and-white picture, the compromise adjustments are made to produce a pure "white field" at the expense of any minor impurity in the individual colors.

Those who have worked with color receivers know that stray magnetic fields—whether caused by the earth, or a nearby coil or magnet—can affect purity. For example, the shadow mask is made of steel. If it becomes magnetized, the resultant field will change the electron-beam angle, producing impurity. A degaussing coil prevents this impurity by removing any stray magnetism from the chassis and cabinet. Every time a receiver is moved, it's remagnetized by the earth. This causes impurity. *For this reason, purity adjustments must be made with the receiver in its final viewing position.*

Recent receivers incorporate automatic degaussing circuits; whenever the power is turned on, the CRT is degaussed. Such sets, when properly set up, *may* be moved without earth-field impurity. But, whether automatically or manually, always degauss the set before you make any purity adjustments. If you don't, you may find an "improper" setting of the purity magnet and yoke that will cause what seems to be an acceptable picture. Then, when the set is degaussed (automatically or manually), the purity will be incorrect.

Convergence

While purity is a static function only, convergence contains both static and dynamic elements. Time is no factor in purity, since it doesn't matter when a particular phosphor dot is excited. Once correct purity adjustments have been made, they will be correct no matter how slow or fast the beams are traveling when they hit the phosphors.

The same is not true of convergence. Fig. 3 shows two spotlights on a table aimed at a screen. Each spotlight

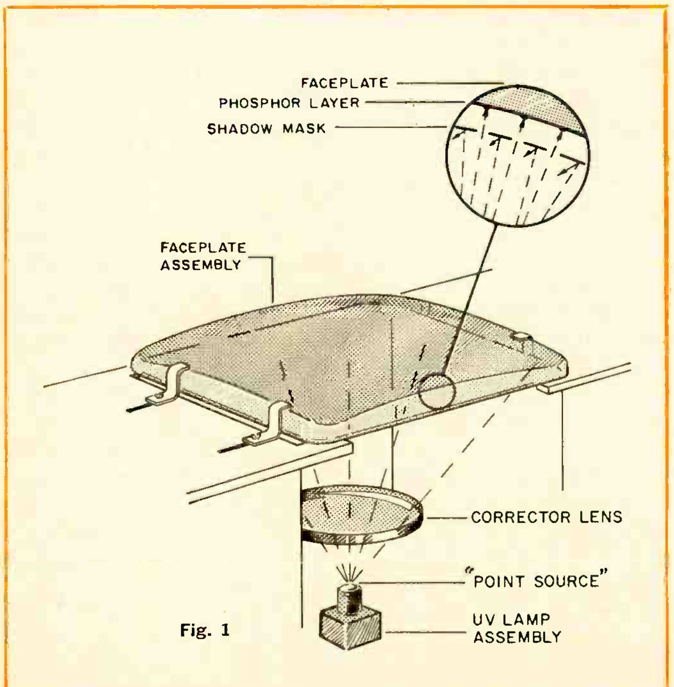


Fig. 1

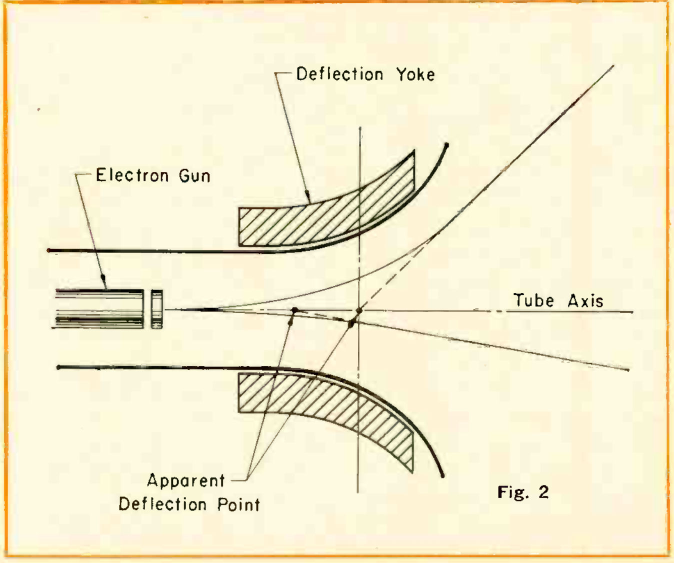


Fig. 2

Fig. 2—One thing necessary for purity—apparent deflection point of beam must be shifted to compensate for flat faceplate.

Fig. 1—Beginning of a color picture tube. The colored phosphor dots are deposited on the faceplate with ultraviolet light.

is fitted with a color filter—one red, one green. When the spotlights point at screen center, their beams converge into a single yellow spot. When the table is turned slightly to the right sometime later, the beams *overconverge* (shown by dashed lines) and form separate spots of red and green on the screen. Why? The distance from the table to the edge of the screen is greater than the distance from the table to screen center. Notice that the respective positions of the lamps on the table hasn't changed—only the direction the table points (a function of time). The only way to make the lights converge at the edge of the screen now is to change their mounting positions on the table.

The electron guns and beams in a tricolor picture tube operate much like the spotlights of Fig. 3. First, convergence adjustments cause the beams to converge at screen center. When the yoke deflects the beams—as the spotlight table was turned—the beams do not converge (hit the correct dots) simultaneously at the edge of the screen. During any time interval that a color CRT is being operated, its beams are being deflected by the yoke. As the respective positions of the spotlights had to be changed to converge their beams, so the electron-beam deflection angles have to be changed in the CRT so they strike the correct landing spots. Thus time is a factor in convergence.

Fig. 4 illustrates convergence and misconvergence in the color picture tube. Each electron gun is tilted toward the tube's center axis so the beams converge precisely at screen center. Convergence at other parts of the screen is made with respect to the center. In an actual tube, gun tilt is approximately 1°. (In Fig. 4, gun tilt is exaggerated for clarity.)

Magnets are used for fine adjustment of the point where the beams hit the screen. They compensate for any slight errors in mechanical positioning of the guns during picture-tube manufacture. By proper adjustment, the two beams illustrated (red and green) will converge into one point of yellow light at screen center.

Now observe, in Fig. 4, what happens at the edge of the screen. Both beams are deflected the same amount (30°) by the deflection yoke. Since both guns are pointed toward screen center at an angle off the tube axis, each beam is deflected off the center axis by a different amount. The beams also travel farther to the edge than they did to the center. Since the beams converged at screen center on the shadow mask, but now must travel further to the edge of the screen, they now converge before reaching the mask. Thus the beams fall on the screen as two individual spots of light.

The dots in Fig. 5 represent beam-landing points before correction. The arrow on each dot shows the direction in which the beam must be moved to converge that particular portion of the screen. Since all three beams are already converged at the center of the screen, corrections are started there. Note that every blue arrow points upward, every red arrow points to the lower left, and every green arrow points to the lower right. This means that, whatever portion of the screen is being converged, the direction of each beam travel is always the same. The arrows are of different lengths however, showing that different amounts of correction may be required at various screen locations.

Convergence circuits

Suppose the gun tilt shown in Fig. 4 was adjustable from 4° to 7°. Then, regardless of yoke deflection, we could slightly adjust the deflection angle of each beam. The overall deflection would then be the vector sum of the yoke deflection plus the beam tilt. The dynamic-convergence assembly of the actual picture tube does just that—not mechanically of course, but by magnetically tilting the path of the electron beams. The currents in the convergence coils are adjusted by electronic means to reduce the tilt to something less than the angle set by the gun positioning.

Remember, all beam corrections are applied in a direction *away* from the center of the CRT, since the tendency is to overconvergence, or crossing before they reach the screen. As misconvergence varies with beam position over the screen, it is a dynamic or changing characteristic of the tube. Any corrections must also be dynamic. (As we pointed out earlier, time is a factor in convergence action.)

In a color receiver, the horizontal and vertical deflection circuits provide power to operate the convergence circuits in step with the horizontal and vertical scanning. The basic correction applied is a parabolic (bowed) waveform. This wave goes to zero at the center of each cycle, and has a peak at both beginning and end of the deflection period. Since convergence correction for a particular beam is always in the same direction and at screen edges, the two peaks

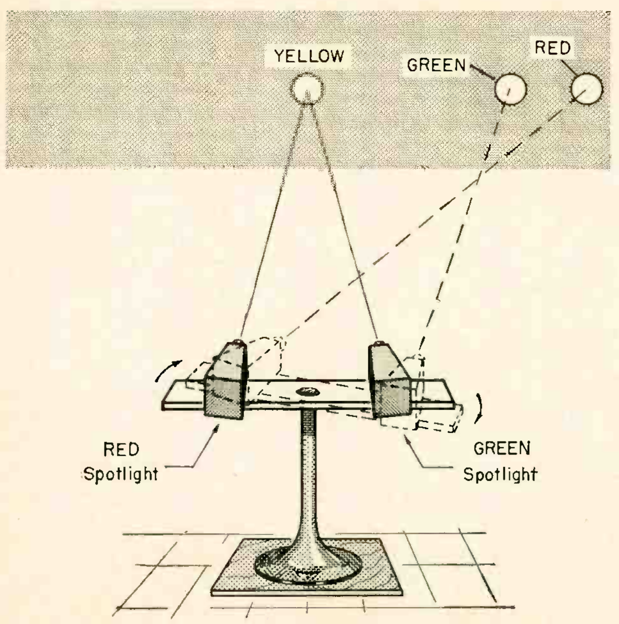


Fig. 3

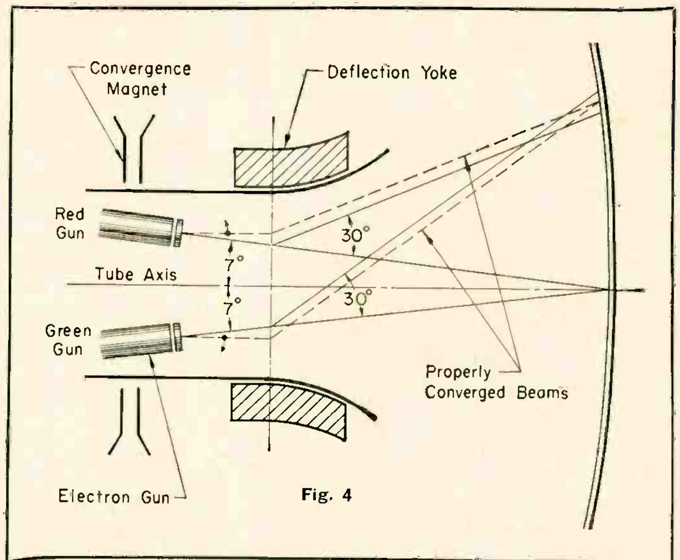


Fig. 4

Fig. 4—The amount of dynamic convergence needed depends on where the beams are on the screen at any given moment.

Fig. 3—Spotlights simulate action of electron beams in color CRT, showing why convergence correction is necessary.

of the parabolic waveform will deflect the beam in the required direction.

As Fig. 5 shows, different amounts of deflection are required for a specific beam from top to bottom and left to right, but the correction is applied in the same direction. No dynamic convergence is required at screen center—the zero point of the parabolic wave. The convergence circuits in a receiver modify the basic parabolic waveshape so the two peaks can be adjusted to different amplitudes.

Many receiver setup manuals state: Make all vertical convergence adjustments on a vertical line through the center of the screen; ignore any errors appearing on either the left or right side.

Why such a procedure? No horizontal deflection is applied to any of the beams anywhere along this vertical center line. The three beams are mechanically converged by gun tilt (and static convergence magnets) in the center. The *only* misconvergence that can occur along this vertical line is due to vertical deflection of the beams. A similar method is used for horizontal convergence. Thus, the two components of convergence error—horizontal and vertical—can be separated for ease of viewing during adjustment.

Corner convergence is more complex. The beams land, in a corner, at a point determined by the *vector* sum of the horizontal and vertical distance from each gun to the screen. That is, there is both a *horizontal* angle and a *vertical* angle which determines the point where each beam lands. However, convergence correction is applied by only one magnetic field, which is the *simple* sum of the horizontal and vertical convergence corrections.

A very complex circuit—expensive to build and difficult to adjust—would be needed to obtain *perfect* convergence over the entire screen. Such a circuit is not used in color receivers. Thus, there is normally slight misconvergence in the corners when the horizontal and vertical axes are perfectly adjusted. In addition, it may not be possible to adjust the circuit for the precise waveform needed to converge a specific yoke-and-picture-tube combination at some small area of the screen. In practice, therefore, convergence must be made for the best overall compromise.

The static convergence magnets have two important jobs: To correct for any mechanical misalignment in the tube, and, as a part of the dynamic convergence circuit, to offset the effect of ac coupling on the convergence signals.

These magnets correct any slight mechanical misalignment of gun tilt (as pointed out previously). They also offset any slight dynamic convergence voltage that exists at the center of the screen.

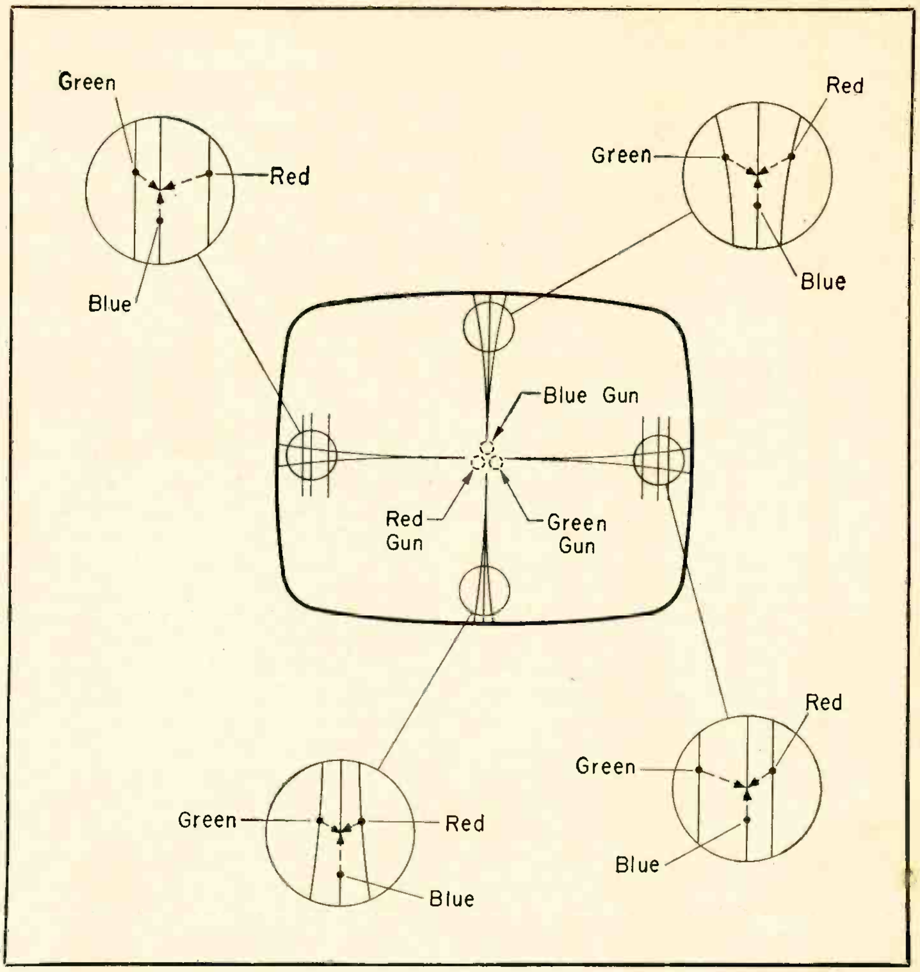


Fig. 5—The dynamic convergence signal is a parabolic wave. It applies zero correction when the beams scan screen center. More is used as the beam approaches the edges.

Remember that zero dynamic convergence signal is required at screen center, but since the various convergence voltages are ac-coupled, they will go both positive and negative from zero. This means if the beam is shifted to the right at the edge of the screen, it will be shifted to the left at the screen center. The static magnet is used to buck out the effect of this negative (or unwanted) dynamic convergence at the center.

There is one other convergence control—the blue lateral magnet. A static control, it is used primarily to correct for slight gun misalignment by shifting the blue beam horizontally to intersect the converged red and green beams. (Some receivers, however, use a dynamic control to improve overall convergence.)

There is an additional point—sometimes overlooked—which we haven't covered. Static convergence should be adjusted reasonably close before making any purity adjustments. It doesn't matter if the three fields are impure when making this adjustment; the important thing is to converge the beams.

Interaction of dynamic convergence circuits with purity has been minimized by the tube manufacturers. The dynamic convergence signal reduces the 1° beam tilt to achieve convergence, and also shifts the beam away from the "point source." As mentioned so often, any point shift causes impurity.

The lens system in the exposure table that's used in screen manufacture is designed to correct for this interaction. The apparent "point source" for the edges of the screen is shifted to coincide with the shifted beam caused by the convergence signals. Therefore, when the correct amount of convergence is applied to the edges of the screen, the now "shifted" electron beam will pass through an also "shifted" point source.

In summary, purity and convergence are separate factors in the operation of a color picture tube. Like sparkplugs and the carburetor in a gasoline engine, though separate, they are interrelated because they work on a common third element—the release of energy from gasoline, or the display of a picture on a color CRT. Just as carburetor misadjustment can cause poor sparkplug performance, misadjustment of the convergence circuits can cause poor purity. END

1967 COLOR-TV ROUNDUP

Refinements and innovations appear in new crop of multihue receivers

By WAYNE LEMONS

THERE IS NO QUESTION THAT MORE color TV receivers will be sold and serviced in 1967 than ever before. More manufacturers are making sets and many are introducing additional models.

Color, much like b-w some 10 or 12 years ago, is in a state of change and consequently has some growing pains. Designers are pressing toward that ever-elusive "standard" circuit by widely varying routes. Transistors, which started trickling into color design a couple of years ago, now are spreading into all color circuits. Not even power stages will remain sacred to the vacuum tube for long. This year several brands use an audio-output transistor.

Color TV designers, who once took all their cues from RCA, no longer worship at the shrine and have started condensing, refining and even revolutionizing their circuits. Composite color oscillator–demodulators such as Motorola's, Zenith's gated-beam demodulator, and G-E's diode color demodulator, today employ fewer tubes, but without a sacrifice of good engineering practices. For example, the G-E color circuit uses only three tube envelopes in the entire color section and one of these is a video amplifier!

In 1967 designs, many tube functions have been taken over by transistors and IC's (integrated circuits). Philco, for instance, has nine transistors in a single color chassis, including three in one of the first solid-state color tuners. RCA is using an IC in the sound section of the CTC21 chassis.

Because of this scramble to solid-state circuitry in new color sets, most of this survey will concern the uses, functions and service problems of the new solid-state designs. First, however, let's look at the more-or-less mechanical aspects of the new sets.

The "Blue Wide-Field Correction" used by RCA and others is just such a mechanical innovation. One of the frustrations that all of us have had, especially with rectangular color CRT's, is that often the blue vertical lines (using crosshatch) were to the left of the red and green lines on the left-hand side of the screen and to the right on the right-hand side. In other words, the blue field was wider than the others. On all but a few receivers (chiefly Motorola) there was no adjsutment to compensate for this defect. It was an annoyance to both the technician and to the critical customer.

The side-blue problem occurs because the blue gun is closer to the right-angle field of the deflection yoke than either the red or green gun and thus has slightly more scan sensitivity. The Blue Wide adjustment used by RCA minimizes or eliminates the defect by allowing for some up-and-down movement of the deflection yoke, which can be adjusted by a screw at the bottom of the yoke housing (Fig. 1). By careful positioning of the yoke, the blue-field sensitivity can be made comparable to the red and green fields. (This is a factory adjustment and will seldom need to be changed.)

Other mechanical features you'll be seeing more of will be the combination blue-lateral and purity-magnet assembly. And you'll be seeing more dc-magnet assemblies that will not fall out of adjustment so easily when the set is transported. For example, the wheel-type magnets in Fig. 2 are representative of those used by Admiral, Magnavox, Zenith and others.

Post-purity adjustment (purity rings in front of the deflection yoke), used by Zenith for a couple of years, has bit the dust. The reason is probably an economic one, not to mention the

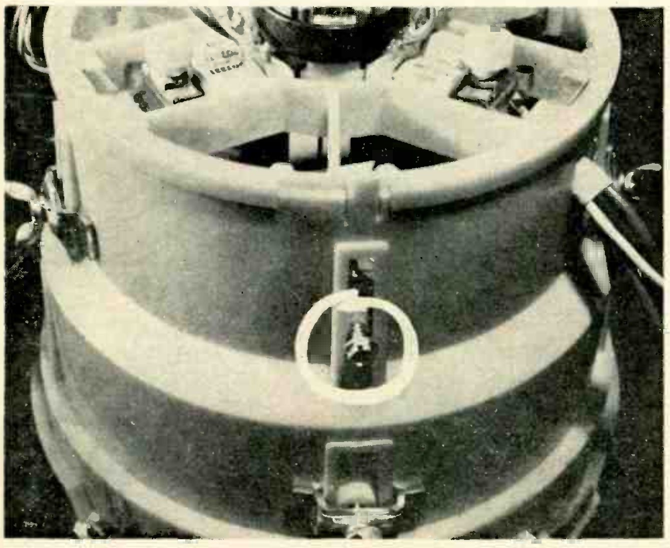


Fig. 1—Circled screw is blue-wide adjustment on RCA models.

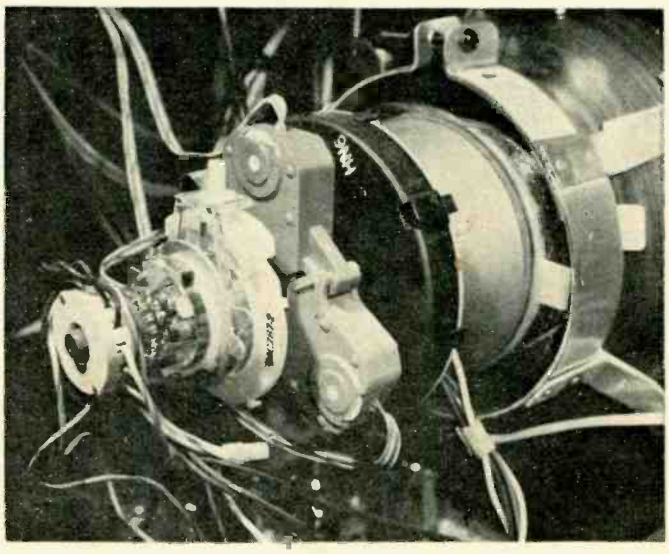


Fig. 2—Some sets use new wheel-type magnets near CRT base.

fact that post-purity-ring adjustment always required a CRT degaussing afterward.

For the first time this year, many manufacturers have taken more than a passing interest in seeing that their color sets are, or will be, properly tuned by the customer. Although Magnavox has had tuner afc for a while and Motorola has had a color indicator lamp, this year RCA has added tuner afc, Philco has a tuning eye and G-E a tuning meter that permits the customer almost-perfect assurance that the set is tuned correctly to receive the best color or black-and-white picture and sound.

Pincushion adjustment is still done by tubes, transistors, saturable reactors or some combination of the three. Some manufacturers use little or no horizontal correction but all have simple-to-elaborate means of vertical correction. Motorola has added a transistor circuit for horizontal correction this year, to go with its already transistorized vertical pincushion circuit (Fig. 3).

A lot of manufacturers are turning out color receivers with 19-inch screens, and in most cases the 19-inch chassis is identical to the same manufacturer's 23- or 25-inch chassis. The only really portable color is probably still the 11-inch Porta-Color made by G-E. This chassis with its small CRT has provisions only for dc convergence and very minimal dynamic-convergence adjustments.

New controls

Additional controls have been added by some set makers to simplify setup procedure. RCA, for the first time this year, has made its setup switch a three-position unit. (It isn't, however, the first to do this.) They have labeled the switch NORMAL–SERVICE–RASTER. The NORMAL and SERVICE positions are the same as before, but the RASTER position is what Wesinghouse and others have called a PURITY position. This position is useful when adjusting purity or setting gray scale, since it provides a snowfree raster without having to pull an i.f. tube. (Many technicians connect a dot/bar generator to produce dots and then simply disregard the dots when adjusting for best purity.)

Some of this year's RCA models contain another new switch (Fig. 4), a RED/GREEN control switch. This function allows the red- and green-signal outputs to be switched between the CRT's red and green cathodes. Such switching can be useful if the red phosphor of a particular CRT happens to be more efficient than its green—a situation that might often arise when installing a replacement CRT.

Motorola's TS918 chassis, which is essentially the same as its earlier TS914 (except for the horizontal pincushion correction already mentioned), now includes a pair of switches on the convergence board. The switches reverse the phase of vertical-tilt voltages, when necessary, to get better convergence. Such phase reversal was done on the TS914 with plug connectors.

The BLUE SHAPE coil used on the convergence board of some 25-inch receivers has been made nonadjustable by some manufacturers. This step was taken because the coil is not a part of the convergence procedure and its misadjustment can overload the horizontal sweep circuit.

High-voltage regulation

The 6BK4 shunt regulator was pretty much of a standard in this stage until a year or so ago, when Motorola introduced its diode feedback control. Now the circuit has been given another look (Fig. 5) by Zenith designers. They use a new regulator tube (6HS5) in a low-impedance circuit—across the damper instead of from high voltage to B+. Essentially, the regulator samples boost voltage and loads the damper circuit to the extent required to maintain a constant load on the horizontal sweep system. A VDR (voltage-dependent resistor) in the 6HS5 grid circuit tends to "amplify" larger voltage changes while acting as a normal resistor during lesser changes. This arrangement gives better HV regulation for changes in load.

Silvertone uses a VDR, as does Philco, to provide voltage regulation at the grid of the horizontal output tube

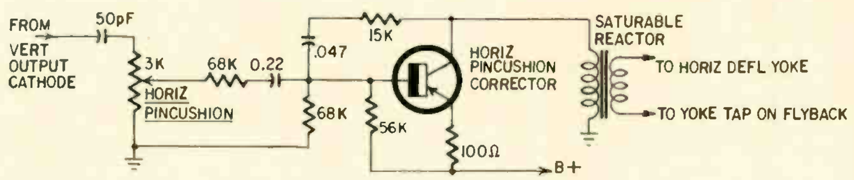


Fig. 3—Motorola TS918 receiver uses pincushion correctors for both horizontal and vertical deflection.

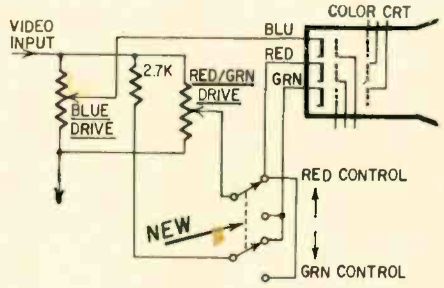


Fig. 4—Gun-drive switch on RCA CTC21 allows compensation for lack of phosphor efficiency in CRT.

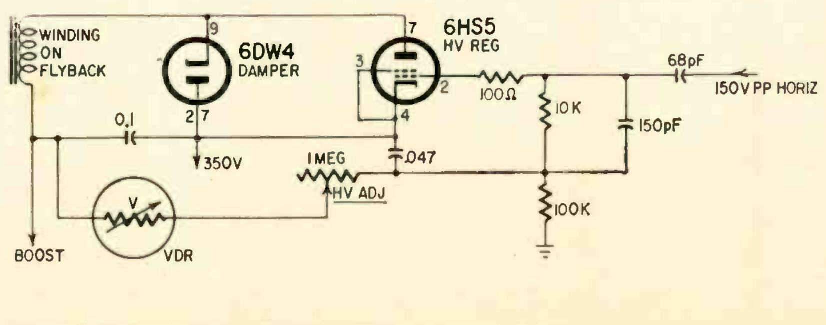


Fig. 5—Unusual power tetrode is used across damper in Zenith 23X chassis for HV regulation.

(Fig. 6). The principle and effect are similar to Motorola's circuit. A feedback loop is established, containing a variable control element (the VDR) which holds horizontal sweep voltage constant. Since flyback input voltage is constant, flyback output (HV) is also constant.

The circuit used by G-E and shown in Fig. 7 at first appears to be a diode regulator. It is actually called a "hold-down" circuit by G-E. It works like this: If the high-voltage shunt-regulator tube should burn out, most of the HV circuit load would be gone. With a small load, the high voltage would soar, along with all horizontal-sweep voltages, causing breakdowns and HV arc-overs. The silicon holddown diode prevents this condition by conducting more current when flyback pulse voltages increase. This higher conduction develops a more negative grid potential at the output tube. In a sense, the diode is a sort of standby or safety HV regulator.

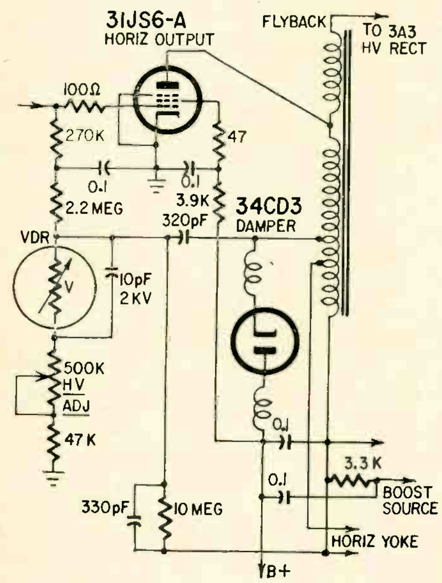
Other circuits

The transistor and the IC (integrated circuit) are moving quickly and steadily into color circuit design, as we noted earlier. Although these devices may at first cause consternation to service technicians, they promise to be a boon to serious technicians. Do-it-yourself tube jockeys will find IC's and solid-state devices mighty baffling.

Transistors first appeared in TV at the video stage in b-w receivers. The same is now true for color, where some manufacturers use at least one transistor to drive the luminance channel. The low impedance of the transistor is ideal for matching to the delay line. Some even use two transistors in cascade, to provide more gain ahead of the delay line. This permits the designer to use a lower-G_m video-output tube, and such tubes usually cause fewer service headaches.

In G-E's "KC" chassis this year, the video circuit (Fig. 8) uses *two* npn transistors. Bias for the first stage is unconventionally derived from the power-transformer filament winding, rectified by D1, and filtered by R1, C1 and C2. It's quite similar to applying fixed bias to the cathode of a vacuum tube. No base bleeder resistor is needed, and the bias voltage is fairly stable.

The circuit of Fig. 9—from an RCA CTC 21—is, to our knowledge, the first in a color set to use a transistor audio-output stage. The unit is a special high-voltage transistor with 160 volts on the collector, and it is protected against overloads in two ways. A 60-mA fuse is in series with the collector, to guard against excessive current as well as leakage. To place a limit on collector voltage, a reverse-biased diode is connected between the collector lead and the 270-volt line. Collector voltage therefore cannot exceed 270, for above this limit the diode conducts, clamping the collector voltage at 270. In servicing this circuit, note that if the fuse opens, the



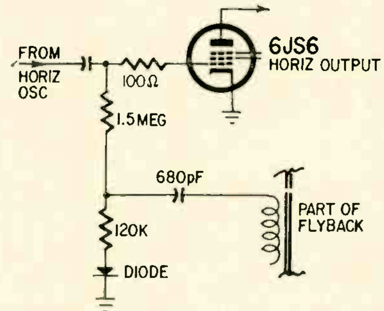


Fig. 7—G-E calls this a "hold-down" circuit. The diode prevents 6JS6 runaway if the HV regulator should fail and remove its load.

Fig. 6—Entire horizontal sweep and HV section is regulated by VDR in output-stage grid circuit of Silvertone 528.625 chassis.

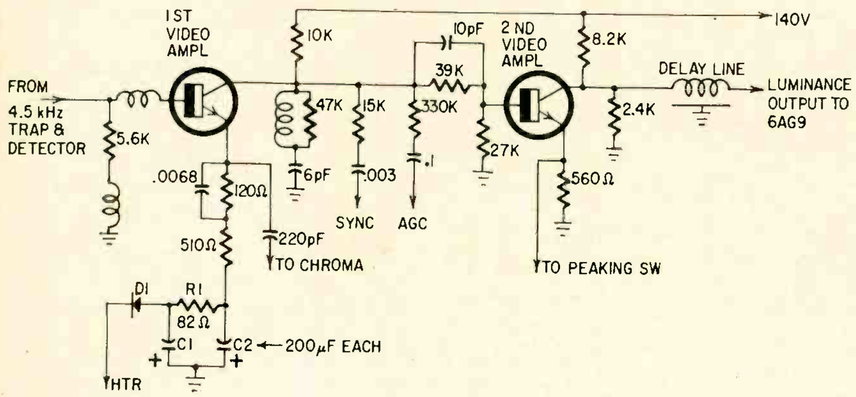


Fig. 8—G-E KC series video circuit obtains transistor bias from heater winding.

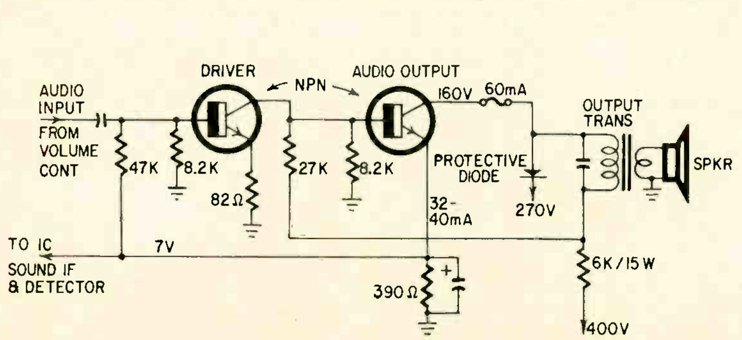


Fig. 9—Audio section of RCA CTC21 uses special high-voltage transistors.

diode may short; always check it. About 7 volts is developed across the output-stage emitter resistor. This voltage is used not only as driver-transistor bias but as supply voltage for the 4.5-MHz sound IC, which draws about 17 mA.

The most elaborately transistorized color this year is found in Philco's "P" line. Here npn silicon transistors constitute a high-gain i.f. circuit with agc from a two-transistor circuit.

A simplified form of Philco's agc circuit is shown in Fig. 10. The first transistor (Q1) is biased by the first video amplifier's plate voltage. The agc control in the emitter circuit sets stage gain, while the collector is keyed from a flyback winding. Q2, the second agc transistor, is *ac*-coupled to Q1 through C1. Negative pulses across the 6.8K resistor increase as Q1's conduction increases. These pulses, after passing through C1, are rectified by D1. Greater pulse size causes greater positive voltage at Q2's base. This action increases the positive output voltage to the agc line. As with most transistorized agc circuits, saturation agc is used: the transistors are overbiased and driven toward saturation to decrease the gain of the stage, rather than toward cutoff.

You'll find a transistor used as noise gate in several 1967 color circuits. Silvertone's 528.625 chassis, a portion of which is shown in Fig. 11, is typical. The collector of Q1 is connected to the cathode of the sync separator tube. Normally the transistor is conducting and the tube cathode is essentially at ground potential. However, when a large negative noise pulse is coupled from the video amplifier cathode to Q1's base, the transistor is cut off. When Q1 stops conducting, its collector voltage rises, as does the cathode voltage of the sync separator. This cuts off the sync tube, blocking the noise pulse from the sweep-oscillator circuits.

Tuning indicators and afc

Two circuit innovations that really caught on with designers this year are the tuning indicator and tuner afc. In the G-E "KC" chassis a transistor dc amplifier operates a tuning meter (see Fig. 12).

The indicator and tuner-afc circuits have much in common as to takeoff points and adjustment. Signal takeoff in every case is done at the output of the third i.f. amplifier, by means of a 45.75-MHz coil.

