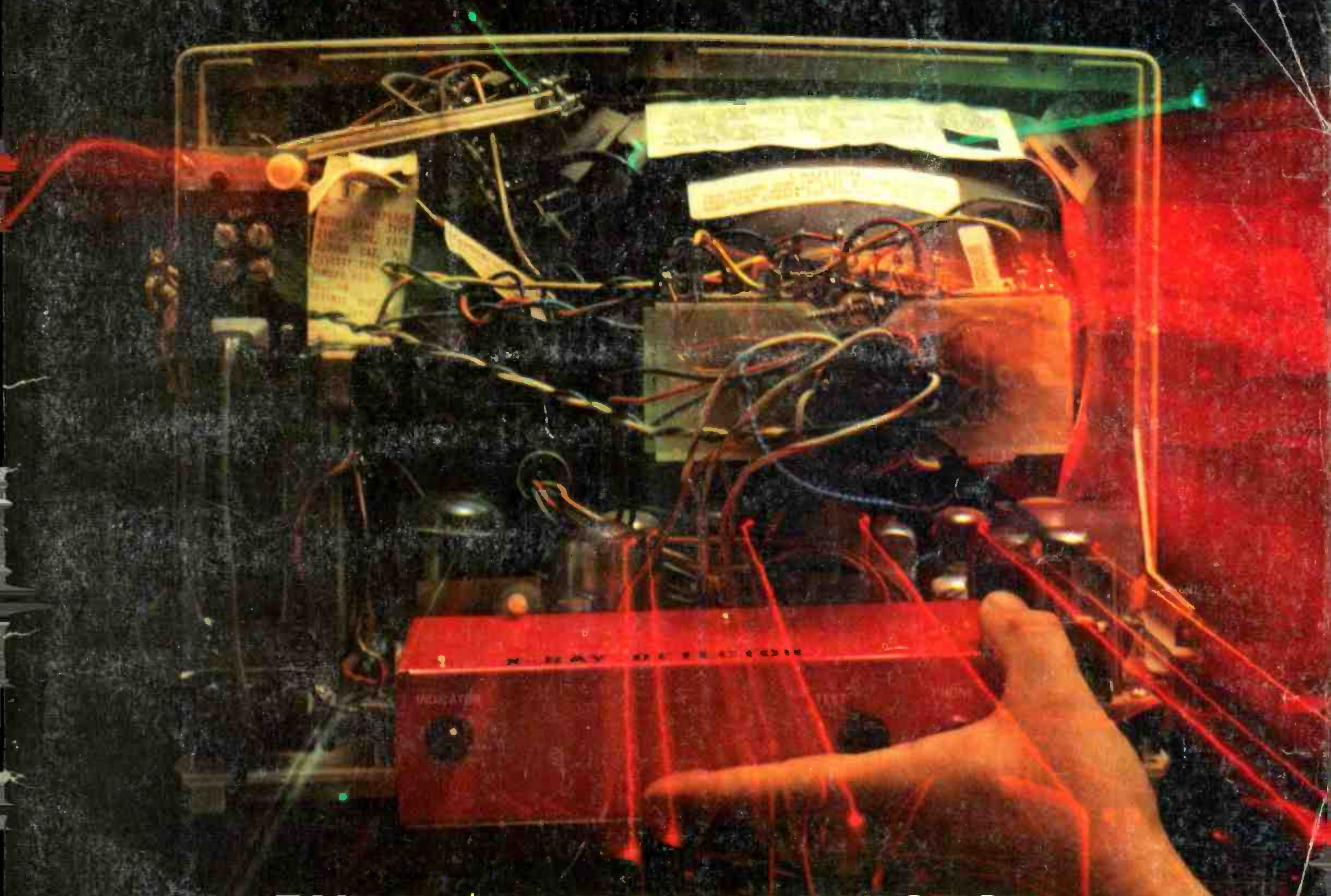
60c ■ JAN. 1971

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

SPECIAL ISSUE—COLOR TV 1971



BUILD $40 X-RAY DETECTOR
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CAMERA TO PIX TUBE
How Color TV Works

JACK DARR TELLS HOW
To Use Color Test Gear

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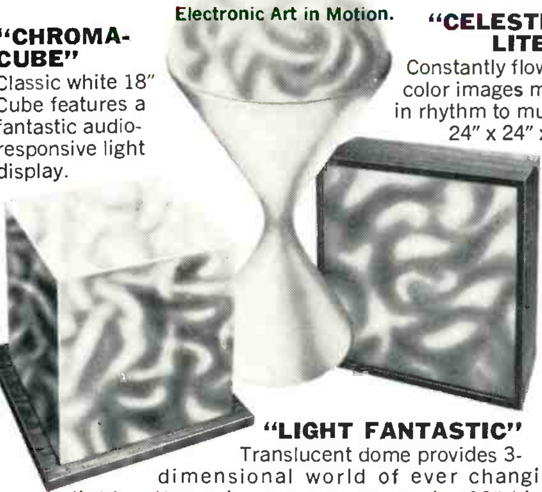

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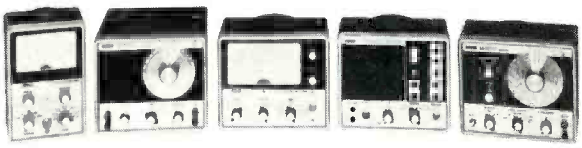

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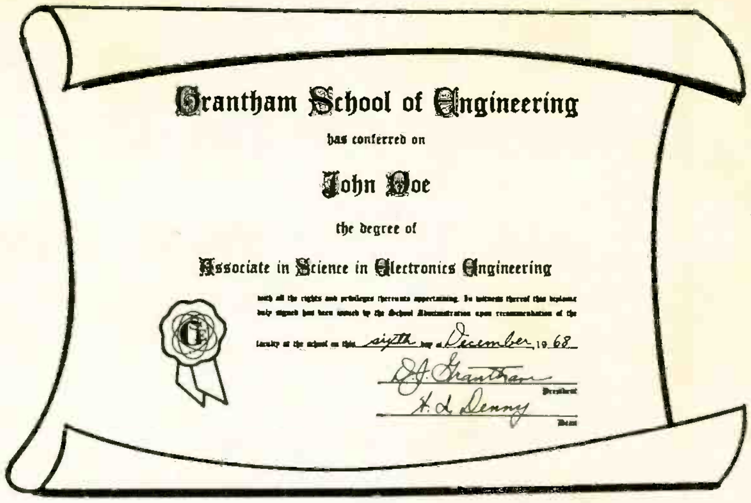

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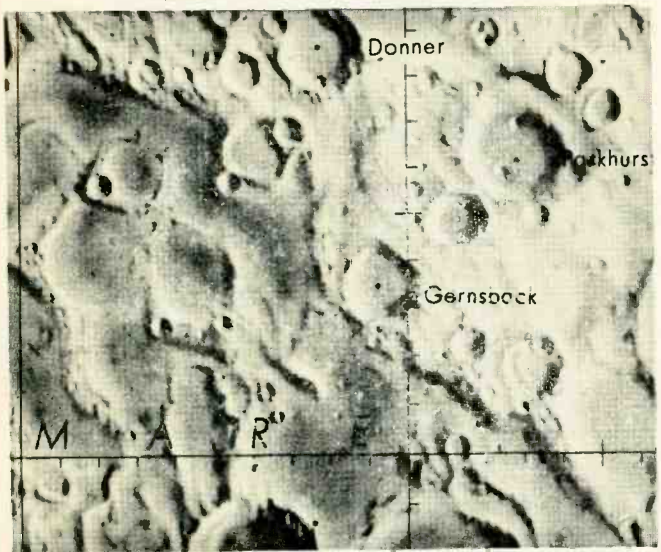
NEW & TIMELY

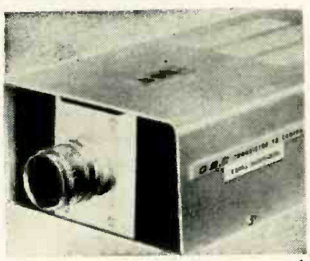
Volume 42 Number 1 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS January 1971

HUGO GERNSBACK CRATER ON THE MOON



CLOSEUP LOOK AT HUGO GERNSBACK CRATER on the moon. The crater is located in a strip of the moon that runs between the front and back sides of the moon. As a result, it can be viewed from Earth at some times of the month. On the lunar map it lies between coordinates 36S and 37S, and right on 99E.

TOTAL DARKNESS CAMERA INTRODUCED



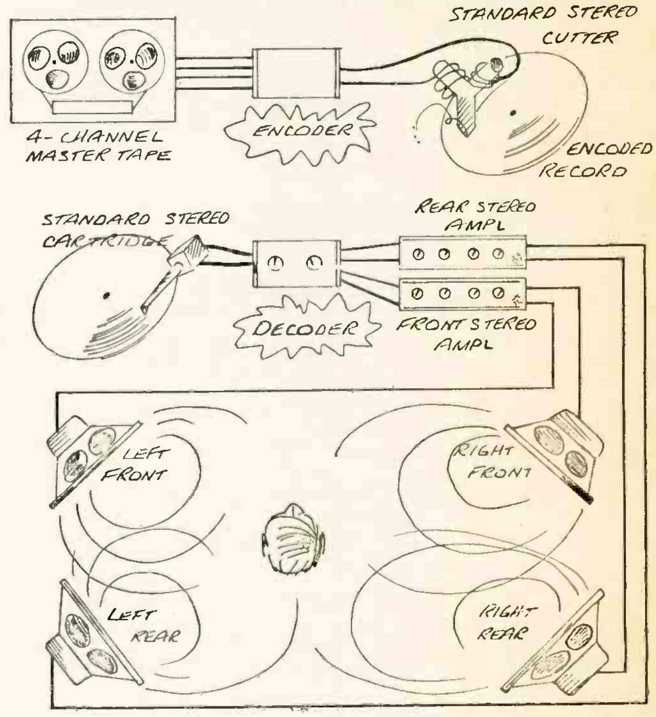
NEW YORK, N.Y.—GBC Closed Circuit TV Corp., demonstrated a commercially available "See in the Dark" TV system. The GBC TD-1400 Closed Circuit TV Camera sees clearly under visible and invisible illumination.

The system delivers clear pictures from daylight to moonlight conditions. It can be controlled locally or from a distance. The camera operates like regular daylight cameras. Various fixed focal lengths and zoom lenses provide desired fields of view. The motorized zoom lens can also be used to control the camera lens from a remote location. The camera can also operate with infra-red illumination which (although not required) when used, provides high-resolution video pictures in total darkness.

A key element in the camera is a virtually indestructible solid-state light sensitive wafer in place of the delicate chemical film used in most camera tubes. Depending on the color of illumination there is three to ten times the sensitivity as conventional b-w vidicon tubes under the same range of visible light. Under infra-red illumination, the sensitivity is 12 to 17 times greater.

Since the system is considerably more sensitive than some low-light level cameras, it has negligible lag at lower light levels where the lag and blooming in other cameras may be excessive. From 6 to 10 grey scale levels can be detected over the entire illumination range. The array of more than one-half million diodes in the camera vidicon cannot be "burned" by exposure to intense light. ★

4-CHANNEL STEREO DISC



NEW YORK, N.Y.—A new system for broadcasting and recording four-channel stereo sound using existing two-channel equipment was demonstrated starting at the Audio Engineering Society convention and exhibit. Named "Electro-Voice Stereo-4", the system requires only a simple "encoder" at the broadcast or recording source and an inexpensive "decoder" in the home.

The encoded signal is completely compatible with existing equipment and techniques. It will be received and reproduced as regular two-channel sound in existing standard home stereo systems where a decoder is not used.

Prototypes of the home decoder were shown by Electro-Voice. It is a small unit that plugs into an existing stereo system. Available about January 1, the suggested retail price of the decoder is expected to be well under $100.00.

Use of the Stereo-4 decoder in the home will also expand any existing two-channel source material (FM broadcast, records, or tape) to four independent channels of sound. Records and tape now owned do not become obsolete. Four different sound channels are created from two-channel sources.

The Electro-Voice system allows broadcasters to be on the air immediately with four-channel stereo information, as existing stereo transmitting equipment is used. Four-channel program material, as from a tape player, is fed through the E-V encoder and then to the standard multiplex generator and FM transmitter. The encoding process causes negligible distortion, noise, phase shift, or other signal degredation, requires no change in bandwidth, and is fully compatible with current two-channel receivers. The system, therefore, requires no approval or other action by the F.C.C. It is claimed that it is superior to any previously announced matrixing system.

The Stereo-4 system is a joint development of Electro-Voice, consulting engineer Leonard Feldman and Industrial Patent Development Corp. (turn to page 6)

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

January 1971 • Over 60 Years of Electronics Publishing

COLOR TELEVISION

Equipment Report . . . . 26 . . . . Larry Steckler
Winegard Sensar Antennas

In The Shop . . . . 27 . . . . . . Jack Darr
Comb color troubles out of your hair

How Color TV Works . . . . 32 . . . Wayne Lemons
See how the picture gets from the studio to you

Remote Controls For Color TV . . . . 45 . . . . . Larry Allen
Care and repair of these ever more common gadgets

Replacing TV Circuit Breakers . . . . 70 . . . . James A. Fred
The inside story on this simple device

Service Clinic . . . . 76 . . . . . . Jack Darr
R-E's Service Editor solves your problems

COLOR TEST EQUIPMENT

Build A $40 TV X-Ray Detector . . . . 36 . . . Stoms & Kuerze
Start checking TX x-rays now

Test Equipment For Color . . . . 40 . . . . . . Jack Darr
How to select and use the gear you really need

Build An IC Convergence Generator . . . . 50 . . . John C. Votipka
2 IC's are all you need to make this handy little unit

GENERAL ELECTRONICS

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Current happenings with future overtones

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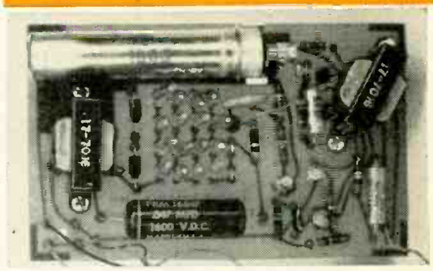
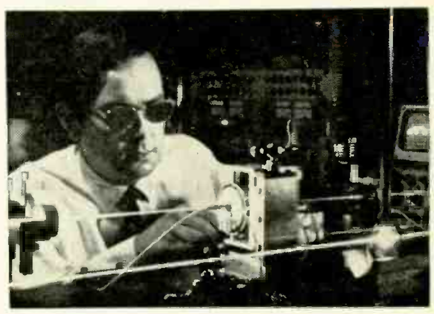
How the cover photo was shot—Nikon FTN 35-mm camera on tripod. Kodachrome II film. Nikkor 43-86 mm zoom lens. With lens set at 43 mm, an overall exposure was made with a 5000-watt-second electronic flash reflected off the ceiling. With shutter still open, the lens was slowly zoomed out to full 86-mm magnification. Backlighting from four reflector floods, covered by colored gels, created an edgelight around the subject, which swept across the film as the lens magnification was increased. Total exposure varied from 5 to 30 seconds, with aperture set at F14.



X-Ray Detector is great for that final check before you button up the back of the TV. . . . see page 36

Test Equipment For Color has Jack Darr telling how to fix color sets with a minimum of test gear. . . . see page 40



The Laser is today's exciting scientific apparatus. Here we start a series telling what it's all about and showing experiments you can perform with it. . . . see page 58

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LOOKING AHEAD

Volume 42 Number 1 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS January 1971

by **DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

Out on a limb

The January issue of RADIO-ELECTRONICS traditionally is our color television issue. And January traditionally is the month to look ahead at what the year holds in store. So, putting two traditions together, we'll try to take a look at television 1971. If we're right about what happens in 1971, we'll probably take credit for it in a later issue. If we fall off the limb, you can be sure we'll never mention it again and hope you forget it, too. So here goes.

The multi-purpose display

This will be the year that the home television receiver begins its transformation from a single-purpose to a multi-purpose device. To understand what we're driving at, consider the history of the home audio amplifier. It entered the home as an essential part of the radio. Later, the amplifier became a part of the electronic phonograph and the tape player. Today in the home, a single high-fidelity amplifier (with its associated speakers) does at least triple duty.

By contrast, the more complex and costly video circuits and color picture tube still perform only one single function—displaying pictures picked up off the air. This waste of a versatile visual device seems certain to be corrected in the future. The first moves are scheduled to come in 1971.

The home videoplayer

If all goes well, the first home cartridge VTR will be on the market in 1971, giving the home TV set new flexibility. Although 10 or more non-compatible varieties of home videoplayer are scheduled for marketing by 1972, only one of these has been definitely promised for 1971. This is the Cartrivision system, developed by Cartridge Television Inc., a subsidiary of Avco Corp., to be marketed by both Cartridge TV and Admiral in a color TV-VTR combination at less than $900. A $400-$500 deck is promised later.

The entire television industry, from manufacturer to retailer, will be watching the Cartrivision effort closely, to see how enthusiastically the public responds to the concept of the easy-to-use home VTR-player. Cartrivision will be offered with an extensive rental library of feature films, how-to lessons, musical video records and documentaries. In addition, a user will be able to record color TV off the air for later viewing and to make home TV movies in black-and-white with a $200 accessory vidicon camera. Our forecast is that 1971 will indeed go down in history as the year the first cartridge VTR entered the home, but so few will be produced in this first year that it will be impossible to draw any conclusions as to the success of this new product.

Other cartridge videoplayer manufacturers are taking a more cautious route—offering industrial-institutional-educational models first, and scheduling home editions for 1972. CBS's playback-only EVR film system went into production late in 1970. Scheduled for 1971 production are institutional catridge VTRs by Ampex, Sony and Philps—all touted as forerunners of 1972 home units.

Cable TV

In 1970, the FCC indicated its intention to require program originations by the larger cable TV systems, and many systems already have started limited originations. This means that CATV no longer stands for "Community Antenna Television," but finally represents a new source for program material—a new use for the TV box. The new year will also be a year of research into the potential of the widely heralded two-way home cable systems. One of the most imposing experiments may result from a recently formed combination of 25 corporations known as Broadband Communication Network. The group includes several major cable TV system owners, electronic equipment manufacturers (Magnavox is one), computer hardware and software firms (Honeywell), communications specialists including the New York Times and Los Angeles Times-Mirror.

The aim of this group will be to establish a working, two-way pilot home broadband communications system, budgeted at $10-$20 million, possibly as early as 1972. If preliminary studies indicate the project is feasible, a multi-corporation consortium, BCN Inc., will be formed to undertake the project. Services being explored for the new system, which has a goal of 10,000 subscribers and profitable operation, are information retrieval for the home (examples: recipes, best auto routes, library reference service), programmed learning, airline and theater ticket sales, banking, entertainment programming of the viewer's choice on demand, stock quotations on demand, teleshopping, facsimile newspapers, fire and intrusion surveillance, opinion surveys, possibly electronic mail delivery.

Better color transmission

Now back to 1971 and more prosaic developments. The year is likely to see vastly improved color consistency and uniformity between program and program, and between station and station, as a two-year high-level engineering study is gradually implemented. Some of the recommendations already are being put into effect—such as more uniformity in TV film colorization. Others may take FCC action—use of vertical interval to convey color standard information, tightening of some transmission tolerances. But the entire broadcasting and receiver manufacturing industries are now uniformity-conscious, and major improvements should be noticeable on color TV screens in 1971.

This, in turn, could lead to more fuss-free receivers. Pre-set tint controls, sometimes in combination with brightness and contrast, will soon be practical. Some appeared on receivers in 1970; they'll be more worthwhile in 1971 with increasing uniformity of the transmitted color signal. (The pre-set tint controls shouldn't be confused with so-called "automatic tint," the flesh-color compensation circuits offered by most major U.S. television manufacturers in 1970.)

Receiver innovations

Having suffered nearly disastrous sales setbacks in recession-plagued 1970, TV set manufacturers will be more inclined toward making money than making history in 1971. Some major innovations penciled in for 1970-71 have already been postponed until such time as the set makers feel the public is willing to pay for them. However, there will be some evolutionary changes in 1971 color receiver lines. Probably the most significant will be a rather large-scale increase in the number of all-solid-state receiv-

(continued on page 14)

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(continued from page 2)

NEW UHF DX RECORD

FT. MCPHERSON, GA.—"Why not?"

"Yes, let's break the 2,300 MHz world DX (long-distance) record!"

This might have been the gist of a conversation earlier this year between Bill Byrd (WA4HGN) of Muscle Shoals, Ala., and Paul Wilson (W4HHK) of Collierville, Tenn. And break the world record they did!

Bill and Paul are both amateur radio operators, and members of the Third U. S. Army Military Affiliate Radio System (MARS) as AD4HGN and A4HHK, respectively.

On July 9, Bill drove a panel truck to a place called Sunset Rock near Bon Air, Tenn. Inside the truck was seemingly enough exotic radio equipment to monitor a space flight, and on a trailer behind, looking not unlike a large mechanical turtle, was a specially tuned and rigged 10-foot dish antenna.

Working from an elevation of nearly 2,000 feet above sea-level, and using an astro-compass to point his dish antenna in precisely the right direction, Bill first attempted to contact Paul on the morning of July 10. Repeated attempts that first day were unsuccessful, but early on July 11 another call brought the looked-for response: "This is W4HHK reading you loud and clear!"

The record thus established was for 249 statute miles, as established by aeronautical charts. And the record is now official, having been recognized early in September this year by the American Radio Relay League.

Two hundred forty-nine miles may, to the uninitiated, not seem like a very astounding distance in this age of moon voyages and globe-girdling communications. But the record set by Messrs. Byrd and Wilson was at a frequency of 2,300 MHz, approximately three times as high as that of the highest-frequency UHF TV stations on the air in the US.

Also, there's the matter of power. Commercial UHF TV stations routinely use more than a million watts of power to send an acceptable signal 50 miles or less. Bill and Paul communicated over their record-breaking distance using less than a thousand watts, the legal limit for all radio amateurs. ★

SMALLER THAN A BREAD BOX, Raytheon's Model 2900 radar fits into the limited space found on most pleasure boats. The transistorized radar paints an electronic picture of land contours and other vessels up to 32 miles away. Its 33-½ inch radome-protected antenna weighs only 48 pounds. The radar is offered by Raytheon Marine Products, at $2,850. ★

MICROWAVE RADIATION

Rockville, Maryland—A new Federal standard that sets limits on radiation from microwave ovens has been issued by the Health, Education and Welfare's Environmental Health Services' Bureau of Radiological Health. As published in the Federal Register, under the Radiation Control for Health and Safety Act, the standard states that microwave home or commercial cooking ovens manufactured after October 6, 1971, "may not emit radiation in excess of 1 milliwatt per square centimeter prior to oven sales" and "may not emit radiation in excess of 5 milliwatts per square centimeter throughout the useful life of the oven." Allowance is made under the 5-milliwatt limit for the possibility that a gradual increase in radiation emissions may occur as a result of normal oven wear. In contrast, a maximum of 10 milliwatts per square centimeter has been recognized as a voluntary standard by the microwave oven industry up until now.

The limitation was initiated after local, state, and Federal public health agencies sur-

(continued on page 12)

Radio-Electronics

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When you train at home with NRI, you train with your hands as well as your head. You learn the WHY of Electronics, Communications, TV-Radio the NRI pioneering "3-Dimensional" way. NRI training is the result of more than half a century of simplifying, organizing, dramatizing subject matter, and providing personal services unique for a home study school. You get the kind of technical training that gives you priceless confidence as you gain experience equal to many, many months of training on the job.

NRI—The 53 Year Leader in Electronics Training

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

Earn $5 or more an hour spare or full time in

TV-RADIO SERVICING

Color Television has arrived. Sales are soaring, along with the continuing popularity of other home entertainment equipment like portable radios, tape recorders, hi-fi sets, phonographs and auto radios. TV-Radio servicing is one of your best routes to spare-time earnings, a good paying job or a business of your own. NRI not only trains you quickly and expertly, but also shows you how to get started in Servicing soon after you enroll, earning as you learn. NRI trains you in today's methods of installing and repairing all Electronic equipment for the home—including booming Color TV. You even build, experiment with and keep to enjoy your own solid-state radio and your choice of black-and-white or Color TV receiver. Like thousands of others, you can be earning $5 or more an hour extra in spare time starting soon.

There's money and success awaiting you in

BROADCASTING—COMMUNICATIONS

The experience you gain from intensely practical NRI training in Complete Communications equals as much as two years of training on the job. With NRI, you can train for a choice of careers ranging from mobile, marine and aviation radio to TV broadcasting and space communications. You learn how to install, maintain and operate today's remarkable transmitting and receiving equipment by actually *doing* it. You build and experiment with test equipment, like a VTVM you keep. You build and operate amplifier circuits, transmission line and antenna systems, even build and use a phone-cw transmitter suitable for transmission on the 80-meter amateur band. Whichever of five NRI Communications courses you choose, you prepare for your FCC License exams, and *you must pass your FCC exams or NRI refunds your tuition in full.*

Move ahead in America's fast growing industry as

ELECTRONICS TECHNICIAN

Electronics touches everyone's lives. This vast field of opportunity is open to you with NRI training. Industrial/Military Electronics training—like all NRI courses—prepares you quickly, thoroughly the practical "hands on" way. You build with, and learn to understand the functions of, today's miracle solid-state components like printed circuits, diodes and transistors. You build and experiment with Electronic circuitry used in automation, data processing, ultrasonics, telemetry. Whatever your interest in Electronics, NRI training can fill your needs. Prove to yourself what nearly a million NRI students could tell you . . . that you get more for your money from NRI. Check the postage-free card and mail it today for your FREE NRI Color Catalog. No salesman will call. NATIONAL RADIO INSTITUTE, Electronics Division, Washington, D.C. 20016.

YOU GET MORE FOR YOUR MONEY FROM NRI— Build, test, explore, discover. Everything you see here is included in one NRI course—including Color TV. Other courses equally complete. And you'll be surprised at the low tuition costs. Text for text, kit for kit, dollar for dollar—you get more for your money from NRI.

(continued from page 6)

veyed tested ovens and found that 20 to 30% of those teted emitted microwave radiation in excess of the industry's standard. Some levels were found to be capable of inducing biological effects in animals.

Changes were also made in provisions covering safety interlocks on oven doors, which turn off the cooking microwaves automatically when the door is opened. The standard asks for at least two safety interlocks which would have to be concealed, safe from tampering. The issued standard requires one interlock to be concealed to allow the use of more effective types of interlocks to minimize hazards. The standard stipulates, "failure of any single mechanical or electrical component of the microwave oven shall not cause all safety interlocks to be inoperative." ★

TAPE RECORDER STANDARDS

NEW YORK, N.Y.—"Swift introduction of such a three-part program is essential to avoid competitive chaos" was stated by Virginia Knauer, President Nixon's Consumer Adviser in regard to her proposed standardization program for the Tape Recorder Industry. It will cover manufacturing, performance, and product information.

She warned it is equally necessary that Government prodding be headed off by developing voluntary standards within the industry.

In Mrs. Knauer's speech at the International Tape Association's first conference, she spelled out four specific areas where full standards are needed, including terms and definitions for product information, materials and specifications, dimension and interchangeability standards, and product and component requirements for cassettes, recorders, and other related equipment. ★

Surveillance Radar System

PITTSBURGH, PA.—A surveillance radar system using a helicopter to elevate the antenna for better radar coverage is now being evaluated by the Air Force. The engineering model was developed for the Air Force System Command's Rome Air Development Center by the Westinghouse Aerospace and Electronic Systems Division.

Due to the earth's curvature, a ground radar's detection range for an aircraft flying at tree-top level is about 10½ miles providing there is no interference from terrain or foliage. However, if the terrain or foliage cut just one degree from the angle of the radar's beam path, the detection range is reduced from about 10½ to one-half mile.

Using a helicopter increases the low-altitude detection range which is limited by the earth's curvature, terrain and foliage effects.

In flight, the antenna rotates at nine revolutions per minute beneath a UH-1 helicopter. For take off and landing, the antenna folds into the space between the landing skids. It can be deployed or retracted in 30 seconds.

Since the radar looks down to the same extent that a ground radar looks up, the effect of ground clutter—noise in the system due to radar energy reflected in a variety of ways by everything on the ground—is greatly increased. These severe ground returns compete with the returns from targets. The helicopter supported radar therefore has to have exceptional clutter compensating ability.

Two radar innovations alleviate the clutter problem in the developmental radar. These are a digital moving target indicator and coded pulse anticlutter circuitry. In addition to reducing the

(continued on page 14)

TCA-40

= TCA-40

4-track, 4- and 2-channel playback

TCA-40

TCA-40

\+

RA-41

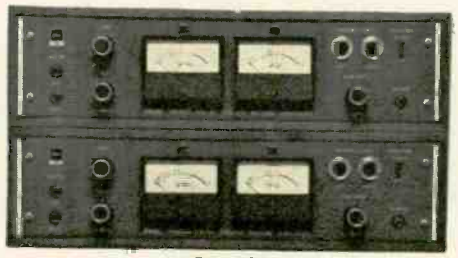
(record amplifier)

= TCA-41

4-track, 4- and 2-channel playback
2-channel record

TCA-40

\+



2 RA-41's

= TCA-42

4-track, 4- and 2-channel playback
4- and 2-channel record

HIGHER MATH

(Mounting cradle and dust cover optional)

Three decks, three capabilities: the Simul-trak® TCA Series from TEAC.

Buy one, add onto it, and you're up to the next model. Keep going till you reach the top. Or start at the top, and get everything going for you at once.

All three units feature 4- and 2-channel playback – the only brand with auto reverse. And Models 40 and 41 can be modified to the full 4-channel capability of Model 42 as shown. Meanwhile, any one of these decks is compatible with your present 2-channel equipment without modification.

Other 4-channel tape decks may look like ours. But they either have only one motor – or they cost a king's ransom. (They don't sound as good, either.)

And any way you add them up, the TCA Series can never be obsolete. You don't even need a slide rule to show you why. Just a good pair of ears.

TEAC.

MEMBER INSTITUTE OF HIGH FIDELITY INC.

TEAC Corporation of America
2000 Colorado Avenue
Santa Monica, California 90404

New & Timely

(continued from page 12)

problem of ground clutter, these also lessen the effects of weather clutter. Some ability to detect ground targets has also been observed.

The digital features combined with the use of solid-state components for everything but the high power transmitter and display tubes made the system lighter in weight, use less power, more reliable and stable than would have been possible with conventional techniques.

The radar is a two dimensional system operating in the L frequency band.

The antenna is an array of stripline dipoles separated from a ground plane and mechanical support by a hard foam plastic layer. This type of construction eliminated the feed horn and the large, heavy parabolic antenna and has built-in provisions for a radar beacon signal reception and transmission.

A data link to provide radar information to a ground display is part of the system. It provides two-way communications over a slant range of ten miles. Two antennas are used on the helicopter for the data link, one in front and the other in back, so there is always one antenna in the line of sight of the ground antenna.

In a tactical situation, helicopter supported radars could be used to augment ground early warning radar systems to fill gaps in coverage, and to provide radar coverage in contingency situations before ground radars are emplaced. **R-E**

LOOKING AHEAD

(continued from page 4)

ers offered to the public. Japanese television makers are joining in a unified campaign to eliminate receiving tubes entirely, and they'll go the major distance toward their goal in 1971. While the Japanese are phasing tubes out of color portables, their American counterparts will continue to phase solid-state chassis into their console lines.

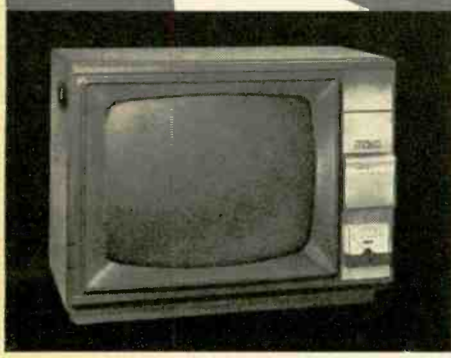
There's an outside chance that the first substantially integrated-circuit receiver could show up in 1971—and it probably will be from Japan, where the entire television industry is pooling its efforts to develop standard TV ICs. Although the U.S. leads in IC technology, American manufacturers so far have shown no inclination to work toward standard circuits which could make widespread use of ICs economically feasible. The Japanese efforts could jolt them into standardization—but probably not before 1972.

Other trends to watch in 1971: Color tubes—More of the new square-cornered types, the 25-inch, the newer 19-inch, probably a few 21-inchers. The short color tube with 110-degree deflection is currently being offered only by RCA in an 18-incher, but 19-inch versions (high priced) will come on the market in 1971. Electronic tuning—This will proliferate in a limited fashion, at the high end of some TV lines. You may see the first digital-tuning all-channel set, using two Nixie tubes as indicators, along with signal-seeking action. This could set a trend.

Warranties

With the increase in solid-state sets, and continuing "consumerism" pressures, we're almost certain to see further extensions of warranties in 1971. The one-year parts-and-labor policy will become standard for solid-state receivers, and it wouldn't be surprising to see some experimentation with two- and three-year warranties before the year is out. Television receiver prices will rise to cover the warranties. **R-E**

ICTJ*



RCA CALLS IT ICTJ. YOU'LL CALL IT THE GREATEST SERVICE AID EVER TO COME ALONG.

ICTJ* is more than a test jig. It's a complete system designed by RCA to help you service Color Television faster and more precisely.

With the updated ICTJ system you'll be able to service more than 90% of *all* Color TV consoles on the market—that's over 1,500 different models from more than 17 different manufacturers.

Here's what it includes: First, the test jig itself, in bench or portable models.

Second, an assortment of adapters engineered to match almost any Color console chassis to the test jig.

*Industry Compatible Test Jig

Third, a complete reference book to take the guesswork out of which adapter to use with each chassis—and RCA keeps it up to date through a subscription service.

And there's also a new optional high voltage meter kit to give you safe, accurate and continuous monitoring

ICTJ lets you pull a chassis with the complete assurance that the picture in your shop will be the same as the customer sees in his home.

See your RCA Parts and Accessories Distributor today; chances are you'll find a less important use for that old jury rig.

Deptford, New Jersey

RCA Parts and Accessories

Correspondence

WRONG STATION

In your October issue you mentioned a quadrophonic broadcast in San Francisco. The involved stations were KLOL and KRON. You gave one the incorrect call letters. KIOI is at 101 megacycles and the letters are KIOI, not KLOL.

D. TABER
San Francisco

Our thanks for unscrambling those call letters. As you can see, it was caused by a slipped finger on the typewriter.

WHERE DO I GET PLL IC'S?

In your November issue there was an article on the Phase Lock Loop which I found to be quite interesting. However, you mentioned that the new IC's were developed by Signetics, but did not indicate where they are located and how an interested person might contact them. Could you possibly publish their address in an issue soon, so others like myself can write to them for buying details?

SYDNEY JOHNSON
New York, N.Y.

You and any other readers interested in getting more data on PLL IC's and their availability should contact Signetics directly. Their address is 811 E. Arques Ave., Sunnyvale, Calif., 94086.

ACHIEVEMENTS UPDATE

My article, "Measurements of Your Achievements" which appeared in the December, 1970 issue of Radio-Electronics, requires a little updating. The fee for the Certified Electronics Technician Examination has been increased from $5.00 to $10.00, and for further information on this program, the reader should contact Mr. Leon Howland, Chairman, NEA Certification Program, ITTA Building, 1309 W. Market St., Indianapolis, Indiana 46222.

LOUIS E. FRENZEL, JR.
Silver Spring, Md.

(continued on page 22)

35,000 parts for a dollar.

What do you do when a customer walks in with a TV set which has a brand name that sounds like hara-kiri, and you find that one of the transistors has committed suicide?

You can tell him to throw the set away.

Or, if the transistor has a number, you can look it up in Sylvania's ECG Semiconductor Replacement Guide and pop in an ECG replacement.

The Guide lists over 35,000 transistors, FETs, diodes, rectifiers, Zener diodes and linear ICs. It includes JEDEC, European and Japanese types.

All of them can be replaced by only 87 ECG semiconductors.

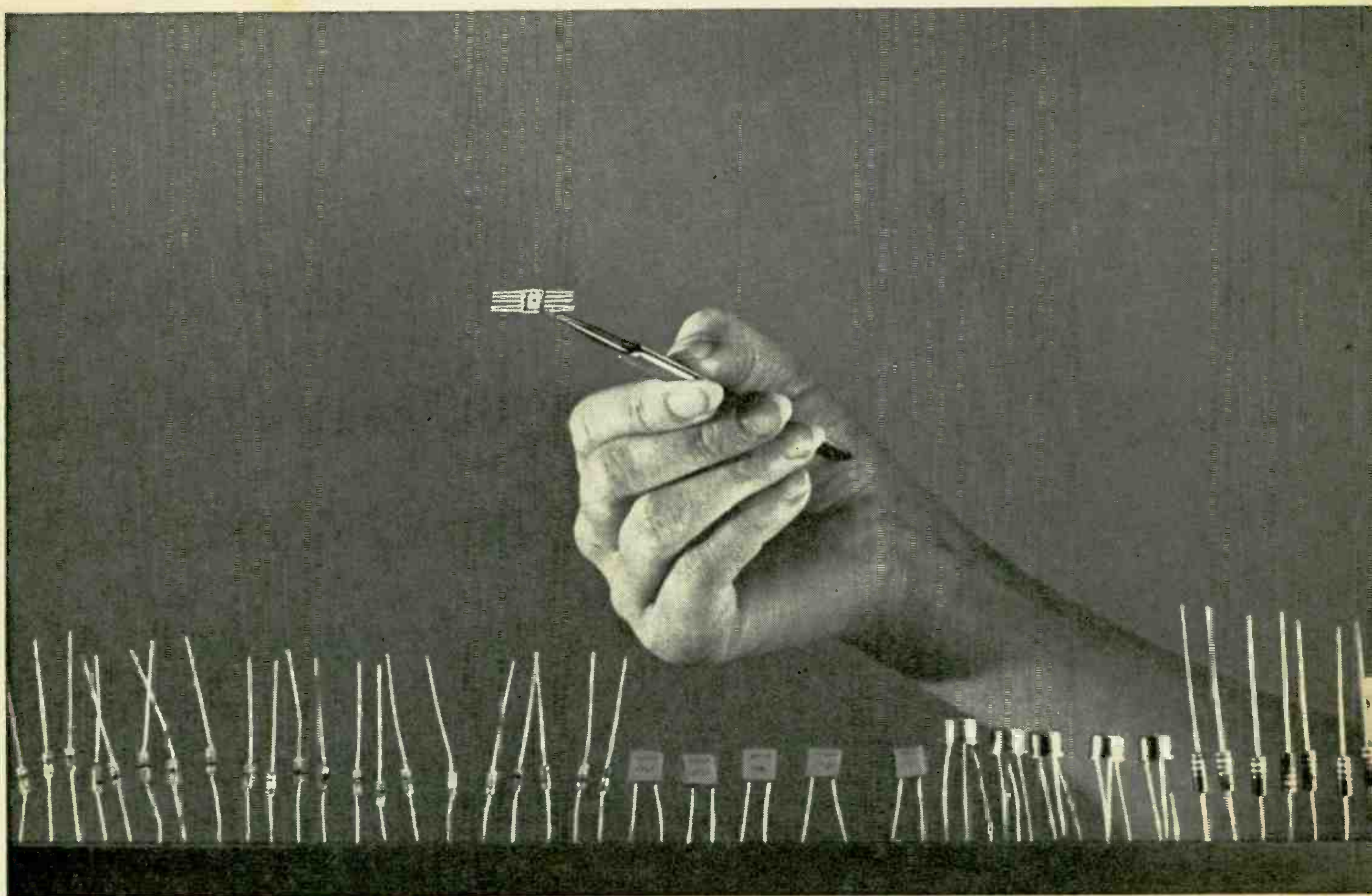
So you don't have to own a warehouse to do your job.

You just need a few drawers of ECG parts.

And one buck...

for which your Sylvania Distributor will gladly sell you the Guide. He also has the entire ECG replacement line. Remember: Sylvania supplies you; we don't compete with you.

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS



50 functions in a single chip. *The functions of 50 separate transistors, diodes, resistors and capacitors can now be performed by the tiny dot in the center of the integrated circuit held by the tweezers.*

The "Chip"...will it make or break your future job?

THE DEVELOPMENT OF INTEGRATED CIRCUITRY is the dawn of a new age of electronic miracles. It means that many of today's job skills soon will be no longer needed. At the same time it opens the door to thousands of exciting new job opportunities for technicians solidly grounded in electronics fundamentals. Read here what you need to know to cash in on the gigantic coming boom, and how you can learn it right at home.

TINY ELECTRONIC "CHIPS," each no bigger than the head of a pin, are bringing about a fantastic new Industrial Revolution. The time is near at hand when "chips" may save your life, balance your checkbook, and land a man on the moon.

Chips may also put you out of a job...or into a better one.

"One thing is certain," said *The New York Times* recently. "Chips will unalterably change our lives and the lives of our children probably far beyond recognition."

A single chip or miniature integrated circuit can perform the function of 20 transistors, 18 resistors, and 2 capacitors. Yet it is so small that a thimbleful can hold enough circuitry for a dozen computers or a thousand radios.

Miniature Miracles of Today and Tomorrow

Already, as a result, a two-way radio can now be fitted inside a signet ring. A complete hearing aid can be worn entirely inside the ear. There is a new desk-top computer, no bigger than a typewriter yet capable of 166,000 operations per second. And it is almost possible to put the entire circuitry of a color television set inside a man's wristwatch case.

And this is only the beginning!

Soon kitchen computers may keep the housewife's refrigerator stocked, her menus planned, and her calories counted.

Money may become obsolete. Instead you will simply carry an electronic charge account card. Your employer will credit your account after each week's work and merchants will charge each of your purchases against it.

When your telephone rings and nobody's home, your call will automatically be switched to the phone where you can be reached.

Doctors will be able to examine you internally by watching a TV screen while a pill-size camera passes through your digestive tract.

New Opportunities for Trained Men

What does all this mean to someone working in Electronics who never went beyond high school? It means the opportunity of a lifetime—if you take advantage of it.

It's true that the "chip" may make a lot of manual skills no longer necessary.

But at the same time the booming sales of articles and equipment using integrated circuitry has created a tremendous demand for trained electronics personnel to help design, manufacture, test, operate, and service all these marvels.

There simply aren't enough college-trained engineers to go around. So men with a high school education who have mastered the fundamentals of electronics theory are being begged to accept really interesting, high-pay jobs as engineering aides, junior engineers, and field engineers.

How To Get the Training You Need

You can get the up-to-date training in electronics fundamentals that you need through a carefully chosen home study course. In fact, some authorities feel that a home study course is the best way. "By its very nature," stated one electronics publication recently, "home study develops your ability to analyze and extract information as well as to strengthen your sense of responsibility and initiative." These are qualities every employer is always looking for.

