60¢ ■ MAY 1971

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS ®

CHANGE COLOR PIX TUBES FASTER

How CATV Works Today

GET BETTER PRINTS
Build R-E's Photo Densitometer

TECHNICAL TOPICS
Electronic Touch Tuning No Buttons, No Switches

10 Key Specs For Effective PA

A GERNSBACK PUBLICATION

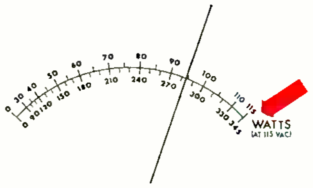
the most practical service tool ever devised!

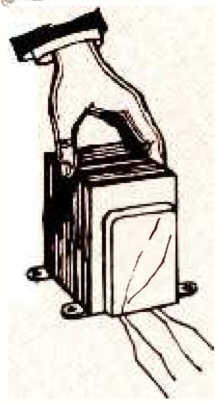
SENCORE POWER MONITOR

PM157 $69.50

Here is an instrument that will pay for itself in time saved the first month you use it.

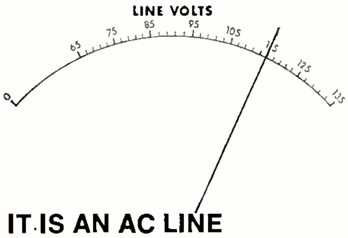
A IT IS A ZERO TO 1150 WATT WATTMETER

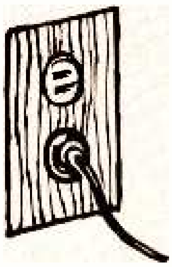




You will know whether or not you are dissipating too much power before you start changing expensive parts.

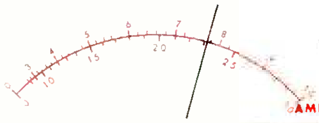
B IT IS AN AC LINE VOLTAGE MONITOR

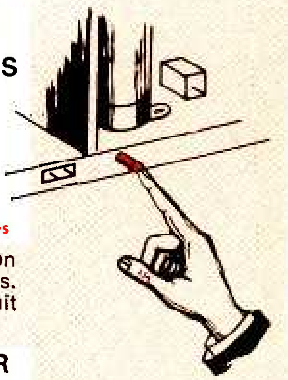




Calibrated right on the nose at 115 volts. How many times has your trouble simply been line voltage and you could have saved so much time?

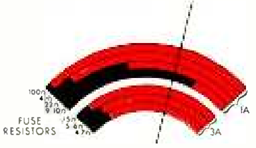
C IT IS AN AC AMMETER TO DETERMINE HOW MUCH LINE CURRENT IS BEING DRAWN

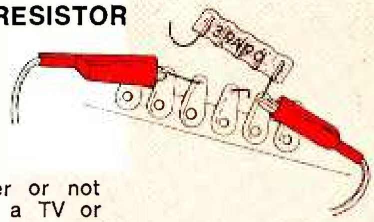




Up to 10 amps. A good check on fuses and other line protectors. How do you know that a circuit breaker is really bad?

D IT IS A FUSE RESISTOR CHECKER WITH SPECIAL SCALES FOR EACH FUSE RESISTOR





You will know whether or not you are sending back a TV or radio set with an overloaded fuse resistor that will go out within hours.

E IT IS PROTECTED BY A 10 AMPERE CIRCUIT BREAKER

Fully protected against shock hazard to appliance being tested, and is also safe for the operator.
8″ x 6″ x 5″ 5 lbs.

THE IDEA PEOPLE

SENCORE

3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

Circle 1 on reader service card

SONY® achieves true integration

In all too many transistor integrated amplifiers, the preamp stage does not quite live up to the performance of the amplifier section.

Not in Sony's new TA-1130. Thanks to an FET front end, this integrated package has a preamp stage that really does full justice to its output section.

Why FET's

For the same reason that we use them in our tuners and receivers, and in our studio professional condenser microphones; because FET's have a far wider dynamic range than ordinary transistor types.

And the preamplifier needs that range. Because it has to be sensitive enough to handle the lowest-output, moving-coil cartridges, yet still accept the highest output cartridges without overloading. (The power amp has it easier: you keep its input level fairly constant with your volume control.)

Power to Spare

But if the power amplifier doesn't need that range, it does need power. The output section of TA-1130 has it: 230 IHF watts (into 4 ohms), with continuous power rated at 65+65 watts into 8 ohms. (With all that power, we made sure that both transistor and speaker protection circuits were included.)

SONY® F.E.T. Amplifier

Nothing Stands Between You and the Sound

Both sections are powered by balanced positive *and* negative supply voltages (not just positive and ground), so there need be no coupling capacitors or interstage transformers between you and the sound.

Without them, the TA-1130 can extend its power band width down to 7 Hertz, and actually *exceed* its rated damping factor of 100 all the way down to 5 Hz.

An Abundance of Audiophile Conveniences

Of course, the TA-1130 has all the control facilities that you could ask for: low and high filters, tape monitor, a speaker selector, and even an Auxiliary input jack on the front panel. The selector switch is Sony's instant-access knob-and-lever system.

There's even provision to use the TA-1130's power amp and preamp sections separately, to add equalizers, electronic cross-overs, or 4-channel adapters to your system.

In fact, you can even get the power output section separately, as the model TA-3130 basic amp. It makes a great match for our TA-2000 preamp, too.

Your Sony dealer has both models available, and at prices—$359.50 for the TA-1130; $239.50 for the TA-3130. Sony Corporation of America, 47-47 Van Dam Street, Long Island City, New York 11101.

Circle 2 on reader service card

NEW & TIMELY

Volume 42 Number 5 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS May 1971

SERVICE FIRMS OK PHILCO PARTS PLAN

PHILADELPHIA, PA.—Philco-Ford Corporation's decision to prepay shipping costs for parts to its qualified service agents has met with enthusiastic approval of independent service firms here, according to *Home Furnishings Daily*.

Officials of the Television Service Association of Delaware Valley said they hoped the move will encourage other major manufacturers to follow suit.

Philco also will offer a 10% discount (over the regular dealer discount) on all parts orders that exceed $75.00.

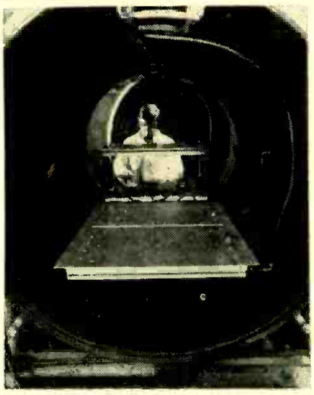
Both facets of the plan are intended to help defray costs of properly inventorying parts. ★

Licensing Bill Proposed In Indiana

INDIANAPOLIS, IND.—Strong legislation to boost the power of the state board of television and radio service examiners has been introduced in the 1971 Indiana General Assembly.

The bill would require licensing the service shop as well as the service technician, with a $15.00 annual fee for a dealer's license and a $500-a-day fine and up to six months in jail for operating without a license.

Another feature of the proposed legislation would make it an illegal act to charge for parts not installed or services not performed. ★



SATELLITE EQUIPMENT TESTED. Electronic guidance and data-handling equipment made by GTE Sylvania for an astronomical observatory satellite is being tested in a vacuum chamber which simulates the environment of outer space. The engineer is preparing tests in a temperature of 50 degrees below zero for equipment including a fine guidance sensor, which orients the spacecraft to targets, and electronics to process data gathered by the satellite and relay it to earth.

Four-Channel Stereo Entry

NEW YORK, N.Y.—Another entrant in the four-channels stereo market is Dynaco, developers of a device called Quadaptor, said to achieve 4-channel sound.

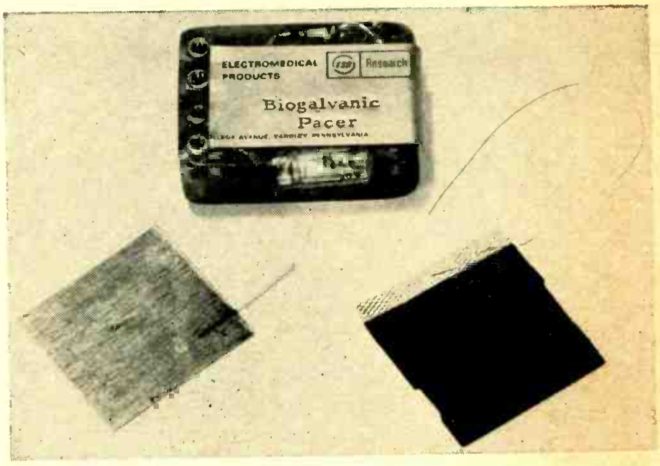
This device, similar to the product being sold by Electro-Voice, uses four speakers, requires one stereo amplifier, and provides the 4-channel effect by hooking up to a conventional stereo system at a point between amplifier and speakers.

In achieving the four-channel effect, the Dynaco (and Electro-Voice) system recaptures ambient sounds that occur at the broadcasting station or recording studio, according to Dave Hafler, president of Dynaco.

These ambient sounds are the echo effects and other out-of-phase sounds that bounce back from walls and ceilings instants after the sound is produced by voices and instruments. They add richness to live performances, but are greatly subordinated in recording or broadcasting playback.

The 4-channel system maximizes the ambient sounds through rear speakers while carrying the direct sounds through the front speakers. ★

BIOGALVANIC BATTERY

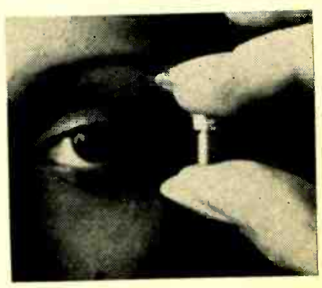


PHILADELPHIA, PA.—Scientists at the ESB Research Center are working on the development of a biogalvanic battery, a device that uses metals and the body's oxygen and fluids to generate electricity. The research is being conducted in alliance with medical teams at Philadelphia's Hahnemann Medical College and the University of Missouri.

By implanting in animals special subcutaneous platinum and magnesium or aluminum electrodes, enough electricity has been generated to power a heart pacer. The electrodes are placed where there are sufficient body fluids and oxygen to react with the metals.

While studies with humans have not yet been conducted, lab experimentation indicates that successful implantation of biogalvanic power sources in humans in the future is highly feasible.

Biogalvanic batteries have potential application in other prosthetic medical devices, including those for stimulating a diaphragm or a bladder. The operating life of such batteries is expected to exceed substantially the usual two to three years life of present heart pacer batteries. ★



The most powerful device of its type, this Raytheon Micro State miniature diode "Space Screw" produces 4 watts of continuous energy at C and X band radar frequencies. The new solid-state avalanche diode is used to replace tubes in microwave amplifiers and oscillators for electronic countermeasures, communications, and radar equipment.

REPLACE COLOR CRT's
It's really easy when you know how. Here, in step-by-step fashion is a complete replacement manual. Turn to page 33.

RCA Goes ACM

CHICAGO, ILL.—That little pushbutton labeled ACM appears on the front panel of several RCA 1972 color sets. It stands for AccuMatic, and when it is depressed it automatically locks color and tint levels within a preset design range, despite variations in a station's color TV signal.

These same color sets use 100% solid-state circuits (the only exception is the picture tube). A large majority of this circuitry is on 12 plug-in modules. These modules are in-
(continued on page 6)

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

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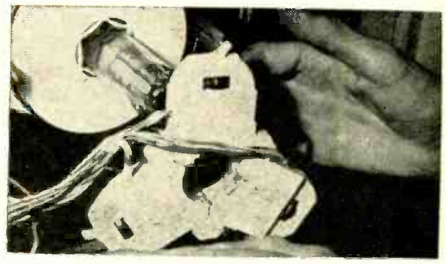
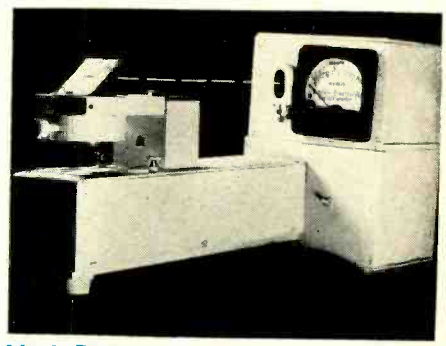
GENERAL ELECTRONICS

AUDIO—HI-FI—STEREO



Changing Color Pix Tubes can be easy. Just follow the steps in this article and you'll be able to do the job faster than ever before. . . . see page 33

Buying A PA System? Learn the key selection factors, and don't get trapped into buying too much or too little amplifier. . . . see page 45



Ideal Darkroom Project is what this densitometer is. Build it and use it, you'll get better prints from your enlarger every time. . . . see page 48

DEPARTMENTS

RADIO-ELECTRONICS, May 1971. Vol. 42, No. 5
Published monthly by Gernsback Publications, Inc., at 200 Park Avenue South, New York, New York 10003. Editorial, Advertising, and Executive offices: 200 Park Ave. S., New York, N.Y. 10003. Subscription Service: Boulder, Colo. 80302. Second-class postage paid at New York City and additional mailing office. Printed in U.S.A. One-year subscription rate: U.S. and possessions, Canada, $7. Pan-American countries, $8. Other countries, $8.50. Single copies 60¢.

POSTMASTER: Notices of undelivered copies (Form 3579) to Boulder, Colo. 80302.

Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)

LOOKING AHEAD

Volume 42 Number 5 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS May 1971

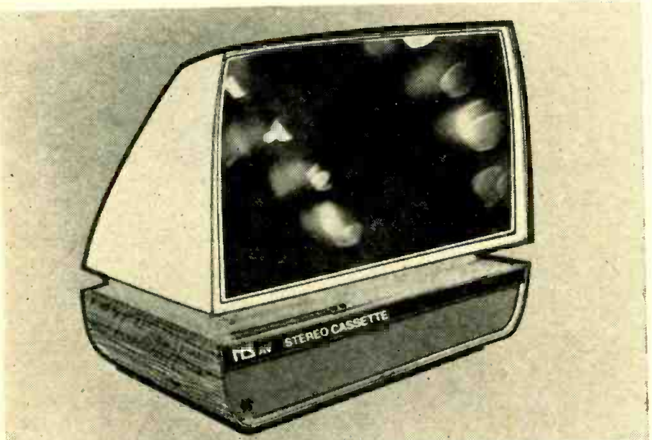
by **DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

Electronically programmed film

There's excitement in the audio-visual instruction field over a new system which combines slides, animation and motion pictures together with sound at a fraction of the cost of sound film. And one manufacturer already has announced a home version to sell for less than $200, with forecasts that future models may come down as low as $50. Electronically programmed film is an outgrowth of the tape-keyed slide projector which changes slides when a cueing pulse comes up on tape. The new version uses super-8 motion-picture film instead of slides and, in many educational uses, lets 50 feet of silent film do the job which formerly required perhaps 400 feet of sound film.

Programmed film uses a combination of film and tape, the tape serving both as soundtrack and film-speed regulator. In conventional motion-picture sound film, the speed is 24 frames per second, regardless of whether the subject at the particular time is a still title, a chart or diagram, animation or full motion. The 24-frame rate is standard for sound film, largely because of the requirements for quality sound reproduction—silent film shows complete motion at 16 frames.

In programmed film, a title or still diagram requires only one frame—instead of 48 or 60 or more used in motion-picture film. The film transport merely stops at the individual title frame long enough for the viewer to read the title. By the same token, full animation requires only nine frames per second or less, a moving close-up with full lip-sync about 10 and a scene showing full and rapid motion 16 frames per second. The frame rate of programmed film is variable from 0 to 24 frames per second.



RCS VIEWER SHOULD LOOK LIKE this artist's sketch. It will have a 19-inch screen, stereo sound, and will cost about $200.

Two versions of the system have been introduced so far. Both use compact rear-screen projectors (which look like portable television sets), super-8 silent color film and one-eight-inch-wide audio tape. The tape is divided into four tracks, tracks one and two being used for sound, track three currently vacant and track four for the film-advance cueing pulse, a 1600-Hz note of 35-μsec duration. But there the similarities end.

The "PIP" system (for "Programmed Individual Presentation"), developed by the Philips company in Netherlands and being manufactured in the United States by North American Philips Co. (Norelco), uses a standard audio tape cassette for cueing and audio, while a similar but somewhat larger cassette holds up to 50 feet (3600 frames) of film. The PIP viewer is designed for individual instruction, has a viewing screen equivalent to a 7½-inch TV set, is pushbutton-operated and has manual single-frame advance, and fast-forward and rewind for both tape and film. The viewer inserts film and tape cassettes in the proper slots, advances the film to a starting reference frame, then pushes the start button and the tape cassette takes over, providing the commentary and advancing the film at the proper speed for synchronization.

The PIP viewer sells for $375, the film cassette for $2.50, and can provide up to one hour's viewing—depending on the ratio of still scenes to motion sequences—but Philips feels that the optimum length for an educational film is 20 minutes. Philips officials estimate that a similar viewer in mass production for consumer use could list for about $150. The use of a separate cassette for sound and cueing makes possible the use of different soundtracks—for example, in two different languages—with the same film.

Another version, using essentially the same principle, is being manufactured by Retention Communications Systems. Called the MODule, this approach differs in that it employs a single cartridge divided into two compartments, to hold both tape and film in endless-loop configurations. The first MODule viewer model has the equivalent of a 10 inch television screen, but by removing the back of the case, it can also be used to project a picture on a wall or screen. The first MODule viewers are priced at $189 in the professional audio-visual market.

The same company has shown the prototype of a home viewer, which it is tentatively calling "StereoVision." This has a 19-inch viewing screen and stereo sound, and it's claimed that it will sell for "less than $200," with production planned for late this year. The company thinks that combination picture-and-sound cartridges could sell for perhaps five dollars or less on the home market, and has already commissioned the production of youth-oriented music programming. Retention Communications Systems regards its player as essentially an audio instrument with the added dimension of pictures. It plans to issue pop and rock-and-roll selections accompanied by animation, abstract designs and some actual photographic motion. It also plans to make available various home how-to series produced by others.

Neither of the two system manufacturers regard programmed film as a competitor to the various proposed home videoplayer and videocassette systems, since it's unsuitable for such lengthy, all-motion entertainments as feature films. However, it's not difficult to imagine an animated encyclopedia, for example, in programmed-film format. Because of the low cost of both film and player, the system could be widely adopted in schools—and, if so, there may come a day when Junior needs a viewer to do his homework.

No x-ray hazard to technicians

"TV technicians aren't being over-exposed" to x-radiation, according to complete results of extensive tests made in the Baltimore area. The source of this statement is Dr. Robert L. Elder, director of the Division of Electronic Products in the Bureau of Radiological Health of the Department of Health, Education and Welfare. We reported

(continued on page 14)

With Sylvania's 3 lines of color tubes, you can meet it.

Customers' wallets come in different sizes.

Thick, thin and in-between.