Tuning-indicator takeoff coils are

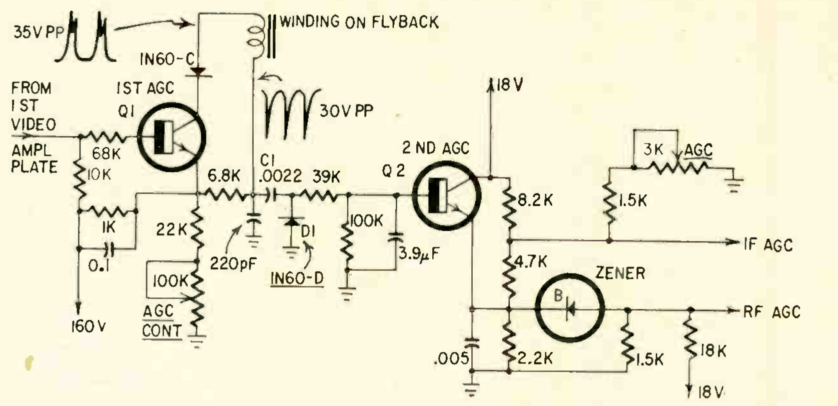


Fig. 10—This is a simplified version of Philco's two-transistor agc circuit.

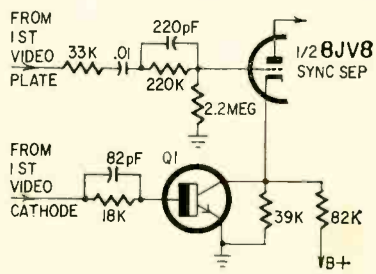


Fig. 11—Transistor gates noise pulses out ahead of sync section. Chassis is Silvertone 528.625 and antinoise circuit is representative of several 1967 color receivers.

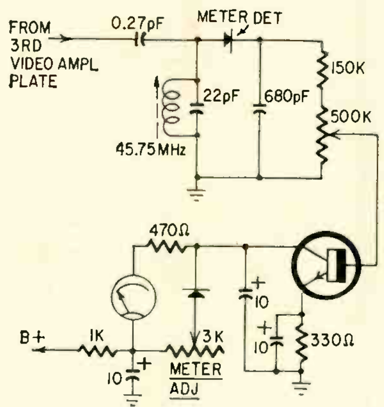


Fig. 12—G-E's tuning-meter circuit.

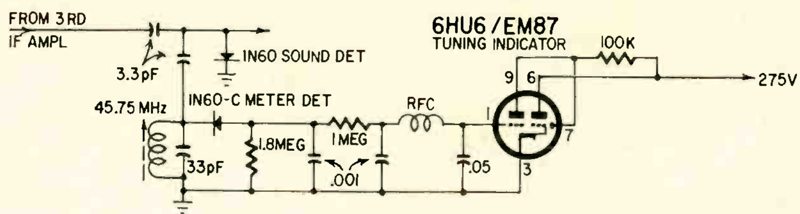


Fig. 13—Philco uses eye tube as tuning indicator in the 17MT80B chassis.

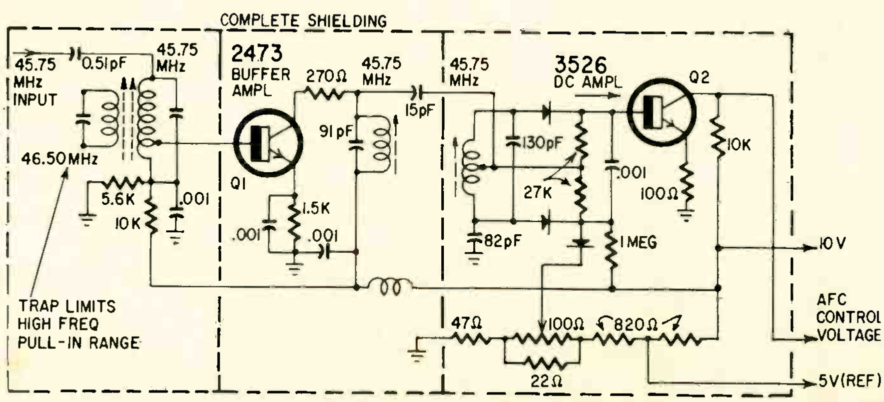


Fig. 14—One innovation this year is tuner afc circuit, here shown in RCA CTC21.

tuned to peak the meter reading or close the eye tube when the picture and sound are properly tuned in. Thereafter, the user fine-tunes for maximum indicator reading.

The tuner afc circuits are more complex. Fig. 14, from an RCA CTC21, uses a transistor amplifier (Q1) for the 45.75-MHz picture carrier. Q1 is followed by a Foster-Seeley discriminator and Q2, a dc amplifier, which furnishes correction voltage for the tuner. An input trap (see diagram) restricts the pull-in range so that the circuit will not attempt to lock in (or out) on any false signals.

An unusual feature of this circuit (Fig. 15) is the use of a transistor as a diode for the controlling element. (Notice the emitter is not connected.) Q3 essentially acts as a variable resistance, causing the 5-pF capacitors to have a greater or lesser effect on oscillator tuning. (The uhf tuner uses a variable-capacitance diode and no reference voltage.)

RCA suggests that the fine tuning be adjusted so that the picture just starts into sound bars. (The afc defeat switch is automatically closed when the fine tuning is being set manually.) Then, when the defeat switch opens, the afc will bring the picture and sound in at the right point.

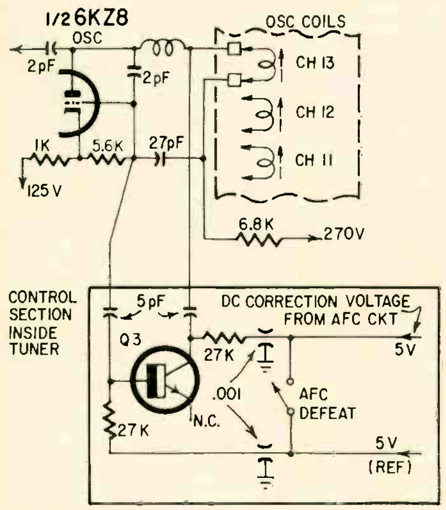


Fig. 15—This RCA CTC21 tuner afc circuit uses a transistor as a diode. Variable resistance of Q3 causes the 5-pF capacitors to shift the frequency of the oscillator and correct the tuning.

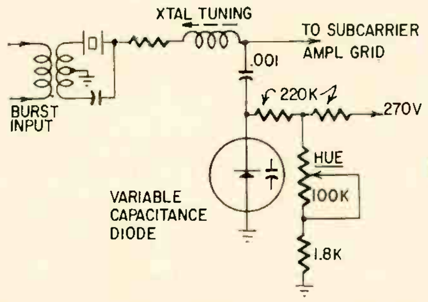


Fig. 16—G-E KC series hue circuit.

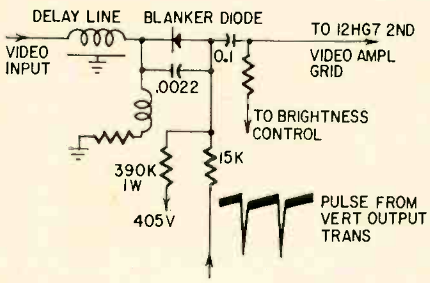


Fig. 17—A vertical-blanking diode is used by RCA in their CTC20 and some late production versions of the CTC19.

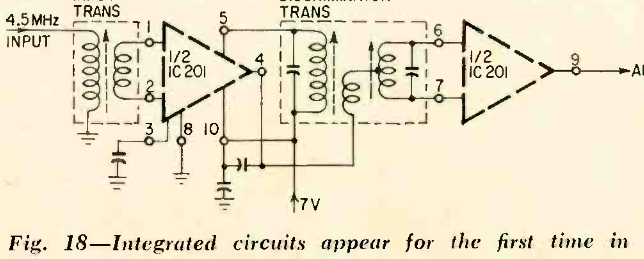


Fig. 18—Integrated circuits appear for the first time in color receivers, being used in the audio section of this RCA CTC21 chassis.

Variable-capacitance diode

A Varicap is being used this year by G-E in the hue-control circuit shown in Fig. 16. Although not new (Packard Bell has used the principle for several years in a conventional burst-amplifier circuit) it is different. The 3.58-MHz crystal is "brute-forced" into ringing, rather than being made to oscillate in the accepted sense. This ringing is made to occur at the right phase by the injection of strong pulses of burst information. The varying capacitance load on the crystal circuit causes it to change phase enough to provide control over hue.

Series-diode blanker

Fig. 17 shows one of the first series-diode blanker circuits we've run across. In this circuit, all video information passes through the diode because of the forward bias placed on it by the 390K resistor to B+. During retrace, however, a vertical pulse through the 15K resistor "opens" the diode (and its low-impedance path to ground) so that a strong negative pulse is applied to the grid of the second amplifier. This pulse is then amplified and inverted by the second video stage, producing a strong positive pulse at the CRT cathodes and eliminating retrace lines.

Integrated circuits

To my knowledge, only RCA is using IC chips in its color sets. The circuit used in the CTC21 is shown in Fig. 18 as it appears in the schematic. (Note that each IC's internal circuitry is *not* shown.) When troubleshooting, you'll have to use exact replacement IC's. [For the complete schematic of these IC's, see "The IC Comes to TV," page 27, RADIO-ELECTRONICS, June 1966.—*Editor*]

Summary

Color TV is going to be big in 1967. Technicians, of course, cannot ignore the fact that they must learn new servicing techniques to deal with new solid-state circuitry. The all-transistor color set can't be too far away and the time to learn its techniques is during the transition. Essentially the change in technique won't be as drastic as you might think—but neither will it be as minimal as you might hope. It's a time for all of us to roll up our sleeves, attend service meetings, digest magazine articles and books, and look forward to a really bright and colorful future. END

What Happened at Oslo?

Why there isn't worldwide agreement on a color-television system

By THOMAS R. HASKETT

PREVIOUS RADIO-ELECTRONICS ARTICLES have discussed color television as proposed throughout the world.* This subject was one of several considered by participants in a conference at Oslo, Norway, during June and July 1966. To find out exactly what was discussed, why it was discussed, and why the conference ended the way it did (RADIO-ELECTRONICS, October 1966, p. 4), we interviewed two US delegates.

Dr. George H. Brown is executive vice president, research and engineering, of the Radio Corporation of America. Long a radio and television engineer, he is the developer of the *turnstile* antenna, the most widely used television transmitting antenna.

Mr. Frederick M. Remley, Jr. is chairman of the Video Tape Recording Committee, Society of Motion Picture and Television Engineers, and technical director of the University of Michigan's Broadcasting Service.

RADIO-ELECTRONICS: Gentlemen, would you tell us how the Oslo conference came about?

DR. BROWN: From time to time, the member countries of the United Nations wish to discuss matters in the areas of radio, television and communications. Routine specialized topics are rarely discussed in the General Assembly, but usually handled by the UN agency responsible for such affairs. The particular agency for radio, television and communications is known as the ITU—International Telecommunications Union.

R-E: Then the ITU sponsored the Oslo conference?

MR. REMLEY: Not directly. ITU is a large organization, involved in many fields of international communications. One of ITU's divisions is known as the CCIR, from the French-language initials for International Radio Consultative Committee. The Oslo conference was the eleventh fully attended assembly of the CCIR. A previous meeting of a portion of CCIR at Vienna set part of the agenda for Oslo, and the discussion of a single worldwide color-television system was scheduled.

R-E: How many delegates to this color-television conference were there?

DR. BROWN: There were nearly 800 delegates to the conference, but color television was only one of the subjects discussed. You see, CCIR consists of 14 study groups, which are concerned with all forms of radio communications, their standards and definitions, and so on. Study Group XI is concerned with television, and color was formally discussed at the meetings of this group.

C. Hoyt Price, of the State Department, was head of the US delegation to the full CCIR conference. Arthur Hall, of Bell Laboratories was spokesman for the US in Study Group XI, to which I was a delegate representing industry. There were some 12 or 15 other delegates to SG XI from the US, by the way, including people from the FCC.

MR. REMLEY: I participated primarily in Study Group X, where we were concerned with things like television film standards, for example. However, I attended some meetings of Study Group XI, and my own group discussed color-television problems, but we took no official action.

R-E: How was the question of a universal color-television standard brought up?

DR. BROWN: First, let me say there's quite a difference between a *standard* and a *system*. A standard is a rule or definition, established by government or industry, which everyone uses. A good example is the US standard of 525 horizontal lines in a complete television frame or picture. A system, on the other hand, is a method or means of accomplishing some goal. NTSC and SECAM are two different color-television *systems;* both can be used with 525-line *standards,* as well as with other standards.

At the beginning of the Oslo conference, Study Group XI Chairman Erik Esping, of Sweden, asked two questions of the delegates: "When do you expect to start color-television broadcasting in your country?" and "What system or systems do you prefer?" The chairman then asked for "expressions of opinions," not votes. These expressions showed that the various countries favored a total of 4 systems. [See Table I.—*Editor*] It was asked if there should be a single worldwide system, and if so, which one? Well, it was obvious that with such a large group—about half the 800 delegates to the entire conference—very little could be accomplished toward arriving at some sort of agreement. The group was just too large and unwieldy. The chairman recognized this, and adjourned the meeting for several days after suggesting discreetly that some "cloakroom bargaining" occur before another meeting.

R-E: Could you explain where the various systems were developed and what differences exist between them?

MR. REMLEY: SECAM III is a French development, like its earlier and now-obsolete predecessors SECAM I and II. SECAM III seems inherently inferior to the other systems. It uses an FM subcarrier which is always present and causes interference in some pictures, depending on scene composition. The overall picture quality is often relatively poor. The system requires a complicated receiver, which would probably be more expensive to manufacture than receivers for the other systems. SECAM III's advantages are that it can be recorded easily by ordinary monochrome video tape machines and can be transmitted by limited-performance cable and microwave systems.

SECAM IV is the French name for

* *"Color Television Throughout the World," January 1965; "The Case for NTSC in Europe," March 1965; "Color Television Systems: Which Way Will Europe Go?" July 1966.*

Definitions

ART	Additional Reference Transmission
CCIR	International Radio Consultative Committee (UN)
NIR	National Research Institute (USSR)
NTSC	National Television System Committee (US)
OIRT	International Radio and Television Organization (USSR and satellites)
PAL	Phase Alternation Line
SECAM	Sequential by Memory


Dr. George H. Brown of RCA (left), and Frederick M. Remley, Jr. of SMPTE (right).

Table I—Color-system Preferences by Country

System	Country	Start
NTSC	Canada	Sept. 1966
	China (Nationalist)	1968
	Ecuador	Undecided
	Japan	Sept. 1966
	United States	1953
	Saudi Aradia	Undecided
PAL	Australia	Undecided
	Denmark	Undecided
	Finland	1970
	Germany (West)	1967
	Iceland	Undecided
	Ireland	Undecided
	Lichtenstein	1970
	Netherlands	1967-70
	New Zealand	Undecided
	Norway	1970
	South Africa	Undecided
	Sweden	1968
	Switzerland	1970
	United Kingdom	1967
SECAM	Algeria	1970
	Bulgaria	1970–1973
	Cameroon	1970
	Central African Republic	1970
	Cuba	1973
	Greece	1975
	Rumania	1970
	Yugoslavia	1969–1970
SECAM III	Colombia	1976
	Congo (Brazzaville)	Undecided
	Czechoslovakia	1970
	Dahomey	1970
	France	1967
	Gabon	1969
	Hungary	1970
	Ivory Coast	1969–1970
	Lebanon	1967–1968
	Malagasy	Undecided
	Mali	1970
	Monaco	1967
	Mongolia	1969
	Niger	Undecided
	Poland	1967
	Senegal	1970
	Togolese Republic	1970
	Upper Volta	1971–1972
	USSR	1967
SECAM IV	Mauritania	1969–1970
	Portugal	Undecided
	Tunisia	1969–1970
	Miscellaneous answers	
Abstained	Austria	
Evasive answer	Belgium	
No preference	Kuwait	
Undecided	Brazil	
	Congo (Democratic Republic)	
	India	
	Iran	
	Israel	
	Italy	
	Jordan	
	Kenya	
	Luxembourg	
	Mexico	
	Peru	
	Spain	
	Turkey	

the same system the Russians call NIR. Both countries shared development of the system, and have agreed to share credit. SECAM IV has never been field-tested. It looks good on paper, and should be easily handled by video tape, cable and microwave. We don't know for certain what receiver requirements are.

DR. BROWN: A great deal has been said of the ability of PAL and SECAM to overcome differential phase errors. It was fully proven in 1965 that SECAM worked a benefit in the presence of differential phase, and SECAM did not suffer too much from circuit noise. But, in the presence of both noise and differential phase, SECAM failed miserably. Furthermore, NTSC has been transmitted over a thousand miles on the Russian microwave system, from Moscow to many cities in Western Europe, and from Rome to London. The NTSC signal suffered very little degradation in these test transmissions. The French attempted the same feat with SECAM and didn't make it.

PAL is a West German development, and at least it works, which is more than you can say for SECAM. Its primary advantage is its transmission quality, which is excellent. It can be handled well by limited-performance cable and microwave facilities, as well as video recorders.

The Germans want to use full PAL all the way from the camera to the receiver, which isn't necessary. Besides, using full PAL makes the receiver more costly than it needs to be, and is PAL's major defect. We estimate that a PAL receiver, produced in the US, would cost the consumer $40 to $50 more than an NTSC model.

The Germans claim that PAL alleviates ghosting and multipath distortion—which it does. But they make a big thing out of this feature, while we in the US know that, with few exceptions, a good antenna takes care of ghosting. PAL wasn't developed to avoid multipath—it was developed to overcome transmission problems.

R-E: What transmission problems?

MR. REMLEY: Most European cable and microwave transmission facilities have been built without enough phase and amplitude linearity to handle NTSC color. To use NTSC in Europe would mean either rebuilding many intercity transmission channels or not using networks. It's too bad this is so, for I think that unofficially many delegates felt NTSC was the best system, technically.

Unfortunately, although simple to manufacture, simple PAL receivers have at least one serious defect—line crawl. Full PAL avoids this defect. The latest version of full PAL, by the way, while supposedly good on video tape, raises new problems. PAL gates the fields 1–2–3–4, unlike NTSC, and keeping track of the fields could be a problem, and might entail a more complicated tape machine.

R-E: Was ART proposed?

MR. REMLEY: ART, for Additional Reference Transmission, is really NTSC with additions. [ART may also be used with PAL.—*Editor*] Its development is still incomplete, as work was done and papers filed almost simultaneously by both British and West German researchers. While never considered formally at either Vienna or Oslo, it was unofficially proposed by some as a simpler, cheaper alternate to PAL.

R-E: Was NTSC proposed, and did it have any chance at Oslo?

DR. BROWN: Yes, the US position favored NTSC. We have used it here since 1953; Japan uses it, and Canada started using it last September. There are at least ten million NTSC receivers in use in the US alone, to say nothing of Japan and Canada. Compare this with possibly a few hundred experimental PAL and SECAM receivers. We've had time to work the bugs out of NTSC, and I don't think anyone contests the fact that it looks very good today.

American industry has spent a lot of money developing NTSC color, and the American people have a lot of money invested in it. It would be foolish to scrap all that—which is why the US won't change our system. The British agreed with us until we got to Oslo. No, I'm afraid NTSC didn't have much of a chance at Oslo.

R-E: Why not?

DR. BROWN: Well, at one point, the chairman of Study Group XI asked: "Are you in favor of a single system of color? If so, are you authorized by your government to change your vote?"

The Germans answered that they could change their vote, but only after returning to West Germany and consulting with 5 or 10 agencies and committees, which would take nearly a year. The British said substantially the same thing. The French said they had the freedom to vote for either SECAM III or SECAM IV. The Belgians were very confusing in their answer.

R-E: In other words, in spite of NTSC's obvious technical advantages, except for European cable and microwave problems, the delegates would not favor NTSC, nor any other single system. Why do you suppose this happened?

DR. BROWN: Each country's decision to favor a certain color system was political, not technical. For instance, PAL is supported by West Germany, Great Britain and several other European countries. It may become a European standard. But Russia will *never* adopt a German system, because of the deep anti-German feeling that still exists from World War II. Similarly, France refuses to consider PAL because of the pride they feel in their SECAM.

R-E: Were engineering features of the various systems considered *at all?*

MR. REMLEY: Engineering features were the ostensible reasons for favoring one system over another. As mentioned earlier, European transmission circuits make NTSC transmission more difficult there at present. And PAL is touted as a great cure for ghosting. But underlying the technical reasons were political motives.

R-E: What about the possibility of a compromise?

DR. BROWN: The French made a suggestion to that effect, but it wasn't much of a compromise. They proposed that all member countries stop their present research on NTSC, PAL and any other systems, and pool their resources for one year to perfect SECAM IV. If at the end of one year, SECAM IV proved to be a good system, it would be adopted as the worldwide system. If SECAM IV didn't work out, we would then be forced, by the terms of the compromise, to adopt SECAM III as the system. France's proposal, I'm afraid, didn't get very far.

R-E: Was any position taken by Study Group XI on a color system for the world, or for Europe?

DR. BROWN: No. The only result was that, after a couple of weeks of the delegates' doing nothing, Chairman Esping appointed a small group to write a report. This report outlined the engineering features of the systems that had been proposed. No single system was recommended or adopted by Study Group XI.

MR. REMLEY: It was unfortunate, I think, that there was no agreement. I believe the various nations of the world are playing ostrich; many have too little concern about seeing what's going on outside their own countries—and I include the US in this statement. Think of what a tremendous advantage a single worldwide system and standard of both monochrome and color television would be! With satellite relays and possibly direct satellite-to-home telecasting, a single system and standard would permit instant communication between all nations.

Such events as the Olympic Games, President Kennedy's or Winston Churchill's funeral, Queen Elizabeth's coronation, could be shown live to the entire world. A single pooled camera crew could handle the origination. At the present time, such an event requires a completely separate camera crew, with tons of equipment, for each system in use. Of course, you can use film, which is playable equally well on all systems, but you lose immediacy.

DR. BROWN: It would be nice to have a single worldwide system, but I don't think it's possible—at least not through the UN. You've got to remember that most actions of the UN are basically unenforceable. Even if a decision is reached, it's subject to voluntary compliance by member nations. What do you do if several countries decide not to cooperate?

R-E: Several monochrome systems are presently in use in the world [see Table II—*Editor*]. The British have used 405 lines for some time, and the French, 819 lines. Most of the rest of Europe uses 625 lines. Recently both Great Britain and France started supplementary 625-line services, while maintaining their other facilities. Do you think this heralds a single European monochrome standard?

DR. BROWN: Well, there was general agreement of Study Group XI several years ago that when anyone went to color in Europe they'd do it with 625 lines. You must remember that 625 lines is the 50-field equivalent of the US 525 lines, which is of course on 60 fields. There are some differences between British, French and other European 625-line systems, but these could well be ironed out and we *might* see a single European standard.

MR. REMLEY: Speaking of 50-field standards, which are used in Europe because of 50-Hz power lines, the use of 50 fields and 25 frames causes noticeable flicker as compared with our system, which uses 60 fields and 30 frames.

R-E: At present, what facilities exist to allow, say, British audiences to view a live US telecast?

MR. REMLEY: *Standards converters* are used. The US networks have them—at least in New York City—and the BBC and others have them in Europe. They are complicated, expensive, and may reduce definition. There are two types—electronic and optical. When the frame rates of the two systems are identical, it's possible to use an electronic converter, which gives the better picture.

R-E: To summarize, then: The UN-sponsored Oslo CCIR conference did not result in a decision to adopt a single world system of color television. It did show, however, that the various countries grouped themselves around three systems—NTSC, PAL and SECAM. These groupings seem to be political, and the technical advantages and disadvantages of the three systems were not the main reasons for the groupings. END

Table II—World Television Standards

System	British	US	French	CCIR	Irish	OIRT	French
No. of Horiz. Lines	405	525	625	625	625	625	819
Video bandwidth (MHz)	3.0	4.2	5.0	5.0	5.5	6.0	10.4
Channel Bandwidth (MHz)	5.0	6.0	7.0	7.0	8.0	8.0	14
Sound-to-picture spacing (MHz)	−3.5	+4.5	+5.5	+5.5	+6.0	+6.5	±11.15
Horiz. freq. (kHz)	10.125	15.75	15.625	15.625	15.625	15.625	20.475
Vert. freq. (Hz)	50	60	50	50	50	50	50
Picture modulation	+	−	+	−	−	−	+
Sound modulation	AM	FM	AM	FM	FM	FM	AM
Where in use	Hong Kong, United Kingdom	Canada, US and most of Western Hemisphere, Cambodia, China (Nationalist), Iran, Japan, Korea, Phillippines, Thailand	Belgium, France	Most of Europe and Africa, Argentina, Australia, India, New Zealand, Pakistan, Syria, Turkey, United Kingdom, Venezuela, Yugoslavia	Ireland	Albania, Bulgaria, China (Red), Czechoslovakia, Hungary, Poland, Rumania, USSR	Algeria, Belgium, France, Luxembourg, Monaco, Tunisia

The Professional Touch for CB

By JACK DARR

IT MAY NEVER HAVE OCCURRED TO YOU but the Citizens' band is truly the domain of the "amateur." Not the licensed ham, but the honest-to-John amateur in the dictionary sense of the word—a person unfamiliar with two-way radio theory and practice. Since many CB units are installed by these enthusiastic but inept amateurs, the professional touch is usually lacking. Overall performance often can be improved significantly with established techniques.

Disappointing useful range is the most frequent complaint from CBers. With only 5 watts output, CB sets suffer severely from mistuning, poorly located or inefficient antennas or mismatched transmission lines. Many sets enter the shop suffering primarily from "screwdriveritis" in one or another of its several forms. There seems to be an unexplained madness, not entirely limited to CB enthusiasts, that forces an otherwise logical man to shove a screwdriver blade into the slot of any adjustment screw and give it a couple of turns. As a result, a careful tuneup often will increase the talk-in range considerably.

Make sure the antenna-base flange is *well* grounded (I've found them *floating*). The rf output impedance of most CB rigs is 50 ohms, but for reasons of economy a 75-ohm transmission line occasionally is used. This won't have much effect in a mobile installation, but where the cable run is lengthy, as at the base station, the loss will be significant. For base-station transmission lines, low-loss coax like RG-8/U also will give a measurable improvement in output—about 3 dB per 100 ft.

Check the length of the output coax on mobile rigs. Many antennas are designed to accept a half-wavelength cable—about 11 feet 9 inches, or a multiple of that length. The half-wave cable is usually long enough to reach from a dash-mounted set to a rear-mounted antenna. The direct route is best—under the floor mat, alongside the driveshaft tunnel, then into the trunk.

The most useful accessory for antenna tuning is a field-strength meter. You can make a simple yet effective one from a diode, a pickup rod and a milliammeter (Fig. 1). A tuning device of this type reads only *radiated* rf power. A peak on the meter means the antenna is tuned for maximum output, and that's what you're after.

To use the meter, set the field-strength detector near the antenna and place the meter where you can see it. Peak the antenna-tuning adjustments for maximum deflection.

Some CB transceivers include a tuning meter on the panel as an aid to tuning the antenna. A typical circuit is shown in Fig. 2. These devices are useful for preliminary adjustments, but for maximum output use the reading obtained from the field-strength meter, which indicates actual radiated rf energy. Panel meters are usually diode-coupled to the rf output stage, and a lot of things can happen between there and the antenna. If the panel and field-strength meters peak at different tuning-adjustment settings, make a careful investigation, because something's wrong. Check grounding, antenna length, lead-in length, etc.

A TVI trap is usually provided in the output stage to attenuate the second-harmonic radiation which falls nicely into channel 2 on 54 MHz. A portable TV set is a very good indicator for use in adjusting the trap to eliminate any interference.

Left alone, most receiver i.f. sections are very stable and trouble-free, but screwdriver mechanics find the slotted adjustment screws impossible to resist. If receiver sensitivity seems low, a quick check of i.f. alignment using a signal generator often will produce a big improvement. A fairly reliable indication of "screwdriveritis" can be obtained by checking the i.f. cans. Shaved metal at the tuning-adjustment openings suggests the use of a carpenter's screwdriver and no professional ability.

In all mobile units, the antenna stage of both receiver and transmitter must be peaked after installation to compensate for changes in antenna effects, stray capacitance, etc. You can peak the receiver using a signal radiated from the signal generator.

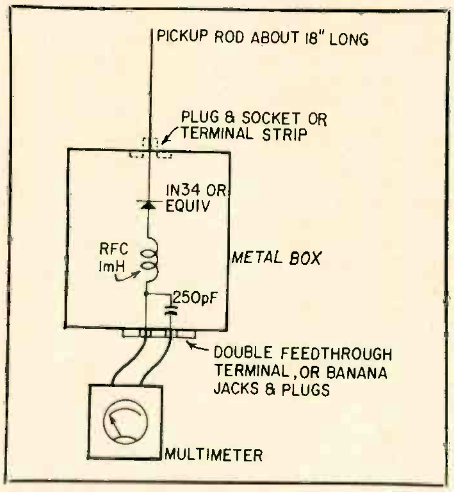


Fig. 1—Simple field-strength meter for CB.

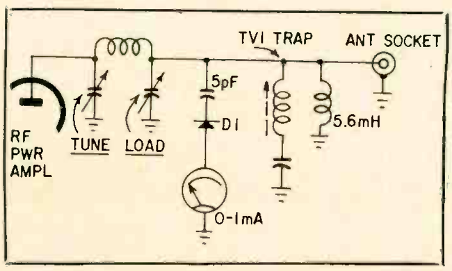


Fig. 2—Transmitter output-tuning meter.

It's often a good idea to sweep-align the i.f.'s to attain maximum selectivity. Some technicians have signal generators with AM sweep capabilities—the Hickok 188, for example. Others find their TV sweep generator can be tuned to provide a usable signal—at the 27-MHz carrier if not at the 455-kHz i.f. frequency. A sweep curve can be obtained by feeding the signal in at the antenna, if necessary. Sweep width should be cut down to about 1.0 MHz or less, but you can "read the curve" by increasing the horizontal sweep of the scope and spreading the trace enough to give a usable display.

Sweep alignment often reveals the presence of incipient oscillation or regeneration in rf or i.f. stages. A good response curve will be symmetrical, rising smoothly to a slightly rounded top, then falling off without notches or too wide a skirt. If feedback occurs in the circuit, you'll see a characteristic triangular-shaped trace with a pronounced sharp peak and a ragged-looking overall appearance. While a signal will pass through the i.f.'s, the audio will be harsh and screechy. It's also characteristic of feedback that, while you're tuning the i.f. strip, the curve will peak normally to a certain point, then suddenly break up as the stage goes into oscillation.

In mild cases, the malady can be cured by overall correct alignment. In severe cases, however, a filter capacitor probably will have to be replaced somewhere. The commonest cause of unwanted oscillations is insufficient capacitance to prevent feedback through the power supply.

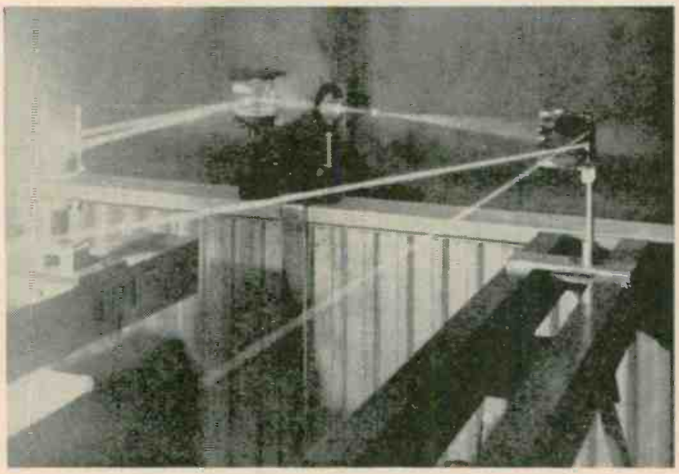
You also can use the scope to obtain an indication of overall transmitter performance. Set a vertical-channel probe near the antenna, key the transmitter, and pick up the "bar" pattern of the rf carrier. Modulate the transmitter with a tone generator or by whistling into the mike. Look for the increase in pattern height that indicates upward modulation. Full modulation should increase the output by 22.5%. If the pattern shrinks or remains the same, there's trouble in the modulator section or in the final output stage.

Even though CB transceivers generate low-power signals, they should be fed into a dummy antenna during bench checks. A suitable load can be made from a pair of No. 47 pilot lamps in parallel, connected to a suitable plug and cable. END

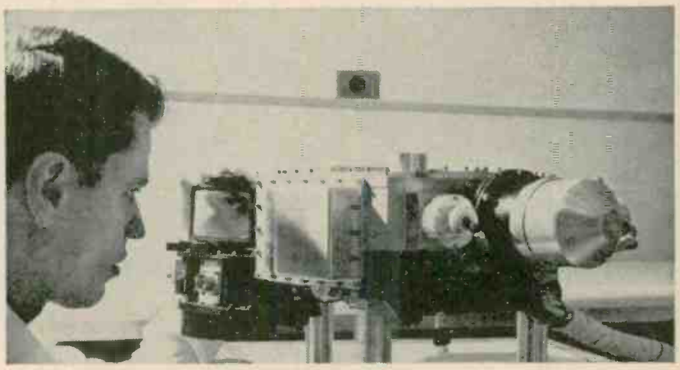
WHAT'S NEW

WORLD'S FIRST MULTIANTENNA TOWER for uhf broadcasting stands 1,050 feet above Detroit area, where it's used by WKBD-TV and WTVS. WJMY-TV will add third antenna later.

NO-TALK TELEPHONE MADE BY WESTERN ELECTRIC speeds filing of quality-control information. The instrument has new-style pushbuttons, but no handset. As worker tests an assembled product for quality, she "dials" data-storage department and "punches" her inspection results into a computer bank.



INFRARED LASER BEAM CONVERTED TO GREEN at several hundred megawatts of power. Accomplished by Compagnie Générale d'Electricité in France, green coherent light will bring greater accuracy in laser telemetry for determining satellite orbits. Technique may also be used for lunar mapping.



NEW CAMERA USES DIELECTRIC PLASTIC TAPE, records image electrostatically. It's designed for space-vehicle use by NASA in weather study and planet mapping. Single-unit camera and recorder is nearly immune to radiation, uses 100 feet of tape.

SAMPLE PICTURE TAKEN BY RCA-BUILT DIELECTRIC CAMERA illustrates good definition. Tape may be replayed or erased and reused indefinitely. Base of tape is coated with a gold-copper conductor, an arsenic selenide photoconducting material and a layer of insulating material. Optical image is "written" into insulator and stored until read out or erased. END

DIRECT-VIEW 3-D IM

A startling new scientific technique can create images so real you almost think you can touch them

By ALLEN B. SMITH

THREE-DIMENSIONAL IMAGES, WHICH could be viewed without glasses, goggles or filters, have long been dreamed of. Most of us are so accustomed to viewing photographs—which are really abstract representations of real objects—that we find it difficult to imagine solid-appearing images. Such images are no longer dreams. They are being created right now.

During a recent trade-show demonstation of a new optical technique for creating images of remarkable reality, a respected physicist viewed an image intently, then reached out his hand. Encountering nothing but air, he shook his head slowly. "I've been reading about this for months," he said. "But I honestly didn't expect to see such a perfect image. It's really a little spooky!"

Known variously as laser photography, lasography, lensless photography and wavefront-reconstruction photography, *laser holography* resembles photography in only one respect—each records a pattern of light waves on a light-sensitive plate or film.

Human vision depends on the fact that white light falling on an object is reflected in several ways, each of which carries some specific information about the object. Three types of information are particularly significant: intensity (amplitude), direction (phase) and color (frequency). If it were possible to record all these elements, the object could then be reconstructed in image form. The recreated image would be identical to the original object; it would, in fact, be impossible to distinguish the two except by touch.

The problem is complex, however, because white light contains all wavelengths of visible light, from 3,800 Angstroms (violet) to 7,500 (deep red). Since each microscopic point on the surface of any object reflects the amplitude and phase, as well as the color, of each discrete wavelength, white light reflected from even the simplest object contains a staggering amount of information. No means has yet been discovered to record it all.