If you do decide to advance your career through spare-time study at home, it makes sense to pick an electronics school that specializes in the home study method. Electronics is complicated enough without trying to learn it from lessons designed for the classroom instead of correspondence training.

The Cleveland Institute of Electronics has everything you're looking for. We teach only Electronics—no other subjects. And our courses are designed especially for home study. We have spent over 30 years perfecting techniques that make learning Electronics at home easy, even for those who previously had trouble studying.

Your instructor gives your assignments his undivided personal attention. He not only grades your work, he analyzes it. And he mails back his corrections and comments the same day he gets your lessons, so you read his notations while everything is still fresh in your mind.

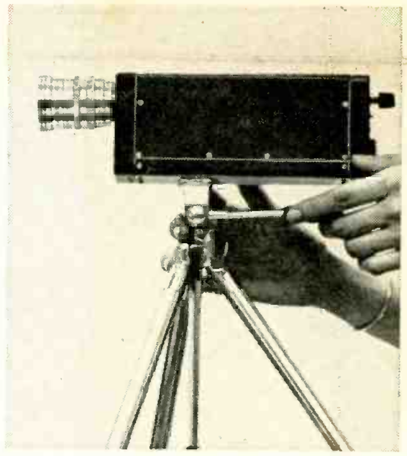
Always Up-to-Date

Because of rapid developments in Electronics, CIE courses are constantly being revised. Students receive the most recent revised material as they progress through their courses. This year, for example, CIE students are receiving exclusive up-to-the-minute lessons in Microminiaturization, Logical Troubleshooting, Laser Theory and Application, Single Sideband Techniques, Pulse Theory and Application, and Boolean Algebra. For this reason CIE courses are invaluable not only to newcomers in Electronics but also for "old timers" who need a refresher course in current developments.

ENROLL UNDER NEW G.I. BILL

All CIE courses are available under the new G.I. Bill. If you served on active duty since January 31, 1955, or are in service now, check box on reply card for G.I. Bill information.

Tiny TV camera *for space and military use is one of the miracles of integrated circuitry. This one weighs 27 ounces, uses a one-inch vidicon camera tube, and requires only four watts of power.*



Get FCC License or Money Back

No matter what kind of job you want in Electronics, you ought to have your Government FCC License. It's accepted everywhere as proof of your education in Electronics. And no wonder—the Government licensing exam is tough. So tough, in fact, that without CIE training, two out of every three men who take the exam fail.

But better than 9 out of every 10 CIE graduates who take the exam pass it.

This has made it possible to back our FCC License courses with this famous Warranty: you *must* pass your FCC exam upon completion of the course or your tuition is refunded in full.

Mail Card for Two FREE Books

Want to know more? The postpaid reply card bound in here will bring you a FREE copy of our school catalog describing today's opportunities in Electronics, our teaching methods, and our courses, together with our special booklet on how to get a commercial FCC License. If card is missing, use the coupon below.

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COLLEGE-LEVEL COURSE IN ELECTRONICS ENGINEERING

for men with prior experience in Electronics. Covers steady-state and transient network theory, solid state physics and circuitry pulse techniques, computer logic and mathematics through calculus. A college-level course for men already working in Electronics.

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2. Your book on "How To Get A Commercial FCC License."

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Accredited Member National Home Study Council
A Leader in Electronics Training . . . Since 1934

RE-86

Circle 11 on reader service card

CORRESPONDENCE

(continued from page 16)

HUMIDITY SENSOR AVAILABLE?

Some time ago an article in RADIO-ELECTRONICS featured a type HA-26 humistor (humidity sensor). I have not been able to locate the manufacturer nor the source of this element. We are developing an automatic microbarograph recorder and want to measure relative humidity also. The HA-26 humistor seems the ideal sensing element for this purpose. Can you supply the name and address of the manufacturer or a catalog source?

VAGN H. JENSEN
University of Tasmania
Hobart, Tas.
Australia

The Road-Icing Alarm, described in the October 1968 issue, was a popular item and its description was reprinted in a number of foreign publications.

The Hygropak humidity sensor is made by Photo-Crystals, 604 Prairie Street, St. Charles, Ill. 60147. It is carried by Allied Electronics, 2400 W. Washington Blvd., Chicago, Ill. 60680. The catalog number for the Hygropak HA-26 is 60 D 7747 and the matching socket is No. 60 D 7748. The HA-26 and socket are $6.00 and $0.30, respectively.

HELP A READER TODAY

Some months ago I was shown an electrical device that I would like more information about.

I am sorry that I do not know the trade name nor am I able to give any more information to help you trace it down for me than what I have outlined below.

The device is an electro-chemical unit, that when activated by a 1½ volt battery, will produce heat on one side and cold on the other side. The active material is tellurium salts with perhaps other agents used as catylists. The physical size is approximately ¼ of an inch thick by 1½ inches wide by 3 inches long. Two terminals are connected on either side of the 1½ inch top. The back and front of the unit have small copper plates imbedded in the plastic case on both sides of the unit.

I would appreciate it very much if you would forward this letter or send me information as to the manufacturer and address so that I can write a letter of inquiry.

J. D. TAYLOR
627 Fraser St.
Kamloops B.C.
Canada

It would be of great help to me if someone could answer these questions. To date I have solicited answers from several sources, but without success.

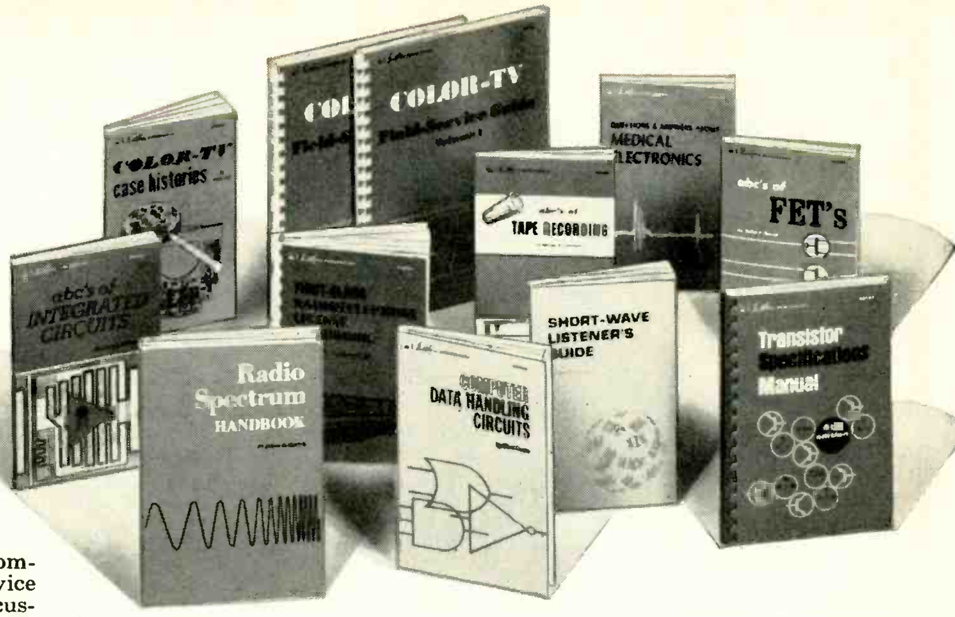
Specifically, I am trying to find out what companies manufacture the Navy Ordinance Locaters, Mark I model 0, Mark 10 model 0 and the current Army Mine Detector (transistorized)? Are any of these units available in civilian or surplus form on the open market? What companies make waterproof earphones that could be used with some of the current commercial metal detectors, especially White's SAM I underwater detector? Is there a listing of metal detector manufacturers, particularly underwater models?

Your help in obtaining answers to these questions would be greatly appreciated.

W. J. KEITH
Marine Biologist
South Carolina Wildlife Resources Dept.
Marine Resources Div.
217 Fort Johnson
Charleston, S.C. 29407

Ok men, that's two of your fellow readers with a problem. If you can offer any assistance why don't you drop them a card? **R-E**

Important New SAMS Books



Color-TV Field-Service Guides

These invaluable guides have been compiled to enable the technician to service color-TV more efficiently in the customer's home. Charts provide chassis layouts showing type, function, and location of all tubes and/or transistors used in a particular chassis, ratings and locations of fuses and circuit breakers, location of service controls and adjustments, etc. Specific field-adjustment procedures are shown on page opposite chassis layout. Index provides instant reference to the proper chart for any particular TV chassis. Each volume contains 80 diagrams covering over 3,000 chassis.
Volume 1. Order **20796,** *only* **$4.95**
Volume 2. Order **20807,** *only* **$4.95**

Questions and Answers About Medical Electronics

by EDWARD J. BUKSTEIN Anyone familiar with basic electronic circuits will find this a fascinating and readily understandable book emphasizing the applications of electronic equipment in clinical and research medicine, general principles of equipment operation, special features of the equipment, and the related medical terminology.
Order **20816,** *only* **$2.95**

ABC's of Integrated Circuits

by RUFUS P. TURNER. This basic introduction to the integrated circuit (IC) will be welcomed by hobbyists, experimenters, and students who have some familiarity with semiconductors. Describes the fundamentals of the IC, and its applications in amplifiers, oscillators, control circuits, communications, test equipment, and computers.
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Transistor Specifications Manual. 4th Ed.

by THE HOWARD W. SAMS ENGINEERING STAFF. Lists the electrical and physical parameters (along with the manufacturers) of virtually all of the transistor types now in use. Also includes frequency, gain, and leakage parameters, as well as a special section on rf power transistors. Comb-bound.
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ABC's of FET's

by RUFUS P. TURNER. Clearly explains the theory and describes the operating principles of FET's (field-effect transistors), special semiconductor devices with unique qualities. Describes FET circuit design and typical applications in a number of practical circuits.
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Computer Data Handling Circuits

by ALFRED CORBIN. This book offers the beginner a valuable introductory course in practical digital data circuit analysis. Makes understandable the semiconductors and circuitry used in digital equipment. Explains digital data logic and the associated mathematics. Analyzes the basic logic circuits and their functional blocks, as well as digital display devices. Invaluable for anyone desiring to be conversant in the operational theory of data handling circuits.
Order **20808,** *only* **$4.50**

Color-TV Case Histories

by JACK DARR. Case histories not only provide the TV technician with solutions to troubles he is likely to encounter, but enable him to compare his troubleshooting methods with those of others. Each of these case histories of troubles actually happened. The symptoms are given for each trouble, along with the method used to locate it.
Order **20809,** *only* **$3.50**

Radio Spectrum Handbook

by JAMES M. MOORE. This book fills the "information gap" about the many types of radiocommunication which exist apart from radio and TV. Each chapter covers a given frequency-allocation range; a table provides an overall summary of the uses of all frequencies in that range, followed by text describing the individual radio services available. Includes information on receivers available for the various frequency bands described. Hardbound.
Order **20772,** *only* **$7.95**

First-Class Radiotelepone License Handbook. Third Edition

by EDWARD M. NOLL. Completely updated to cover all the new material included in the recently revised FCC Study Guide. Book sections include: Theory and discussion of all phases of broadcasting; all the questions (and the answers) included in the FCC Study Guide; three simulated FCC examinations; appendices containing the most relevant FCC Rules and Regulations. This book will not only help you acquire your license, but will also serve as a textbook for broadcast engineering training. Order **20804,** *only* **$6.50**

Short-Wave Listener's Guide. 4th Ed.

by H. CHARLES WOODRUFF. Completely revised and enlarged to include the most recent changes in SW broadcasting schedules. Lists world-wide short-wave stations by country, city, call letters, frequency, power, and transmission time. Includes Voice of America and Radio Free Europe stations, and stations operating behind the Iron Curtain. With conversion chart and handy log.
Order **20798,** *only* **$2.95**

ABC's of Tape Recording. 3rd Ed.

by NORMAN CROWHURST. Newly revised and updated edition of this popular handbook. Explains how tape recorders work (transport mechanisms, heads, controls, etc.), how to choose the best recorder for your needs, and how to use it most effectively for both entertainment and practical purposes. Includes tips on recording quality and recorder care. Order **20805,** *only* **$2.95**

HOWARD W. SAMS & CO., INC.

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Circle 13 on reader service card

NEW exciting home training to be a COMPUTER TECHNICIAN

NRI program includes a complete, operating computer, with memory, to make you thoroughly familiar with computer organization, design, operation, construction, programming, trouble shooting and maintenance.

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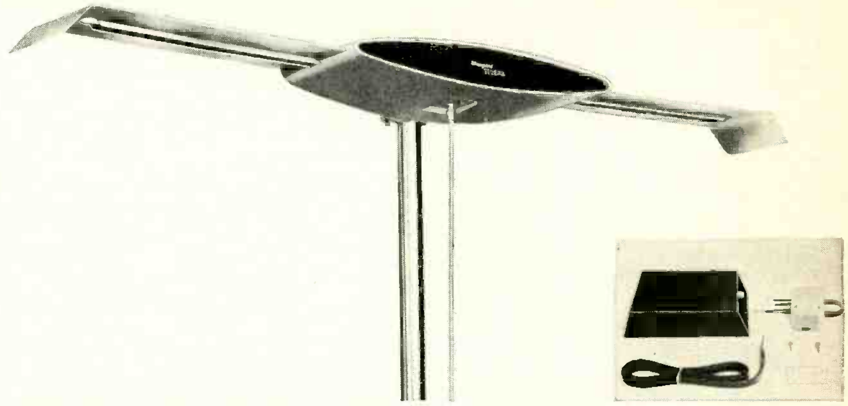
EQUIPMENT REPORT

Winegard Sensar TV Antennas

For manufacturer's literature, circle No. 18 on Reader Service Card.



These two new all-channel TV antennas present a striking contrast to the traditional outdoor antennas we are accustomed to working with. They are small and lightweight, easy to mount, and highly wind and weather resistant. For fast mounting on a rooftop, in an attic or under the eaves they are hard to beat. Both are intended for color and black and white reception of uhf and vhf channels. The FM band is attenuated, so don't expect good performance here.

The SR-20 version contains a solid-state modular amplifier in the antenna head. This amplifier boosts the signal strength of all signals received. The SR-10 is the same basic antenna, but without the amplifier. The antennas are connected to their control box (near the TV) by 75-ohm coax cable. The control box provides two sets of 300-ohm antenna outputs.

Winegard recommends using the SR-20 at distances up to 40 miles from the transmitter. With this in mind I set up a Sensar SR-20 on my roof, some 32 miles from the nearest TV transmitters, and directly compared performance of the Sensar with my existing multi-element "fringe area" antenna.

Results were surprising. Reception with the Sensar was good. When switching from one antenna to the other there was little noticable change in picture quality.

There was, however, one drawback—ghosts. In my location, there is a water tower about two blocks in back of my house, and on channels 2 and 4 this resulted in a strong ghost as this tower is almost directly in line with the TV transmitters. The multi-element antenna I now use is directional enough to eliminate the ghost, but the bi-directional qualities of the Sensar could not eliminate it.

As a result of these tests I would advise using the Sensar in areas where directional characteristics are not vital. Under these conditions the Sensar can be extremely useful.

But where directivity is a must for good reception, the Sensar probably cannot be used successfully.

Because of the ease of mounting, even a window frame is suitable, the Sensar SR-10 antenna is extremely convenient for installation in metropolitan areas.

To wrap it up, the Sensar may not work well in every location, but where-ever it can be used, it will afford the technician with an easy installation. And the antenna will deliver good pictures.—*Larry Steckler*

SPECIFICATIONS

ANTENNA
Dimensions: 46" x 6" x 1¾"
Turning Radius: 24"
Bandpass: VHF 54-88 and 174-216 MHz UHF 470-890 MHz
Output Impedance: 75 ohms unbalanced
Power Requirements: 12 Vac
Directivity: Bi-directional
Weight: 2 lbs. 8 oz.
POWER COUPLER
Dimensions: 6" x 3 3/16" x 1¾"
Power Requirements: 110-125 Vac
Power Output: 12 Vac
Input: 75 ohms
Outputs: two, 300 ohms

"Your TV is ok Mr. Clawson. I'm afraid someone played a little trick on you while you were dozing."

In the Shop . . . With Jack

By **JACK DARR**
SERVICE EDITOR

COMB COLOR TROUBLES OUT OF YOUR HAIR!

WHEN WE'RE LOOKING FOR TROUBLES IN color TV, we need all the help we can get. This is especially true in the newer hybrids and solid-state sets. We can't disconnect, check and replace as easily as we did. So we need a method that will pinpoint the trouble area, fast!

Where we need the most help is in the ones with "Got a raster but no picture!" symptom. Since the signal-path in every radio and TV set ever built is a **series circuit,** all we need to know is "Where is it broken?" In other words, where does the signal stop or lose a lot of amplitude?

So back we go to one of the oldest test-methods—signal-tracing. Of course, there's nothing like the scope for this. It shows you the signal. It also shows you the amplitude, any distortion, and so on. For the quickest results we need a signal we can identify instantly.

We've got one. The color-bar pattern from the bar-dot generator makes an unmistakable "Comb" pattern on the scope (see Fig. 1). The beauty of this is its simplicity. Just hook the bar-dot to the antenna terminals, turn the set on and away you go. Follow the signal through the signal-path until it stops. Then we go to the dc voltmeter and find out what's happened.

This can be used in any stage. For chasing signals through the video i.f. stages, use a crystal demodulator probe. The waveform of Fig. 1 was taken at the collector of the 2nd i.f. transistor in a hybrid Magnavox 936 color TV chassis. This one happens to be about 2.0 volts p-p. You do not have to read p-p voltage on every test point. As long as you can see an increase in pattern amplitude between input and output of a stage, OK.

If you want to take a shortcut, eliminating at least four tests, take your first reading on the video detector output with the direct probe. This should be at least 2.0 to 3.0 volts p-p and look exactly like Fig. 1. If this signal is present at this point, you've cleared the tuner, video i.f., agc, dc voltage supply and a raft of other things!

After the video detector, the low-capacitance or direct probes can be used. The same comb signal can be followed through the video amplifier stages. Look for changes in amplitude to check the gain. Starting with 2 to 3 volts p-p at the videa detector, we should wind up with 250 volts p-p at the output of the video amplifier. If you see much less than that, you'll have a weak picture. Fig. 2 shows the comb-pattern taken at the 2nd video amplifier of the Magnavox 936, with a direct probe.

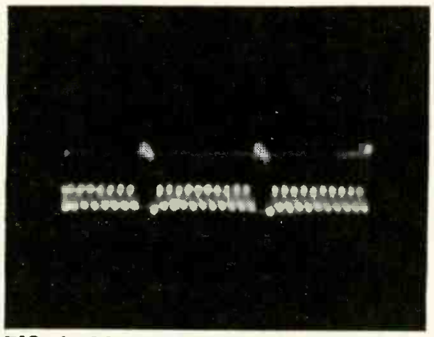


FIG. 1—COMB PATTERN taken with demodulator probe on collector of 2nd video i.f. amplifier.

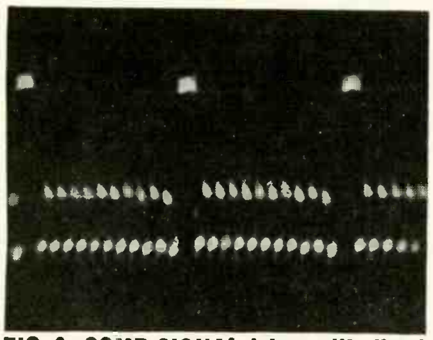


FIG. 2—COMB SIGNAL taken with direct probe at the base of the video driver. 1.2V p-p, sync positive-going.

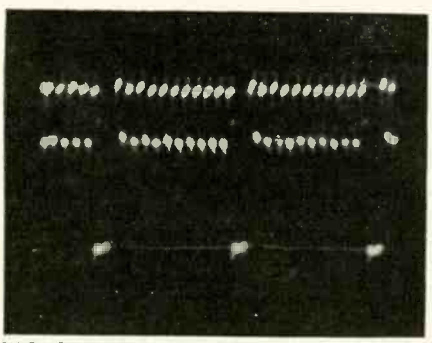


FIG. 3—SAME SIGNAL on grid of video output amplifier tube. 8.0V p-p, inverted; sync negative going.

Obscure problems can be traced rapidly with this method. For example, there should be no signal inversion through an emitter-follower stage, but there should be as you go through a common-emitter stage. If you see the same signal, amplitude and polarity, at the input and output of a common-emit-

(continued on page 76)

Second in a series...

Can you solve these problems in electronics?

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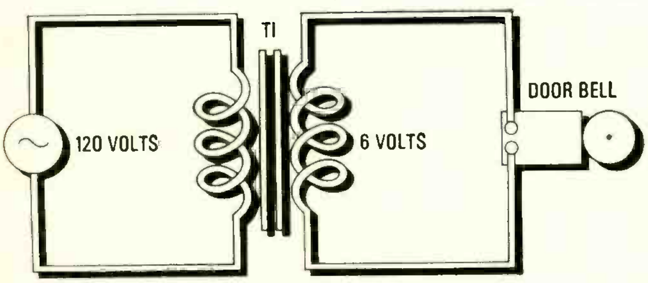
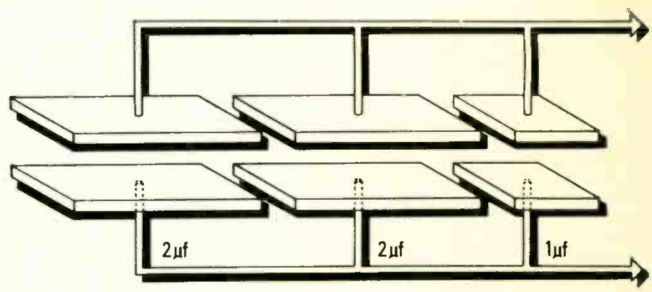


In this door bell circuit, which kind of transformer is T_1 —step-up or step-down?

Note: if you had completed only the first lesson of *any* of the RCA Institutes Home Study programs, you'd easily solve this problem.

This one is more advanced.



What is the total capacitance in the above circuit?

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5 µf

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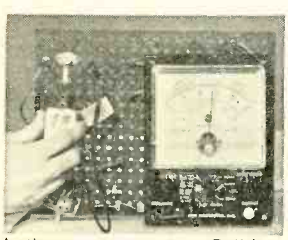

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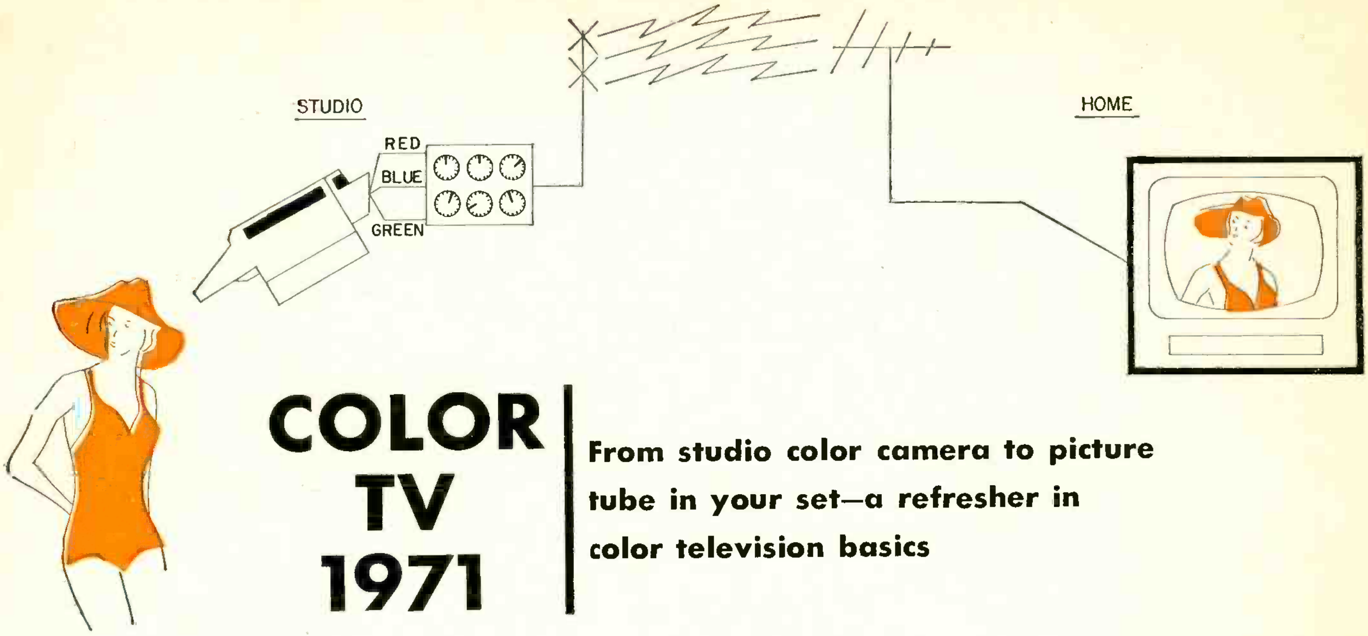


COLOR TV 1971

From studio color camera to picture tube in your set—a refresher in color television basics

How COLOR TV Works

by WAYNE LEMONS

THIS IS NOT AN IN-DEPTH STUDY OF ALL the complexities of color TV broadcasting and reception, but rather a review of the information every technician should know.

So let's start where the picture starts, in the TV studio. Figure 1 is a block diagram of a camera chain. This is a 3-tube camera (some cameras have 4, one for black and white and 3 for color). The scene to be televised enters the camera lens, and following this the scene is "separated" into the basic primary light colors of red, green and blue. The output of the camera tubes are mixed (engineers call it matrixing) 59% green, 30% red and 11% blue. This mixture produces an output which is the same as a black and white camera tube would produce. This mixture is called "Y"; it corresponds to a normal monochrome signal and is used to modulate the TV transmitter so that black and white sets can receive a color picture (in black and white of course).

The next step is to add color without increasing the bandwidth of the transmitted signal or interfering with the luminance (brightness) information. Analysis of a b-w signal proved that, although the brightness information extended up to 4.5 MHz, all the energy was concentrated in narrow-band clusters centered around harmonics of the frame frequency (30 Hz) and the line frequency (15,750 kHz). The best color transmission (compatible with b-w) could be obtained by using the chroma information to amplitude modulate a subcarrier placed at about 3.58 MHz above the picture carrier.

Thus color information is obtained by taking the outputs of the red and blue camera tubes and feeding them into another adder or matrix along with a −Y (inverted Y) signal. The output of each adder then goes into a balanced modulator along with the carrier (3.58 MHz). (Balanced modulators suppress the carrier; leaving only the two AM sidebands.) Figure 2 shows a simplified circuit of a balanced modulator. Note that the 3.58-MHz signal input will cause first one transistor to conduct and then the

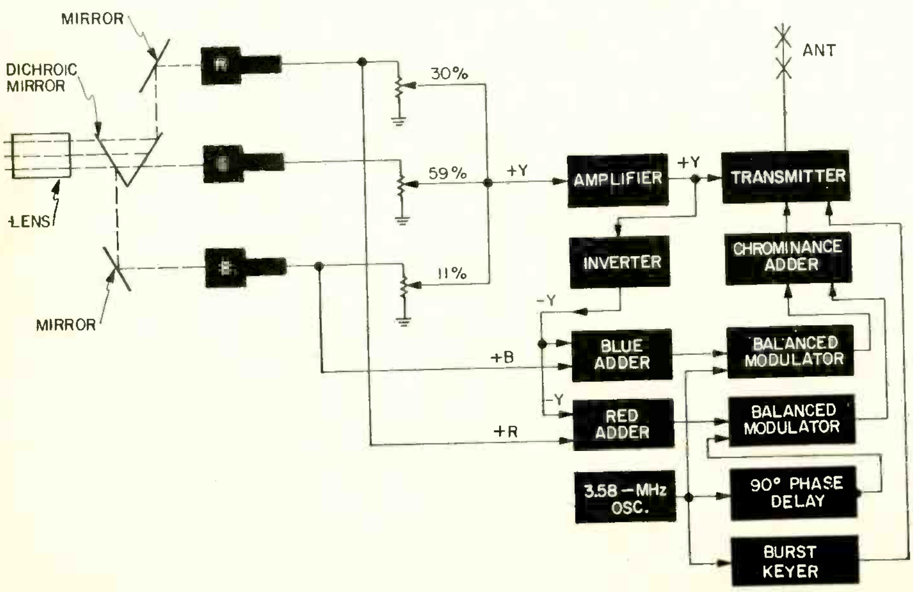


Fig. 1—A SIMPLIFIED BLOCK DIAGRAM of a color camera chain at a TV station for cameras using 3 orthicon tubes.

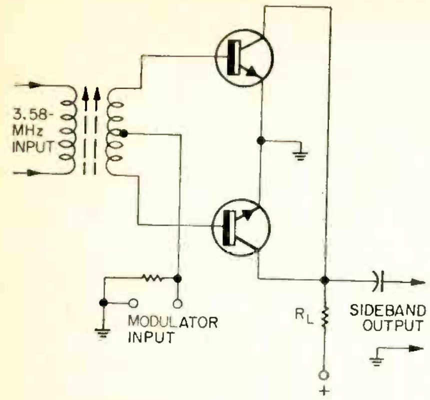


Fig. 2—SIMPLIFIED DIAGRAM of a balanced modulator. With no modulator input the 3.58 signal is cancelled in the output.

other but with the collectors of the two transistors connected together the output across R_L will be zero. Thus with only the 3.58-MHz carrier input there is no output from this circuit. However by inserting modulation at the center tap of the input transformer, whichever transistor is turned on at any given instance can have output depending upon the amplitude and polarity of the modulating signal. The output then is a replica of the input modulation except now it is in 3.58-MHz "steps". In other words, the 3.58-MHz signal has sampled the modulation input at the rate of 3.58 million times a second so that the sidebands have the same dc envelope as before (Fig. 3) except that it has been

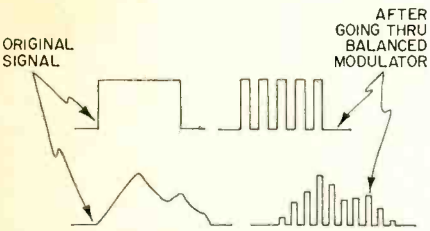


Fig. 3—A DC SIGNAL that has been "chopped" by the balanced demodulator still retains the average dc value.

"chopped" up at the rate of 3.58 MHz.

The advantage of the balanced modulator is that when there is no color there is no carrier signal and the transmitter's modulation is zero in the color channel. The disadvantage of this system is that the 3.58-MHz carrier must be reinserted at the receiver exactly in step with the original. How this is done will be covered a little later.

There are two balanced modulators in the color camera, one for the red and one for blue. The blue modulator has the 3.58-MHz signal fed in with no phase lag while the red modulator has the 3.58-MHz signal input delayed by 90 degrees. Figure 4 shows two identical signals with one lagging the other by a quarter cycle. Note that when the amplitude of one is maximum, the other is minimum; like two switches, one off and the other on. This also means that the two balanced modulators are switching off and on alternately, in others words, one takes a look at the color modulation signal and then the other takes a look.

This gives us two colors but where is green? To find out let's look again at Fig. 1. Note that the +Y signal is inverted making it a −Y and this −Y signal is fed to both the blue

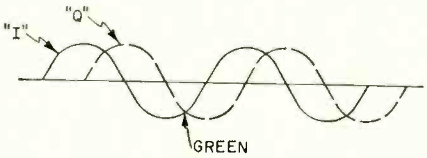


Fig. 4—"I"N PHASE AND "Q"UADRATURE (90°) signals are direct opposites in amplitudes. When one is maximum the other is minimum.

and the red adders so the modulation for the balanced modulator is really not red and blue but rather R−Y and B−Y. And since Y is made up of red, blue and green, it follows that whatever is NOT R−Y and B−Y must be green (G−Y). Take for example a completely green scene being transmitted—the Y output will be green only and the −Y will be the only thing left at the blue and red adders since with a green-only picture the red and blue camera tubes have zero output. Thus the green signal is negative and the only source to both the balanced modulators so green is modulated 180 degrees or on the "backside" of both modulators.

One other thing required of a color transmitter is the *burst* signal. This is an 8-cycle sample of the 3.58-MHz signal. Its purpose is to synchronize the color oscillator in the receiver. The burst is sent on the *back porch* of the horizontal sync pulse (Fig. 5) so that it can't get into the picture and interfere. In the receiver the horizontal sync pulse will be used to key on the burst amplifier so the sample can be retrieved.

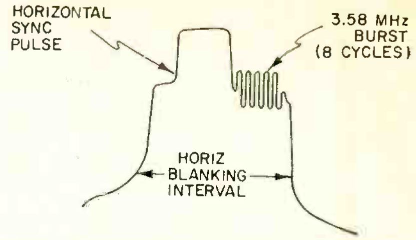


Fig. 5—THE COLOR BURST SIGNAL IS SENT ON THE "BACK PORCH" of the horizontal sync signal.

The exact frequency of the color oscillator (called a subcarrier) is 3.579545 MHz but it is called 3.58 for short. The exact frequency was chosen because (1) it had to be as far from the video carrier as possible to minimize any beats between the two (2) but it had to be low enough so that a 0.5-MHz sideband above would not get too near the 4.5-MHz sound carrier and (3) it needed to be on an odd-harmonic of half the horizontal frequency so that any beat between the color and the horizontal frequency would cause one scan line to go black and the next to go white thus minimizing the noticeable effect of the beat.

The old frequency of 15,750 Hz for monochrome horizontal was changed to 15,734.264 for color and the vertical is no longer at 60 Hz but at 59.94 instead.

A look at the color receiver

The composite color signal having left the transmitter and arriving at the receiving antenna is processed the same as a monochrome signal until it gets to the last i.f. stage (Fig. 6). Two detectors are used in color sets, one for the video or Y signal and the other for the sound (and sometimes sync. Two detectors makes it easier to keep the sound carrier (4.5 MHz) out of the color amplifiers tuned to around 3.58 MHz. The output of the video detector has two color signals, one the burst signal and the other the color sidebands (often called

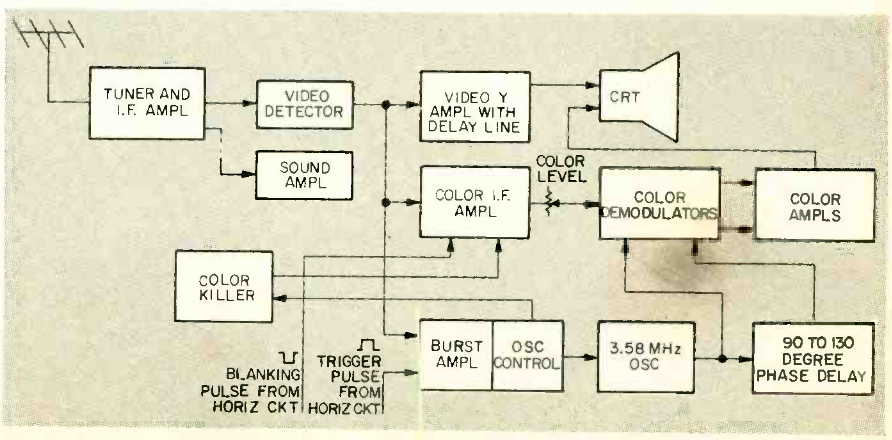


Fig. 6—BLOCK DIAGRAM of the signal portion of a typical color TV receiver.

chroma). Since the burst is on the back porch of the horizontal sync signal, a horizontal pulse is used to turn on the burst amplifier only during the horizontal sync time.

On the other hand, the color amplifiers disregard the burst and accept only the chroma by being turned off during the horizontal sync time. Should the keying pulse for burst amplifier be lost the chroma will be amplified by the burst amplifier and color lock will be lost or very erratic. Should the keying pulse be lost and the burst get into the color i.f. amplifiers it will often cause a faint

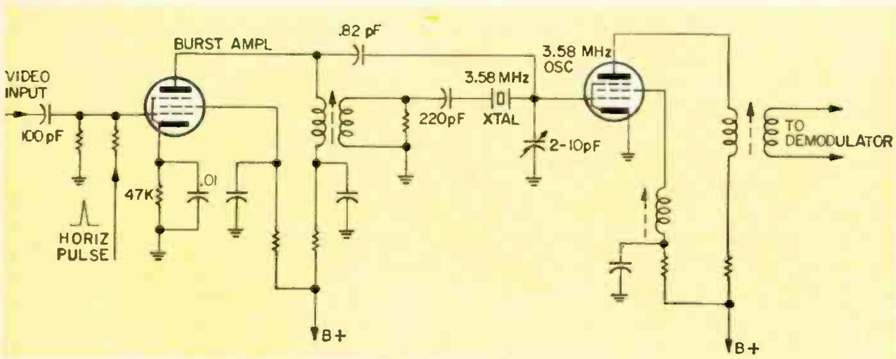


Fig. 7—A DIRECT DRIVE or "brute force" oscillator control circuit used in a color set.

color smear usually green in color but can vary depending upon the receiver.

The burst amplifier

The output of the burst amplifier is used to either directly or indirectly lock-in the color oscillator so that it is exactly in step with the transmitted 3.58-MHz signal. Nearly all early sets used the indirect method with the burst signal applied to a dual-diode phase detector which in turn provided dc control to slow down or speed up the crystal oscillator and keep it in sync.

Another method that has become quite popular because it requires fewer parts is the "brute force" method shown schematically in Fig. 7. Here the 3.58-MHz crystal is driven directly by the output of the burst amplifier and forced to oscillate in step with the burst signal. The 0.82-pF and the adjustable 2–10-pF capacitor are neutralizing capacitors which cancel any burst signal at the oscillator grid.

The color i.f.

The color i.f. amplifier(s) amplify the chroma signal and feed it through a COLOR LEVEL control to the color demodulators. The color i.f. has a bandwidth of around 1 MHz. This comparatively narrow bandwidth "slows down" the color signals so that they would arrive at the CRT slightly later than the Y signal and this would mean that a door post's color for example would be slightly to the right of the Y signal door post. To correct for this all color sets have a delay line in the Y amplifier somewhere between the color takeoff point and the CRT. The delay line slows down the Y signal so color register is perfect.

The color killer

Some sets do not use a color killer but most still do. The color killers job is to prevent colored snow on a monochrome picture. It is triggered directly or indirectly by the burst signal. When a monochrome picture is being transmitted, the killer circuit detects the fact that there is no burst signal and biases the color i.f. amplifiers to cutoff. The reason this is necessary is that even though no color is being transmitted there still can be video or noise at or near 3.58-MHz which would be amplified by the color i.f. chain and cause color snow on the screen.

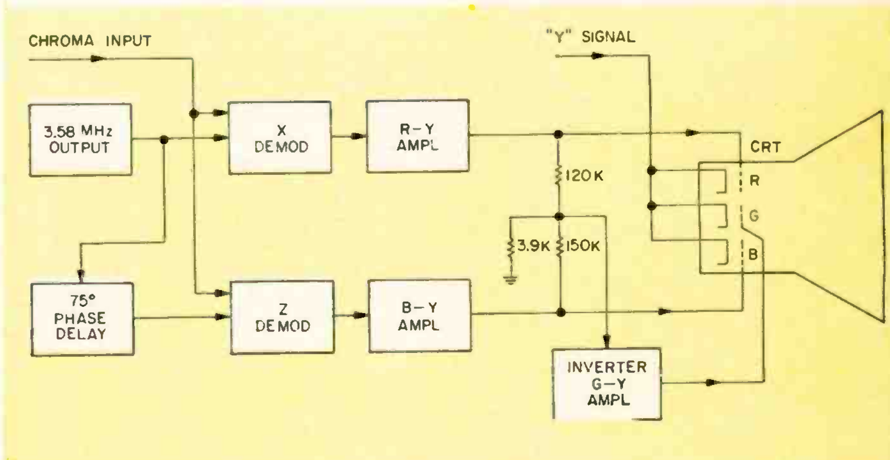


Fig. 8—A BLOCK DIAGRAM of "X" and "Z" color demodulation.

The color demodulator

Color demodulation can be derived in a number of ways. The oldest popular way is as shown in Fig. 8 where the demodulators "looked" at the color sidebands about 75 degrees apart then applied the output to R−Y and B−Y amplifiers. The outputs of the two −Y amplifiers were then tapped off (with a bit more of the R−Y signal than the B−Y signal) and fed to an amplifier (which inverted it) making a G−Y output. The fact that the outputs taken from the −Y amplifiers were unequal had the effect of "widening" the phase angle so that the final result is about 90 to 95 degrees.

Color demodulation like the original color modulation in the camera is a process of electronic switching. It is the process of taking a look in sequence of the red, blue, and green values in the scene. It is a common error to suppose that only two colors are transmitted, actually all three must be in the sidebands or they could not be derived at the demodulators. (At the transmitter the blue camera output modulates the B−Y, after approximately 90 degrees lag the red camera output modulates the same 3.58-MHz signal and approximately 140 degrees later the green camera output is modulated on the "backside" of the blue and red modulation.)

Actually it is only necessary to transmit two parts of a three-part whole if we combine the two outputs to provide the third part. The demodulator in Fig. 8 is a perfect example where the R−Y and B−Y outputs are combined and inverted and presto-chango we have G−Y.

To get a little more technical, the color camera does not transmit any specific color at all. It transmits I the *in-phase* signal, and Q the 90 degree *quadrature* signal (Fig. 9). The color set demodulators are then correctly phased so that the proper colors appear on the screen. It was common practice for color demodulators to demodulate for B−Y and R−Y about 90 degrees apart until a few years ago when manufacturers found that they had less problems with greenish fleshtones if they widened the demodulation angle to about 100 to 105 degrees.

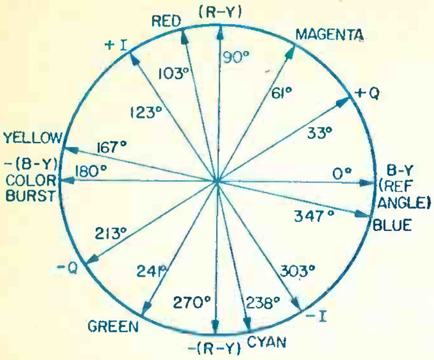
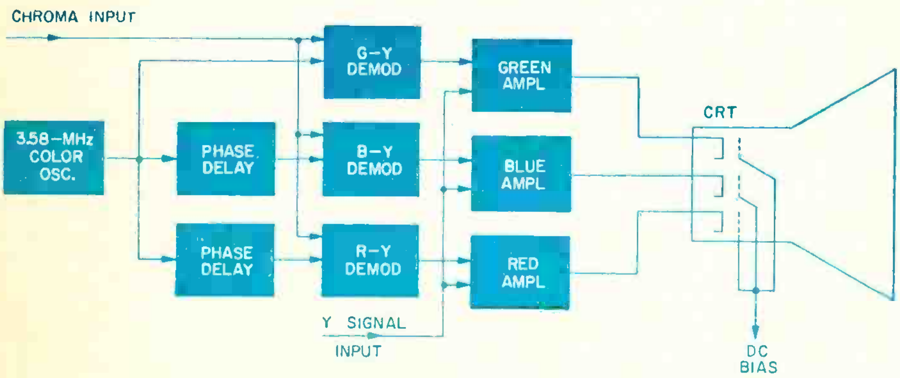


Fig. 9—A COLOR WHEEL SHOWING THE RELATIVE POSITIONS OF COLORS. Any color with a large amount of white is said to have low saturation, if all colors have low saturation then the result is white.