With Sylvania's 3 complete families of replacement color picture tubes, you can be sure of having the right-priced tube for each one.

At the top end of the line, you've got the *color bright* 85®XR, the tube with our brightest phosphors and X-ray inhibiting glass.

And in the middle, you have the *color bright* 85® RE. This is the tube that brought color TV out of the dark ages. Its bright rare-earth phosphors still make it *the* tube to watch.

For economy, there is the *color screen* 85 family of replacement tubes. But, economy doesn't mean cheap construction. You can still give your customer features like Sylvania's Sharp-Spot electron gun and a rare-earth phosphor screen without breaking his budget.

When you sell Sylvania, you're selling from the broadest line in the industry. You'll have the tube to match the set.

And a price to match the wallet.

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

Every man has his price.

(continued from page 2)

tended to improve the reliability of the set and when service is needed, speed the repair, thereby lowering the repair bill. ★

WIN A SCHOLARSHIP

The **Radio-Electronics** Hugo Gernsback Scholarship Award grants $125. per year to eight deserving students studying at eight electronics home-study schools, to be used toward furthering their education in electronics.

This Award is being made annually to honor the late Hugo Gernsback, founder of **Radio-Electronics,** an inventor, writer, educator and prophet of the future in science, radio and television. Hugo Gernsback was an electronics pioneer who contributed so much to his field, and who, if alive today, would be expending his efforts toward development of the technological skills of our nation's youth.

Lewis E. Barnhouse of CIE and Garry W. Greenshields of NRI were the first two winners announced in April. This month we are proud to introduce Clayton L. Hallmark and Robert E. Richardson in our New & Timely column.

Hugo Gernsback Award Winners Announced

HOLLYWOOD, CALIF.—Clayton L. Hallmark is the recipient of the 1971 Hugo Gernsback Scholarship Award for his studies at Grantham School of Engineering. The $125.00 grant is made yearly to students enrolled in an electronic home study program at eight different institutes.

Twenty-five year-old Clayton lives in Cincinnati, was graduated from Grantham ASEE program this February, and plans to complete the requirements for a Bachelor of Science Degree in Electrical Engineering. His experience as a broadcast engineer at station WMAN whetted his appetite for the course which he states "offered a unique opportunity to acquire academic background at a professional level." ★

CHICAGO, ILL.—Bell & Howell Schools have granted the Hugo Gernsback Scholarship Award for 1971 to Robert E. Richardson of Janesville, Wisconsin. Mr. Richardson is enrolled in the Electronic Operations Technology and Computer Controls program, along with his studies as an apprentice machinist toward journeyman rating.

Married, with a 15-month-old son, Robert studies in his own trailer home and performs experiments at a relative's house. "In a home-study program I can work at my own pace. . . . The lab units help to make the theory considerably easier to understand," states Bob when explaining why he began the course. ★

Atomic Time Accuracy On Radio

NASHVILLE, TENN.—WSM-AM (650) is now the only commercial broadcaster with "atomic time," a 4/10 of a second "beep" every 15 minutes over the facility which serves most of the mid-South during the day and most of the nation at night.

WSM now supplements service handled previously by the Bureau of Standards, which moved its stations to Colorado about ten years ago.

Pete Montgomery, WSM engineer, says that by the time the signal got to the East it had lost some of its accuracy due to length of path changes. The loss is enough to be noticeable where precision measurements of time or frequency are involved. "The precision crystal idea was to make the station sufficiently accurate to be used as a secondary standard in the eastern United States," states Montgomery. "Our time signal will be as accurate as our frequency." He estimates this at one-ten-thousandths of a second.

Atomic Standard Time is

(continued on page 12)

Radio-Electronics

HUGO GERNSBACK (1884-1967) founder

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Cover design by Marius Trinque
Cover photo by Phil Koenig

RADIO-ELECTRONICS is published by Gernsback Publications, Inc.
200 Park Ave. South
New York, N.Y. 10003
(212) 777-6400
President: M. Harvey Gernsback
Secretary: Bertina Baer

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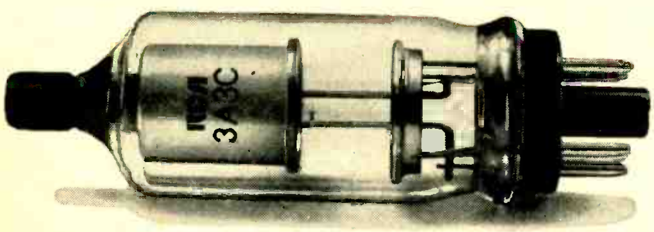
Stops arc-backs and cuts call-backs...

RCA-3A3C HIGH VOLTAGE RECTIFIER



It's the tube that saves you time, trouble and dissatisfied customers . . . because it minimizes arcing in rectifier circuits of TV receivers and other high voltage applications.

RCA makes this tube with special equipment that pre-coats the cathode and pressure welds the coating . . . producing such a smooth, uniform surface that arcing is significantly reduced.

The RCA-3A3C takes 38,000V peak inverse plate voltage and supplies 100 mA peak plate current.

For high voltage applications, put the RCA-3A3C high on your tube inventory list. This high-volume replacement type is available from your RCA tube distributor along with all the other types you need for your service business.

RCA | Electronic Components | Harrison, N.J. 07029.

RCA

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

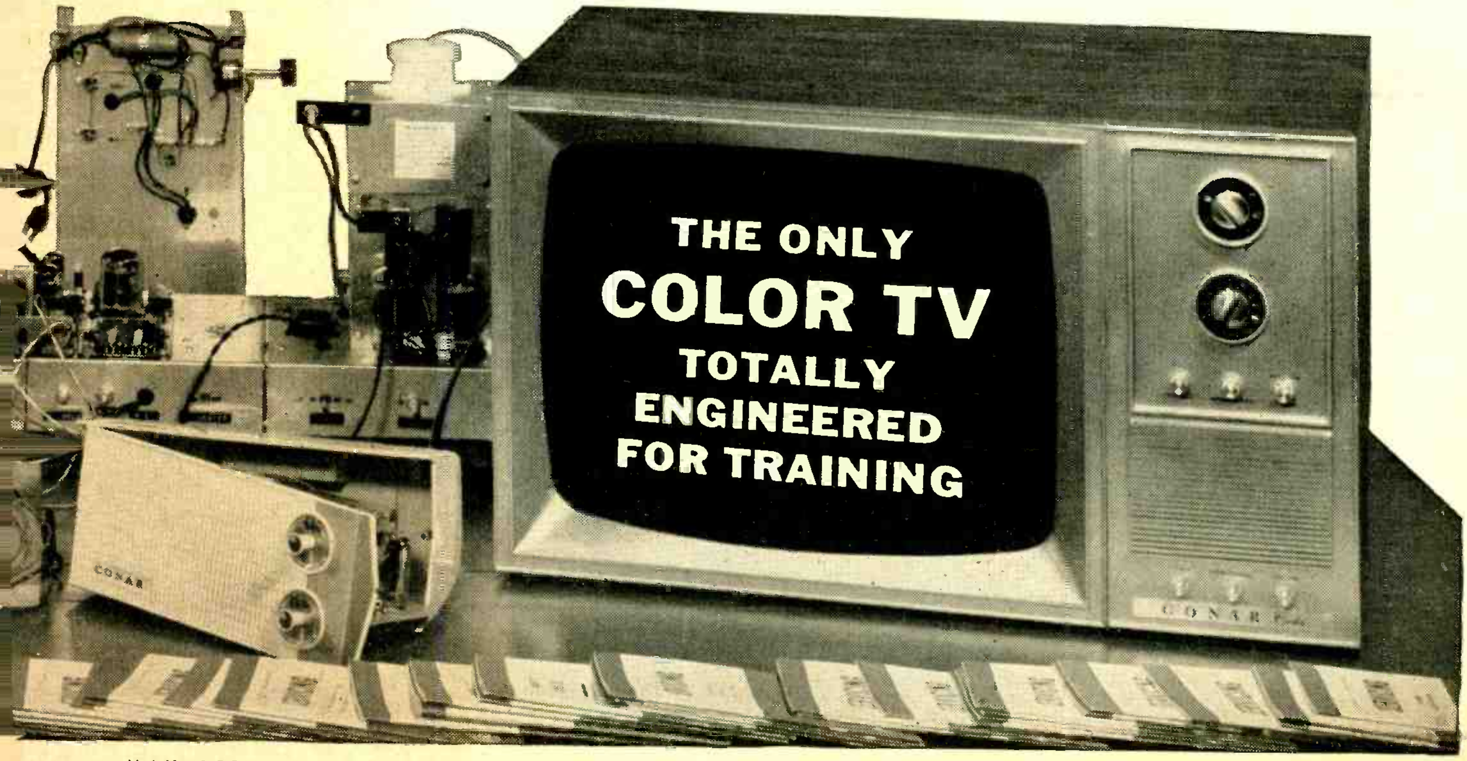
The experience you gain from intensely practical NRI training in Complete Communications equals as much as two years of training on the job. With NRI, you can train for a choice of careers ranging from mobile, marine and aviation radio to TV broadcasting and space communications. You learn how to install, 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.



New & Timely

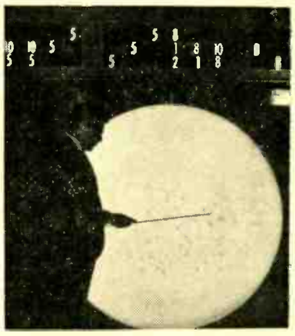
(continued from page 6)

derived from a cesium beam and doesn't vary. Cesium is a rare, highly reactive, soft metallic element of the alkali metal group used chiefly in photoelectric cells. ★

Data Displays

FULLERTON, CALIF.—Large-screen data display units, designed to enable shipboard commanders to observe operational tactics at sea, are being evaluated by the Navy.

"The new units for the first time will enable groups of senior officers aboard a ship



to share a common display for planning tactical operations and instantly monitoring their execution," stated Dr. Norman H. Enenstein, manager of Hughes Aircraft's data processing products division. (Hughes is manufacturing the gear.) Under present procedures, information is displayed on small, individual consoles, each operated by one man, with reports usually being relayed verbally to the command and staff group.

The new screens measure five feet in diameter, and depict symbolic pictures covering an area of more than 100 square miles. ★

Trial For Two-Way CATV

NEW YORK, N.Y.—A new experimental two-way communications network is now underway. The 10-terminal, question-answer system, which uses modified CATV converters, is operated by Manhattan Cable Television.

Signals in the form of questions are asked in a program emanating from the company's studios on 61st Street. The responses are made via buttons on the faces of converters located at various terminals around Manhattan. The results are broadcast in seconds.

Persons at terminal points were asked to indicate their answers to such questions as which channel they chose, which of two girls they voted for to be "Miss Home Terminal of 1971", which vacation spot they preferred. They answered by pressing any button or combination of buttons on their converters. All answers were tabulated at the studios.

Although this experiment was tabulated by hand, Charles Dolan, president of Manhattan Cable, stated that, in the future, instant communication to 40,000 simultaneous queries will be possible since questions and answers can go through a central computer bank.

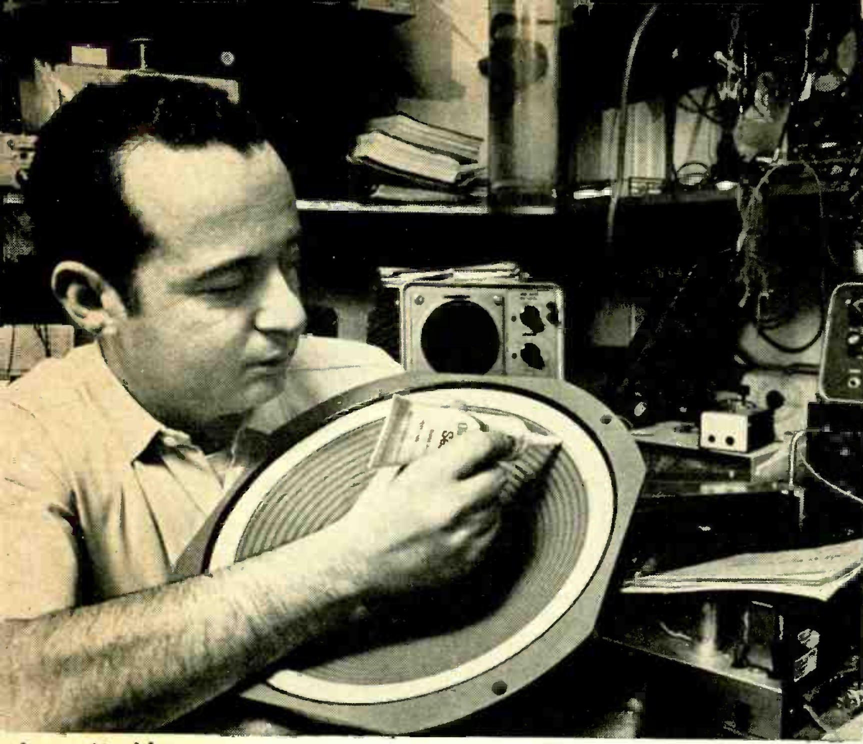
The procedure will have applications in many fields, especially retailing, polling, stock quotations, education, security devices, utility-meter reading, banking, and bookkeeping. "You'll be able to order anything you want," remarked Mr. Dolan. ★

Licensing Now Law For Florida TV Repairmen

TALLAHASSEE, FLA.—A state law now in effect requires licenses for all TV repair businesses. Enforcement begins with the registration of approximately 4,000 firms doing repairs, according to Malcolm McNeill, State Division of General Regulation.

Two options are open to the State to protect the consumer having problems with a repair company: either withdrawing their license or filing a suit against them.

(continued on page 14)



Larry Steckler
Editor
Radio-Electronics

Wayne C. Leckey (Top)
Home and Shop Editor
Popular Mechanics

Jim Hall
Designer of the Chaparral 2J, world's most advanced racing car

Match wits with the experts and win a $1000 shopping spree.

Three top pros challenge you to come up with an imaginative use for General Electric Silicone Seal or Silicone Lubricant. Something they may not have thought of.

Using the seal, electronics expert Larry Steckler repaired a speaker cone, and sealed an antenna lead-in feedthrough and outdoor antenna terminals. With the lube, he sprayed telescoping auto and TV antennas, a record changer mechanism and slide, and an antenna rotator.

With the sealant, home-and-shop expert Wayne C. Leckey dabbed rubber "feet" onto a trinket chest, sealed a rain gutter and caulked a bathtub. With the lube, he sprayed a fishing reel, some stuck drawers and all of his tools.

On his Chaparral 2J, Jim Hall used Silicone Seal to make formed-in-place gaskets, to seal all electrical connections, and as an adhesive to hold components to the body. Then he spray-lubed the throttle linkage, suspension ball joints, wheel lugs and battery terminals.

Now here's what you can do: send in another use for either product, different from those mentioned above, and enter our sweepstakes. (To win, all you *must* do is fill in your name and address and the name and address of the store where you saw GE Silicone Seal and GE Silicone Lubricant on display.)

Grand Prize: $1000 worth of anything from your favorite store carrying GE Silicone Seal and GE Silicone Lubricant. Next 100 prizes: $25 worth each. Next 1000 prizes: one-year subscriptions (or renewals) to the magazines from which you clip your official entry blank.

GE Silicone Seal: The most reliable adhesive/sealant/insulator/moisture-proofer/instant rubber. Guaranteed for 10 years. Ignores temperatures from −60°F. to 500°F. Won't harden, soften, crack or shrink. Ever. Dab it on, overnight it becomes a strong, flexible, permanent rubber. In white, black, clear and metallic. In 3-oz. tubes and 12-oz. cartridges.

GE Silicone Lubricant: The slipperiest stuff in a can. Longest wearing, strongest moisture resister, best corrosion fighter. Age, water and temperature (−70°F to 400°F) can't hurt it. *First lube of its kind that can be painted over.* Really works on just about everything, even aluminum. (Not recommended for TV tuners.) In 6-oz. aerosol cans.

GENERAL ELECTRIC

OFFICIAL RULES—NO PURCHASE REQUIRED

(1) On Official Entry Blank or plain piece of 3"x5" paper, print your name, address, zip code and the name and address of your favorite store carrying GE Silicone Seal and GE Silicone Lubricant. Include suggestions for new or different uses for either product, and name of magazine in which you saw this ad.
(2) Enter often, but mail entries separately to: MATCH WITS, P.O. Box 250, Murray Hill Station, New York, N.Y. 10016. Entries must be postmarked by July 5, 1971 and received by July 12, 1971.
(3) Winners selected in random drawings by an independent judging organization. Decisions final. *All* prizes awarded. Only one to a family.
(4) BONUS PRIZE: If you win the Grand Prize and your entry includes a new or different use, you receive a Bonus Prize of $100.
(5) Any resident of the U.S. is eligible except employees and their families of General Electric Company Silicone Products Dept. and its agencies. Void where prohibited. Subject to all federal, state and local laws and regulations.

OFFICIAL ENTRY BLANK

MATCH WITS
P.O. Box 250, Murray Hill Station
New York, N.Y. 10016

Here's what I did with (check one) ☐ GE Silicone Seal or ☐ GE Silicone Lubricant: ____________

(attach extra sheet of paper for additional uses)

Name ____________
Address ____________
City ____________ State ________ Zip ______
Name and address of my favorite store carrying GE Silicone Seal and GE Silicone Lubricant ____________

Radio-Electronics

(continued from page 12)

According to *Home Furnishings Daily*, false advertising, raising charges more than 10% above an estimate without informing the customer, and not revealing if a replacement TV picture tube is rebuilt; are all outlawed.

Technicians are required to return all replaced parts to the client except the picture tube. ★

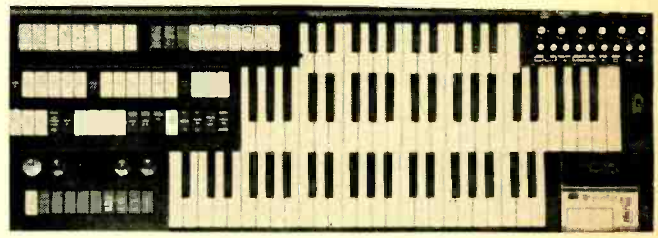
Rating Rule In Amp Ads

WASHINGTON, D.C.—The FTC proposed an industry rule on advertising the power output of sound amplifiers for such products as radios, record and tape players, and component hi-fi equipment. Charging that "wide abuse of output ratings has occurred as a result of the use of ratings based on numerous standards and testing methods," the FTC stated it has taken action because the industry itself has not determined a standard for rating audio power amplifiers.

The Commission's proposed rule provides for rating of power output according to the rms or continuous power method. The proposal insists that it would be unfair competition and a deceptive act or practice to represent any power output, band, or frequency, response or distortion capability or characteristic of this equipment without disclosing: the manufacturer's rated minimum sine wave continuous rms (effective) power output in watts per channel; the load impedance for which the manufacturer intends the equipment to be used; the rated power frequency response; the rated percentage of maximum total harmonic distortion at any power level from zero watts to the rated power output.