A logical approach to the problem would be to develop some means of recording the amplitude and phase information using spectrally pure light—that is, light of a single wavelength. Early attempts by Gabor to use filters and minute point-source apertures to obtain useful narrow bands of monochromatic light were handicapped. Such techniques produced illumination levels too low to be useful. Gabor did, however, develop a technique for recording amplitude and phase information on what he called *holograms*. These holograms (from the Greek *holos*, meaning whole) were light-wave records, captured as patterns on photographic plates, which contained phase and amplitude information from reflected light waves. Image quality of early holograms was very poor, however, as a result of the impure light used to form them.

Nearly 15 years elapsed between Gabor's early experiments and the development of a light source having the unique properties necessary for making high-resolution holographic images. With the development of the laser, experimenters in several laboratories—particularly at the University of Michigan—began using the laser beam for making holograms. Made to order for this kind of optical recording, the laser emits light of a specific frequency from an extremely small point source. These qualities and spatial (fron rity are known as c quality of laser light.

The processes of flected light waves (making and reconstructing the recor (making a visual image) depend basic optical phenomena. The fi known as *interferometry*, an opti method for converting phase relationships into equivalent visual amplitude variations that can be recorded as a photographic pattern. The second, *wavefront reconstruction*, is a technique for transforming the pattern of recorded light waves on the hologram into an equivalent visible light beam. This light beam exhibits precisely the same characteristics of amplitude and phase as the light used in making the hologram. In other words, the reconstructed image looks exactly like the original object.

If coherent light from a laser is beamed onto a single reflective point, the reflected wave will radiate from the point in a series of ever-expanding, concentric, hemispherical energy pulses called wavefronts (Fig. 1-a). These wavefronts travel outward from the point until absorbed or diffused. Suppose that, instead of a single point, the laser beam illuminated an object consisting of a large number of reflecting points. (Any two- or three-dimensional object contains such points.) In this case, the result is a complex wave pattern made up of all wavefronts reflected from and concentric to each separate point. This badly scrambled wave (Fig. 1-b) contains all the data required to form an image of the object.

Since the complex wave cannot be recorded directly without destroying certain essential information, it must be modified by using interferometric tech-

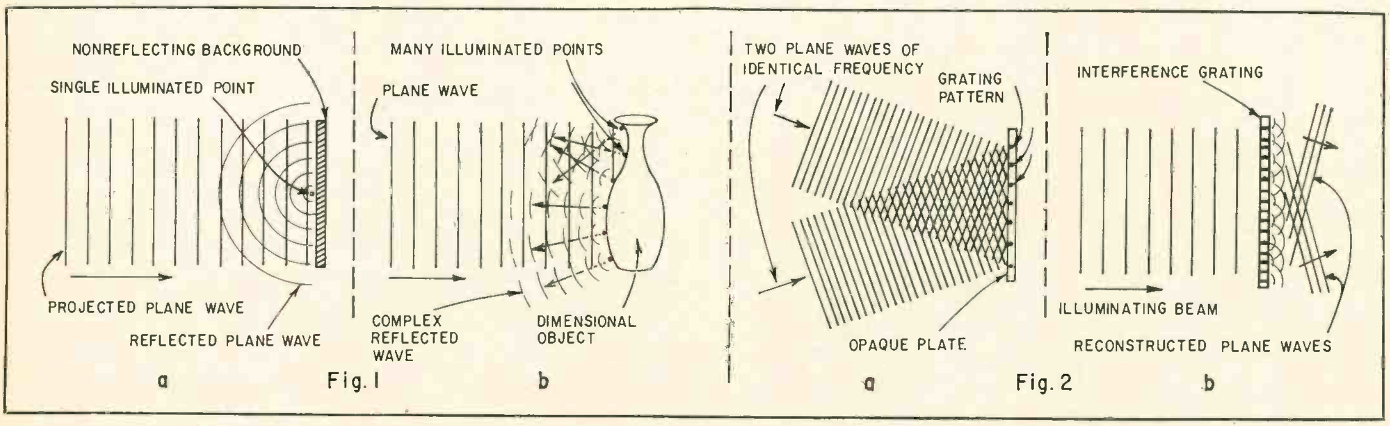
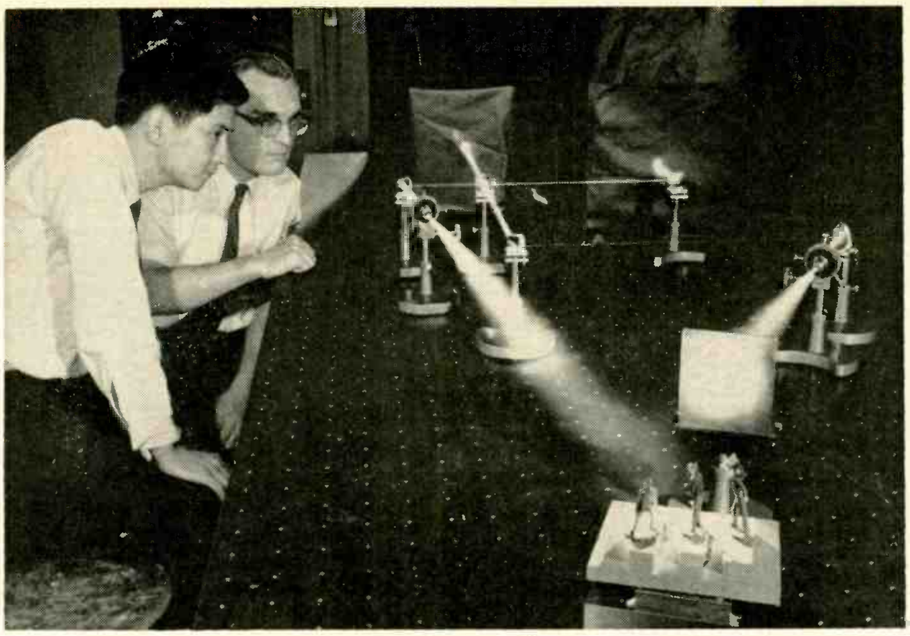
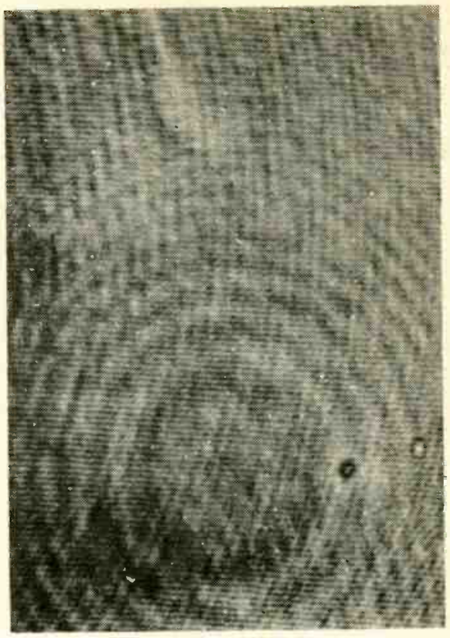


Fig. 1—Coherent light reflected (a) from a single point and (b) from many points. Note circular reflected wave patterns.

Fig. 2—Two laser beams interact (a) on plate, form grating. Illuminating beam (b) recreates original waves from grating.



Bell Labs scientists examine mixed-beam holographic apparatus making color recording.



Hologram grating pattern and whorls.

niques. The phase variations are thereby converted into amplitude equivalents. When this is accomplished, a photosensitive plate can be used to form a permanent record of the complex wave.

Fig. 2-a illustrates a simple case of light-wave interference in which two identical plane waves (wavefronts of coherent light perpendicular to the direction of the beam) fall on an opaque surface from different angles. These waves form a series of parallel interference fringe patterns on the opaque surface. The distance between the fringes depends solely on the angle formed by the two waves.

The fringes appear because at some points on the surface the two plane waves arrive in phase, their amplitudes adding and producing areas of increased illumination. At other points, the waves arrive out of phase so their amplitudes cancel, producing areas of reduced illumination. Intermediate points have values somewhere between light and dark. A chemically processed photographic recording of the pattern contains a series of parallel lines called a *grating*. When this grating is illuminated by a beam of coherent light as shown in Fig. 2-b, interaction between the light beam and the grating creates a procession of plane waves identical to those which formed the grating. The original waves are thus reconstructed.

In making an interference pattern, when one of the coherent waves is a plane wave and the other a complex wave reflected from a three-dimensional object, an interesting situation develops. Instead of being regular, the grating exhibits an irregularity which matches precisely the amplitude variations formed as the complex reflected wave strikes the plate. Where the amplitude elements of the complex wave are greatest, the fringes have highest contrast; where the wave amplitude is least, the fringe pattern is lowest in contrast. *Amplitude* variations in the complex wave, then, control *contrast* variations of the fringe pattern.

Since fringe spacing depends on the angle formed between the two light beams, the fringe pattern is relatively fine where the complex wave makes a large angle with the plane wave. Similarly, the pattern is coarse where the angle is small. *Phase* variations in the complex wave, then, alter the *spacing* of the fringe pattern.

Two of the foremost experimenters in the field of laser holography—Emmett Leith and Juris Upatnieks of the University of Michigan at Ann Arbor—have described the formation of holograms, using the reference-beam method outlined above, in terms of communications theory. In their useful analogy, the plane wave or reference beam is likened to a local oscillator and the complex wave to a modulated signal. The photographic plate, therefore, acts as a mixer stage for the two signals. Leith and Upatnieks, in fact, illustrate mathematically that fundamental, sum and difference light-wave frequencies are recorded on the plate and later recovered during wave reconstruction.

This analogy provides a good basis for describing what happens when the beam of coherent light from a laser is directed onto the completed hologram. The process of reconstruction is basically the reverse of the process which produced the hologram. The coherent light beam, when projected on the grating, interacts with the recorded fringe pattern. The effect is to impress the amplitude and phase information contained in the hologram onto the light beam.

When the light beam meets the hologram at the same angle as did the reference beam during the recording process, the light emerging from the hologram consists of two useful signals. The first consists of the difference frequencies, which are identical to the original complex wave used in constructing the hologram. This reconstructed wave generates a virtual image which seems (to an observer) to lie on the light-source side of the hologram. This image is an exact replica of the object from which the original complex wave was reflected. It resembles a solid object.

The second signal consists of the sum frequencies, and these form a second image that seems to hang in mid-air between the viewer and the hologram. This combined image has a "pseudoscopic" appearance; some of its elements are reversed, making it look unnatural. Further processing of this second image (as discussed by Rotz and Friesem) produces an image of uncanny reality.

Using the two principles described, it's possible to record the complex light waves reflected from any three-dimensional object and then to "play back" that recording and reconstruct the complex wave. Since the reconstructed wave is identical to the original in all important aspects, the image formed by it is identical to that formed by the original object. Simply stated, the hologram captures the light waves reflected from an object, stores them and later releases them on command—a very satisfactory "light recorder."

The hardware required to make a holographic recording is quite simple, with the obvious exception of the all-important laser-beam generator, and is arranged as in Fig. 3. Since the illuminating and reference beams must be of exactly the same wavelength, a beam-splitter-and-mirror setup is used. This produces two coherent beams having the same wavelength. Diverging lenses A and B are microscope elements used to spread the sharply focused laser beams enough to light the entire object and cover mirror B.

Both mirrors are front-surface types used to avoid specular breakup and distortions of the beam due to double imaging. The photographic plate is a type used primarily in astronomical photography. It has extremely high resolution. (Eastman Kodak makes one type, the 649-F, in various sizes.) The object can be any three-dimensional form, the size of which does not exceed the incident-beam coverage area.

When developed (by ordinary chemical means) the photographic plate becomes the completed hologram. In appearance, the hologram resembles a granular photographic negative of a concrete slab, sometimes showing concentric *whorls* which look like fingerprints (see photo). (These whorls serve no useful purpose; they are simply noise elements caused by dust particles on the mirrors, beam splitters, lenses and photographic plate.) When examined under a microscope, the hologram reveals only an apparently random arrangement of exposed silver granules.

Holograms constructed as described here have a curious property. Each segment of the hologram contains all information necessary to reconstruct the original complex wave. This is true because each spherical wave advancing on the plate passes across the entire plate, exposing the complete surface of the emulsion. Because of this characteristic, two holograms can be made from one simply by breaking it into two segments. Increasingly smaller pieces, however, produce images of decreasing fidelity and resolution.

Because of the long exposure times and the very short wavelength of the light beamed from the laser, absolute rigidity of all hardware elements is required. Movement as slight as three or four millionths of an inch can inhibit formation of the pattern necessary for reconstruction. For this reason, most setups are made on massive steel plates with finely machined surfaces.

Wavefront reconstructions from the hologram are made using the arrangement of Fig. 4. The laser source is generally the same one used in constructing the hologram, and the diverging lens is similar to that previously used. As described earlier, the laser beam striking the hologram interferes with the recorded grating and generates the sum and difference signals indicated in the diagram. The unique optical characteristics of the two images have been covered earlier.

The laser beam used in reconstructing the image must strike the hologram at the same angle used during the recording process. This means the hologram can hold more than one set of information. Several entirely separate images may be recorded on a single photographic plate, using different reference-beam angles for each record. A succession of reconstructed images can therefore be produced simply by altering the angle at which the illuminating beam strikes the hologram. Using this property of discrimination, several experimenters have constructed images that appear animated.

The most recent development in the field was achieved last summer by Dr. George W. Stroke. He used a focused-image technique to obtain a three-dimensional laser-holographic image on an otherwise conventionally focused photographic plate. The hologram, observable in white light, has all the characteristics of holographic reconstruction described earlier. The importance of this new technique becomes clear when one realizes that the image is obtained using normal photographic procedures and equipment —lens, camera (though unconventional) and film—plus, of course, laser illumination and a reference beam. The reference beam, however, is introduced "in line" with the optical axis of the lens and reflected beam, not at an angle.

Several difficulties are found in conventional holographic techniques—"ghost images" and the spectral dispersion suffered in usual white-light reconstructions, for example. These are absent in the focused-image recording technique and in its white-light reconstruction. Sharpness and brightness levels of the images also surpass those previously attained by other methods.

Fig. 5 shows the basic setup for Dr. Stroke's technique. The focusing lens forms a conventional real image on the surface of the photographic plate, and the coherent reference beam is injected into the optical axis of the lens by the beam splitter. Two mirrors, along with the beam splitter, extend the path length of the reference beam so that it corresponds to that of the reflected beam. Interaction between the real image (formed by the reflected beam) and the reference beam provides the three-dimensional information in a manner similar to that used to record a conventional hologram. However, the familiar interferometric diffraction grating is not present. The image formed still is the result of an interference pattern, but one of a different class than that which forms a grating.

The focused-image hologram records only a small fraction of the information contained in a conventional hol-

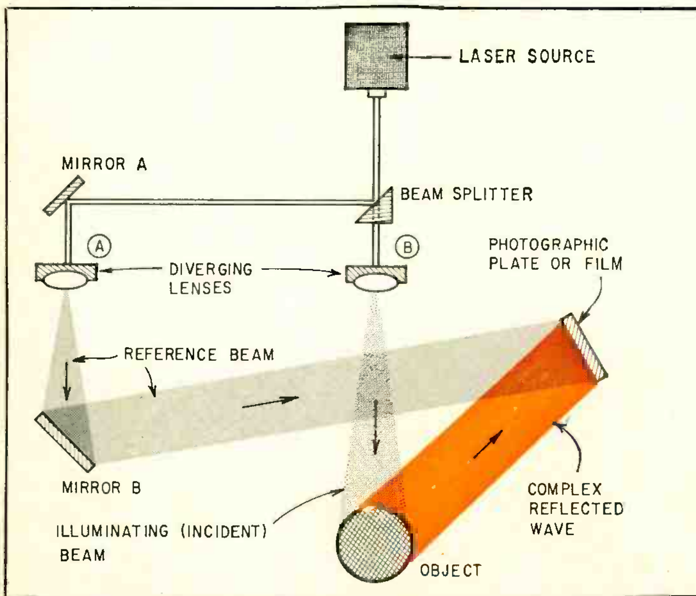


Fig. 3—The holographic arrangement for recording images.

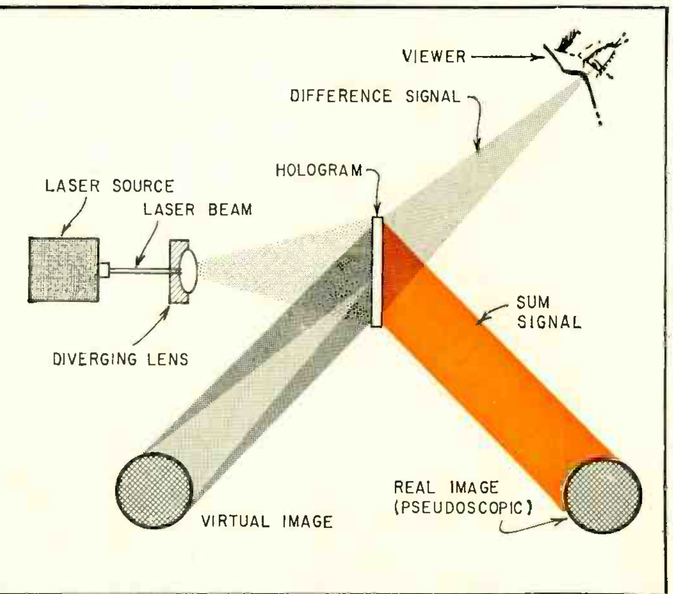


Fig. 4—To view recorded holograms, this setup is used.

ogram and still allows reconstruction of a three-dimensional image of high quality. (With the lens-formed image, there is a 1-to-1 correspondence between each point on the object and every point on the plate. In a conventional scattered-beam hologram, each point on the object is recorded at all points on the plate.) Focused-image holography, therefore, may solve the wide-bandwidth problem now associated with 3-D hologram transmission.

Most observers at holographic demonstrations ask how this new technique may be applied to everyday uses. There are many possibilities—three-dimensional motion pictures and television are two often discussed. There isn't space here for a complete summary of experimental work, but a few significant advances must be mentioned.

Most active research programs are seeking to overcome several factors which now restrict holographic techniques almost exclusively to the laboratory. There are several basic restrictions: exposure times are long; reconstructed images assume the color of the coherent light used; it's difficult to impart motion to the reconstructions, and there are extreme bandwidth requirements for image transmission. In all these areas, progress is being made.

Dr. Jerald Parker, a physicist for Electro-Optical Systems, Inc., has reported construction of an ionized-argon gas laser emitting light in the range of 5,145 to 4,545 Angstroms with a power of 1 watt. Because the light from this device lies in the most sensitive portion of photographic emulsions, required exposure times are reduced to about 10 seconds. Further promise comes from a technique (described by Jacobson and McClung) in which a mode-controlled pulsed laser has been used to produce high-resolution, two-beam holograms with exposure times of only *30 nsec.*

One company, Technical Operations, Inc., is actually marketing a device called a Laser Fog Disdrometer which uses laser-holographic techniques to record all particles of fog, mist or other aerosols within a given three-dimensional space. Using a pulsed laser and exposure times of approximately 30 nsec, the device produces holograms that form images of the particles. The images can then be studied with all the advantages of parallax and dimensionality.

Other experimenters, notably Lawrence H. Lin and Keith S. Pennington of Bell Telephone Labs, and Dr. George W. Stroke and Antoine Labeyrie of the University of Michigan, have developed a method for making holograms that can be viewed using sunlight (or any other noncoherent white light). The holograms still must be constructed initially using laser illumination, however.

Lin and Pennington of Bell Telephone Labs were among the first to create multicolor holograms using two laser sources emitting coherent light at different wavelengths. Employing a helium-neon device with an output at 6,328 Angstroms (red) and an argon-ion device at 4,880 Angstroms (blue), these scientists have developed a mixed-beam holographic technique capable of producing two-color reconstructions. Using the same basic concept, it should be possible to create full-color holograms and reconstructions as soon as laser devices having the required spectral colors are produced. Obviously, there are many potential applications.

In September 1965, engineers at Stanford University's Systems Technique Labs demonstrated the first holographic movies. Although very simple movements were recorded—steel balls rolling on a table and the hands of a wristwatch in motion—the technique laid the groundwork for further efforts to generate moving holographic images and present them for viewing by a large audience. The problems still are immense, but most serious experimenters are confident that dimensional motion pictures will be developed using holographic techniques.

Although wide-screen three-dimensional television in the home undoubtedly is years from actuality, Leigh and Upatnieks have fully described a television system employing wavefront-reconstruction techniques. As they describe the system, high-power pulsed-laser light sources—all locked in frequency to satisfy the coherency requirement—illuminate the scene to be televised. Using 10-nsec pulses, normal motion of the actors can be permitted without exceeding the wavelength of visible light. A continuous-wave laser of low illumination intensity, also synchronized with the pulsed lasers, is directed to a photosensitive grid in the camera system. This grid is similar to that of a standard image-orthicon tube. The coherent light reflected as a complex wave from the scene being televised falls on the detector grid and interacts with the CW-laser reference beam, forming the photoelectric equivalent of a standard hologram. The video signal resulting from scanning the fringe pattern can then be transmitted to the receiver.

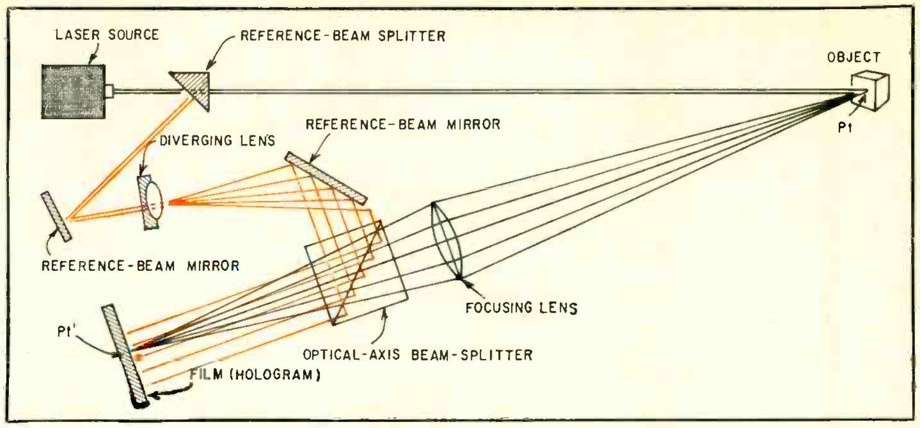


Fig. 5—This setup is used to produce a hologram on film which can be viewed directly.

The receiver most likely would consist of a screen of photochromic glass, a material which has extremely fine resolution. A laser beam, modulated by the transmitted video signal, would form a raster on the screen. Thus a hologram would appear on the screen for each field. A second laser, synchronized to the frequency of the studio-camera reference beam, would then illuminate the hologram creating the by-now-familiar virtual and pseudoscopic real images.

The fundamental difficulty in constructing a practical 3-D television system lies in the severe bandwidth requirements necessary to transmit dimensional video. The process which forms the interferometric fringe pattern generates frequencies extending beyond the present US bandwidth standard of 4.2 MHz. Because there is redundant information in a hologram, Stroke's focused-image technique described earlier seems the most likely solution to the bandwidth problem. Another possibility is the use of present light-wave-transmission techniques instead of rf-transmission methods. Another solution has been proposed by Winston E. Kock—the use of microwave, rather than laser, illumination. This method's feasibility has already been proved by R. P. Dooley and D. Duffy of General Electric. This light-source substitution would reduce the bandwidth requirement of the holographic video to the current US standard. It remains to be proved, however, whether adequate fidelity can be attained by this method.

Whatever benefit derives from these experimental efforts, the best is undoubtedly yet to come. So, make room in your life for a new basic technological tool that promises a broad range of communication, entertainment, research and analytical possibilities. END

Triggered Scope for Color

By LARRY ALLEN

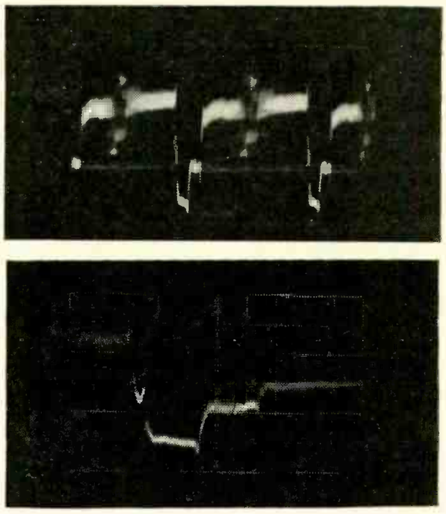


Fig. 1—Video waveform at top is expanded below with scope magnifier, showing burst.

THE BARBER POLE WAS TURNING VIGOROUSLY. But not outside the barber shop—it was inside. And the pole was not motor-driven; it was electronic.

A few days before, Rocky had bought a brand-new 19-inch color set to entertain his customers while they waited for haircuts and shaves. It made a hit, too. That is, it did until Friday morning. Rocky had no idea there was trouble. The first three shows were black-and-white, and they looked fine. The first color show was another matter. Venetian blinds of color seemed to move around all over the screen.

By noontime Friday, there I sat, watching nine twisty barber poles wind their way up and down the face of that little 19-inch receiver. I had hooked up my color-bar generator, but couldn't get the colors to sync.

A bad tube, I thought, flipping open my tube caddy. A few minutes and I'd have the set (and Rocky) all settled down. Hah! Little did I know.

Tubes didn't do it. Neither did some hopeful twisting of controls, nor even one desperate, careful twiddle of the phase-detector transformer. Reluctantly, and with Rocky's pointed protests ringing in my memory, I hauled the set off to the shop. Rocky's parting reminder was a word picture of his Saturday customers sitting around with nothing to do but gossip and read papers and magazines. And something about not paying for a set that wouldn't work . . . I sort of tuned out that part.

I decided I'd try to get the little 19-incher going again before I finished my other calls. What helped me decide, a little bit, was a new triggered scope shining on its rollabout beside my bench—just waiting for me to try it out on a TV set. I had just got it all set up but hadn't had a chance to see if it was better than my regular scope.

Well, let me tell you—it was! I can't remember when I've gotten so enthusiastic about something. For the first time since I started servicing TV, I had the feeling I was really seeing what goes on inside a color set.

Anyway, I put this little color set on the bench and began scope tracing. There was a color show on channel 5, so I tuned it in. Take a look at the waveform I picked up at the video detector (Fig. 1-a). Did you ever see one that clear on a service scope? I never did. This was one line of color video signal. With the X5 expander on the triggered scope, I spread that waveform out like Fig. 1-b. Note how well you can see those burst cycles. What detail! It looked so good I wanted to play with the scope.

The thought of Rocky's parting words nudged me back to business. The coupling capacitor from the video detector to the first color amplifier (Fig. 2) is pretty small, so I didn't expect to get enough waveform at the color-amp grid to trigger the scope. But at the plate I found the waveform you see in Fig. 3-a; burst there was fine. (For your reference, Fig. 3-b shows the same waveform, but with no burst coming from the video detector.)

Again because of a small-value coupling capacitor, the waveform (Fig. 3-c) at the grid of the burst amp doesn't tell much. Any burst information there is overcome by the flyback pulse that keys the tube on during burst period, to eliminate whatever video might remain in the waveform. Therefore, you can't tell if the burst is present. For that, go to the plate. What I found there (Fig. 3-d) showed that the burst was okay that far. Fig. 3-e shows how it would look without burst; keying action causes the horizontal-rate blip, contaminated with slight video.

But the scope showed nothing at one pin of the phase-detector diode. Working backward slightly, I touched the scope probe to first one end and then the other of the phase-detector transformer secondary. At both points I got the fine waveform shown in Fig. 3-f. The answer was easy: either the 330-pF capacitor was open or the board had a bad solder joint. Running a hot solder-gun tip over the connections cleared up the trouble.

Done. Tracked down in minutes by a triggered scope. Rocky had his set back for the Saturday games and it's been working fine ever since.

Yes, I could have found the trouble with any wideband scope, or even by enough testing with a vtvm. But I liked the waveforms I saw on the triggered scope—the feel of solid sync and the accuracy of the traces. There was no doubt of what I was seeing. Believe me, that makes waveform analysis twice as easy as it ever was before.

Triggered vs recurrent sweep

How can a triggered scope show a waveform so much cleaner and more stable than a recurrent-sweep scope can? Partly because good bandwidth is usually built in, but even more because of how the trace is synchronized in a triggered-sweep scope.

Fig. 4 may help you understand synchronization in a recurrent-sweep scope. The sawtooth sweep oscillator runs all the time. A part of the vertical input waveform is fed (usually after it has been run through some of or all the vertical amplifier stages) down to a sync section. There it locks the sweep oscillator to the exact frequency of the input waveform. A switch usually allows you to sync on either the positive-going (Fig. 4-a) or the negative-going cycle (Fig. 4-b). With an asymmetrical wave, you generally choose the polarity of the most dominant leading edge. If the input waveform contains more than one frequency, as many complex waveforms do, the poor sweep oscillator has a tough time picking out a dominant frequency to synchronize on.

The sweep oscillator in a triggered scope is one-shot. It sweeps only once each time it is activated and then waits

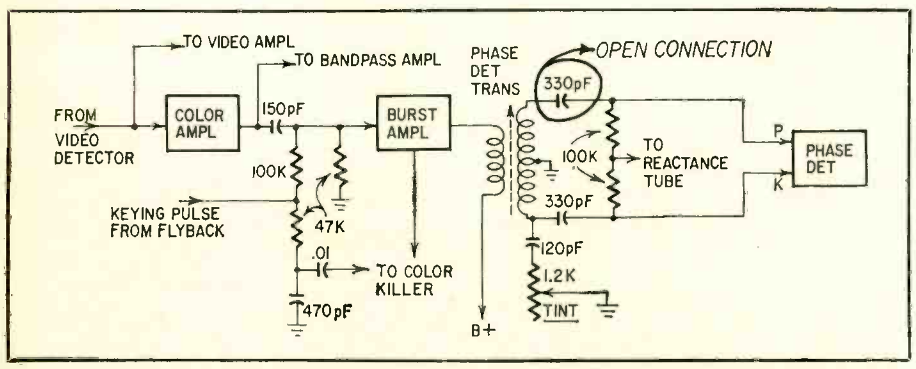


Fig. 2—Chroma circuit contained shifting-color fault, which was found with scope.

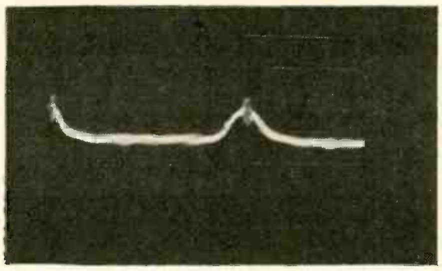
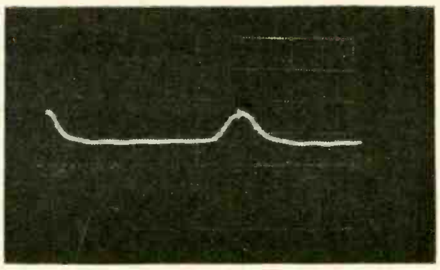
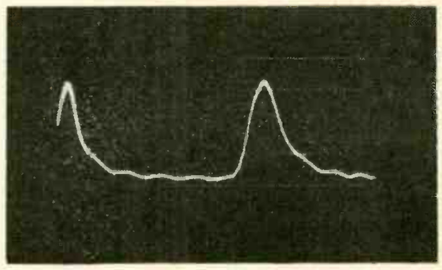
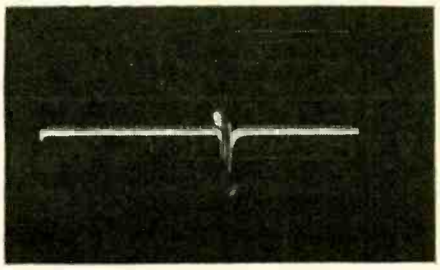
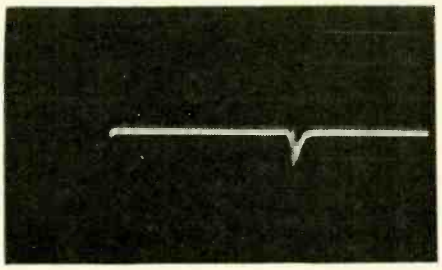
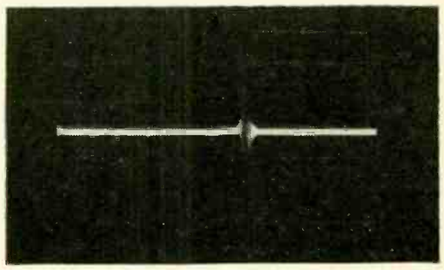




Fig. 3—Waveforms found at (a) color-amplifier plate, with burst; (b) color-amplifier plate, no burst; (c) grid of burst amplifier;

(d) plate of burst amplifier, with burst; (e) plate of burst amplifier, without burst; (f) phase-detector transformer secondary.

for another pulse of the chosen amplitude to trigger it again. On my triggered scope, the TRIGGER LEVEL control moves in either direction from zero-amplitude, so you can choose positive- (Fig. 5-a) or negative-cycle (Fig. 5-b) triggering. How far you turn the control from zero-center sets the level of input waveform that will fire the oscillator (Figs. 5-c and 5-d).

Once the triggering level is chosen, the sweep oscillator fires on the first excursion of the input waveform that reaches that level. The sweep moves the CRT beam across the scope screen at a speed that is chosen by the TIME/CM switch; the beam sweeps just fast enough to cross 1 cm of the scope graticule in the time chosen by the switch. Then the beam stops, snaps back to the left side of the scope face, and sits there waiting till some point of the input signal next reaches that triggering amplitude again. While the beam is sweeping the full screen width, the oscillator won't fire again, because the time constant chosen by the TIME/CM switch keeps the sweep going till it is all the way across the scope. Thus the TIME/CM switch can be set to show as many cycles as you wish of any particular waveform, no matter what triggering point (level) you choose with the TRIGGER LEVEL control.

So, you see, with this form of sync, you just set the TIME/CM switch to show the number of cycles you want to display (depending on the main frequency of the waveform), set the triggering with the TRIGGER LEVEL control, and the triggered sweep displays the trace you want, steadily and solidly.

Makes you wonder why everyone doesn't use a triggered scope, doesn't it? Cost has been a factor, but my scope is a kit type (a Heathkit Model IO-14) that didn't cost much more than a top-priced service unit. Another factor is lack of familiarity; a lot of technicians just don't know how to use a scope with triggered sweep. The instruction booklet that came with mine shows in considerable detail how to put a triggered scope to work. Also, there are other books available that explain how triggered scopes work. Few mention, however, the steps to take to use a triggered scope specifically for troubleshooting color TV. Here are a few hints.

Setting up the scope

Follow the instructions that come with the scope for turning it on, adjusting intensity, focus, positioning of beam, etc. Turn up the graticule light, as the centimeter marks are a useful guide when analyzing waveforms.

The only really tricky part of setting up a triggered scope is the setting of the STABILITY and TRIGGER LEVEL controls. Short the probe leads together, and turn the TRIGGER LEVEL control to either end. Turn the STABILITY control up till the sweep is visible, then down just enough to quench it. This is the most stable and sensitive setting of the triggering system, so *do not* touch the STABILITY control any more during subsequent operation.

Next thing to think about is the *expected* amplitude of the voltage you're going to test. Take for example the 6.3-volt ac heater voltage. You'll want to set the vertical input attenuator (VOLTS/CM) to show a trace of reasonable height on the graticule; otherwise, the scope can't trigger properly. The 6.3 volts rms will cause a peak-to-peak trace of about 17.6 volts. With the VOLTS/CM switch set for 5, you'll get a trace over 3 cm high. If you're using a 10:1 low-capacitance probe, set the switch for 0.5 volt/cm. Always set this switch before using the probe.

Next in order is to set the TIME/CM switch. The setting depends on the frequency of the dominant waveform you want to observe, and on how many cycles of it you want to look at. For the 60-Hz heater waveform we're using as our first example, set the TIME/CM switch to 10 msec. This setting will show five full cycles and part of another in the 10-cm-wide graticule.