Fig. 10—A 3-DEMODULATOR SYSTEM with the "Y" and color signals mixed prior to the CRT (prematrixing).



Now at least one manufacturer provides a customer preference switch which shifts the demodulation angle to about 132 degrees to minimize the change of fleshtones when switching from one station to another. Obviously this also distorts the remainder of the color spectrum but the fleshtone change is the most objectionable to a viewer because he has a "standard" to go by. Who really knows, unless he is looking at two color sets at the same time and even then he really doesn't, whether a background is greenish-blue or bluish-green and how many really care?

But back to demodulators proper. In the last few years various companies have gone to a 3-demodulator system rather than deriving the G−Y from the output of the other two. This is especially true of transistor sets and sets that use *prematrixing*. Prematrixing is the mixing of the Y and color signals before they reach the picture tube. In the older method the Y signal goes into the cathodes of the CRT and the color signals into the grids and the mix takes place in the CRT itself.

Figure 10 shows the 3-demodulator system with prematrixing. You might question the fact that there is no phase delay between the color oscillator and the G−Y demodulator when the color wheel shows that B−Y is closest to zero degrees. But you have to remember that the color oscillator output circuits are tuned and so the actual phase of the color oscillator output is not the same as the burst input. This makes no difference so long as the two maintain an *exact* phase delay, as in this case where the natural phase delays of the circuit cause a fixed 240-degree phase lag between the burst phase and the oscillator output.

Again, though, this circuit shows that green (G−Y) is actually being transmitted and is in the chroma signal otherwise it could not be derived in the demodulator. It is still the "backside" of the other two signals but the backside in this case is ob-

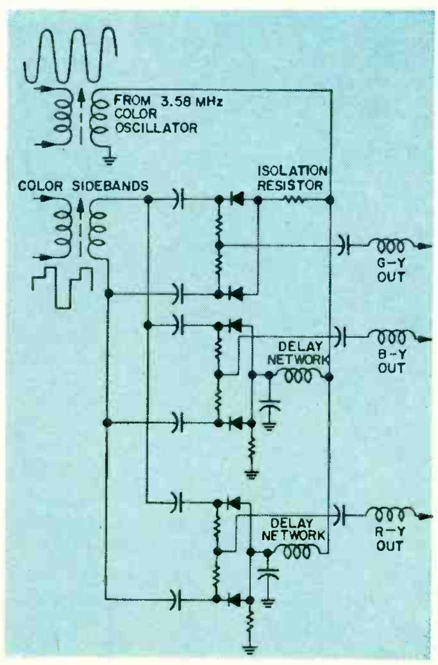


Fig. 11—A COMPLETE 3-DEMODULATOR dual-diode color demodulator.

tained simply by delaying the phase of the color oscillator output.

Figure 11 is a complete 3-demodulator circuit using diodes. Note that the circuits are identical except for the delay network. An interesting feature of this demodulator is that, like the balanced modulator discussed earlier, the 3.58-MHz signal is cancelled in the output. When the 3.58-MHz signal goes positive the diodes are both turned on but the output so far as the 3.58-MHz signal is concerned is zero since the output comes at the center tap of two identical resistors. The color sidebands (chroma) produce an output because they are fed 180 degrees out of phase between the two diodes. In other words, the output is again a dc replica of the input at the color camera.

In summary, color transmission is simply a black and white transmission with the color signals switched in at a 3.58-MHz rate to "paint" the large and medium size areas of the black and white picture since our eyes cannot discern color in small detail parts of the picture. The 3.58-MHz "switch" is recreated at the receiver and locked in the transmitter "switch" by the burst signal. The transmitter switch is called a modulator and the receiver switch a demodulator. The tint or hue in the color receiver can be changed by changing the phase relationship (at what specific time the 3.58-MHz switch looks at the color sidebands) between the burst and the receiver color oscillator, thus a HUE or TINT control is simply a phase changer. The relationship of the colors can also be controlled.

Figure 12 shows a modification

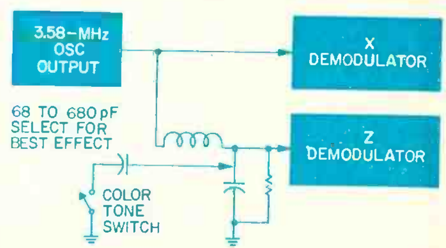


Fig. 12—A CIRCUIT YOU CAN EXPERIMENT WITH in your own color set to give you "automatic" tint correction.

you can make to any set with an X and Z demodulator to shift toward the more "orangey" colors and so keep fleshtones out of the green cast through a wider variation of transmissions from different stations, in other words, the TINT will not appear to need touching-up when you switch between color stations. This circuit can be added to any color receiver by trial and error, while watching the color picture use various size capacitors to change the delay of the color oscillator signal going into the demodulators. In some demodulators you might have to add a capacitor to both phase delay circuits. Keep the leads fairly short to the switch but because of the low impedance of the circuit lead lengths of one foot or less will not generally cause any problem. Do not use coax lead since you will not be able to "switch out" the capacitance of the lead itself. **R-E**

COLOR TV 1971

New color TV sets do not present a radiation hazard. They include circuitry that makes excessive x-rays impossible. Older sets radiate excessive x-rays only when misadjusted—high voltage too high, bad regulator or hv rectifier, or the high voltage cage not closed. When servicing a color set be sure to check these points.

BUILD $40 X-RAY DETECTOR

check color sets accurately

by **RICHARD K. STOMS & EDWARD KUERZE***

Three simple circuits for detecting color-TV x-rays with a thin-wall Geiger-Mueller counter are described. The first instrument presents visible and audio outputs that represent the detector counting rate. It costs about $40 to build. The second includes a count-rate meter. A manually switched and electronic-oscillator high-voltage power supply are described. A simple circuit and count-rate calibration of the metered circuit are included. All circuits are easily built from commonly available components.

There are several ways to measure x-rays radiating from color TV receivers. One of the best from the standpoint of sensitivity and economy uses a Geiger-Mueller (G-M) tube as the sensing device.

The G-M tube instrument consists of three basic sections—the sensor, high-voltage supply, and readout. G-M tubes have a cathode, anode, and are gas filled. The gas is usually a mixture of a noble gas (argon or helium) and a quenching gas such as alcohol vapor or one of the halogens.

When a positive voltage is applied to the anode, the electric field is highest around the thin-wire anode and decreases rapidly as the distance from the wire increases. The high electric field gradient around the wire permits operation in the Geiger region, with a lower applied voltage than with a thick-wire anode.

Geiger operation

Ionizing radiation, such as x-rays and cosmic rays, enter the tube, and a small percentage react with either the tube wall or the gas to produce free electrons in the gas. As the voltage on the anode is raised from the cathode voltage, some of the free electrons collect on the positive anode and some recombine with gas molecules. As the anode voltage is increased further, more electrons collect and less recombine.

If the voltage is raised still higher, a point is reached where the electrons are accelerated to a high enough velocity to knock electrons (secondary electrons) from the gas molecules with which they collide. Thus, more electrons are collected than were originally produced by the radiation. At an even higher voltage, the electrons reach such high velocities that they cause many secondary electrons, which are in turn accelerated to high enough velocities to produce even more electrons.

As a result, an avalanche of electrons is formed and the tube is said to be operating in the Geiger region. The final number of electrons collected is approximately a constant and independent of the number and energy of the original electrons produced by the radiation. It depends only upon the applied voltage within the Geiger region.

The quenching gas causes the tube to revert to its previously de-ionized state after the avalanche occurs.

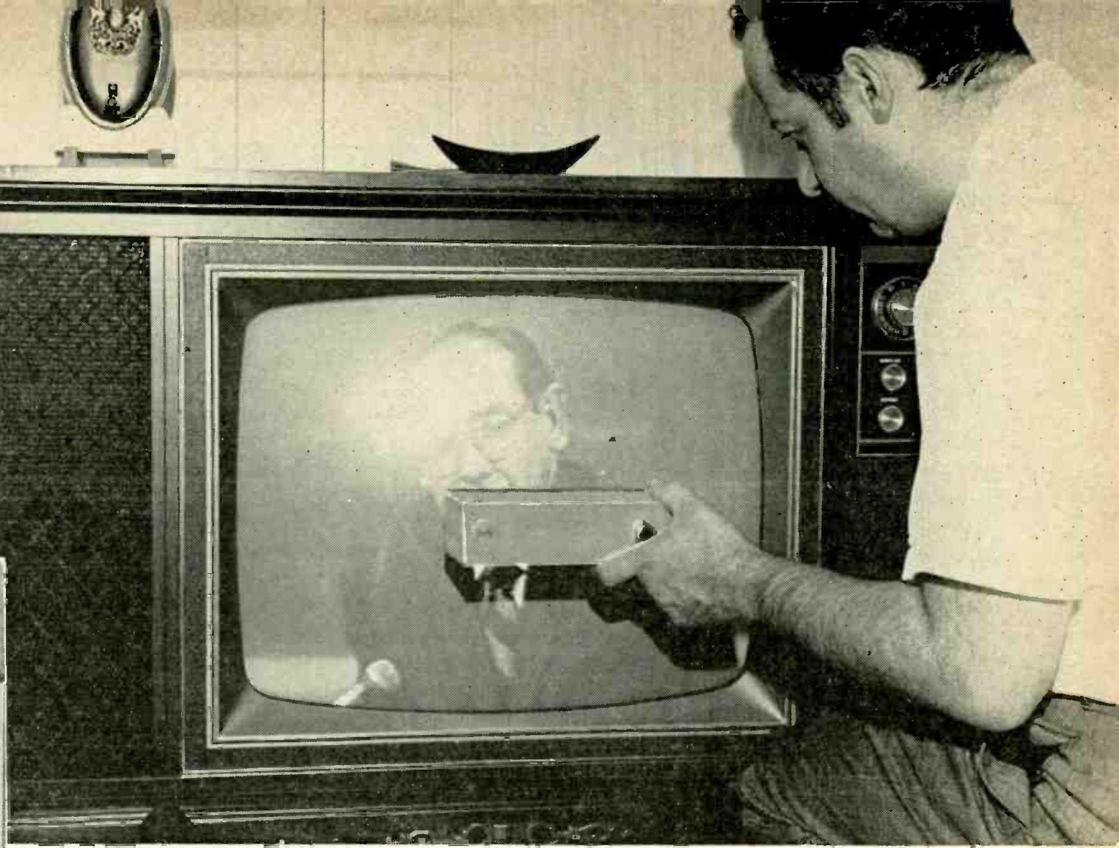
Circuits for detecting x-ray emission from television receivers have been designed with low cost and ease of construction as criteria. The Geiger tube chosen for the instruments described here is the Victoreen 1B85 which is available from a number of supply houses (about $18). The 1B85 was selected because of its thin-wall construction which permits detecting low-level radiation.

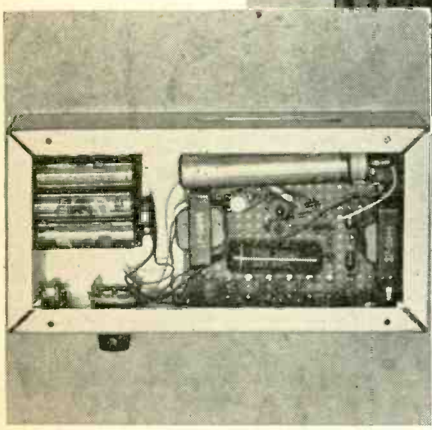
The high-voltage supply for the 1B85 should provide between 800 and 1000 volts dc. The current required from the power supply is minimal. A 0.047-μF capacitor charged to 900 volts will operate the G-M tube for more than an hour at normal background count rates. The high-voltage supplies for the meters described do not have to be highly regulated since the variation in the counting rate expected from the lowest to the highest voltage over which the tube will operate is only 5% or 6%. However, some form of regulation is provided to prevent a catastrophic overvoltage which could destroy the G-M tube.

The transformer and other components for the power supply are rather common. A wide variety of filament, output, or interstage transformers will work. Regulation is provided by a series string of low-cost NE2 neon lamps. The readout can take many forms—lights, audio, or meters.

Any of the instruments described here will determine whether a color TV receiver is emitting x-rays and indicate in a general way, the source of the x-rays (picture tube, high-voltage component, etc.). In all known cases of x-radiation, the emissions could be

*Public Health Service
Bureau of Radiological Health





CHECK THE FACEPLATE for x-rays too. Scan the entire front of the screen slowly. At left is a closeup of the detector. This set had no x-ray problem.

reduced to near zero by high-voltage adjustments to manufacturers' specifications; by replacing either the high-voltage rectifier or shunt regulator tubes, or in a few cases by replacing the high-voltage cages or covers which had been left off. These instruments will determine whether or not a color TV is emitting significant radiation and whether or not repairs have eliminated that radiation.

Since detecting significant x-ray radiation rather than an accurate determination of x-ray exposure is our goal, a meter readout is not necessary. Using headphones or an indicator lamp, the average background count rate will range between 40 and 150 counts per minute, depending upon geographic location, elevation and the possible presence of slightly radioactive materials.

An x-ray field of 0.5 mR/hr produced by a shunt regulator or high-voltage rectifier tube will produce a count rate of about 4000 counts per minute. It is therefore obvious when a TV is emitting x-rays. Any vast increase in count rate when checking the receiver is the tipoff.

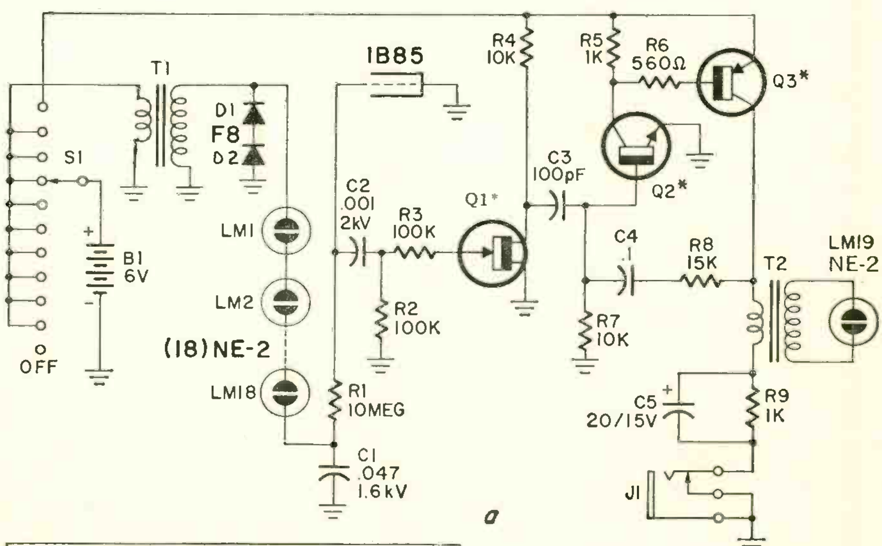
Counter circuit 1

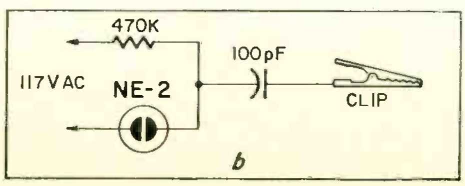
A very simple instrument is shown in Fig. 1. High voltage is developed by repetitively operating switch S1. Several operations of S1 will charge capacitor C1 to its terminal voltage. Once C1 is

PARTS LIST (Fig. 1)

All resistors ½-watt 10%
R1—10 megohms
R2, R3—100,000 ohms
R4, R7—10,000 ohms
R5, R9—1000 ohms
R6—560 ohms
R8—15,000 ohms
C1—0.047 μF, 1600 V
C2—0.001 μF, 2000 V
C3—100 pF
C4—0.1 μF
C5—20 μF, 15 V
D1, D2—F8 (Sarkes-Tarzian)
Q1—2N5457 (MPF 103) or 2N4221 (Motorola)
Q2—2N635A, 2N697, 2N706, 2N1605, 2N3567, 2N3646, or 2N5133
Q3—2N404, 2N414, 2N652, 2N741, 2N1038, 2N1193, 2N3133, 2N3638, 2N3645, 2N5140, or MA206
T1—Filament transformer; 6.3-volt secondary. (Allied 54-1416, 54-1449) or input transformer 100/98,500 (Triad A-1X)
T2—same as T1 plus input transformer 10,000/2000 (Calectro D1-719) (Lafayette 99-6124)
LM1 to LM18—NE-2 neon lamp
LM19—NE-2 or NE-51 neon lamp
S1—any 3 to 11 position switch, make before break
BATT—6-volt (4 AA cells)

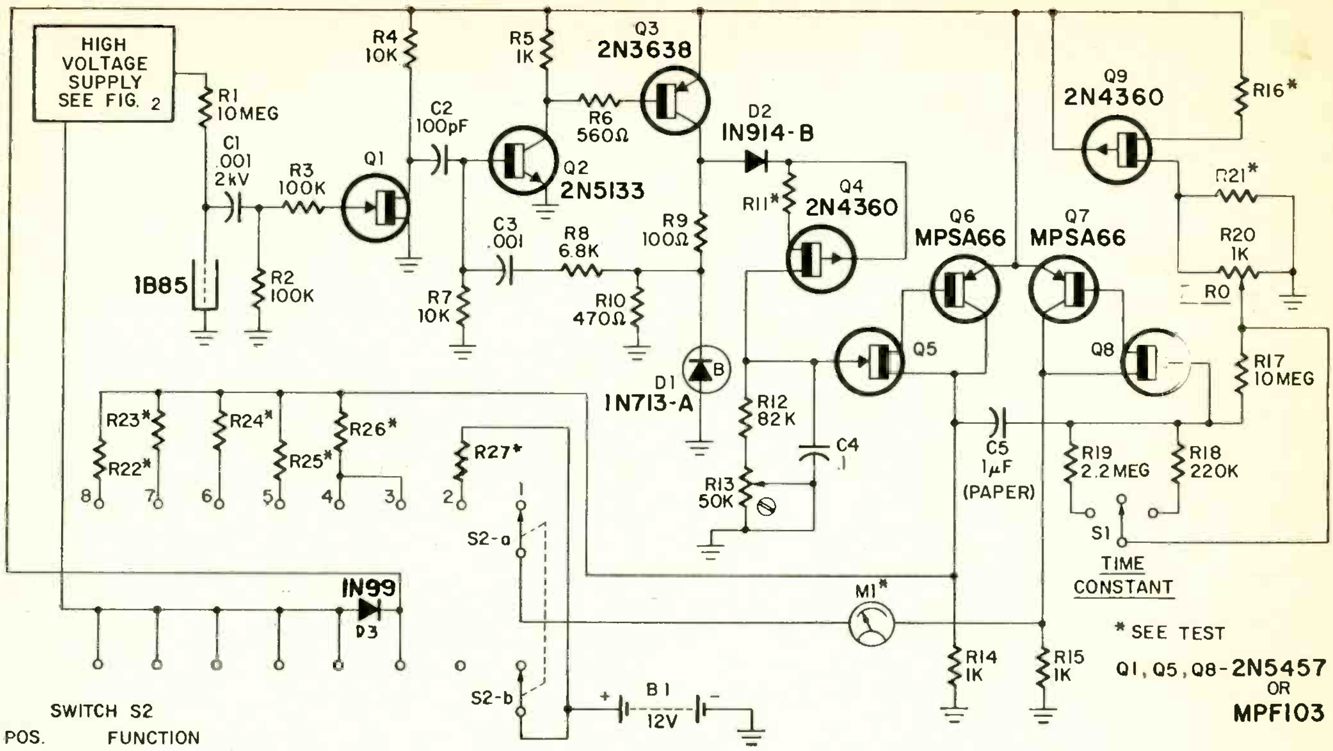
An etched and drilled circuit board for this circuit, made of G-10, is available. The price is $5.50 postpaid. Order board RE-1B71 from Photolume, 118 E. 28 St., New York, N.Y. 10016





* SEE PARTS LIST

FIG. 1—SIMPLE RADIATION DETECTOR can be built for less than $40. Neon lamps provide overvoltage protection.



SWITCH S2

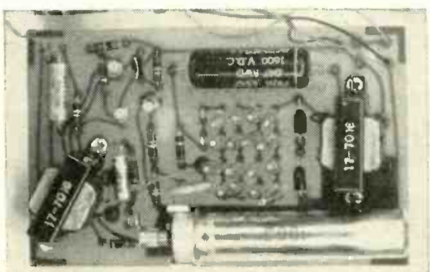
POS.	FUNCTION
1	OFF
2	BATT TEST
3	ZERO METER
4	1,000 cpm
5	3,000 cpm
6	10,000 cpm
7	30,000 cpm
8	100,000 cpm

PARTS LIST (Fig. 3 above)

All resistors ½-watt 10%
R1—10 megohms
R2, R3—100,000 ohms
R4, R7—10,000 ohms
R5, R14, R15—1000 ohms
R6—560 ohms
R8—6800 ohms
R9—100 ohms
R10—470 ohms
R12—82,000 ohms
R13—potentiometer, 50,000 ohms
R17—10 megohms
R18—220,000 ohms
R19—2.2 megohms
R20—potentiometer, 1000 ohms
R11, R16, R18, R19, R21 to R27—see text
C1—0.001 μF, 2000 V
C2—100 pF
C3—0.001 μF
C4—0.1 μF
C5—1 μF, paper
D1—1N713A
D2—1N914B
D3—1N99
Q1, Q5, Q8—2N5457 (MPF103) (Motorola) HEP-801 (Motorola)
Q2—2N5133 (Fairchild) HEP-10 (Motorola)
Q3—2N3638 (Fairchild) HEP-52 (Motorola)
Q4, Q9—2N4360 (Fairchild)
Q6, Q7—MPS A66 (Motorola pnp Darlington
S1—spdt center-off toggle
S2—2-pole 8-position rotary

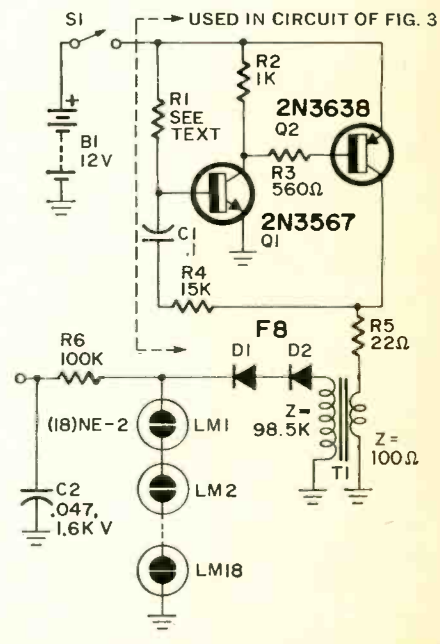
PARTS LIST (Fig. 2 right)

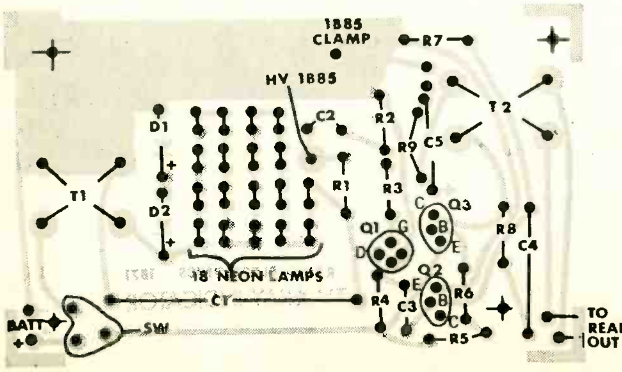
All resistors ½-watt 10%
R1—see text
R2—1000 ohms
R3—560 ohms
R4—15,000 ohms
R5—22 ohms
R6—100,000 ohms
C1—0.1 μF
C2—0.047 μF, 1600 V
D1, D2—F8 (Sarkes-Tarzian)
Q1—2N3567 (Fairchild)
Q2—2N3638 (Fairchild)
LM1 to LM15 or LM18—NE-2 neon lamp
T—100 ohms/98,500 ohms (Triad A-1X)
BATT—12 volts

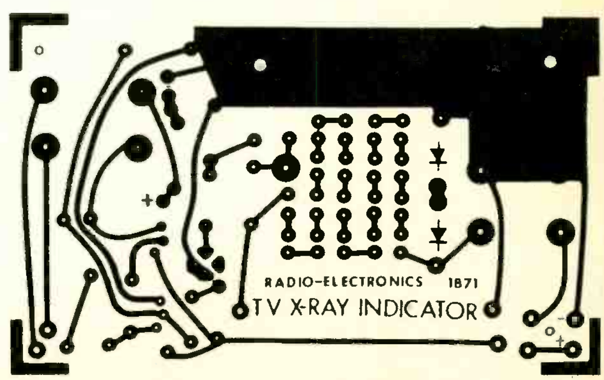


PRINTED-CIRCUIT BOARD for the detector is shown below. Foil pattern (right) is half actual size. Parts layout is at the left. A photo of the assembled board is shown above.

FIG. 3—(top of page) ACCURATE DETECTOR uses meter to give exact readout figures. FIG. 2—(below) HIGH-VOLTAGE multivibrator circuit is used in Fig. 3 and can be added to circuit of Fig. 1 to replace charging switch S1.







charged, it will operate the 1B85 for about an hour at background rates and for more than ten minutes at 4000 counts per minute. This allows ample time to check a color TV for x-ray emission.

Phasing of transformer T1 must be set so when S1 is operated, the increasing current in the primary (low turns side), which occurs each time the wiper makes contact, induces a negative voltage at the high side of the secondary. This forward biases D1 and D2 which clamp T1's secondary to ground, and no voltage appears across the NE2 lamps. When the wiper moves off a contact, current is suddenly cut off, producing a high positive voltage at the high side of the secondary. D1 and D2 are now back biased and the positive voltage is applied to the NE2 lamps. Note that S1 can be any type of rotary switch that has a break-before-make action. Rotating S1 alternately closes and opens the primary circuit of T1. An 11-position single-deck switch is desirable, although any number of positions will work, S1 should never be left in an intermediate position or T1 primary current will flow continuously and rapidly discharge the batteries.

The voltage from T1 will cause conduction in the string of NE2 lamps. Current through the lamps charges C1. When C1's voltage is below the extinguishing voltage of the NE2 string, C1 will charge with every pulse. However, when C1 is charged to about the extinguishing voltage, the next pulse will charge it above this voltage. Then, C1 will charge to a higher voltage during the pulse and then discharge back through the NE2 lamps until their extinguishing voltage is reached. Thus, the terminal voltage on C1 is determined by the extinguishing voltage of the NE2 lamps.

When selecting a transformer, set up the high-voltage circuit shown. An acceptable transformer will produce noticeable flashes in the NE2 lamps every time S2 is rotated. If no flashes occur, either the primary or secondary leads should be reversed. Also, to provide some safety margin, use 18 NE2 lamps when selecting a transformer.

D1 and D2 are rated at 800 volts piv. They are avalanche protected, which is a must in this circuit. The voltage appearing across the combination is approximately the voltage on C1 (about 900 volts) plus the voltage required to ignite the NE2 string (about 1100 volts). This adds up to about 2000 volts.

As mentioned above, 18 NE2 lamps are used to select a transformer. Provide space on your circuit board for 18 lamps. The exact number used in the final circuit will depend on the specific lamps you use. A method for selecting the final number of lamps is described later.

Neon lamp selection

High voltage is applied to the 1B85 through anode load resistor R1. Its value is not critical, and any resistance between about 1 megohm and 10 megohms can be used. The signal produced by a Geiger discharge at the 1B85 anode is a negative pulse. Its amplitude and width are primarily functions of the high voltage, load resistor, coupling capacitor, and following-stage input impedance. Typically, it is about 2 volts peak and 20 μsec wide with the values shown.

Q1 is an amplifier that increases the signal level and inverts the pulse to drive monostable multivibrator Q2 and Q3. An FET in this stage is not mandatory, although it does do a good job. A standard bipolar transistor, properly biased and with an adequate frequency response will work in place of an FET.

Q2 and Q3 form a one-shot or monostable multivibrator. Normally, R7 causes Q2 to be cut off, so the voltage drop across R5 is zero. This, in turn, causes Q3 to be cut off. A positive pulse at the base of Q2, derived from Q1, will start to turn Q2 on. The falling voltage at the collector of Q2, and hence at the base of Q3 will start Q3 conducting. The increasing voltage at Q3's collector is coupled to Q2's base through R8 and C4, which further tends to cause Q2 to conduct. This positive feedback action causes Q3's collector current to increase rapidly and remain until C4 becomes fully charged and positive feedback action stops. This makes Q2 and Q3 revert to the nonconducting state. The magnitudes of R7, R8, C4, and collector load of Q3 will determine the output pulse width.

A neon lamp and an earphone are shown in Fig. 1 for readout. Either or both may be used. Transformer T2 is any one of a large variety of types. The earphone is a low-impedance unit. Most speakers will also work well.

Circuit number 2

For those who prefer not to operate a switch to obtain high voltage, the circuit in Fig. 2 will be useful. Free running multivibrator Q1 and Q2 is quite similar to the one-shot multivibrator in Fig. 1. The only difference is that R7 in Fig. 1 is deleted and replaced by R1 in Fig. 2. R1 is selected so Q1 conducts slightly. This slight conduction sends a signal through Q1's collector to Q2's base and then through Q2's collector back to Q1's base. This positive feedback turns Q2 on hard until C1 is fully charged and positive feedback stops. Now Q1 and Q2 turn off and the cycle repeats. On and off times of this circuit are not necessarily equal. With a fixed C1, the ON time is determined primarily by R4 and the repetition rate by R1. The transformer is more critical than the one in Fig. 1 because Q2 cannot interrupt current as quickly as a mechanical switch nor can it supply as much current to the transformer as the switch.

All circuits (Fig. 1, Fig. 2, and Fig. 3) should be enclosed in and grounded to a metal box since they are sensitive to electromagnetic fields, especially those caused by the horizontal output circuit of a TV. Cut a rectangular hole in the side of the box so the G-M tube is exposed. This hole should be 2¾" x ¾". If any rf sensitivity is noticed, cover the hole with one layer of aluminum foil glued in place. Obviously it is best to keep the high-voltage section as far from the input circuitry as possible.

We mentioned earlier that the circuit board should provide for 18 neon lamps. The high-voltage circuit should work with all 18 lamps in series. The G-M tube should not be connected to the high voltage at this time. First, short out 5 of the lamps with a jumper so that 13 lamps are left in series. Now insert the G-M tube and turn on the circuit (operate S1 in Fig. 1). The high voltage should be too low, and there will be no output from the counter. Now turn the unit off and reconnect the jumper so 14 neon lamps are connected in series, and turn the unit back on. Continue this procedure, adding one more lamp to the series string at a time, until an output indication is obtained from background radiation. You may have to wait about 15 seconds to determine if the counter is woking since the background rate is low and random. Add one more neon lamp in series after counting starts.

One word of caution. Do not short the high-voltage capacitor when it is charged and transistor Q1 is in the circuit. The resulting sudden change in voltage can damage the gate of Q1. Remove the transistor or connect a lead from gate to ground when working on the high-voltage circuit.

Circuit number 3

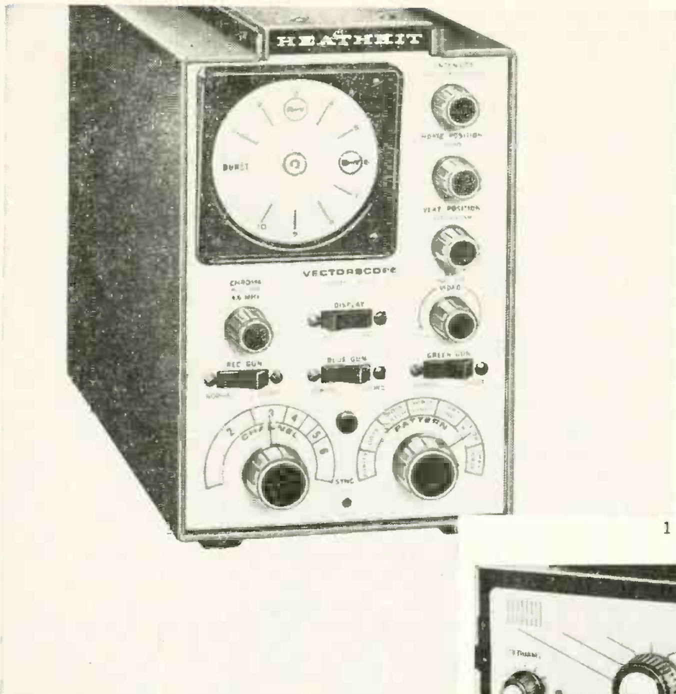
This circuit (Fig. 3) delivers more accurate measurement of the G-M tube counting rate than the counter in Fig. 1. The power supply of Fig. 2 is used to generate the high voltage. Transistor Q1 and multivibrator Q2 and Q3 are as previously described except for a change in Q3's collector circuit.

In operation C4 is charged by current pulses through Q4. Each pulse from the G-M tube results in a constant-amplitude constant-width current pulse into C4. R13 is used to adjust the voltage output.

The selection of meter ranges depends upon the intended use of the instrument and on the meter movement selected. For example, if full scale ranges of 1000, 3000, 10,000, 30,000, and 100,000 counts per minute are desired, the total range is 100 to 1. If a 50 mV meter movement is available, the upper voltage to be delivered by the integrating circuit and voltmeter circuit is 5 volts, which is well within their capabilities. A 100-mV movement would require a 10-volt upper range which would be obtained by an 18-volt supply voltage to the multivibrator, integrating circuit and voltmeter circuits. Meters with a higher mV requirement would necessitate restricting the ranges or arranging to switch in various values for R12 and R13 (or alternately R11).

The instrument is calibrated in counts-per-minute, by disabling the high voltage or by removing the G-M tube. Resistors in the meter circuit are then selected to provide full-scale meter readings for the desired set of full-scale input voltages at Q5's gate (e.g., 0.050,

(continued on page 79)



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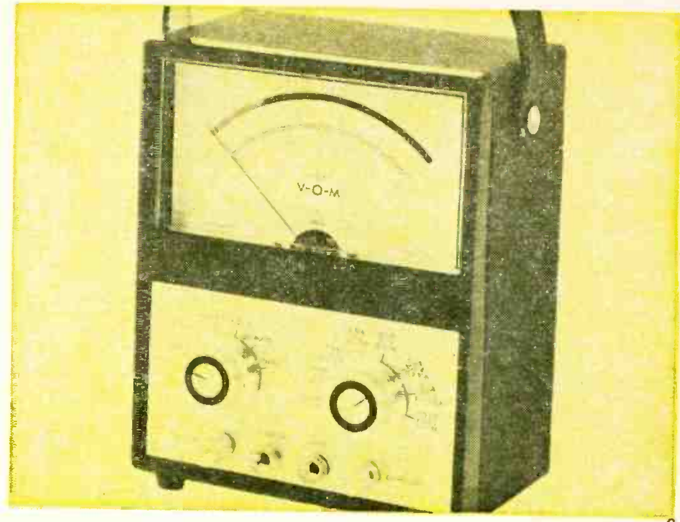

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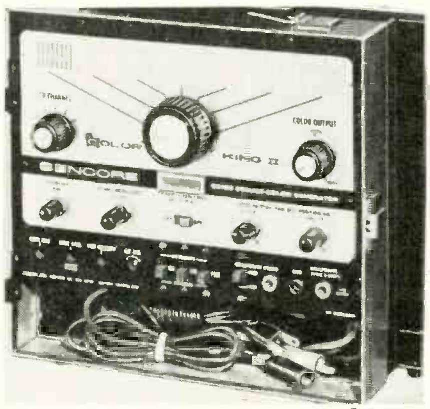
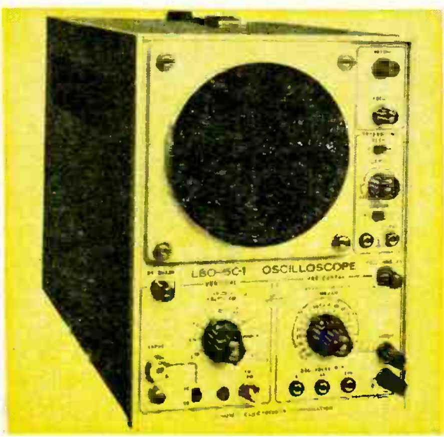


3

TEST FOR

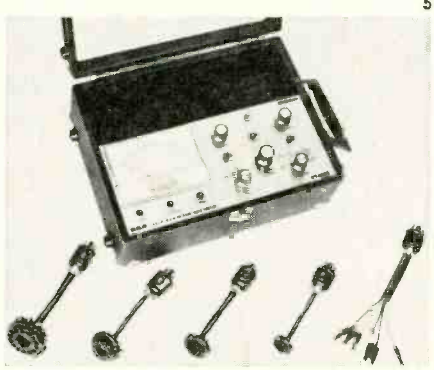
What you



4

Instruments on this page are: 1) Heath IO-101 Vectorscope. 2) Delta 3000 FET Voltohmmeter. 3) Sencore CG153 Color Generator. 4) Leader LB-501 Scope. 5) RCA WT-509A Color CRT Tester. 6) EICO HVP-5 High-Voltage Probe. 7) B&K 1246 Digital Color Generator.

5



6

7

EQUIPMENT COLOR

need and how to use it

By JACK DARR
SERVICE EDITOR

THERE ARE TWO MAJOR CLASSES OF TEST EQUIPMENT THAT ARE absolutely essential for all color TV work. The first class comes in only one model; it comes in a great many different shapes and sizes. The color makes no difference. Fig. 1 is a typical example. Every technician should have at least one.

The second class of test instruments are housed in metal boxes. They are used to augment the somewhat feeble sensors of Fig. 1. Their indications are normally fed in through the eyes, although the ears are used in some cases, as well as the nose. (This last is often useful for finding burnt out power transformers, etc.)

The basic method

There's a very simple, basic method for using your head. The trouble symptoms are observed, your brain puts them all together and feeds out a "hypothesis", as to the location of the trouble. The physical instruments are then used to make various tests to check this hypothesis and find out if it is correct. (Hypothesis is of Greek origin and means "A theory imagined or assumed to account for what is not yet understood." Shortform is "guess"!)

If the instrument readings agree with the hypothesis, then it shapes up and becomes a "diagnosis". (The Greeks had a word for this too: "to ascertain from symptoms the true nature of the trouble", or "to find the true cause".) If the instrument readings do not agree with the original hypothesis, it is cheerfully discarded and a new one worked up which fits the observed facts. This is the point where the blue mud makes most of its mistakes; it insists on staying with the original hypothesis. Always be quick to pitch out an unproven hypothesis and build up a new one!

Since practically all technicians have at least one Class 1 instrument, we'll spend most of the time discussing the many different kinds of No. 2's, and how they can help solve the many problems found in color TV repair work.

Inputs and outputs

Basically, color TV test equipment can be divided into two classes, which could be called "INPUTS" and "OUTPUTS". The INPUTS are signal generators. They feed in test signals, so that we can have a known and controllable source of test signals to measure the performance of any circuit.

The OUTPUTS are just that. With a known test-signal input, we should have a certain output from any circuit being tested. By reading the signal input and output, we can tell rapidly whether this circuit is working or not.

For all color TV work, the color bar generator is probably the single most versatile instrument. It delivers an input signal which will produce a color bar pattern on the screen of a working TV set. If this pattern doesn't come through, we know that there definitely is trouble and we set about finding out where it is. There is one other signal-generator which is very useful, but it is discussed later.

For reading outputs, the scope, is most versatile. It will not only display the waveform of any signal, but will also tell us whether its amplitude is correct. So it tells us whether a given stage has the right amount of gain.

This input/output test should be the first step in any diagnostic procedure. If the signal doesn't get through a certain stage, then we lay down the scope probe and use the second most useful instrument, the vtvm. (In this article, "vtvm" means any very high impedance voltohmmeter—tube or solid-state unit.) With it we read the "operating values" around the faulty stage; dc voltages, currents, resistance, continuity, etc. These are the simple things which "gotta be there" before the stage can work and are too often overlooked. (I know of one technician who made several complicated tests around a dead 3.58-MHz oscillator stage, before he found that he'd overlooked a nice simple thing—the tube had no voltage on its screen-grid because the dropping resistor was open! So, don't overlook the simple things—there are a lot more of them than complex ones!

"Comb" out the trouble

The first thing we need to do, in any kind of TV work, is find out "where the signal stops". The typical symptom of this is "no picture—just a blank raster". A less complicated one is "No color, but good b/w picture". With the first, you know that *most* of the set is working. Evidence—you do have a raster, so the dc power supply, both sweeps, etc. are working. Something has broken the *signal-path* between the input (antenna) and the output (picture tube).

In all TV sets this is a *series* circuit (Fig. 2). Now you start the detailed tests needed to find out where the signal stops. It's simple, if you use the right equipment. Feed the color-bar generator into the antenna, tune the set to the right channel and pick up the scope. With it, you can trace the unmistakable "comb" pattern all the way through the set.

In the i.f. stages, use a crystal detector probe. Your pattern will look like Fig. 3. The signal at this point is still rf, so you must provide the detector. After you pass the video detector, you can switch to either a direct probe or low-capacitance type. Incidentally, even narrow-band scopes will show you the typical comb pattern, as in Fig. 4, which is a little blurry but very useful; taken at video detector output with a direct probe. Amplitude at this point should be about 2-3 volts p-p.

From the video detector it is easy to follow the comb all the way through the video amplifier stage(s) to the cathodes of the picture tube. If you do not have black-and-white bars on the screen (minimum), you'll find some point in this circuit which has input but no output. This method is completely universal—it will work on all types of TV set—B/W, tube, hybrid, solid-state, color—they all do the same thing to the *signal*.

"Color-only" problems

For a variation, if you do have bars on the screen, but no color; you can eliminate the first four parts of the circuit immediately. The tuner–i.f.–video detector–video output stages are working. The trouble is entirely in circuits which handle only color signals. This is true in the original color circuit and in later models with "cathode-feed" or "R-G-B" circuitry.