The FTC believes this ruling will provide the consumer with a valid basis for comparison in the marketplace. ★

COMPACT CONTROLS FOR SYNTHESIZED EFFECTS



DEKALB, ILL.—The Wurlitzer Orbit III synthesizer manual and two 44-note organ manuals give compact arrangement of the 82 controls. By using controls to activate the synthesized effects adjustable as rapidly as the controls used on organs, the Orbit III facilitates live and recorded performance of synthesized music.

Another feature adapted from Wurlitzer's theatre organ is "second touch." This permits the synthesist to obtain two musical effects from one key by depressing the key either to normal playing depth, or further, into "second touch," for special effects. R-E

LOOKING AHEAD

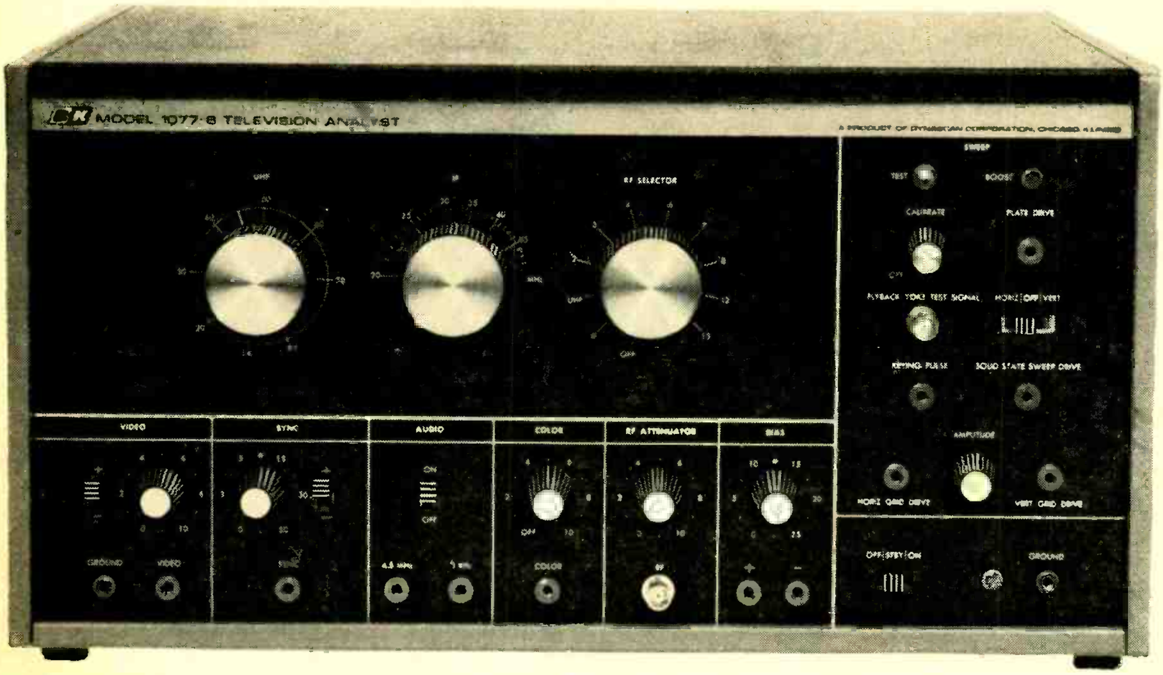
(continued from page 4)

on the results of the survey at the halfway mark (**Radio-Electronics** Oct. 1970), and the complete tests bear out earlier indications. All of the test results hadn't yet been published at press time, but Dr. Elder said: "We found essentially no radiation above 0.5 milliroentgens per hour at five centimeters [HEW's maximum permitted amount] on anything." Dr. Elder praised the cooperation of technicians' groups and technicians themselves in making possible the thorough tests—in which servicers wore supersensitive detection devices in eyeglass frames, finger rings and belts.

Meanwhile, HEW is gradually exempting black-and-white sets from x-radiation testing and reporting requirements, on a model-by-model basis. The first to be exempted were all solid-state receivers, but it's believed that eventually all monochrome sets will be declared to pose no possibility of excess radiation because of the relatively low voltages used. It's also indicated that with the eventual move to solid-state color sets, along with new x-ray-proof glass in picture tubes, even the possibility of any excessive radiation from television receivers will be a thing of the past.

A color TV camera for $500?

The lowest-priced generally available NTSC color cameras sell for about $10,000. So it was only natural that a demonstration of a new camera by Sony Corporation, designed to sell initially for about $1,000, later for $500—created something of a stir. The camera uses a single pickup tube, with a color-striped filter to separate colors. The secret, says Sony, is in a "unique electronic indexing system" keyed to a phase-discrimination system. Technical details haven't been released, but the camera gave excellent resolution and color rendition when demonstrated using non-moving subjects. Among other low-cost color cameras under development is one by Magnavox, to be offered initially at about $3,000. R-E



Who said B & K couldn't improve the only complete Television Analyst?

Now there is a new model . . . the 1077-B, with solid state sweep drive.

The B & K Television Analyst has become standard equipment in repair shops everywhere. And for good reason. It's the quickest, simplest way to test every stage of any TV.

But even classic instruments have to keep up with the times.

That's why we've added a solid state sweep drive in our latest model. It can check any new transistorized color set on the market today.

It's so easy, too. Because the unique B & K signal substitution technique eliminates the need for external scopes or wave-form interpretation.

Whether it's tubes or transistors, VHF or UHF, simply inject the appropriate test pattern or any other known signal. The new Model 1077-B, with its exclusive flying spot scanner, checks everything from the antenna terminals to the input of the picture tube.

Ask your distributor about the new Television Analyst. Only B & K makes it. And now B & K makes it even better.

Model 1077-B $389.95

B&K

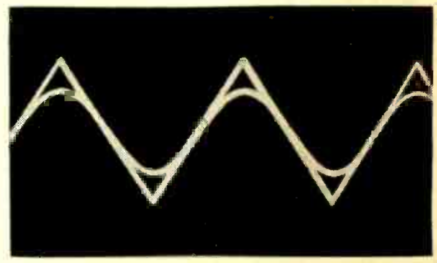
Product of DYNASCAN CORPORATION
1801 W. Belle Plaine, Chicago, Illinois 60613

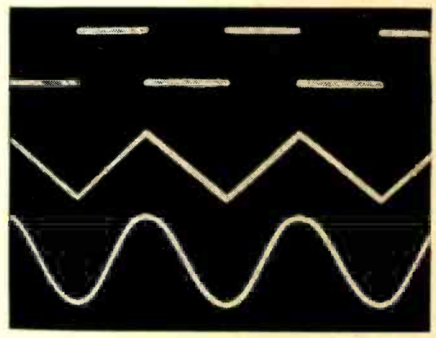
Circle 6 on reader service card

Correspondence

FUNCTION GENERATOR REPORT

In your November 1970 issue I read with great interest the construction article on how to build a 3-way Waveform Generator with IC's. Because such an instrument interested me for my own experiments I constructed it immediately. The generator





has been working perfectly from the beginning, as you can see in the two oscillograms. The frequency may be varied from 10 Hz to 100 kHz, without any effect on the waveform.

JOHANNES KLEEMANN
Stuttgart, Germany

SHORT SUMMER COURSES

I would like to let your readers know of two short courses being offered by the School of Electrical Engineering at Purdue University, during June 1971.

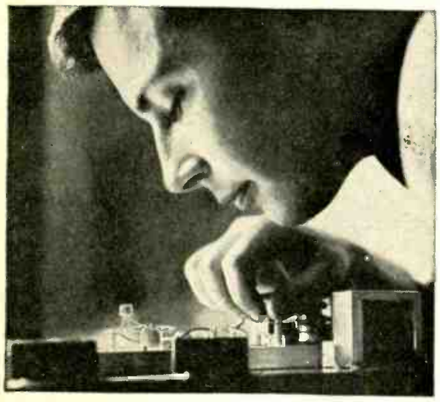
"PCM Communications Systems—Theory and Practice" is intended to familiarize engineers with state of the art of transmitting analog and digital data (voice, TV, fascimile, telemetry, data, etc.) over digital channels. Topics to be covered include source encoding, quantization, error correction coding, modulation, phase lock loops and multiplexing. Dates of the five-day course are June 7 to 11. *(continued on page 22)*

NEW!
Announcing the CIE "LEARNING LABORATORY"

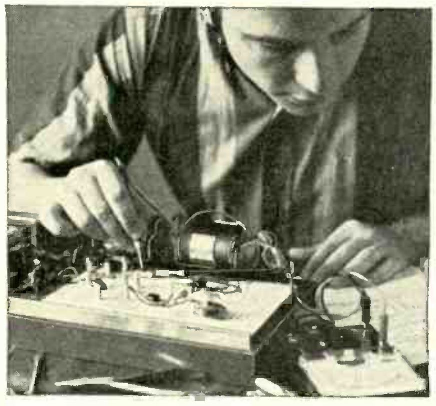
Electronic "kits" are out!

Now you can have your own electronics laboratory.

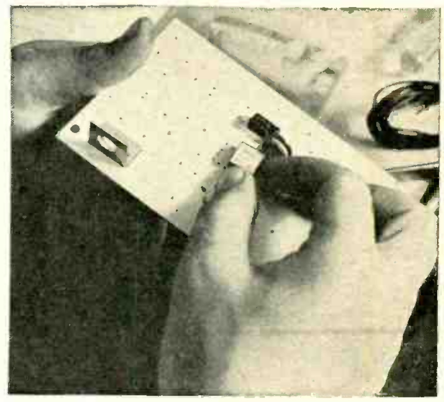
You'll perform hundreds of exciting experiments like these with authentic electronic components used by industry.



Working with basic single transistor circuit — Student learns best installation and troubleshooting techniques. He has constructed a basic single transistor circuit, first step toward understanding more complex solid-state circuitry.



Observing transistor operating as shunt-fed amplifier — Student has installed an oscillator and shunt-fed amplifier. He takes various measurements and observes the transistor operating as an amplifier. This is a typical solid-state circuit.



Assembling integrated circuit on a printed circuit board — Circuit is identical to one used in latest IBM System 360 computers. Student is constructing an oscillator combined with a Darlington pair output amplifier.

Prepare now for a high income career in the fast growing field of electronics.

Electronic miracles are changing today's world with breathtaking speed.

And with this electronics explosion has come a brand new need . . . a demand for thousands of electronic technicians, trained in theory and practice to build the products, operate them and service them.

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Step-by-step learning cannot compare with learning-by-doing. Now you can learn "why" as well as "how." You'll find out for yourself the right way as well as the wrong way to use electronic components, to construct your own circuits, to discover trouble spots and learn how to fix them.

This new CIE course, Electronics Technology with Laboratory, teaches you electronics by making it work before your eyes. And you do it yourself, with your own hands.

Importance of FCC License and our money-back warranty

An FCC License is a legal requirement for many important jobs. And it is not easy to get!

But more than 9 out of every 10 CIE graduates who take the Government licensing exam pass it!

We are so certain that our Laboratory Course will successfully prepare you for a First Class FCC License examination, with Radar Endorsement, that if you fail the exam we will refund all tuition payments.

You get your FCC License, or you get your money back!

You'll have high-paying job opportunities

Electronics is in its infancy. Everywhere you turn you find new products and equipment using space-age circuitry. Computers. Improved radar for air traffic control. Mobile microwave communications. These and many more examples of electronic technology have created thousands of new jobs — in companies like American Airlines, American Telephone and Telegraph, General Electric, IBM, North American Rockwell, Raytheon and Westinghouse.

Once you're enrolled with CIE you will get a bi-monthly listing of many high-paying, interesting jobs open in designing, manufacturing, testing, operating and repairing.

More and more jobs will be created in the next few years. Start today to get ready for an exciting, new career in electronics . . . the industry of tomorrow.

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Circle 9 on reader service card

CORRESPONDENCE
(continued from page 16)

"Image Processing, Coding, and Transmission" is designed to acquaint engineers with the state of the art of image processing by digital techniques. A review of the properties of the human visual system, image modeling, image enhancement, feature extraction, image encoding, bandwidth compression and image transmission over noisy channels will be studied. The four-day course will be held June 1 to 4.

For additional information telephone me at 317/749-2533 or write me at the address below.

PAUL A. WINTZ
School of Electrical Engineering
Purdue University
Lafayette, Ind. 47907

HEATHKIT IG-57 MODIFICATION

I wish to correct an error in your Equipment Report of the Heathkit IG-57 TV Post-Marker Sweep Generator which appeared in the October 1970 issue of RADIO-ELECTRONICS. The IG-57 has only one bias supply; the later model IG-57A has two dc bias supplies and incorporates a video sweep modulation (VSM) capability for more accurate alignment. A modification kit to add VSM to an IG-57 is available from the Heath Company.

DALE E. BALDRIDGE
Design engineer
Heath Company
Benton Harbor, Mich.

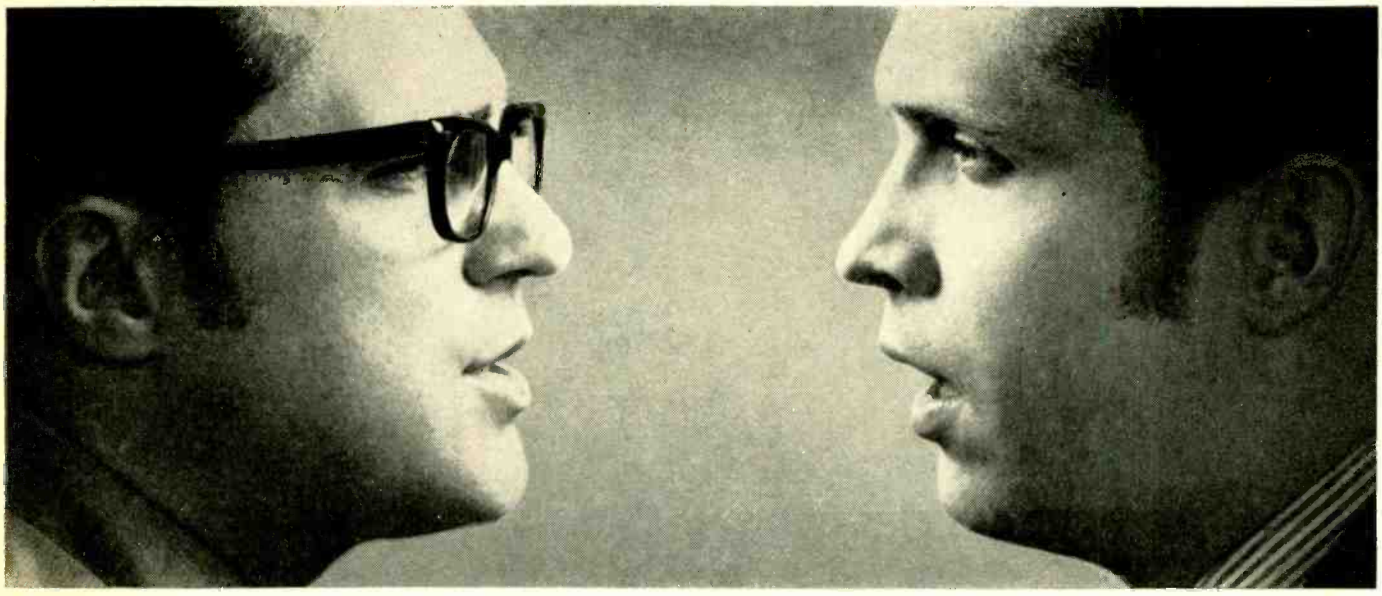
CORRECTION

There is a discrepancy between the type numbers listed for Q1 and Q2 in the parts list and on the schematic of the One-IC Audio Generator on page 37 of the February issue. The author specified the types in the parts list but used the 2N3904/2N3906 complementary pair in the generator we tested. The discrepancy was noticed too late for us to alter the parts list or add editorial comment.

The 2N3053 and 2N4037 are complementary pairs with electrical characteristics similar to the 2N3904 and 2N3906. The circuit should perform equally well with either pair of transistors. **R-E**

Said a student technician named Peter,
"Car-radio work is much neater!"
He got hung in the gears,
he's been there for two years,
and they're feeding him soup through
the heater!

Jack Darr



Why do you always use RCA SK Replacement Devices?

Because SK's are specifically designed and engineered for replacement use in home-entertainment equipment. RCA doesn't make SK types unless they're needed in the field and serve the professional.

Will I need a large inventory?

Not at all. Only 67 types cover a broad range of replacements in TV, hi-fi, and other entertainment equipment. It's the shortest line of product with the broadest range of replacement applications. That's just one of the reasons I like it.

What's another reason?

Quality — it's assured! SK's are tested with the finest dynamic testing equipment, operated by the same personnel who test other RCA power, signal, and IC devices. They're even tested again at the factory warehouse before shipment.

Are you saying RCA is the only source for reliable solid-state replacements?

No. But SK's are top quality, and the SK Replacement Guide is a truly reliable source for cross-reference information. RCA only cross references types where there is engineering assurance that the SK will do the job as well as, or better than, the original.

Seriously, is the SK Replacement Guide that great?

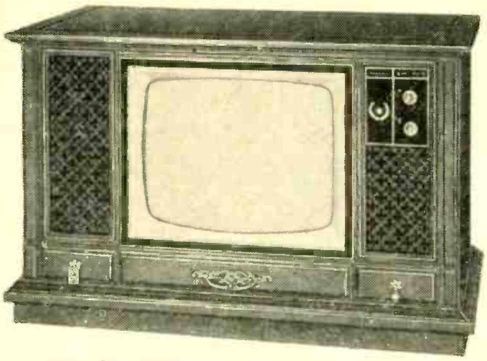
Better! It includes technical information on the line, plus a "Quick Selection Chart" which is unique in the industry. Now I can choose the proper SK replacement for almost every type made.

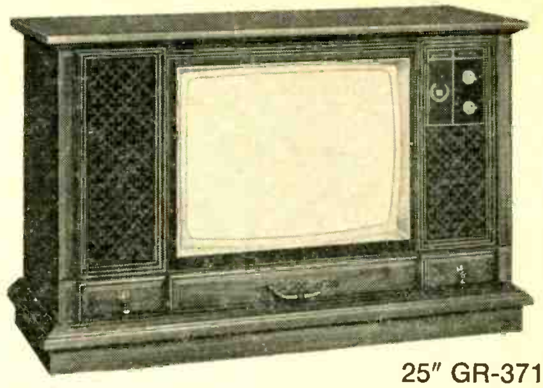
I'm sold! How can I go wrong with RCA SK's?

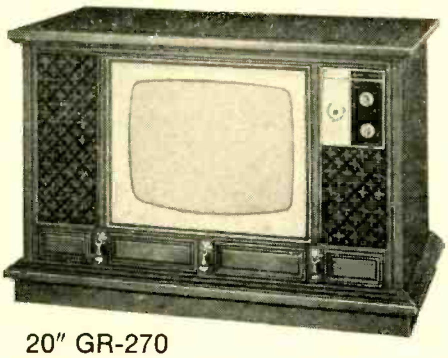
You can't. No one can!