In conjunction with the TIME/CM switch there is sometimes a MULTIPLIER switch, especially when the TIME/CM switch is a decade type (in steps of 10). If you want to look at fewer cycles of the 60-Hz signal, set the TIME/CM switch for 1 msec/cm. Since a 60-Hz sine wave takes almost 17 msec to complete a cycle, one cycle will extend well beyond the 10 cm of the graticule. Set the MULTIPLIER at 2, however, and you will have calibrated your graticule

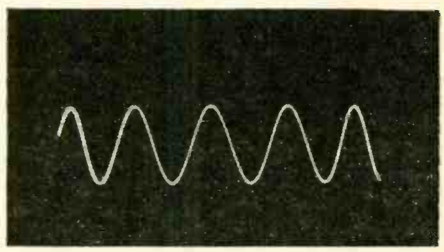
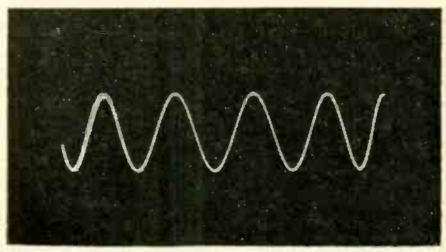



Fig. 4—Recurrent-sweep scope can sync on positive (a) or negative (b) half-cycles.

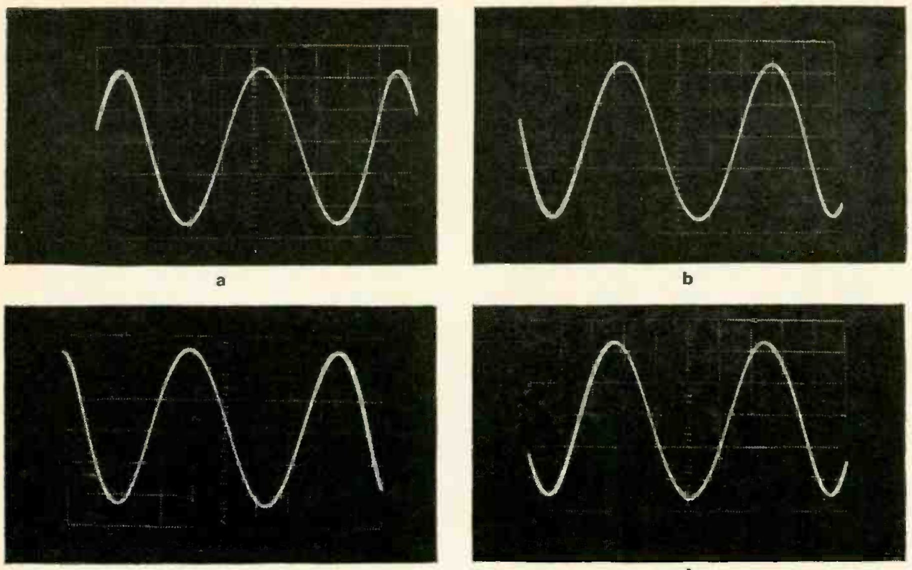


Fig. 5—Triggered scope can not only lock on (a) positive- or (b) negative-going waveforms but also at any level throughout the trace, as illustrated above by (c) and (d).

for 2 msec/cm. You will find one cycle of a 60-Hz waveform occupies about 8.4 cm of the graticule.

Settings for color troubleshooting

In the color receiver, you will be interested mostly in viewing video waveforms at either the horizontal-line or the vertical-field rate. Horizontal is by far the most useful—it is the only rate you'll use in chroma circuits. A horizontal line takes about 63.5 μsec to complete. Consequently, if the TIME/CM switch is set for 10 μsec, one line of horizontal information—a sync pulse, the associated blanking pedestal, color burst (if present), and one line of video information—will extend for almost 6.4 cm across the graticule. Move the MULTIPLIER to 2, and each cm of graticule will mean 20 μsec; you will be able to see three full lines of horizontal waveform in the 10-cm-wide graticule.

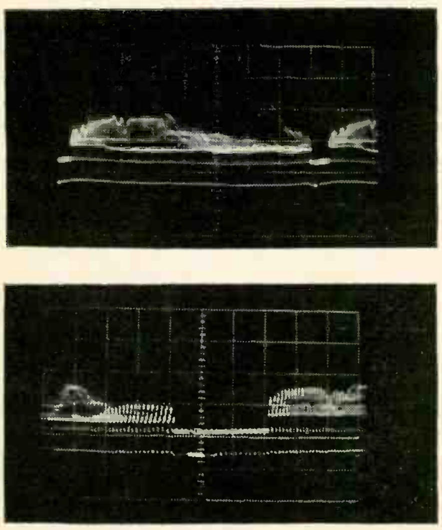


Fig. 6—Upper trace is normal width, bottom is expanded. External sync used.

On occasion, you may want to examine a small section of a video waveform—say, the color burst on its back porch of the horizontal sync pulse. You can use the expander or MAGNIFIER function of the scope. It has two positions: X1 or normal, and X5. Begin by setting the TIME/CM switch for 10 μsec, and the MULTIPLIER at 1. Then merely switch the MAGNIFIER on (on most scopes a small warning lamp will light to remind you it is on). The sweep trace will expand to 5 times its former length, and you can move the HORIZONTAL POSITIONING control to look at the exact portion of the trace you are interested in. Be sure to switch the MAGNIFIER off and recenter the POSITIONING when you are through.

For viewing vertical-rate waveforms, the triggered scope may seem difficult to synchronize solidly. This is because the scope sweep tries to trigger on horizontal pulses too, since they are as tall in amplitude as the vertical pulses. Since it wants to trigger on the first pulse that reaches the triggering level, the triggering circuit finds it difficult to choose the right one. One way this is solved is by using external triggering. Just clip a lead from the EXT TRIGGER SOURCE pin to the vicinity of the vertical-sweep circuits in the receiver. Fig. 6-a, taken at the video detector, is synchronized with a lead clipped to the insulation of one vertical output transformer lead. Don't forget to turn the SOURCE switch to EXT. (And don't forget to turn it back to INT later for ordinary use.)

You can get a really good look at the vertical sync pulse by spreading it out with the X5 magnifier (Fig. 6-b). It was necessary to reposition the trace horizontally to see this portion of it.

When it doesn't work

After spending time teaching technicians how to use a triggered scope, I've found a few points that seem to be the biggest stumbling blocks. If you'll watch out for these pitfalls, you'll be able to teach yourself to run a triggered scope successfully.

The first problem usually is caused by inability to get a trace. If this happens to you, take these steps:

(a) *Temporarily* turn up the STABILITY control. You should see a trace. If not, check the intensity and positioning controls.

(b) With the STABILITY control still up and trace visible, turn the TRIGGER LEVEL to one end. Short the input probe to ground and turn the STABILITY control down slowly until the trace just barely disappears.

(c) Recenter the TRIGGER LEVEL control. This is very important.

(d) Turn the VOLTS/CM switch to its lowest position—.05 on my scope. Unground the input probe and touch it with your finger. You should get trace and vertical deflection. To see the trace better, set the TIME/CM switch to 1 msec.

(e) Turn VOLTS/CM to approximately 1/10 the voltage you expect (if 10 volts p-p, set at 1; if 1 volt p-p, set at 0.1; etc.). Reconnect to your test voltage and adjust the VOLTS/CM switch so you have a trace height within the graticule.

(f) Adjust TIME/CM for whatever waveform you're watching.

The other problem that crops up regularly is a trace that won't stand still but creeps or runs horizontally. I described this earlier in conjunction with viewing vertical-rate video waveforms. The trouble is caused by complex waveforms in which more than one frequency reaches the same maximum height or amplitude. In that case, even though you turn the TRIGGER LEVEL far from center, you finally go clear above the trace (thus blanking it out altogether) before you find a single peak to lock on.

The solutions to this problem aren't always simple, but they can be generalized by suggesting external sync as the best solution. In the case of video, an integrator can be used and an integrated video signal fed to the EXT TRIGGER input.

For viewing complex signals other than TV, there are other sources of trigger. Probably most often used is a very stable audio generator.

You now have enough information to do a capable job of troubleshooting color chassis with a triggered-sweep scope. Once you try it out and learn how to set up the controls, you'll find the triggered instrument much easier to use than any recurrent-sweep scope. You'll be as happy with it as I am. END

Color Voltages Ain't Circular to Me!

Round and round or up and down—which way does the color signal travel?

By STEPHEN KIRK

COLOR MODULATION AND DEMODULATION are basically simple—it's the gosh-awful explanations that make it bewildering and as inscrutable as the genetic code. At least it seems that way to me.

After I had plodded through elucidations without number, I could easily have believed that a color demodulator is some kind of special beast that perhaps uses a vacuum tube with a circular plate and a cathode that sprays electrons into carefully calibrated slots every 30° to accommodate color-bar generators.

Now, I don't mind going around in circles (I've done it often enough), but it *is not* a circular voltage that, say, makes a picture-tube red gun conduct more or less. It's just a plain old up-and-down voltage that does it, the same as for any other tube grid. Up is positive, and down is negative.

The trouble is that engineers often use rotating vectors—those "circular" voltages with arrows in them—to make color modulation and demodulation more "understandable." What they too often succeed in doing (for me, anyway) is making the clarification more complicated than the problem. It has often left me feeling that a demodulator must be something like a woman—necessary, but inherently baffling. That's why I'm telling you here about my "different approach."

Color-television transmitters are modulated with up-and-down voltages. If the scene is redder, the output of the camera's red tube goes up. If a part of the scene is bluer, the output of the blue tube goes up. If the scene is magenta then both the red and the blue tubes put out more voltage.

At the receiver, these up-and-down signals are demodulated. If there is more red voltage for the red gun, the red on the screen will be brighter. When the blue is stronger, the blue gun will conduct more. If both guns conduct the same amount at the same time, the scene will be magenta or some shade mixing red and blue. That's what we see, and so the only important thing that is circular about color TV is the eyeball that's watching it.

Vectors would probably never have entered the picture if two carriers on different frequencies had been used for the color-difference signals, sometimes called R−Y and B−Y. But, to conserve space and bandwidth, the color engineers ingeniously used two carriers at the same frequency with separate modulation. A good explanation of how that's done (good, at least for electronics people) can be based on the electrostatically deflected CRT shown in Fig. 1. This shows how voltages at right angles to each other do not adversely affect one another.

If we put a certain voltage on plate A, the dot (beam) will move to position 1. If we remove this voltage and place it on plate B, the dot will move to position 2. Now if we put that amount of voltage on both A and B, the dot will move to position 3.

What's the point? The point is that the dot moved the same *upward* distance when the voltage was on both plates as it did when the voltage was on only plate A, and it moved the same *sideways* distance when the voltage was on both plates as it did when only plate B had voltage. In other words, if we referenced the dot movement to zero (no voltage, dot at center) and measured the distance it moved either up or sideways, it's the same as far as either plate is concerned regardless of what's happening on the other plate.

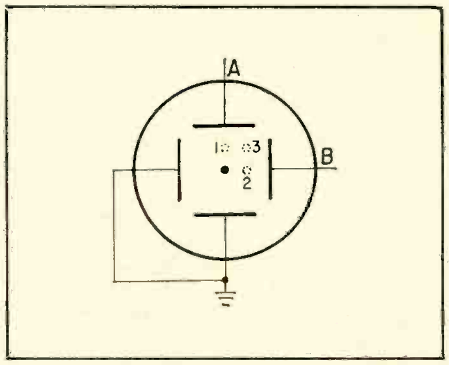


Fig. 1—CRT explains quadrature action.

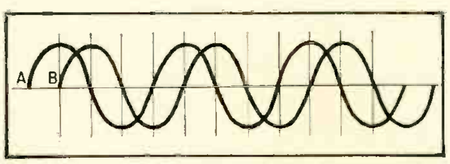


Fig. 2—Carrier B starts a quarter-cycle (90°) after carrier A, or in quadrature.

That, in a nutshell is the basis for the theory (and it works) that two identical signals 90° apart can be modulated with two different sources at the same time with no complicated interaction. This sort of thing is what's done all the time with stereo cartridges that separate left channel from right with one needle in a single groove.

The stereo cartridge gets 90° or right-angle shift by mechanical means. You can get the same effect electronically by starting one sine-wave signal at a certain time and another just like it one-quarter of a cycle (90°) later (Fig. 2). This second signal is sometimes called a *quadrature* signal. The *quad* part of that word (they tell me) has to do with right angles, each of which is of course 90°. That's where the quad signal is—90° away from the first signal. The first signal is called *I*, for in phase—with itself, I guess.

Why all this talk about putting two signals close together? It has to do with saving bandwidth and making color compatible with black-and-white TV.

The color TV camera picks up nothing but R, G and B signals. (Yeah, I know they've got a new camera with a black-and-white pickup tube in it, but let's forget about it for now.) R, G and B are combined into a Y (luminance) signal that's 30% R, 59% G and 11% B. That's the monochrome, or compatible, signal that you see on a black-and-white receiver. It's also the starting point for the color picture on a color CRT.

You see, if they transmitted R, G and B on separate channels, there'd be no way for a black-and-white set to get a picture from a color program, without adding more circuitry. But the luminance signal worked fine. Now, to make a color picture, they needed additional color signals.

First, the color-TV engineers thought they'd transmit Y, R−Y, and B−Y. No need to transmit G−Y; since

Y contains elements of all three colors, if you took R−Y and B−Y away from Y, all you'd have left would be G−Y. Okay—but it just so happens that they don't transmit all three colors with full bandwidth. There just isn't room within the standard 6-MHz television channel for such extravagance. Instead, the Y part of the color signal is transmitted with 4.2-MHz bandwidth (rather than 4-MHz, as with black-and-white), while one of the color-difference signals is transmitted with 1.5-MHz bandwidth, and the other, 0.5-MHz. Why? Just wait and I'll explain.

It so happens that the unmodulated or zero point of R−Y is around bluish-red and bluish-green. The zero point of B−Y is around reddish-green and yellowish-green. These are vital points.

Somebody found that you can paint a picture with only two colors (orange and a type of blue called *cyan*) and fool the eye into thinking it's a full-color picture, so long as you do this for *small* objects. When you get into large things, you gotta have all three colors. For the *really* fine details, like sharp edges of objects, or the checked pattern on a man's suit, you need only black-and-white information. The eye doesn't see color for fine details.

So the color engineers knew they'd have to transmit black-and-white with full 4.2-MHz bandwidth, and orange and cyan with 1.5-MHz bandwidth, to accurately reproduce fine detail, and small objects in color. For large objects, they'd need all three colors, but this meant a bandwidth of only another 0.5 MHz, which was easy.

The black-and-white was no problem—they simply combined R, G and B into Y and used 4.2-MHz bandwidth. But to make orange and cyan with R−Y and B−Y, you'd have to transmit both with 1.5-MHz bandwidth, and there wasn't room. What to do?

They decided to shift the reference points of the two sets of color sidebands and they arbitrarily called the first one I—for in phase, as mentioned earlier. I is transmitted with 1.5-MHz bandwidth. The other they called Q—for quadrature; it has 0.5-MHz bandwidth.

Again to save bandwidth, the engineers used a single carrier for both I and Q signals. They split the carrier into two channels, delayed one 90° with respect to the other, and modulated the two with I and Q, respectively.

To keep from cluttering the total signal with beat frequencies, the 3.58-MHz carriers are removed before final transmission. To establish a sense of timing at the receiver, just a few cycles of the 3.58-MHz signal are sent out with the rest of the TV signal. It is this *burst* that locks in the locally generated 3.58-MHz carrier in the receiver. That adjusts timing in the demodulators for the main or I-signal carrier. The Q-signal carrier is then also redeveloped by delaying a sample of the I signal by 90°.

As we have already shown, you can have up-and-down color modulation on these two separate carriers without worrying about interaction between them. How can we recover these same two modulating voltages in the receiver? The secret, of course, is because we have recreated the two separated carriers in the receiver and have locked them in time with the transmitter. Now we can demodulate exactly what was modulated at the transmitter.

Demodulate a set of voltages in step with the first carrier, and you get a specific output. Then demodulate the same set of voltages in step with another carrier 90° later, and you get another specific output. In reality, then, you can take this modulated composite voltage and get two entirely separate outputs from it. That's how a composite color voltage can be transmitted without sending the carriers along.

There are several ways of actually converting the incoming video signal to R, G and B for the CRT. All present systems detect the Y signal (black-and-white video) in one or two stages, separate from the color stages. The circuit differences come from the methods of getting the color-difference signals.

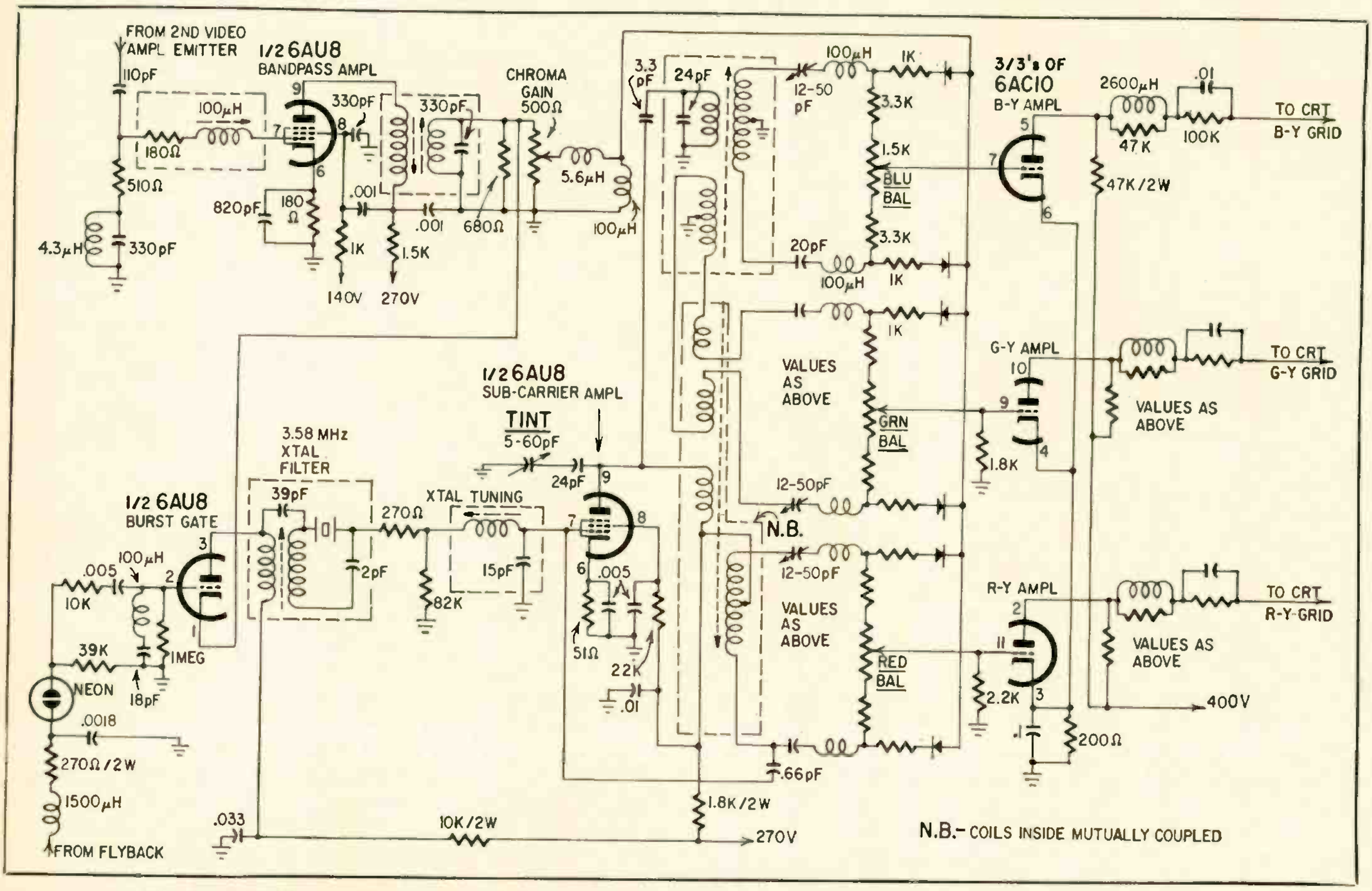


Fig. 3—G-E chassis CB uses one of the newest types of color demodulation, matrixing before detection.

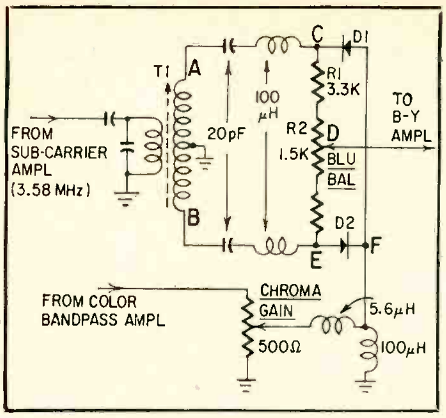


Fig. 4—B—Y detector in G-E KC chassis.

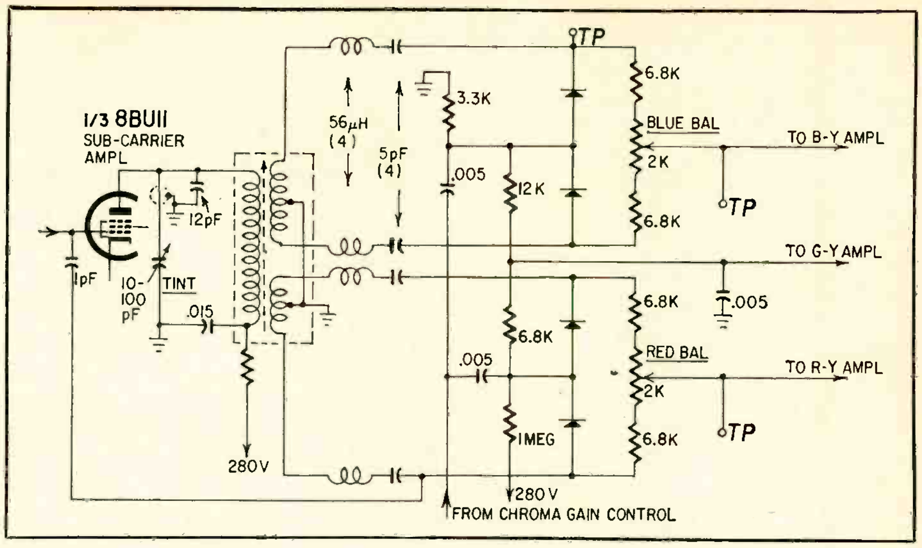


Fig. 5—Circuit of G-E Porta-Color uses two demodulators, with three outputs.

One way is to set up two demodulators, operate them on the I and Q reference points, combine their outputs in a certain manner to produce R and B. R and B are then combined and subtracted from Y to produce G.

Another way is to again use two demodulators, operating them on R—Y and B—Y references. By also using the Y signal, the demodulator outputs can produce R and B, as well as G.

A third method, used extensively now, is to employ still a *third* set of reference points, called arbitrarily X and Z. Their outputs are mixed differently from the previous examples, but the results are the same—R and B and, by using Y, G.

Engineers are ingenious, though (as well as baffling), and they have come up with another variation. Many receivers detect Y and the two color-difference signals first, then matrix the demodulated signals to produce R, G and B. Some newer circuits matrix color-difference signals *before* demodulating, usually by inductive coupling of three demodulators. Outputs are then some form of R, G and B.

This new arrangement is used by G-E in their KC and CB chassis.

Three essentially identical diode demodulators are used: one for B—Y, one for R—Y and another for G—Y. Fig. 3, the color demodulator circuit of G-E's "CB" chassis, will give you the idea. Obviously the signal from the color carrier must be of the right polarity. If there is *more* blue in the picture then we must have *more* positive voltage on the blue picture-tube grid. Getting the right polarity is simply a matter of connecting the diodes in the circuit correctly.

If we follow the signal through a single demodulator, we can see what happens (Fig. 4). Whenever the signal goes negative at the top end of T1's secondary, diode D1 will conduct. At the same time, the other end of the secondary is positive and, since D2 is opposite in polarity from D1, diode D2 will conduct too. Because these two diodes are in opposition, the output at the center of R1–R2–R3 will be zero.

On the next half-cycle of 3.58-MHz signal, both diodes will be cut off. The voltage at the center of R1–R2–R3 remains zero.

So you can see that with a plain unmodulated (no color) 3.58-MHz signal applied to the diodes, the output is zero regardless of whether the diodes are conducting or not.

But let's suppose that, during the time when the diodes *are* conducting, a positive-going color signal arrives and is introduced between point F and ground.

Diode D1 will conduct more when this happens and diode D2 will conduct less. The two diodes now develop a positive voltage at point C and a more negative one at point E.

This means that during the time the diodes have been made to conduct by the half-cycle of the 3.58-MHz signal, a color-modulation signal will cause an up or a down output voltage. This can be amplified and used to drive the picture-tube grid voltage up or down. (Nothing circular here.)

On the next half-cycle of 3.58-MHz signal, though, both diodes are blocked and any color signal arriving at that time is disregarded by the demodulator.

We've now recovered one signal, let's say the B—Y. To recover the R—Y, all we need do is to build another demodulator and key it with our 3.58-MHz signal that is delayed by 90°. When the same composite color voltage arrives at this modulator, it will find a different zero-reference point, and the output voltage will represent only whatever was sent on the transmitter's quadrature carrier. In other words, these diodes are turned on at a different time—90° or one quarter-cycle later—so they see only the modulation on the quadrature carrier.

To get a G—Y signal, which is derived by using a portion of the inverted R—Y and the inverted signals, G-E elects in their big-screen models to inject a portion of both carriers in the correct phase. This is how the green difference signal is recovered. In other words, they matrix *before* they demodulate. Most other companies choose to use only two demodulators and then matrix after demodulation to recover the G—Y signal.

In Fig. 5 is a portion of G-E's 11-inch Porta-Color set, which uses a G—Y voltage developed from between the back sides of the diode B—Y and R—Y demodulators. I guess you could call this matrixing *at* demodulation.

Other color demodulators work essentially the same. The 3.58-MHz signal is allowed to "key on" a tube or diode at the right time and in the right polarity. The resulting output is a simple up or down voltage, moving up and down in step with whatever color appears in the scene being televised. Thus it turns the color guns in the picture tube on at the right time to make the picture redder or less red, bluer or less blue—or any one of the combinations of colors in between. All these combinations of colors are in reality then mixed and matrixed by our brains.

Color signals are AM—once the carriers have been recreated at the receiver, the modulation can be detected just as with any other AM signal. At the transmitter, they put two signals seemingly into one by two carriers of the same frequency (3.58 MHz) but 90° apart in phase. At the receiver, that's how they have to be recovered. And this is the reason color demodulators are sometimes called synchronous detectors; they have to detect *only* in sync with their respective carriers. It makes no difference whether you call these reinserted carriers I and Q, R—Y and B—Y, or X and Z. The result is the same: Up-and-down voltages drive each CRT grid—up and down, not around in circles! END

Exploring the Jungle of Color Troubles

The trail leads down winding paths past hidden traps and misleading signals. Without logic, you'll be lost

By HOMER L. DAVIDSON

"WILL YOU PLEASE SEND A MAN OVER this morning to check my color TV? The color seems to come and go, and sometimes it's *terrible*."

How many times have you come to the shop bright and early, to be greeted by a call like this? Sometimes you wonder where to start, there are *so* many components that could cause poor color.

Start at the source. The signal originates at the TV station, travels to the antenna, into the receiver, and eventually arrives at the CRT (same sequence for black-and-white or color). Why poor color? The station (or network) may be having color problems. Check this possibility first—try a known-to-be-good receiver at the shop before you go to the customer's house. If it shows a good picture on the station, you can assume the signal's okay to the antenna.

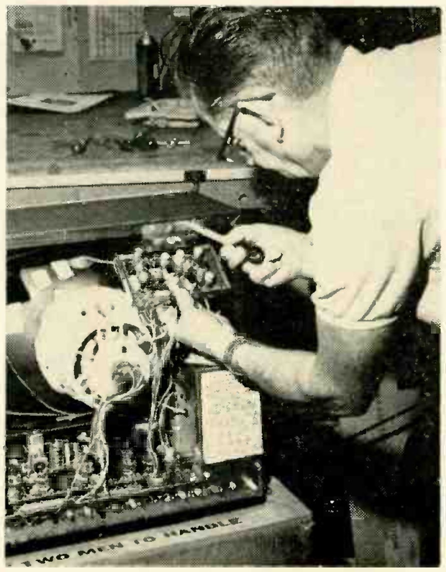
Next, suspect the customer's antenna. Except in high-signal locations, an indoor antenna isn't much good for color. Neither is an attic model—one day the color is there and the next it's weak or gone. A broadband antenna is a must. It's also got to be directive to eliminate multipath reception, which is the enemy of color burst. All this applies especially to the uhf color antenna. Often, you'll need a good four-stacked broadband model, and it should be on the roof.

The next link in the chain is the lead-in. Four good varieties are available: The round polyethylene-filled lead does a good job in close-in locations. Another local-fringe lead is a heavy-duty 300-ohm lead three times as thick as the old flat version. If interference is a problem, you can use a 72-ohm coax with transformers at each end, or a new 300-ohm shielded lead.

With the signal clean up to the antenna terminals, it's time for a look at the front end. Be sure the tuner and video tubes test good. Also see that all tubes are in their proper sockets. It's pretty easy for someone to carelessly interchange tubes.

This happened to me recently with an Admiral 1G11 chassis. The first tube should be a 6JH6, but a 6GM6 was there instead. In the second stage I found a 6GM6 which is the correct tube. In this case, the receiver had a good black-and-white picture, but was weak on color—especially on fringe-area stations. A lot of valuable time was lost on this job, simply because I *assumed* the tubes were in their proper sockets. *Never assume anything!* Substitute and check those tubes from the first rf through the chroma section. Be sure to replace any tube shields removed while testing tubes.

At this point, you've checked the obvious preliminaries, and so long as the receiver shows good black-and-white but defective color, you can safely dig into the sections used for color only.



Most color receivers have convergence-board mounting that's handy for setup.

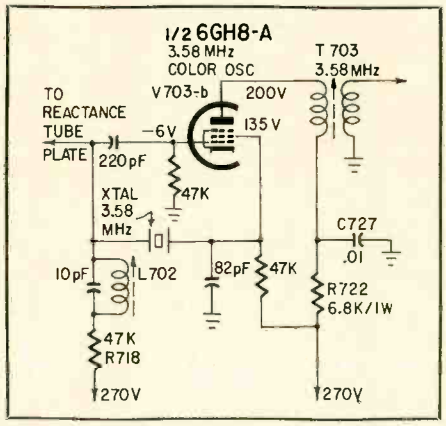


Fig. 1—The 3.58-MHz oscillator should be the first chroma stage that you check.

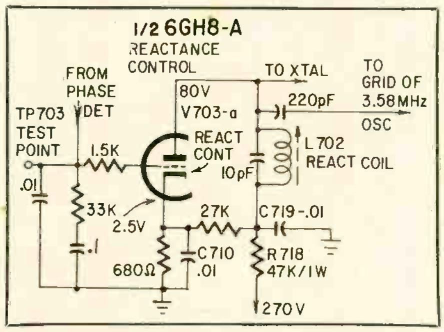


Fig. 2—Another possible trouble source.

Chroma section

It's a good idea to go right to the color-oscillator stage. Check the tube if there's no color at all. The 3.58-MHz oscillator is a crystal-controlled circuit whose frequency is varied slightly by a reactance tube. In older receivers the oscillator was a 6U8. Later, the 6EA8 came along: it did the job better. Now most color receivers use the pentode section of a 6GH8-A. Plug in a new tube to see if the oscillator will take off. Still no color? Take a voltage reading on the oscillator grid—it should be somewhere between −6 and −10 when a color program is being received.

A weak or intermittent 3.58-MHz crystal will cause poor or intermittent color (Fig. 1). You may find the color seeming to "breathe in and out" on the screen. This was found in early production runs of Admiral's G11 chassis. Besides color drifting in these models, you'll notice the fine tuning is critical. It's even worse on uhf, where color is more difficult to tune.

Again referring to Fig. 1, if C727, a .01-μF bypass capacitor, has any leakage there will be no color and a correspondingly low voltage at the 6GH8 plate. A burned condition or a decrease in resistance of R722 will cause weak or no color with a very, very low grid voltage.

It's also possible that the reactance-tube circuit is at fault (Fig. 2). In some cases a slight adjustment of L702, the reactance plate coil, will start the circuit oscillating. Turn no more than a half turn of the small core, and do this only when voltage checks have failed to show up any oscillator trouble.

An RCA CTC16E chassis carried a slow-warmup complaint—20 minutes to get color from a cold start. While color would generally hold, it dropped out intermittently. When I arrived to check the set the owner, of course, had it running and there was plenty of color. I changed the color oscillator and hoped for the best. He called me at eight-thirty the next morning—the trouble was back. I told him to turn off the set, I'd be out in a couple of hours.

Sure enough, there wasn't a sign of color on the screen; I replaced the burst- and bandpass-amplifier tubes. No luck. Then I replaced *all* the tubes on the color board. Even the color-killer setting was turned up full. After about 20 minutes color came rolling in. I found I could make color come and go by pushing and prodding on the chassis.

The chassis was pulled and checked; all connections seemed tight. Never had trouble before with 3.58-oscillator transformer connections, and these seemed good. Finally, I found one end of C727 (Fig. 1) sticking through the etched board and lacking solder. A slight movement of the etched board, caused by normal operating heat, would make the contact. If C727 opens up, there's no color.

If you get into the 3.58-MHz stages at all, it's well to check alignment. Follow the factory afpc alignment instructions. Most RCA 3.58-MHz oscillator alignments (in the CTC16, for example) can be done in the following manner:

Connect a color-bar generator to the receiver antenna terminals. Adjust the receiver for normal color reception. Set the tint control to the middle of its range and the killer threshold control fully counterclockwise. Place a jumper from pin 1 of V702 (the burst-amplifier cathode) to ground. Connect a vtvm in series with a 470K resistor to pin 1 of V705A (the phase detector). Now adjust T703, the 3.58-MHz transformer, for maximum reading on the vtvm. If the 3.58-MHz oscillator is not running, adjust reactance plate coil L702 to start the oscillator.

When the reactance control stage isn't working correctly, color will run in waves through a black-and-white picture. The reactance control tube is in parallel with the tank circuit of the 3.58-MHz oscillator so that the signal produced in the oscillator will either lag or lead the signal produced in the tank circuit. In the RCA CTC16 chassis, half a tube is the oscillator and the other half is the reactance tube.

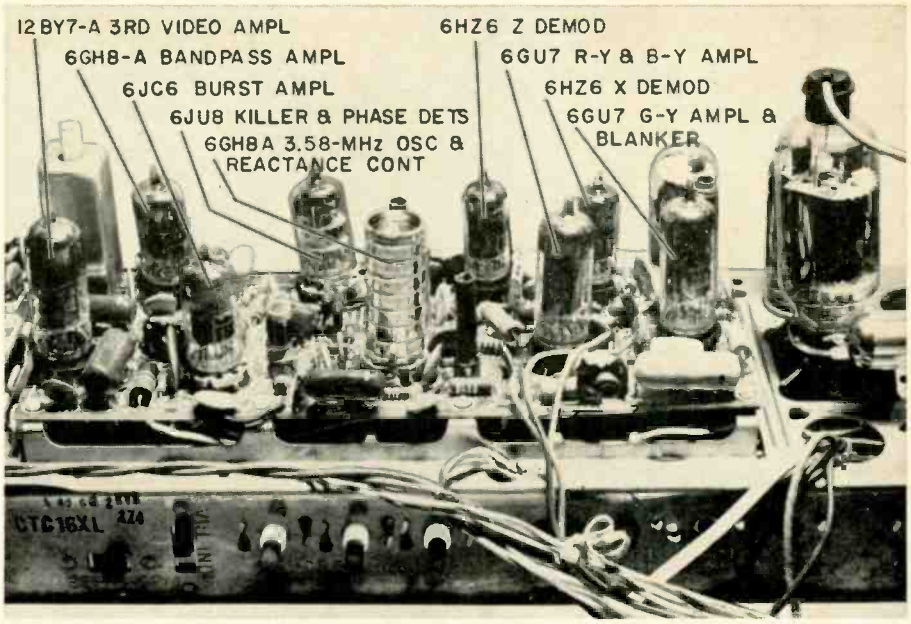
In oscillator or reactance-tube troubles, first replace this tube with a new one and then test the old one. If C719 or the reactance tube (Fig. 2) shorts, R718 gets real warm and its resistance decreases to the point where color sync is lost.