So go straight to the color bandpass amplifier(s). Once again, this is basically an rf signal (3.58 MHz sidebands, AM), so use the crystal detector probe. In a lot of circuits you'll be able to see the pattern with a direct or low-cap probe. Fig. 5 shows a typical comb on the grid of a bandpass amplifier, which is a fairly low level. Fig. 6 shows the pattern on the plate of the bandpass amplifier, also with a crystal probe. This will catch one of the common troubles—if the color-killer is faulty, it will bias-off the 2nd bandpass amplifier, and you'll have input but no output here.

Fig. 1

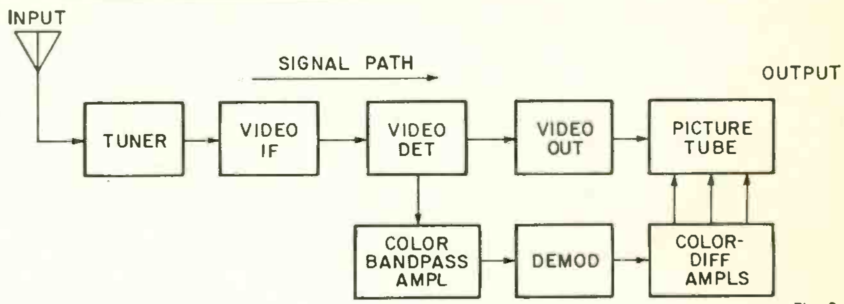


Fig. 2

EMC 116 FETVOM

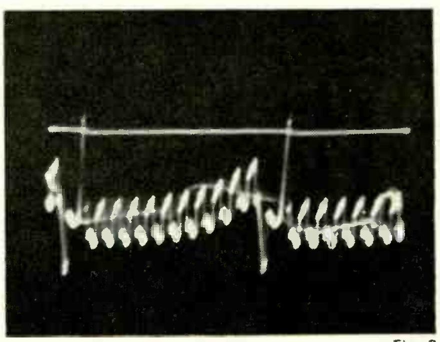


Fig. 3

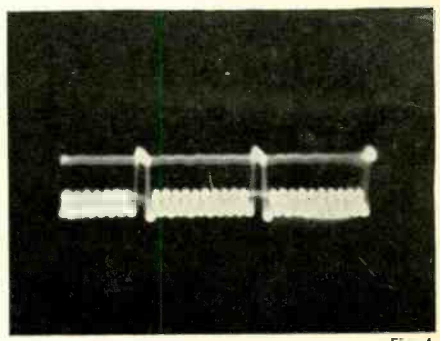


Fig. 4

"Is the 3.58-MHz oscillator working?"

There's a very simple test, in this sequence, for the 3.58-MHz oscillator. Just look at the waveforms on the picture tube *grids*. If you find the same *flat-topped* comb pattern you've been tracing, the oscillator's dead. These must have the characteristic "rocker" shape. Fig. 7 shows the pattern on the red grid, and Fig. 8 on the blue grid. Both of these were taken with a direct probe.

These waveforms will be found on the schematics. Note that on the red grid, the 3rd pip from the blanking is the highest, meaning maximum amplitude. On the blue grid, the 6th pip is highest. You can check these out on the crt screen, too. This waveform can also be used to check demodulator action. Any problems will cause distortion or absence of certain key waveforms, and these are some of them.

To get these, set the scope sweep at 7875 Hz, to display two lines of horizontal signal. As we said before, even the old narrowband scopes will show you this pattern. It may blur, but it will be distinct enough to tell you whether it's there or not! One of the most useful applications of the scope is just that—it will tell you whether there is a signal at a given place or not, and that's what you need to know!

Power supply test instruments

The power-supply section in a color TV chassis provides a lot of the more common troubles. Because of the higher power used, plus the need for HV regulation, and so on, this section must be in perfect shape before we can make any other tests. The right test equipment, properly used, will speed this part of the job.

Three of the instruments are very important—the vtvm for reading dc voltages and currents, the HV probe for reading and adjusting high voltage and focus voltage, and as usual, the scope. The HV probe can be a large multiplier resistor in a special "handle" for use with the vtvm or it can be a special probe type with its own meter. The separate HV probe is very useful, since it can be hooked up, and watched while the vtvm is used to take other necessary readings; for example, adjusting the horizontal efficiency coil.

The very important cathode-current of the horizontal output tube can be read on a special test-adapter. This is much easier than pulling the chassis to disconnect the cathode wire. There are several types, one for each different class of horizontal output tubes. (Some have the cathode on pin 3, others on pin 6, and so on.) You simply pull the tube, plug the adapter in, then put the tube into the adapter. The test leads are then plugged into the vtvm, or, better still, into a separate 0 to 500 dc milliammeter, to free the vtvm for other work.

The scope in power supply testing

The scope is invaluable in power supply testing. Beside smoothing the ac ripple in the dc supply, the filter section has another, and much more important, job. It must provide an absolutely zero-ohms path to ground for all stages in the set, for their power-supply return circuits. Since the power-supply is common to all stages it must get rid of "used" signals by passing them off to ground. If the filter has a "non-zero impedance", these signals will develop voltages across the power supply! These will feed back into other stages, and the result will be the damndest mess of symptoms you ever saw!

Any time you find a color TV with multiple symptoms—two or three different things going on at the same time, look into the power supply. For instance, one set had bending in the picture, vertical shading bars on blank raster, periodic loss of vertical sync, and an intermittent loss of color sync.

Scoping the dc power supply showed the waveform of Fig. 9-a. The 60-Hz ripple here is complicated by the presence of a high *horizontal-frequency* ripple, too. Also, if you look closely near the center of the waveform, you'll see a "notch". On the scope screen this was easy to identify as a vertical blanking pulse! When this got to the vertical oscillator, it cancelled the regular sync pulse, and the picture rolled. Peak to peak voltage of this pattern was over 50 volts. (Normal ripple, almost zero!) Fig. 9-b shows a very similar pattern taken across one of the main filter capacitors in another color set. Here too we see the notch. The widening of the basic 60-Hz ripple trace was again due to the presence of a high horizontal hash, which caused the waveform to jitter so rapidly that the photo is blurred.

However, blurs make no difference in this test! If the scope shows you anything except a nice straight line, look out! Normal maximum ripple in any dc power supply should be not more than about 1.5 volts peak to peak. Anything else means trouble, due to feedbacks. Replace any capacitor that shows this kind of a pattern.

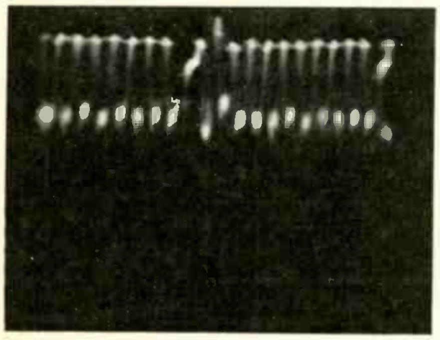


Fig. 5

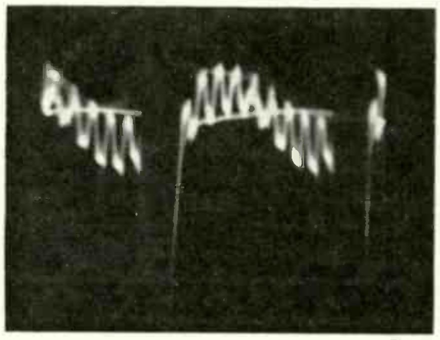


Fig. 7

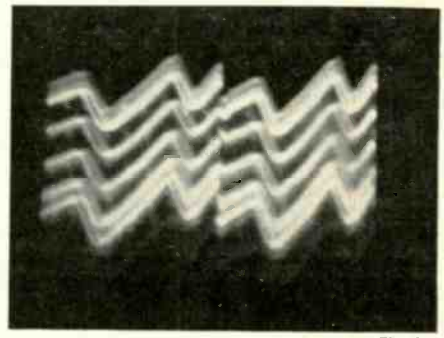


Fig. 9-a

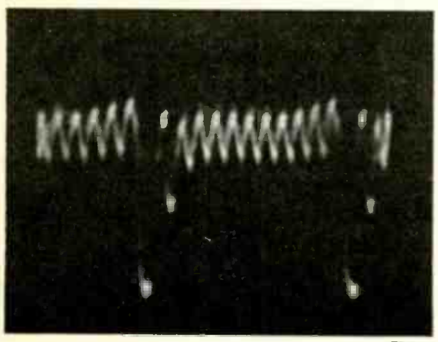


Fig. 6

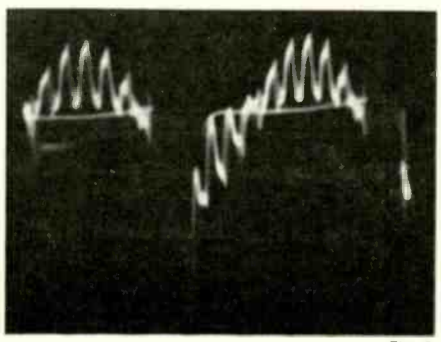


Fig. 8

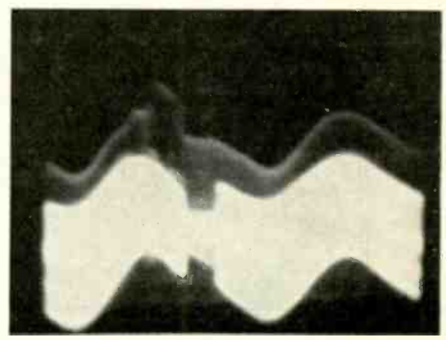


Fig. 9-b

The wattmeter

Shorts or open circuits in the dc power supply can be quickly isolated with a test instrument that can read the input ac power—a wattmeter. By comparing the normal power input as given on the schematic, you can tell instantly what's going on inside. If the reading is 25% or more above normal, there is either a short or a high leakage. If you read 25 to 30% less than normal, you've got an open circuit in a supply resistor to one of the high current stages. This instrument is invaluable when power transformers have been replaced. You can get an instant reading which will tell you whether the short that blew the first transformer is still there or not!

Picture tube or TV chassis?

One of the harder questions to answer, especially in "one-color" problems, or wrong-color trouble, is: "Is this the color picture tube or something in the TV chassis?" Without the right test equipment you can get an expensively wrong answer! Incidentally, the loss of *all* color, with a good black and white raster, is *never* the picture tube! If the tube will make a black and white picture or a white raster, all three guns *must* be good and properly balanced! However, symptoms such as "one color flares up" or "one color missing" can be caused by either the picture tube itself or the TV chassis.

The quickest answer is a good color picture tube tester. With it, you can find heater-cathode shorts in one gun (causes that color to flare up), an open cathode in one gun, (complete loss of that color), and/or very low emission of one or more guns.

With this instrument, low-emission guns can be rejuvenated, singly, to bring their emission up to match the others. If this doesn't give lasting help, a brightener can be used to raise the filament voltage (and cathode temperature) slightly.

If the tube-tester shows that all guns are capable of a minimum, say at least 300-400 μA of emission, forget the tube and start checking the circuits of the TV chassis—CRT screen voltage, grid voltages, cathode voltages, etc. Something is wrong in that area—the chassis isn't driving the tube to normal output.

The hard ones

For those hard-to-pin-down troubles which are centered in or around the picture tube, a CRT analyzer can be a lot of help. It is connected into the circuits between the CRT and its socket. All dc voltages, except the HV, can then be read by setting a selector switch. The current can be read in any circuit, by pushing a button.

With this test you can read and compare the cathode-currents (beam current) of all three guns, and see if they are drawing *enough* current to give normal brightness. Incidentally, only the cathodes should show any current reading at all! The others are all dry circuits; voltage but no current! If you do read current in any of these, such as a grid, this means trouble—probably gas in the tube, or an internal short.

When the CRT tester confirms the diagnosis of picture tube trouble, don't give up—not yet. There are little things that can help a lot. For example, if a picture tube with good emission has a heater-cathode short, you can clear it with a special isolation transformer in the heater circuit. It looks like a standard brightener, but it isn't. It is a two-winding transformer, 1:1 ratio, which does not increase the heater voltage. It isolates the heater from the "ground" or dc voltage applied to the heater to prevent such shorts! (Since it's already happened, we can forget it.)

In "one-gun" troubles which can't be cleared up by rejuvenation a potentiometer which is inserted into the circuit between the G1 and G2 grids of the defective gun and used to balance the bias voltage so this gun will conduct normally. It is installed with solderless connectors, and can be of a lot of help!

The test jig

Color TV chassis aren't too big. However, some come in monstrous cabinets that can be up to nine feet long! Color TV servicing can be a lot easier if you can take only the chassis to the shop and leave that big cabinet at the customer's home.

To operate the chassis on the bench you'll need a test jig, which consists of a cabinet, color picture tube, deflection and convergence yokes, and extension cables to hook up the chassis. A test jig can be used with a great many different chassis. The manufacturers publish a cross-reference guide which gives the make and model number of various sets and the number and type of conversion cables needed to make a particular chassis work on the jig.

Making things easier

There are a lot of small, inexpensive test equipments for color TV that don't look like it. I mean the "little things" that make certain tests much easier, saving a lot of time.

The simplest and smallest of these are "test socket adapters." They make diagnostic testing much faster, since you can read actual socket voltages on any tube from the top of the chassis. The tube is pulled, plugged into the adapter, and put back. You can then read voltages and/or signals on each element. There is a tiny numbered metal tab brought out from each one.

Extension cables are another very useful item. Using them, you can take the chassis out of the cabinet—unplugging the picture tube, yoke, and high voltage lead—and put it on the bench. It can be hooked up and operated, with its own tube, yoke, etc., by connecting them with extension cables. Console cabinets can be left on the floor. These make testing a great deal easier, and faster.

In the big multiple-combination units, radio-TV-phono sets, there is a great deal of "interconnection" between the units. Most of this is done with multi-conductor cables, and (too often) special plugs/sockets. Most manufacturers make up sets of extension cables for their own brand.

You can also buy "universal" extension cables, for all types of CRT's, yokes, and so on. In sets using "Molex" plugs, special cable-sets are now available in radio-TV supply houses.

The vector scope is a most useful instrument for pinning down certain elusive troubles. This is a color bar generator with its own oscilloscope. It displays the ten color bars of the pattern in a "flower" like pattern, as in Fig. 10. Each petal is one of the color-bars, and the gap is the burst.

In the 3-tube (transistor) color difference amplifier circuit, the pattern is read clockwise from the gap. The third bar (red) should be straight up, and the 6th bar (blue) should be at about 90° (straight to right), etc. With this instrument, any odd phasing problems can be quickly checked out. It can even be used to align the color bandpass and/or demodulator stages. This is the *only* test instrument that can read *phase-angles* in color demodulators!

The vector scope can be an invaluable tool for testing and adjusting the ever-more-popular "Automatic Tint Control" circuits. All of these affect the phasing of the color demodulators, in one way or another. Their effect can be seen and analyzed, by looking at the vector scope flower pattern. You can see the bars shift as the atc circuit is switched on and off, and make any adjustments needed.

The vectorscope can be used in the "direct drive" or R-G-B color circuits often found in transistor TV sets. Here, the connections are made to the picture tube cathodes, and the flower pattern is reversed; you count bars counter-clockwise, but the display is basically the same.

Alignment problems

Last, but most certainly not least, we come to something that has bugged a whole generation of TV technicians, even before the advent of color, where it is of far greater importance—sweep alignment. Incorrect alignment can cause a host of problems—washed out pictures, ringing, ghosts, poor color, color smearing—you name it, it's in there somewhere. The "old guys" (self included) weren't too hot on sweep alignment, simply because it was such a long job to get all of the things hooked up and calmed down. It was a long, hard job and we didn't use it as often as we should.

However, there's a whole new "generation" of sweep-alignment test instruments. With them, sweep-alignment is just as simple as hooking up a color-bar generator and looking at the output on a scope! Everything you need, including as many as three separate bias supplies, are all there "in the same box".

These sweep generators have all of the regular swept-signal outputs—rf, i.f., color bandpass, and even the 10.7-MHz for FM i.f.'s. However, instead of the single marker that we had to run up and down the curve, watching the marker generator and the scope at the same time, these instruments have a great many individual, crystal-controlled markers, any or all of which can be displayed on the curve *at the same time*.

In these units, the markers are added to the output after the swept signal has passed through the circuits being aligned. This removes all chance of marker distortion, one of the old head-

(continued on page 83)

SENCORE SM158

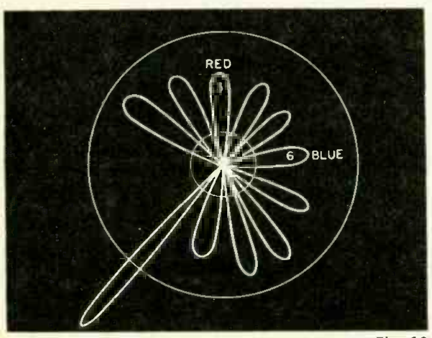


Fig. 10

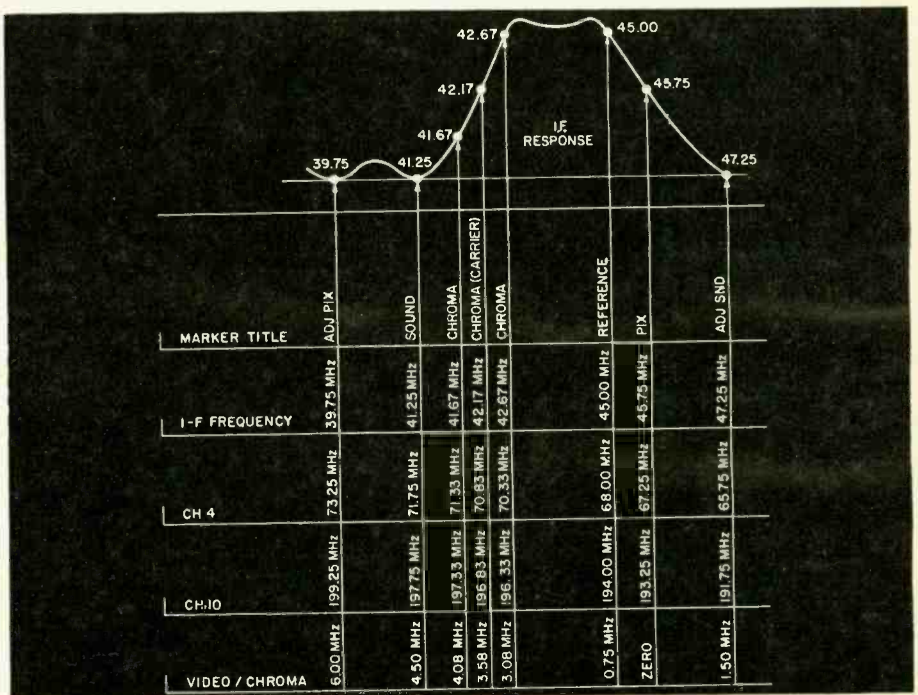


Fig. 11

COLOR TV 1971

PROGRAMMED

by LARRY ALLEN

COLOR TV BY REMOTE CONTROL

Just read each easily digested frame of information. Then test your grasp of it by answering a multiple choice question. If you choose correctly, you're guided automatically to the program capsule. If you miss, don't worry; programed extra information helps you to a correct answer.

1

Remote control for TV sets went through a heyday a few years ago and then faded. But it's back. The popularity of color has revived interest in working the set from across the room.

Remote controls today are more complex than those of yesteryear. For one thing, there are more functions to control. An elaborate system for a color set can (1) turn it on or off, (2) adjust its volume, (3) select a channel, (4) shift hue to either end, and (5) set color intensity. This can involve a dozen operations. Practical systems combine operations, doing most or all of these with six to eight functions.

For example, a vhf channel selector may rotate in one direction only; that takes only one remote function. A uhf tuner may be a "search" type that stops when it encounters a station; one remote function is needed to start it searching. On-off is often combined with volume. A few remote systems omit the color-intensity function, as hue control is far more important.

Question: *Which of the following are most likely to be accomplished by the same function button in a color-set remote control?*

Color intensity and hue control. Read **Frame 9** before proceeding.

Volume and on-off. Check in **Frame 18.**

Uhf tuning and color intensity. Try **Frame 22.**

2

Oh, yes it has. The voltage across it couldn't change value if it didn't. Then the igfet conduction couldn't be varied. Better read **Frame 20** over again and have another look at the answers.

3

No, it can handle more operations than that, if you count the on-off extension of the volume-control action. Examples are the Motorola and the Sylvania. Go back to the chart in **Frame 8** and count them. Then answer the question again.

4

No. The RCA is electronic—often called a transistorized transmitter. Its output definitely is acoustic, produced in a transducer driven by an oscillator. But the tone isn't derived mechanically. Go back and answer the question in **Frame 23** again.

5

You got it. *Mechano* means the ultrasonic tone is produced mechanically, and *acoustic* means it travels through the air to the receiver, like sound. The rod in the Zenith, vibrating after being struck by the hammer in the transmitter, emits a sound you can't hear. The RCA, and others like it, uses an oscillator to produce an ultrasonic signal and a transducer to make it acoustic. It isn't mechanical.

The ultrasound travels through the air and is picked up by a microphone in the TV set. Converted thus back to an ultrasonic signal, the tone is amplified by a broadband preamp (Fig. 1). In some receivers, the preamp is an IC. In others, it uses four to six transistors.

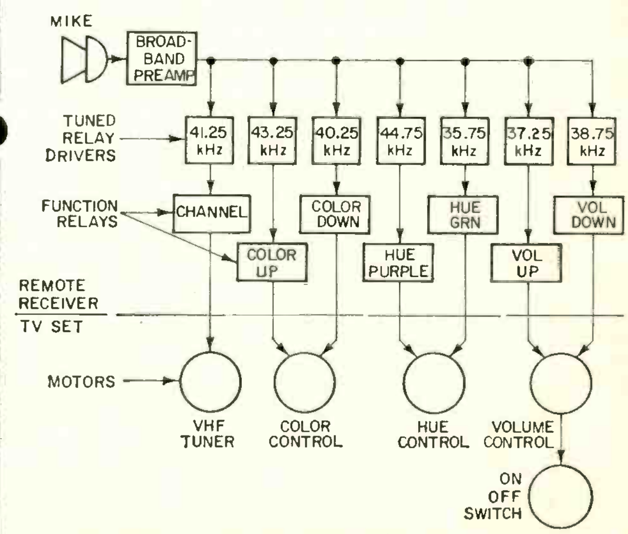


FIG. 1—TYPICAL REMOTE RECEIVER has broadband preamp and a series of tuned relay-drivers.

5 After that, the signal is applied to relay driver transistors. Each one has a resonant circuit. It is therefore actuated only by one tone. The driver stage that accepts that particular tone closes the associated relay.

Each relay supplies voltage to a motor in the TV chassis. The tuner motor turns in only one direction. But the motors on the color, hue, and volume controls are reversible, depending on which relay makes the voltage connection. A control motor, through a system of gears, turns the control at a speed that works out to about 10 rpm.

In Fig. 1, the Sylvania, the ON-OFF switch is part of the volume control. RCA and Magnavox have a like system. When the motor that's turning volume down reaches its limit, it shuts the set off. The motor that turns volume up turns the set on as it starts rotation.

Question: *The preamp in most remote-control receivers is broadband. About what is its center frequency?*

About 22.675 kHz. Check your answer in **Frame 24.**

About 40.0 kHz. Move the **Frame 17** to see if you're right.

About 44.75 kHz. Look at **Frame 16.**

6 **Yes, that's how many.** You didn't forget to count the muting operation which is an extra one for the function-change relay. The operations in this system are: Tune up, tune down, hue red, hue green, mute, volume up, TV on, TV off. The volume can't be turned down without going through "off," because the stepping relay only turns in one direction.

The Motorola TRR-7 remote system is a radical departure from those discussed so far, although control frequencies are about the same. Move along to **Frame 20** and read how it is unusual.

7 **Not quite.** The RCA handles eleven of the operations listed on the chart in **Frame 8,** and so does the Magnavox. But they use eight frequencies. Neither one runs both tuners in both directions. The Magnavox substitutes automatic action for the Tint (Hue) operation, in some chassis. Go back to the chart and study the Motorola and Sylvania seven-frequency systems. Then answer the question again.

8 All the major color-set makers have remote control chassis in their lines. The chart in Fig. 2 lists functions and frequencies for a few popular brands. Frequencies are similar, but they're not used for the same functions in the various brands.

Most of them are simple in concept. A small receiver picks up an ultrasonic tone from a remote-control transmitter. A resonant circuit in the remote receiver lets that tone activate a relay which performs the operation in the TV set. One tone causes one operation (except for on-off, which will be explained later.)

FIG. 2—REMOTE CONTROL FREQUENCIES FOR COLOR TV

	VHF TUNE Up	VHF TUNE Down	UHF TUNE Up	UHF TUNE Down	COLOR Up	COLOR Down
Magnavox 704054	40.0		43.0	41.5	37.0	35.5
Motorola TRR-7	43.0				35.0	40.0
RCA 10A/12C	40.25		41.75		44.75	37.25
Sylvania for D12-3	41.25				43.25	40.25
Zenith 600	41.25	40.25				

	HUE (TINT) Purple	HUE (TINT) Green	VOLUME Up	VOLUME Down	POWER On	POWER Off
Magnavox 704054	44.5[1]	46.0[1]	44.5[1]	46.0[1]	38.5[2]	
Motorola TRR-7	41.5	37.0	38.5	44.5	38.5	44.5
RCA 10A/12C	35.75	34.25	43.25	38.75	43.25	38.75
Sylvania for D12-3	44.75	35.75	37.25	38.75	37.25	38.75
Zenith 600	40.25[3]	41.25[3]	37.75		37.75	37.75

All frequencies in kHz.
[1] In chassis with automatic tint control (atc) these frequencies are for volume.
[2] Turns off automatically when no station is picked up for 60-90 seconds.
[3] Must receive 38.75-kHz tone first, to close mute/function relay.

The Zenith 600 system is different. The transmitter produces only four ultrasonic tones. The 41.25-kHz tone turns the vhf channel selector toward higher numbers, and the 40.25-kHz tone turns it toward lower ones. A third tone, 37.75 kHz, operates a stepper relay that first turns on the set; the next three steps turn up volume, and the one after that turns the set off.

A fourth transmitter tone, 38.75 kHz, operates a relay that mutes sound and changes what the first two tones do. The 40.25-kHz tone then turns the Hue control toward purple and the 41.25-kHz tone then turns it toward green. Thus six operations are performed with only four tones.

Question: *How many operations can a seven-frequency remote-control transmitter perform in an ordinary color set?*

Seven. See **Frame 3.**
Nine. See **Frame 23.**
Twelve. See **Frame 7.**

9 **Too bad,** missing your very first try. These two functions must be handled separately. The only way they could be on the same button is if a second button switches operation from one to the other. Even then, two buttons are required for color intensity because it has to be turned both up and down. Hue has two directions, also.

A combined function has to have two operations that don't interfere with each other. If you stop and think how the TV set is operated manually, you'll probably be able to go back to **Frame 1** and pick the right answer.

10 **Oops!** You slipped up on that one. You counted the operations *and* the frequencies wrong. Consider all the frequencies in Fig. 3 and then count the operations each of them causes in the TV receiver. Then you should be able to come up with a better answer to the question in **Frame 17.**

11 **Yes, that's the path both ways.** Voltage in one polarity ionizes the neon bulb and lets the charge build up on the memory capacitor. An opposite polarity also ionizes the bulb, and lets the charge drain off. (If it were allowed to, it would eventually charge the capacitor in opposite polarity.)

You've got a pretty good idea what remote control systems are all about. Now move along to **Frame 12** and get some pointers on how to service them. It's pretty simple, actually.

12 Servicing color-TV remote controls isn't complicated. You can probably figure out most of the steps yourself.

Start with the receiver. Use a transmitter—one you know is okay—for a signal source; an audio generator isn't accurate enough. Align each channel of the remote receiver carefully, making sure you use the right frequency for each coil. The coils all look alike, so check the diagram furnished by the manufacturer.

There may be a broadband coil in one of the preamp stages. If there is, peak it at the center of the passband.

A vtvm set for the dc ranges, is a good alignment indicator. Connect it to the collector of each relay-driver transistor. You'll be able to judge the peaking of the coil associated with that transistor. If it doesn't peak, either the coil is bad, the signal isn't getting that far, or the transistor is faulty.

A scope shows if the signal is getting to the base of the transistor. So does an ac vtvm. There should be very little signal at the collector, because a large capacitor and the relay coil smooth it out to dc.

An ohmmeter is okay for checking relay contacts, but only with the plugs between remote and TV chassis disconnected so no voltages are on the contacts. If that's unhandy, and it may be if the same plug powers the rest of the remote receiver, use a voltmeter. The relays apply ac power to the motors. A vtvm should tell you if the voltage is getting to the proper motor when a particular tone is received. Occasionally burnishing the contacts of relays keeps them from getting sticky. Even pulling a strip of lens-cleaning paper through the closed contacts is a help.

So . . . you can conclude that a system of signal tracing, alignment, and voltage tracing is the best troubleshooting method.

12 **Question:** *The scope can be used for tracing signals . . .*

. . . at the base and collector of the transistor. See **Frame 21.**

. . . up to and including the base. Try **Frame 15.**

. . . all the way to the motors. Check **Frame 25.**

13 **Not even a little bit.** If any of the electrons from the capacitor get in there, it's because the IGFET is shorted. The memory module would be useless. Go back and read **Frame 20** again. Do it more carefully this time and you'll get the right answer easy enough.

14 **Oh yes, one of them is.** *Mechano* means the ultrasonic tone is produced mechanically. *Acoustic* means the tone gets to the receiver by traveling through the air, like sound. Keeping those ideas in mind, go back to **Frame 23** and pick another answer.

15 **Yes, that's right.** The scope shows the ultrasonic signal all the way from the preamp input to the base of the relay drivers. It isn't as good as an alignment indicator, though. Its cables can detune the resonant circuits when connected across them. Alignment peaking is best checked with a dc vtvm connected to the transistor collector.

And that completes this little course. **R-E**

16 **No, that's not the center.** It is one of the frequencies the amplifier must pass, but it's at the upper limit. Go back to **Frame 5** and see what the lower limit is. Then, with those in mind, pick out an answer that seems more in the center.

17 **Sure.** The frequency that's half-way between the lowest and highest is the center of any broadband response. If you study the chart in **Frame 8,** you'll see that 40 kHz is about the center for all the remote systems listed except Zenith.

Frequencies for tht Zenith 600 system are close to 40 kHz, but they're distributed a bit differently. The approximate center of preamp bandpass is 39.5 kHz. The diagram is shown in Fig. 3.

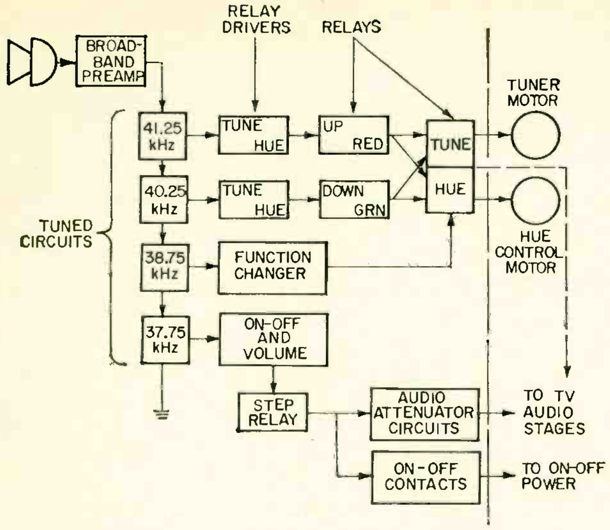


FIG. 3—ZENITH REMOTE CONTROL RECEIVER uses a function-change relay to convert tune stages to control hue.

17 Any signal tone is fed right through all the tuned circuits. Only the tuned circuit that's resonant at the tone's frequency intercepts it. The tone actuates that driver transistor and closes that relay.

The changeover operation was described briefly before. In its regular state, the function-change relay leaves the tune relays connected so they apply voltage to the tuner motor. The tuner is rotated up-channel or down-channel according to whether 41.25 or 40.25 kHz is received.

But a 38.75-kHz signal operates the function-change relay. That relay connects the 41.25- and 40.25-kHz drivers and relays so they apply voltage to the hue-control motor instead of to the tuner motor. The buttons of the remote transmitter that formerly turned the tuner now turn the hue control.

The small dashed line from the function-change relay to the TV audio stages represents the muting function. An extra set of contacts cuts off all sound while this relay is closed.

The step relay that turns the set off and on and controls volume was already explained, in **Frame 8.**

Question: *How many operations are handled in the Zenith system, and with how many frequencies?*

Eight operations with four frequencies. Turn to **Frame 6.**

Six operations with four frequencies. Move to **Frame 19.**

Seven operations with three frequencies. Go to **Frame 10.**

18 **Right.** It's handy to let the volume-up operation turn the set on first, and let the volume-down operation turn the set off at its finish. This isn't necessarily the way it's always done, but this is the most-likely combination of operations. Now move back to **Frame 8** and learn about specific systems.

19 **You left out a couple.** Count them for yourself. Two tuning operations, two hue operations, volume in one direction, TV on and off, and audio mute (that extra operation of the function-change relay). Now go back to **Frame 17** and pick out the right answer.

Not long ago Motorola came up with a unique remote control for its Quasar transistor color TV. The TRR-7 system does away with motors on controls. The only motor left is for tuning. Most relays are eliminated, too.

The heart of this new system is diagramed in Fig. 4. The dashed line enclosed what is called a "memory

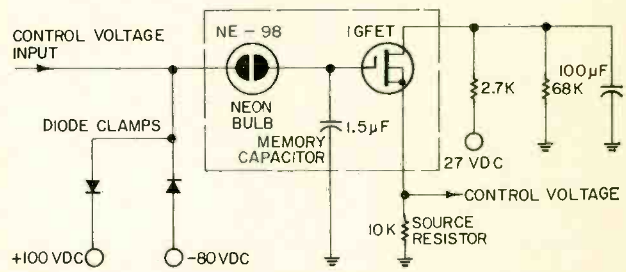


FIG. 4—MEMORY MODULE IS HEART of Motorola's silent remote control. Has igfet, charging neon, and high-quality capacitor. Igfet conduction sets control.

20 module." It consists of a neon bulb, a capacitor with absolutely no leakage, and an insulated-gate field-effect transistor (IGFET).

Clamp voltages and diodes at the input of the module hold input voltages (from the arrow) within limits that are safe for the IGFET yet high enough to fire the neon bulb.

When the neon fires, the capacitor charges. It stops charging when the voltage is no longer applied. But there's no discharge path for the electrons that are stored in the capacitor. The gate of the IGFET can't let them out, nor can the neon bulb.

The voltage across the capacitor is also across the IGFET, gate-to-source. It therefore controls conduction through the IGFET channel from source to drain. That conduction develops a dc voltage across the source resistor.

The voltage across the resistor is used instead of motors to control various functions. For example, volume. The remote receiver has its own group of audio amplifiers. During remote operation, these are used instead of those in the TV set. Their gain is adjusted by the control voltage from the audio memory module.

When a 38.5-kHz tone is received by the Motorola remote receiver, a voltage is applied to the audio memory module that fires the neon bulb and raises the charge across the capacitor. The IGFET conducts more and the control voltage gets higher. Audio is increased. When the control tone is no longer present, the voltage—and thus audio volume—remains at whatever level it reaches when the tone stops.

When a 44.5-kHz tone is received, a reverse-polarity voltage is applied to the memory-module input. It discharges the memory capacitor. IGFET conduction reduces, control voltage goes down, and so does volume.

A special voltage-sensitive relay circuit controls on-off. When the audio control voltage gets below a certain point, the circuit shuts the set off. As soon as it rises above that point, it turns the set on. Thus on-off is controlled by the same tones as volume.

Memory-module circuits just like this one operate the hue and color. A color amplifier in the remote receiver takes the place of the color i.f. amp in the TV set. Its gain is set by the voltage across the source resistor of the color-control IGFET. That, in turn, is controlled by an input voltage applied to the module whenever a 35.0- or
20 40.0-kHz tone is received.

Likewise, a phase-control stage in the remote receiver controls burst phase (and thus hue) in the TV set. It is controlled from the memory module, which is activated by voltages generated whenever a 41.5- or 37.0-kHz tone is received.

The Motorola system is completely silent except for channel-changing. Only the tuner has a motor. The only relays are for on-off and for the tuner motor.

Question: *What is the charge-discharge path for the Motorola memory capacitor?*

It has none. See **Frame 2.**

Through the channel of the IGFET. Check **Frame 13.**

Through the neon bulb. Try **Frame 11.**

At the base you can, but not at the collector. The transistor and a capacitor-coil load keeps the output
21 smoothed out almost to dc. The scope isn't that helpful as an alignment instrument. Go back and read **Frame 12** again, and pick another answer.

Extremely unlikely. Before you go back, however,
22 move to **Frame 9** and read it. That will help you pick the right answer.

Right. Both the Motorola and the Sylvania use seven frequencies to control nine operations. The extra two come from combining on-off operations with volume.

It's just like operating the volume control by hand. When the control reaches the end of its down-volume rotation, it's rotated a little further to turn the set off. The same remote-control tone does it. Likewise, before
23 the volume starts going up, the on-off switch snaps on, activated by the volume-up tone of the remote transmitter.

Only one of the manufacturers in our chart still uses a mechanical transmitter. That's Zenith. A rod-and-hammer arrangement produces the ultrasonic vibration that is picked up by the remote-control receiver. On the hand-held transmitter, a button is depressed; a spring-loaded plastic striker slips off its retainer latch and hits a metal rod. The rod is physically "tuned" to an ultrasonic frequency. Its vibrations go through the air to a tiny pickup microphone in the TV set.

Other manufacturers have battery-operated electronic transmitters. They transmit ultrasonic notes, not electromagnetic radiation. An example is the RCA model 10A transmitter in Fig. 5.

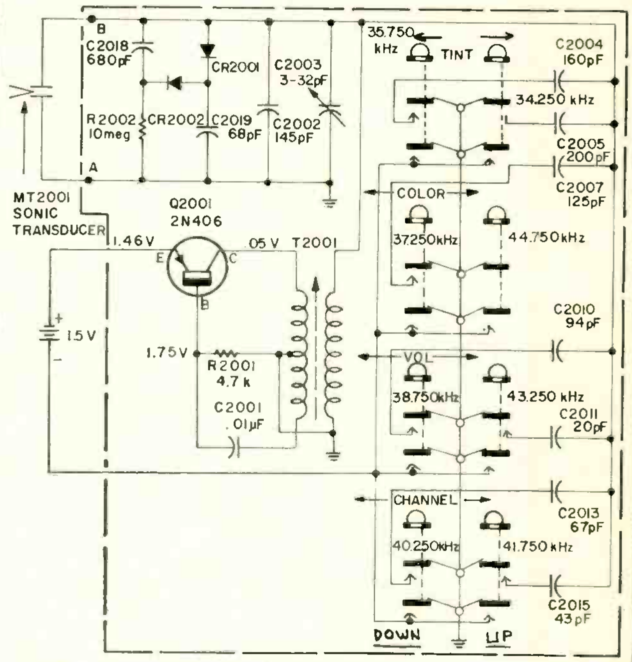


FIG. 5—EIGHT-BUTTON TRANSMITTER supplies ultrasonic tones from transistor oscillator and acoustic transducer.

23 The oscillator is a transistor with collector-to-base feedback. The transformer is tuned by C2002, trimmer C2003, and whichever other capacitor the button-switches connect across it. The osillator tone is coupled to a transducer that radiates the ultrasonic vibrations into the air.

Question: *Which of the two remote transmitters in this frame is classified as mechano-acoustic?*

The Zenith. Move to **Frame 5.**

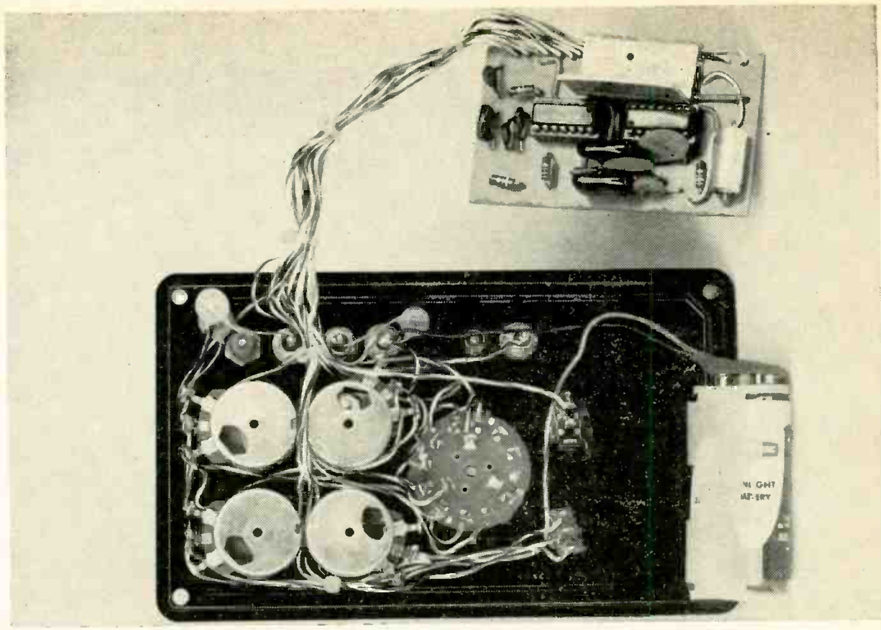
The RCA. Move to **Frame 4.**

Neither one. Check **Frame 14.**

You're wrong. Where did you get those numbers? The center frequency of a broadband amplifier is the one to which you'd tune it during alignment. If the
24 frequencies on each side are to be amplified without serious attenuation, the peak frequency must be about half-way between the high-frequency and low-frequency limits. Figure that out in **Frame 5** and try picking a better answer.

Heavens, no. If you try it, you may find some kind of waveform, but it won't be the ultrasonic signal. You should restudy the portion of this course beginning with
25 **Frame 5.** Pay careful attention to what signals go where in the remote receiver. You'll see why this answer is wrong, and you'll get valuable review working your way back to where you were when you answered this one wrong.

COLOR TV 1971



Build with IC's color convergence generator

by JOHN C. VOTIPKA

Two IC's form the heart of this little generator. It makes bars, crosshatch, dots for color set convergence and audio tone for use as a signal injector.

HERE'S A HANDY DUAL-PURPOSE GENerator you'll want to have. It's a dot-bar generator for color-TV alignment and a signal injector for radio, tape recorder or record player repairs.