RCA

RCA | Electronic Components | Harrison, N.J. 07029


23″ GR-370


25″ GR-371MX


20″ GR-270


18″ GR-269


14″ GR-169

There's a Heathkit® solid-state color TV to fit every size and budget need. Think about it.

Consider the choice. Heath offers five different solid-state color TV's in easy-to-assemble kit form, from the portable 14″ GR-169 to the largest screen in the industry, the 25″ GR-371MX. All offer Heath's famous modular plug-in circuit board design that makes assembly easier. Only two tubes (picture and high voltage rectifier). And Heathkit color TV's are the only sets available at any price that can be serviced by the owner, without special test equipment or years of training. The famous Heath manual, combined with the special volt-ohm meter supplied, enables you to perform every adjustment required. And each set includes the No-charge 90-day Warranty Service on solid-state modules and 2 year picture tube warranty. Here's the rundown on the Heath series of solid-state color TV's. Think them over, you'll find one just right for your own size and budget requirements.

25″ GR-371MX . . . the top of the Heath color TV line. Compare this list of **standard** features on the 371MX . . . there isn't another set available that offers all these extras at no extra cost. Giant 25″ Matrix picture tube delivers the biggest, brightest color picture you'll ever see . . . 315 sq. in. And pictures don't wrap around the sides as before. Specially formulated etched-glass face plate cuts out glare, increases contrast without reducing brightness.

Automatic Fine Tuning delivers perfectly tuned picture and sound with a push of a button. "Instant On" circuitry provides sound instantly, picture in seconds. Exclusive Heath MOSFET VHF tuner gives superior reception, even under marginal conditions. VHF Power Tuning is built-in . . . a push of a button lets you scan thru all VHF and one preselected UHF channel. High resolution circuitry improves picture clarity and adjustable video peaking lets you select the degree of sharpness you desire. Adjustable tone control . . . adjustable noise limiting and gated AGC . . . hi-fi sound output . . . 75 & 300 ohm VHF antenna inputs . . . Automatic Chroma Control — all standard. Plus three luxurious optional cabinets to choose from: Mediterranean, Early American or Contemporary. Plenty of reasons to order your new GR-371MX now.

Kit GR-371MX, (less cabinet), 125 lbs. **$579.95***

23″ GR-370. Actually the GR-371MX with a smaller picture tube. Features a premium quality bonded face, etched-glass 23″ screen . . . 295 sq. in. of viewing enjoyment. Includes the same standard high performance features as the 371MX above, except the Matrix picture tube is a low cost option.

Kit GR-370 (less cabinet) 127 lbs. **$539.95***

Kit GR-370MX, as above with Matrix picture tube **$549.95***

20″ GR-270. In reality, the feature-packed GR-371MX with standard 20″ bonded-face, etched-glass picture tube providing 227 sq. in. of colorful TV viewing. See the GR-371MX above for all the other standard features. Easily your best buy in a medium size solid-state color TV, and ideal screen size for smaller living rooms.

Kit GR-270 (less cabinet), 114 lbs. **$489.95***

18″ GR-269 . . . the Heathkit "compact" color TV. Has the same highly sophisticated modular solid-state circuitry as the GR-371MX, but modified to accept the popular 180 sq. in. color picture tube. Features AFT, "Instant On", 3-stage IF, MOSFET VHF tuner, switch-controlled degaussing . . . all standard.

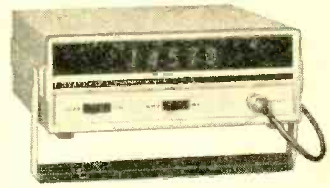
Kit GR-269, (less cabinet), 100 lbs. **$399.95***

14″ GR-169 delivers console performance with portable convenience. Here's the GR-371MX modular circuitry modified slightly to accept a 14″ diagonal picture tube. Features MOSFET VHF tuner, 3-stage IF, switch-controlled degaussing, complete up-front secondary controls, built-in VHF & UHF antennas. Handsome portable cabinet included.

Kit GR-169, 69 lbs. **$349.95***

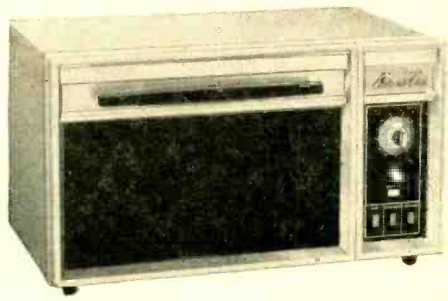
TO-101 Legato Theater Organ

IO-102 5" Scope



IB-101 Frequency Counter

GD-29 Microwave Oven



And here are a few of the more than 300 other Heathkit thoughts for the budget minded:

New Heathkit "Legato" 25-pedal Theater Organ. Now you can save hundreds of dollars by building this versatile instrument yourself. All solid-state design. Features 15 manual voices, 4 pedal voices. 25-note heel & toe pedal board, range 16′ & 8′ CO to C3. Two 44-note keyboards; accompaniment range 8′, F1 to C5. Solo manual 16′, 8′, 4′, 2′, F1 to C7. Color-Glo key lights have you playing like a pro in minutes. Two solid-state amplifiers deliver 200 watts peak power . . . one amp for the rotating 2-speed Leslie, one for the two 12" main speakers. Tape record/playback jack on amp. Bandbox & Playmate accessories available. Bench included.
Kit TO-101, 299 lbs. **$1495***

New Heathkit Microwave Oven . . . tomorrow's cooking revolution here today in easy-to-build kit form. Exclusive patent pending Heath double door interlock prevents oven from being turned on if door is open. Cooks meals in minutes, not hours . . . eliminates dirty pots & pans by cooking on paper, glass, china. Low profile design fits nearly anywhere. 120 V operation.
Kit GD-29, 97 lbs. **$399.95***

New Heathkit 5" Solid-State Scope . . . ideal for all general lab & shop applications. Wide 5 MHz response, 80 nanosecond rise time and 30 mV/cm sensitivity make the IO-102 a truly high performance, low cost scope. Convenient switch-selected AC or DC coupling. Frequency-compensated 3-position attenuator. FET input provides high input Z (1 megohm) to minimize circuit loading. Recurrent, automatic sync type sweep provides 5 ranges from 10 Hz to 500 kHz with vernier. External horizontal and sync inputs. One volt P-P output. New flat face 5" CRT with removable 6x10 cm ruled graticule. Zener-regulated power supplies give excellent display stability. 120/240 VAC operation. Choose easy to assemble kit or factory-wired version.
Kit IO-102, 29 lbs. **$119.95***
Assembled IOW-102, 29 lbs. **$179.95***
Assembled PKW-101, 1 megohm probe, 1 lb. .... **$ 19.95***

New Heathkit Solid-State Frequency Counter . . . delivers highly accurate measurement from 1 Hz to over 15 MHz. All IC circuitry for top performance. Automatic trigger level for wide range input without adjustment. Hz/kHz ranges & overrange give 8-digit capability. 1 megohm input Z.
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Circle 11 on reader service card

HOME APPLIANCE ELECTRONICS

by JACK DARR
SERVICE EDITOR

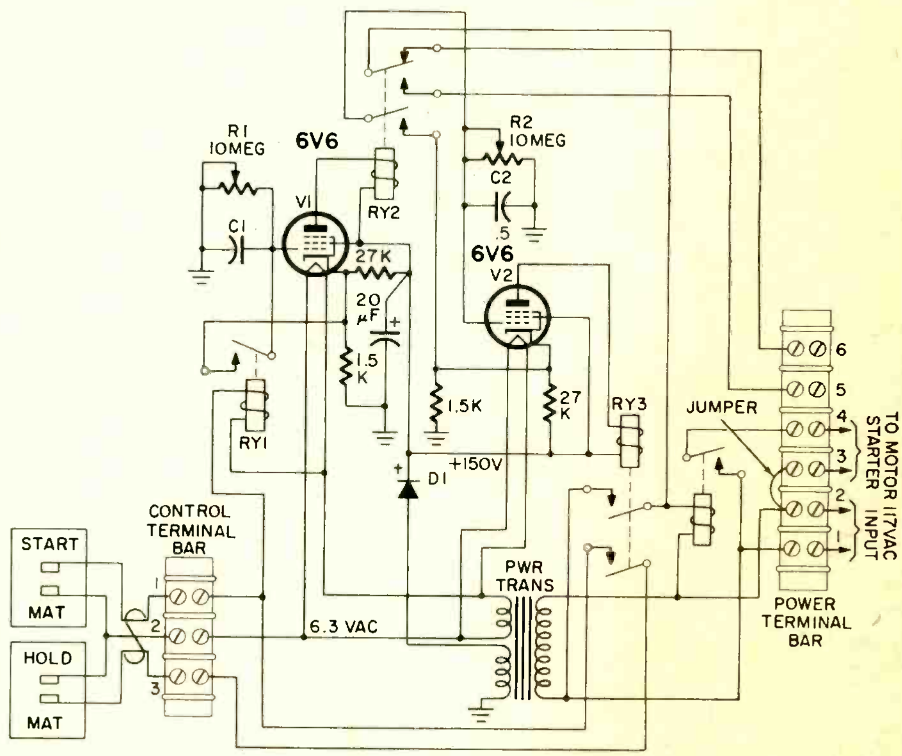
TIME CONSTANTS

ELECTRICAL APPLIANCES, INDUSTRIAL electronics apparatus, and a lot of common things, make use of electronics principles. Most of these are old hat to us, but may be pretty strange to other people. The applications of ordinary, simple electronic principles are many and varied. None of them will be complicated, if you know your electronic ABC's. Look for these, and you'll find a lot of things that you can fix! Some of the uses for these might surprise you.

A good example of this is a job that I got rung in on not too long ago. Friend was working on an automatic door-opener—you know the things where you step on the little mat in front and the door opens without you even having to say "Open, Sesame"? This one was working, but you had to yell "Jump!" as soon as you got the words "Open, Sesame" out! In other words, the door opened as soon as you stepped on the mat, but then it chased you through! If you were fast enough, you could make it ahead of the door, which started to close instantly!

Since this was the door that let the customers *into* the store, the manager was understandably upset. The one that let 'em out was OK. So, we began checking. I said, prophetically, it turned out, "Sure has a short time-constant." It did. According to the instruction book, the door was supposed to open, hold for a minimum of three seconds, then close. (This being a new piece of gear to both of us, we did it the hard way—we read the instruction book first!)

The door itself was operated by a hydraulic mechanism, which was obviously working fine. The control was a nice simple two-tube electronic circuit, with two 6V6 tubes. The drawing shows the schematic. The sequence was started when you stepped on the mat; this closed a switch, and this in turn closed relay RY1, a plain 6-volt ac spst relay.



When the contacts of RY1 close, a positive voltage, coming from the V1's cathode, and a dropping resistor to the dc power supply, is applied to the grid. Plate current flows, and re-

(continued on page 84)

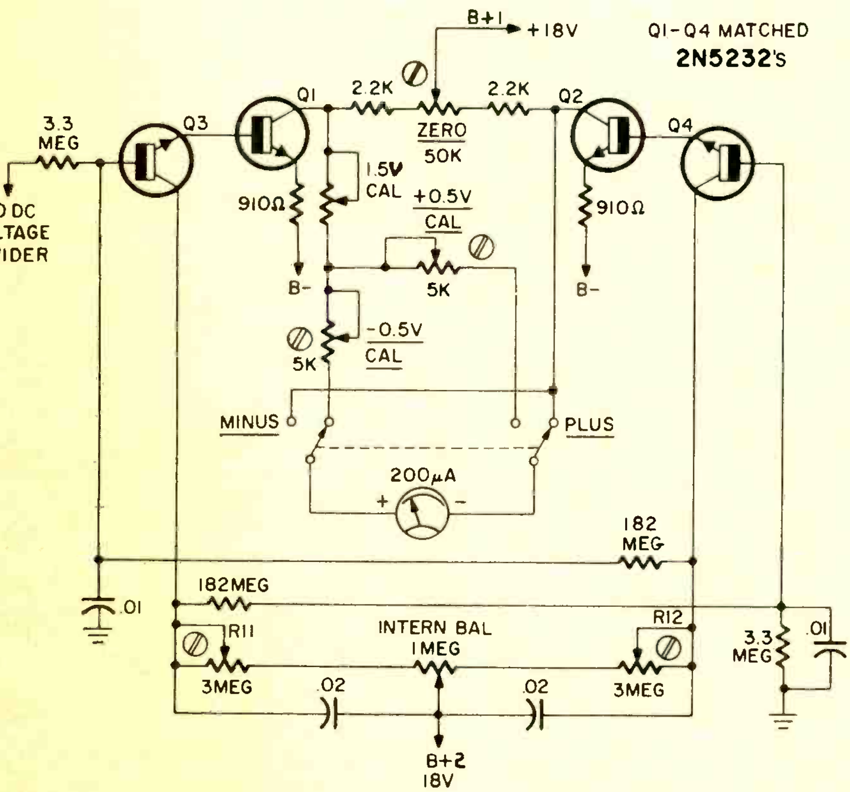
EQUIPMENT REPORT

RCA WV-510A Solid State VOM

For manufacturer's literature, circle No. 16 on Reader Service Card.

IN MANY RESPECTS: SELECTING A TEST instrument is similar to courtship and marriage. In both cases, we survey top-notch products until we find one with which we are compatible. Comes the purchase (or marriage) and we settle down to grow old gracefully, loving each other, overlooking shortcomings, and forgiving errors.

Much of the equipment on my basement workbench is "old enough to vote" but I've grown up with it and have learned to love it; compensating for glitches on scope traces, the cracked face and bent needle on the vom and the erratic output of the sweep generator. It is only when there is "something new and glamorous" around that I yearn to stray from the fold and sow a few wild oats.



The model WV-510A is "the new gal in town"—the latest in RCA's long line of Master Voltohmysts electronic multimeters. I've given her a workout and we two have really got something going for us.

This gal is really sharp—3½ lbs., 6⅞" x 5¼" x 3⅛", solid-state, stable and drift-free. Up front, she features a mirrored 4" x 6⅝" 200-μA readout that dwarfs the meters on our old-faithful WV-95A and the stand-by WV-77.

WV-510A operates from internal batteries and from ac power lines. She's wired for 110–135-volt operation but can be set up for 240 volts by unsoldering a lead from one point and resoldering it to another. A 1.5-volt D cell powers the ohmmeter circuit and four 9-volt transistor-radio type batteries (RCA VS323 or equal) deliver operating voltages to the 4-transistor balanced amplifier (see diagram). Maximum life for the 9-volt batteries is assured by a trickle-charge circuit that operates when WV-510A is powered by the ac line.

Input resistance is 21 megohms on all dc voltage ranges. There are eight ranges covering 0.5 to 1500 volts in decades of 1.5 and 5 volts. Seven ac ranges cover from 1.5 to 1500 volts rms and 14 to 4200 volts peak-to-peak (full-scale). Ac input resistance is 0.83 megohm shunted by 70 pF on the 1.5-, 5-, 50- and 150-volt ranges, 1.3 meg shunted by 60 pF on 500 volts and 1.5 megs shunted by 60 pF on the 1500-volt range. Response is flat within 1 dB from 30 Hz to 3 MHz on the 1.5- and 5-volt ranges.

Direct current is measured in ranges of 0.5, 1.5, 5, 15, 50, 500 and 1500 mA.

Resistances of 0.2 ohm to 1000 megs are measured using seven decade multiplier ranges.

All voltage and resistance measurements are made with the WG-

(continued on page 79)

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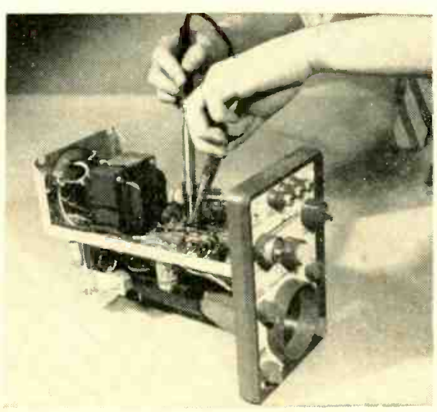
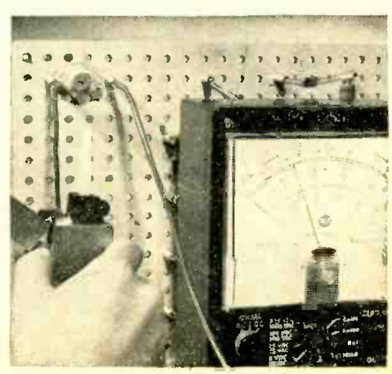


Construction of Oscilloscope.

Temperature experiment with transistors.



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CHANGE COLOR PIX TUBES FASTER

by **TOM RICHMOND**
Service Manager, Channel Master Inc.

Save time and trouble the next time you replace color picture tubes

Replacing a color TV picture tube is a lot harder than replacing a monochrome CRT. However, you can save time and trouble by approaching the job with a step-by-step procedure. If you use and perfect this procedure each time you replace a color picture tube you can probably cut the time you normally take for the job in half.

In planning your replacement procedure, keep these basic principles in mind:

1. Move things as little as possible. Position is important. Chances are the adjustments are pretty close to where they should be. You'll save a lot of time if you handle everything gently and carefully and put everything back just as it was when you took it apart.

2. Have a complete set of tools on hand. To replace a picture tube, you'll need:

Regular television hand tools such as screwdrivers, pliers, etc.

A set of nut drivers, including a long-shaft ¼" nut driver.

A degaussing coil.

A dot-bar generator.

A fairly large mirror.

A rug, blanket or pad, large enough to hold two color picture tubes.

A grease pencil.

The TV set service manual, if available.

3. Use a first quality replacement picture tube. Unlike replacing a monochrome CRT, there's a lot of labor involved in a color tube installation. If the tube goes bad or delivers substandard picture quality you have to do the job all over again. It doesn't pay to try to save money on replacement tube. Choose a tube with as long a warranty period as possible. Some color tubes are now available with three-year warranties.

Replacing the picture tube

The first step in changing a color picture tube is to pull the chassis out of the set. This should leave you with only the picture tube and the components that fit around its neck in the cabinet.

Then turn the cabinet face down on a rug, blanket or pad. Be careful not to scratch the safety glass.

Next, remove the new tube from its box. Almost all picture tube cartons tell you which side to open. Be sure to open the carton from this side so you can remove the tube face up. Do not support the picture tube by holding it by its neck.

Very carefully place the new tube face down on the rug, in exactly the same position as the tube in the cabinet. Check the position of the high-voltage anode button to be sure you have it right.

The next step is simple, but important. Do it right and you'll save a lot of time later on.