If cathode capacitor C710 has any leakage the result is the same. If C710 opens up, however, you can't tell a lot of difference in a color picture.

To align the reactance plate coil (L702) correctly, hook a color-bar generator to the antenna terminals, and adjust the receiver for normal color reception. Ground the reactance-tube input; most RCA receivers have a base wire protruding through the etched board (TP703) with a short ground clip (Fig. 3). Adjust the reactance plate coil (L702) to zero-beat with the 3.58-MHz oscillator. Watch the screen and adjust the slug so the color bars stand still or merely drift slowly across the screen.

The burst amplifier, which is keyed into conduction by a horizontal pulse, amplifies the 3.58-MHz burst riding just after the horizontal-sync pulse. A weak burst-amplifier tube, therefore, will produce a poor color picture. Referring to Fig. 4, if cathode bypass C706 shorts, the tube will draw heavy current. You will notice on most of these tubes that the plate and screen voltages are high. The cathode will vary from 22 to 55 volts on a color broadcast. A change of bias on the burst-amplifier tube results in poor color. Also, if R706 burns or decreases to about 1,000 ohms, the tint (or hue) of the color picture will shift toward green. Likewise, if R705 decreases to 1,000 ohms, there will be no color. Even if R705 only drops to half value, color becomes weak (perhaps no color in extreme fringe areas).

An easy pitfall to avoid: If you go to a customer's home to troubleshoot a weak-color case, be careful how you use a color-bar generator. Too much signal



Here's where the tubes are found in the chroma section. Compare with Fig. 3 below.

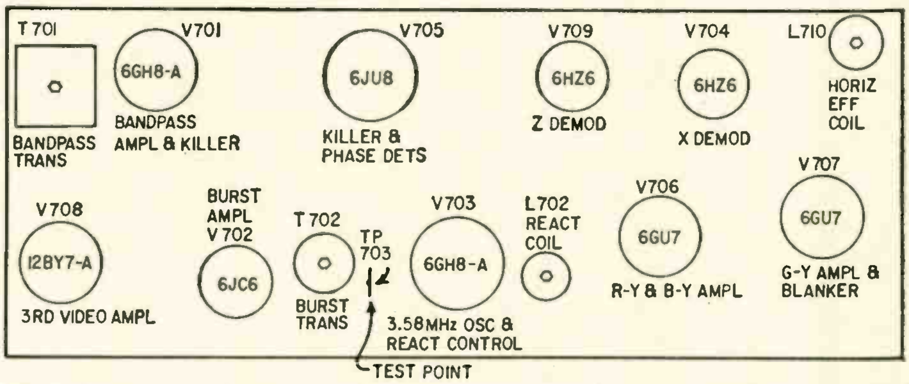


Fig. 3—Top view of chroma printed-circuit board shows the location of big components.

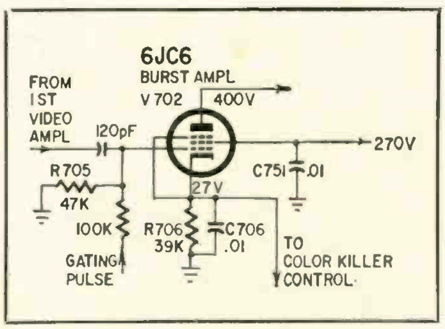


Fig. 4—The burst-amplifier stage must operate properly for correct color sync. Cathode voltage depends on signal level.

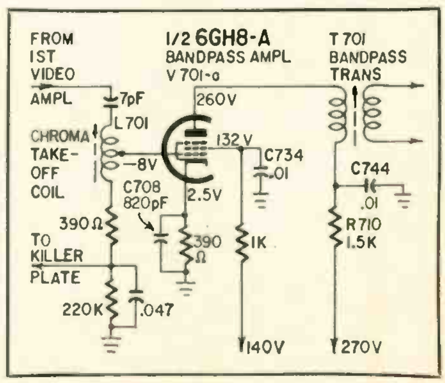


Fig. 5—The chroma bandpass amplifier.

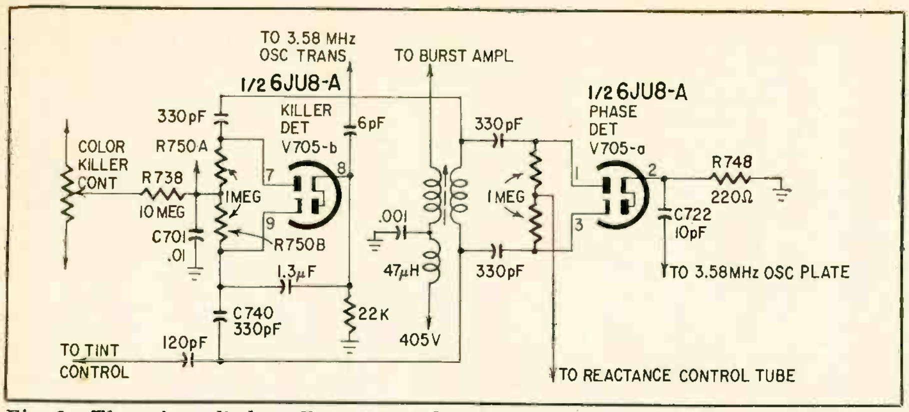


Fig. 6—These four diodes, all in same tube, detect presence and phase of color burst.

from the generator will make the receiver work okay. But the customer doesn't want to watch your generator! Use the station signal—even though it's weak—to troubleshoot the receiver.

The bandpass amplifier amplifies both color and sideband frequencies (Fig. 5). Do not attempt to align the chroma takeoff coil or bandpass amplifier without a scope and a marker generator. If there's a loose or poor solder joint on the chroma takeoff coil, you'll get intermittent or poor color. If cathode capacitor C708 shorts, normally pink flesh tones will become reddish. You'll also find tint control regulation is poor.

If screen bypass C734 leaks or shorts, color will be weak or nonexistent. If C744, the plate-supply bypass shorts, there will be no color in the picture and the color screen will become dark. If you find a shorted C744, be sure to check R710, because the short will draw an overcurrent through this resistor. This may possibly change its resistance. A decrease in R710's resistance will not affect color much, but an increase in resistance can result in no color.

The color phase detector (V705A) compares oscillator phase with incoming burst phase. This detector supplies a correction voltage to keep the reactance tube in sync with the station signal. Color may be missing or out of lock if there is a weak or dead phase-detector tube. The color bars will then roll up or down the screen.

Referring to Fig. 6, if C722 shorts there will be no color, and B+ will appear at pin 2 of V705A. R748 will get quite warm and smelly. Check or replace the phase-detector tube when the color will not lock in.

The color killer, of course, keeps color out of a black-and-white picture when a color program is not being received. If there's no color on a color program, check the setting of the killer control. In fringe areas it may be wide open. In other cases the best color may be when the control is set to midrange. This is true in some Admiral 23-inch receivers. Also, color may be fine on a strong signal. But, on another channel, the control will have to be set higher to receive good color. Be sure and check out each channel individually, for good color, and set the color killer control accordingly. (You may have to compromise here.)

Refer again to Fig. 6. R738 can often cause a lot of color troubles. If the killer control opens up there will be color in the picture at all times. When capacitor C701 shorts out, color will become weak, and the killer control will act like a regular contrast control.

In the killer detector circuit, R750A and R750B are a balanced pair. If either changes resistance you'll get weak or no color. If C740 shorts it will cause poor or weak color, and a shifting of tint in the picture.

The two demodulator circuits in a color receiver must be capable of both amplitude and phase detection of color signals. Naturally, these stages can cause poor color. A weak X-demodulator tube will cause poor or weak red color in the picture, a weak Z-demodulator tube, poor blue. Many times coupling capacitors C726 and C731 (Fig. 7) will leak or short, placing B+ on the color-amplifier grids. Sometimes the 3,900-ohm demodulator plate-load resistors will become hot and decrease in resistance. If either of the coupling capacitors (C731–C726) becomes defective, be sure to check R723A and R723B for correct values. A change in resistance here will show weak color on the screen.

The R−Y, G−Y and B−Y amplifiers tie directly to the control grids of the CRT. Any change in the tubes will change both the color and black-and-white picture. If the screen is all green on a black-and-white picture, check the R−Y amplifier tube and circuits. An all-red picture will be caused by a defective B−Y amplifier tube.

If C731 (Fig. 7) shorts or leaks there will be a greenish picture. A high B+ voltage will be on pin 2 of V706A, causing the R−Y amplifier to pull heavy current. R728, a 270-ohm cathode resistor, will burn and change resistance.

Capacitor C726 can cause similar action, producing a reddish color on the screen. It is always wise to change both capacitors, even though only one goes bad. Also change the common cathode resistor R728 and the plate resistor of each demodulator tube whenever you suspect overcurrent trouble.

When a customer complains of the picture being too blue or too green, check the color-amplifier tubes and circuits. A defective color CRT can also change the tint of a black-and-white picture. This happens when the tube ages—especially the older-model CRT's. Use a good CRT tester to check out any picture tube troubles.

It really isn't too difficult to troubleshoot color, if you progress logically through the set, function by function, stage by stage. Don't skip any links in the chain from the station signal to the CRT screen. And don't *assume* that something is okay just because it's supposed to be. Be skeptical, and you'll find the trouble. END

This 3.58-MHz crystal is in the grid-to-cathode circuit of the reference oscillator.

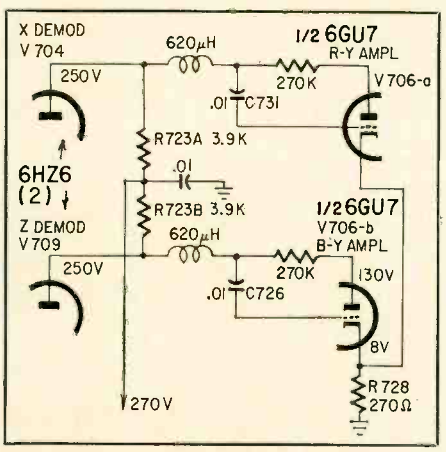


Fig. 7—Color-difference demodulators and amplifiers divide incoming chroma signals.

The Development of Color-TV Signal

Luminance, chrominance, hue, saturation, and burst—they're all necessary to make a color picture

By MILTON A. SIZER

A BEAUTIFUL GIRL IN A COLORFUL COSTUME is lounging in an attractive room. Would you like to have her lounge in *your* living room? Now it is possible—by way of color television. It takes but the flip of a switch, but this is no indication of the hours of mathematical development which went into this very complex system. The telephone was remarkable—the radio outstanding—television was a masterpiece—but *color* TV is an absolute miracle.

How does this miracle occur, and just what goes into the signal which finally brings the beautiful girl into your home? First of all there must be a color camera in the TV studio. It is much like a black-and-white camera except that it is really three cameras in one. There are three pickup tubes, each with a colored filter in front of it—red, blue and green. (Some cameras use a fourth tube for straight black-and-white, but this is not necessary to produce color. The resulting signal looks the same on the oscilloscope as that from the three-tube camera.)

The signal from each tube is regular video, just as in a monochrome camera. The tube with the red filter (we'll call it the red tube) sees only red, and the red components of other colors. The green tube sees only green, etc. We *could* send the signals from each of the tubes directly to the transmitter, and thence to your receiver. But this would require more than 12 MHz of broadcast channel, and since each channel is limited to 6 MHz, a different method must be used. The three signals are instead processed in a unit called a colorplexer or encoder (depending upon the manufacturer).

To visualize what is happening we must think about a few things first. You know what a conventional black-and-white signal looks like. At horizontal line rate an oscilloscope shows sync and blanking (including front and back porch) and video (see Fig. 1). This signal produces the brightness we see on a b-w receiver. It is called the *luminance* signal. In a color transmission we also have the same luminance signal, but along with it (superimposed as far as the scope picture is concerned) is the color information called *chrominance,* which is all occurring at 3.58 MHz (nominal). On the scope it gives a "fuzzy" appearance to an otherwise rather "clean" signal (Fig. 2)

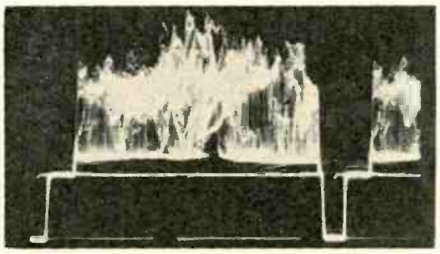


Fig. 1—Oscilloscope display of a black-and-white television signal at horizontal rate.

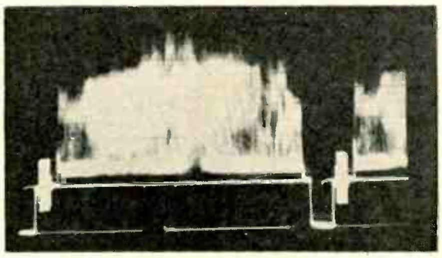


Fig. 2—Same display as Fig. 1, but this is a color TV signal complete with burst.

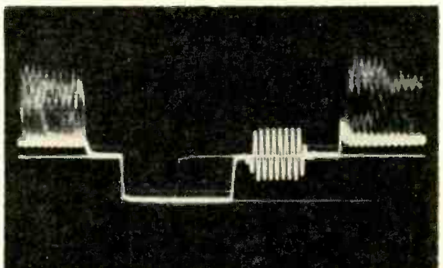


Fig. 3—Expanded scope trace of Fig. 2 shows details of color burst on back porch.

In addition, something new has been added to the back porch. It is a burst of 3.58 MHz (8 or 9 cycles worth), called the "color burst" or "reference burst" (Fig. 3).

Let us see what is the makeup and purpose of each of these new signals. It is necessary for us to be able to combine a lot of information at the transmitting end, and then separate it all at the receiver. In black-and-white, brightness is the only variable, but in color, along with brightness, there is hue (that's the color—red, yellow, pink, aqua, etc.), and saturation (the intensity of the color—pale red, deep red, etc.). Even hue itself is the result of many combinations of the original red, blue and green signals, so you can see that many variables must be combined in what is called chrominance.

You are familiar with the method of transmitting a signal by means of amplitude-modulating a sine-wave carrier of steady frequency. Recently a method was discovered of modulating two carriers differing in phase, mixing them, and then at the other end unmixing them and demodulating each. This saves considerable space in the electromagnetic spectrum. In the color-TV system the 3.58-MHz subcarrier is divided into two such carriers differing only in phase (by 90°). Picture a steady sine wave at 3.58 MHz. Now picture an identical signal, but shifted by 90° (see Fig. 4).

When properly modulated by the signals from the red, blue and green tubes, these carriers become known as I and Q, respectively. (I stands for *in* phase, and Q for *quadrature,* or 90° out of phase with I. Actually the I signal is not in phase with anything in particular, but is used as a reference for the Q-signal phase.)

A lengthy, although not difficult, mathematical derivation (which can be presented at a later date if there is a call for it) shows us how to modulate

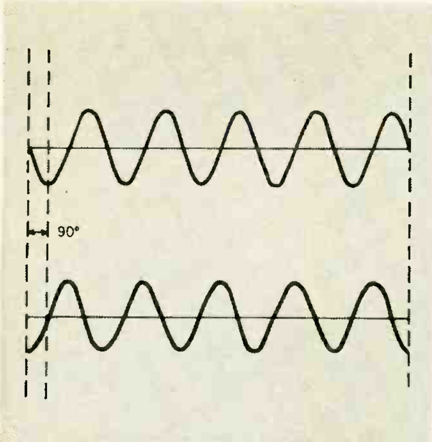


Fig. 4—Two continuous sine waves, of same frequency, with 90° phase difference.

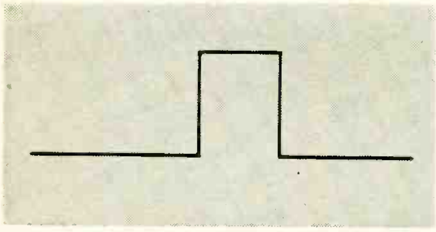


Fig. 5—Pure red output from red camera tube, when scanning all-red object in scene.

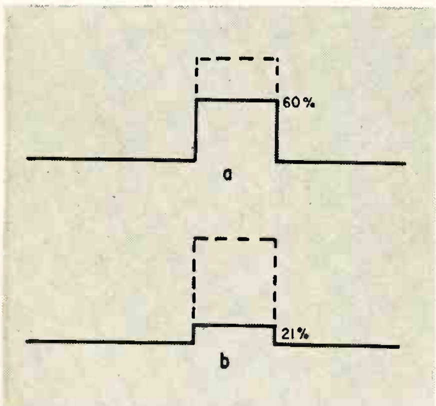


Fig. 6-a—The I signal takes 60% pure red. b—The Q signal takes only 21% pure red.

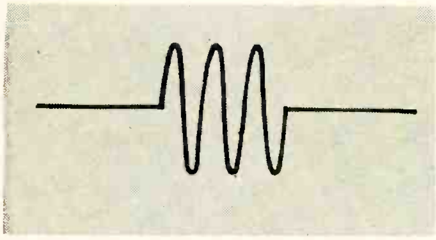


Fig. 7—The I signal after modulation by the red camera signal shown in Fig. 6-a.

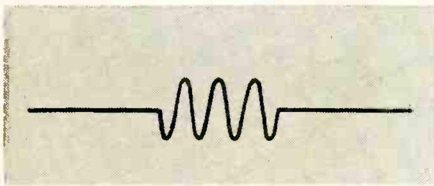


Fig. 8—Q signal after being red-modulated (Fig. 6-b) is still 90° out of phase with I.

the two carriers so that they will produce a usable chrominance signal. Here is the result of that derivation:

$$I = 0.60R - 0.28G - 0.32B \qquad (1)$$

This means that the red signal is passed through a resistor matrix which reduces it to 60% of normal, producing 0.60R. The green signal is matrixed down to 28%, and then sent through an inverter stage to make it negative, producing −0.28G. The −0.32B is similarly produced. These three signals are then added electronically and the sum used to modulate the I portion of the divided carrier.

The Q carrier, differing in phase by 90° from I, is modulated according to the equation:

$$Q = 0.21R - 0.52G + 0.31B \qquad (2)$$

In the modulation process, using balanced modulators, the carrier is suppressed and only the sidebands remain. One modulator stage processes the I signal, while another handles the Q signal. These two sets of sidebands are added together to produce the chrominance signal. This sum is also a 3.58-MHz signal containing all the needed information regarding color in the original scene. This is now added to the luminance signal (which will be discussed later) and the color signal is complete, except for the color burst on the back porch. An illustration of the formation of I and Q and the addition of the two are in order here.

The beautiful girl we've been talking about is wearing a red dress. Just for convenience, let us substitute a vertical red bar against a black background for the beautiful girl in the red dress. The output of the red tube would look like Fig. 5 on a scope. The output of the green and blue tubes would be zero in this area.

Equation (1) for I calls for 0.60R (green and blue are zero). Refer to Fig. 6-a. Equation (2) for Q calls for 0.21R (green and blue are zero). Refer to Fig. 6-b. The 60% signal, through a doubly balanced modulator, modulates one carrier, suppresses the video and carrier itself, and results in the sidebands only (I signal—see Fig. 7). The 21% signal modulates the carrier which differs in phase by 90° (Q signal—see Fig. 8). The I and Q signals are now added together, as shown in Fig. 9. Note that each signal has been spread out horizontally for clarity.

The final result is a sine wave of 3.58-MHz (nominal) frequency, with a new phase all its own. In this case red is illustrated. If another color were used, such as yellow or brown or pink or turquoise, other phases would result, since not only red but also portions of blue and green would be used.

Red in a picture will always have the phase relationship to I and Q shown in Fig. 9. All other colors will have slightly different phase relationships, but always the same for any one color. A phase chart can be constructed (Fig. 10) representing all the colors in their phase relationships to each other. Note that red is of slightly different phase than the I phase (20°), but quite different than that of Q (70°), corresponding nicely to Fig. 9.

Since the carriers have been suppressed for transmission, they must be reinserted at the receiver, to separate the original I and Q signals and then to demodulate them. (This is done by sideband suppressed-carrier theory, a topic too lengthy to cover here.) However, these carriers must be reinserted in the same phase relationship with respect to the colors as the original carriers at the broadcast station. In the receiver there is a very accurate 3.58-MHz oscillator which needs only a reference phase to lock to, in order that it can be reinserted as a carrier. This reference is a small burst of 3.58 MHz on the back porch of every horizontal blanking period, sent by the station in exactly the proper and desired phase relationship to the colors.

For various reasons related to the mathematical derivation mentioned above, the I phase is 57° away from the reference burst, and the Q phase 147° from the reference burst, at the transmitting station. The receiver oscillator locks on this burst, and is then delayed 57°, at which time it exactly duplicates the original I signal. Using a couple of modulators acting this time as synchronous detectors, this reinserted I-signal carrier allows the I modulation to be retrieved while canceling Q modulation.

At the same time, a 90°-shifted 3.58-MHz sine wave is combined (in a different set of synchronous detectors) with the same signal, and the Q modulation is removed while the I is canceled. This sounds complicated (and it is) but the net result is this: Three different color video signals are combined to produce I and Q signals which, after transmission, are recovered in the receiver. How they are now reconverted into three primary colors will be taken up shortly.

So far we have completely ignored a very important part of the total color signal. It is the black-and-white portion, or the luminance. If a fourth pickup tube is used in the camera, this luminance signal is easily obtained. However, if a fourth tube is *not* used, the luminance signal (sometimes called the Y signal, or in other literature the M signal, for monochrome) can be obtained in a manner similar to the I and Q signals. This process is given by the following equation:

$$Y = 0.30R + 0.59G + 0.11B \qquad (3)$$

These values of red, green and blue were selected because of eye sensitivities to various colors. This particular combination produces a signal which results in a proper gray scale in a black-and-white receiver. It is *not* used to modulate a carrier, but remains as pure video. This Y, or luminance signal, is transmitted right along with the I and Q sidebands, or chrominance signal (see Fig. 2).

In a black-and-white receiver only the Y signal is viewed, since there are no chrominance processing circuits. However, in a color receiver, the Y signal also plays a very important part. Whether we like it or not, we will now have to do a little mathematics. After all, the receiver performs this math, so we ought to be willing to do it too!

Using inverter and adder stages as well as resistor matrices, the receiver performs the following mathematical steps: (Remember now that we have a 3.58-MHz sine wave for I and a similar-but-90°-displaced sine wave for Q.)

If we take 96% of the I amplitude and add it to 62% of the Q amplitude we end up with a signal called R−Y. Mathematically stated:

$$R-Y = 0.96\,I + 0.62\,Q \qquad (4)$$

Similarly,

$$B-Y = -1.10\,I + 1.70\,Q \qquad (5)$$

and

$$G-Y = -0.28\,I - 0.64\,Q \qquad (6)$$

Now we have three signals: R−Y, B−Y and G−Y. If we add Y to each one in three adder stages immediately preceding the color tube, and feed right into each of the grids, we get:

$$R-Y+Y = R \qquad (7)$$

$$B-Y+Y = B \qquad (8)$$

$$G-Y+Y = G \qquad (9)$$

Thus our three original colors have been restored, each in its entirety, and produce a full color picture on the face of the picture tube.

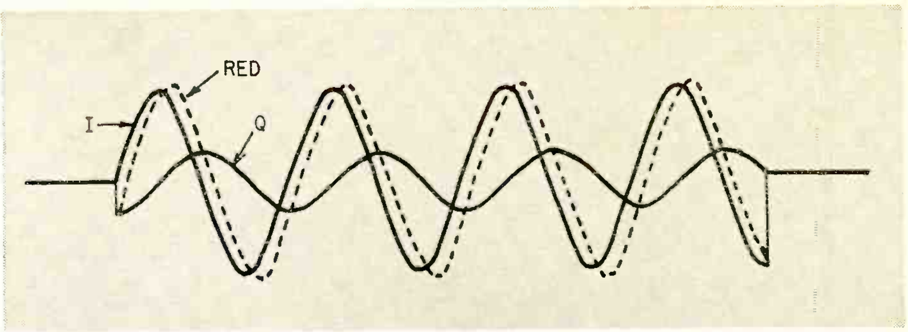


Fig. 9—Addition of I and Q signals (all-red modulation) produces dashed-line waveform.

The actual signal that you see on an oscilloscope really consists of the normal sync and blanking of a monochrome signal with the addition of the color burst on the back porch. The video contains not only mono information (luminance) but also color information (chrominance) which is a combination of the I and Q signals. Each color from the original scene (not just red, blue and green) is represented in the chrominance as a 3.58-MHz sine wave with a definite phase relationship to the reference burst on the back porch. When the viewer switches from one TV channel to another, the local 3.58-MHz oscillator in the receiver *immediately* locks onto the new reference burst so that the correct colors are *assured—provided the station is transmitting colors in the proper phase relationship to the burst—and provided further that succeeding pieces of equipment do not shift this relationship by any one of several possible discrepancies.*

If a difference in flesh-tone hue is noted when switching from station to station, it is a sure sign that camera chains or tape machines in one or both stations are not aligned perfectly, *or* that all discrepancies in equipment have not been entirely eliminated. Particularly in video tape reproduction there are numerous possibilities for errors, and even with constant vigilance the results are not going to be perfect. Transmitting equipment and alignment also varies from station to station, and even from day to day in any one station.

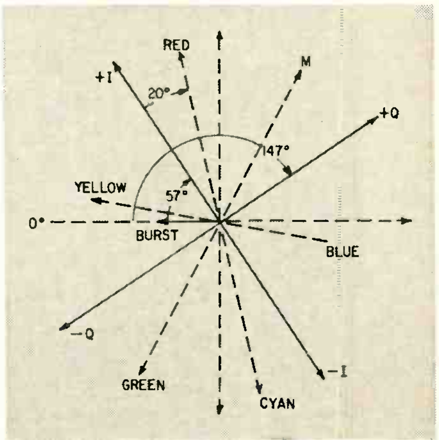


Fig. 10—This phase chart shows how the various colors relate to I and Q references.

But after all, that is why there is a phase (hue) control in the receiver—to counteract some of the discrepancies in the transmission of the signal. Unfortunately there is so far no sure method of counteracting these problems at the receiver, but some day the problems at the broadcast station will one by one be minimized. END

WHAT'S YOUR EQ?

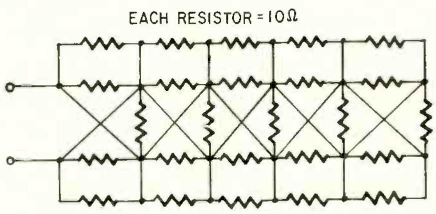
Conducted by E. D. CLARK

Two puzzlers for the student, theoretician and practical man. Simple? Double-check your answers before you say you've solved them. If you have an interesting or unusual puzzle (with an answer) send it to us. We will pay $10 for each one accepted. We're especially interested in service stinkers or engineering stumpers on actual electronic equipment. We get so many letters we can't answer individual ones, but we'll print the more interesting solutions—ones the original authors never thought of.

Write EQ Editor, Radio-Electronics, 154 West 14th Street, New York, N. Y. 10011.

Answers to this month's puzzles are on page 99.

Resistor Network

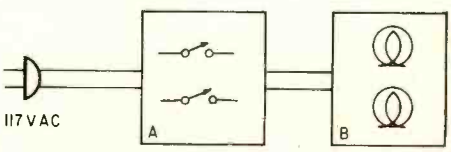


Another insomniac's R_T nightmare. Forget about Kirchoff's laws and loop-circuit calculations, though. Study the diagram *carefully* for about 30 seconds.

What's the total resistance at the terminals?—*Dennis Howard*

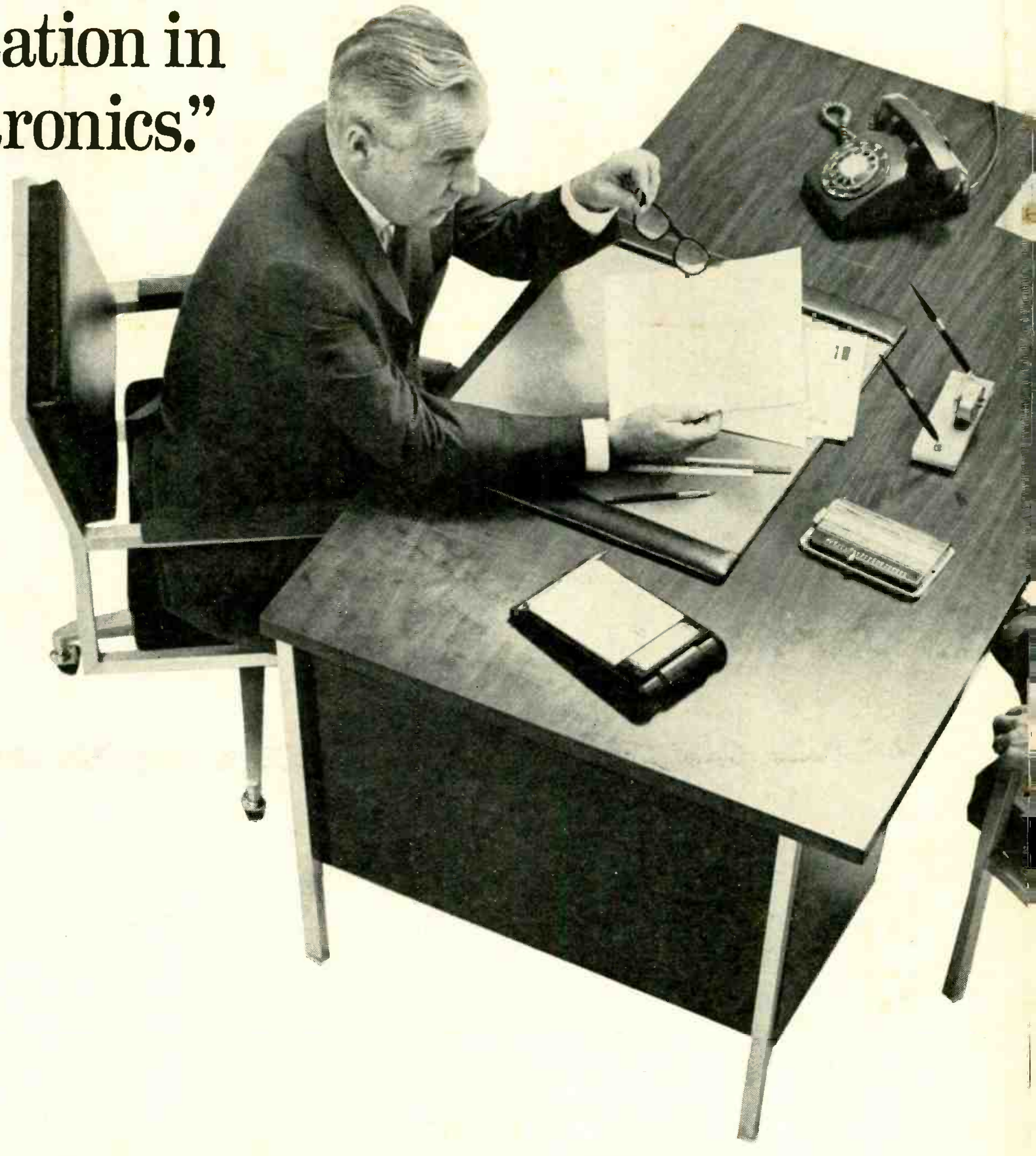
Light Switching Circuit

Either one or both of the lamps in box B may be turned on by throwing either one or both of the switches in box A. In normal electrical work, this hookup would require three conductors between the boxes, not two, as shown.



What's inside the boxes and how is everything wired?—*Jim Wilhelm*

"He's a good worker. I'd promote him right now if he had more education in electronics."



EQUIPMENT REPORT

Sencore CG-10 "Lo-Boy" Color Generator

Circle 38 on reader's service card

COLOR-BAR GENERATORS ARE GETTING smaller and handier all the time. One of the newest is the Sencore CG-10 Lo-Boy, which is only 3 inches high, 10 inches wide and 10 inches deep. It's all-transistor and powered by self-contained dry cells, eight of them. With a total drain of only 16 to 20 mA, battery life ought to be pretty good.

All the standard color-TV test patterns are provided in the CG-10: vertical and horizontal lines, dots, crosshatch, and the 10-bar keyed-rainbow color pattern. Two crystals are used: a 189-kHz for the timers, and a 3.56-MHz for the color-bar pattern. The rf carrier can be tuned to any low-band TV channel from 2 to 6. Fourteen transistors, 6 diodes and a Zener are used in the CG-10.

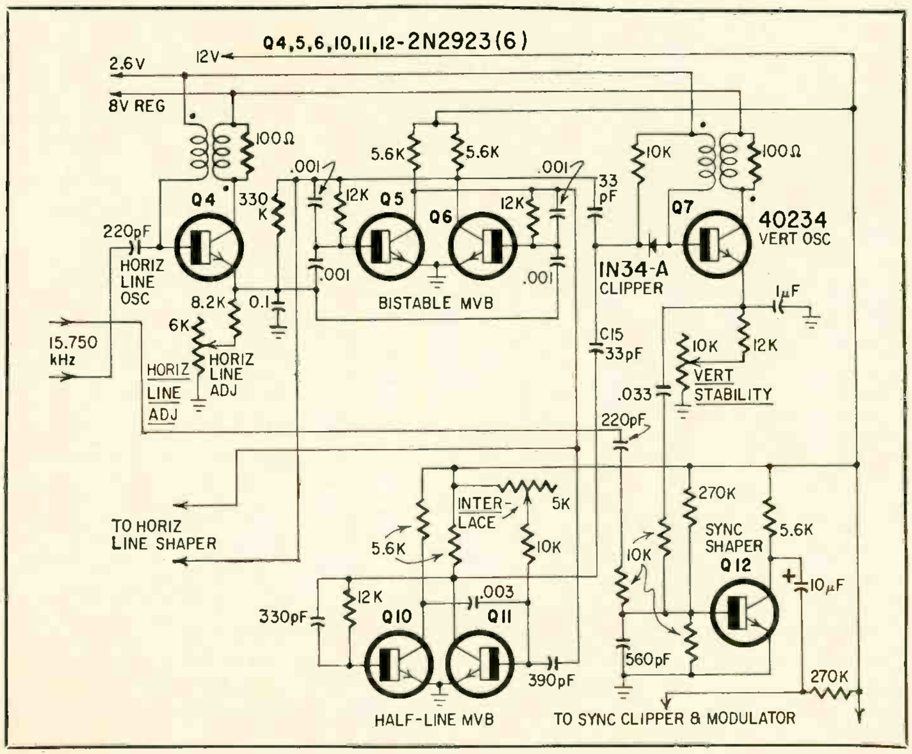
All controls are on the front panel (see photo), except for dot-size and rf tuning, which aren't needed so often and are on the bottom. A gun killer, separate from the generator circuits, has its control switches on the front, and a plug-in cable assembly is on the back.

The circuit starts with the familiar 189-kHz crystal oscillator, followed by only three "timer" or countdown stages. (Some original versions of this circuit used six or seven!) These timers are actually blocking oscillators. The "timing elements" are the only difference between them. A very high divide ratio is used. The first stage divides by 12, the next by 17 or 18 and the last by 15.

This high countdown ratio is made possible by the inherent characteristics of transistors. Their low rise time and very sharp cutoff characteristics make them ideal for pulse-generator work, and that's what these circuits are.