The unit is reliable, compact, inexpensive, and completely portable. It's powered by two penlight cells and since the unit draws only 21 mA, battery life is long. A drawing of the panel is shown in Fig. 1.

How it works

The dot-bar generator section puts out clear and stable horizontal and vertical bars, dots, and a crosshatch pattern.

The generator is built around two integrated circuits (Fig. 2). IC1 makes up the vertical oscillator, a multivibrator operating at 189 kHz, the 12th harmonic of the horizontal frequency, and four signal shapers. Transistors 1 and 2 of IC1 comprise the multivibrator. Its output is shaped by differentiating circuit C1 and R1 and fed to transistor 3 for further shaping. This output is fed to transistor 4 for final amplification before being sent to transistor NOR gate 3 for shaping, in IC2. Depending on the output desired, transistor 3 either forwards its signal to S2 or to NOR gate 4 in IC2 for inversion first. The output of this section alone produces vertical lines.

The horizontal section of the generator is composed of NOR gates 1 and 2 in IC2, making up the multivibrator which operates variably around 660 Hz, the 11th harmonic of the vertical frequency. The output of this oscillator is fed to transistor 6 of IC1 for shaping after it has been sharply differentiated into a 40-μsec pulse by C5 and R2.

After amplification in transistor 6, transistor 5 accepts the new pulse shapes it, and sends it to nor gate 3 in IC1 and on through the output stages which are the same for the vertical circuit. This circuit alone produces horizontal lines.

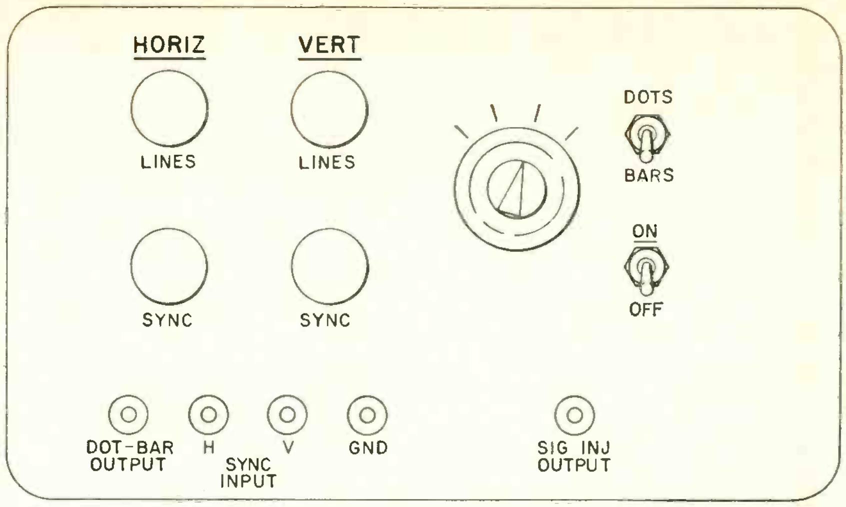
Switch S1 makes the selection of outputs, either bars, dots, or crosshatch. The signal injector is composed of NOR gates 1 and 2 in IC2. The signal output of this circuit is coupled to J5 through coupling capacitor C10 for maximum isolation from the circuit under test.

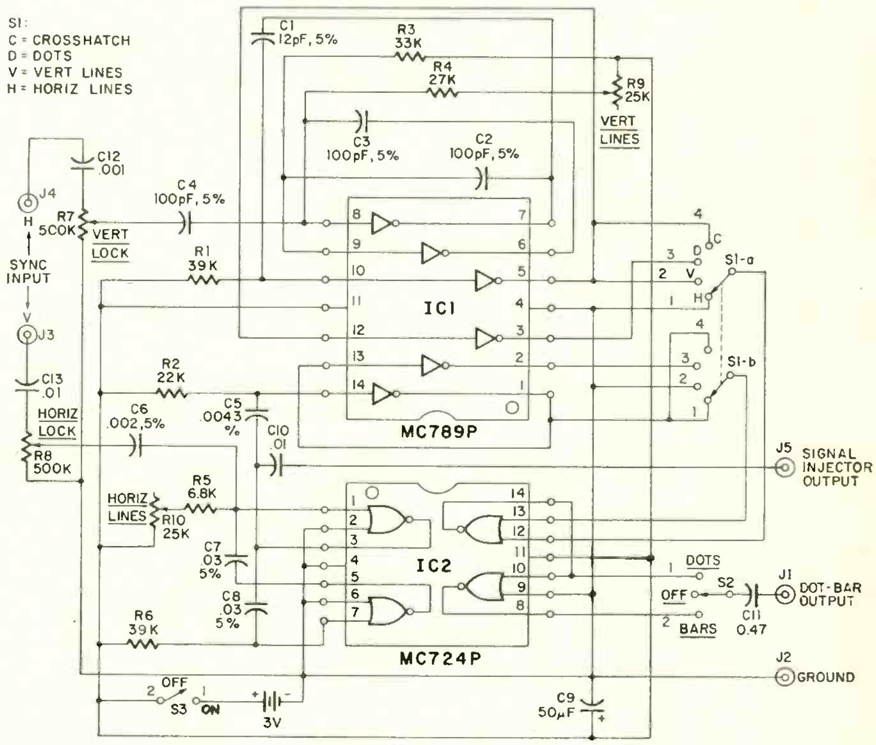
Construction

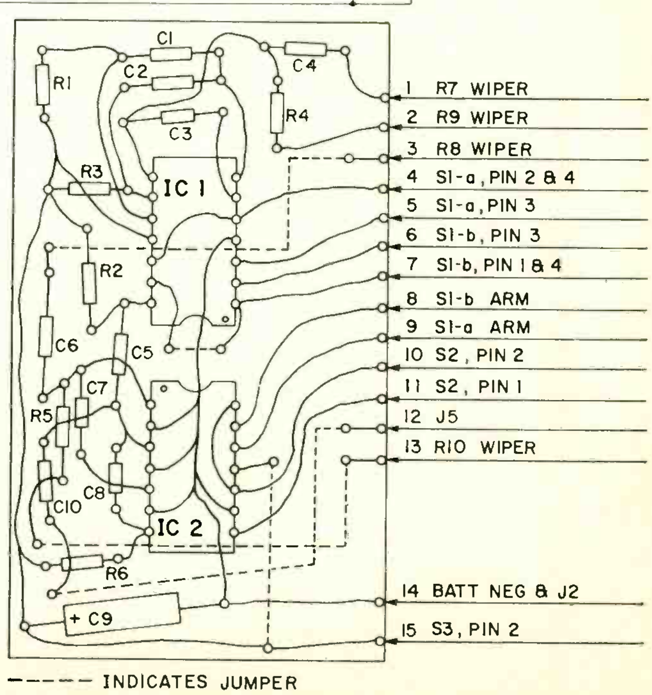
Layout is not critical and any chassis can be used. The only suggestion here is that you use IC sockets for the integrated circuit components. An exact size printed circuit template (Fig. 3) is provided for your use. If you decide to make your own printed board, a component layout and wiring diagram are given in Fig. 4. Capacitors C1 and C5 are the only critical components. They set a pulse width which gives you clean, thin bars.

To use this instrument as a convergence generator, hook leads between the ground jack J2 and the television chassis; J1 (dot-bar output) to the control grid of the last video amplifier. To get vertical sync, simply clip a lead to the yellow wire on the yoke. For horizontal sync clip onto the red lead on the yoke. Place S3 in the ON position, tune to a strong station, adjust the contrast and brightness for best clarity. Adjust R9 and R10 for the number of vertical or horizontal lines you desire. For the best stability of the lines, adjust potentiometers R7 and R8. To obtain dots on the screen, rotate S1 to the DOT position and flip S2 to position "B".

The signal injector is superb for troubleshooting; just connect ground terminal J2 to the chassis of the radio, and J5 to the grid or base of each tube or transistor back-tracking from the speaker. For even higher frequencies, connect the hot probe to J1 and tune to horizontal bars. This will allow you to reach high into the MHz range. For maximum protection when you inject a signal into a sensitive FET or junction transistor circuit, place a piece of electrical tape between the probe and the gate or base of the transistor involved. **R-E**





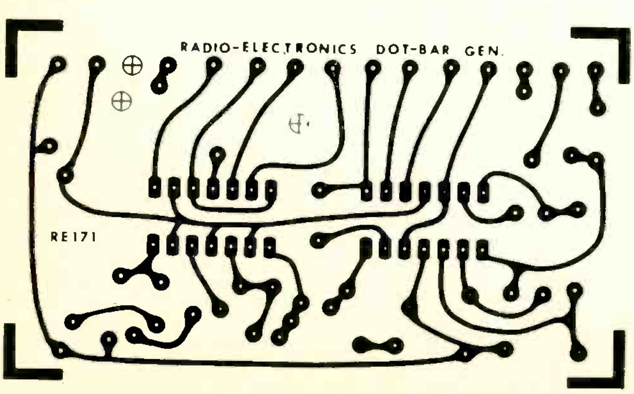


PARTS LIST

All resistors ¼-watt 10%
R1, R6—39,000 ohms
R2—22,000 ohms
R3—33,000 ohms
R4—27,000 ohms
R5—6800 ohms
R7, R8—potentiometer, 500,000 ohms
R9, R10—potentiometer, 25,000 ohms
C1—12 pF, 5%, mica
C2, C3, C4—100 pF, 5%, mica
C5—0.0043 μF, 5%, mica
C6—0.002 μF, 5%, mica
C7, C8—0.03 μF, 5%, ceramic
C9—50 μF, electrolytic
C10, C13—0.01 μF, ceramic
C11—0.47 μF, ceramic
C12—0.001 μF, ceramic
IC1—MC789P (Motorola)
IC2—MC724P (Motorola)
S1—2-pole 4-position, rotary
S2—spdt center-off toggle
S3—spst toggle
Case, 4" x 6" x 2" or larger
Miscellaneous harware

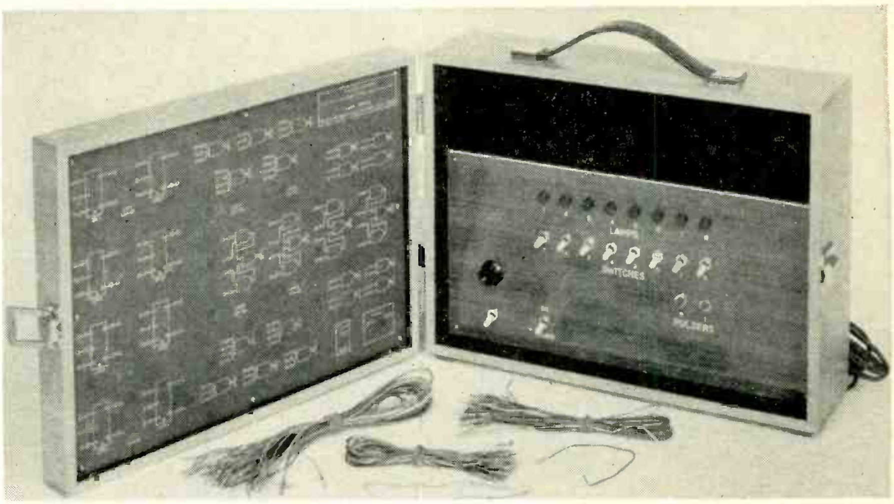
Full size etched and drilled printed circuit board for this unit is available. G-10 glass epoxy board is $3.50 postpaid. Order part No. RE-171 from Photolume, 118 E. 28 St., New York, N.Y. 10016

FIG. 1 (top)—PANEL LAYOUT. Drawing is about three-quarters full size. Fig. 2 (middle)—SCHEMATIC DIAGRAM is simple when IC's are only active components. FIG. 3 (right)—PARTS LAYOUT and wiring diagram. FIG. 4 (below)—FULL SIZE PC BOARD layout may be used as pattern.



BREADBOARD A COMPUTER WITH
R-E's Logic Laboratory

by DAVID KORMAN



Last month we presented the first part of the computer laboratory. This month construction details, testing and operating instructions are presented.

Clock-lamp driver card

Assemble all diodes and resistors on the card as per the information on the printed circuit card. All diode bands go down or toward the furthest edge of the card. Solder and clip off excess lead lengths.

Install transistors Q0 thru Q7 with flat sides toward the IC's or furthest edge of the card. Solder and clip. Install unijunction transistor Q8 with the flat side toward the nearest edge of the board. Solder and clip.

Install the IC's. There is a black dot on the drawing (solid) and a copper spot on the circuit card to indicate the orientation of the dot on the IC's. Carefully solder all leads. **Do not clip these leads.**

Install the capacitors and insure that the positive end of the tantalum capacitor goes to the positive pad on the circuit card.

Test before using

Testing the gate circuits of the logic laboratory is really quite a simple procedure. The test suggested would not be adequate for extremely high clock rates but will give a good indication of the devices ability to function in the laboratory.

First it would be well to establish a few points:

As with the lamp drivers, the inputs to the logic gates look like a logical "1" if left open or disconnected. This is not acceptable procedure for design purposes for reasons that are best understood by a careful reading of the literature on TTL integrated circuits, but it will work fine at the low clock rates and loads associated with the lab.

There will be more information on this later but here are the necessary NAND circuit conditions to allow you to perform the tests. It requires all "1's" into a NAND gate to get a "0" out. Any zero in will give a one out!

In the test setup shown, the CLOCK output is connected to LAMP 0. The output of the gate being tested is connected to LAMP 1.

All inputs but one of the gate being tested are left open (logical "1") and the clock set for minimum speed is connected to the input to be tested. When the clock goes to "1", the output of the gate will go to "0" (all "1's" in give a zero out). This means that the CLOCK LAMP, LAMP 0 will be lit and the output lamp, lamp 1, will be out. As the clock goes to "0", the output of the gate goes to "1". The clock lamp goes out and the output lamp comes on.

In other words, if the lamps alternate on and off out of step, the gate input being tested is good. Test the other inputs to the gate in the same way for all 2, 3 and 4 input gates.

Operating instructions

Since every piece of electronic equipment available to industry normally has a set of operating instructions, they are included here followed by a set of test procedures that will

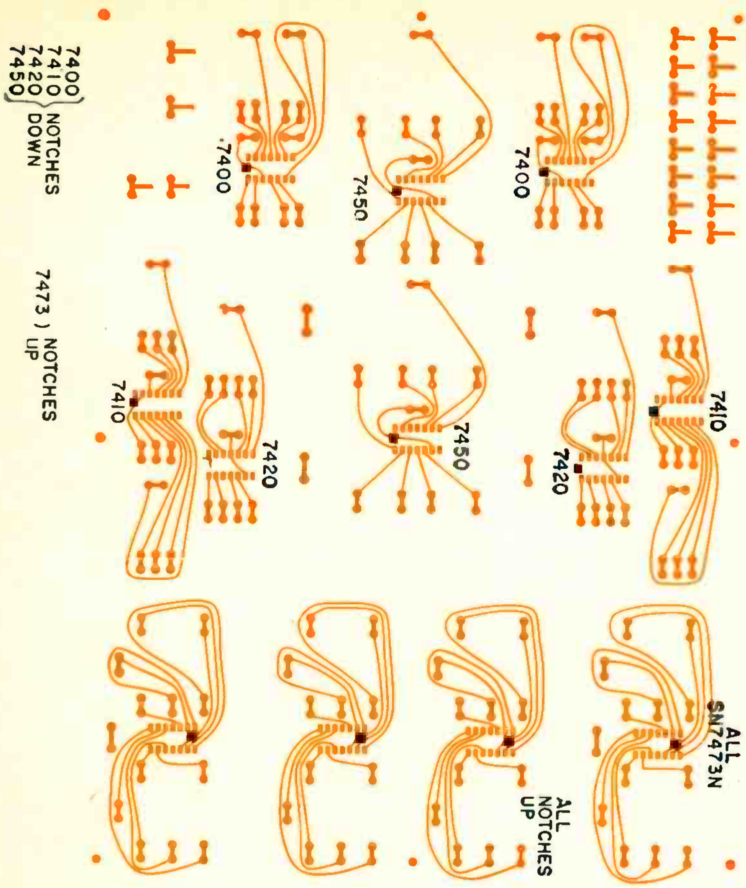
The diagrams on the facing page are repeated from our December issue. Misregistration of color last month made them unusable.

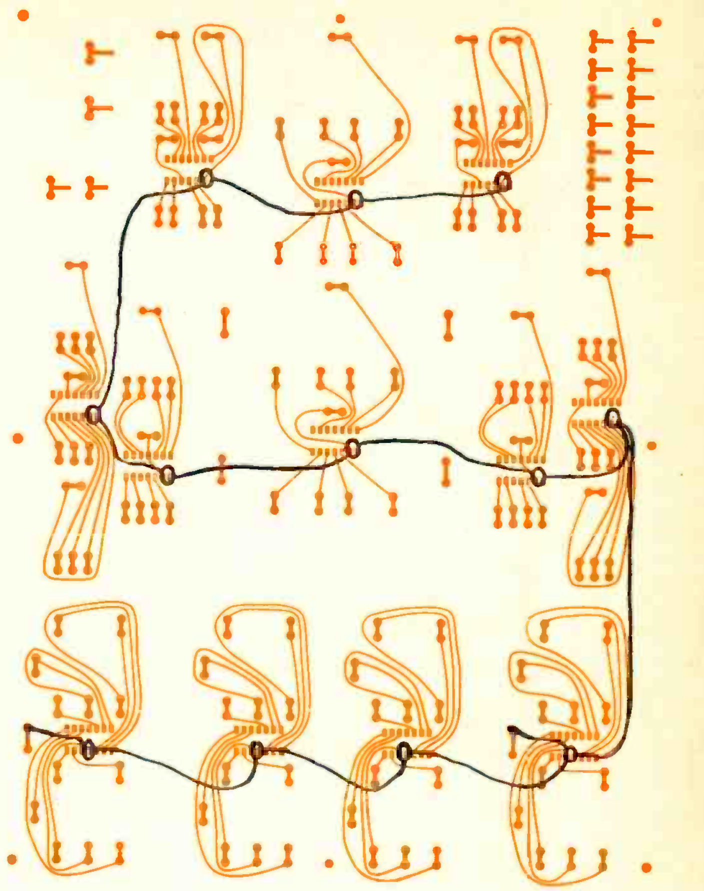
LOGIC LAB HARDWARE SPECIFICATIONS

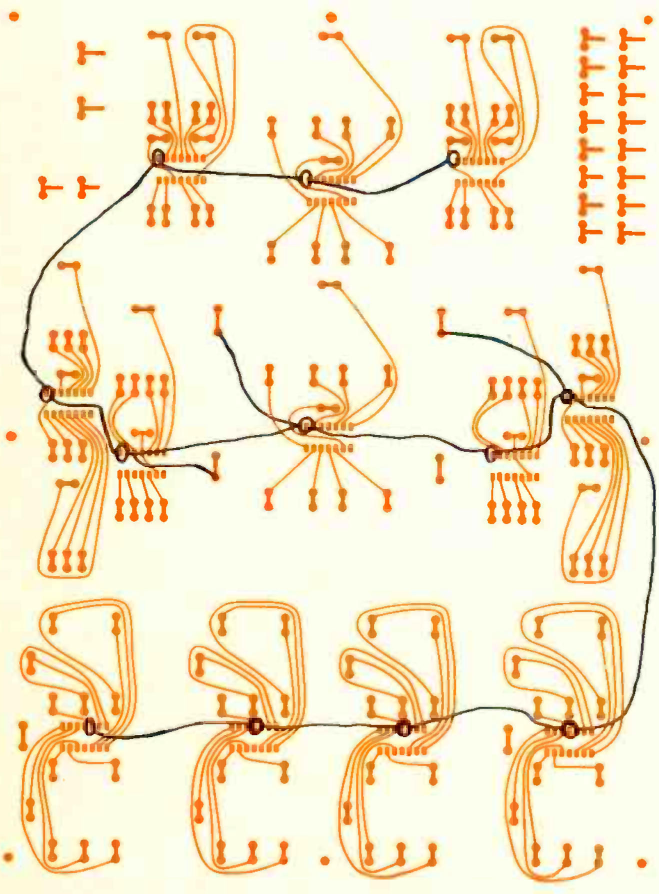
GENERAL SPECIFICATIONS
1. Size—12.75 x 9.75 x 4.5 inches (stackable)
2. Finish—lacquered birch
3. Weight—5.5 pounds
4. Power requirements—50 or 60 Hz, 105 to 120 volts ac
5. Power switch—toggle on display panel

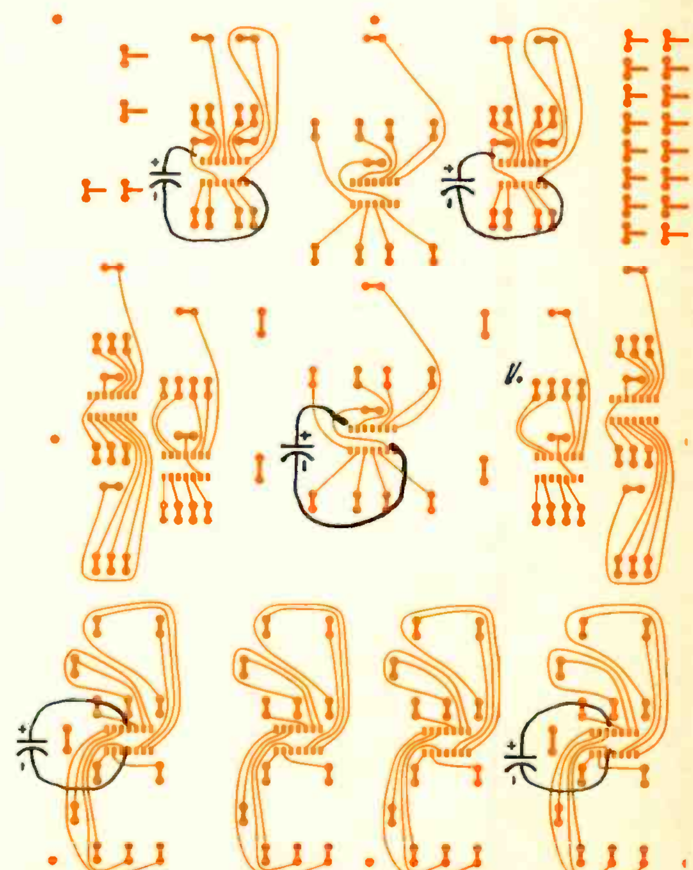
ELECTRONIC LOGIC SPECIFICATIONS
1. Functions available:
   8 Master-slave J-K flip flops
   8 2 input NAND gates
   6 3 input NAND gates
   4 4 input NAND gates
   4 AND/NOR gates (Exclusive OR or Half-Adders)
2. Type of circuit:
   7400 Series IC's using Transistor-Transistor Logic
3. Logic levels:
   HIGH—+5 volts nominal (+2.4 volts lowest)
   LOW—Ground nominal (0.0 to 0.4 volt)
   Internal Supply Voltage: +5 volts available at HIGH terminals of LOGIC PANEL.
4. Input Loading:
   Unit Load: 1 TTL Load = 1.6 mA at ground. +40 μA at +3 volts. Gate inputs and Flip-Flop J and K inputs present one unit load. Flip-Flop Clock and Reset (C & R) inputs represent two unit loads each.
   Lamp inputs present one unit load each.
5. Output Drive:
   The fan-out of an output indicates the number of unit loads that output can drive. Logic ouputs on the LOGIC PANEL have a fan-out of 10. (They will each drive 10 unit loads.)
   Pulsers and clock have a fan-out of 10.
   Toggle switches and HIGH outputs have an unlimited fan-out.

CONTROL AND INDICATOR SPECIFICATIONS
1. Functions available:
   8 toggle switches to generate steady-state logic levels.
   2. pulser switches
   8 lamps used as indicators
   Variable frequency clock
2. Toggle switches:
   Give a HIGH output when toggle is up.
   Give a LOW output when toggle is down.
   Fan-out: limited only by power supply
3. Pulser switches:
   Normally provide a HIGH output.
   LOW output when depressed, remains LOW until released.
   Fan-out: 10 unit loads
   Latches prevent noise from switch bounce.
4. Lamp indicators:
   Normally ON with no input. Can be turned OFF by "daisy-chaining" unused lamps to ground.
   ON when corresponding input is HIGH.
   OFF when corresponding input is LOW.
   LOAD: 1 unit load each.
5. Clock:
   Repetition rate: LO and HI (with each variable)
   Fan-out: 10
   Output: Square wave









TYPE AND LOCATION (top left). The 7473's have their notches pointed up; all others point down.

THE NEXT STEP (bottom left) is to add the ground leads as shown in this figure.

POWER WIRING (top right) on logic panel. Black overlay shows points to be connected with jumpers.

TANTALUM CAPACITORS (bottom right) are wired into position as shown in the black overprint.

allow you to check out the computer lab completely and also give you an opportunity to learn a little of how it works and how the experiments will be detailed in later material.

Logic levels

The computer lab uses positive logic definitions throughout. This means that a more positive voltage (up to 5 volts) will represent a logical "1" and a more negative voltage (ground or almost 0 volts) will represent a logical "0".

These levels are available from several sources. On the LOGIC PANEL, the terminals labeled HIGH are 5 volts or logical "1". The terminals labeled LOW are ground or logical "0".

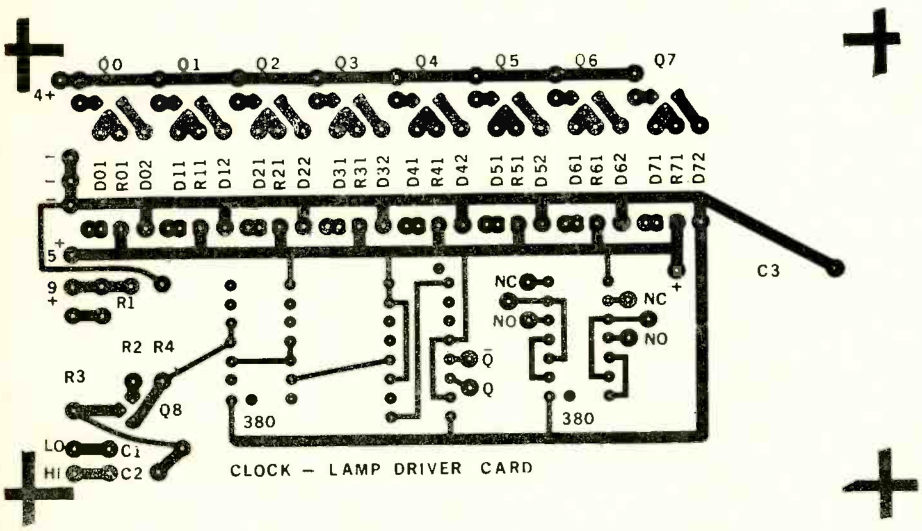
The DISPLAY PANEL toggle switches have two positions. In the DOWN position, the switch output on the LOGIC PANEL will be grounded (logical "0"), and in the UP position it will have +5 volts as an output or logical "1".

Pulser switches

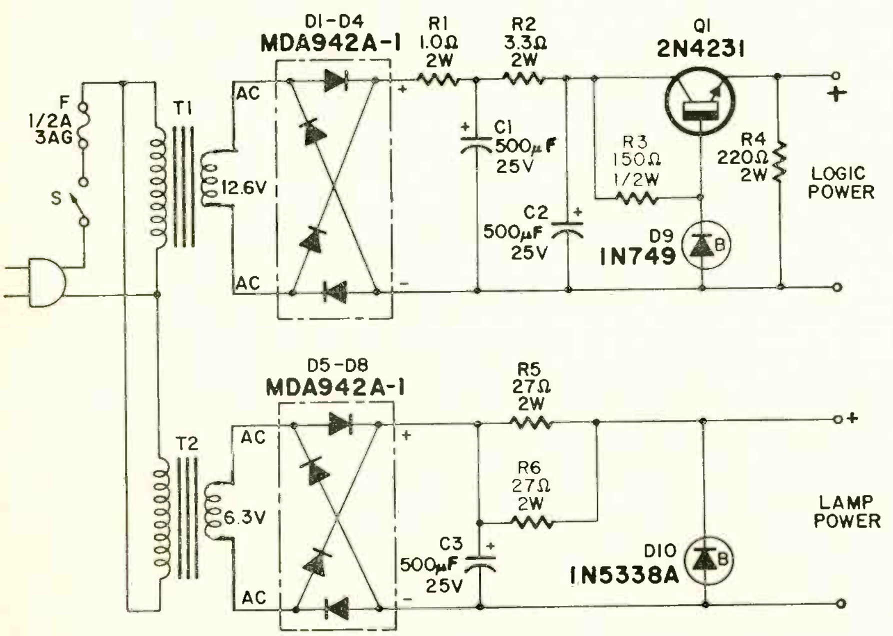
Two pulsers are provided on the display panel. The output of these pulsers appears on the logic panel terminals labeled PULSER. The output of these terminals is normally HIGH. Pressing one of the switches drives the corresponding output terminal to a LOW level for as long as the switch is depressed. When the switch is released, the output goes back to HIGH.

A NOR gate latch is part of the circuitry and insures that even though the contacts of the switch may bounce, the output from the pulser circuitry, once it has made the transition to the new level will remain at that level. The toggle switches are not provided with this type of circuitry.

The configuration was chosen because these pulsers will normally be used as clock inputs to flip-flops which require a negative going transition to cause them to change state. A positive going pulse can be obtained by feeding the pulser outputs through an inverter as will be described later.



PRINTED CIRCUIT PATTERN for the clock-lamp driver circuit. This pattern is shown actual size and can be copied directly. Complete boards are available from Southwest Technical Products, 219 Rhapsody, San Antonio, Texas.



NOTES:
IN5338A – 5 WATT 5.1V ZENER
IN749 – 400mW 4.3V ZENER
MDA942A-1 – 1.5A 50V BRIDGE
2N4231 – 2A 35W NPN POWER

POWER SUPPLY is not built on a circuit board. This supply provides regulated dc to the logic circuitry. A separate section of the supply provides power to the lamps. This dc supply uses a Zener diode to regulate the lamp supply at 5.1 volts.

Pulses

A pulse is a signal voltage that goes from one more or less steady level to its opposite level for a short period of time and then returns to its original level.

A pulse that goes from a LOW level (logical "0") to a HIGH level (logical "1") and back to a LOW level is called a POSITIVE, HIGH or "1" pulse.

A pulse (as with the pulsers) that goes from a HIGH level to a LOW level and back to HIGH is a NEGATIVE, LOW or "0" pulse.

Every computer needs a clock. The computer lab is no exception. Unlike the computer lab, however, computer clocks usually run in the megahertz range. The lab clock frequency can be varied from about 1 Hz to several hundred Hz with the toggle switch in the LO position, and from several hundred to several thousand Hz in the HI position.

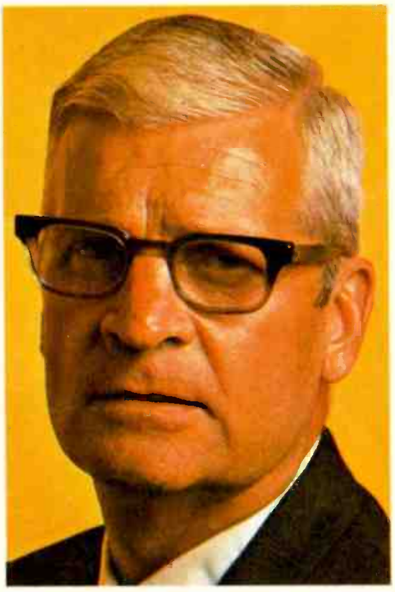
After a great deal of consideration, the very high and intermediate frequencies were left out. The lab will be used in two basic modes. In the first mode, all outputs and inputs will be monitored with the lamps. For this reason, high frequencies are unnecessary. It would be impossible to follow lamp transistions at more than a few hundred cycles per second even when using a long chain divider.

The HI frequencies were chosen to supply stable oscilloscope displays even with long chain dividers.

The clock also outputs logic compatible square waves instead of pulses which along with the adoption of only two basic frequency levels makes the clock inherently less expensive than similar systems. If necessary, the output of the clock can be made a pulse with circuitry that will be described in appropriate experiments.

The operation of all experiments

"Stop kidding yourself about your future in electronics."



Men without advanced technical education will find few opportunities in electronics in the years ahead. But industry will offer exciting work, good pay and excellent security to men who become specialists in these key areas:

- Electronic Engineering Technology
- Aeronautical & Navigational
- Television
- Communications
- Nuclear Instrumentation & Control
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with the lab can be monitored with the lamps. By keeping the frequency low, all of the experiments will change conditions slowly enough to allow the lamps to respond. A lamp will light if its corresponding input is high and will be off if the corresponding input is low. With no connection, the lamp will be on. This configuration saves money and it is easy to put all lamps out as was demonstrated in the testing section.

Unused inputs

Although all of the literature associated with 7400 Series logic suggests that all unused inputs to gates, flip-flops and other elements should be tied to a HIGH level, this is not completely necessary for low frequency operation. The logic circuit, because of its input characteristics, treats an open (unconnected) input as a logical "1" or HIGH level and will operate satisfactorily for almost all low frequency applications. Should the experiment give improper results, connect all unused inputs to a HIGH level before deciding that something is wrong with the IC's or other circuitry.

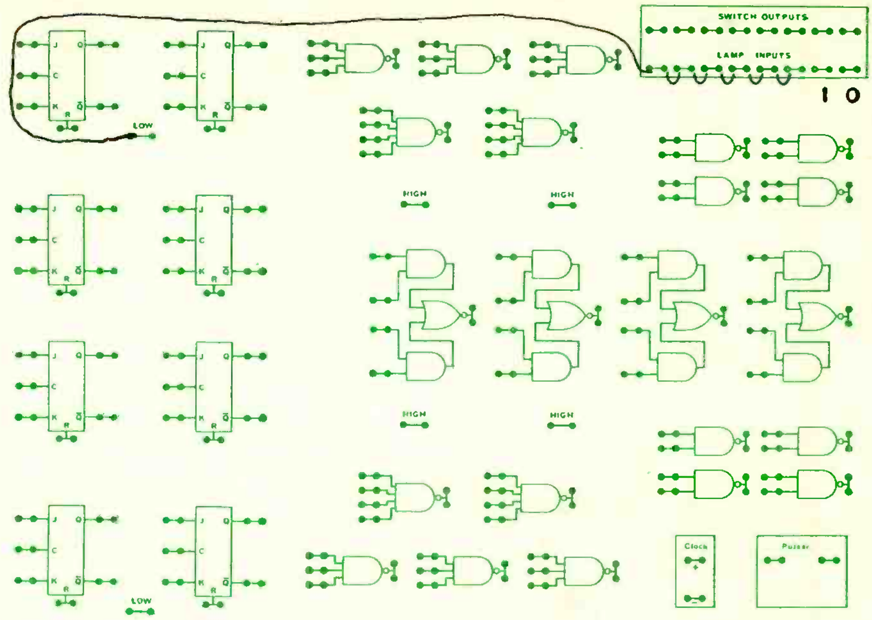
Building larger systems

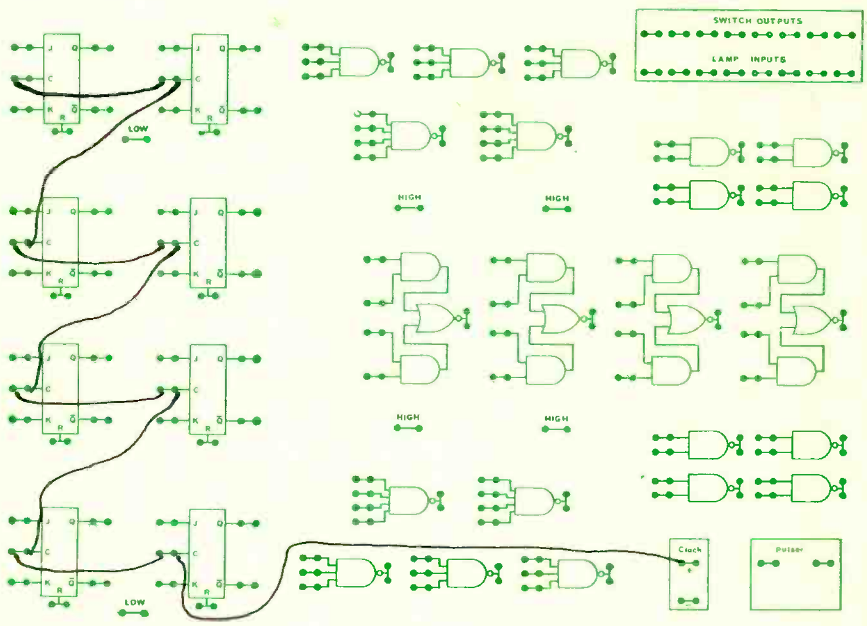
Two labs can be used together (or more if desired) to build larger logic systems. An even better approach might be to obtain additional logic panels and a heavy duty power supply. In this way it would not be necessary to duplicate the lamps, switches and clock circuitry each time extra logic was required (unless these were also necessary). The only connection that *must* be made between logic panels or additional labs is a ground connection. Simply run a jumper from the LOW terminal on one panel to the LOW terminal on the other panel or panels.

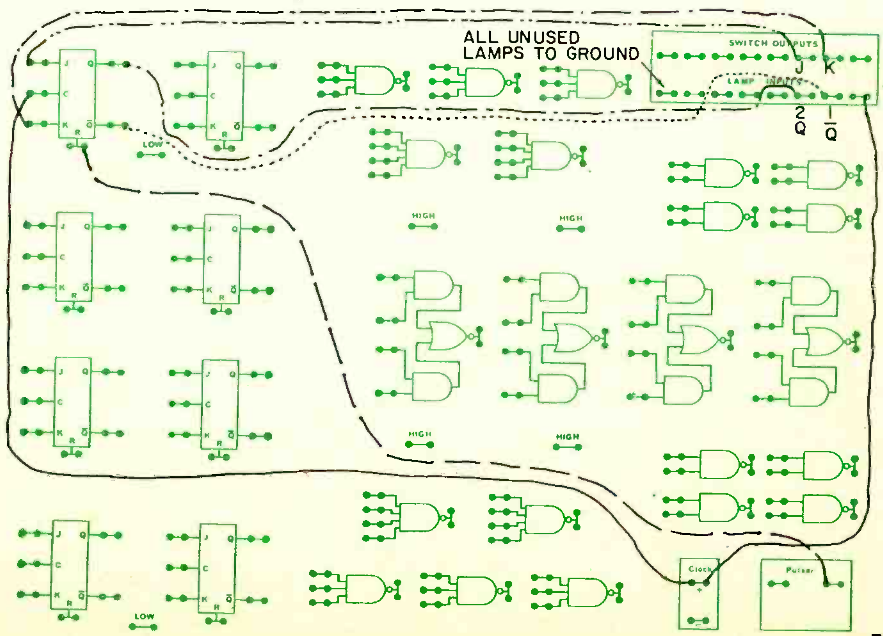
Logic lab wiring

Wiring on the LOGIC LAB is done using a technique called "daisy chaining". If more than two outputs are required from the clock + side, for example, connect one of the clock + outputs to the first flip-flop C input. Run a lead from this C terminal to the next flip-flop C terminal and so forth. In this way, any number of inputs can be supplied from a single output terminal. **R-E**

(Experiments start next month)





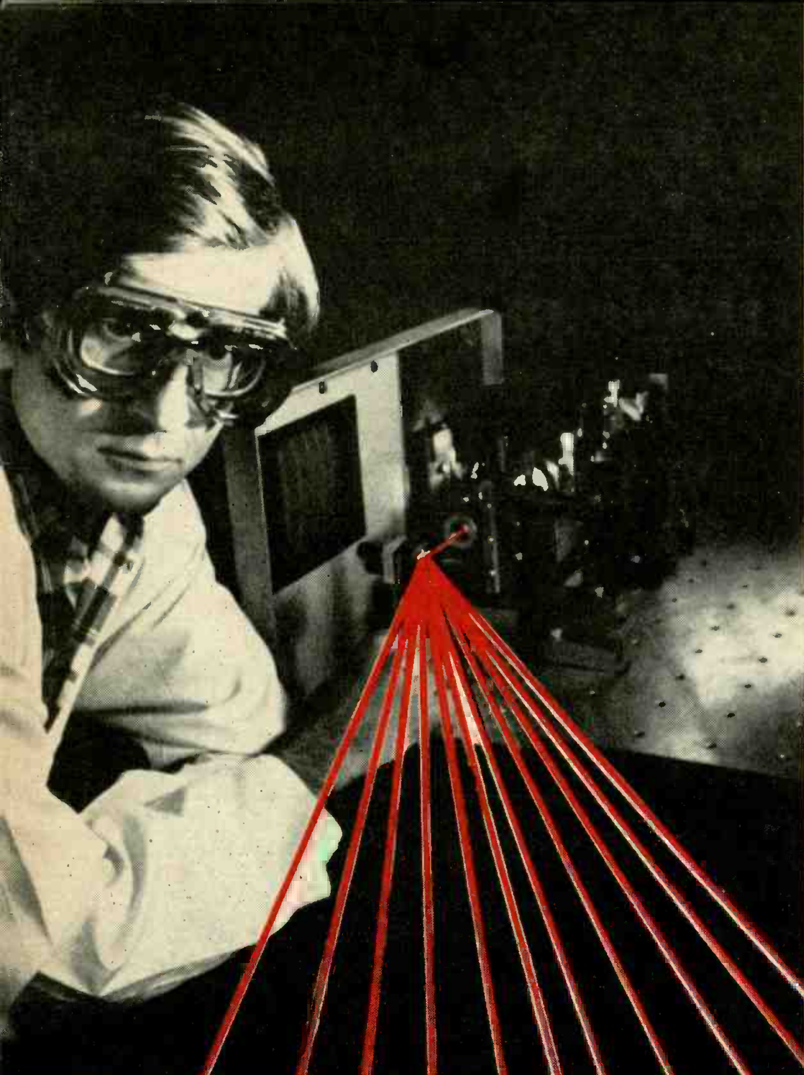


LAMP INPUTS (top) chained together to ground turn off the corresponding lamps.

DAISY CHAINING (center) flip-flop "C" inputs from a single clock output.

TESTING FLIP-FLOPS (bottom) is more elaborate than testing other sections.

THE LASER



Bell Labs Photo

THE TERM "LASER" STANDS FOR "LIGHT AMPLIFICATION BY Stimulated Emission of Radiation." Thus the laser is a device which produces and amplifies light. The light produced by the laser is unique, for it has properties which are very desirable, but almost impossible to obtain by any other means.

To get a better understanding of what a laser is and what it can do, we start with a short review of some of the phenomena involved in laser action. A good subject to start with is light.