Notice the positions of the degaussing coil, the yoke, the purity rings, and the convergence magnets. The trick here is to move this entire assembly to exactly the same positions on the new picture tube. Notice that the yoke is not flush against the bell of the picture tube, as it is in monochrome sets. Some play is allowed, to permit purity adjustment. It's important, therefore, that you mark the distance between the yoke and the bell of the tube.

With all this in mind, lift the entire assembly off the old picture tube. Put it gently and carefully onto the new tube, as close to the right position as you possibly can. Do this accurately and you'll often be able to get passable pictures on the new tube without making any adjustments.

At this point, remove the old picture tube. Before replacing it, take a few minutes to clean out the cabinet. The lady of the house will probably be delighted to lend you her vacuum cleaner for this purpose. Then, use a good aerosol mask and glass cleaner to clean the safety glass, the

face of the new picture tube if it is not a bonded-face tube. Don't forget to clean the control panel later.

Finally, install the new picture tube, securing it firmly in place. Now, all you have to do is to replace the chassis, connect everything up and set it up for a good picture.

Color adjustments must be made

Physically replacing a color picture tube is only half the battle. You must still make adjustments to get good color pictures on the screen.

Before you can make these adjustments, however, you have to let the set "cook." Put the color set in approximately the position in which it will normally be viewed and turn it on, with the back off.

It can be dangerous to operate a color set with the back off, so warn the family to keep children and pets away from it, and don't leave the set unattended.

"Cooking" time should be 20 to 30 minutes. Use this time to degauss the set, or to ask "What else needs fixing in the home." If you have a service manual for the set, review the manufacturer's recommended color set-up procedure while you're waiting for the set to get hot.

Once the set is warmed up, you're ready to start making adjustments. A final preliminary step is to set a large mirror up on a chair in front of the set so that you can see what's happening on the screen while you make adjustments at the rear of the set.

Degaussing technique

A color set doesn't have to be warmed up to be degaussed. It doesn't even have to be turned on. You have to use a degaussing coil to de-magnetise a color set even though modern sets have built in automatic degaussing. Any stray magnetism on the picture tube shadow mask makes it almost impossible to get good purity or convergence. Automatic degaussing can keep the set working well, but it can't do the thorough demagnetizing like a degaussing coil can.

Degaussing is easy, but you must do it right. Plug the degaussing coil into an ac socket and turn it on. Hold the flat side of the degaussing coil about an inch from the safety glass. Move the coil in small circles so it covers the entire front, top and sides of the set. The sides and top are important because you must eliminate any slight magnetism of the tuner chassis or main set chassis. Finish up by going over the entire front of the screen a second time.

Do not turn the degaussing coil off while it is close to the set. This can defeat your whole purpose, leaving magnetized spots. Instead, back away slowly 6 to 8 feet from the set, turn the coil so that it is perpendicular to the screen, and then turn it off.

Purity adjustments

Your objective is to make the rasters of each of the three guns pure in color. However, you make this adjustment with the red raster alone.

Your first step, therefore, is to cut off the blue and the green guns, so you can observe the red alone. Many sets have gun switches, which makes the step easy. All you have to do is set the blue and green switches to off.

In some sets, it's a little more difficult to kill the blue and green. You might have to remove clip leads from a terminal strip or plug an adaptor into the picture tube base. If no other means are provided, ground the dc voltages on the blue and green guns through 100,000-ohm resistors. Some receivers have resistors already mounted on the PC board and connected to the CRT grids. All you have to do is put jumper wires to ground.

Once the blue and green guns are disabled, set the contrast control fully counterclockwise, and the brightness control to the center of its range. Then, observe the raster.

Most instructions on purity tell you to move the yoke back away from the bell of the tube, use the purity rings to center the resulting red splotch and then move the yoke forward again until the red just fills the screen.

If you've been careful about positioning the purity rings and the yoke, however, this won't be necessary. These adjustments will already be pretty close, requiring only a fast touch up. Use the purity rings to get a uniform, pure red and move the yoke, if necessary, so that the red raster just fills the screen.

If you can't get a pure, uniform red in this way, chances are degaussing was not complete. You'll have to go through the degaussing procedure again and start from the beginning.

Color temperature adjustment

Some manufacturers call this grey scale adjustment. What you're trying to do is to mix red, green and blue to just the right proportions. When you achieve this, all monochrome pictures, whether light or dark, will be reproduced without color. If you don't get color temperature right, you'll see colors in a black and white picture at certain settings of the contrast and brightness controls.

The basic controls that affect tracking of greys and whites are: kine bias, red/green drive, blue drive, red screen, blue screen and green screen. All of these controls affect electron gun dc operating voltages.

To adjust color temperature, turn all of the above controls fully counterclockwise. Turn the brightness and contrast controls to the center of their range and set the Raster—Normal—Service switch to the Service position.

Then, turn the red screen control up slowly until you see a faint red line across the tube. Back off slowly till the red line just disappears. Repeat this procedure with the blue and green screen controls.

If you turn one of the screen controls fully clockwise and still can't get a line across the screen, the kine bias control is probably set too low. Turn it up (clockwise) and make all three color screen adjustments over again.

To make the final color temperature adjustment, set the Raster—Service—Normal Switch to Raster and turn the control all the way up. Then, adjust the red/green drive and the blue drive for a grey picture. Switch the red/green drive switch from red to green to adjust these two colors separately. (NOTE: Some receivers have no "red" drive control and others have three separate controls.)

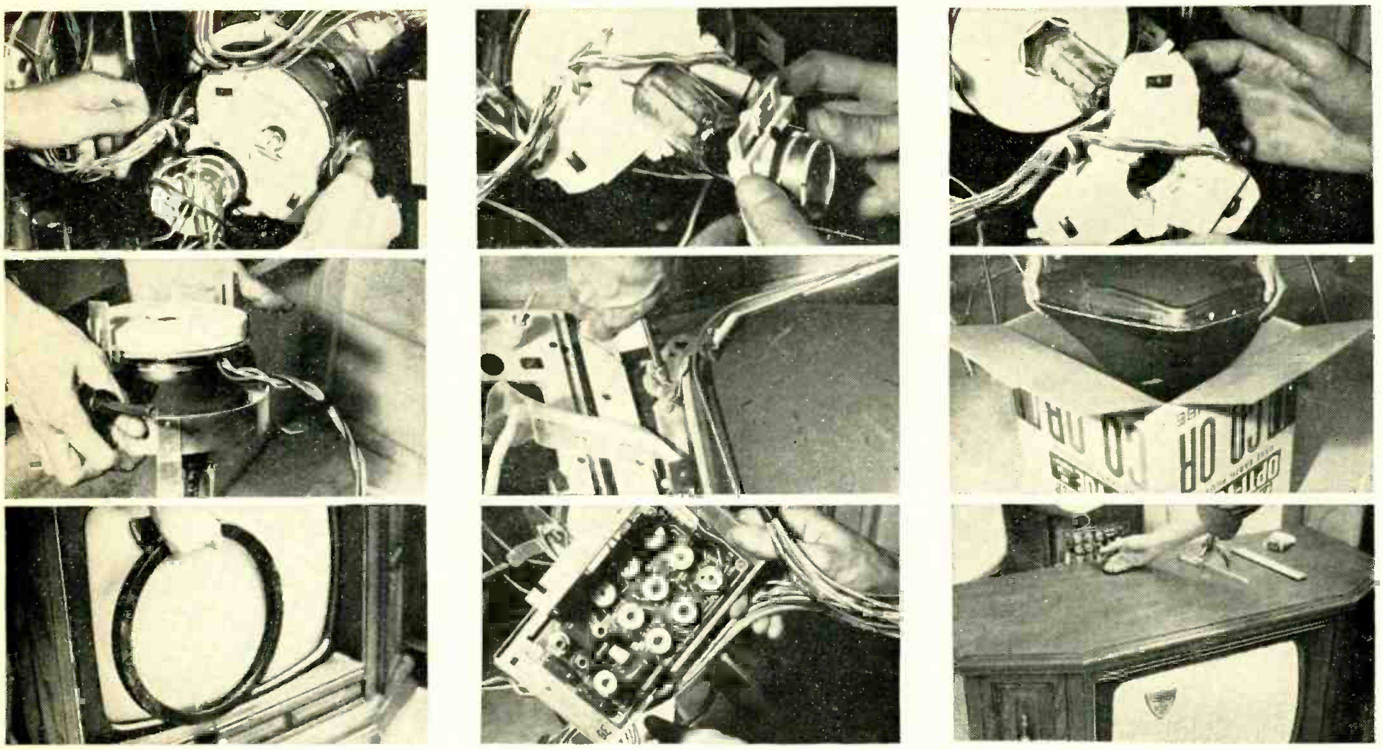
Once you get a grey raster, without traces of color, switch to the Normal position and adjust the set for a good monochrome picture. Run brightness and contrast up and down, to be sure the grey scale is tracking properly. If you see traces of color, you'll have to make these adjustments over again, but if you're careful you can get it right the first time.

Convergence isn't hard

If all three rasters are to be superimposed on one another, the beam from each color gun must pass through the aperture mask holes at precisely the right angles. Making sure that each raster beam lights the right phospherescent dots is called convergence.

There are two parts of convergence, both of which require a color bar-dot generator. Static convergence takes care of the center dots. It's quick and easy and should be done first. Dynamic convergence takes care of the corner dots. This takes a little longer.

Connect the color bar-dot generator generator to the TV set's antenna input terminals and set it so it generates a dot pattern. Draw a grease pencil circle around the dots in the center of the screen. Otherwise, you'll have to search for the center dots every time you glance away from the



TOP ROW, left to right. Loosen the screws that fasten the yoke assembly in place. Removing tube socket and blue-lateral magnet assembly. Convergence coils slip off tube neck.

MIDDLE ROW, left to right. Yoke assembly is removed from neck of tube. Picture tube mounting band is being released. Remove replacement from carton. Do not handle by neck.

BOTTOM ROW, left to right. Degaussing is done before convergence. Get the convergence panel out in the open. Final convergence is done while watching screen of set.

screen. The object is to get the red. green and blue center dots to converge, to produce pure white dots.

This is done by adjusting the static convergence magnets. There's one static convergence magnet for the red gun, one for the green gun and two for the blue gun. The red and green magnets move their beams diagonally. The blue magnet moves the beam vertically and the blue lateral magnet moves the beam horizontally.

Start by moving the red dot over the green dot so they form one yellow dot. If the blue dot gets in the way, you can kill the blue beam as you did when making the purity adjustment. You should be able to get a pure yellow dot. Then, reactivate the blue beam and move the blue dot over the yellow dot to get a pure white dot. If you've moved the yoke assembly over to the new tube carefully. very little adjustment will be required to complete static convergence.

Switch the color-bar generator to a cross-hatch pattern and examine the TV screen carefully. If you see any color fringing at the corners of the screen. you'll have to go through the time-consuming process of dynamic convergence. However, if you've done everything carefully and well up to now, chances are your job has been completed.

If you've used a top quality picture tube, you should be able to get fairly good results, but even the best color CRT's are not 100% uniform. Remember, the family that watches the set on a normal picture from across the room is not as critical as the technician who looks closely at a cross-hatch pattern.

All of the controls for dynamic convergence are mounted on a single board. The vertical controls are usually on the left, horizontal controls on the right. If possible, position this board so that you can adjust it while watching the screen directly.

Dynamic convergence

There are many variations in dynamic convergence controls, so it's best to follow the manufacturer's instructions. Start by switching the generator back to a dot pattern and lining up the middle vertical row of dots. As with static convergence, the object is to get pure white dots in the middle vertical row. You also have to make sure the line is straight and parallel with the open vertical lines. Kill the blue gun and line up red and green to produce yellow first. Then, switch on the blue and line it up to make all of the middle vertical row of dots white.

Next, look at the middle horizontal row of dots. These should be converged exactly like the vertical row to produce pure white dots. The horizontal line should be straight and parallel with a raster line.

Unfortunately, this is not as easy as it sounds. You get quite a bit of interaction between controls. And when you get the outer edges of the screen converged, you may find that static convergence is out. When all the dots are white, you may see bending in the lines. Therefore, you have to go back and forth making touch-up adjustments.

You will probably have to repeat the convergence at least two and probably three times to get it right. It will help if you look away from the dots to rest your eyes from time to time.

You'll save time by being very careful. Notice where each control is before you touch it. Then, if the "touch up" doesn't help, return the control to its original position.

If you end up with a slight bit of poor color convergences at the edge of the screen, ignore it.

Your last step is to re-check color purity and color temperature. In many cases, no readjustment will be necessary, but this is by no means a sure thing. If you do have to move the purity rings or the screen controls, you will also have to go through the convergence procedure again. Frustrating as this seems, it is necessary because these controls do interact.

In many ways, the job of replacing a color picture tube and making the necessary adjustments sounds a lot tougher than it really is. With good organization, the right tools, and a little practice, you can do the job fast. **R-E**

SOMEWHERE OUT THERE, IN THE AREA SERVED BY TWO OR three TV channels that you can pull in with a super deep-fringe antenna, a very special tower is being built. The tower will eventually have a cluster of precisely cut TV receiving antennas on it—one for each channel that can be picked out of the air. At the bottom of the tower, a "doghouse" will hold some special electronic equipment. From that doghouse, an aluminim-sheathed cable crosses to a small building a few dozen yards away. Inside, more electronic equipment, including a small TV studio, flesh out the installation. From there, another aluminum-sheathed cable wends its way down streets, branching off at intersections, feeding TV to houses by wire instead of over the air.

It's called cable television, abbreviated CATV (Community Antenna TV), and it's a growing trend among today's viewers. Service calls to cable customers are a very special sort of animal. There's no antenna problem to speak of, but the set or the local cable drop (the RG-59/U connection between the subscriber's TV set and the cable tapoff on the telephone pole outside) may have developed problems. If the set's in trouble, it's the TV technician's job; if there's something wrong with the cable and/or associated hardware, it's up to the cable company to fix it. About the only way to tell for sure is to carry a mini-TV set on service calls and plug it into the cable feed.

Cable TV offers a variety of reasons for deserting the rooftop antenna. For one thing, the channels usually picked up off the air will come in crisp and sharp, with no ghosts, snow or color shifts. In addition to these regular channels, there will be bonus TV channels from other, more distant cities—some as far as 200 miles away. These distant signals are often "imported" via a private microwave system run by the cable operator. There will also be local TV channels that originate right in that mini studio near the antenna. These can offer some special services, such as continuous news, time, weather, stock market reports and special news broadcasts. There will also be a local channel focusing on community affairs, politics, government, schools, sporting events and so on. In effect, the cable system provides the community with the TV station that it can't afford to support through conventional broadcasting.

Isolated viewers

CATV started in the late 1940's as a true community antenna for isolated towns that couldn't receive a good TV signal from the nearest broadcasting stations. The classic example is the town cut off from the transmitters by an intervening mountain. In such places, community co-operatives were sometimes set up, assessing each TV home for an equal share in the cost of erecting and maintaining an antenna on the mountaintop. Amplifiers would boost the received signals which would then be distributed via coaxial cable to each TV home.

Soon, such community antennas were taken over by private operators, who charged a nominal installation fee and a monthly rental. Today, virtually all major CATV systems are run this way. The connection fee can be anywhere from $10 to $30, depending on location and the operator's costs. In New York City, for example, a relatively high price applies because of the cable operators' extremely high costs.

A cable system's monthly rentals are typically $3.00 to $6.00, again depending on operating costs and the number of channels and special features offered. A favorite gambit in New York is to advertise the "untelevised" hockey and basketball games that are not carried on any of the regular TV stations. Cable subscribers, however, can watch these games at no extra charge.

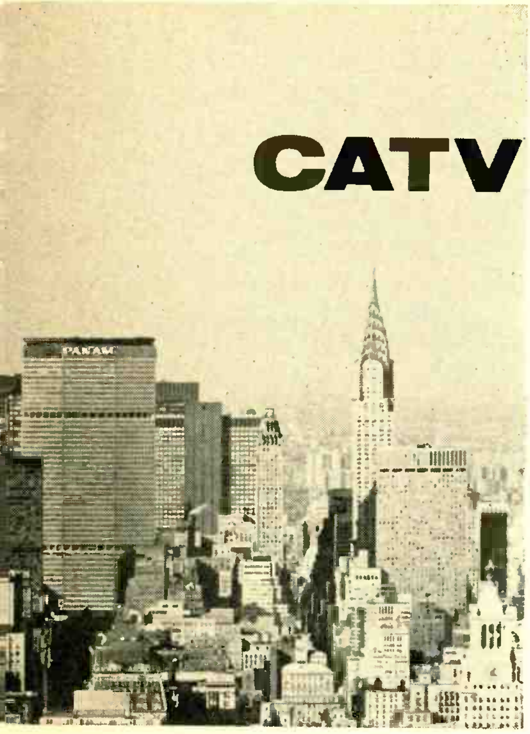
Basically, most CATV systems offer these features: more uniform picture quality on *all* channels delivered on the cable; additional, distant channels that the subscriber would not be able to receive by his own devices; additional "local" and special-information channels that are carried on the cable; extra feature and pay channels, some of which are optional at extra cost.

The head end

The tower, receiving antennas and special electronic processing equipment in the doghouse at the base of the tower compromise the head end. As a rule, multi-channel antennas are not used; instead, each receiving antenna is cut to the precise frequency for the channel it receives. Some antennas are fairly straightforward Yagi arrays or modified log periodics. These do duty for the nearby channels that would ordinarily be received by rooftop antennas in the area.

Higher up on the tower are the more specialized, high-gain antennas, used to pull in stations 100 to 150 miles away. These antennas are sometimes rhombics or modified dish types. This is also where the microwave dishes are located to grab the imported signals that are relayed from the really distant stations.

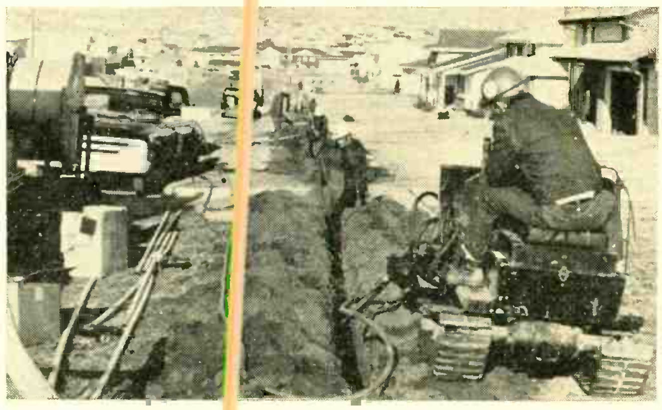
The incoming signal for each channel goes to its own single-channel amplifier in the doghouse. Usually, this signal is down-converted to a video-modulated low frequency that can be handled more easily by the amplifiers and processors that follow. It's very much like TV-set conversion



CATV and the Wired City

by **WALTER G. SALM**

CATV—community antenna TV—where it came from, where it is and where it is going.