Dividing 189 kHz by 12 gives us the 15.75-kHz line frequency. This is fed through a shaper circuit, to develop horizontal pulses in the sync shaper, and also feeds a sync signal to the second timer, Q4.

The timer circuit (see diagram) is novel: Q4 divides the 15.75-kHz signal *alternately* by 17 and 18, controlled by bistable multivibrator Q5-Q6. Q4's output is 450-Hz pulses, for third counter stage Q7. Another set of 450-Hz pulses comes through C15 from a circuit called a half-line multivibrator (Q10–Q11).



The last ones are delayed so that they appear between the first pulses, and the result is 900-Hz pulses! The third counter stage (Q7) divides the 900-Hz signal by 15 and makes 60-Hz vertical sweep. This signal is also fed to a sync shaper to make vertical-sync pulses.

Each time the horizontal-line oscillator (Q4) divides by 17, the half-line multivibrator fires and generates a new pulse 20-40 μsec later. This "later" can be controlled by the INTERLACE control on the front panel. The vertical oscillator locks to this pulse source every *other* time it fires (it divides by an *odd* number); this allows us to shift one *field* of the TV raster by about 10 μsec. Try this on a TV set with a sharply focused raster, and you can see the interlace change; one set of lines moves up and down! This is used to change the horizontal lines, making them wider or narrower, as you like. It also helps to get rid of jitter in the patterns. A similar arrangement is used to help to stabilize the horizontal-line pattern.

A gun-killer assembly is provided, completely separate from the rest of the generator. The control switches are on the right end of the front panel. A polarized socket on the back connects them to a set of color-coded leads. Each lead has a 100K isolating resistor mounted inside the insulation-piercing alligator clip. No adapters are needed. Just hook up to the solid-colored wires on the base of the color CRT—they're the grids. Ground return is made through the low dc resistance of the rf output cable ground lead.

The CG-10 is powered by eight C-cells in two plastic tubes. The tubes are replaceable, so if you forget and leave the batteries in too long, it won't damage the instrument. A battery-test terminal board is mounted on the back panel. This is connected through the on–off switch, so that you automatically measure battery voltage under full load, as you should.

The power supply to the crystal oscillator and timer stages is regulated at 8 volts by a Zener diode. All other stages are fed from the 12-volt line. The generator works well with a supply voltage from 12 to 9.5, below which batteries must be replaced.

As I said, this instrument uses only three timer stages. The controls are on the front panel. Each is plainly marked with "what it does": At the top is the horizontal-hold control, at the bottom the vertical-hold control, and in the center, the intermediate timer, which controls the number of horizontal lines you see in the pattern. As it says, "Adjust for 13 bars."

The hold controls act just like their receiver equivalents. If you get a slant-

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ing-line pattern, out of horizontal sync, simply adjust the upper or horizontal-hold control, and the pattern will lock in. Hold-control adjustment is easy; you set each to a knob index, perhaps twiddle it slightly, and the pattern falls into sync right away.

I recommend using a strong station signal to set H and V hold controls on a receiver, and then setting the generator's sweep controls to match. This method uses the program as reference, which is what the customer watches! Also, you avoid misconvergence if your generator happens to be slightly off.

For a complete convergence job, most manufacturers recommend starting with vertical lines only, getting them all lined up, then going to horizontal lines only, then finally to the crosshatch for final touchup.

The gun killer is, of course, very useful. You kill the blue gun, for example, and go through the R and G adjustments. You should wind up with a nice yellow raster.

The CG-10, by the way, doesn't come on instantly. Although solid-state, it contains a large (100-μF) electrolytic across the 8-volt regulated line, which must charge. This takes 8 or 10 seconds. At this point, the generator's output appears. I made my pet stability test—tuned the CG-10 to color bars (as seen on a receiver), then turned it off for a few minutes, then turned it back on. The bars came in right on the button! This is an exacting test; any tuning drift shows up instantly as a change in colors of the bars.

The instruction book is helpful and informative. A full, legible schematic shows all operating voltages and currents. A trouble chart tells you how to keep the instrument working properly. On the back cover is a layout chart of the PC board used in the CG-10. It even tells which color wire goes to what terminal!

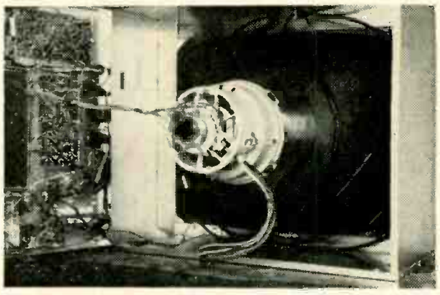
Things that impressed me: All controls and cables are plainly marked, so you can't get confused. Battery replacement information is marked on the CG-10's case. All in all, this generator is useful and compact at a reasonable price. Nice.—*Jack Darr*

Price: $89.95, wired only

Heathkit GR-25 Color Receiver

Circle 39 on reader's service card

FOR SEVERAL MONTHS NOW, I'VE PROBably answered more questions on Heath's GR-25 color TV receiver than on any other piece of current electronic equipment. Friends who've seen my GR-25 generally ask, "Why can't I get a good picture like that on my color set?" or "Why did you build a set when your experience should enable you to purchase a good set for less?"



In reply to the first question, I point out that the brighter picture with more vibrant colors is produced by a picture tube that uses new rare-earth phosphors that were not used until just a year or so ago. I then add that the picture on a color set is adversely affected by stray magnetic fields. In the GR-25, the picture tube is almost completely shielded from external magnetic fields. In many other sets, the CRT's are not shielded and are easily magnetized by nearby lightning strokes, by the turning off of a nearby fan or vacuum cleaner, or even by the earth's magnetic field when the set is moved around while cleaning or decorating. Too, the picture tube, like in many sets made during the last 2 years, is automatically demagnetized (degaussed) each time you turn the set on. This insures good color purity and registration—even after the set has been moved around.

Also, the receiver uses the very latest in circuit developments to greatly simplify convergence—making it possible for the set builder to do a better convergence job in less time than many experienced technicians can do on an older model.

In answering the second question, I point out the pleasures of building (and troubleshooting) a piece of complex equipment, of being able to make color adjustments to meet my personal taste rather than accept the standards of a technician who sets up a factory-built set. The design of the chassis makes all test points and components readily available to the builder who wants to do his own maintenance. The built-in dot

RCA ANNOUNCES NEW ANTENNA ACCESSORIES ENGINEERED FOR COLOR TV

New catalog tells the full-line story.
Get it from your RCA Distributor.

5

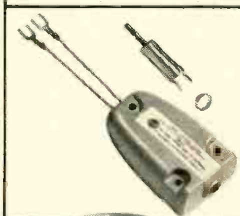
RCA Deluxe Transistorized Antenna Amplifiers . . . a full line of dual purpose units with the most advanced silicon transistors in high-gain, low-noise circuits. They are masterfully designed to bring in the sharpest picture on color or black and white TV. Or they can drive multiple receivers from a single antenna using RCA multi-set couplers as a small distribution system. Five types include: 300 ohm UHF type 10P223; 300 ohm VHF/FM type 10P213; 75 ohm coaxial VHF/UHF type 10P215 and 10P235; and 300 ohm VHF/UHF type 10P233—all with remote, A.C. operated power supplies.

4

RCA Deluxe Multi-Set Couplers . . . UHF/VHF/FM 300 ohms, couple two or four sets to one antenna or amplifier. Channels 2 to 83, types 10P302 and 10P304. Also VHF/FM 75 ohm coaxial types 10P752 2-set coupler; 10P754 4-set coupler.

3

RCA Deluxe Band Splitters . . . Separate UHF, VHF and FM signals from a single transmission line or combine separate antennas. 300 ohms. Three types include: 10P311 couples VHF/UHF signals to one line; 10A135 separates UHF and VHF at set; 10P312 separates UHF, VHF and FM.



3

RCA Deluxe Coaxial-to-twin lead Transformers . . . streamlined for fast installation. Coax plugs in using solderless connector. Terminals for twin lead connections. Models: 10P723 and 10P753 for indoor use and 10P375 for outdoor use.

2

RCA Deluxe Lightning Arrestors . . . Positive contact with all varieties of twin-lead (flat, round, and oval). Eliminate lead stripping, insert line in slot, screw on cap for fast installation. Low insertion loss, does not increase VSWR of a good antenna even at critical UHF frequencies. Screw mount type 10A118; and strap-mount type 10A119.

When you buy antenna accessories bearing the RCA Mark of Quality, you know they're reliable.

RCA PARTS AND ACCESSORIES, DEPTFORD, N.J.

RCA® **The Most Trusted Name in Electronics** generator (see diagram) eliminates the necessity of using a color generator—in most cases one of the most essential color test instruments.

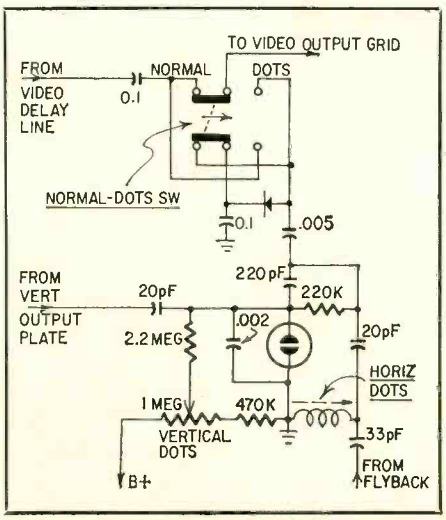
If you are looking for a color set for a custom installation, the GR-25 is one of the few available without a cabinet but with a finished escutcheon (front panel). You can build it into a wall, a custom cabinet or install it in the oiled-walnut cabinet available from Heath. In the latter, the 12 convergence adjustments and the height, vertical linearity, agc, sync, color-killer and dots controls are on the convergence bracket. The bracket can be mounted in a spot convenient to the operator or the service technician. In the Heath cabinet, the convergence bracket is mounted on the tilt-out speaker panel.

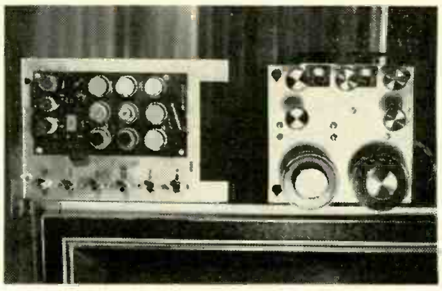
The set has 27 tubes, 10 diodes and 1 transistor (in the uhf tuner). The picture tube is completely shielded—except for the face—by a steel case or cabinet which Heath calls the Magna-Shield. The rear of this case is hinged and is used as the chassis.

In replying to interested readers, I give them a rundown on the set's circuitry and features of interest to the knowledgeable do-it-yourself'er, student and technician, pointing out that building and adjusting a color set is an excellent way to put theory into practice.

Building the set is not difficult. The 180-page manual is well laid out and very easy to follow. The tuner and i.f.-amplifier circuit board are prewired and aligned. The horizontal-output and high-voltage sections are prewired. All you have to do is mount the parts on the printed-circuit sound-sync, color and convergence boards; mount the remaining parts on the chassis and connect them with multiconductor color-coded wiring harnesses.

Heath says that the set can be completed in about 25 hours. Taking my time, I completed the wiring, prelimi-





nary adjustments and dc convergence in about 30 hours and had a beautiful black-and-white picture.

Sync was a little critical and there was a hum that varied with the setting of the vertical hold control. Voltage and resistance measurements were within tolerances when measured at the tube socket terminals on the underside of the printed boards. I suspected a cold solder joint and concentrated on checking the connections I had made. Finally, I used socket adapters and repeated the voltage measurements. The screen grid of the sound i.f. and sync amplifier read 20 volts at the adapter socket and 145 on the underside of the board. A magnifying glass revealed a hair-line crack in the foil at the screen-grid terminal. A dab of solder solved this problem and gave me stable sync and beautiful hum-free sound.

The next step was dynamic convergence. This was quick and easy—much simpler and faster than I'd imagined it would be. Now, only one thing was wrong: no color on color broadcasts. Well, back to the soldering iron and magnifying glass. By repeatedly touching up all soldered joints—even those remotely connected to the color-killer, color-oscillator and related circuits—I finally got good color reception.

A few construction hints: When you've completed the wiring and are ready for preliminary adjustments, you'll find the manual instructs you to hang the convergence bracket and tuner on the right side of the shield box. There is a 12-wire cable that runs from the convergence bracket to the pole-piece assemblies on the rear of the yoke. When you swing the vertical chassis into place, make sure that this cable does not snag on tubes or other components on the i.f. circuit board. You could break a tube or do even more serious damage. Too, watch out for the lead from the chassis to the degaussing coil. You'll snip it in half if it gets caught between the bottom of the chassis and the shield.

Inspect the pole-piece assemblies carefully before you mount them in their holders. On two, I found that the leads from the coils had not been soldered to the lugs.—*Robert F. Scott* END

Price: $469.95, kit only

MICROCIRCUITS & TUBES NEW SEMICONDUCTORS;

We are starting the year with one new tube developed for color receivers and follow this with a variety of new devices ranging from FET's and diodes to all-glass rectifiers.

VERTICAL AMPLIFIER FOR COLOR

The RCA A40607C is a new developmental beam power tube designed for vertical output circuits in color receivers. Its benefits include improved linearity, true height control, minimum interaction between height and linearity controls, fewer components and greater independence from variations in tube characteristics. The circuits (see diagram) designed for this tube are fairly conventional. The difference lies in the use of stabilized feedback provided by an integral diode connected internally to grid 3.

The diode develops bias and a drive waveform for grid 1. During the retrace, C1 charges negatively through the diode. LINEARITY control R1 determines the amount of charging current, thus setting the start of the scan waveform on grid 1.

During the scan C1 discharges through R4, R1, R3 and R2 back to B+. R2 controls the discharge rate. C1 provides the negative feedback voltage to grid 1 which makes the circuit virtually independent of tube characteristics and insures that height and linearity controls have little effect on vertical frequency.

NEW DOUBLE-GATE MOS FET

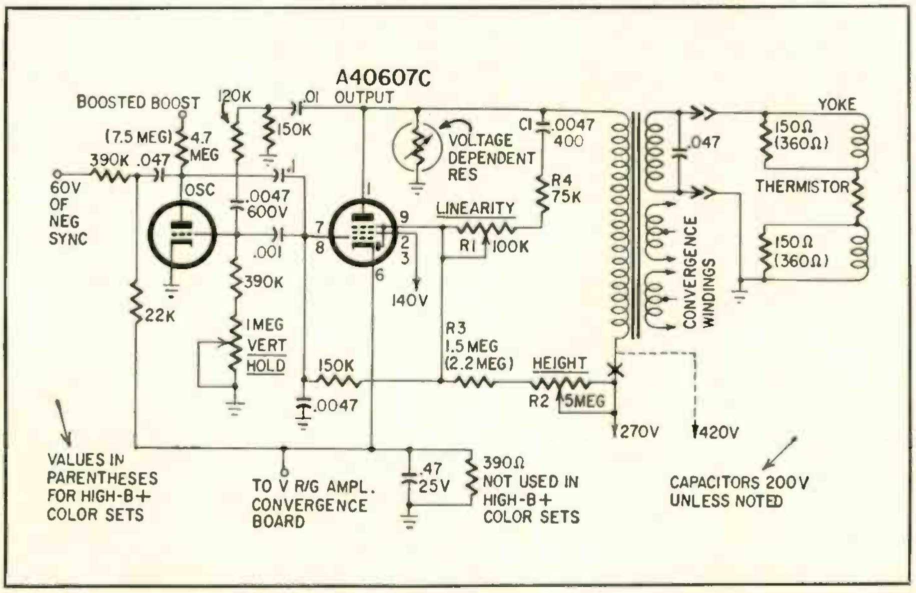
The developmental type TA7010 transistor is designed to improve cross-modulation performance, noise figure and dynamic range in rf and i.f. amplifiers in vhf/uhf military and industrial communications receivers up to 500 MHz. Its internal circuit configuration and performance are similar to two vacuum-tube triodes in a cascode circuit. It features extremely low gate-leakage currents, feedback capacitance around .01 pF, high transconductance (10,000 µmhos at 7 mA drain current) and square-law transfer characteristics.

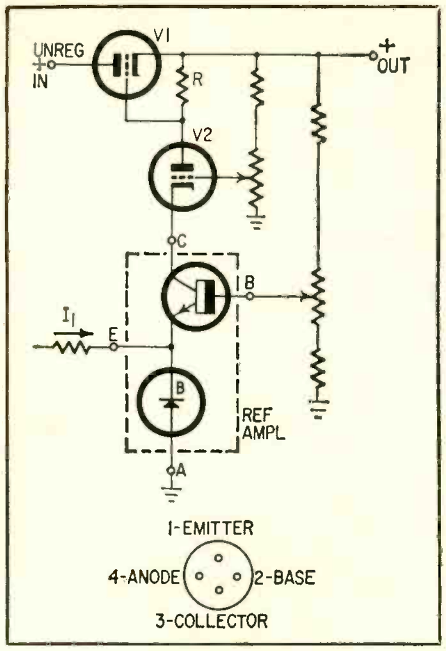
The RCA TA7010 is an n-channel, depletion-type silicon insulated-gate MOS FET packaged in a 4-lead TO-72 case. At 200 MHz it has a typical power gain of 20 dB and a noise figure of only 2.8 dB. At 400 MHz, gain is 13 dB and the noise figure 4.5 dB.

Evaluation quantities are now available and production quantities are expected in mid-1967. Additional technical information is available from Commercial Engineering, RCA Electronic Components and Devices, Harrison, N. J.

SOLID-STATE REFERENCE AMPLIFIER

The DRA 7E-10, -25, -50, -100 make up a series of 7-volt reference amplifiers designed as a combination voltage reference and error amplifier for regulated power supplies. These Dick-





son Electronics units consist of an npn silicon transistor and a silicon voltage regulator diode having equal but opposite temperature coefficients. In addition, these elements are assembled to minimize the temperature differential and thus permit operation over a wide range of temperatures.

Maximum ratings: collector-to-emitter voltage 30, collector current 10 mA, total VR diode current 10 mA, power dissipation (25°C in free air) 300 mW. The numeral suffix indicates the temperature coefficient in parts-per-million. Complete electrical characteristics and application notes are contained in a comprehensive data sheet. The diagram, taken from the data sheet, shows how the reference amplifier may be used in a typical tube-type voltage regulator. The value of R is set so 100 μA flows through it with a nominal value of output current. If the output voltage tends to increase, the reference-amplifier collector current increases. This increases the plate current of V2. The increased voltage drop across R increases the plate current of V2, thus lowering the voltage to its desired value.

ALL-GLASS RECTIFIERS

The 1N4383 through 1N4386 form a series of new Sylvania all-glass rectifiers. These silicon double-diffused units are capable of delivering 1 amp at 100°C at reverse working voltages to 1 kV. The glass package, 0.35 in. long and 0.12 in. in diameter, provides a hermetic seal with a leak rate less than 1×10^{-10} cc/sec. These 48-cent units can be used as half- or full-wave rectifiers, voltage multipliers and in blocking, damper and surge-suppressor applications. END

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How To Have Fun While You Save...

Regardless Of What You Pay For A Color TV... It Can't Perform As Well As This New Heathkit® "180" For Only $379.95*

Here's Why!

Exclusive Features That Can't Be Bought In Ready-Made Sets At Any Price!

All color TV sets require periodic convergence and color purity adjustments. This new Heathkit GR-180 has exclusive built-in servicing aids so *you* can perform these adjustments anytime ... *without* any special skills or knowledge. Just flip a switch on the built-in dot generator and a dot pattern appears on the screen. Simple-to-follow instructions and detailed color photos in the GR-180 manual show you exactly what to look for, what to do and how to do it.

Results? Beautifully clean and sharp color pictures day in and day out . . . and up to $200 savings in service calls throughout the life of your set.

Exclusive Heath Magna-Shield!

This unique metal shield surrounds the entire picture tube to help keep out stray external fields and improve color purity. In addition, *Automatic Degaussing* demagnetizes and "cleans" the picture everytime you turn the set on from a "cold" start . . . also permits you to move the set about freely.

Vertical Swing-Out Chassis!

All parts mount on a single one-piece chassis that's hinged to make it more accessible for easier construction, care and installation.

Your Choice Of Installation!

Another Heathkit exclusive . . . the GR-180 is designed for mounting in a wall or your own custom cabinet. Or you can install it in either of Heath's factory-assembled and finished cabinets.

From Parts To Programs In Just 25 Hours!

. . . and no special skills or knowledge needed. All critical circuits (VHF and UFH tuners, 3-stage IF assembly and high voltage power supply) are prebuilt, aligned and tested at the factory. The GR-180 manual guides you the rest of the way with simple, non-technical instructions and giant pictorials. It's like having a master teacher at your elbow pointing out every step. You can't miss.

Compare These Advanced Performance Features . . . And The Price!

Hi-Fi 180 Sq. Inch Rectangular Tube with anti-glare safety glass, plus "rare earth phosphors", smaller dot size and 24,000 volt picture power for brighter, livelier colors and sharper picture definition.

Automatic Color Control and gated automatic gain control to reduce color fading, and insure steady, jitter-free pictures even under adverse interference such as nearby aircraft traffic.

Deluxe VHF Turret Tuner with "memory" fine tuning so you don't have to readjust everytime you return to a channel.

2-Speed Transistor UHF Tuner for either fast station selection, or fine tuning of individual channels.

Two Hi-Fi Sound Outputs... a cathode follower for play through your hi-fi system, plus an 8 ohm output for connection to the GR-180's limited-field 4" x 6" speaker.

Two VHF Antenna Inputs . . . a 300 ohm balanced and a 75 ohm coax to reduce interference in metropolitan or CATV areas.

1-Year Warranty on the picture tube, 90 days on all other parts. In addition, liberal credit terms are available.

***Kit GR-180,** everything except cabinet for custom mounting, 102 lbs. **$379.95**

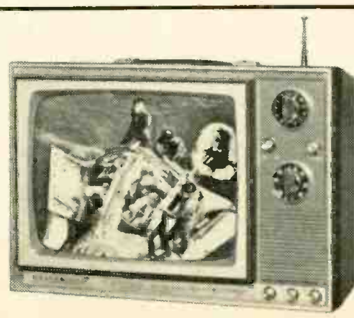
Assembled GRA-180-1, walnut cabinet shown above, 30 lbs., 18¼" D x 28¼" W x 29" H. . **$49.95**

Assembled GRA-180-2, Early American cabinet, 37 lbs., 18¼" D x 28¼" W x 31¾" H. . . Available February **$75.00**

New 12" Transistor Portable TV — First Kit With Integrated Circuit

Unusually sensitive performance. Plays anywhere . . . runs on household 117 v. AC, any 12 v. battery, or optional rechargeable battery pack ($39.95). Receives all channels; new integrated sound circuit replaces 39 TV parts; 3-stage IF for maximum gain with controlled bandwidth; gated AGC for steady, jitter-free pictures; instant "on" AC operation; preassembled & aligned tuners for peak performance; transformer operated power supply; front panel mounted speaker; easy 12-hour assembly. Rugged high impact plastic cabinet measures a compact 11½" H x 15¾" W x 9⅜" D. 27 lbs.

Kit GR-104
$119.95



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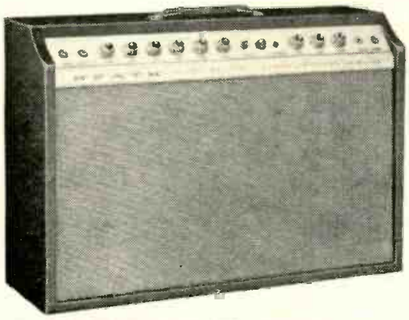
Build Your Own Heathkit® Electronics



Heathkit "Starmaker" 60-Watt Transistor Guitar Amplifier

Kit TA-16

$129^95

$300 Value!

60 watts peak power; two channels — one for accompaniment, organ or mike, the other with tremolo and reverb for lead guitars; two inputs per channel; two 12" heavy-duty speakers; line bypass reversing switch for hum reduction; 13 transistor, 6 diode circuit; 28" W x 9" D x 19" H. Leather-textured black vinyl cabinet of ¾" stock; 120 v. or 240 v. AC operation; extruded aluminum front panel. 52 lbs.

Harmony-By-Heathkit® Electric Guitar

Kit TG-46

$219^95

$331.50 Value!

Double cutaway style; hollow body; 3 pickups with 18 adjustable pole pieces; professional Bigsby vibrato tailpiece; 6 volume & tone controls; ultra-slim fingerboard — 24¼" scale; 2" thick curly maple body, shaded cherry red. Includes carrying case, neck strap, visual tuning aid, cord, pick, instruction book and record. 2 other models available at $99.95 and $119.95. 17 lbs.

New! SB-101 80-10 Meter SSB Transceiver — Now With Improved CW Transceive Capability

Kit SB-101

$360^00

(less speaker)

Now features capability for front panel switch selection of either the standard 2.1 kHz SSB filter or the optional SBA-301-2 400 Hz CW filter . . . plus simplified assembly at no increase in price over the already famous Heathkit SB-100. Also boasts 180-watt P.E.P. input, 170 watts input CW, PTT & VOX, CW sidetone, Heath LMO for truly linear tuning and 1 kHz dial calibrations. 23 lbs. SBA-301-2, 400 Hz CW filter . . . $20.95. Kit HP-13, mobile power supply . . . $59.95. Kit HP-23, fixed station supply . . . $39.95.

NEW Transistor Portable Phonograph Kit

Kit GD-16

$39^95

Worth At Least 50% More! And it sounds better. Assembles in just 1 to 2 hours . . . simply wire one small circuit board, mount the 4" x 6" speaker and plug in the preassembled changer . . . ideal beginner's kit. Features automatic mono play of all 4 speeds; dual Sapphire styli for LP's or 78's; 45 rpm adapter; olive and beige polyethylene over sturdy, preassembled cabinet. Operates on 117 v. AC. 23 lbs.

NEW Heathkit®/Magnecord® 1020 4-Track Stereo Recorder Kit

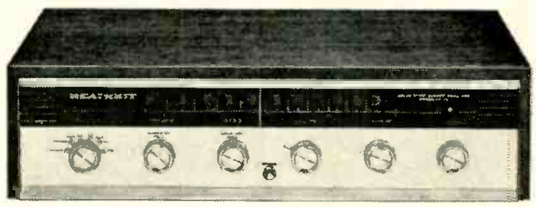
Kit AD-16

$399^50

(less cabinet)

Save $170 By Doing The Easy Assembly Yourself.
Takes around 25 hours. Features solid-state circuitry; 4-track stereo or mono playback and record at 7½ & 3¾ ips; sound-on-sound, sound-with-sound and echo capabilities; 3 separate motors; solenoid operation; die-cast top-plate, flywheel and capstan shaft housing; all push-button controls; automatic shut-off at end of reel; plus a host of other professional features. 45 lbs. Optional walnut base $19.95, adapter ring for custom or cabinet installation $4.75

30-Watt Solid-State FM/FM Stereo Receiver



World's Best Buy In Stereo Receivers. Features 31 transistors, 10 diodes for cool, natural transistor sound; 20 watts RMS, 30 watts IHF music power @ ± 1 db, 15 to 50,000 Hz; wideband FM/FM stereo tuner; plus two preamplifiers; front panel stereo headphone jack; compact 3⅞" H x 15¼" W x 12" D size. Custom mount it in a wall, or either Heath cabinets (walnut $9.95, beige metal $3.95). 16 lbs.

Kit AR-14

$99^95

(less cabinet)

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FROM THE TECHNICIAN'S NOTEBOOK:

Don't Neglect Color-TV Linearity

A fine point in receiver servicing that's often overlooked, adjusting the raster to correct proportions will establish you as a "pro"

By MATTHEW MANDL*

WHEN YOU GET INVOLVED IN CONvergence, purity and degaussing, don't forget to give the vertical and horizontal linearity a going-over. Too often the color adjustments take so much time we're apt to neglect this final step. True, the linearity touchup won't improve the color reception, but it will add that final professional touch and the customer will enjoy the picture more, even though he may not always know why.

In making home calls for black-and-white servicing, a technician doesn't always carry a crosshatch generator. But the experienced man can do a fairly good job with a few simple tricks.

For the horizontal, adjust the width very slightly beyond the sides, so transmission variations will not show lack of width on some stations. Horizontal drive (if the set has a control for it) is then adjusted to give an average scene good linearity.

For the vertical, more accurate results are possible. Deliberately misadjust the vertical hold control to get a slow vertical roll. Watch the dark blanking bar as it rolls. Adjust the vertical linearity and height until the bar stays the same thickness throughout the roll.

The same procedures work for color receivers. With color test equipment on hand, however, we have a ready way to check linearity accurately by using the vertical and horizontal pattern-generating features of the equipment. We can do a much better job than we could otherwise.

Technicians use color bar generators to check a color set by injecting the signal into one of the video stages. This produces a rainbow color bar pattern on the screen and helps pinpoint poor color rendition, lack of color, and unbalance between colors. The color display contains colors ranging from yellow through orange, red, blue and green.

Even though vertical and horizontal crosshatch bars are available from these instruments, the horizontal linearity can be checked with the rainbow pattern. Fig. 1 is a black-and-white version of the rainbow pattern on a color receiver that has poor horizontal linearity. Note the wider spacing of the center bars. Here a simple width-control adjustment did the trick, since a misadjustment of this control alters horizontal linearity.

For checking vertical linearity, set the generator to produce horizontal lines as shown in Fig. 2. Note the wider spacing at the top of the screen. Here both the vertical linearity control and the height control have to be adjusted several times to correct the linearity and mask the picture properly in a vertical direction.

While there is interaction between height and linearity controls, requiring juggling with both for final results, there is no interaction between vertical and horizontal linearity. We don't have to go back and recheck horizontal linearity after doing the vertical. And, of course, once you've set vertical and horizontal linearity, they hold for color or black-and-white. Because the job is so simple, there's no reason to neglect it during color servicing—particularly since your color test equipment helps speed the work. END

* *Industrial electronic consultant and faculty member of Technical Institute, Temple University.*

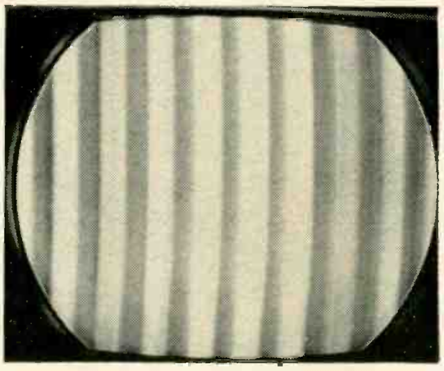


Fig. 1—Black-and-white reproduction of color-bar pattern. Nonuniform width of bars indicates poor horizontal linearity. Adjust horizontal drive for even spacing.

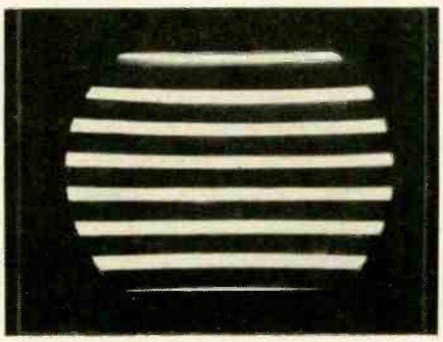
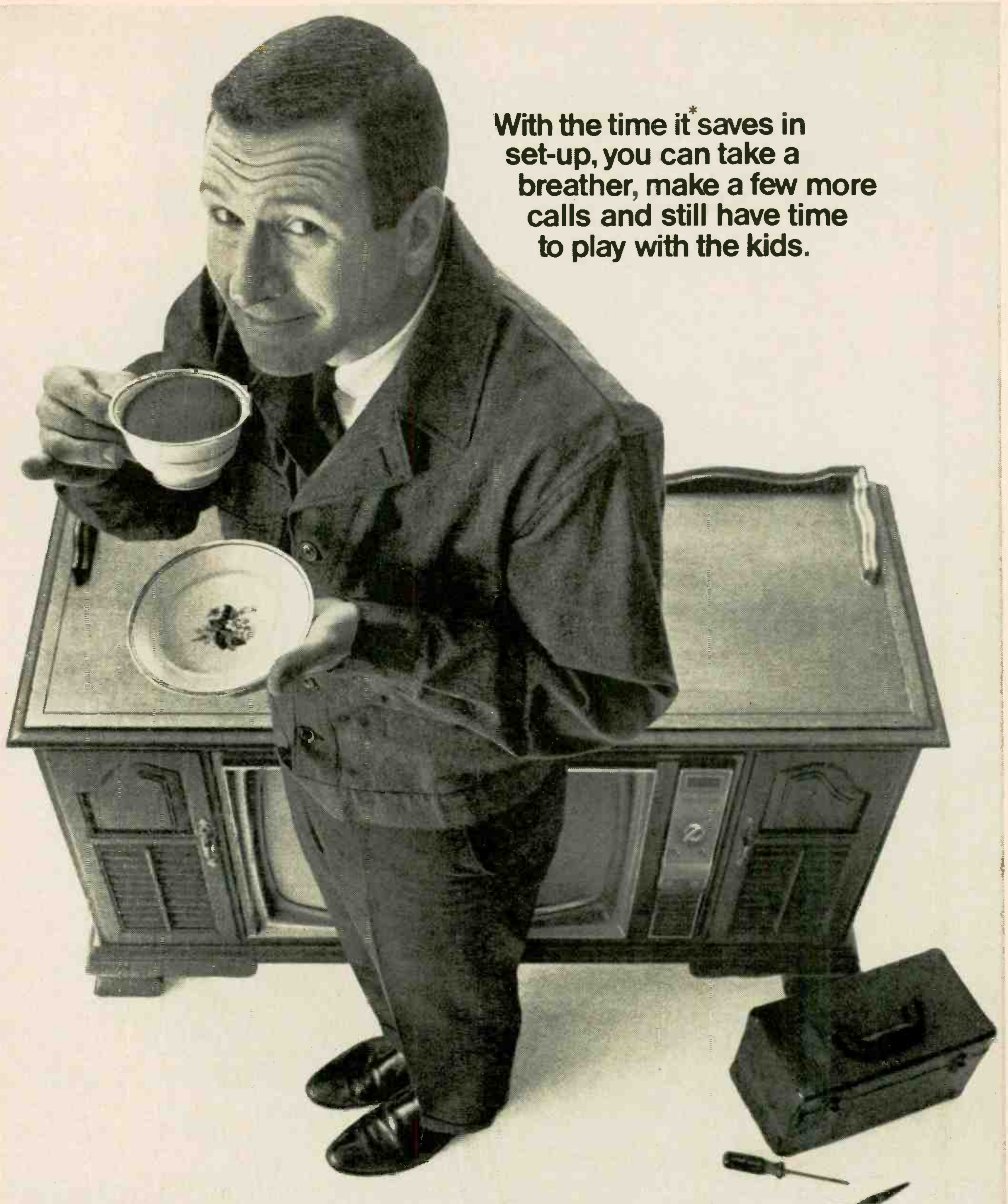


Fig. 2—Horizontal lines, unevenly spaced, point up a case of bad vertical linearity.



***RCA's new Hi-Lite Color Tube with Perma-Chrome**

If you've been waiting half an hour for the picture tube to warm up every time you repair or install a set, here's good news. RCA's new rectangular Hi-Lite Color Tubes with Perma-Chrome lock colors in place instantly, eliminate distorted color as the set warms up. Colors are true and unchanging from turn-on to turn-off. Saves hours of set-up time. New Hi-Lite Color Tubes with Perma-Chrome now in RCA Victor consoles. **New service switch in all 1967 color chassis.** Three-position for Normal, Service and Raster. When Raster is selected, all video and noise is removed from the color picture tube, leaving a noise-free Raster. Purity is adjustable without removing an IF tube or using other means to remove noise and/or interference from the screen.