Light is a basic form of electromagnetic energy. It occupies the portion of the electromagnetic spectrum with which man first dealt because it was visible to the human eye. Originally, the term "light" included only the visible frequencies. About 1800, however, the British-German astronomer W. Herschel placed a thermometer just beyond the blue portion of a spectrum produced by a prism using sunlight and found its temperature was raised. Later, invisible light was found on the other side of the visible spectrum. These frequencies outside the visible range were lumped with the visible frequencies and called "light."

Later, when X-rays, radio waves and other discoveries were made, light was found to be a part of a spectrum of electromagnetic radiations. The distinction between these radiations is primarily energy which is proportional to frequency. Light is generally considered to be the portion of the electromagnetic spectrum having wavelengths between 100 and 10,000 nanometers (nm $= 10^{-9}$ meters) as shown in Fig. 1.

Electromagnetic radiations simultaneously display two seemingly contradictory properties. Electromagnetic radiations:

1. Propagate through space as *waves*

2. Possess a definite *particulate nature,* since a discrete energy and momentum are associated with them

Each of these properties is important to the complete understanding of the behavior of all electromagnetic radiations. Both properties are combined in the current concept of light as described by quantum mechanics.

Frequently, for aid in visualizing wave behavior, light is said to move in much the same fashion as waves on a body of water. While this is not entirely true, certain characteristics are common to both types of wave motions. The fact that a definite energy is associated with the radiation is often considered a particulate property. Therefore, it is difficult to visualize electromagnetic radiations as continuous waves, propagating continuously through space. One way of partially relieving this conceptual difficulty is thinking of the radiations as consisting of a limited "wave packet" which we call a "photon" (see Fig. 2). The photon is thought to move through space, thus satisfying a human need to visualize what cannot be seen.

Electron energy levels

Light can be produced by atomic processes, and it is these processes which are responsible for the generation of laser light. Let's look first at atomic energy levels and then see how changes in these energy levels can produce laser light.

Many simplifications can be made regarding the concept of the atom. For this discussion let's assume that the atom consists of a small dense nucleus and one or more electrons in motion about the nucleus.

The relationship between the electrons and the nucleus is described in terms of energy levels. Quantum mechanics predicts that these energy levels are discrete. A simplified energy level diagram for a one-electron atom is shown in Fig. 3.

Radiative transitions

The electrons normally occupy the lowest available energy levels. When this is so, the atom is in its ground state. However, electrons can occupy higher energy levels, leaving some of the lower levels vacant. The electrons change from one energy level to another by absorbing or emitting energy. One way an atom can change its energy state is through what is called a radiative transition.

There are three types of radiative transitions. Two of these, absorption and spontaneous emission, are quite familiar, but the third, stimulated emission, is relatively unfamiliar. It is this third type of radiative trasition that is the basis for laser action. Each form of transition is described below.

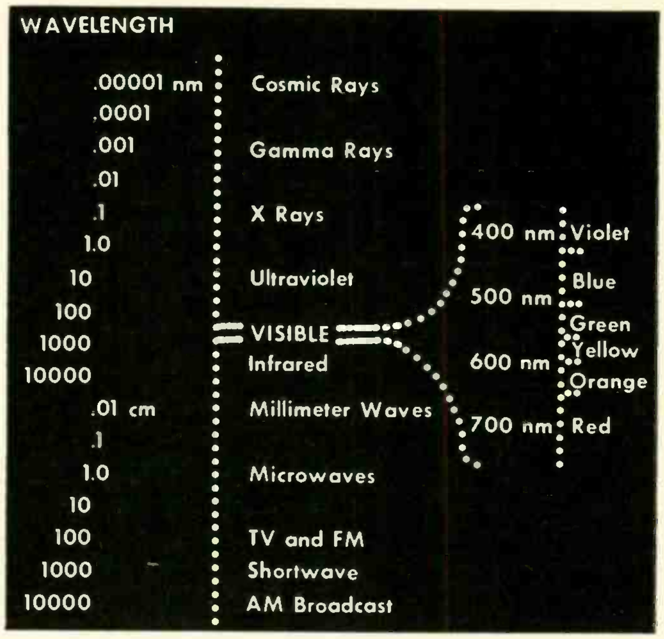
Absorption—An electron can absorb energy from many external sources. For a laser two modes of supplying energy to the electrons are of prime importance. The first is the transfer of all of the energy of a photon to an obital electron. The increase in the energy of the electron causes it to "jump" to a higher energy level; the atom is then said to be in an "excited" state. It is important to note that an electron accepts only the precise amount of energy that will move it from one allowable energy level to another. Hence only those photons of the energy or wavelength acceptable to the electron will be absorbed.

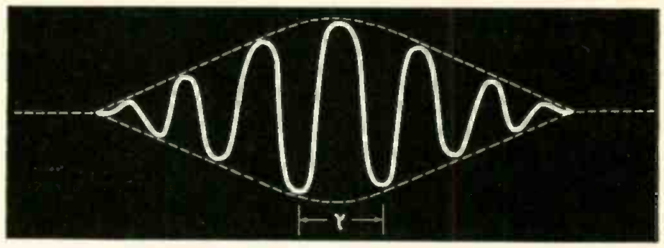
The second method often used to excite electrons is an electrical discharge. In this technique the energy is supplied by collisions with electrons accelerated by the electric field. The result of either type or excitation is that through the absorption of energy, an electron has been placed in a higher energy level and the atom of which it is a part is also said to be excited.

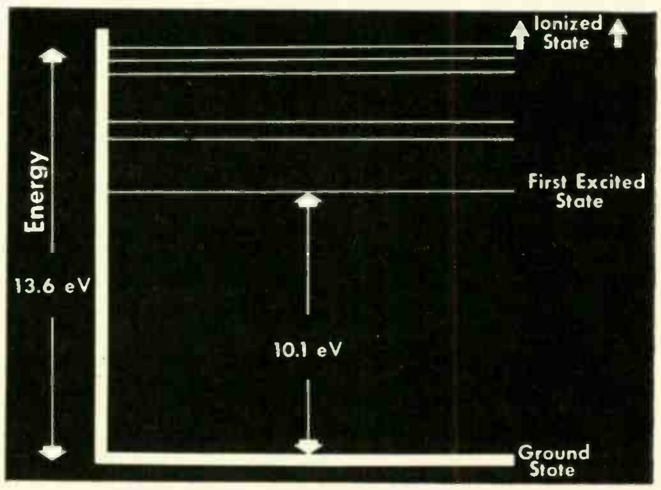
Spontaneous Emission—The entire atomic structure tends to exist in the lowest energy state possible. An excited electron in a higher energy level will attempt to "de-excite" itself. Some of the energy may be converted to heat. Another means of de-excitation is the spontaneous emission of a photon. The photon released by an atom as it is de-excited has a total energy exactly equal to the difference in energy between the excited and lower energy levels. This release of a photon is called *spontaneous emission*. One example of spontaneous emission (and absorption) is seen in phosphorescent materials. Here the atoms are excited by photons of appropriate energy from the sun or a lamp. Later, in the dark, they de-excite themselves by spontaneously emitting photons of visible light. A second example is the common neon sign. Atoms of neon are

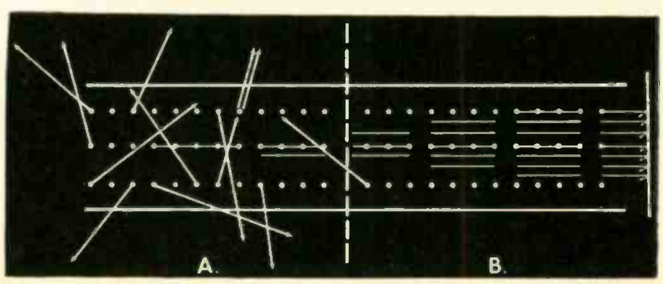
HEORY AND EXPERIMENTS. This is the first art of a detailed series of articles on lasers and eir applications. It is based on a publication by e Department of Health, Education, and Welre; Bureau of Radiological Health. It was epared by W. F. Van Pelt, H. F. Stewart, R. W. eterson, A. M. Roberts, and J. K. Worst. We ink this is the most complete text of its kind.

FIG. 1—(top) **LIGHT WAVELENGTHS** range between 100 and 10,000 nanometers. **FIG. 2**—(second from top) **PHOTONS** are the working parts of light. **FIG. 3**—(third from top) **SIMPLIFIED ENERGY LEVEL** diagram for one-electron atom. **FIG. 4**—(bottom) **ILLUSTRATION** of normal and stimulated emission states.









excited by an electrical discharge through the tube. The de-excite themselves by emitting photons of visible light. Note that in both of these examples the exciting force is not of a unique energy, so the electrons may be excited to any one of several energy levels. The photons released in de-excitation may have any of these several discrete frequencies. If enough discrete frequencies are present in the appropriate distribution, the emissions may appear to the eye as "white" light.

Now let's look at the third and probably least familiar type of radiative transition.

Stimulated Emission—In 1917, Einstein postulated that a photon released from an excited atom could, upon interacting with a second similarly *excited* atom, trigger the second atom into de-exciting itself by releasing a photon. The photon released by the second atom would be identical in frequency, energy, direction, and phase with the triggering photon, *and* the triggering photon would continue on its way, unchanged. Where there was one, now there are two. These two photons could then trigger more atoms through stimulated emission.

If an appropriate medium contains a great many excited atoms and de-excitation occurs *only* by spontaneous emission, the light output will be random and approximately equal in all directions as shown in Fig. 4-a.

The process of stimulated emission, however, can cause an amplification of the number of photons traveling in a particular direction—a photon cascade—as illustrated in Fig. 4-b. A preferred direction is established by placing mirrors at the ends of an optical cavity. Photons not perpendicular to the mirrors will escape. Thus the number of photons traveling along the axis of the two mirrors increases greatly and light amplification by the stimulated emission of radiation occurs.

Population inversion

Practically speaking, stimulated emission will not produce a very efficient or even noticeable amplification of light unless a condition called "population inversion" occurs. If only two of several million atoms are in an excited state, the chances of stimulated emission are infinitely small. The greater the percentage of atoms in an excited state, the greater the probability of stimulated emission. In the normal state of matter, the electron population has most of the electrons in the ground or lowest energy levels, leaving the upper levels somewhat depopulated. When

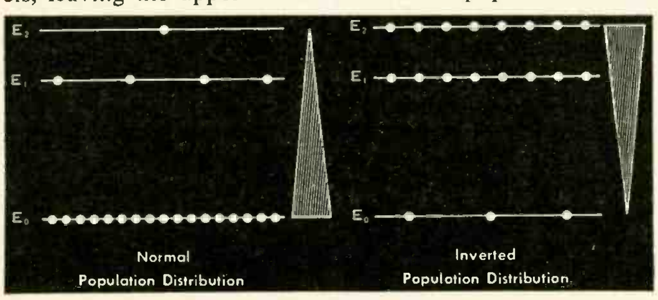


FIG. 5—POPULATION INVERSION is required before stimulated emission or lasing can occur. This does not happen normally.

electrons are excited and fill these upper levels to the extent that there are more atoms excited than not excited, the population is said to be inverted. This is illustrated in Fig. 5.

How does the laser operate?

Now that some of the phenomena have been discussed, let us see how a laser is constructed and how it operates. Three components are needed: an active lasing medium; an input energy source (called the "pump"), and an optical cavity.

Lasers can be classified according to the state of their lasing media. Four common families of lasers are recognized today.

Solid-state lasers use a lasing material distributed in a solid matrix. One example is the ruby laser, using a precise amount of chromium impurity distributed uniformly in a rod of crystalline aluminum oxide. The output of the ruby is primarily at a wavelength of 694.3 nm (nanometer), which is deep red in color.

Gas lasers use a gas or a mixture of gases in a glass tube. Common gas lasers include the He-Ne laser, with a primary output of 632.8 nm and the CO_2 laser, which radiates at 10,600 nm, in the infrared. Argon and krypton lasers, with outputs in the blue and green regions, are be-

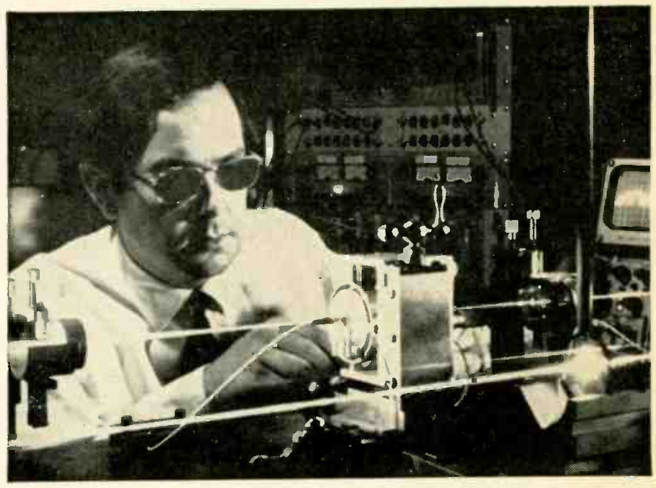


FIG. 6—TYPICAL LASER SETUP in the laboratory. Gerard White of Bell Laboratories adjusts an optical modulator for his laser system.

coming quite common. Even water vapor can be made to deliver a laser output in the infrared.

Liquid lasers are relatively new, and the lasing medium is usually a complex organic dye. The most striking feature of liquid lasers is their "tunability." Proper choice of the dye and its concentration allows light production at almost any wavelength in or near the visible spectrum.

Semiconductor lasers should not be confused with solid-state lasers. Semiconductor devices consist of two layers of semiconductor material sandwiched together. One material consists of an element with a surplus of electrons, the other with an electron deficit. Two outstanding characteristics of the semiconductor laser are its high efficiency and small size. Typical semiconductor lasers produce light in the red and infrared regions.

Pumping methods

Laser action can occur only when a population inversion has been established in the lasing medium. This population inversion is produced by pumping energy into the lasing medium. Several methods of pumping are commonly used. Optical pumping is employed in solid-state and liquid lasers. A bright source of light is focused on the lasing medium. Those incident photons of correct energy are absorbed by the electrons of the lasing material and cause them to jump to a higher level. Xenon flashtubes similar to strobe lights used in photography, but more powerful, are commonly used as optical pumps for solid state lasers. Liquid lasers are usually pumped by a beam from a solid state laser.

Electron collision pumping is used in gas lasers. An electrical discharge is sent through the gas-filled tube. The electrons of the discharge lose energy through collisions with gas atoms or molecules and the atoms or molecules that receive energy are excited. Electron collision pumping can be done continuously and can result in a continuous laser output.

(to be continued)

Design for STEREO

how to design your own solid-state audio amplifier

by MANNIE HOROWITZ*

Part II: Diodes and sine waves are vital elements in designing power supplies for audio amplifiers. Here we see how it's done

LAST MONTH THE FORWARD AND REverse characteristics of the diode were discussed. We saw that the diode conducts when the anode or p-type semiconductor material is made positive with respect to the n-slab, the cathode. The diode will not conduct when the voltages are reversed.

Due to these unique characteristics of the diode, it can be effectively used in power supplies. Before attacking this application, it is useful to review some aspects of the ordinary sine wave. Familiarity with these characteristics is important here as well as in the discussion on power amplifiers, several months hence.

The sine wave

As you are aware, direct current and voltage are theoretically constant at all times. Disregarding aging, the voltage at the positive post of a battery is always a fixed amount above that at the negative terminal. The reverse is never true. This is not so with sinusoidal ac voltages and currents.

With respect to one voltage terminal of an ac generator, the voltage at the second terminal varies as shown in Fig. 1. The single cycle in Fig. 1 is repeated many times a second depending upon the frequency involved. It is repeated 60 times a second for a 60-Hz power supply. Each cycle is divided into 360 degrees. The amplitude varies from zero at 0° to a positive peak, V_p, at 90°, back to zero and on to a negative peak at 270°, returning to zero thereafter.

This very basic description was introduced here to enable us to discuss, define and get a complete insight into the meaning of rms, average, peak and peak-to-peak voltage.

The average dc voltage is the constant voltage at the terminals of a cell or battery. The average ac voltage of a sine wave is zero over the complete cycle, for the two equal portions—the positive and the negative—are added vectorally and cancel.

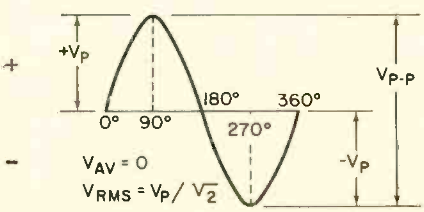


FIG. 1—A SINGLE CYCLE of ac voltage.

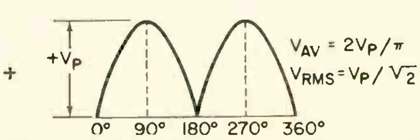


FIG. 2—TWO HALF CYCLES of same polarity deliver same power as in a sinewave.

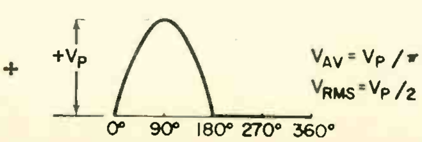


FIG. 3—NEGATIVE PULSE has been cut off, leaving only the positive pulse.

The sine wave does deliver power despite the fact that the average voltage over the complete cycle is zero. The ability to deliver power is due to the availability of voltage (and current) in each individual half of the cycle. The power is delivered due to an *effective* or *rms* voltage which is equal to $V_p/\sqrt{2}$ or 0.707 V_p.

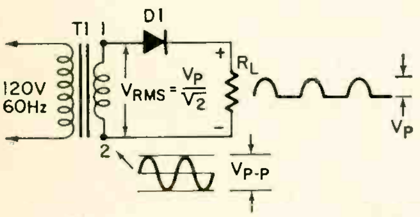
Now let us assume that the negative half of the sine wave is flopped over so that it is always positive as shown in Fig. 2. As the same varying voltage and current appear as before (only the polarity of one-half of the cycle is changed, not the amplitude) it can deliver as much power as the cycle in Fig. 1. The rms voltage will remain unchanged at 0.707 V_p. But since it delivers current and voltage in one direction, there is also an average value for the voltage. This is $2V_p/\pi$ where π is always equal to 3.14.

It is important to clearly understand the difference between average and rms voltages. The average voltage has nothing to do with power. It just tells you what voltage you would have if the amplitudes of the sine wave were added at each point on the curve and then divided by the number of points considered. It is as if the sinusoidal voltage were flattened by squashing the upper part of the curve down to a flat level and raising the bottom part to that level. The area under the flat curve is equal to that under the sinusoidal form.

*Chief Project Engineer, EICO Electronic Instrument Co., Inc.

On the other hand, the rms voltage involves power and is derived from considering the power delivered to a load by the fluctuating sine wave. The dc voltage capable of delivering this power into the same load is considered. The ac and dc voltages are assigned identical numbers in volts and amperes when they deliver identical amounts of *power*. The ac voltage, known as rms, is then compared to the peak sinusoidal voltage and a relationship between peak and rms is established.

Now, let's see what happens if the negative pulse of the sine wave is entirely eliminated and only the positive pulse (0° through 180°) remains. The voltage is zero from 180° through 360° in each cycle. See Fig. 3. The average voltage is half that for the curve in Fig. 2 while the rms voltage is that in Fig. 2 divided $\sqrt{2}$.



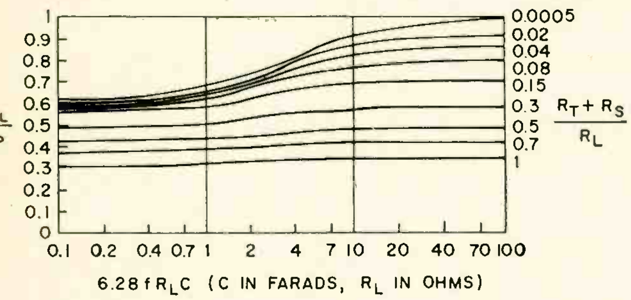
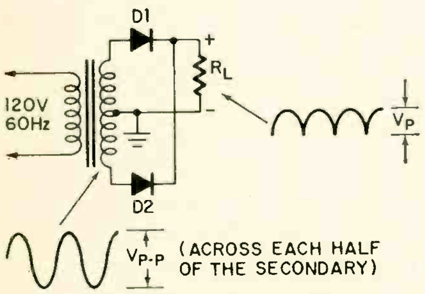


FIG. 4 (top)—HALF-WAVE rectifier. FIG. 5 — (left) — Design CURVES for half-wave power supply. FIG. 6—FULL-WAVE RECTIFIER reverses polarity of alternate half cycles.



The power supply

The audio amplifier uses many different types of power supplies to convert the ac line supply into useful dc power at the required voltage and current levels. They are all based upon the simple half-wave supply shown in Fig. 4.

The 120 volts from the power line is reduced or raised to usable levels by power transformer, T1. The voltage ratio of the primary to the secondray is, of course, proportional to the turns ratio of the two windings of the transformer.

The secondary voltage is applied across the load, R_L, through diode D1. Current flows through the circuit when terminal 1 of the transformer secondary is positive with respect to terminal 2. Only then is the anode of D1 positive with respect to its cathode, biasing the diode in its forward conducting mode. The output across R_L consists of positive half-cycle pulses. On alternate portions of the cycle, the diode is reverse biased and it does not conduct.

The average voltage across the load is almost V_p/π while the rms voltage of this half cycle is just about $0.5V_p$.

The pulsating dc across the load has a large amount of ripple. As it stands, the circuit has little value as a practical power supply for an audio amplifier. A large capacitor across the load reduces this ripple so the supply is usable as a smooth source of dc power. The capacitor charges through the rectifier during the conducting half of the cycle and will be only somewhat discharged through the load during the portion of the cycle when the diode does not conduct. It will maintain the voltage across itself and the paralleled load at a relatively clean and constant dc.

The dc voltage across the load will depend upon several factors, namely:

1. The line frequency, f.
2. The load resistance, R_L.
3. The sum of the resistance, R_T, of the transformer secondary with all other resistance, R_s, in series with the rectifier, as well as the resistance of the rectifier, r_{ac} (r_{ac}, the forward ac resistance of the rectifier is 26/I, where I is the average or dc current flowing through the rectifier and expressed in milliamperes).
4. The size of the filter capacitor.

A series of curves relating these factors is shown in Fig. 5.

To use this plot, the initial requirement is to determine the particular curve applicable to the circuit in question. To do this, determine the ratio of $(R_T+R_S)/R_L$. Use the curve which most nearly approximates this ratio. If you like, you can interpolate between two curves. Next, calculate the product $6.28 \times f \times R_L \times C$ for your circuit (where C is in farads and R_L is in ohms). Mark this point on the curve you selected and note the ratio V_{RL}/V_p at the left-hand vertical axis. V_P is the peak voltage at the secondary of the transformer, or the rms voltage multipled by $\sqrt{2}$. Then calculate V_{RL}, the dc voltage across the load, from the information derived.

The amount of ripple that can be allowed to ride on the filtered dc depends upon the section of the audio amplifier to which the rectified and filtered voltage is applied. Obviously, more ripple can be tolerated when the voltage is applied to the output stages than when applied to the higher gain inputs. In high-gain stages, the ripple is amplified more than in power amplifiers, and may thus be objectionable. Increasing the size of the filter capacitor C will reduce the ripple. Figure 5 can be used to recalculate the output voltages as related to different C's. Note that the output remains relatively constant as the product of $6.28fR_LC$ is increased above 100.

A full-wave rectifier, as in Fig. 6, reduces ripple and eases the filtering problem. However here, the ripple is of the more objectionable 120-Hz type rather than of the 60-Hz variety found in the half-wave supply. (This, of course, assumes a 60-Hz power supply.)

In the full-wave supply, two diodes are used—each conducts on alternate half cycles. The missing half cycle pulse at the output of the half wave supply in Fig. 4 is filled in here. The unfiltered average dc voltage across the load is $2V_p/\pi$ while the rms voltage is $0.707V_p$.

With a filter capacitor across the load, the ripple will be less than in the half-wave supply case because the ripple frequency is twice the supply frequency and the capacitor is not required to hold the charge as long here as was previously necessary. The capacitor gets recharged each half-cycle rather than waiting a full cycle for the next pulse, as was the case with the half-wave supply.

The curves in Fig. 7 illustrate the various relationships for the full-wave supply as did the curves in Fig. 5 for the half-wave supply. Here, V_P refers to the voltage across *half* the secondary of the transformer.

Specifying rectifiers and power transformer

Two primary factors which determine the rectifier to be used in any circuit are the dc forward current it must pass and the dc reverse voltage it must block.

The current that flows through the load is V_{RL}, the voltage across the load, divided by R_L, the load resistance. In the half-wave circuit, the rectifer must carry all this current. In the full-wave circuit, the load current is divided equally between the two diodes.

As a 0.7V forward voltage drop across the diode exists simultaneously with the forward current flow, I_F, the power dissipated by the diode is the product of the rms current and rms voltage averaged over the complete cycle. This power generates heat which must frequently be drawn away from the junction by heat sinks. Large rectifiers are mounted in metal cases which can be clamped to a chassis or other mass of metal for this purpose. Small units, rated up to about 3 amperes, use thick leads for conducting heat away from the junction. This latter structure uses either a glass or plastic case. The plastic case is more desirable for better heat dissipation while the glass envelope is used where an absolute hermetic seal is required.

So as a start—specify the average forward current. Use maximum figures if the load and diode currents vary. Give yourself plenty of leaway—multiply the calculated or measured current by two.

Next, the forward *surge* current must be considered. Normally, the load current is I_F. However, the filter capacitor across the load is a short circuit at the instant ac is applied. It is a partial short until the capacitor is fully charged. During this time, the only resistance in the circuit is the sum of transformer and diode resistances. The load resistor is shorted by the filter capacitor. A surge current exists initially due to this low circuit resistance. It is approximately the peak voltage V_P (see Fig. 4 and 6) divided by the sum of all the resistance remaining in the circuit that is not shorted by the filter capacitor.

Diode surge capabilities are denoted by the peak current permitted to flow for ½ or for a full cycle. The duration of a cycle of 60-Hz current is $\frac{1}{60}$ or .0167 second. Half cycle time is obviously half that figure or .0083 seconds. For 50-Hz lines, this becomes .02 and .01 for full and half cycle time, respectively. It doubles for the 25-Hz line.

The time constant of the power supply circuit is the product of the filter capacitor in farads (1,000,000 microfarads) with the sum of the ac resistance of the rectifier ($26/I_F$ expressed in milliamperes) and the dc resistance of the transformer winding. This product must be less than .0167 for a permissible surge current when the diode is rated for 1 cycle surge and less than .0083 for an allowed surge current when the diode is rated for ½ cycle surge. This of course, assumes 60-Hz is the base frequency.

Another consideration is the peak inverse voltage rating of the rectifier. The reverse voltage, V_R, the rectifiers must withstand is equal to twice V_P. However, there are frequently peaks and pulses in the power line which can exceed the calculated V_R by a large factor. It is wise to use rectifiers with V_R ratings exceeding the calculated value by two.

The various shapes the reverse breakdown curve can take is shown in Fig. 8. Two different types of diode characteristics, *A* and *B*, are shown. Both diodes have the same breakdown voltage, V_{BR}. Diode *A* has a lower ac and dc resistance after breakdown than does diode *B*. A large current and voltage pulse is more likely to overheat the junction of *B* than that of *A*. A diode with the breakdown characteristics of *A* is more desirable. These are referred to as controlled avalanche breakdown rectifiers.

The power transformer can be specified with the help of the curves in Fig. 5 and 7. Temperature rise is an important part of the transformer's specifications. Actually, it is desirable to limit the final transformer temperature to 95°C as the insulation is normally guaranteed to about 105°C. Considering that the transformer should, at worst, operate in a 55°C ambient, the temperature rise should be limited to 95° − 55° = 40° Celsius.

Designing a supply

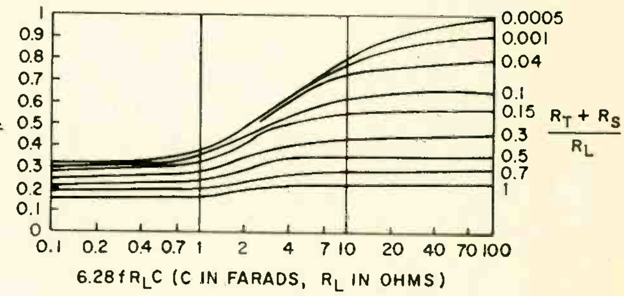
As an exercise, assume you need a power supply to deliver 30 volts at 1 ampere. You want low ripple so you select the full-wave circuit with a shunt filter capacitor. The load resistance is R_L = 30 volts/1 ampere = 30 ohms. For reasonable regulation (variation of output voltage with the change in load current) the resistance of the transformer, R_T, should be low. Assume all is satisfactory if the ratio of $R_S + R_T$ to R_L is 0.08. As r_{ac}, the only factor comprising R_S, is negligible compared to R_T, R_T must be equal to .08 R_L = 2.4 ohms.

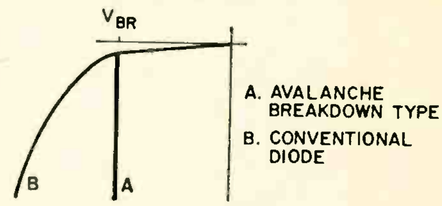
It can be shown that the ripple is fairly low if $6.28fR_LC$ is made equal to or greater than 5. Substituting f = 60 and R_L = 30 into the equation, yields a filter capacitor of at least 443μF. Feed this information into the curve in Figure 7.

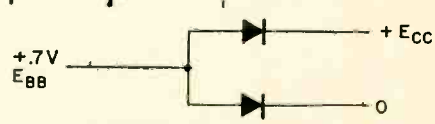
The ratio of the output voltage, V_{RL}, to the peak supply voltage, V_p, for half the transformer, is about 0.73. As V_{RL} is 30, then $V_p = 30/.73 = 43$ volts. The rms voltage across each half of the transformer is $V_p/\sqrt{2} = 43/1.41 = 30.4$ volts. From the calculations, you find you need a transformer with a 60.8 volt center-tapped secondary and a maximum effective total winding resistance of 4.8 ohms.

The continuous dc forward current rating of the silicon rectifiers can be 1 Ampere. The surge current in the circuit is $V_p/R_S = 43/2.4 = 18$ Amperes. The RC time constant is $(2.4)(443 \times 10^{-6}) = 1060 \times 10^{-6} =$ .0016 seconds. As this is less than the time for ½ cycle, a diode with a surge current rating of more than 18 amperes for ½ cycle is satisfactory.

FIG. 7 (right)—CURVES for full-wave rectifier design. FIG. 8—REVERSE-VOLTAGE break-down curves for conventional and avalanche diodes. FIG. 9 (bottom)—TWIN DIODE EQUIVALENT of bipolar transistor.







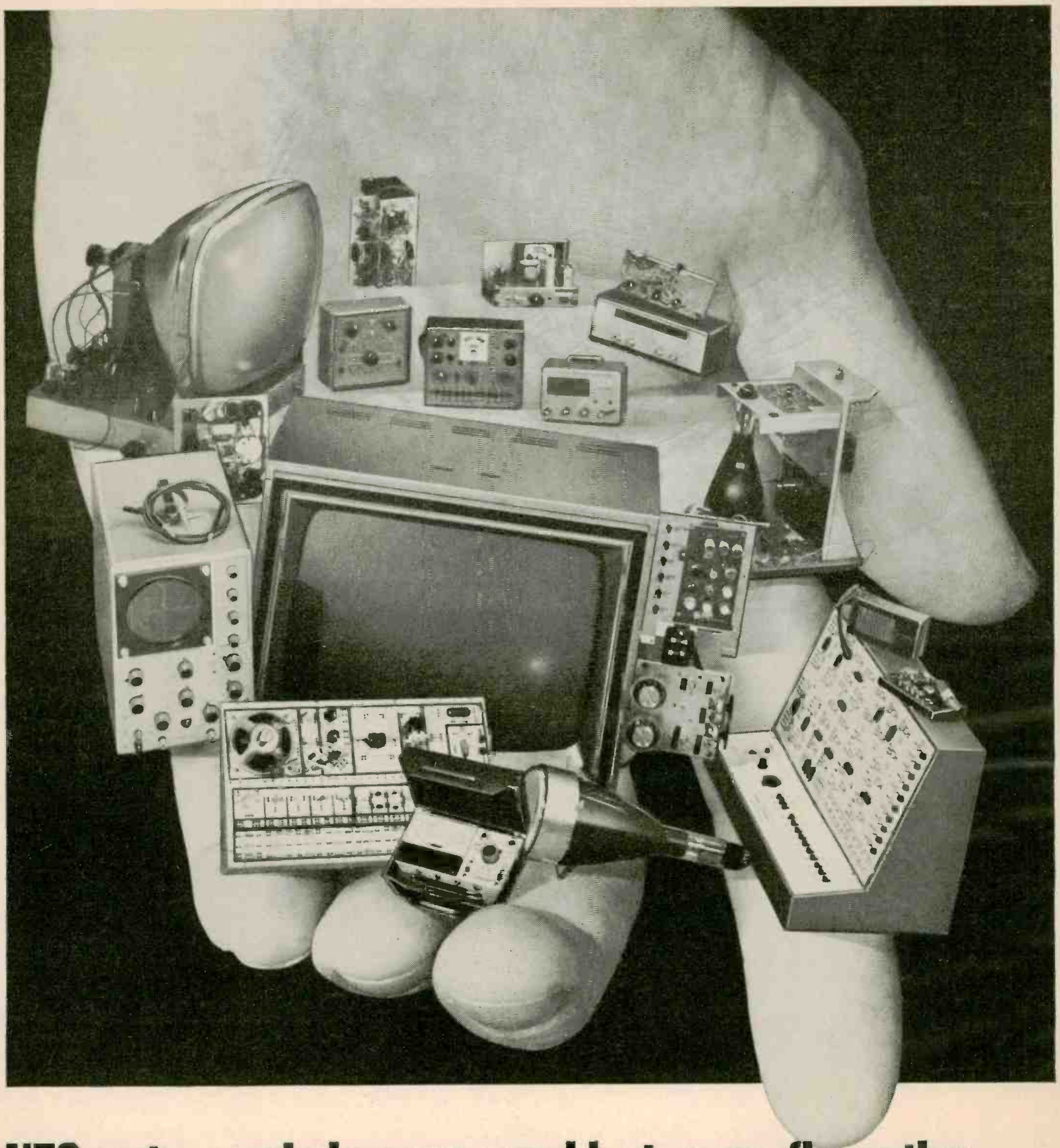
The peak inverse voltage rating for the rectifiers must be greater than $2V_p$ = 86 volts. A 100-volt rectifier will be satisfactory if there are no instantaneous surge voltage peaks in the line. To account for these surges, you can double your voltage specification for the rectifier and/or use a device with a sharp avalanche breakdown characteristic.

Another diode application

Figure 9 shows two diodes connected to power sources. This is the basic equivalent and bias circuit of the bipolar transistor.

The details of how bipolar and FET transistors operate and amplify will be discussed in the next installment of this series.

(to be continued)



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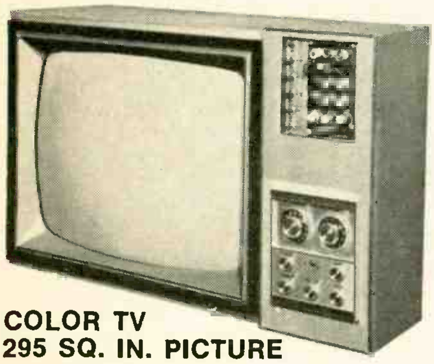

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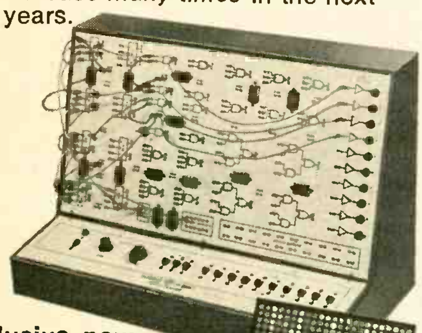

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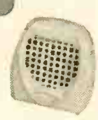

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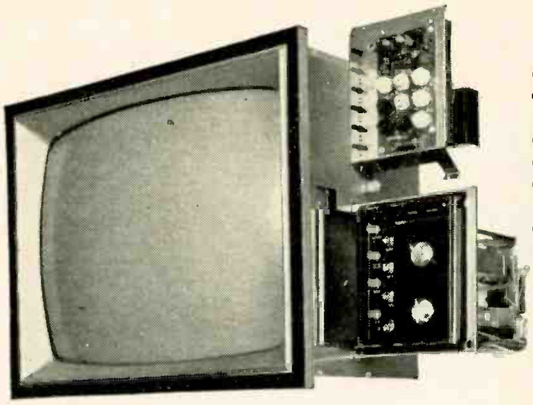
New Heathkit® Solid-State

Design and performance features add up to one-of-a-kind superiority.

Over five years were spent in research and development to achieve the notably superior performance, improved convenience features, and ease of service now embodied in the new GR-270 and GR-370. They are premium quality receivers in the truest sense, and, we believe, the finest color TV's on today's market. Here's why...



Compare these features:

- Modular plug-in circuit board construction.
- MOSFET VHF tuner and 3-stage IF.
- Adjustable video peaking.
- Sound instantly, picture in seconds.
- Built-in Automatic Fine Tuning.
- Pushbutton channel advance.
- Tilt-out convergence and secondary controls.
- Hi-fi sound outputs — for amplifier.
- Virtually total self-service capability with built-in volt-ohm meter, dot generator, and comprehensive manual.
- Premium quality bonded-face etched glass picture tubes.
- Choice of 295" or 227" picture tube sizes.

Exclusive solid-state circuitry design... total of 45 transistors, 55 diodes, 2 silicon controlled rectifiers; 4 advanced Integrated Circuits containing another 46 transistors and 21 diodes; plus 2 tubes (picture and high voltage rectifier) combine to deliver performance and reliability unmatched by conventional tube sets.

Exclusive design solid-state VHF tuner uses an MOS Field Effect Transistor for greater sensitivity, lower noise, and lower cross-modulation ... gives you sharply superior color reception, especially under marginal conditions. Gold/Niborium contacts give better electrical connections and longer wear. Memory fine tuning, standard. Solid-state UHF tuner uses hot-carrier diode design for increased sensitivity.

3-stage solid-state IF has higher gain for better overall picture quality. Emitter-follower output prevents spurious signal radiation, and the entire factory-aligned assembly is completely shielded to prevent external interference.

Automatic Fine Tuning — standard on both sets. Just push a button and the assembled and aligned AFT module tunes in perfect picture and sound automatically... eliminates manual fine-tuning. Automatic between-channel defeat switch prevents tuner from locking in on stray signals between channels. AFT can be disabled for manual tuning.

VHF power tuning...scan through all VHF and one preselected UHF channel at the push of a button.

Built-in automatic degaussing keeps colors pure. Manual degaussing coil can be left plugged into the chassis and turned on from the front panel... especially useful for degaussing after the set is moved some distance.

Automatic chroma control eliminates color variations under different signal conditions.

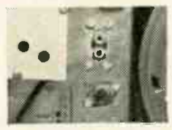
Adjustable noise limiting and gated AGC keeps pulse-type interference to a minimum, maintains signal strength at constant level.

High resolution circuitry improves picture clarity and new adjustable video peaking lets you select the degree of sharpness and apparent resolution you desire.

"Instant-On". A push of the power switch on the front panel brings your new solid-state set to life in seconds. Picture tube filaments are kept heated for instant operation, and extended tube life. "Instant-On" circuit can be defeated for normal on-off operation.

Premium quality color picture tubes. Both the 227 sq. in. GR-270 and 295 sq. in. GR-370 use the new brighter bonded-face, etched glass picture tubes for crisper, sharper, more natural color. And the new RCA HiLite Matrix tube is a low cost option for the GR-370. See below.

Adjustable tone control lets you choose the sound you prefer ...from deep, rich bass to clean, pronounced highs.



Hi-fi output permits playing the audio from the set through your stereo or hi-fi for truly lifelike reproduction. Another Heath exclusive.

Designed to be owner serviced. The new Heath solid-state color TV's are the only sets on the market that can be serviced by the owner. You actually can diagnose, trouble-shoot and maintain your own set.

Built-in dot generator and tilt-out convergence panel let you do the periodic dynamic convergence adjustments required of all color TV's for peak performance. Virtually eliminate technician service calls.

Snap-out glass epoxy circuit boards with transistor sockets add strength and durability and permit fast, easy troubleshooting and transistor replacement. Makes each circuit a module.

Built-in Volt-Ohm Meter and comprehensive manual let you check circuits for proper operation and make necessary adjustments. The manual guides you every step in using this built-in capability. Absolutely no knowledge of electronics is required.

Easy, enjoyable assembly ... the Heathkit way. The seven-section manual breaks every assembly down into simple step-by-step instructions. With Heath's famous fold-out pictorials and simple, straightforward design of the sets themselves, anyone can successfully complete the assembly.

Heathkit Solid-State Modular Color TV represents a significant step into the future...with color receiver design and performance features unmatched by any commercially available set at any price! Compare the specifications. Then order yours today.

Kit GR-270, all parts including chassis, 227" picture tube, face mask, UHF & VHF tuners, AFT & 6x9" speaker, 114 lbs. **$489.95***

Kit GR-370, all parts including chassis, 295" picture tube, face mask, UHF & VHF tuners, AFT & 6x9" speaker, 127 lbs. **$559.95***

Kit GR-370MX, complete GR-370 with RCA matrix picture tube, 127 lbs. **$569.95***

GR-270 AND GR-370 SPECIFICATIONS — PICTURE TUBE SIZE: GR-370 Approximate Viewing Area: 295 Sq. In. GR-270 Approximate Viewing Area: 227 Sq. In. **DEFLECTION:** Magnetic, 90 degrees. **FOCUS:** Electrostatic. **CONVERGENCE:** Magnetic. **ANTENNA INPUT IMPEDANCE:** VHF 300 ohm balanced or 75 ohm unbalanced. UHF: 300 ohm balanced. **TUNING RANGE:** VHF TV channels 2 through 13. UHF TV channels 14 through 83. **PICTURE IF CARRIER:** 45.75 MHz. **SOUND IF CARRIER:** 41.25 MHz. **COLOR IF SUBCARRIER:** 42.17 MHz. **SOUND IF FREQUENCY:** 4.5 MHz. **VIDEO IF BANDWIDTH:** 3.58 MHz. **HI-FI OUTPUT:** Output impedance — 1 k ohm. Frequency response — ±1 dB 30 Hz to 10 kHz. Harmonic distortion — less than 1% at 1 kHz. Output voltage — 0.3 V rms nominal. **AUDIO OUTPUT:** Output impedance — 4 ohm or 8 ohm. Output power — 2 watts. **POWER REQUIREMENTS:** 110 to 130 volts AC, 60 Hz, 240 watts. **NET WEIGHT:** GR-370, 114 lbs.; GR-270, 101 lbs.