CATV CONDUIT AND CABLE (far left) are paid out into trench in underground installation in modern housing development.
Daniels Associates

TWO CATV LINEMEN (left) install coax cable on poles shared jointly by power and communications utility lines.
Jerrold Electronics

HYDRAULIC BORER (right) is used to pass CATV conduit under streets, walks and driveways.
Daniels Associates

to an i.f. frequency. In this processor, dirty signals are cleaned up as much as possible; they get plenty of filtering, phase adjustments and in some cases color enhancement. The signal output is almost uniformly superior to the incoming signal.

Up-converting the channels

At this point, the signals are up-converted to the channel frequencies that will go out over the system. Wherever possible, the up-converted frequency will be the same channel that was received. This is important; it means that the customer who has gotten used to watching a particular program on channel 2 will continue to see this program on channel 2. But in some areas, the local signal strength from the channel 2 transmitter may be so strong that there will be some stray pickup by the coax or even by the internal wiring of the TV set. In such cases, this local signal can interfere with the cable's signal, causing a degraded picture. If interference exists in a CATV service area, the channels are up-converted to a different, unused channel.

If there are simply not enough available empty vhf channels in an area—such as when there are three strong local channels and the cable system has 14 channels of programs going out on the pipe—a uhf converter is added to the subscriber's TV. Such a situation exists in New York City, where most if not all the local TV stations present a strong local signal, but received picture quality is so bad that the cost of a cable subscription is preferable.

There are several types of set-top converters, but the most common type offers about 18 to 20 channels of capability. The selector knob on the converter has the usual channels 2–13 and about six additional channels designated "A, B, C, D, E" and "F." The control knob turns a detent-type tuner, very much like the standard TV tuner. The converter's output is rf at the precise frequency for a channel that's not used in that area. If it happens to be channel 8, for example, the TV set's tuner will be set and fine-tuned for channel 8 at all times. Then all the program selection is done by the knob on the converter.

The signal that leaves the head end and goes out on the cable is usually a composite of a dozen or more TV channels. The main trunk cables are typically one-inch aluminum-sheathed coaxial cable. The cable is carried on telephone poles by arrangement with the local telephone company, or if ordinances require, the cables are buried. Some systems may use a combination of both aerial and buried cable because of zoning differences in various areas of a community.

The signal in this cable is maintained at as high a level as possible. Every so often—usually at distances of about two to three miles—a broadband amplifier is inserted in the line. Depending on the number of channels being handled, and the amplifier design, the load may be handled by a single amplifier or two units optimized to split the channel load between them. Power for these amplifiers is carried on the trunk cable itself, since it's dc and won't have any effect on the TV rf. These amplifiers are housed in thick, cast-aluminum, weatherproof boxes right up there on the line—possibly reinforced by a couple of extra stranded support wires hanging from the nearest utility pole. In underground installations, the box is also underground, but with an access cover directly above it. If it shares underground conduit with the utilities, the amplifier box will usually be right at a manhole for quick and easy access.

Color quality

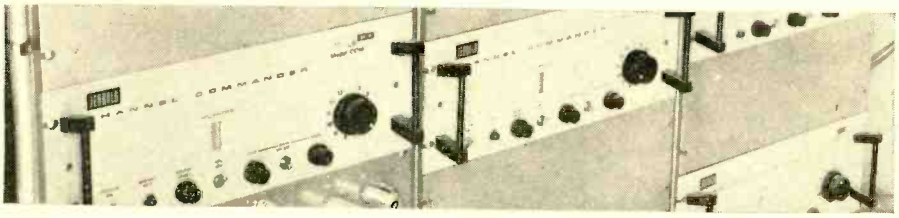
Crisp color is one of the major selling points for CATV today, not to mention all those additional channels. To be sure, there is still a handful of antique, isolated cable systems—dating back to their community antenna origins—that can't handle color, but these are the exception rather than the rule. Most CATV systems are operating in a highly competitive market, with such noteworthy and powerful rivals as the telephone company, the huge cable operators who have major systems dotted all over the country, and the TV networks themselves who also own cable systems. This competition means that cable operators can lose no time at all in converting to color if they don't already have it.

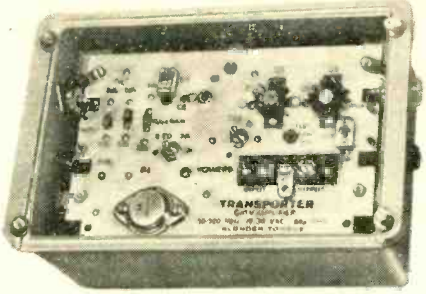
low-cost color TV cameras local programs are more frequently carried in color. CATV systems may offer as many as three or four such local channels altogether.

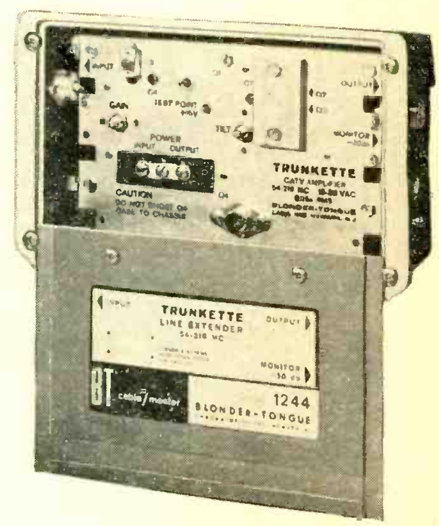
Municipal services

In setting up a new cable system, the operator must grant certain accommodations to the local municipal government, in exchange for the franchise. For one thing, the cable operator pays a tax of about five or six percent of his gross to the municipality. He must also provide free cable drops to all municipal buildings and schools, and often must agree to install facilities for broadcasting live programs from public meeting halls.

Remote telecasts from the schools and municipal buildings is becoming easier and cheaper for the CATV operator. New line amplifier designs will handle TV signals going in *both directions*, making it possible to use the same trunk lines for carrying all TV channels to the subscribers and remote feeds to the studio at the same time. Such bidirectional amplifiers bring closer the day when CATV will also function as a utility—letting the housewife order merchandise displayed on the special shopper's channel, allowing the student to answer questions in a programmed learning course, carrying burglar and fire alarm signals from all subscribers' homes to a central office, and eventually, making the TV telephone economically viable.







HEAD-IN CATV AMPLIFIERS (above) of a bank of nine in a community antenna TV distribution system in Latrobe, Pa.

CATV TRUNKLINE AMPLIFIER (right) hangs from messenger cable and produces 24.5 dB gain over 20 to 220 MHz.

LINE AMPLIFIER (far right) mounts on the messenger cable and is used as a line extender and for short trunk lines.

Automatic time and weather

Even when a cable system is totally colorized, one of its local channels will always be monochrome. This is the time/weather channel, which is easily the most boring one to watch continuously. An inexpensive monochrome camera at the studio is mounted on a motor-driven swivel. It rotates slowly through a 180° arc, focusing first on a clock face, then the face of a king-size barometer, then a humidity meter and so forth. At each end of its arc, it pauses for a few seconds on a card that advertises a sale at the XYZ Furniture Company and another that extolls the virtues of a drug store's free delivery service. The audio channel carries some innocuous canned music, possibly interrupted by special news bulletins and advertising announcements. The same channel or similar ones show a stock market ticker printout continuously, interrupted periodically by printed or spoken news bulletins.

Unlike these service channels, the "local origination" channel carries more interesting fare. This can consist of studio interviews with the mayor and other public officials, televised school board and town council meetings, and even the high-school's home basketball games. This channel operates with a mix of both live and taped programming and possibly some old movies. For years, the local origination, when offered, was monochrome. Now, with the advent of

In the meantime, pay TV has entered the cable market, with optional add-on channels available at extra cost to the subscriber. Such options include continuous first-run movies for an extra $5.00 per month; adult education channels for $3.00; children's educational programs; special medical service channels for physicians.

Another option that is growing in importance is the piggyback FM service carried by some CATV systems. Where the market and terrain warrant it, subscribers may receive piped-in FM stations for a nominal extra fee—around $1.50 per month. Usually these stations are at translated (different) frequencies for the same reason that the TV channels are converted to different channel locations on the tuner. There are still serious limitations on the FM carriage, since each station offered requires its own amplifier, converter and processor at the head end. But once processed, these signals ride piggyback on the TV channels, and are handled by the same cables and line amplifiers. A conventional FM receiver does the job in the customer's home, but instead of a dozen or so stations, he may only get three or four from the cable. Once the cost of capturing and processing these FM stations comes down, total FM coverage for the cable customer will become a reality on most systems. **R-E**

Horizontal and Vertical Blanking feeding transistor video amplifier

Kwik-Fix™ picture and waveform charts

SCREEN SYMPTOMS AS GUIDES — WHERE TO CHECK FIRST

SYMPTOM PIC	DESCRIPTION	VOLTAGE	WAVEFORM	PART
	Picture overbright; ringing lines at left of raster	no help	WF5	D3
	Contrast too high; brightness control can make picture out-of-focus	no help	WF3 thru WF6	C3
	Picture won't lock vertically; rolls slowly; blanking bar washed out	no help	WF5	R24
	Picture too bright; focus okay; brightness control has little or no effect	Q1 base Q1 emitter	not much help	R5, R7, R8, R9, R10
	Screen very dark; could be blacked out	Q1 collector Q3 emitter	WF6 WF7	R22
	Picture goes out of focus and dark as brightness is turned up	not much help	WF5 WF6	R4
	Retrace lines showing	not much help	WF4 WF6	R19, R20, R23, C7, Q3
	Screen black	Q1 emitter Q3 emitter	WF3 WF6	R4, R6, R7, L1, Q1
	Picture rolls uncontrollably	no help	WF4 WF6	R19
	Picture too bright and out of focus; brightness control has little effect	Q1 emitter Q3 emitter	WF5 WF6	R2, R7

	Picture stretched out of shape vertically	no help	WF6 WF7	R19
	Picture dark; not enough brightness	Q3 emitter Q1 emitter	WF5	R2, R3, R5, R6, R8, R10, C3

NOTES:

Use this guide to help you find which key voltage or waveform to check first.

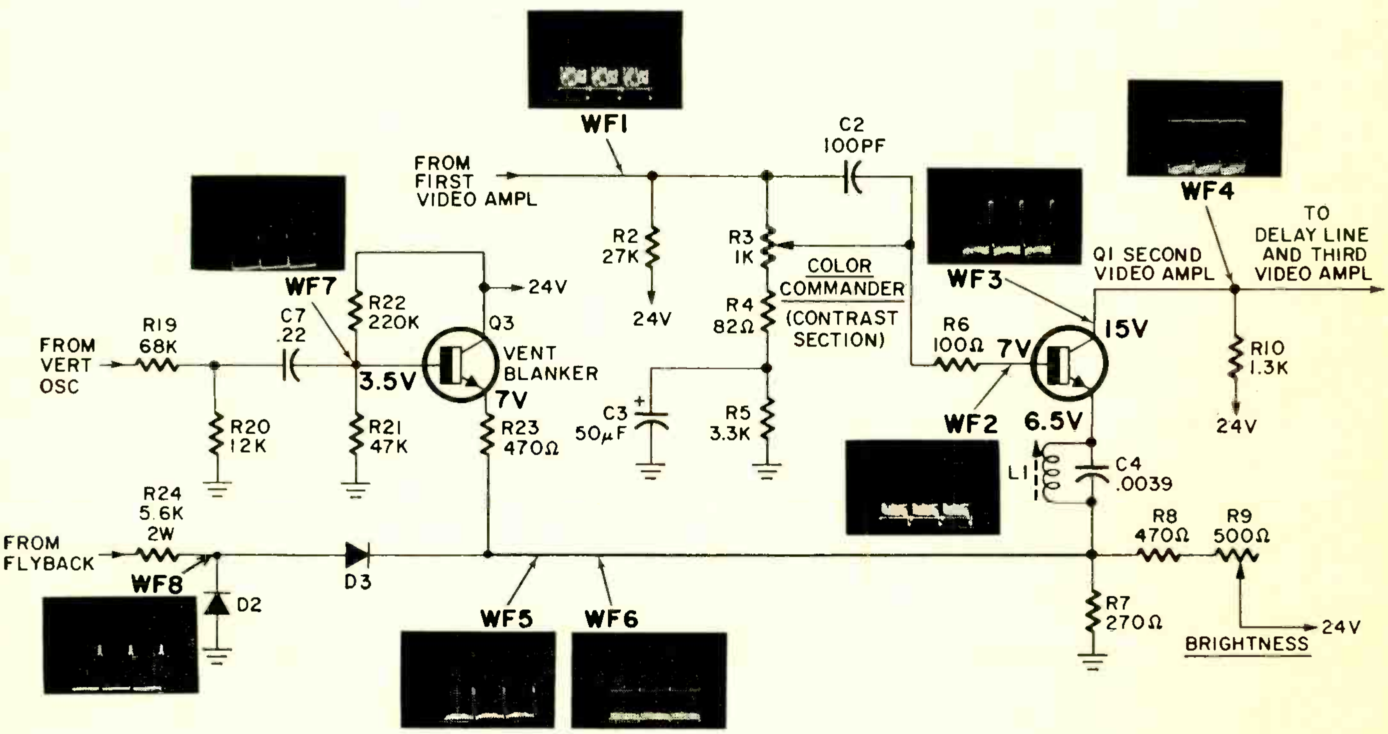
Study the screen and the action of the two controls.

The most helpful clues for each symptom are found at the key test points listed for it.

Make voltage or waveform checks as suggested.

Use the Voltages Guide or Waveforms Guide to analyze the results of those tests.

For a quick check, test or substitute the parts listed as the most likely cause of the symptom.



THE STAGES

Vertical retrace blanking is common in all TV sets, but horizontal blanking is found mainly in color chassis. In this example (Zenith 4B25C19 hybrid), a transistor stage shapes vertical blanking and diodes do the same for horizontal blanking.

Both blanking signals, once shaped, are fed to the emitter circuit of the second video amplifier. (You may recognize that video stage; it appeared in two previous *Kwik-Fix*™. This *Kwik-Fix*™ includes only enough of the stage to show how blanking is applied and how waveforms in the stage develop.)

SIGNAL OPERATION

The source of signal for horizontal blanking is the flyback transformer. A fairly large positive pulse is applied through R24 to the diodes. They reduce its amplitude and shape it, resulting in **WF8.**

Vertical blanking is developed from a signal supplied by the vertical oscillator (vertical output stage in some brands and models). Divider R19–R20 cuts amplitude down. C7 feeds what's left to the base of Q3. The transistor is wired as an emitter follower. It shapes the pulse and feeds it through R23.

Both blanking pulses, shaped, are applied to the emitter circuit of Q1. The input load is R7. You can see the blanking pulses, both positive-going, in **WF5** and **WF6.** Since video is applied to the same stage, at the base, both waveforms contain video.

Blanking is amplified along with video. The output waveforms, **WF3** and **WF4,** show the increase in amplitude. Notice video is inverted but blanking is not. That's because video is applied to the base and taken from the collector; that always inverts the signal. The blanking is applied to the emitter and taken from the collector; that does not invert the signal.

The Q1 stage is fed video from the first video amplifier R3–R4 form the input load, with C3 decoupling them from R5 (the purpose of which was explained in an earlier *Kwik-Fix*). The slider of R3 picks off the desired amount of video and feeds it to the base of Q1 through R6. Capacitor C2 is for frequency compensation.

DC DISTRIBUTION

The collector of Q3 is fed directly from the 24-volt dc

DC VOLTAGES AS GUIDES						
Voltage change	**to zero**	**very low**	**low**	**slightly low**	**slightly high**	**high**
Q1 base	R7 shorted	R5 open R7 low	R3 open (1) R7 low R8 open R9 open Q1 faulty	R2 open, high R6 open R8 high	R7 open	
Q1 emitter	R7 shorted	R7 low	R3 open (1) R7 low R8 open R9 open Q1 faulty	R2 open, high R5 open R6 open R8 high	L1 open	R7 open R8 low
Q1 collector		Q1 faulty	R4 open, high		R22 low	R2 open, high R3 open R5 open R6 open R7 open R8 low R22 low L1 open Q1 faulty
Q3 base Normal 3.5 V		R21 low	R22 high R23 low	Q3 faulty	R7 open R8 low R23 open C7 leaky	R21 high, open R22 low
Q3 emitter Normal 7 V *5.5 V at max Brt	R7 shorted		R7 low R8 open, high R9 open R23 open	R2 open R3 open R5 low R6 open C3 leaky L1 open Q1 faulty Q3 faulty		R7 open R8 low R22 low

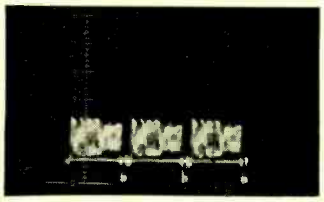
(1) Volts low because of Brightness setting

Use this guide to help you pinpoint the faulty part. Measure each of the five key voltages with a vtvm. For each, move across to the column that describes whatever change you find in that voltage. Notice which parts might cause that change. Finally, notice which parts are repeated in the combination of changes you find. Test those parts individually for the fault described.

line. The base is biased by divider R21–R22. The emitter dc path to the ground is through R23 and R7. It shares R7 with the emitter circuit of Q1, and voltage for the Q3 emitter is partly from R7–R8–R9 and partly from conduction through Q3 dropping voltage across R23.

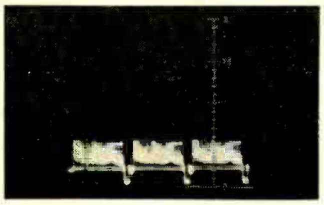
The collector of Q1 is fed by R10 from the 24-volt dc line. The base voltage is set by divider R2–R3–R4–R5, and applied to the slider of R3 and resistor R6. The setting of R3 has no dc effect because the value of R3 is so small a portion of the whole divider. The emitter voltage of Q1 is determined by R7–R8–R9, fed from the 24-volt dc line.

The output of Q1 is dc-coupled to the third video stage that follows, which in turn is dc-coupled to the three color video amplifiers, which in turn are dc-coupled to the color-



WF1 Normal 2.5 V p-p

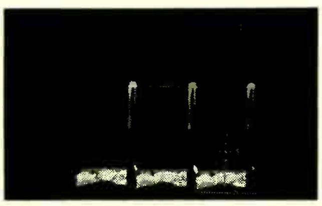
This is the input waveform, coming from the emitter of the first video amplifier stage. Polarity is the same as the signal right out of the video detector, with sync pulses pointing negative. This waveform is displayed at the horizontal rate, because the vertical-rate waveform here doesn't show much information of value.



WF2 Normal 0.7 V p-p

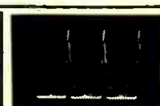
Taken at the base of Q1, this waveform is the signal from the slider of R3, the contrast control. The amplitude listed here is about normal to produce a picture with good gray scale, if all the stages from here to the picture tube are working properly. Control R3 is set about two-thirds clockwise. The scope locks this waveform best in the negative sync mode.