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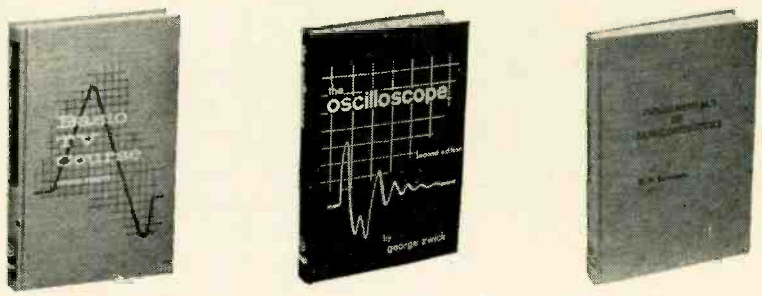

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By George Kravitz. Perfect introduction to TV. in clear. non-mathematical language. Starting with the forming of the picture, the book shows how the picture tube works. the television signal, the television receiver, antennas and tuners. how the video IF works. the video detector and AGC. the video amplifier at work, how the sync section works, horizontal output and high voltage supply, how the sound section works, how transistor portable TV's work. 224 pages, completely illustrated. Retail Price $5.75.

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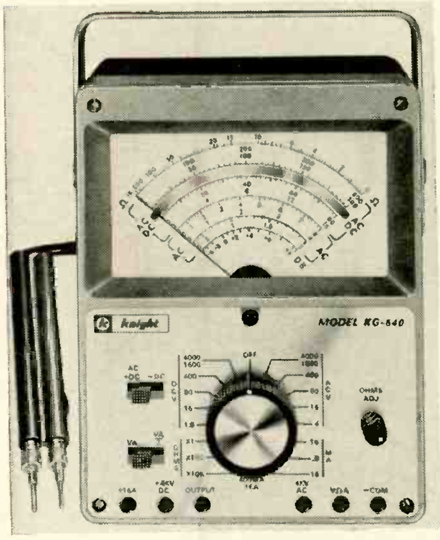
KNIGHT-KIT VOM, *model KG-640,* has 57 ranges, from 0.8 Vdc. Ac volts (12 ranges): 2, 4, 8, 16, 40, 80, 200, 400, 800, 1,600, 2,000, 4,000 full scale. Dc volts (12 ranges): 0.8, 1.6, 8, 16, 40, 80, 200,



400, 800, 1,600, 2,000, 4,000. Output volts (8 ranges): 2, 4, 8, 16, 40, 80, 200, 400 full scale. Resistance (3 ranges): 0–1,000, 100,000 ohms, 10 megs. Center scales at 12, 1,200 and 120K. Current (10 ranges): 80, 160, 400, 800 μA; 8, 16, 200, 400 mA; 8–16 amps dc. Dc sensitivity: 20,000 or 10,000 ohms per volt (function of scale multiplier switch). Frequency response: 20 Hz to beyond 200 kHz. Accuracy: within 3% of full-scale reading on dc to 1,600 volts; within 5% on ac to 1,600 volts. Batteries: 1 standard C-cell, 4 standard penlight cells.—Allied Radio Corp.

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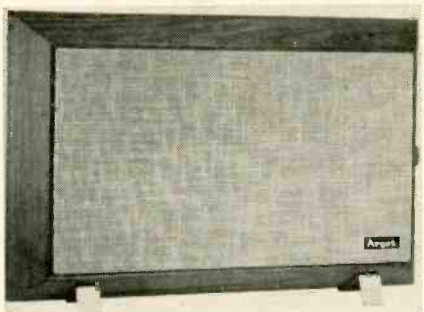

HI-FI SPEAKER SYSTEMS, the *Astra* and the *Solitaire. Astra* built on same design principle as sound column. Four speakers, 2 high-compliance Jensen woofers, 2 direct-radiator tweeters. Response 50–17,000 Hz. Oil-finished walnut cabinet 33¼ x 10½ x 4 in. *Solitaire* (see photo) designed to hang on wall or stand on own removable feet, for home or office use. High-compliance Jensen woofer balanced and matched to separate direct-radiator tweeter. Built-in volume control. Oil-finished walnut cabinet 18 x 12 x 3¼ in.—Argos Products Co.

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BASS-GUITAR SPEAKER SYSTEMS, the *PMC-1* and *PMC-2.* Portable. Designed to obtain maximum performance from bass-guitar amplifiers. Design reduces cone travel for given amount of power; high efficiency allows lower volume control setting to deliver given amount of acoustical power without work-

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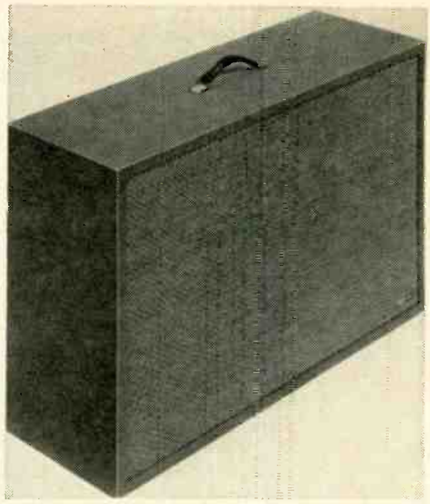

ing speaker at maximum capability. 12-in. speakers. 2-in. diameter voice coils, 2-lb magnets. *PMC-1* has 12-in. woofer, handles 60 watts. *PMC-2* has two 12-in. woofers, handles 120 watts.—Utah Electronics

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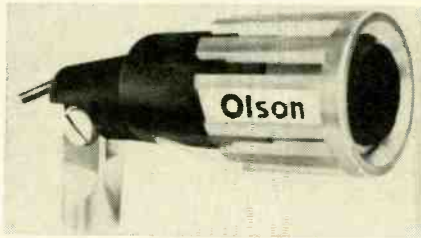
CARDIOID DYNAMIC MICROPHONE, *model M216*. Reduces feedback in PA, recording applications. Hermetically sealed cartridge. Cast-metal case.



Fits any stand with ⅝-27 thread. Impedance: 50K ohms. Response: 100–12,000 Hz. 1⅞ x 4½ in. 20-ft shielded cable.—**Olson Electronics, Inc.**

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PORTABLE 12V RECHARGEABLE POWER SOURCE, the *CRL-1200 Power Pack*. Built-in charger. For wide range of applications. Continuous operation to

40 hr or more, depending on current or wattage requirement of equipment used. Charging time 7 hr for 90% charge; 12 hr for complete charge. Operates from $-30°F$ to $+122°F$. Not damaged by temperatures as low as $-60°$ or as high as $+158°F$. Charge loss during storage 3% per month. Recharges to full capacity after 2½-yr shelf life. Two type RP-680 6-volt 8-amp/hr lead–silica-gel batteries; CRL-1000 solid-state automatic charger. Black leather carrying case. 8½ x 2¼ x 9 in., 9½ lb.—**Centralab, Electronics Div. of Globe-Union, Inc.**

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PORTABLE SOLID-STATE SPEECH SCRAMBLER, the *E75*. Provides privacy over telephone land lines and radiotelephone circuits. Code card scrambles voice into any of 2,000 possible electrical speech patterns unintelligible to anyone other than person with matching code card and identical equipment. No special technical knowledge required for operation. Switch controls. Power source 117 Vac, 12 Vdc. Packaged in standard attache case—**Lynch Communication Systems Inc.**

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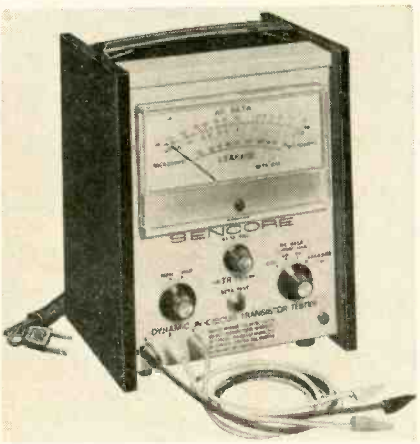

IN/OUT-OF-CIRCUIT TRANSISTOR TESTER, the *TR-139*, checks transistors or diodes without disconnecting lead. Two readings: ac beta and leakage current (I_{cbo}). In- and out-of-circuit pro-

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cedures identical. Parameters of unknown transistors determined without setup book or manual.—**Sencore, Inc.**

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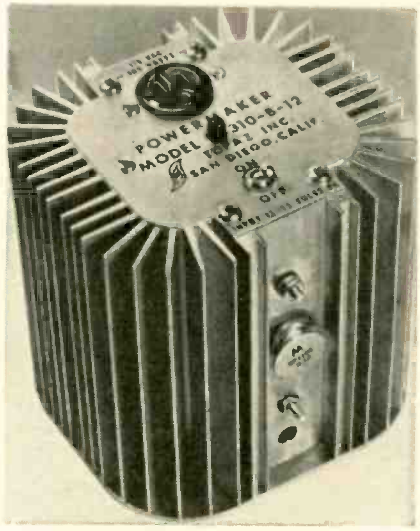
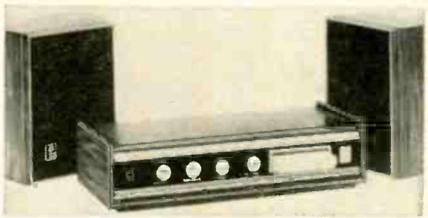


POWER CONVERTER, the *Powermaker.* Converts 12- or 24-volt battery power to 60 Hz ac; 300 watts continuous power. Accepts standard 2- or 3-prong plugs. Transistorized. Models available operating from 24-volt batteries to supply 400-Hz; also remote-control unit and automatic battery selector for 2-battery vehicles. 5½ x 6⅛ x 6$^{13}/_{16}$ in., 11½ lb.—**Topaz Inc.**

Circle 53 on reader's service card

MICROCIRCUIT TAPE PLAYER, *model M8610.* Utilizes microcircuit in audio amplifier section. Plays 8-track stereo cartridges currently used in many automobile systems. Cartridge automatically switches at end of each program; repeats automatically until turned off.



Pushbutton control. Shifts from one to another of 4 selections on 8-track cartridge. 9 x 6-in. stereo speakers. The model U8-600, not shown, plays through any stereo radio phonograph with standard input jacks. Tone, volume, balance are controlled through companion radio or amplifier. Cartridge component 4 x 8 x 18 in.—**General Electric, Consumer Electronics Div.**

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AM-FM MULTIPLEX STEREO RECEIVER, the *ER-420.* Tuned rf amplifier stage, 4 tuned i.f. amplifiers. Double cascade limiter for top and bottom clip-

ping of noise pulses. Two-channel push-pull output; harmonic distortion at full rated output less than 1%. Frequency response essentially flat over audio range of 20–20,000 Hz. Low- and high-cut filters. Simultaneous tape recording jacks, tape monitor switch. Operates from 117- or 220-volt line. Front-panel earphone jack.—**Pioneer Electronics U.S.A. Corp.**

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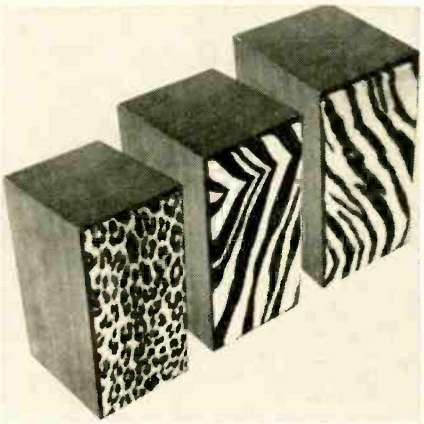

SPEAKER SYSTEM, the *Baby Grand.* 3-in. tweeter, 5-in. styrene suspension-cone woofer. Frequency response: 40–20,000 Hz; input: 35 W; impedance: 8 ohms. Oiled walnut cabinet; leopard, tiger, zebra skin or standard grillcloth. 11½ x 6¼ x 7¼ in.—**Martel Electronics**

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NICKEL-CADMIUM DISC CELLS, *models S131, S132, S133.* Built-in safety vent protects cell and equipment from charging malfunctions. Sintered negative and positive plates; porous structure increases volume of active material in direct contact with electrolyte. *S131*: 225-mA/hr cell; 0.985 x 0.350 in., 0.45 oz. *S132*: 150-mA/hr cell; 0.985 x 0.250 in., 0.35 oz. *S133*: 500-mA/hr cell, 1.350 x 0.360 in.,

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0.95 oz. can be stacked in shrink-on plastic jackets to form batteries as shown.—**Sonotone Corp.**

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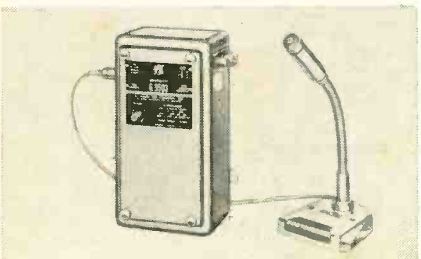

PAGING SYSTEM, uses 8 D-batteries, 12-volt storage battery, or 110–220-Vac with adapter. Solid-state 15-watt amplifier, dynamic cardioid microphone, gooseneck support, press-to-talk base. Additional amplifiers, with own speakers, may be connected in series. System can be powered by one microphone.—**Audio Div., American Geloso Electronics, Inc.**

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2-BAND WEATHER RECEIVER, the *Weatheradio*, tunes special weather frequencies as well as standard broadcast band. Weather band covers the FAA net-

work of reporting stations. Weather information transmitted continuously and can be tuned any time of day or night. 8-transistor receiver is also broadcast radio. 6 x 2½ x 3½ in., 14 oz.—**Nova-Tech., Inc.**

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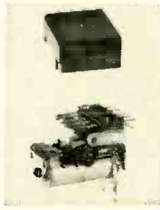

REPLACEMENT TV RELAYS for specific television chassis. Nylon cams; glass-filled nylon bobbin and cover; acetyl copolymer material in integral molded platform/bearing and armature hinge to reduce friction. Stainless-steel antiresidual. Open, snap-on dust cover, or hermetically sealed construction. —**Cornell-Dubilier Electronics Div.**

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OSCILLOSCOPE, PLUG-INS BROCHURE, 20 pages, looseleaf-punched. Describes *model 777* dual-beam high-frequency oscilloscope, 20 plug-ins, accessories. Specifications. Illustrates cross sampling of display capabilities of combinations of plug-ins.—**Fairchild Instrumentation, Div. of Fairchild Camera & Instrument Corp.**

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UNDERWATER COMMUNICATIONS EQUIPMENT BOOKLET, 4 pages. Describes equipment for submersibles, underwater stations and ranges, surface vessels, divers. Specifications, some illustrations.—**Underseas Div., Westinghouse Defense & Space Center**

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COLOR TV TEST EQUIPMENT, the *Commander* line. Spec sheets, looseleaf-punched. Includes photographs, accesories and applications.—**Amphenol Corp.**

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1967 STEREO COMPACT GUIDE, 16-page brochure. Explains stereo hi-fi and how it works. Complete color photos, descriptions, specifications. Full line of components.—**H. H. Scott, Inc.**

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1967 PLAYBACK STEREO COMPONENTS AND SYSTEMS CATALOG, *No. AL-1353,* 10 pages. Illustrations, specifications on full range of products. Includes high-style equipment cabinets. —**Altec Lansing**

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GENERAL CATALOG, *No. 18, Barry's Greensheet,* 71 pages. Variety of electronic equipment, components, accessories. Includes miscellaneous items. Tube price list.—**Barry Electronics Mail Order Corp.**

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PRESS-TO-TEST INDICATOR LIGHTS, *Catalog L-201.* 4 pages, looseleaf-punched. Subminiature, miniature. Meet or exceed requirements of MIL-L-7961B, MIL-L-3661. Lamp-selection charts for lamps employed by indicators (T-1¾, T-3¼ incandescent lamps). Complete data, descriptions, drawings, new number designations.—**Dialight Corp.**

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By 10 Servicing Experts. Top technicians like David R. Anderson, Ed Bukstein, Jack Darr, Homer L. Davidson, Art Margolis, Robert Middleton and Warren Roy have created here an important tool for the profit-minded service technician. Tells you clearly and concisely just what can go wrong in color TV receivers and how to fix them. First each trouble symptom is described in detail, then a perfect solution is provided for the problem. Book covers color circuits. ABC's of color TV servicing, antennas and boosters, replacing the color picture tube, how to pinpoint the defective color section fast, servicing the chroma circuits, unexpected causes of TV color failure, troubleshooting with a color bar generator, color servicing tips, plus a glossary of color TV terms. 106 pages.

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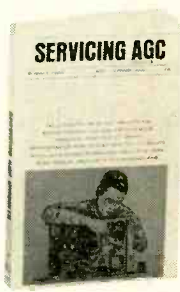

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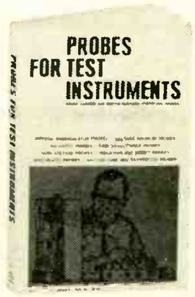

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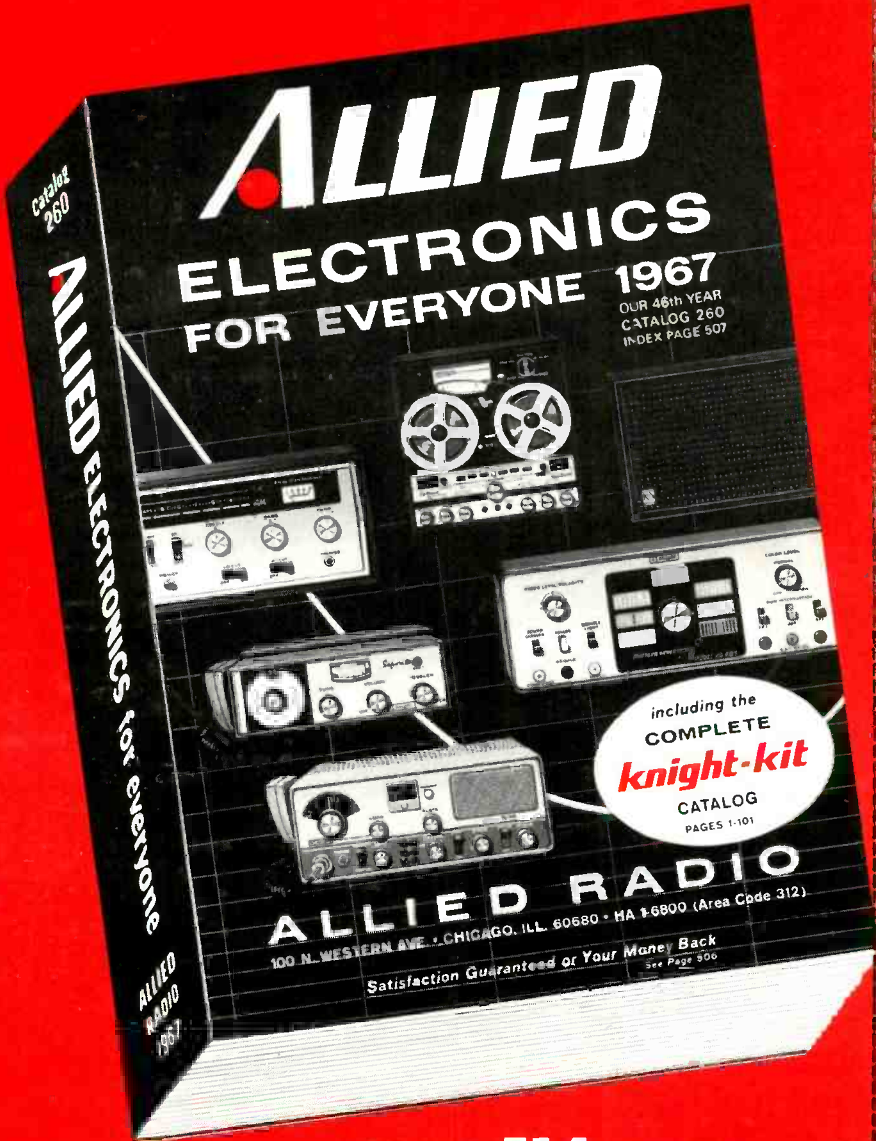

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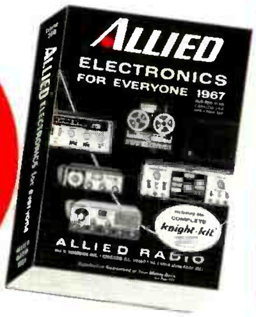

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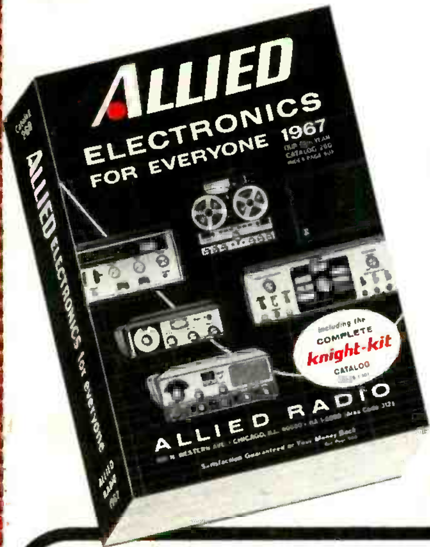

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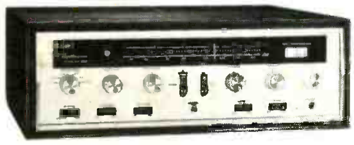

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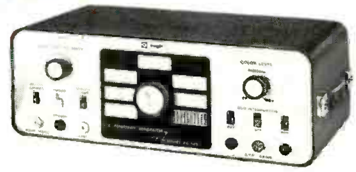

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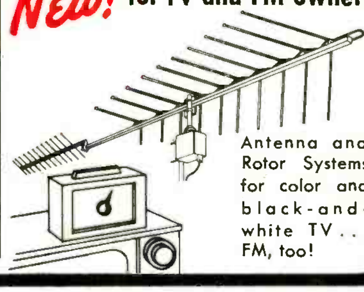

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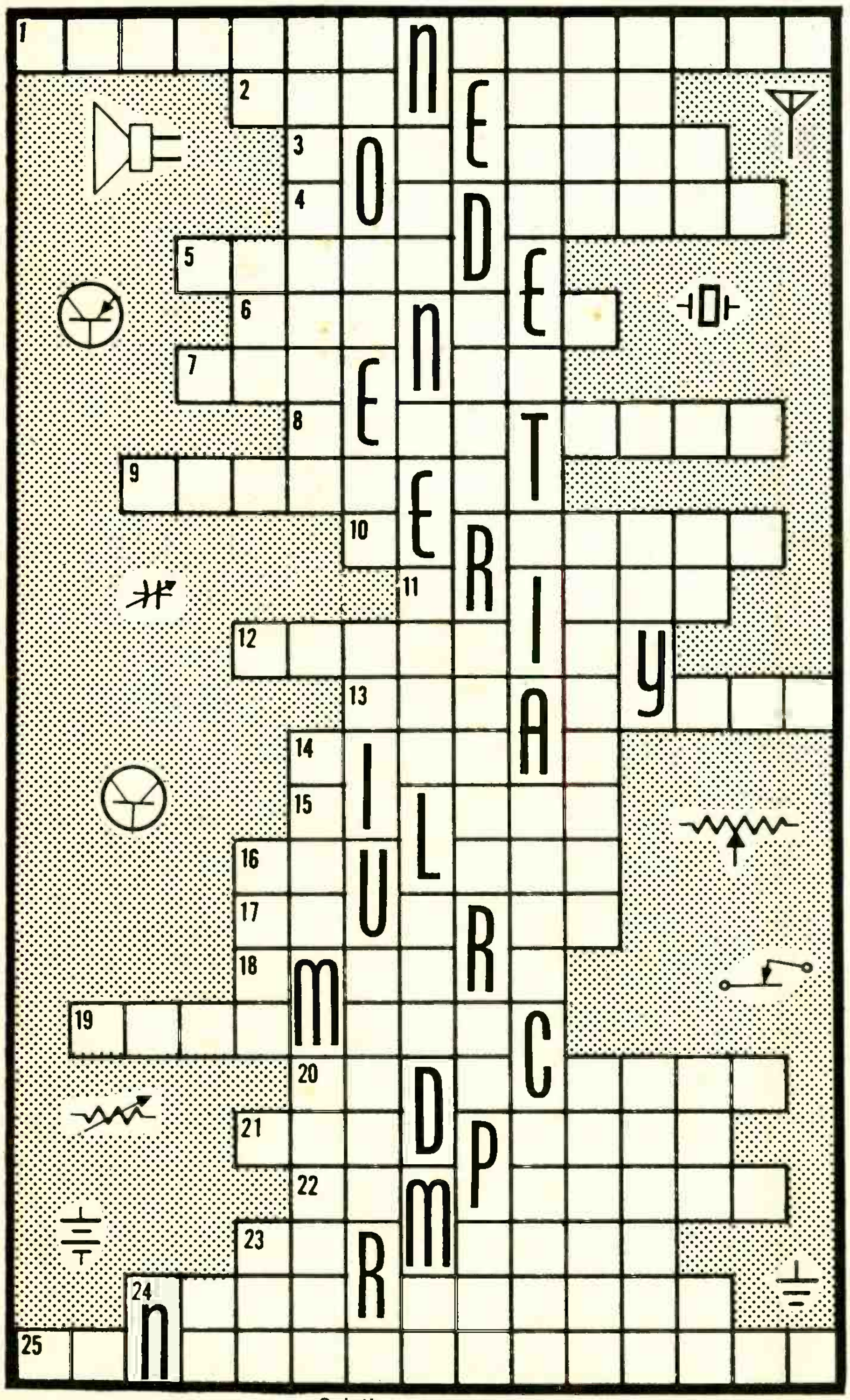
R-E PUZZLER

Try this electronics word puzzle based on electronics terms. Perfect score is 100; give yourself 4 points for each correct word you fill in.

1 Precise matching of two waves or functions.
2 Has the force that attracts ferrous metals.
3 Tubular coil for producing a magnetic field.
4 Substance capable of transmitting electricity.
5 Tube containing anode, cathode, control electrode and two grids.
6 Aids more accurate measurement or adjustment.
7 Radiates electromagnetic and electrostatic fields.
8 Opposition to the flow of alternating current.
9 Element to stir up electron emission in tubes.
10 Fitting for making electrical connections.
11 Outermost area of TV reception.
12 Ability to receive, contain, or absorb.
13 Two million changes every second.
14 Conveyor of communication information.
15 Permits certain range of frequencies, suppressing others.
16 Unit of quantity of electric charge in MKSA system.
17 One of three elementary particles.
18 Unit of movement of electrons.
19 Way of showing circuit, parts, assemblies.
20 Helical or spiral devices that retard or prevent changes in current flow.
21 Actuates auditory nerves.
22 Constituent part or assembly.
23 Sinusoidal wave with frequency that is multiple of another.
24 Balances out internal feedback voltage of high-gain amplifier stage.
25 Radiation pattern of a vertical antenna.



Solution next month

The Trouble That Couldn't Happen

By MILTON LOWENS

Part I—The Problem

MR. GOLDSMITH'S VOICE OVER THE TELEPHONE SOUNDED frantic. "Election day and my TV is crazy. Can you help me out? I'll pay double time—anything—to watch the returns tonight."

"Well, I'm pretty busy. Do you have any sound?"

"Oh, the sound is fine. So is the picture. Except for one minor detail."

"What's that?" I asked, beginning to feel a bit annoyed. Could this be just a perfectionist crank with no real emergency?

"Well, I have a good picture, but it's upside down."

I wasn't sure I understood.

"Upside-down? What do you mean?"

"Just what I said. Upside-down. The picture would be fine if I stood on my head. It might be more comfortable if I turned the TV upside down, though."

I could hear the smile on the customer's face. I tried another tack.

"What did you do to the set?" I asked sternly, figuring that somehow the yoke must have been turned 180 degrees. Maybe this was a do-it-yourself amateur job gone wrong.

"Nothing!" the voice sounded sincere. "I haven't touched the set. It's 3 years old and this is the first time we ever had trouble with it. The back has never been off; no tubes have been changed. You know we've been your customers for years. We never call anyone else. How about helping us out now?"

"I'll be over in an hour." My curiosity was stirred, as well as my desire to help. "By the way, what kind of set is it?"

"A big Magnavox. It had a beautiful picture. We were watching a Western, I think, when the picture collapsed into a horizontal line for a moment and then opened up again—but upside down. We thought there might be something wrong at the TV station so we switched around. But all the channels were upside down. That means the trouble must be in the set, doesn't it?"

"Certainly seems that way. You wouldn't know the model number, off hand?" I wanted to check the schematic before I went over.

"No, I'm sorry," was the reply. "It's a big stereo-hi-fi combination. Too heavy for me to move to see the back."

"Okay, it's not too important. By the way—did you notice any burning smell or any change at all in the sound when the trouble came?

"No, nothing like that at all. Matter of fact, the set is playing right now, upside-down picture and all. My youngster likes it that way. Says it's different, for a change. Is it okay to leave it on?"

"Sure." I figured whatever the trouble, it had stabilized and I wanted to see it as it was. I had seen too many peculiar troubles that disappeared between the phone call and my service call. "I'll see you in an hour or two."

I wasn't really busy at all, but Mr. Goldsmith might as well figure I was doing him a favor. I had taken the day off and had lots of time. I had voted already. I wanted the time to think this one over. In my TV service training we always stressed the importance of careful diagnosis, of thinking through a problem before tackling it.

So, I started to figure. An upside-down picture could result from reversed leads to the vertical deflection coils. That would change the phase of the vertical sweep by 180°. But if nobody had touched the yoke or its leads, then I must look for other causes of the 180° phase shift. What causes such shifts? Amplifiers! I could almost hear a student reciting. "Every time a signal passes through an amplifier its phase is shifted 180°." That must be it! One of the vertical amplifiers must have failed in such a way as to pass the signal without amplifying it. Therefore no reversal of phase as required and the picture is upside down. So the elaborate problem must be a simple tube change. It wouldn't take long. I glowed inside.

Mr. Goldsmith greeted me warmly, and led me to his big, well-furnished living room without delay. There it was, just as he had said: A teen-ager on the sofa, his heels against the wall where his head should have been; his head hanging over the edge of the cushion. He was watching the picture; it was upside down. "Sure is strange," I admitted. Might as well be frank. "I've never seen anything like it before."

I studied the picture intently. Mr. Goldsmith's technical description had not been quite accurate. The picture was not normal. There were clear retrace lines, and vertical deflection was about two-thirds of what it should have been to fill the screen. There was no evidence of any foldover, but the top of the picture (where the heads were) was compressed. The vertical linearity control corrected the distortion at the further expense of height. Still, insufficient vertical deflection seemed to confirm my theory of tube failure, so I couldn't wait to get the back off and change a tube or two.

While I was at it, I noticed that all the screws were tight; none were missing. No, this was a virgin set. My early suspicions about someone tampering were unjust. To be extra sure, though, I quickly checked the yoke leads, looked at the plug that connected the yoke to the chassis to make sure it had not been plugged in wrong, and the yoke clamp, too. Everything was as it must have been when it left the factory. Might as well change the tubes in the vertical circuit. The tube layout chart indicated only one possible suspect: a 6CM7 twin-triode used as vertical oscillator and output. Without shutting off the set, I plugged a new tube into the socket and watched the bright horizontal line intently as the tube warmed up. Mr. Goldsmith watched too. The line expanded, the picture rolled a bit and locked in solidly, as before. Upside-down!

There was nothing left but to lend Mr. Goldsmith the little portable I keep in my truck for such occasions, and pull the chassis.

Back in my workshop, I couldn't wait to get the set hooked up. After all, my theory about the defective amplifier stage still was tenable. Even if the tube was okay, there might be some kind of a grid-plate short in the socket or printed circuit which might feed the vertical oscillator output directly to the yoke: hence insufficient height and no phase reversal. I turned the set on. The sound came on first, loud and clear. I had hit a station break. Then as the picture jelled, I almost fell off my stool. No, the picture was still upside-down; but it was backward, too—a mirror image, just as if the leads to the horizontal deflection coils had also been reversed. *Both sweeps*, horizontal and vertical, were 180° out of phase. For a moment I thought I might have put the yoke onto the neck of my test picture tube backwards, but no such luck; it was a 90° yoke and the big flare at the front made mistakes impossible. My theory was falling apart fast. A few voltage checks demolished it. Every voltage was exactly as specified by the manufacturer!

The widely experienced TV service technicians who serve as electronics instructors at Gompers Vocational were skeptical when I told them about Mr. Goldsmith's upside-down-backward picture at lunch the following day. The consensus was that the customer was pulling my leg.

"I wouldn't believe him, Milt," George said. "This guy must have had trouble and called someone else. Now he's ashamed to admit it. Chances are that they had a fight about

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the price or something and the serviceman switched the leads on the yoke to get even because he didn't get the job."

"What about the retrace lines and insufficient height? Switching yoke leads wouldn't cause that," I replied.

"True," Manny chimed in, "but maybe that was the trouble to begin with. Why don't you troubleshoot that and stop worrying about the reversed sweeps? You know there isn't one chance in a million for both to go bad at the same time in the same way. And there's nothing in common between the horizontal and vertical sweep except the power supply and sync. I can't see how either would cause an upside-down and backward picture."

"But I could swear that the customer isn't the kind of man to kid me. I *know* him. And besides, I think I can recognize a factory soldered lug and one that has been altered. And the back, with all its screws. And the chassis mounting screws, factory-tight . . ."

"So, what's all this factory stuff?" Irv broke in. "Why don't you call Magnavox Technical Service and see what they say about your story? I'll bet they laugh at you!"

Irv was right. They did.

The technician was incredulous. "Never heard anything like it," he said. "Are you sure no one switched the yoke leads?"

It was beginning to have a familiar ring. "No, I checked that first."

"How about the plug from the yoke? It's an octal tube base. Is the key broken off? Maybe it's plugged in wrong."

"No," I sighed. "I checked that too."

"And you say the picture is normal except for retrace lines and height? How about foldover at top or bottom?"

"No foldover—only distortion. And of course the picture is upside down and backwards."

"Yes, you said that." He sounded annoyed. "Did you check the blanking circuit? It's tied in with the vertical output autotransformer."

"No," I replied. "All I know is that the tubes and voltages check okay."

"Well, I don't see how the blanking circuit could reverse everything, but I'd start there anyway. You have to start someplace."

"All right," I said sadly. "I'll start there, but what do I tell the customer if it turns out to be a blind alley?"

"I don't know. I just don't know. I never heard of such a trouble. Are you *sure* no one reversed the yoke leads . . ."

At the test bench that afernoon, I turned on my scope only to have the fuse blow. What a time for the scope to go bad. "Oh well, let's see, the blanking circuit . . ." I said to myself as I studied the schematic. "A 40-volt negative spike comes from the bottom of the vertical output autotransformer and is coupled to the grid of the picture tube via a .0033-μF capacitor. Of course, since the video signal is applied to the cathode, the spikes cut off the tube during retrace."

I turned on the set and studied the prominent retrace lines. They were thick and heavy, not at all like the faint lines you sometimes see when you turn down the contrast. I tried the contrast and brightness controls. They had little effect on the retrace image.

"Oh well," I figured, "I can't see the blanking spikes since my scope is out, so let's see what happens if I remove them by disconnecting the .0033-μF coupling capacitor."

Can you guess what happened?

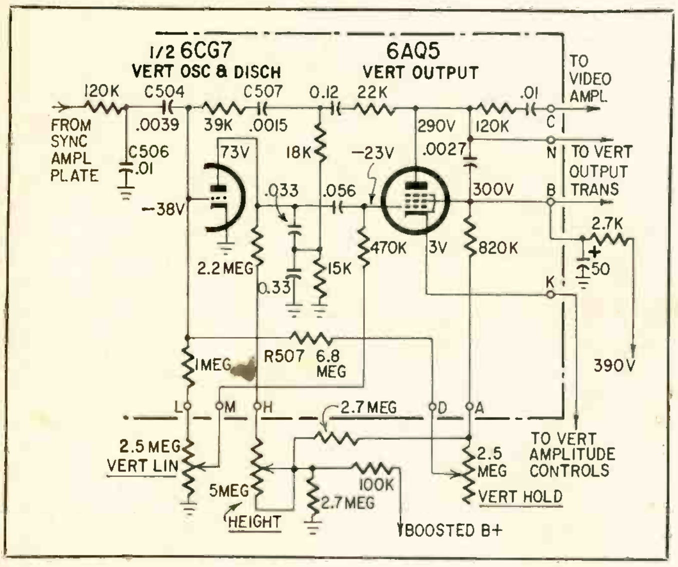
Did you say the picture reversed itself twice to become normal? Sorry, no such happy ending in this real-life problem. But the heavy retrace lines *did* disappear. And that led me straight to the trouble. Can you figure out what it was?