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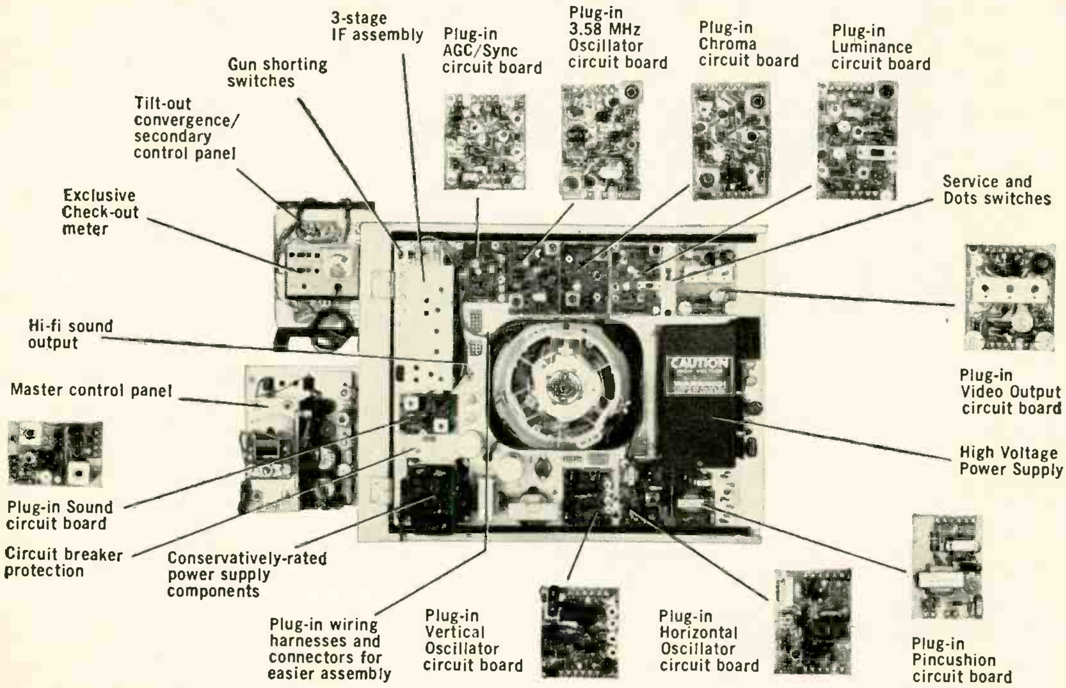

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Kit GRA-70-6, 6 lbs. **$64.95***

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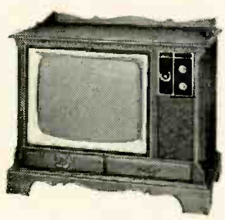

Contemporary Walnut Cabinet . . . factory assembled of fine veneers & solids with an oil-rubbed walnut finish. 29-17/32" H x 35-13/16" W x 19⅞" D. **Assembled GRA-301-23**, 56 lbs. **$74.95***

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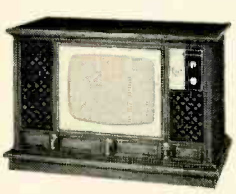
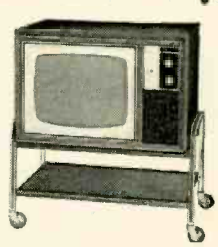


Contemporary Walnut Cabinet and Base Combination. Handsome walnut finished cabinet sits on a matching walnut base. Cabinet dimensions 20-31/32" H x 31-7/16" W x 18⅝" D. Base dimensions 7¾" H x 27¾" W x 18⅝" D. **Assembled GRA-203-20 Cabinet**, 45 lbs. **$49.95*** **GRS-203-6** above cab. w/ matching base, 58 lbs. **$59.95***

Handy Roll-Around Cart and Cabinet Combination. Features the GRA-203-20 walnut cabinet plus a walnut-trimmed wheeled cart with storage shelf. **Assembled GRA-203-20 Cabinet**, 45 lbs. . . . .**$49.95*** **GRA-204-20 Roll-Around Cart**, 18 lbs. . . .**$19.95*** **GRS-203-5, Cart & Cabinet Combo**, 58 lbs. **$59.95***



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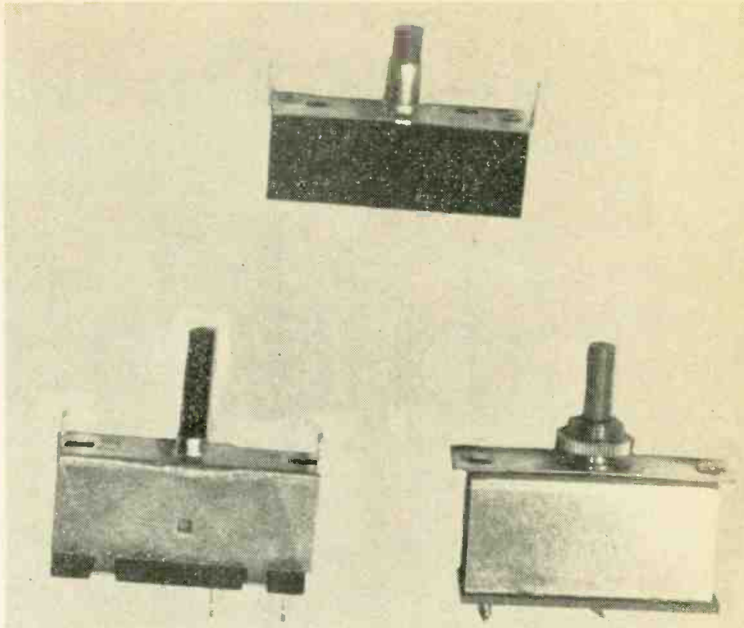


THREE COMMON BREAKERS. Top unit is Workman. At lower left is Littelfuse unit and Mel-Rain breaker is at bottom right.

Replacing TV Circuit Breakers

by JAMES A. FRED

On most TV's you will find a little red button on the back of the set. This button resets a circuit breaker that protects the TV from many potentially serious troubles. Other TV's have the circuit breaker built into the on-off switch.

The circuit breaker can be in the power transformer primary or it may be in the center of the high voltage winding on the transformer. The circuit diagram in Fig. 1. is typical of TV's that use power transformers. The circuit breaker protects the B-plus circuits from current overloads.

The second circuit diagram, shown in Fig. 2, is typical of sets that do not use a power transformer. The circuit breaker removes the line voltage from the set whenever the B-plus current exceeds the circuit breaker rating.

The circuit breaker rating is established by engineers at the TV set manufacturer's laboratory. The operating current rating is determined by measuring the current drawn by a number of sets when operated at various line voltages. The break current is 150% of the operating current.

More recently introduced is a new dual circuit breaker for color TV sets. This circuit is shown in Fig. 3. There are two circuits through the breaker: one protects the B-plus while the other protects the horizontal output. Excessive current in either circuit will open the breaker and remove all B-plus from the set.

Several replacements are available

Four companies are marketing circuit breakers for replacement use. They are: Littelfuse Corp., Des Plains, Ill.; Workman Electronic

(continued on page 85)

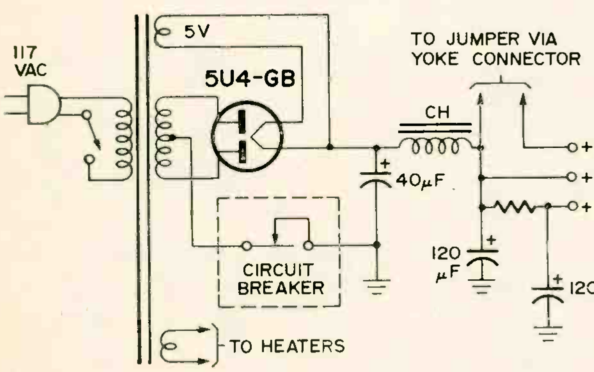


Fig. 1

FIG. 1—TYPICAL TV POWER SUPPLY in a receiver that uses a power transformer. Note the location of the circuit breaker in the ground portion of the B-plus supply.

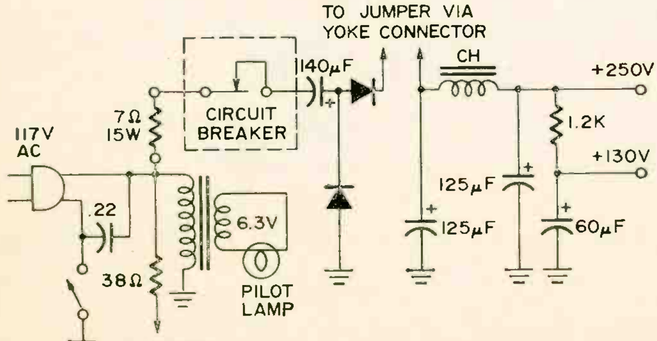


Fig. 2

FIG. 2—TRANSFORMERLESS VOLTAGE-DOUBLER power supply has the circuit breaker after the heater string takeoff. When breaker opens, B-plus is removed from the set.

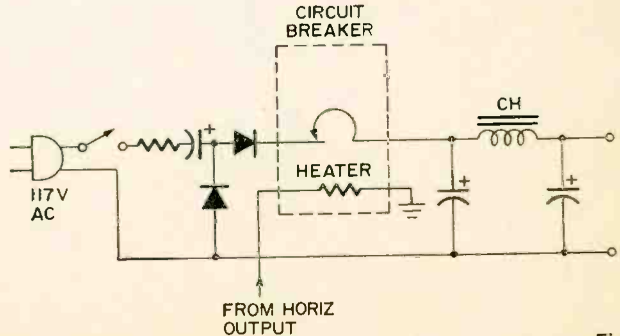


Fig. 3

FIG. 3—DUAL-ELEMENT BREAKER is often used in color TV's. Overloads on B-plus line or horizontal output circuits will cause it to open.

To call it "an amplifier" would be like calling a Porsche "Basic transportation."

There is unusual satisfaction that comes from fulfilling a prosaic task in a far from prosaic manner.

Hence this amplifying system: the Sony TA-2000 professional preamplifier and the Sony TA-3200F power amplifier. Together, they perform all an amplifier's standard tasks in a satisfyingly impeccable manner; but their 67 levers, switches, meters, knobs and jacks allow you to perform some interesting functions that are anything but standard.

Dual-purpose meters.

The two VU meters on the preamplifier front panel, for example, are no more necessary than a tachometer on an automobile. But they do serve the dual purpose of simplifying record-level control when the TA-2000 is used as a dubbing center, and of allowing you to test your system's frequency response and channel separation (as well as those of your phono cartridge), and to adjust the azimuth of your tape heads.

A broadcast/recording monitor console in miniature.

The TA-2000 resembles professional sound consoles in more than its VU meters. In addition to the 20 jacks and seven input level controls provided on its rear panel for permanent connections to the rest of your hi-fi system, the TA-2000 boasts a professional patch board in miniature on its front.

Thus, you can feed the inputs from microphones, electric guitars, portable recorders or other signal sources into your system without moving the preamplifier or disturbing your normal system connections in the least. And a front-panel Line Out jack feeds signals for dubbing or other purposes into an external amp or tape recorder, with full control of tone and level from the front-panel controls and VU meters.

The tone correction and filtering facilities are also reminiscent of professional practice, allowing a total of 488 *precisely repeatable* response settings, including one in which all tone controls and filters are removed completely from the circuit.

The amplifier—no mere "black box"

A power amplifier can be considered simply as a "black box" with input and output connections, a power cord, and an on/off switch; and such an amplifier can perform as well (or poorly) as the next one. But in designing the TA-3200F Sony took pains to match the amplifier's facilities to the preamplifier's.

Thus to complement the TA-2000's two pairs of stereo outputs, the TA-3200F has two stereo pairs of inputs, selected by a switch on the front panel. Other front panel controls include independent input level controls for both channels, a speaker selector switch, and a power limiter (in case your present speaker should lack the power handling capacity of the next one you intend to buy).

Circuitry unusual, performance more so

The single-ended, push-pull output circuitry of the TA-3200F amplifier is supplied with both positive and negative voltages (not just positive and "ground") from dual balanced power supplies. This system allows the amplifier to be coupled directly to the speakers with no intervening coupling capacitors to cause phase shift or low-end roll-off (A switch on the rear panel does let you limit the bass response below 30Hz if you should want to, otherwise, it extends all the way down to 10Hz.)

The individual stages within the amplifier are also directly coupled with a transformerless complementary-symmetry driver stage, and Darlington type capacitorless coupling between the voltage amplifier stages.

As a result, in part, of this unique approach, the TA-3200F produces 200 watts of continuous (RMS) power at 8 ohms, across the entire frequency range from 20 to 20,000 Hz; IHF Dynamic Power is rated at 320 watts into 8 ohms (and fully 500 watts into a 4-ohm load).

But more important by far is the quality of the sound; intermodulation and harmonic distortion levels are held to a mere 0.1% at full rated output, and 0.03% at the more likely listening level of one-half watt. The signal-to-noise ratio is an incredible 110dB. And the full damping factor of 170 is maintained down to the lowest, most critical frequencies (another advantage of the capacitorless output circuit).

The companion TA-2000 preamplifier also boasts vanishingly low distortion and a wide signal-to-noise ratio, but this is less unusual in a preamplifier of the TA-2000's quality (and price). What *is* unusual is the performance of the phono and tape head preamplifier circuits; for though they have sufficient sensitivity (0.06mV) for the lowest-output cartridges (even without accessory transformers), these preamplifier circuits are virtually immune to overload—even with input signals 80 times greater than normal.

Their sole vice: they are hardly inexpensive

Of course, at a price of $329.50 (suggested list) for the TA-2000 preamplifier, and $349.50 (suggested list) for the TA-3200F power amp, this system cannot be considered other than a luxury. But then, it was intended to be. For there are those to whom fulfillment of prosaic tasks is unfilling. And among them are not only many of our customers, but also many of our engineers. Sony Corporation of America, 47-47 Van Dam Street, Long Island City, New York 11101.

SONY

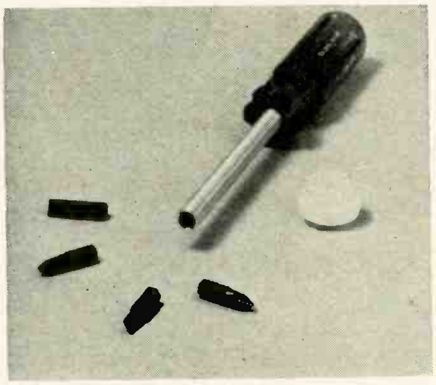
Porsche is a trademark of Dr.-Ing.h.c.F.Porsche KG

Circle 17 on reader service card

NEW PRODUCTS

More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card on page 91 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

MAGNETIC SCREWDRIVER—*Vaco-Matic,* features four interchangeable bits—two conventional and two Phillips—is four tools in one. Large contoured



handle allows for minimum hand fatigue. Aluminum shaft has an integral magnet to hold screws in hard-to-reach places. Wide selection of interchangeable bits available.—**Vaco Products Co.,** 510 N. Dearborn St., Chicago, Ill. 60610.

Circle 31 on reader service card

CASSETTE CARRYING CASES, *models 1509 and 1510* are available in a wide range of colors and patterns. *1509* stores 12 cassettes, *1510* for 12, 8-track

cartridges. Made of sturdy molded plastic, compartmented trays assure full protection of tapes and are removable. **RMS Electronics, Inc.,** 50 Antin Place, Bronx, N.Y. 10462.

Circle 32 on reader service card

STEREO RECEIVER, *model KR-5150,* is 180-watt unit. Terminals for three sets of speakers with a front panel speaker selector switch, center channel output and inputs for two phonographs, two

auxiliary lines and terminals for a tape deck are built in. Frequency response is 20-40,000 Hz (plus 1.5 dB), a power bandwidth of 17Hz-30kHz and 0.5% distortion at rated output. The tuner section has 2 FETs, a 4-gang tuning capacitor, a signal strength meter and an FM zero center tuning meter with FM stereo indicator light. Pushbuttons control loudness, tape monitor, FM muting and high and low filter, $319.95.—**Kenwood Electronics, Inc.,** Dept. P. 15711 S. Broadway, Gardena, Calif. 90247.

Circle 33 on reader service card

LASER SCIENCE KITS for those interested in science and conducting experiments in light, communications and photography. Kits include a loose-leaf manual outlining a range of experiments. With the *Laser Optics Kit,* hobbyists can progress from the beginning concepts of

light, through geometric optics, and on through physical optics, including holography (three-dimensional photography). Each kit is built on a modular concept that allows expansion of the range of experiments as interest grows.—**Metrologic Instruments Inc.,** 143 Harding Ave., Bellmawr, New Jersey 08030.

Circle 34 on reader service card

MOBILE FM TRANSCEIVER, *model HR-2.* For operation in the 144-148 MHz band. Features a 10-watt power output with any of 6 transmit and re-

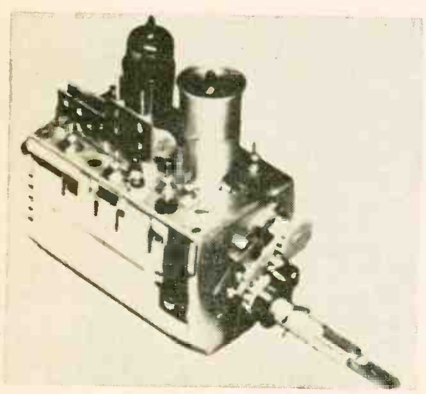
ceive channels in the band. The receiver section is double conversion, superheterodyne with a ceramic filter for operation on both wide and narrow band signals. Sensitivity is 0.35 μV, 20 dB quieting and audio output at 5 watts. Transmitter has phase modulation for stability. Built-in SWR load mismatch circuitry protects against open or shorted antenna conditions. Includes ceramic microphone, built-in speaker and mobile mounting bracket, and one pair of installed transmit and receive crystals. $229.00.—**Regency Electronics, Inc.** 7900 Pendleton Pike, Indianapolis, Ind. 46226.

Circle 35 on reader service card

LOW BAND TRANSCEIVER, *model 2303A*, available for use in either the 32.5-41-MHz or the 42-50-HMz bands. Provides two-way communications in metropolitan areas for fire and police depts. and all public services and business applications where tall buildings are a problem. The unit delivers 1.6 watts output. Features separate transmit and receive channels, a squelch circuit, and includes external connections for antenna, earphone and battery charger. Supplied with crystals for one channel and a set of 12 AA batteries. $475.—**Sonar Radio Corp.,** 73 Wortman Ave., Bklyn., N.Y. 11207.

Circle 36 on reader service card

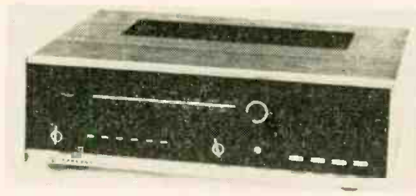
REPLACEMENT TV TUNERS, for color or black & white receivers with 40-MHz i.f. systems. Available with heater circuits for 6.3V, 600-mA, 450-mA and 300-mA supplies. Short and long shafted styles enable the TV technician to cut and match to original tuner shaft, up to



12 inches. All models aligned for 41.25-MHz sound i.f. and 45.75-MHz video i.f. Equipped with memory fine tuning, they have uhf position with plug input for amplifying the uhf tuner output. B-plus supply for the uhf tuner is automatically switched on when uhf position is selected. Available in 8 models ranging from $8.95 to $11.00.—**Castle TV Tuner Service,** 5710 N. Western Ave., Chicago, Ill.

Circle 37 on reader service card

HI-FI MULTIPLEX RECEIVERS, *Mark 10, Mark 12, Mark 20.* All are top-of-the-line products with 100-, 150-, and 300-watt outputs respectively. *Mark 10* has an accessory ac outlet for use with another music source. *Mark 12* in-

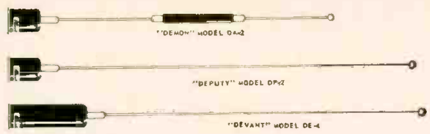


corporates switched and unswitched accessory ac outlets plus 75 and 300 ohm antenna inputs. The *Mark 20* includes a ceramic i.f. amplifier, scratch filter, interstation muting, and a calibrated slide adjustment system for bass, treble, balance and volume control. Each unit has linear logging scales and a center reading tuning meter for FM and maximum reading signal strength meter for AM. Tape monitoring and front panel provisions, stereo headphone jacks, and loudness contour controls are standard features on all models.—**Concord Electronics,** 1935 Armacost Ave., Los Angeles, Calif. 90025.

Circle 38 on reader service card

CB WHIP ANTENNAS, *models DA-2, DP-2, DE-4.* These three mobile antennas are for automobile mounting and are useful for the 26.9 to 27.3 MHz Citizen's band. All are omnidirectional, have a VSWR of 1.5/1 or better. Feedpoint impedance is 52 ohms. The whip elements are made of stainless steel. The

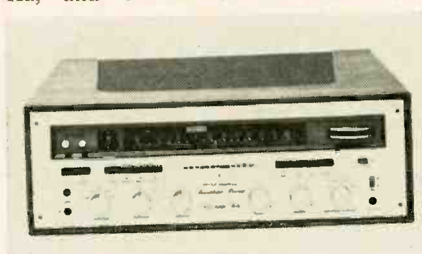
DA-2 and *DP-2* are paralleled capacitor matched, while the *DE-4* has a shunt feed. The *DA-2* is intended for CB use,



while the *DP-2* can also be used for 10 meter amateur band, and can handle 200 watts AM, 400 watts PEP SSB input to the final. The *DE-4* can handle 250 watts, AM, 500 watts PEP SSB input to the final on the 10 meter amateur band. The *DA-2* is 17 5/16" long. The *DP-2* is 44" long. The *DE-4* is 46 1/6" long.—**Mosley Electronics Inc.**, 4610 N. Lindbergh Blvd., Bridgeton, Mo. 63044.

Circle 39 on reader service card

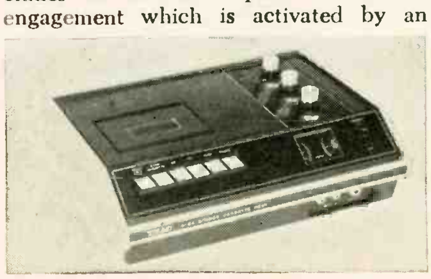
STEREO FM RECEIVER, *Marantz model 19.* Features built-in oscilloscope for precise tuning. Push-button controls select desired operating mode. Channel separation in excess of 45 dB at 1000 Hz, and 30 dB at 15 kHz. Elec-



tronically triggered photo-electric circuits for automatic stereo switching. Butterworth i.f. filters reduce distortion and give better high frequency separation. Parametric inter-station muting circuit. Two dubbing jacks are provided for a second recorder's inputs and outputs for copying tape from the system's recorder to another. Other features include a tape monitor switch, high-low filters, an antenna attenuator, and a front panel headphone jack. $1,000.—**Superscope, Inc.** 8150 Vineland, Sun Valley, Calif.

Circle 40 on reader service card

CASSETTE DECK, *model A-24,* has a frequency response of from 40-12,000 Hz. The transport utilizes a hysteresis-synchronous outer-rotor motor for precise tape speeds and smooth performance. Includes an automatic pinch roller disengagement which is activated by an



end-of-cassette sensing circuit. This engages the mechanism and eliminates deformation of drive components. Provides its own input selector to choose tuner or line sources and can be integrated into any component system. $199.50.—**Teac Corp.**, 2000 Colorado Ave., Santa Monica, Calif. 90404.

Circle 41 on reader service card

AUTO BURGLAR ALARM, *Audiotex 30-3180,* installs rapidly, uses no special tripping or triggering switches. Detects any sudden drop in battery voltage, no matter how small. Such a drop occurs when a door or lighted glove compartment, trunk, or engine compartment

are opened, when the starter is used, headlights turned on, or radio used. The voltage drop sounds a loud emergency bell. Kit includes step-by-step instructions. $29.95.—**GC Electronics**, Div. of Hydro-metals, 400 S. Wyman St., Rockford, Ill. 61101.

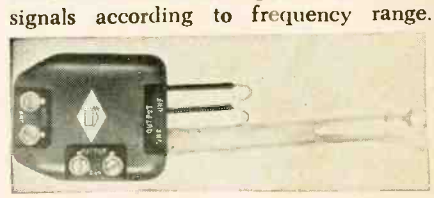
Circle 42 on reader service card

SOLDERING IRON HOLDER, *Big Hex,* is designed for heavy duty irons with case diameter up to 1¼". May be mounted either above or below a bench. Features a solder splash shield and cup

for operator safety and an open frame for better air circulation.—**Hexacon Electric Co.**, 161 W. Clay Ave., Roselle Park, N.J. 07204.

Circle 43 on reader service card

VHF/UHF/FM SIGNAL SPLITTER, *Model FS-1314-FM.* Separates incoming signals according to frequency range.



Signals are available at three 300 ohm outlets: vhf from 54 to 216 MHz, uhf from 470 to 890 MHz and FM from 88 to 108 HMz. No lead stripping is needed. $3.95.—**Jerrold Electronics**, 401 Walnut St., Phila., Pa. 19105. R-E

Circle 44 on reader service card

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader Service Card on page 91 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

TV ACCESSORY CATALOG, Telematic's professional line features brighteners, antenna couplers, antenna switches, service extensions, replacement sockets, test jig accessories, and hi-voltage accessories. Also offers service aid kits.—**Telematic,** 2245 Pitkin Ave., Bklyn., N.Y. 11207.

Circle 45 on reader service card

DRY TRANSFER CATALOG, *1970,* lists technical instant lettering, dry transfers, and related products for engineers, industrial designers, draftsmen, chemists, and technical illustrators. Included are 128 JotDraft printed circuit and component patterns and a series of direct etch resist kits. Includes protective coatings, electronic symbol drafting set, titles for electronic equipment, and an alphabet and numeral cross-reference table. Also tells how to use dry transfers effectively.—**Datak Corp.** 85 Highland Ave., Passaic, N.J. 07055.

Circle 46 on reader service card

ELECTRONIC PARTS CATALOG—*No. 710.* This 468 page buyer's guide offers the latest in stereo amplifiers, tuners, changers, turntables, reel-to-reel tape recorders, cassette and cartridge players for home and auto, digital clock radios, television, two-way radios, marine equipment, tools, and thousands of electronic components.—**Lafayette Radio Electronics,** Dept. PR, Box 10, Syosset, L.I., New York 11791.

Circle 47 on reader service card

INDUSTRIAL SOLDERING TOOLS, *catalog N5,* lists technical and performance information on controlled output soldering tools, tip styles and accessories, standard, miniaturized, isolated and low voltage tools are also included. A basic soldering tool selector guide relates specific Weller tools to typical soldering situations. In addition, economy tools and field service kits are listed.—**Weller division of Cooper Industries** Box 345, Easton, Pa. 18042.

Circle 48 on reader service card

CATALOG of *Closed Circuit TV's.* Includes indoor and outdoor cameras, sound, wireless, transistor and infra-red cameras, video monitors, lenses, video switchers. Also lists tripods, vidicon tubes, camera stands, and others.—**GBC TV Corp.,** 74 Fifth Ave., New York, NY 10011.

Circle 49 on reader service card

CB MOBILE ANTENNAS CATALOG, features CB whips and nine interchangeable mounting accessories offering the equivalent of 78 antenna systems. For custom designing, each part can be bought separately. Detailed information is given on the Demon, Deputy, and Devant Whip models—**Mosley Electronics,** 4610 N. Lindbergh Blvd., Bridgeton, Mo. 63044.

Circle 50 on reader service card

CAPACITOR REPLACEMENT GUIDE, lists Arcolytic replacement products by original manufacturer's part number for color and black and white receivers. Also includes cross reference guides. Sets listed were manufactured from 1958 through January, 1969. Each set manufacturer is listed alphabetically and manufacturer part numbers are cross-referenced to the proper replacement.—**Loral Distributor Products,** Pond Hill Industrial Park, Great Neck, L.I., N.Y. 11022.

Circle 51 on reader service card

SEMICONDUCTOR DEVICE DIGEST, Lists IR's line of electronic devices including, silicon controlled rectifiers, power logic triacs, high power silicon rectifiers, selenium rectifiers, Zener regulators, low power silicon rectifiers, silicon assemblies, light sensitive devices and heat exchangers. Each category of semiconductor devices is presented in compact tables and charts giving ratings, parameters, and other specifications. Complete alpha-numeric cross reference index of individual device numbers. Dimensional case drawings included.—**International Rectifier, Semiconductor Division,** Dept. 781, 233 Kansas St., El Segundo, Calif. 90245

Circle 52 on reader service card

REPLACEMENT SEMICONDUCTOR GUIDE, *Entertainment Semiconductor Almanac,* is broken down into three sections, I for technical data, II for replacement guides, and III for experimenter and hobbyist components. Listings include Quartz crystals, Zener diodes, terminal drawings, crystal diodes, silicon and germanium rectifiers, dual diodes, and kits, with cross referencing. Listed in numerical order. **General Electric** Tube Dept., Owensboro, Ky. 42301.

Circle 53 on reader service card

Write direct to the manufacturers for information on the following items.

TV PRODUCT CATALOG, covers the full line of general TV distribution products plus a guide to MATV systems. Includes nearly 300 products with photos, specification tables, diagrams and drawings. Covers several TV distribution product lines. Categories include system and home antennas, amplifiers, preamplifiers, plus traps, filters, converters, modulators, demodulators, outlets, connectors, adapters, cameras and accessories. 56 pages. **$1.00—**from **Jerrold Electronics,** 401 Walnut St., Phila., Penna. 19105.

MASTER INDEX to **Supreme Publications,** Carries Most-Often-Needed Television and Radio servicing information. Names of manufacturers are listed in alphabetical order. Listed at the left under each manufacturer in numerical order are models and chassis numbers listed in various Supreme manuals. Across from each listing, reference is made to manual and page where service material for each set begins. Separate section for models prior to 1965. Tells how to obtain diagrams.—**Supreme Publications,** 1760 Balsam Road, Highland Park, Ill. **R-E**

Circle 62 on reader service card

IN THE SHOP
(continued from page 27)

ter stage, you've found the trouble. You'll also see a *negative* picture on the screen! If the "colors look very odd" turn the color off and see if the video isn't negative.

You do not need a wideband scope to make these tests. If the bandwidth and sensitivity of your old scope is a little limited you won't see sharp clean patterns, but you'll see 'em. The waveforms of Figs. 1, 2 and 3 were made on a scope old enough to vote. With the newer models you will be able to see signals of much lower amplitude; for example, the signal at the tuner output, which is only a few hundred microvolts.

With this method you can chase down trouble anywhere in the set—sync, agc white-compression, sync-clipping, and many others. The comb pattern has both vertical and horizontal sync pulses.

Using the demodulator probe you can trace the color signals through the bandpass amplifiers, clear up to the demodulator input. Use the demodulator probe, for the color signals at this point are really rf; between 3.08 and 4.08 MHz, and AM at that. However, they will "demodulate" to show you the same comb pattern you see in other stages. Signal level at the input will be only a few volts, 1 or 2V typical. Output at the demodulator grid (input) will average about 30 volts p-p.

If you can see the color signals at this point, but still have no color on the screen, you can eliminate the bandpass amplifiers, the color killer (which generally cuts off the 2nd bandpass amplifier) and several other things—cc, afpc, and so on. Go and scratch around in the 3.58-MHz oscillator or burst-amp circuits. The chances are that they're not working properly. A great many other "obscure" troubles can be found and fixed in this way, by eliminating certain things as possible causes.

There are a lot of other troubles that can be pinned down by signal-tracing. So, have at it! **R-E**

Service Clinic

By JACK DARR
SERVICE EDITOR

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, 200 Park Ave. South, New York 10003.

NO B+ VOLTAGE ON DAMPER PLATE?

This Admiral portable, a G4 chassis, has no raster. Sound is very low, but clear. I get no boost voltage at all; in fact, there's no voltage, even on the plate of the horizontal output tube! Also, no B+ on the plate of the damper tube! Help!—G.K., Utah.

Ah yes! I've seen this one before. Start at the damper plate, pin 2 of the 38HE7 combination horizontal output-damper tube, and check continuity back toward the B+ 135 volt

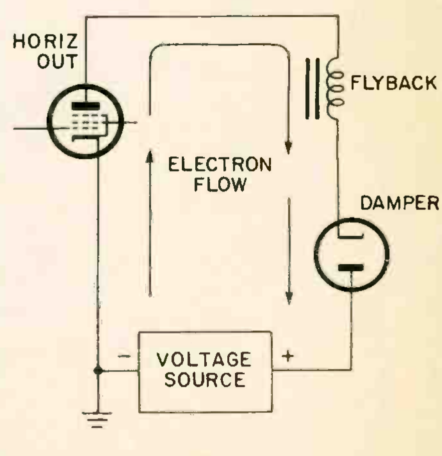


FIG. 1

source. You'll find an open circuit somewhere!

The damper tube must have B+ before any circuit like this can work. The voltage supply for the horizontal output tube plate comes through the damper tube from B+, as in Fig. 1. So, get this first and the rest will probably work. Check the PC board under the 38HE7 socket. If C432, across the damper tube, has been bent over, it can arc to the PC board conductor

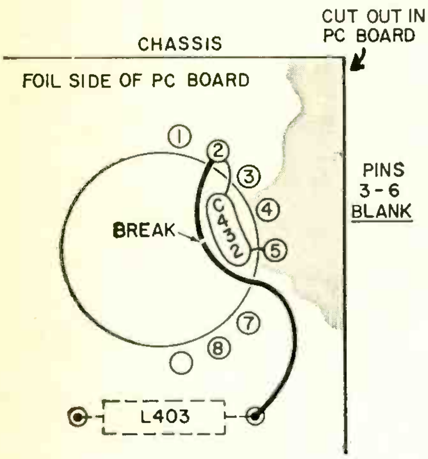


FIG. 2

which connects pin 2 of the 38HE7 to the load end of the rf choke, L403 in Fig. 2. If this has happened, it'll be easy to see. Bend the capacitor up and away from the board and run a bead of solder along the conductor. Job over.

ELECTRIC CLOCK SLOW?

I've an old Telechron electric clock, a 4H12. It ran slow for a while, then stopped entirely. My wife is very fond of it (It's her kitchen timer!) and she wants me to fix it. I think the drive coil is burned; it's so old that I don't know where to get one. Can you help?—D. D., Ink, Ark.

I have the same kind of problems. (Don't we all?) Anyhow try this; check the resistance of that coil. If it's around 600 ohms, it's probably OK. Turn it on and hold a small screwdriver near the frame. If it "buzzes", the coil is OK. Your "gear-box" is probably gummed up.

Take out the 4 screws; the frame will come apart. Try some very light oil on the tiny pinion. If it won't go in, then put the unit over a soldering iron until it's pretty hot. You should see tiny bubbles at the pinion. Now, take it off, and apply the light oil to the pinion; at the same time, spray coolant on the case! This will create a little vacuum inside the case and suck the oil in. If standard light oil won't work, try using some of the silicone lubricant in spray-cans. This is very light, and will get into places where oil won't.

If this won't do it, you can still get the gear-box and coil units from any of several large appliance-parts houses.

HORIZONTAL TROUBLE, MAGNAVOX 908

I've horizontal drive trouble with a Magnavox 908 transistor TV. I get about 7–8 kV of high voltage, but the base waveform on the horizontal output transistor is very distorted. Not as big as it should be, either. Tried a new horizontal output transistor, but that didn't help. I get a peculiar waveform on the primary of the horizontal driver transformer, too.—R. G., Salina, Kansas.

This can be annoying! Check the dc voltages on the horizontal *driver* transistor. I have a deep suspicion that you'll find almost the same voltage on both collector and base! This transistor is probably *shorted.*

The question immediately arises, "How can we get any signal at all through it if it's shorted?". You have apparently got a base-collector short and with the circuit connections used here, you *can* get some drive signal to flow through and get to the horizontal output!

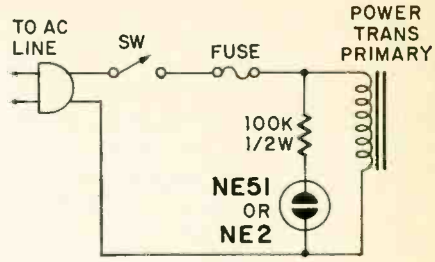
The two isolated transformer windings let this happen. In direct coupled circuits no, but in this case it's possible. **R-E**

TRY THIS ONE

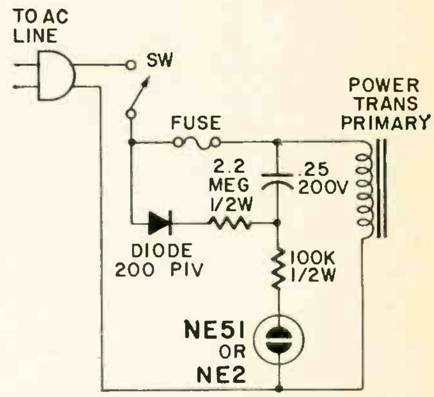
PILOT LIGHT AS POWER LINE AND FUSE MONITOR

The addition of three simple components will convert your neon pilot light to a triple-duty monitor. Figure 1-a shows the circuit before conversion and Fig. 1-b, after conversion. Here's how it works. Under normal conditions, with ac line power present, the neon lamp lights as soon as you turn on the switch. If the equipment fuse blows, however, the circuit automatically becomes a low-frequency relaxation oscillator and the neon lamp will blink on and off continuously. The lamp will, therefore, in addition to its normal pilot light function, automatically and specifically indicate by either blinking on and off or not lighting at all, if your loss of power is due to a blown fuse in the equipment or an ac line problem. The feature of being able to identify the problem immediately can be a great time saver if your equipment is installed so the fuse and/or ac outlet is hard to get at.

The diode can be any silicon rectifier with a rating of 200 piV or more. The values shown for the added resistor and capacitor were chosen to produce a satisfactory blinking rate for the neon lamp. The values may range, however, from 1 meg to 10 megs and from 0.1 to 1 μF depending on the blinking rate that you desire.—*Bill Fisher* **R-E**



a



b

Fig. 1

X-RAY DETECTORS
(continued from page 39)

0.150, 0.50, 1.50, and 5.0 volts full scale for the 1000 to 100,000 count-per-minute ranges mentioned earlier). Input voltage can be obtained from a battery and potentiometer applied directly to Q5's gate without disconnecting previous circuitry.

A pulse generator (negative pulse of about 0.5 to 2.0 volts peak with a rise time of about 0.1 μsec and a width of less than 100 μsec) should be connected across the junction of R2 and R3. The pulse rate can be related to the meter reading by adjusting R13. Only one point needs to be set. The circuit in Fig. 1-b is a convenient way to obtain 3600 counts per minute. The clip is connected to the R2-R3 junction. Usually no ground is required. If so, touching the chassis is enough.

General operating data

Normal background count rates will probably fall between 40 and 150 per minute. Any x-ray emission high enough to justify corrective action will increase this count rate considerably. If there is any question or doubt that the rate has increased, it has not.

In a conventional color TV, x-rays are generated by the picture tube, shunt regulator, and high voltage rectifier. Thus a quick pass, say 30 seconds across the CRT face is enough for this area. Some CRTs emit x-rays from the funnel. In some instances these are transmitted through the cabinet. If the tube emits from the face, it will emit over most of the face area.

The regulator tube and rectifier are usually placed on the opposite side of the cabinet from the tuner. Hence, a pass around the rear, top, side, and if accessible, the bottom of the set in the vicinity of the high-voltage components and CRT should be all that is necessary. Sometimes the x-rays are emitted in a narrow beam, so it is important that you sweep as great an area as possible. When using the instrument move it at rate of about 1 foot in 15 seconds. **R-E**

"I hope it doesn't bother you to have someone look over your shoulder."

EQUIPMENT REPORT

Harman-Kardon Citation Twelve

For manufacturer's literature, circle No. 20 on Reader Service Card.

LEGENDS AND GREAT NAMES NOTWITHSTANDING, RADIO-ELECTRONICS decided to take a critical look at the new Citation Twelve amplifier, Harman-Kardon's first kit product in eight years.

Unpacking our Citation Twelve kit and examining the components and literature, it was apparent that H-K hadn't lost its touch for producing great kits. The 45-page manual is clearly written, profusely and accurately illustrated, and it's obvious that the person who wrote the manual actually assembled the amplifier, with comments such as "watch your fingers when installing these connectors" sounding like the voice of experience itself. It's all kind of reassuring.

Accompanying the assembly manual are ten life-size pictorial diagrams that accurately depict every detail, even showing which direction to wrap wires around terminals. The manual and pictorials are well integrated and virtually foolproof.

We found no defective parts or shortages in our kit. Small components and hardware are divided into nine labeled plastic bags. Each one is opened at the appropriate time in the assembly sequence. We liked this approach—it's far superior to rummaging through all the bits and pieces to find one odd washer or a particular disc capacitor. We've seen "fancier" kits, with clever packaging of components, but we like this "no-nonsense" approach better.

The only preassembled components are the massive heat sinks with power transistors mounted in place. Otherwise, you work from scratch.

Aside from the power transistors and the two completely separate power supplies, all active components of the Citation Twelve are mounted on one large, plug-in printed circuit board. The two halves of the board are "mirror images" of each other, each containing six transistors (including a special differential amplifier, consisting of two transistors in a common case).

We completed the assembly of our Citation Twelve in less than nine hours, and were delighted when the unit performed flawlessly on the first try. The only adjustments required are setting the output transistor bias for each channel. H-K even provides a specially marked test meter to facilitate this operation. (The meter is not installed, just used for the initial adjustment.)

The completed amplifier looks as good as it works, with the heat sink fins providing a rugged, handsome appearance as well as doing an excellent job of keeping the amplifier running cool, even under heavy signal loads. Input jacks (standard pin plug type) and the large color coded speaker binding posts are mounted, along with

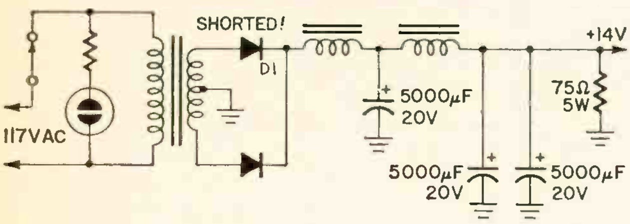
(continued on page 84)

CB Troubleshooter's Casebook

Compiled by
Andrew J. Mueller*

Case 1: Low output voltage. Unit smells.