V p-p low	V p-p high	V p-p zero					
			 8V p-p C3 open	 5V p-p R6 high			



WF3 Normal 13 V p-p

Taken at the collector of Q1, with the scope set to show horizontal pulses. The horizontal blanking pulse dominates this waveform, leaving only a small part—about 3 volts peak to peak—of the overall amplitude taken up by the video. The scope locks this waveform best in the positive sync mode.

V p-p low	V p-p high	V p-p zero					
R2 open R7 open R10 low		R6 open L1 open Q1 faulty C3 leaky	 13V p-p R2 open	 4V p-p R3 open	 13V p-p R4 open	 15V p-p C3 open	
			 20V p-p R6 high	 10V p-p R6 open	 13V p-p R7 low	 13V p-p R24 open D2 shorted D3 open	

WF4 Normal 13 V p-p

This waveform also is taken at the collector of Q1, but with the scope set for vertical frames. Again, the dominant feature is the blanking pulses—vertical blanking in this case. If you look closely, you can see vertical sync pulses between each frame of video. The scope locks this waveform best on positive sync.

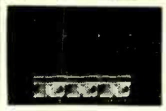
V p-p low	V p-p high	V p-p zero					
R2 open R6 open R7 open R10 low		R6 open L1 open Q1 faulty	 13V p-p C3 open	 20V p-p R7 low	 13V p-p R19 open R20 low R23 open, high C7 open	 13V p-p R19 low	

WAVEFORMS AS GUIDES

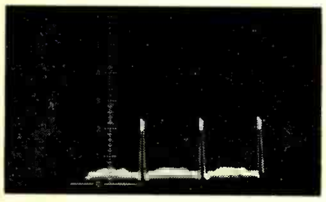
13V p-p
R21 low

7V p-p
R22 low

15V p-p
Q3 faulty



13V p-p
R24 open
D2 shorted
D3 open



WF5 Normal 2.5 V p-p

Taken in the emitter circuit of Q1, with the scope set to show horizontal pulses. Video is almost not noticeable, being overshadowed by the horizontal blanking pulses. Blanking is positive-going here, the same as in the collector circuit; being applied at the emitter, the blanking signal isn't inverted by the amplifier (the video is inverted, being applied at the base).

V p-p low	V p-p high	V p-p zero
R7 low		R2 low

4V p-p
R2 open

4V p-p
R3 open

1.5V p-p
R4 high

4V p-p
C3 open

4.2V p-p
C3 leaky
R5 low

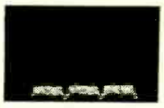
6V p-p
R6 open

4V p-p
L1 open

6V p-p
R7 open

3V p-p
R8 low

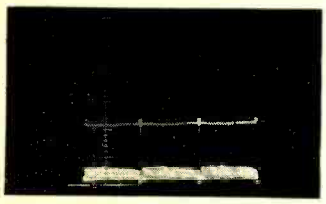
3.5V p-p
Q1 faulty



0.4V p-p
R24 open
D2 open
D3 shorted

5V p-p
R24 low

2.5V
D3 shorted



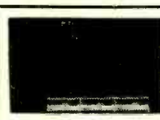
WF6 Normal 5 V p-p

Also taken in the emitter circuit of Q1, but with the scope set for vertical frames. The blanking pulses dominate. You can see the vertical sync, and notice it's the same polarity as the sync pulses in WF1 and WF2—negative-going. There's no inversion from base to emitter in this kind of amplifier. The display locks best with scope sync positive.

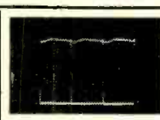
V p-p low	V p-p high	V p-p zero
R2 low R7 low	R2 open	

4V p-p
R3 open

5V p-p
R4 high

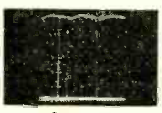


7V p-p
C3 open



6V p-p
C3 leaky
R5 low

6V p-p
R6 open



6V p-p
R7 open, high

4V p-p
R8 low

2V p-p
R19 low

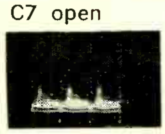
2V p-p
R19 open
R20 low
R21 v. low
R23 open, high
C7 open

5V p-p
R21 low

4V p-p
R22 low
R23 high

3V p-p
Q3 faulty

2.5V p-p
R24 open
D2 shorted
D3 open

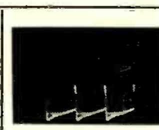


4V
R18 low

WAVEFORMS AS GUIDES

WF7 Normal 25 V p-p

Taken at the base of Q3, this is the input signal that forms vertical retrace blanking. Its amplitude has already been reduced from the original value at the vertical oscillator. The pulses are positive-going. The scope is set for about 20 Hz sweep rate, and locked on positive sync.

V p-p low	V p-p high	V p-p zero					
R21 low R22 low		R19 open R20 low R21 v. low C7 open	 25V p-p R7 open R8 low	 25V p-p R19 low	 10V p-p Q3 faulty		

WF8 Normal 12 V p-p

Taken at the junction of diodes D2 and D3, this is the input signal that forms horizontal retrace blanking. Amplitude is reduced by R24 and R7. D2 doesn't short the pulse to ground because the pulse is positive and applied to the diode *cathode*. D3 passes the pulse, which is applied to its *anode*. The scope is set for about 5 kHz sweep, and locked on positive sync.

V p-p low	V p-p high	V p-p zero					
R7 low R8 open R9 open R24 high	R7 open R8 low R24 low	R24 open D2 shorted	 9V p-p R2 low	 10V p-p R4 high			

NOTES:

Use this guide and the Voltages Guide to help you pin down fault possibilities.
Use the direct probe of the scope. For WF1, WF2, WF3, WF5, and WF8, set the scope sweep at about 5 kHz; for WF4, WF6, and WF7, use about 20 Hz.

Check the eight waveforms at the six key test points. Note amplitude. If it's low or high, check the parts listed under those columns.
Note waveshape. If there's a change that matches one shown, check the parts indicated.

picture-tube cathodes. Varying R9 changes the bias of Q1, which alters collector current. Collector voltage shifts, and the voltage change is passed on all the way to the CRT cathodes. That's how brightness is controlled.

SIGNAL AND CONTROL EFFECTS

The station signal has no effect at all on the two blanking input signals, **WF7** and **WF8. WF1** and **WF2** depend on it, as they are video signals. **WF3, WF4, WF5,** and **WF6** change slightly if station signal is removed; the video portions along the bottom disappear. Station signal has no effect on dc voltages in either stage.

Changing the setting of R3 affects the video amplitude in **WF2** and in **WF3** through **WF6.** It doesn't affect dc voltage on Q1 because R3 is such a small portion of divider R2–R3–R4–R5.

Varying R9 changes emitter and base voltage on Q1. But it affects the emitter most, thus controlling Q1 collector current. Through the collector voltage change, this ultimately controls picture-tube brightness.

QUICK TROUBLESHOOTING

Tracing the blanking pulses with your scope is the fastest way to find if they're missing or distorted somewhere along the path. **WF5** through **WF8** provide the best clues of how blanking is working. Anything that affects blanking in **WF3** and **WF4** usually also affects video.

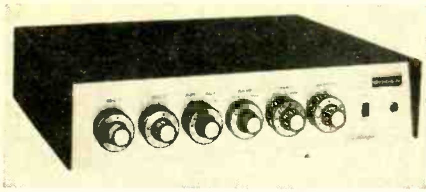
You can use this as a rule of thumb for troubleshooting the stage around Q1: If the trouble is in brightness, use your dc voltmeter to find it; if the trouble is in contrast of the picture, use your scope. **R-E**

10 Key Specs For Effective PA

by **M.S. SUMBERG**

Director of Sales & Marketing, Bogen Division LSI

These are the points that count when you're looking to buy a PA system



TYPICAL MODERN SOUND SYSTEMS include the Bogen Challenger (above), a 35-watt solid-state amplifier; the Bogen CHB35A amplifier in a complete portable system (right); a 40-watt Bogen BT35A mobile amplifier (below); and the Bogen Flex-Pak M120, 120-watt PA Amplifier (below right).

ALL TOO OFTEN THE SOUND INSTALLER tries to set up a PA installation with an amplifier that is not suited to the job. It may cost more than necessary. It may be underpowered. It may not have any of the accessories which extend flexibility and increase PA amplifier usefulness.

The array of available amplifiers is confusing. However, for most installations, the proper PA amplifier can be chosen if *all* of the important factors are considered. Don't settle for estimating power requirements and the number of microphone inputs alone.

1. Output power

Experienced installers have a "sixth sense" for determining the total audio power (in watts) needed for moderately large and smaller sound installations. They know they must consider the size of the area to be covered; noise level; efficiency of the loudspeakers; acoustic condition of the area; and size of the audience.

The table is a good starting point when determining required amplifier output power. Remember, the average cone speaker has an efficiency of about 2% (5% for high-quality two-way theater-type cone speakers). Re-entrant horns are 15% efficient. So horns require only 2/15 as much audio power as the cone speaker—to deliver the same level of loudness.

SELECTING PA POWER

LOCATION	DIMENSIONS (FT)	MINIMUM POWER (W)	RECOMMENDED POWER (W)
CLASSROOM	30 x 20 x 10	0.5	*
HOTEL ROOM	15 x 12 x 8	0.1	*
QUIET OFFICE	100 x 50 x 10	3.0	10
NOISY OFFICE	100 x 50 x 10	6.0	10-15
CHURCH	Small	NA	10-15
CHURCH	Large	NA	30-60
QUIET FACTORY	100 x 200 x 20	NA	30
NOISY FACTORY	100 x 200 x 20	NA	60-100
AUDITORIUM	Typical high school	NA	30
ATHLETIC FIELD STANDS	50 x 200	NA	50

*Depends on number of rooms.

The acoustics of the room and the size of the audience also affect the amount of audio power which the amplifier must deliver to the speakers. In a large auditorium with average acoustics, a 50-watt amplifier can be adequate. But a similar auditorium with sound absorptive walls, and a large audience, can demand 75 watts. If the auditorium has reflective walls and a quiet or small audience, a 35-watt amplifier could be adequate.

Be conservative when determining audio power. This is good insurance against errors in judgement; and provides a reserve for future expansion.

Until you get a lot of experience under your belt, don't hesitate to use "cut-and-try" methods. In most sound installations, you can determine the optimum location of the speakers empirically—and the proper sound level for each—by simple tests. And, if you have not under-rated your amplifier output capability, you will have all the latitude you need to handle the job.

2. Response and distortion

A modern hi-fi amplifier has exceptionally wide frequency response curves designed to reproduce concert music faithfully. Many sound installers assume that very wide frequency response is a "must" for every PA system. This is not so! Although commercial PA amplifiers are available with excellent frequency response characteristics, they are expensive, and their capabilities cannot be realized unless the PA speakers can also handle wide-range sound.

Let's look at frequency range. Do you realize that telephone systems perform well with their restricted frequency band of 250 to 3000 Hz? For speech, a PA system can deliver high intelligibility with a frequency range of 100 to 6000 Hz. And reinforcement of live musical performances can be handled by amplifiers with response curves of 50 to 12,000 Hz. Also, we often restrict the frequency response of a PA amplifier to reduce reverberation and the effects of unfavorable acoustic conditions. So, unless your sound system uses high-priced wide-range speakers, it doesn't make much sense to pay the extra dollars for a PA amplifier that does.

Other components—microphones, loudspeaker line-matching transformers, etc.—can also restrict the response of the system. Low-cost or improperly designed line-matching transformers (with light lamination stacks) don't have enough inductance at low frequencies. In effect, these transformers present a partial short to the amplifier output. This can cause an excessive rate of amplifier output transformer or tube failure in economy PA amplifiers.

Distortion is expressed as a percentage. It is the undesired difference between the input and output signals. As a rule, amplifier prices increase as the distortion figure decreases. Typical amplifiers for commercial installations have about 5% distortion (at full power output). Some deluxe amplifiers are rated as low as 2%. By contrast, the better high-fidelity sound systems for home use have distortion ratings as low as 0.1%.

In a typical PA line distortion percentage is usually listed at *full* amplifier power output. Distortion decreases as output power is reduced (see Fig. 1). Although deluxe amplifiers tend to have very low distortion at all output levels, economy-priced models do improve as output power level is reduced.

If you are using a sound system for speech, even large amounts of amplitude distortion in the amplifier will not seriously affect intelligibility. But when reproducing music, a distortion figure of 5% or better, is desirable.

3. Microphone inputs

To find out how many microphones are needed for a given installation check with the purchaser to determine the exact features he desires. A circus barker probably needs only one microphone. A Protestant church usually uses two to four microphones (four, if pick-up from choir or organ is desired). A Catholic church needs from four to eight microphones.

For a theater stage as many as five microphones may be necessary. A night club featuring a dance band and vocalist will probably ask for at least four microphones.

Standard packaged amplifiers are available for one to five microphones. These amplifiers have individual volume controls for optimum mixing and setting individual input signal levels. As a rule, low-power amplifiers (10 to 15 watts) have only one or two microphone inputs. Amplifiers rated at 30 watts or more can be purchased with 1, 2, 3, 4, or 5 microphone inputs (each input with its own separate volume control). One manufacturer offers a 30-watt amplifier that has five microphone inputs. This unit can be paralleled with another unit to furnish ten microphone inputs (with ten volume controls). The total power output of the paralleled amplifiers is, of course, 60 watts.

In some installations five or more microphones are connected across a single cable which feeds into an amplifier having only one microphone input. These microphones are wired in parallel through momentary press-to-talk switches. The microphone input circuit is active only while the switch is closed. Only one microphone is live at a given time.

Generally, two or more microphones should not be paralleled into a single input since mixing is impossible. In addition, the sensitivity of individual microphones is reduced and over-all signal-to-noise ratio deteriorates.

Once you determine how many inputs you need, the impedance of the microphones must be considered. When the microphone cable is less than 35 feet long, use a high-impedance microphone. If the microphone cable is more than 35 feet long, the capacitance of the high-impedance microphone cable attenuates the signal and you should use a low-impedance microphone.

4. Auxiliary inputs

We often want to feed program material from tuners, record players, and tape recorders into the PA system.

Most PA amplifiers have auxiliary inputs for high-impedance, high-level signals (for tuner or crystal phono cartridge). Some have a properly equalized low-level input for either a magnetic phono cartridge or a tape playback head. Make sure the system you select has the inputs you require.

5. Output impedance

To deliver maximum output power, output impedance must match loudspeaker impedance. In simple systems that have only a few speakers, the 4-, 8-, and 16-ohm amplifier outputs are used. Where a large number of speakers are used or where speakers are driven to varying sound levels, you get a more flexible arrangement by installing a line-matching transformer at each speaker, and using the amplifier's 25- or 70-volt output.

For taping an event, many PA amplifiers provide a tape output.

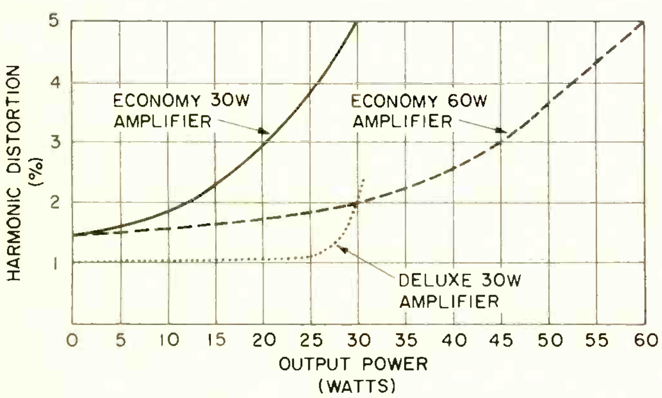


FIG. 1—DISTORTION DECREASES as amplifier output power is reduced.

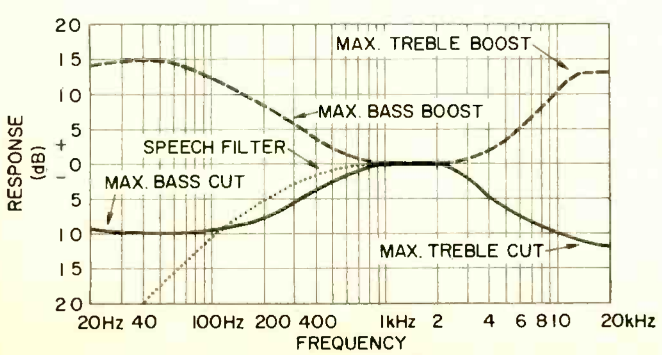


FIG. 2—TONE CONTROL ranges to expect from today's PA amplifiers.

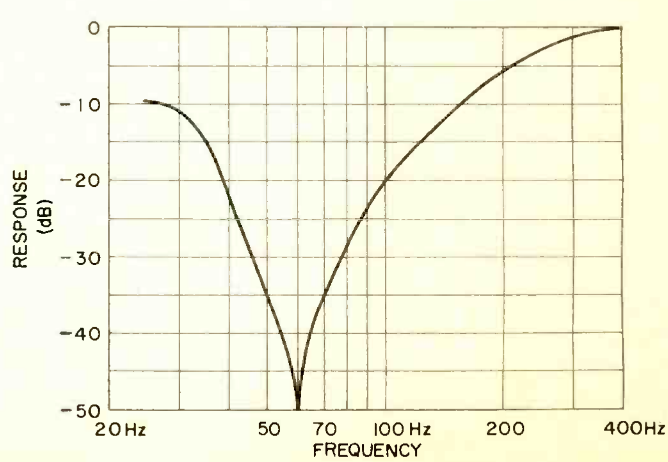
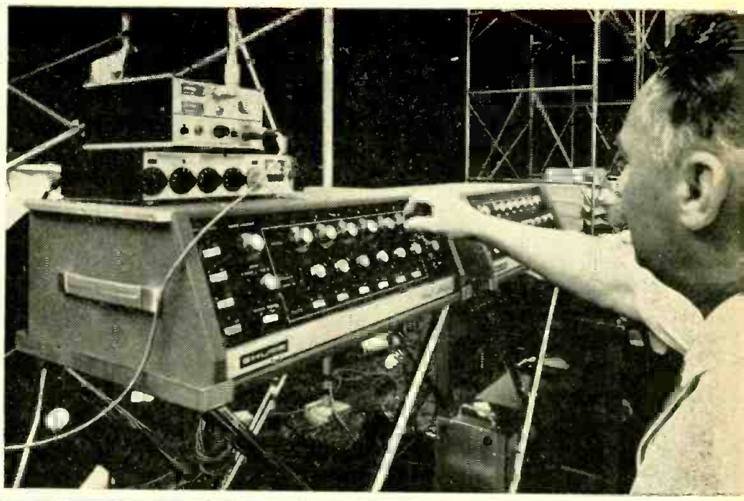


FIG. 3—NOTCH FILTER'S sharp response gets rid of troublesome low frequencies.