SOLUTION NEXT MONTH

TECHNOTES

RCA CTC5—VERTICAL ROLL DURING WARMUP

From cold start picture rolls very fast but can be stopped temporarily with hold control. As set warms up, hold control must be readjusted to hold sync. This continues for about an hour or until temperature stabilizes. This symptom can be caused by slow-heating tubes in the vertical oscillator, vertical output and damper stages but I've also found two capacitors that can cause the same symptoms.



These are C504 and C507 (see diagram). Slight leakage, around 50,000 megs, detectable only with a good capacitor analyzer, is responsible for the trouble. For best results, replace with temperature-stable capacitors such as the Sprague Isofarad 5BF type. While you are at it, check C506. Leakage here will cause soft vertical roll.

If the picture still rolls when the hold control is at the end of its range, check R507 for correct value.—*V. Karitons*

ADMIRAL 25-INCH COLOR—WIDTH COIL

Recent 25-inch color chassis have a coil, part 73B31-14, to limit the width. This coil is located below the chassis and is connected between terminals 1 and 3 of the flyback transformer. These sets will operate without the width coil if a replacement is not immediately available. There will be some overscan.—*Admiral Service News Letter*

GENERAL ELECTRIC CB CHASSIS

Complaints of no color, intermittent or incorrect color have been traced to a defective neon lamp in the grid circuit of the burst gate. The lamp will not light or will flicker and will usually appear black on the internal electrodes. The original NE-2 should be replaced by the rugged NE-83/5AH. If unavailable, use an NE-2H.—*General Electric Service Talk*

RCA CTC16—DIM PIX, SMALL RASTER

The picture was barely visible and the raster was only 6–8 inches high. Screen, height and linearity controls inoperative; high voltage normal. The trouble was traced to an open 100K ½-watt resistor from the boost rectifier to the screen controls. It supplies the boosted-boost line to the vertical sweep circuit. Replace with 1-watt unit.—*Jim Wilhelm* END

COMING NEXT MONTH . . . in February

Radio-Electronics

Whether you're service technician, experimenter, engineer, hi-fi enthusiast, or electronics layman, the February issue is your meat. Just look:

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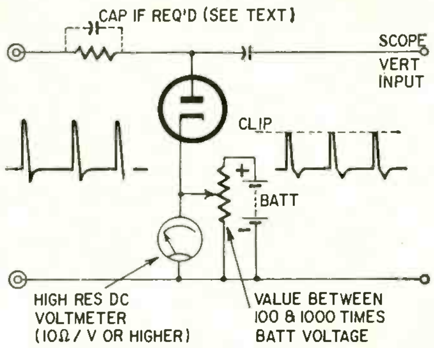
For years, I've tinned the tips of new soldering irons with silver solder. This greatly increases the life of the tip since silver solder does not erode as rapidly as copper. Silver solder is now readily available at plumbing supply houses and most hardware stores. It is easily applied using a small butane or propane torch.—*O. K. Hudson*

PEAK VOLTAGE WITH SCOPE AND DIODE

To measure the peak voltage of a complex waveform, feed the signal to the scope input through the highest series resistor you can use without affecting its shape, and shunt across it a reverse-biased diode having high back resistance and sufficient piv rating. Reduce the bias until you see the peak barely get clipped a little. The bias is then equal to the peak voltage. You can measure either the positive or the negative peak by



turning the diode, the bias source and the voltmeter around, and you can measure with respect to any point in the circuit by returning the low side of the bias to that point. An expensive scope with special features is not necessary and you don't even need to know where the centerline is.

I found I could reset to 0.1 volt using an ordinary receiving-tube diode.

At high frequencies you can shunt the resistor with a small capacitor if necessary to preserve wave shape.
—*A. H. Taylor* END

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WHAT'S YOUR EQ?

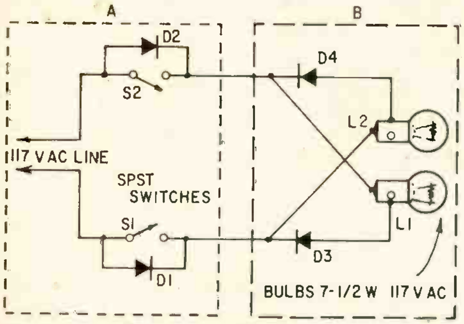
These are the answers.
Puzzles are on page 61.

Resistor Network

The total resistance is ⅔ ohm. Yes, all resistors are in parallel!

Light Switching Circuit

The reverse resistance of the diodes (any receiving-type silicons) blocks current flow to both lamps when both switches are open. When S1 is closed, current flows through D3, L1,



D2, lighting L1. But current cannot flow through L2 because D2 and D4 are back to back in series with L2, blocking current flow on both half-cycles of the ac. END

Circle 136 on reader's service card

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- The Radio Obliterator
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- New Audion and Radiophone Apparatus
- Long Distance Radio Without Aerials
- Radio Detector Development, by H. Winfield Secor
- Action of Detectors in Wireless Telegraphy, by Wilder D. Bancroft
- Marconi Company Sues the U.S. for $1,000,000 Damages, by A. Press, B. Sc.

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COLOR-TV TUBE POPULARITY GUIDE

This compilation lists how often various tube types are used in leading 1964-1966 color TV chassis sold under nearly fifty brand names.

The 6GH8 is front-runner with 381. Some chassis use only one of them; others use up to six. Other leaders are 3A3 high-voltage rectifiers, 6BK4 high-voltage regulators, 6DW4 dampers and 6GU7's and 6GY6's in color demodulator and amplifier circuits.

Tube types—not necessarily new—appearing in 1966 chassis are shown in heavy type. Watch for these and make sure you have an adequate supply in stock and in your tube caddy.

Tube type	No. of tubes	Tube type	No. of tubes	Tube type	No. of tubes	Tube type	No. of tubes
1AD2	2	3A3-A	250	**4EH7**	10	**5MB8**	3
1AU2	2	3AT2	38	**4EJ7**	10	**6AC10**	3
1DK27	1	**3AW3**	4	**4GX5**	1	**6AD10**	10
1K3	2	**3BZ6**	2	4HA5	1	6AF4-B	1
1V2	36	3CA3	2	**4LJ8**	1	**6AF9**	5
2AF4-B	1	3DT6	1	**5AQ5**	1	**6AH5**	1
2AV2	44	**3HQ5**	3	**5CG8**	1	6AL5	11
2BA2	4	**4AU6**	1	**5GM6**	2	**6AL11**	1
2DZ4	1	4BL8	4	**5GX7**	3	6AQ5-A	109
2GK5	2	**4BZ6**	2	**5JK6**	4	6AQ8	3
2HQ5	1	**4CB6**	10	**5KZ8**	1	6AU4-GTA	1

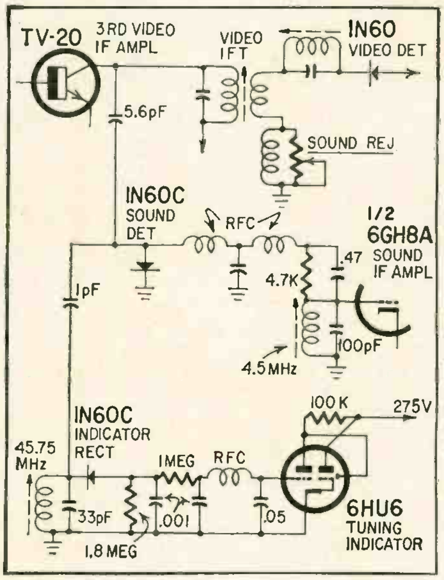
Tube type	No. of tubes	Tube type	No. of tubes
6AU6-A	55	**6CL8-A**	4
6AU8-A	3	6CS6	11
6AV6	1	6CW5	5
6AW8-A	83	6DK6	5
6AY3	2	6DQ5	1
6BA6	2	6DQ6	6
6BA11	18	6DS4	51
6BC6	1	6DT6-A	27
6BH11	4	6DW4-A, -B	268
6BJ8	2	6DX4	1
6BK4-A, -B	262	6DZ4	2
6BL8	46	**6EA4**	1
6BM8	7	6EA8	39
6BN6	5	**6EB8**	2
6BN8	14	6EH7	56
6BN11	9	**6EJ6**	1
6BQ5	10	6EJ7	151
6BS3	2	6EM7	1
6BX6	4	6EW6	187
6BZ6	30	6EW7	4
6C4	1	6EZ5	4
6CB6	3	**6FG7**	9
6CD3	7	**6FM7**	1
6CE3	7	6FQ7/6CG7	165
6CG3	11	**6GB5**	2
6CG8-A	15	6GC5	2
6CJ5	3	6GF7-A	109

Tube type	No. of tubes	Tube type	No. of tubes	Tube type	No. of tubes	Tube type	No. of tubes
6GH8-A	381	6JH8	35	6Y9	9	12BH7	2
6GJ7	27	6JM6	14	6Y10	4	12BV11	2
6GK5	10	6JS6-A	41	6Z10	3	12BY7-A	86
6GK6	12	6JT8	14	7GS7	1	12GC6	2
6GM6	130	6JU8-A	119	7GV7	1	12GE5	2
6GU7	200	6JW8	10	8AC9	1	12GN7	41
6GW8	2	6KA8	76	8AR11	2	12HG7	41
6GX6	2	6KD6	7	8AW8	2	12HL7	3
6GX7	21	6KE8	4	8BQ11	2	12MD8	2
6GY6	225	6KM6	2	8BU11	2	12R-LL5	2
6HA5	45	6KN6	4	8FQ7	19	12T10	2
6HB6	10	6KT8	56	8JV8	11	15CW5	2
6HB7	40	6KZ8	27	9AQ8	3	15DQ8	3
6HE5	19	6LE8	11	9KC6	10	15HB6	1
6HF5	6	6LF8	20	9R-HR2	2	15LE8	1
6HL8	2	6LJ8	10	10CW5	1	16A8	2
6HM5	6	6LM8	20	10JT8	4	19AU4-GTA	3
6HQ5	55	6LN8	2	10LB8	1	21LR8	14
6HQ7	4	6LT8	1	10LE8	10	30AE3	1
6HS5	9	6LU8	25	11BT11	2	31JS6-A	10
6HS8	21	6M11	1	11FY7	2	34CD3	13
6HZ6	103	6MD8	5	11LQ8	10	34CE3	13
6J10	12	6ME8	6	12AV6	10	42KN6	3
6JC6	55	6MG8	2	12AX3	2	50C5	10
6JD6	6	6R-P22	12	12AX7	16	5642	7
6JE6-A	74	6U10	10	12AZ7	8	PL-521	1
6JH6	87	6X9	9	12BF11	2		END

NOTEWORTHY CIRCUITS

COLOR TUNING INDICATOR

Some of the poor color pictures seen on home and showroom TV sets can be traced to improper tuning. Several manufacturers have become aware of the problem and have added color tuning aids. Philco is using an electron-ray type tuning-indicator tube in several of its top-of-the-line chassis. The diagram shows the basic circuit in the 17MT80B hybrid chassis.

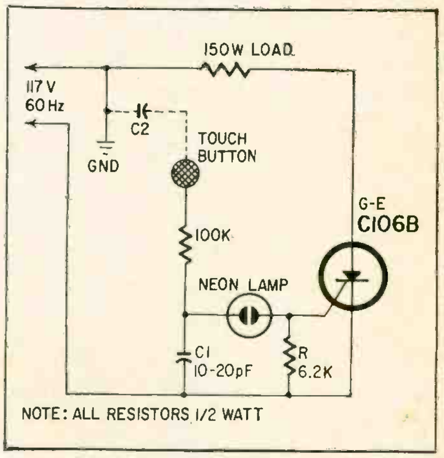


The tuning indicator responds to video carrier level and shows when the fine-tuning control is adjusted for maximum video carrier. Maximum video-carrier level produces the best black-and-white and color picture with proper sound level.

A separate 45.75-MHz detector is used for the indicator. The signal is tapped off the output of the last video i.f. amplifier at the sound takeoff point and coupled to a 45.75-MHz tank through a 1-pF capacitor. This signal is rectified and filtered to develop a negative dc voltage on the grid of the indicator tube. The amplitude of this dc voltage is maximum when the set is tuned for best color. The set is tuned correctly when "eye" closure is maximum.

UNUSUAL CAPACITANCE RELAY

Most capacitance relays or capacitance-operated switches are based on an oscillator whose frequency or loading is changed when a person or reasonably large metallic object approaches the



oscillator coil or an antenna or "touch button". Here is a circuit, courtesy of General Electric, that uses a capacitive voltage divider and an SCR.

Capacitor C1 and body capacitance (C2) of the operator form the voltage divider from the hot side of the ac line to ground. The voltage across C1 is determined by the ratio of C1 to C2. The higher voltage is developed across the *smaller* capacitor. When no one is close to the touch button, C2 is smaller than C1. When a hand is brought close to the button, C2 is many times larger than C1 and the major portion of the line voltage appears across C1. This voltage fires the neon lamp, C1 and C2 discharge through the SCR gate, causing it to trigger and pass current through the load. The sensitivity of the circuit depends on the area of the touch plate. When area is large enough, the circuit responds to proximity of an object rather than to touch. C1 may be made variable so sensitivity can be adjusted. END

NEW BOOKS

THE RADIO AMATEUR'S HANDBOOK. *American Radio Relay League, Newington, Conn. 6½ x 9½ in., 704 pp. Paper, $4, cloth $6.50*

The radio amateur's "bible," this popular book gets larger every year. With a 14-page index, you can find data on almost any imaginable phase of radio transmitting and receiving. Basic theory, advanced techniques, construction practices, legal aspects. Almost no ham is ever without it. Technicians like it, too.

UNITED STATES GOVERNMENT ORGANIZATION MANUAL '66-67. *General Services Administration, Washington, D. C. 20408. 6 x 9 in., 812 pp. Paper, $2.00*

Describes services rendered by various bureaus of the government as well as describing their entire organizational structure. Includes all branches and departments and tells who is in charge of each.

ELECTRIC MOTOR TEST AND REPAIR, by Jack Beater. *Tab Books, Drawer D, 18 Frederick Rd., Thurmont, Maryland 21788. 5½ x 8½ in., 160 pp. Paper, $6.95*

For the service shop that also services electrical appliances, here is a comprehensive text on motor testing and winding. Strictly electrical, covers both large and small motors. Dry reading, but very explicit in its instructions.

ANTENNA ANALYSIS, by Edward A. Wolff. *John Wiley & Sons, Inc., 605 3 Ave., New York, N. Y. 10016. 6 x 9 in., 520 pp. Cloth, $25.00.*

Mathematical from beginning to end, the book is devoted entirely to the physics of antennas and transmission lines. Thoroughly indexed, and includes just about every imaginable antenna configuration. Written for graduate engineers in physics.

ABC's OF CAPACITORS, by William F. Mullin. *Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 46206. 5½ x 8½ in., 96 pp. Paper, $2.25*

Second edition of a popular components manual. Written by a top authority in the field, the information is up-to-date and accurate. Explains construction, operation, applications and testing. Also an excellent chapter on choosing replacements. Written in fairly easy style.

101 WAYS TO USE YOUR COLOR TV TEST EQUIPMENT, by Robert G. Middleton. *Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 46206. 5½ x 8½ in., 160 pp. Paper, $2.95*

Second edition of Middleton's famous "101 Ways" series. This one covers various types of color generators, tells how to trace color signals using the generators and scope, and then breaks color TV into several sections and describes how to use the equipment in each of those sections. Includes over two dozen miscellaneous and unusual uses for the instruments. In step-by-step format, with lots of pattern and waveform photographs. END

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2A5	2.95
2A6	4.50
2D21	1.00
2HA5	1.65
2X2	.75
3A3	1.11
3A5	1.75
3B7	2.39
3BN4	1.20
3BZ6	.76
3CB6	.76
3DG4	.84
3DT6	.88
3Q5	2.20
3V4	.93
4BQ7A	1.58
4BU8	1.10
4BZ7	1.56
4CB6	.88
5AM8	1.35
5AN8	1.89
5AQ5	.83
5AS8	1.64
5AT8	1.62
5AZ4	2.29
5BQ7B	1.62
5BR8	1.79
5CG8	1.34
5J6	1.34
5U4	.70
5U8	1.10
5V4	1.50
5X8	1.49
5Y3GT	.60
5Y4	1.42
5Z3	1.68
5Z4	3.40
6A7	3.45
6A8	2.79
6AB4	1.00
6AB7	2.75
6AC5GT	2.54
6AC7	2.00
6AF3	1.30
6AG5	.94
6AG7	2.40
6AH4	1.38
6AK5	1.15
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6AX7	1.50
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6BA8	1.70
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6C8G	3.50
6CA7	2.36
6CG7	.84
6CG8A	1.10
6CL6	1.61
6CL8A	1.25
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6CW4	2.03
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6CZ5	1.77
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7B6	1.90
7B7	2.95
7B8	2.14
7C4	1.15
7C5	1.27
7C6	2.85
7C7	1.25
7E5	3.50
7E6	3.50
7E7	3.50
7F7	2.90
7F8	3.10
7G7	2.95
7H7	2.30
7J7	3.50
7K7	3.14
7L7	3.00
7N7	2.80
7Q7	3.50
7R7	3.50
7S7	3.50
7V7	1.83
7W7	2.56
7X6	2.98
7X7	3.00
7Y4	3.00
7Y7	3.50
7Z4	2.55
8AU8	1.60
8BQ5	1.20
8CG7	1.00
8FQ7	1.00
8GJ7	1.44
8GN8	1.45
8JV8	1.62
10DE7	1.11
12A8	3.25
12AH7	2.25
12AT6	.65
12AT7	.88
12AU6	.75
12AU7	.84
12AV6	.57
12AX4	.90
12AX7	.89
12BA6	.57
12BE6	.61
12BH7	.96
12BQ6	1.35
12BR7	1.34
12BY7	1.10
12K7GT	2.75
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12L6	1.52
12L8	.50
12Q7GT	1.32
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12SG7	2.03
12SH7	2.25
12SJ7GT	1.60
12SK7M	1.70
12SK7GT	1.55

Type	Price
12SL7	1.50
12SQ7GT	1.32
12SR7	1.79
12V6	1.60
12W6	1.60
13GF7	2.08
14A4	1.75
14A5	1.75
14A7	2.00
14AF7	2.25
14B6	2.00
14B8	2.00
14C5	2.00
14C7	2.30
14E6	2.00
14E7	2.00
14F7	3.00
14F8	2.75
14H7	2.25
14J7	2.50
14N7	2.50
14Q7	2.25
14W7	2.25
14X7	2.25
14Y4	2.35
19	1.50
22	1.15
24A	2.00
25C5	.88
25CD6	2.45
25DN6	2.50
25L6GT	.80
25Z5	1.86
25Z6	1.37
26	1.60
27	1.75
30	1.75
32	1.50
33	1.50
34	2.00
35A5	2.44
35L6	1.23
35W4	.37
35Y4	1.95
35Z3	2.03
35Z5	.65
36	2.25
37	[illegible]
38	2.50
39/44	1.80
41	2.00
42	2.05
43	3.10
45/2A3	3.50
46	2.95
47	3.95
48	4.00
49	2.95
50	2.00
50C5	.70
50L6GT	.90
50X6	2.50
50Y6	1.92
50Y7	1.88
53	3.50
55	3.25
56	1.55
57	1.75
58	1.85
59	4.00
70L7	1.50
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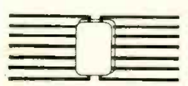

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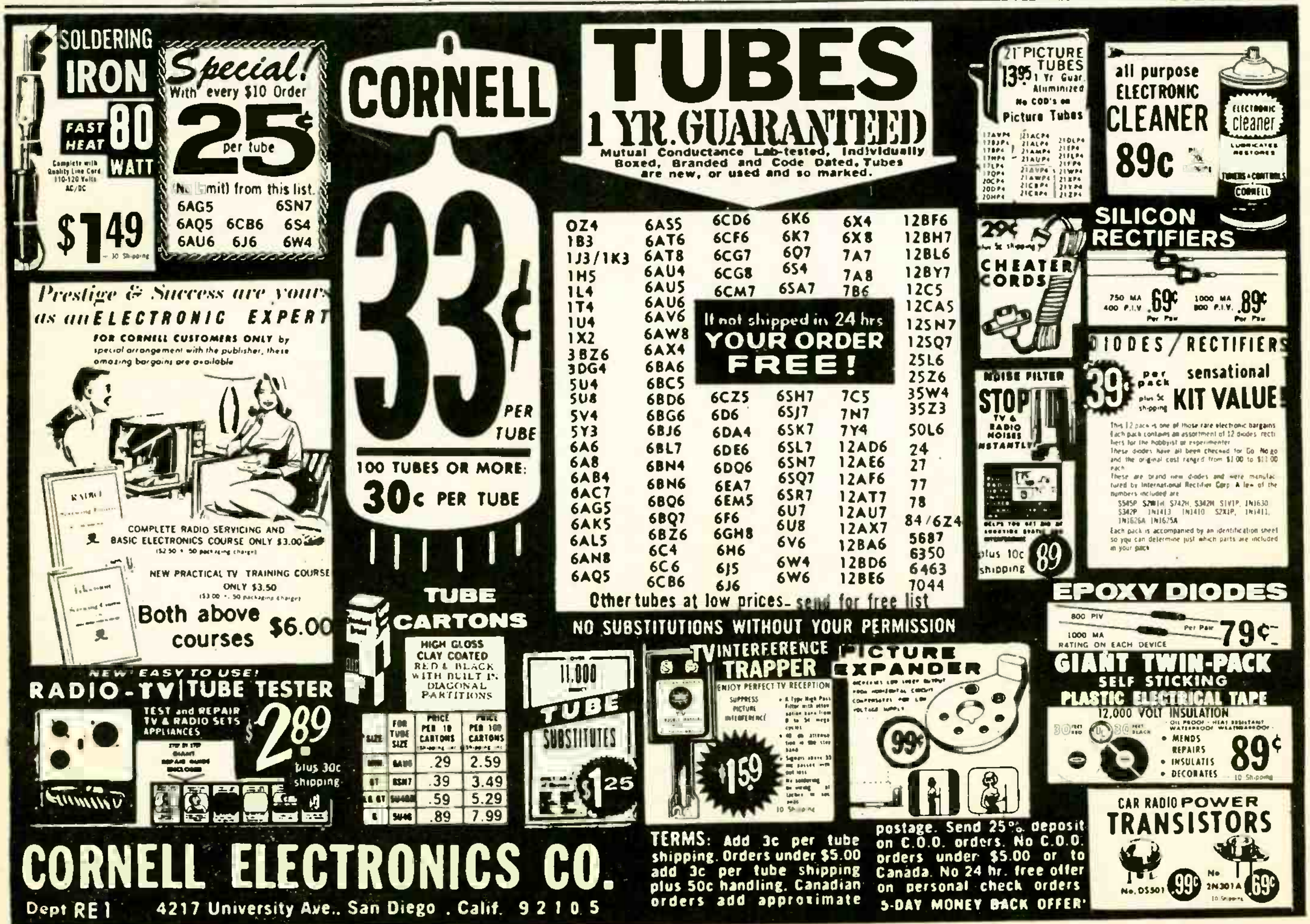

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200	☐ 1.05	☐ 1.70	☐ 2.10
300	☐ 1.60	☐ 2.20	☐ 2.70
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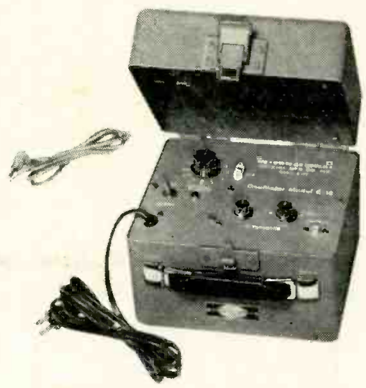

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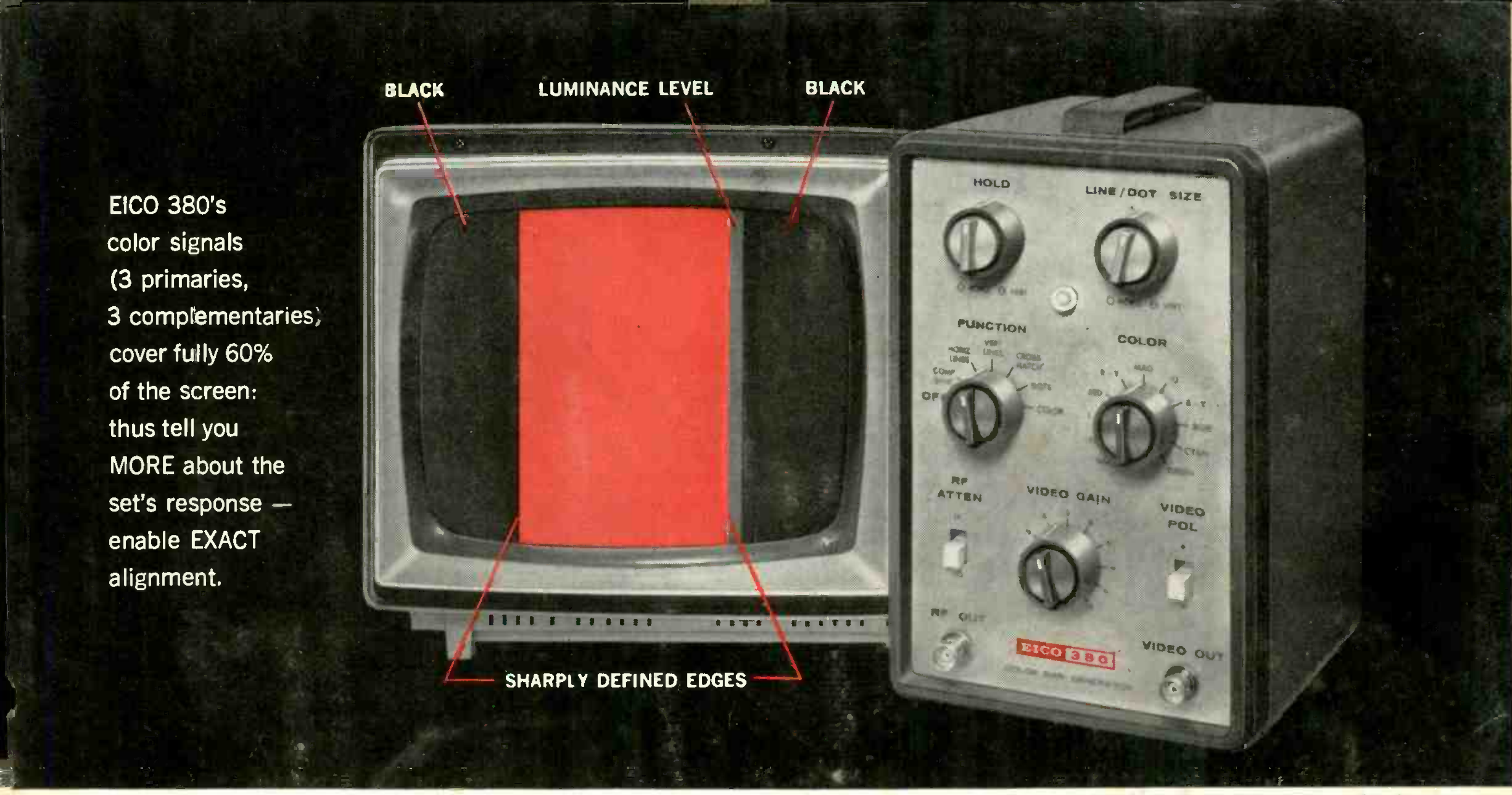

Now you can afford a True NTSC* Color Generator

(NEW EICO ALL SOLID STATE 380 IS ONLY $169.)

Every pro knows

that the best generator to use to do the *best, fastest, most accurate* color servicing is the NTSC type. EICO is first to bring it to you at a serviceman price.

The 380 takes the risky guesswork out of color servicing — because it gives you all test signals *exactly* like the Color TV station. So now you can be *certain* of *exact* results — faster, easier, for more profits per day. You'll also quickly become known as the pro who makes sets *"come alive"* with brilliant *correct* color response!

Only EICO provides you with all these advanced engineering features at so low a cost: ■ *100% true NTSC* full-field color signals,* including both chrominance and luminance exactly as specified for a Color TV station transmission. ■ *No "Gun Killers"* — Faster, easier use by feeding to the RF stage. You don't need to go inside the TV set to feed the color signal. ■ *Each true NTSC* color signal covers fully 60% of the entire TV screen* (as compared to 1-inch from a rainbow generator) — this tells you a full, true picture of what's going on inside the set — all the way from the RF to the screen. ■ *100% solid state* (33 transistors). ■ *5 individual switch-selected alignment patterns* for monochrome and color. ■ *Individual, switch-selected full-field color display.* ■ *Generates I, Q, R-Y, and B-Y signals* for demodulator adjustment, *plus 7 standard color signals* (3 primaries, 3 complementaries, plus black and white). ■ *Adjustable bar width and dot size* down to just visible for *exact* convergence. ■ *3 crystal-controlled oscillators* for true 3.58 MC color signal generation, pattern timing, and RF output. ■ *Drift-free RF output* (crystal-controlled Channel 3) and video output. ■ Conveniently compact: 8" high x 5" wide x 6" long. ■ Portable and light weight (only 4 lbs.) for easier field use. ■ Instant-on operation: time-saving, accurate, drift-free. ■ Excellent for field or shop. And *will not* become obsolete!

Why buy an old-fashioned semi-accurate non-NTSC rainbow generator when you can get all the extra benefits of a 100% TRUE NTSC COLOR GENERATOR for the same money.

See your EICO dealer today for a free demonstration.

Unbeatable Value COMPLETE COLOR/BW TV LAB

With the 380 — plus just the 369 & 435 — you're ready for *anything* in Color/BW servicing: EICO 369 Sweep/Marker Generator gives easiest, fastest visual alignment of color or B&W TV and FM RF and IF circuits. Five sweep ranges from 3-220mc. Four marker ranges from 2-225 mc. Crystal marker oscillator. Post injection of markers. **$99.95 kit, $149.95 wired.**

EICO 435 Direct-Coupled Wideband Scope. DC-4.5mc with 3" flat-face CRT. Zener calibrator. Outperforms 5" scopes three times its price. **$109.95 kit, $159.95 wired.**

How about FM-MX Stereo?

Just add *EICO 342 FM-MX Signal Generator:* Gives both composite audio and FM RF outputs. Inputs for stereo audio, critical A/B tests. **$149.95 wired.**

**The NTSC (National Television Systems Committee) color signal is based on the fact that each transmitted color is produced by an NTSC-defined relationship between a 3.58 MC reference and a 3.58 MC chroma modulated subcarrier, with each color having a standard NTSC brightness component. This is the basis upon which all color-TV broadcasters must operate. There are no separate rules for color-TV reception, or color test sets.*

EICO EICO Electronic Instrument Co., Inc. RE-1
131-01 39th Ave., Flushing, N.Y. 11352

Send me FREE:

- ☐ "Definitive Comparison of NTSC and rainbow generators FROM THE SERVICEMAN'S VIEWPOINT."
- ☐ 32-page catalog on 200 EICO best buys.
- ☐ Name of nearest dealer.

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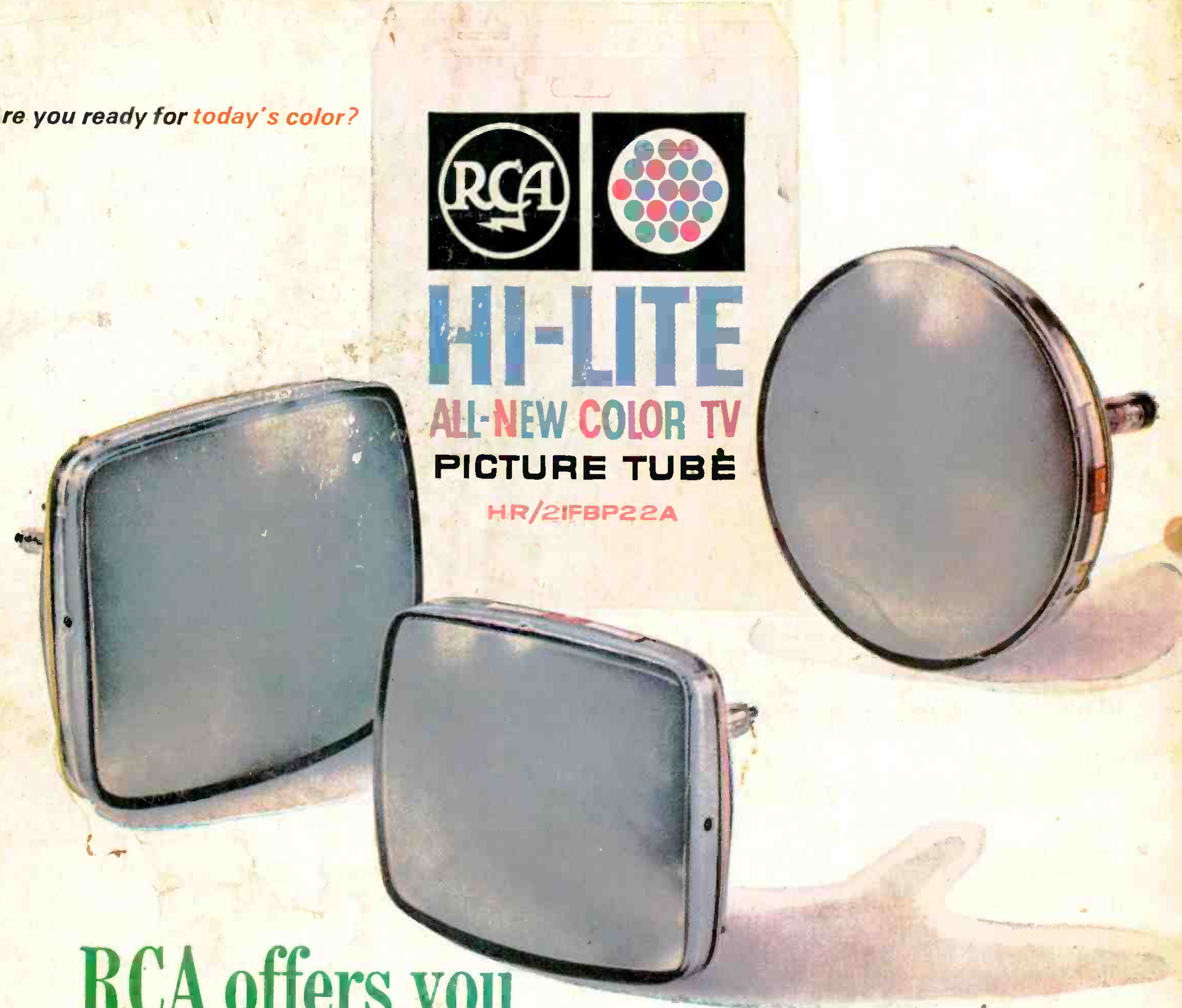
Circle 149 on reader's service card

Are you ready for today's color?



RCA offers you a replacement color picture tube that meets OEM specs

RCA Hi-Lite picture tubes are all-new...glass, gun, the works! They're RCA's best...the same quality...the same tubes...that go into original equipment sets. And because they incorporate the latest technological advances of the world's largest color picture tube manufacturer, you literally "up-date" your customer's color set each time you install one. Here is picture brightness and color fidelity at its finest, available for the service trade in 19-inch and 25-inch rectangular and 21-inch round tube types.

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