Common to: Hallicrafters **PS-20 power supply**

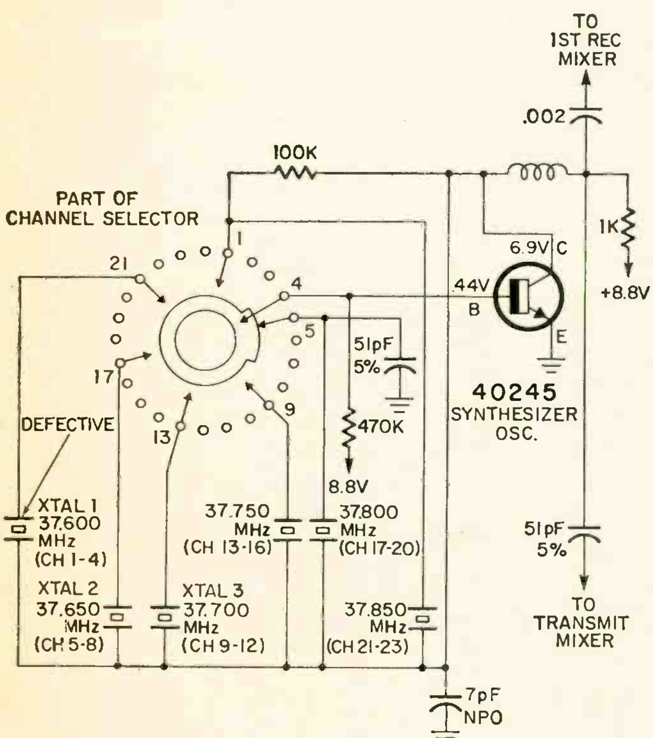


Remedy: Replace D1.

Reasoning: After a lightning storm the supply did not function normally. The output voltage is about 6 volts. The trouble was traced to a shorted rectifier that had failed after a "near miss." Replacement restored the unit to normal operation.

Case 2: Channels 1 to 4 inoperative. Radio is OK on other channels.

Common to: Courier **TR-23S**



Remedy: Replace master crystal XTAL1.

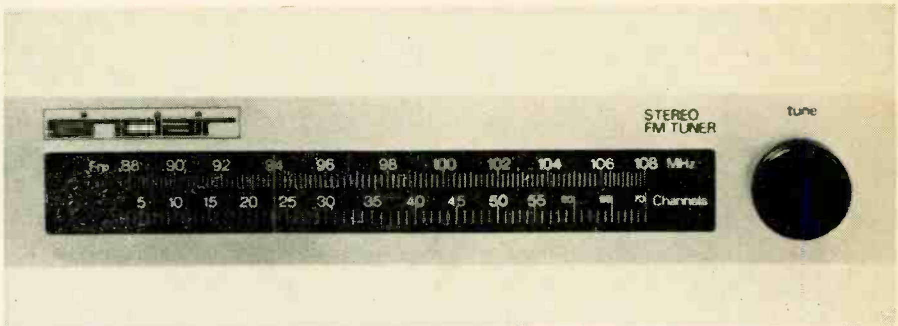
Reasoning: Crystal XTAL1 is the master range crystal for channels 1 to 4. The crystal was fractured and is inoperative. Both transmit and receive are not working because the crystal is used for both modes. When replacing the crystal, be sure to have the frequency checked and the work certified by a licensed technician. **R-E**

*Service Manager, Tel-Air Communications, Inc., Pewaukee, Wis.

EQUIPMENT REPORT

Sinclair Project 60 FM Stereo Tuner

For manufacturer's literature, circle No. 19 on Reader Service Card.



This new FM tuner is claimed to be the first in the world to use the phase-lock-loop (PLL) principle. (See RADIO-ELECTRONICS, November 1970, page 59 for a complete article on phase lock loop.) It also incorporates variable capacitance diodes in the front end for the tuning. They, of course, replace the usual tuning capacitor. Also featured in this tuner are printed circuit coils for the front end and i.f. strip; agc, afc, a squelch circuit that mutes the tuner when it is set between stations, an IC stereo decoder and the option of remote control and push-button tuning.

The tuner is supplied completely assembled, but does have to be mounted in some kind of enclosure. This is actually an advantage, as the unit lends itself to custom installation in furniture that doesn't provide enough room for the more conventional stereo components. When used with the other equipment in the Sinclair line (power amplifier, preamp, active filter and power supply), you can put an entire stereo system almost anywhere.

The tuner works beautifully and completely lives up to its specifications. The standard version (as shown above) was easy to set up and operate. It is easily attached to the rest of the Project 60 system (a review of the other elements will appear in February).

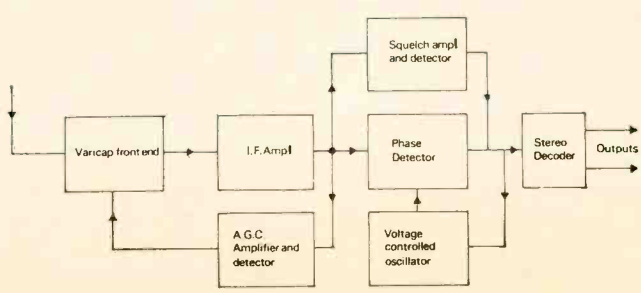
Except for the use of variable capacitance diodes in the front end, the tuner is rather conventional until we get to the demodulator. In this tuner, it is a phase-lock-loop circuit in which a voltage-controlled-oscillator is kept in phase with the incoming signal by a phase comparator or detector which compares the two and feeds a control voltage to the oscillator. This control voltage is the audio output.

Since it is possible to design a vco that has an extremely linear voltage-to-frequency transfer characteristic, it is relatively easy to get excellent audio fidelity. Even more important, the oscillator can track a signal while completely rejecting a nearby, stronger signal which could cause interference in a conventional set.

All in all, this is a tuner worth listening to . . . twice.—*Warren Roy*

SPECIFICATIONS

Tuning Range: 87.5 to 108.5 MHz
Capture Ratio: 1.5 dB
Sensitivity: 2 μV for 30 dB quieting; 7 μV for full limiting
Muting Threshold: 20 μV
Afc Range: ±200 kHz
Signal-To-Noise Ratio: 65 dB
Total Harmonic Distortion: 0.15% for 30% modulation
Stereo Threshold Level: 2 μV
Pilot Tone Supression: 30 dB
Cross Talk/Separation: 40 dB
I.F.: 10.7 MHz
Output: 150 mV rms per channel
Antenna Input Impedance: 75 ohms
Indicators: AC power, Stereo, Tuning
Price: $74.95



BLOCK DIAGRAM of the Project 60 stereo FM tuner. Note the phase detector ahead of the stereo decoder.

Circle 83 on reader service card

TEST EQUIPMENT FOR COLOR
(continued from page 44)

aches. They use a "post-marker" injection circuit, which then feeds the output to the scope's vertical and horizontal inputs.

In color TV i.f.'s, the position of the markers is very important. With one of these sweep generators, you can see all important marker frequencies at the same time. This makes curve-shaping and adjustment a whole lot easier. Fig. 11 shows the output curve you can get, and the number of markers it is possible to see at one time. One very important thing in color alignment is the positioning and shape of the i.f. response curve on the "sound side", where the color carrier (42.17 MHz) is. This must be correct and each marker must be in the right place.

For example, the 42.17 MHz color carrier should be at about the center of this side of the curve, (and at the same height as the picture carrier, 45.75 MHz, on the other slope). The color bandlimit markers, 41.67 and 42.67 MHz, must be at the right places—one right at the knee of the curve and the other on the lower slope, but *never* on the baseline or in the sound trap.

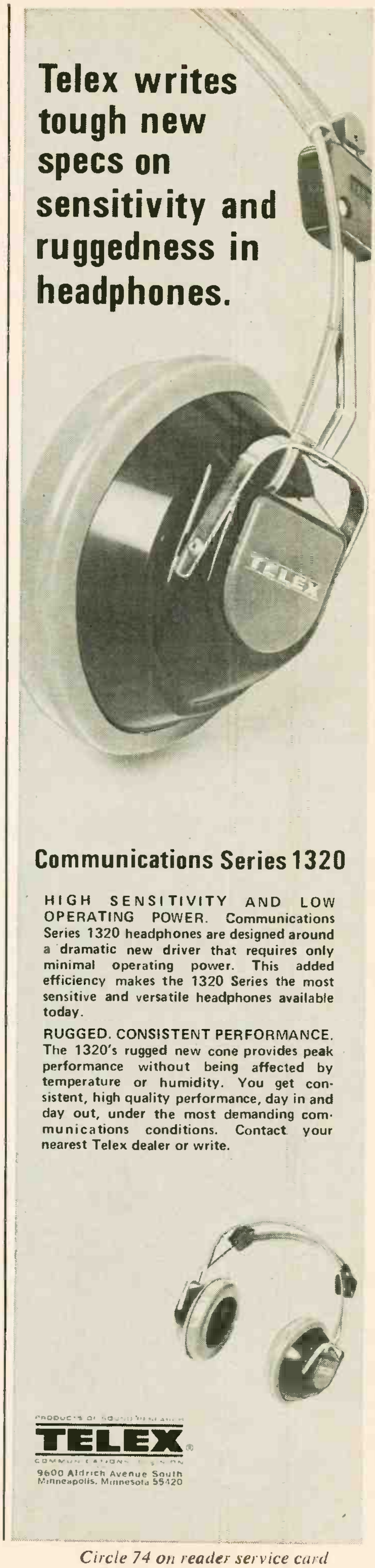
All of the important trap markers are included, of course. 41.25 MHz sound, 39.75 MHz adjacent picture, 47.25 MHz adjacent sound are all there, and with the post-marker adder system, you can *see* them even if they're down on the baseline. In the older type of sweep generator/scope hookup markers often distorted the trace ends, in too many cases, they were invisible!

Strangely enough, one of the most valuable things that these generators do is tell you that you *don't* need to use them! If you have a set of symptoms that make you suspect that this set does need alignment, you can verify this in an amazingly short time. It used to take up to 20 to 30 minutes to hook up and check. Now you can hook one lead to the antenna input, one to the video detector, clip on a bias lead, and have a full sweep curve on the scope in only about three minutes! (These generators are all solid state and they warm up "right now!")

By checking the position of the markers on the curve you can tell whether the set needs alignment or not. If all of the markers are in the right places, it doesn't; and you've eliminated that possibility. If it needs only a touchup, you can do this with ease.

Let's wrap it up

We've tried to include representative examples of all of the test equipment you'll need for servicing color TV sets of any type—tube or solid-state. All of these have been checked out in RADIO-ELECTRONICS' Test Lab. and the results are those found on actual TV sets and circuitry. Of course, no test equipment will relieve you of the need for thinking. However, this test equipment will give you the accurate answers you need to get a valid diagnosis, in the shortest possible time. **R-E**



Circle 74 on reader service card

(continued from page 80)

primary fuses and the pilot lamp, on the decorative panel beneath the heat sinks. The power cord enters through the rear of the chassis.

In operation, the Citation Twelve lives up to the high promise of its published specifications. H-K claims a frequency response that is essentially flat from 1 Hz to over 100,000 Hz, with extremely low phase shift (less than five degrees at 20 Hz). This kind of extended range performance pays off in particular at the low end, where bass response is noticeably cleaner and "tighter" than with our old, high quality, tube-type amplifier of similar power capability (60 watts RMS per channel).

Adding a power amplifier such as the Citation Twelve to a slightly aging component system results in both satisfaction and frustration—the satisfaction of having advanced one key element of the system to a quality level that need not ever be surpassed; the frustration of realizing the deficiencies in the remainder of the components. And so the pursuit of the always elusive "perfect sound" continues its never-ending search.

It is a natural compulsion for a reviewer to want to balance a glowing report with a few dashes of negative criticism, and I am not above such temptation. To find fault with the Citation Twelve is to pick nits, but we feel that at $295.00 (wired; $225.00 in kit form) the user has a right to be a bit fussy. For instance, we think an on-off switch would be an appropriate and inexpensive addition. Even though the amplifier is intended to be powered and controlled by a preamp with ac switching, there might be occasions when we would like to turn off the power amplifier alone without pulling the plug. We'd also like to see input level controls, to compensate for over-enthusiastic preamps that might tend to drive the mighty Citation to speaker destroying levels. Finally, we think it would be smart for H-K to have two identical printed circuit boards—one for each channel—instead of one big board, thus making it a bit more reasonable for the user to keep a spare board on hand, just in case.

So much for the nits. The important issue is, as the ads say, "Citation is Back"—and we're glad!—**Terry W. Barnes** **R-E**

COMING NEXT MONTH

FEBRUARY 1971

- **Replacement Transistors**
  Service Editor Jack Darr tells how to find the right replacement for that mystery semiconductor.
- **What's A Frequency Synthesis?**
  You don't know? Let R-E's expert explain this very recent receiver development.
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The Laser
Jack Darr's Service Clinic
Linear IC's Circuits
Build a Pocket Pipper

CIRCUIT BREAKERS
(continued from page 70)

Products Inc., Sarasota, Fla., G-C Electronics, Rockford, Ill. and Mel-Rain Corp., Indianapolis, Ind. Replacements made by Mel-Rain are marketed exclusively by the Mallory Distributor Products Co., Indianapolis, Ind.

The rotary switch type circuit breaker is manufactured by Mallory Controls Co., Frankfort, Ind. and replacements are available only through the Mallory Distributor Products Co., Indianapolis, Ind.

How to spot a bad breaker

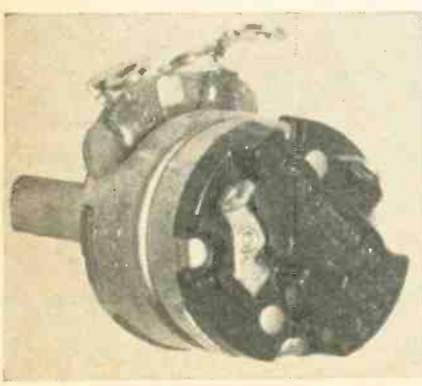
There are several reasons why a circuit breaker will trip and turn off a TV. Some of the more common ones are: shorted rectifiers, leaky or shorted filter capacitors, shorted transformers and lack of horizontal drive. Line voltage surges and lightening flashes are external causes that may cause a breaker to trip. Finding a defective breaker is mostly one of visual observation. First, you can see that the red button has popped out. Secondly, the tube heaters will usually stay lit, but there will be no raster and no B-plus.

One of the most annoying service calls are those caused by a breaker that "pops" open for no apparent reason. Some technicians cure this by replacing it with a larger current capacity unit. This cures the immediate trouble, but can lead to more serious trouble later on.

The experienced service technicians would first observe that the set is off and the red button popped out. He pushes in the button and it may stay in or pop right out. He consults the service literature and checks the breaker to be sure the proper one is in the set. Next he connects his ac ammeter or wattmeter in series with the line cord and checks the current drawn by the set.

If the breaker doesn't stay reset long enough to take a reading he must short around the breaker to get the current reading. If this current is within 10% of the normal current for that set he can conclude that the breaker has gone bad and replace it with one with the same rating. If he gets a higher than normal reading he must dig into the set and find what is wrong with it.

Once the technician finds the defective part and replaces it, current should return to normal and the circuit breaker will work as intended.



MALLORY OCB BREAKER is mounted at the rear of a conventional carbon potentiometer.

Pointers on replacing breakers

Always replace a circuit breaker with a new one with the exact current rating called for or you are destroying the protection the breaker provides. When soldering to the breaker terminals do not allow solder or flux to flow into the unit through holes in the base or case. This could cause the new breaker to malfunction. Do not attempt to adjust or change the breaker setting. Do not pull connecting leads too tight when wiring to the breaker or you may damage the current carrying parts inside the case.

The breaker is an inexpensive part and is often taken for granted, but it can and does act up. The information presented here should help you easily spot and correct troubles caused by faulty circuit breakers. **R-E**

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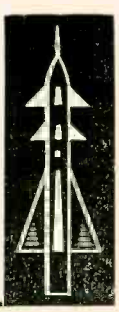

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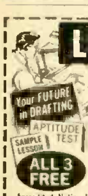

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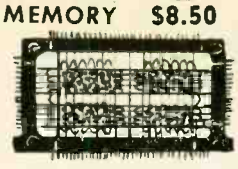

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*microminiature

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Circle 84 on reader service card

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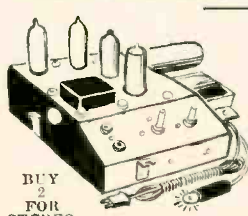

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Price 6 for $1.00

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3A	50 P.I.V.	12 for $1.00
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3A	1000 P.I.V.	2 for $1.00
6A	1000 P.I.V.	each $1.00
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Completely assembled, instant-starting w/three times power output of comparable models. Steady, ripple-free light of moderate (safe) power. Excellent collimation. Particularly useful for studies, experiments in holography, interferometry, diffraction, optical alignment. Simple and safe to use—just plug in, switch on. The 4½ lb. unit reaches 75% power in 2 secs.; full power, typically 0.5 milliwatt (0.3 mW minimum) in 3 mins. Beam divergence only 2 milliradians far ahead of competition, beam only 2 cms at 40 ft.

Stock No. 79,004EH .... $99.50 Ppd.

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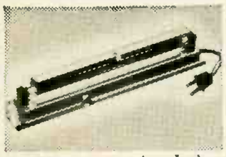
PSYCHEDELIC LIGHTING HANDBOOK

100 information packed pages! Fully explains latest in psychedelic lighting equipment, techniques, developments. Covers all facets of psychedelic light-show production including strobes, black lights, projectors, crystals, organic slides, mirrors, color organs, polarized color, light boxes, Music-Vision, etc. 8½" x 11" looseleaf paper for 3 ring binder.

Stock No. 9100EH .... $3.00 Ppd.

LONG-WAVE BLACK LIGHT FIXTURE



Extremely versatile, compactly designed, long wave (3200-4000 angstroms) black light (ultraviolet) fixture—eliminates harmful shorter wave ultraviolet rays. Use to identify minerals, fungi, bacteria check for surface flaws, oil and gas leakage—perfect for displays with fluorescent paper, paints, chalk, crayons, trace powder. Incl. adjustable aluminum reflector, push-pull switch, connecting plug. Mount vert., horiz., or on corner. 10" L., 1¼" W., 1¼" H.

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Yesteryear's ballrooms echo in mirrored lights that richochet to the beat of today's discotheque. Up to 1,000 lustrous, clear, handmade glass mirrors on each ball create fantastic lighting effects. Motorized—they cast reflections that blow the mind! Ideal for light shows, displays, restaurants, hotels, and modern stores.

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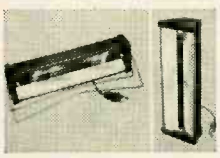
Stock No. 85,180EH ...... (16" Diam.) ...... $75.00 FOB
Stock No. 71,065EH ...... (8" Diam.) ...... $17.50 Ppd.

BLACK-LIGHT MIGHTY MITES



Relatively small (12") fixtures give surprisingly bright blacklight. Mirror-finished reflector makes instant starting 8-watt, high-intensity bulb look like 40-watter. Up to 5,000 hours of safe, long-wave (3660A) black-light to really turn-on parties, light & theatrical shows, psychedelic decors, holiday decorations. Shockproof end-caps remove for safe, easy replacement of bulb and starter. Stands upright or horizontal. Alum. case.

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Sturdy, monocular-type. 3 Coated Achromatic parfocal objectives—5X (0.10 NA), 10X (0.25 NA), 60X (0.85 NA); triple revolving nosepiece. Automatic focusing stop prevents damage to objectives and slides. Fixed 160mm tube. Rack & pinion coarse focusing & fine micrometer type slide adjustments. 3 Huygenian eyepieces: 5X, 10X, 15X. Bakelite stage 4-1/2" x 4-5/16", 2 stage clips accept Edmund graduated mech. stage No. 30,060—Substage equipment: Fixed-condenser lens, iris diaphragm, 1-7/8" diam. plano-concave mirror.

Stock No. 85,049EH..(11¾"H., 11 lbs.W)..$99.75 T.C.C.

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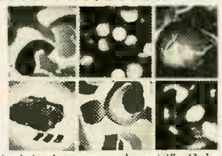

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See moon shots, orbits-stars, phases of Venus, planets close up. 60 to 180 power. Aluminized and overcoated 3" diameter f/10 primary mirror, ventilated cell. Equatorial mount with locks on both axes. Equipped with 60X eyepiece and mounted Barlow lens. 3X finder telescope, hardwood tripod.

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Dazzling colors stream endlessly from constantly rotating light. Facetted, transparent globe has louvered drum inside with red, green, blue & yellow stars. Bulb heat rotates drum which projects flickering star points on walls, ceilings, etc. while individual globe facets present constantly changing array of brilliant colors. 9¾" star—approx. 12" high on bell-shaped base. Surprisingly light. Easily placed on table, TV, fireplace, or Xmas tree top.

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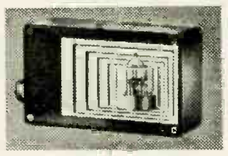

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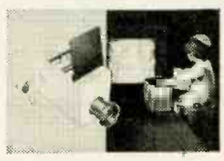

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(1½ lbs.) Orig. Cost Over $19.00 Each **$1.99** Three For **$4.99**

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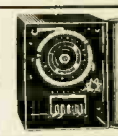

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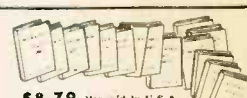

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14 Lead Dual In-Line Pkg

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PRV	1 Amp	3 Amp	7 Amp
50	.20	.25	.30
100	.25	.30	.35
200	.40	.45	.50
300	.60	.70	.80
400	.75	.85	.95
500	—	—	1.00
600	—	—	1.30

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PRV	1Amp	3Amp	6Amp	10Amp	15Amp
100	.40	.50	.75	1.00	1.20
200	.65	.75	1.00	1.40	1.80
300	1.00	1.10	1.25	1.90	2.20
400	1.30	1.40	1.80	2.30	2.60
500	1.60	1.80	2.10	2.75	3.10

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PRV	2Amp	3Amp	5Amp	10Amp
50V	1.25	1.35	1.50	1.70
100V	1.50	1.60	1.75	1.95
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200	.80	1.25	1.40
300	1.10	1.60	1.80
400	1.40	1.90	2.20
500	1.75	2.20	3.00

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912 HALF ADDER	.50
913 REGISTER	.50
940 JK FLIP FLOP	.50

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DECADE DIVIDER	$3.95
RF 112 Dual JK Flip Flop	1.25
MC 415 JK Flip Flop	.85
MC 400 Dual 4 input NAND/NOR gate	.70
4 Bit Storage Register	1.25
9301 MSI ONE-OF-TEN DECODER	2.95

Silicon Power Rectifiers

PRV	3A	12A	30A
100	.09	.24	.50
200	.16	.35	.80
400	.20	.45	1.20
600	.30	.70	1.50
800	.40	.85	1.80
1000	.50	1.10	2.20

Terms: FOB Cambridge, Mass. Send check or Money Order. Include Postage. Average Wt. per package ½ lb. No. C.O.D.'s. Minimum Order $3.00

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consisting of an 11" length of 1/32" dia. fiber optics with bound ends. $2.00 ea.

Controlled Avalanche or Epoxy Rectifiers 1 AMP.

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200	.09	800	.20
400	.11	1000	.30

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Silicon Control Rectifiers

PRV	3A	7A	20A	70A
50	.30	.35	.70	
100	.40	.55	1.00	4.00
200	.60	.80	1.30	8.00
300	.80	1.00	1.70	
400	1.00	1.30	2.10	12.00
500	1.25	1.60	2.50	
600	1.50	1.90	3.00	16.00

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Circle 87 on reader service card

NON-TANGLING TEST LEADS

These are made from a 3-foot length of 300-ohm twin lead. Split lead at each end for 2 or 3 inches and make a hole with a paper punch at the end of the slit to prevent further tearing. Terminate the two conductors with phone tips, spade lugs, etc.—*Henry Josephs*

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With Lakeside Industries precision equipment, you can rebuild any picture tube!
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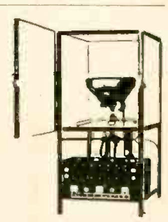

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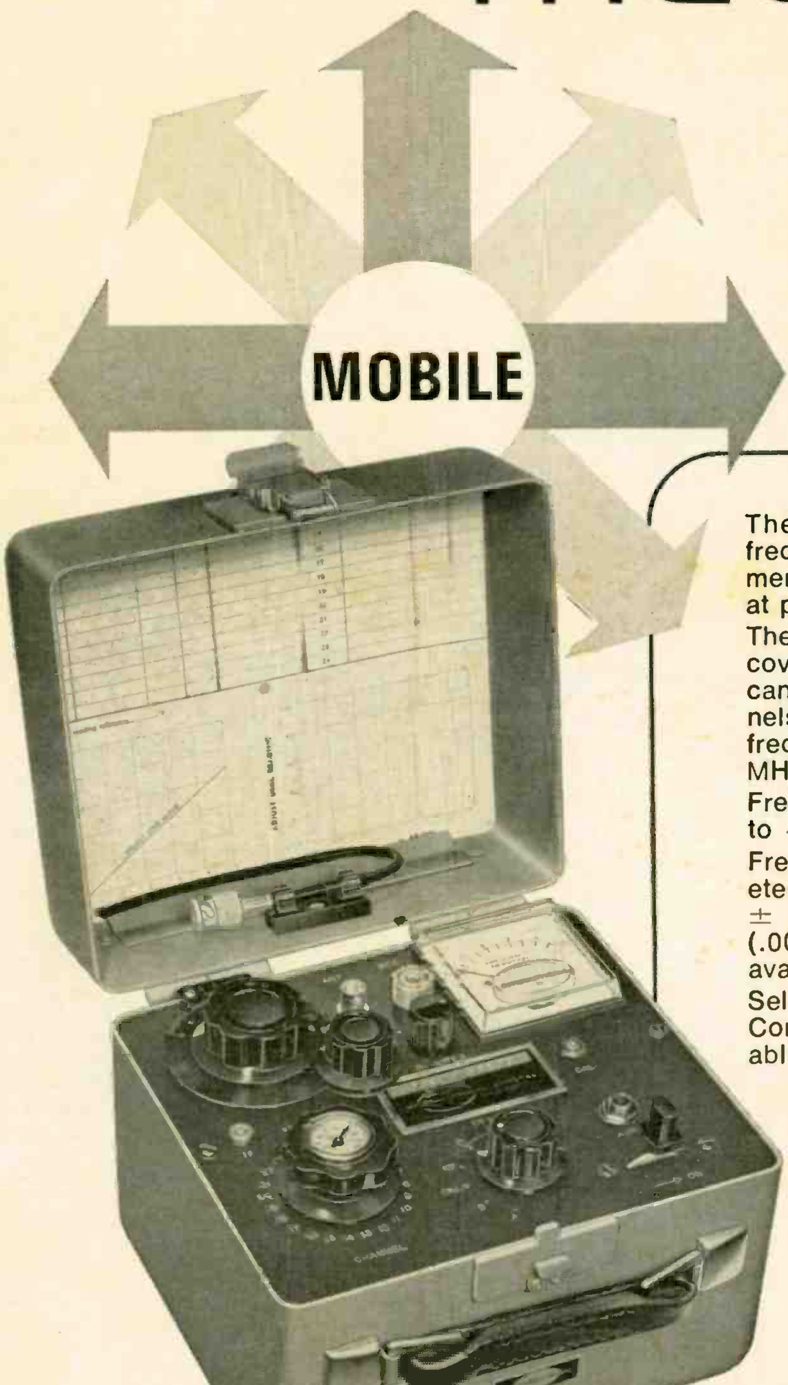
- Measures FM Deviation



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RF crystals (with temperature correction).... **24.00** ea.
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WRITE FOR CATALOG

Circle 80 on reader service card

TV TUNER SERVICE

Castle, the pioneer of television tuner overhauling, now offers the following services

EXACT REPLACEMENTS

Purchase outright . . . no exchange needed. **$15.95 ea.**

Castle replacements made to fit exactly in place of original tuner. Available in the following popular numbers.

ADMIRAL
94E210-1, 94E210-3, 94E227-2, 94E228-1, 94E229-4, 94E229-8, 94D257-1, 94D257-7, 94D257-49, 94E260-8H, 94E260-11, 94E261-1B, 94E261-1C, 94E261-1D, 94D261-4, 94C273-2, 94C273-4, 94C273-7, 94C273-8, 94C273-9, 94C273-10, 94C273-13, 94C273-15, 94C281-1K, 94C286-1D, 94C286-1E, 94C286-1J, 94C286-1L, 94C286-4J, 94C286-5, 94C286-12, 94C286-16, 94C289-1

CURTIS MATHES
7A11, 7A17, 7A38, 7A48, 7A050, 7A53-001, 7A056-001, 7A59-001

EMERSON
471351, 471512, 471515, 471678, 471682, 471700

G E
ET86X188, ET86X208, ET86X212, ET86X213, ET86X214, ET86X215, ET86X221, ET86X224, ET86X227, ET86X230, ET86X231, ET86X232, ET86X236, ET86X242, ET86X244, ET86X255, ET86X256, ET86X265, ET86X2[illegible]7, ET86X28[illegible]

HEATHKIT
110-17, 110-24, 110-25, 110-33, 110-36

MAGNAVOX
340009-1, 340010-1, 340017-1, 340038-1, 340040-1, 340042-1, 340052-1, 340053-1, 340066-1, 340067-1, 340069-1, 340078-1, 340078-2, 3400[illegible]5-2, 340125-1, 340130-1

MOTOROLA
OPTT123C, OPTT123D, TT133A, TT133YA, LTT307A, RTT322A, CPTT332A, CPTT338B, DCPTT338B, CMTT340A, CMTT340B, TT348B, MTT348A, MTT348B, VTT349B, CPTT350B, CPTT356YA, TT361Y, OPTT351YB, CPTT356Y, CPTT366YD, OPTT366YD, NCPTT376YA, CPTT378YA, NCPTT378YA, OPTT385Y, OPTT385YA, OPTT386YA, OPTT388YA, CPTT390YA, OPTT390YB, OPTT394, SCPTT394, AOPTT399, LOPTT399Y, LOPTT399YA, OPTT399YA, OPTT402, LOPTT402, CPTT403, OPTT404, OPTT404A, CPTT405, OPTT414A

MUNTZ
PR0352-1, PR0364, PR0376, PR9021, PR9044, PR9045, PR9050, PR9066

OLYMPIC
CL4692-1, CL5220-1, CL28874-1, CL29554, CL29566, CL296[illegible], CL33579, CL33858, CL34190, CL34835, K24013USA-1C, K50013USAH-3

PHILCO
76-12405-4, 76-13579-5, 76-13579-7, 76-13579-8, 76-13579-9, 76-13851-2, 76-13871-1, 76-13945-1, 76-13945-5, 76-13955-1, 76-13955-2, 76-13955-5

RCA
KRK103A, KRK103C, KRK103F, KRK103L, KRK104A, KRK104C, KRK104F, KRK104L, KRK107A*, KRK107B*, KRK107C*, KRK107D*, KRK107E*, KRK107F*, KRK108A*, KRK108B*, KRK108C*, KRK108D*, KRK108E*, KRK108F*, KRK113B, KRK116B, KRK118A*, KRK118C*, KRK118D*, KRK123A, KRK123D, KRK124AA, KRK124U, KRK127AA, KRK127AB, KRK127B, KRK127BA, KRK127E, KRK127L, KRK127T, KRK127U, KRK127W, KRK128AB, KRK128AE, KRK128U, KRK133A, KRK133BC, KRK133D, KRK133U

SEARS
95-75, 95-141-0D, 95-358-0, 95-437-0A, 95-480-3B, 95-480-3D, 95-481-3A, 95-500-0A, 95-500-1A, 95-500-1B

SYLVANIA
54-11644-3, 54-11702-1, 54-17234-1, 54-17436-2, 54-17436-3, 54-17436-4, 54-17436-5, 54-17778-1, 54-23853-3, 54-23857-2, 54-78093-1, 54-88847-3B, 54-89093-1, 54-89720-1A, 54-[illegible]9220-1, 54-[illegible]-2A, 54-94689-3, 54-97948-6, 54-97948-7

WESTINGHOUSE
470V007H03, 470V019H05, 470V019M01, 470V030H01, 470V049H01, 470V149H01, 470V151H01, 470V158D03, 470V161D03, 470V188D01, 470V188D02, 470V190D01, 470V191D01, 470V191D02, 470V191D03

ZENITH
175-167, 175-168, 175-170, 175-201, 175-202, 175-202A, 175-203A, 175-204, 175-204A, 175-208, 175-212, 175-213, 175-214, 175-216, 175-220, 175-222, 175-228, 175-230, 175-232, 175-254, 175-256, 175-262, 175-264, 175-266, 175-268, 175-272, 175-402, 175-405, 175-406, 175-412, 175-416, 175-418, 175-420, 175-424, 175-426, 175-431, 175-454, 175-601, 175-602, 175-604, 175-621, 175-622, 175-640, 175-641, 175-642, 175-643, 175-644, 175-645, 175-646, 175-647, 175-660, 175-661, 175-66[illegible], 175-66[illegible], 175-66[illegible], 175-667, 175-668, 175-669, 175-671, 175-680, 175-681, 175-682, 175-683, 175-684, 175-685, 175-686, 175-687, 175-688, 175-689, 175-690, 175-707, 175-708, 175-709, 175-711, 175-712, 175-713, 175-715, 175-716, 175-717, 175-718, 175-719, 175-720, 175-721, 175-722, 175-731, 175-732, 175-733, 175-734, 175-735, 175-736, 175-737, 175-738, 175-739, 175-740, 175-741, 175-742, 175-743, 175-744, 175-745, 175-746, 175-747, 175-748, 175-750, 175-751, 175-752, 175-753, 175-754, 175-755, 175-756, 175-757, 175-758, 175-759, 175-760, 175-761, 175-762, 175-763, 175-764, 175-1101, 175-1102, 175-1103, 175-1104, 175-1105, 175-1106, 175-1108, 175-1118, 175-1119, 175-1120, 175-1121, 175-1122, 175-1131, 175-1132, 175-1133, 175-1134, 175-1135, 175-1136, 175-1137, 175-1138, 175-1139, 175-1140, 175-1141, 175-1142, 175-1143, 175-1144, 175-1145, 175-1146, 175-1147, 175-1148, 175-1150, 175-1151, 175-1152, 175-1153, 175-1154, 175-1155, 175-1156, 175-1157, 175-1160, 175-1161, 175-1162, 175-1163, 175-1164, 175-1165, 175-1166, 175-1167, 175-1168, 175-1169, 175-1170, 175-1172, 175-1175, 175-1176, 175-1177, 175-1178, 175-1179

MISC. INCL PRIVATE LABELS
TA82, TA124, TA129, TA131, TA133, TA136, TA138, TA147, TA150, TA157, 25A1241-002B, 25A1241-004B, 25A1241-005B, 25A1241-006B, 25A1245-005D, 25A1245-006D, 25A1245-009, 25A1245-011, 25A1246-001, 25A1246-003, 25A1246-004, 25A1246-005A, 25A1247-002, 25A1249-001A, 25A1249-001E, 25A1253-001, 25A1253-001B, 25A1253-001D, 25A1256-001C, 25A1258-001A, 25A1258-001C, 25A1263-001, 25A1264-001B, 25A1265-001B, 25A1268-001, 25A1270-001, 006-014700, 006-015000, 006-015700, 006-016500, 006-017300, 006-017700, 006-018600, 006-020100, 006-020900, 006-021000

**Supplied with new channel indicator skirt knob, original illuminated dial is not used.*

UNIVERSAL REPLACEMENTS

Prefer to do it yourself?

STOCK No.	HEATERS	SHAFT Min.*	SHAFT Max.*	I.F. OUTPUT Snd.	I.F. OUTPUT Pic.	PRICE
CR6P	Parallel 6.3v	1¾″	3″	41.25	45.75	8.95
CR7S	Series 600mA	1¾″	3″	41.25	45.75	9.50
CR9S	Series 450mA	1¾″	3″	41.25	45.75	9.50
CR6XL	Parallel 6.3v	2½″	12″	41.25	45.75	10.45
CR7XL	Series 600mA	2½″	12″	41.25	45.75	11.00
CR9XL	Series 450mA	2½″	12″	41.25	45.75	11.00

*Supplied with max. length selector shaft (measured from tuner front apron to tip) . . . you cut to suit.

These Castle replacement tuners are all equipped with memory fine tuning and UHF position with plug input for UHF tuner. They come complete with hardware and component kit to adapt for use in thousands of popular TV receivers.

OVERHAUL SERVICE — All makes and models.

VHF or UHF tuner (1963 or later)	$9.95
TRANSISTOR tuner	$9.95
COLOR tuner	$9.95

Overhaul includes parts, except tubes and transistors.

Dismantle tandem UHF and VHF tuners and send in defective unit only.

Remove all accessories . . . or dismantling charge may apply.

Your tuner will be expertly overhauled, aligned to original standards and warranted for 90 days.

CUSTOM EXCHANGE REPLACEMENTS

When our inspection reveals that original tuner is unfit for overhaul, we offer an exact replacement

If exact replacement is not available in our stock we custom rebuild the original at the exchange price.

(Replacements are new or rebuilt.)

CASTLE TV TUNER SERVICE, INC.

MAIN PLANT: 5715 N. Western Ave., Chicago, Illinois 60645
EAST: 130-01 89th Rd., Jamaica, N.Y. 11418

Circle 81 on reader service card

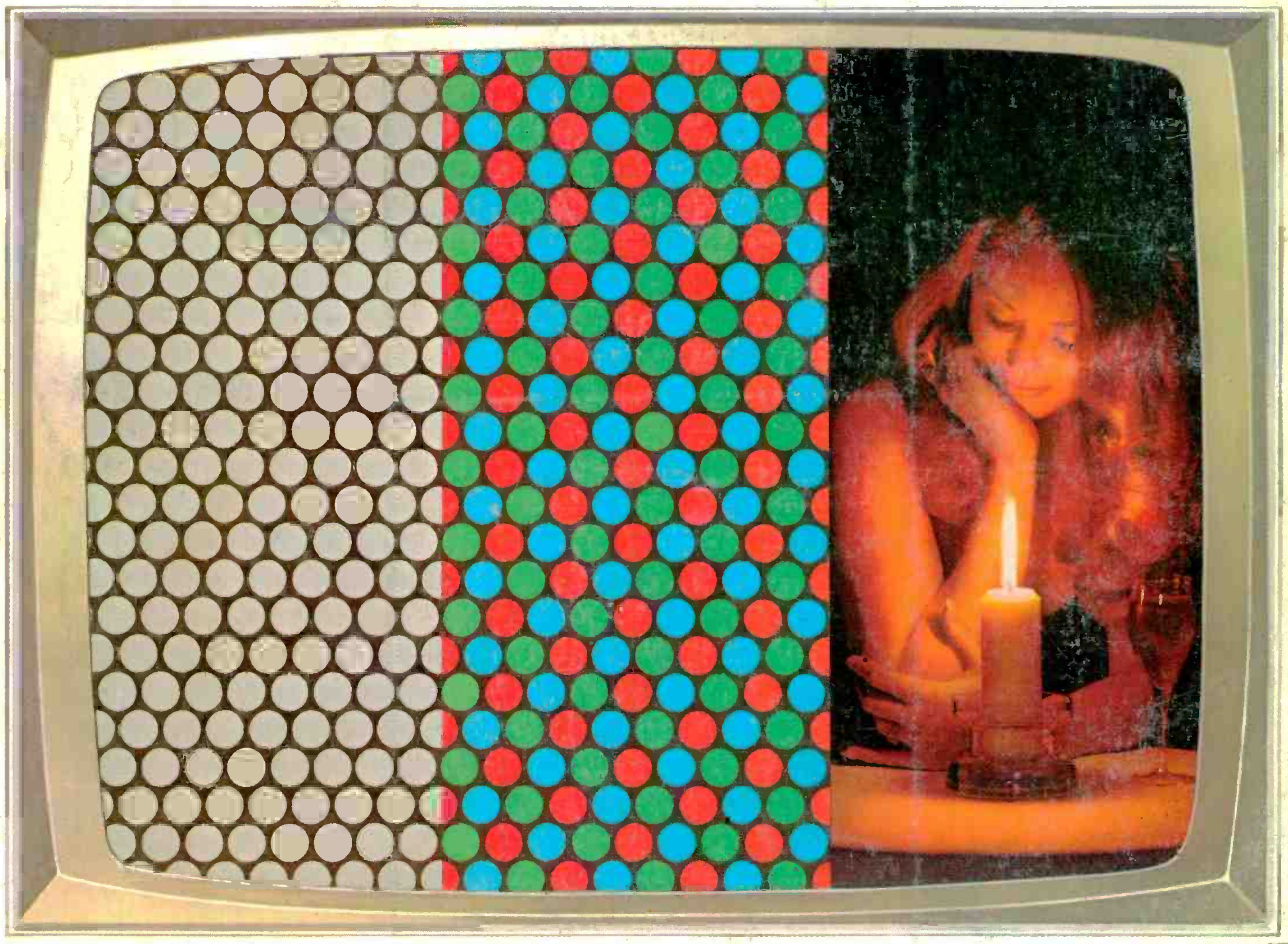
10 million reasons why it pays to promote matrix, the brightest, sharpest color picture tube in RCA history!

Reasons 1 to 10,000,000. Large-screen MATRIX can upgrade the performance of at least 10 million color TV sets *now in use*. The RCA MATRIX 23VALP22 is a direct replacement for the 23VANP22, 23VARP22, 25AP22A, 25BAP22 (Chromacolor), 25BCP22, 25BGP22, 25XP22, and 45 other industry types! Giant-screen sales potential for the RCA MATRIX—practically unlimited!

More RCA Color Picture Tubes are stocked and sold by distributors than any other color picture tubes in the industry. So, MATRIX is more readily available to you no matter where you are, to give your customers faster service and ring up more profitable sales.

MATRIX is the brightest and sharpest color picture tube in RCA history!

Here's why:



The RCA jet-black matrix*
It soaks up room-light normally reflected back at the viewer from the face of the tube. Result: brighter pictures because now there's no need to "filter out" brightness to maintain contrast under strong room-light conditions.

The RCA MATRIX phosphor-dot process*
First, we developed brilliant new phosphors and a unique screening process incorporating a jet-black matrix. Then we deposited the 1,200,000 red, green, and blue high-intensity phosphor dots precisely within the black matrix. Result: brightness doubled with dramatic improvement in contrast and clarity.

The RCA MATRIX picture**
Spectacular! In operation, a new, unique high-resolution gun "shoots" the phosphors with more energy than any other gun previously available. Result: black matrix + phosphors + high-resolution gun = maximum sharpness over the entire brightness range, truer colors under all viewing conditions.

New 4-color consumer flyer on MATRIX is available from your RCA Distributor.
RCA | Electronic Components | Harrison, N. J. 07029

*Magnified drawing **Simulated

RCA