CONTROL CONSOLE at work. Unit shown is Shure VA302-C used at an indoor awards ceremony.

THE MUSIC IS LIVE as student audio aide adjusts Shure Vocal Master for proper balance.

6. Tone controls and filters

Reverberation can seriously reduce the effectiveness of a sound system. Since reverberation time is longer at the lower frequencies, a convenient solution is to use a bass-cut control to attenuate frequencies below 300 Hz. The bass-cut is also desirable when re-entrant horns are used with the system. Horn driver diaphragms can be damaged by extreme excursions caused by low-frequency program material. Fig. 2 shows the range to expect from bass and treble tone controls.

Some amplifiers also include a speech filter which attenuates low-frequency material as much as 20 dB at 40 Hz. Professional amplifiers may also have panel-calibrated variable low-frequency notch filters to remove troublesome frequencies. Fig. 3 shows the response of a typical notch filter.

7. Power supply

Not all PA amplifiers are powered from the ac line There are portable lecterns with built-in battery-operated amplifiers. Recent massive power failures in major cities has stimulated the demand for amplifiers that can operate from a 12-volt battery as well as the ac line.

Mobile amplifiers are normally powered from a 12-volt battery, but sometimes perform double duty as ac units. Several battery powered PA amplifiers are available. There are also several so-called "universal" models, which will run from either batteries or ac.

8. Special features

An amplifier sometimes has to provide special features and functions. Among these are:

1. Remote Volume Control: In many sound-system installations the operator will want to control the volume from a point away from the amplifier. To do this, some amplifiers have remote controllers. In church installations, for instance, the amplifier is usually concealed, but a remote volume controller is set up at the rear of the church so sound level can be adjusted quickly, without distracting the congregation.

2. Microphone Precedance: Factory, restaurant, and retail store sound systems are normally used for background music. For clarity when paging announcements are made the music is muted momentarily. To do this, there are plug-in accessories that are activated by a momentary press-to-talk switch mounted on or near the microphone. When the switch is closed, the music is off.

3. Monitor Panel: This accessory has a VU meter and a small speaker for checking program quality and volume level. It is especially useful when speakers are installed at remote locations.

4. Limiter: A useful device for factory and retail store amplifiers is a plug-in limiter that maintains a pre-set output level. It helps maintain a constant level regardless of signal input levels.

5. Master Volume Control: Multi-output amplifiers usually have master volume control and individual microphone and auxiliary volume controls. This control is used to vary the over-all amplifier output level after mixing as it alters the levels of all input signals simultaneously without disturbing the relationship between inputs.

9. Accessories

Accessories can increase the usefulness of an amplifier. Therefore, the sound-system installer must know what is available and what they can do.

As a rule, the more expensive amplifiers provide for the greatest number of accessories. Some of the more important accessories include:

1. Phono Top: This consists of a 3- or 4-speed turntable and pickup arm mounted on a small base that can be attached to the amplifier case. Most ac amplifiers, and some 12-volt mobile units, can be equipped with these units.

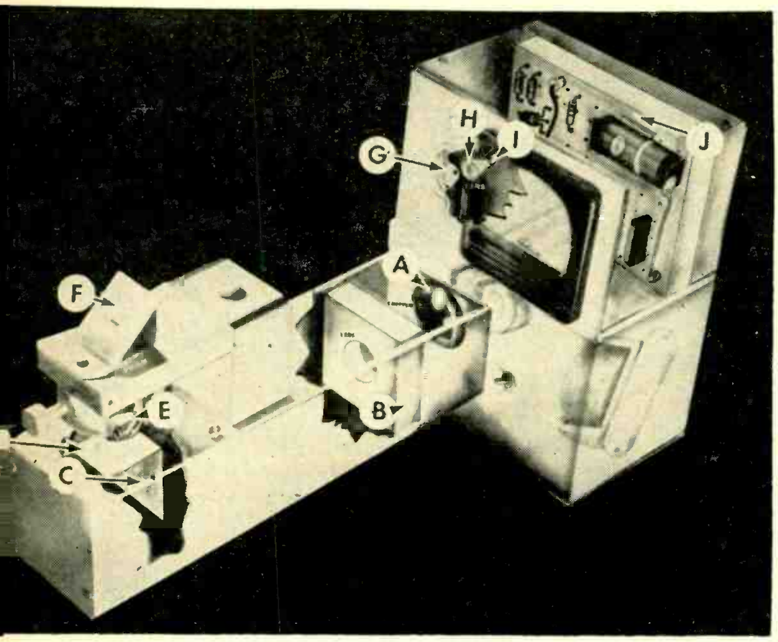
2. Plug-in Microphone Transformers: Transformers are available for microphones with various impedances. They match the mike to the amplifier input.

3. Locking Plates: To keep unauthorized hands off the amplifier controls a protective plate which covers the front panel and locks in place is available.

10. How many dollars?

When selecting an amplifier for a sound system, cost is not as important as it might seem. The price difference between the least expensive amplifier which will do the job and a much higher quality unit is relatively small compared to the over-all outlay for the complete system. Study catalog data carefully so you can make intelligent comparisons. Obviously, an amplifier must be selected to meet a set of requirements. To purchase an amplifier that does much more than is required only runs costs up.

Speaker and microphone quality must also be examined carefully. As with a hi-fi system for the home, the purchaser often overlooks the inter-relationship of the components and selects a system that delivers poor quality because one low-quality component sets an over-all level of poor quality for the entire system. You cannot improve sound quality by installing an expensive amplifier that is driving low-quality speakers. And if the speakers are high-quality units that have wide frequency response capabilities, it makes little sense to buy an amplifier with a poor power response curve. **R-E**



Build R-E's Photo Densitometer

Make better prints with your enlarger. Stop fooling around with test strips

by JAMES A. GUPTON, JR.
PHOTOGRAPHIC ELECTRONICS EDITOR

VERY FEW OF US WOULD EVER CONsider light as being related to the field of electronics. Yet, in Fig. 1, the chart of the Electromagnetic Spectrum clearly shows light as a form of radiant energy and its frequencies fall between those of Microwaves and X-rays. It is interesting to note that the majority of the frequencies of light are invisible frequencies of ultraviolet and infrared while the visible frequencies fall in a very small section of the total frequencies of light.

Since light is simply a form of radiant energy, it stands to reason that we can generate it, transmit it, and receive it like we do radio waves. The spark-gap was the simplest form of radio wave generation, but is so filled with harmonic frequencies it is useless today. Similarly, the tungsten filament is the simplest light generator but is chromatic and incoherent light which simply means that it contains all colors and radiates in all directions like the old spark-gap radio transmitter.

Technology has produced the lasing diodes and the gaseous lasers which generate monochromatic and coherent light. Another simplified definition of this is a single frequency of light and very parallel bundles of light energy. Thus light can be transmitted by collimating incoherent light by means of reflectors and lens or by the use of the coherent light of the laser.

Because we can only receive light optically, this has generally limited its use to visual reception, recording the light on film as in astronomy where the light of stars many light years away is too faint for the eye to detect, and finally by photo detecting electro-optical devices. The basic photo detector is based upon the exhibited photoconducive or photo-emissive features of certain alkali metals when exposed to light. Selenium and silicon are photo sensitive substances that generate a voltage when exposed to light. Cadmium sulfide is a typical photoconductive substance that varies in resistance when exposed to light. Even ordinary silicon or germanium transistors are light sensitive, and you can make a fairly sensitive photodiode simply by filing off the top of a TO-5 transistor can and using the collector-emitter leads in a diode configuration.

One of the important considerations in selecting a photocell is the spectral response of the basic metal structure. Even the human eye does not respond equally to all frequencies of light. Fig. 2 illustrates the spectral response of several photocell materials and of the human eye. So to select a photocell to measure with typical eye response, we would select one with a peak sensitivity around 555 millimicrons or in the yellow-green region. Also shown in Fig. 2 is the response of the photo cathodes used in photomultiplier tubes, which, through design, actually multiply light through electron cascading from element to element within the tube.

The basic schematics of both voltage generating photocells and the photo-resistive circuits are in Fig. 3. The photocell makes a simple power generator that requires only light to operate while the photoresistor must have external power to operate.

For those with a combination interest in electronics and photography, photocells provide a convenient way to measure exposure and negative density. Let us make a photo densitometer a construction project and combine

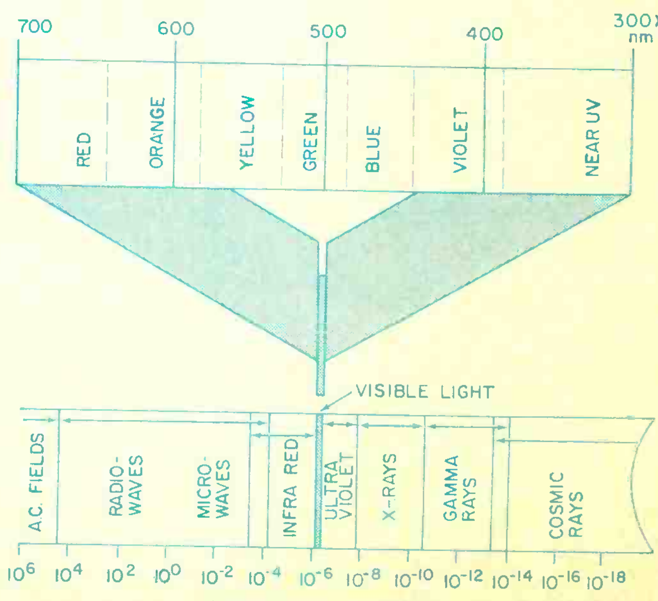
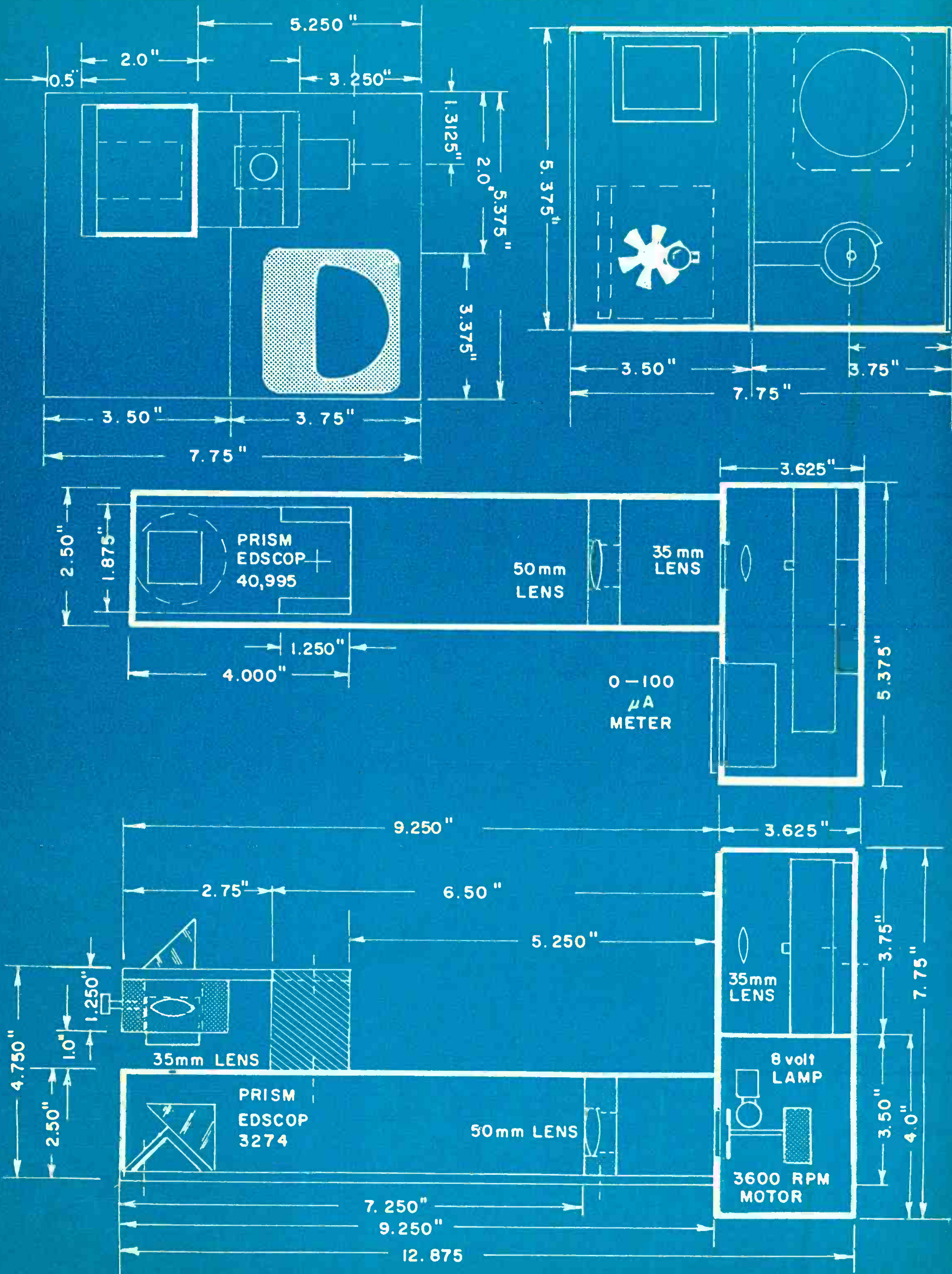


FIG. 1—ELECTROMAGNETIC spectrum chart shows that light is a form of radiant energy that falls between microwaves and x-rays.


5.250"
2.0"
0.5"
3.250"
1.3125"
2.0"
5.375"
3.375"
3. 50"
3. 75"
7.75"
5. 375"
3.50"
3.75"
7.75"
3.625"
2.50"
1.875"
PRISM
EDSCOP
40,995
50mm
LENS
35 mm
LENS
1.250"
4.000"
0 — 100
μA
METER
5.375"
9.250"
3.625"
2.75"
6.50"
5. 250"
1.250"
1.0"
4.750"
2.50"
35mm LENS
PRISM
EDSCOP
3274
50mm LENS
35mm
LENS
8 volt
LAMP
3600 RPM
MOTOR
3.75"
7. 75"
3.50"
4.0"
7. 250"
9.250"
12. 875

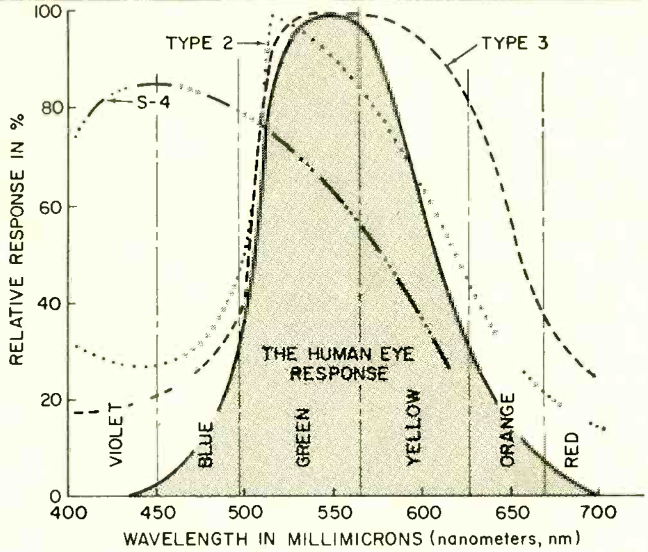


FIG. 2—SPECTRAL RESPONSE of various photocells. Shaded area is the response of the human eye.

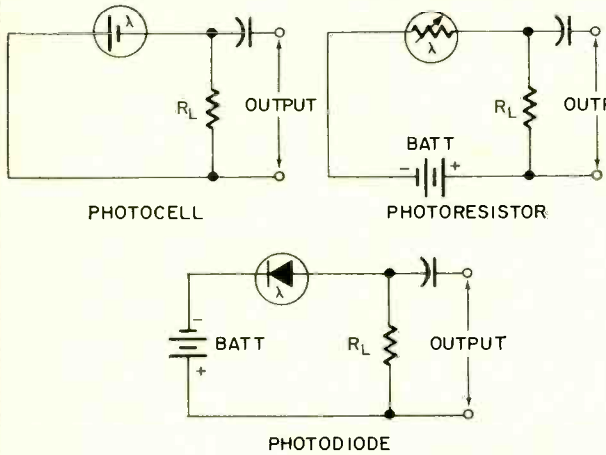
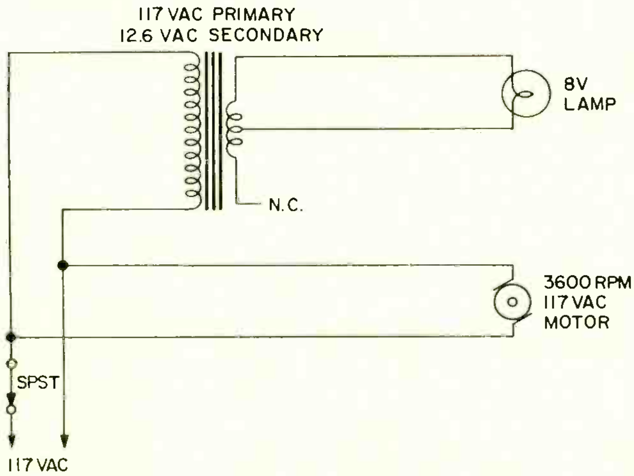
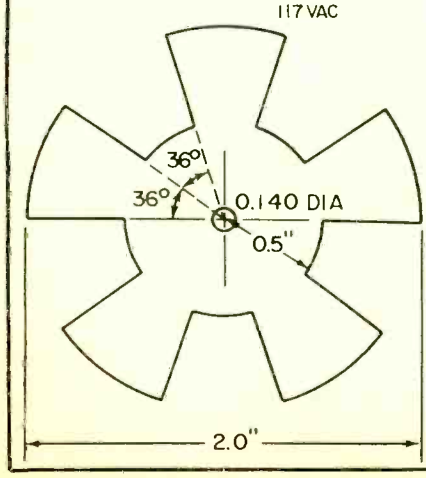


FIG. 3—PHOTOCELLS come in three basic types. They are presented here in basic schematic form.



CHOPPER MOTOR is wired as shown here. The lamp used in conjunction with the motor is also shown.

CHOPPER WHEEL is actual size drawing. Use it to make the wheel for the chopper in your densitometer.



the photocell with electronics for a practical use. Now before anyone claims "foul . . . this guy has a machine shop" let me offer a very handy suggestion. Any local machine shop can be an excellent source of scrap aluminum for construction projects. I built the densitometer detailed here entirely from metal plates salvaged from the scrap barrel in a machine shop. This should be evident from the sectionalizing of the chopper/amplifier compartment. However, standard Bud components are itemized in the parts list for those who prefer them.

The complete mechanical details are shown in the drawing on page 48 and blueprint. page 49. Light source "A" is chopped by a motor driven chopper to modulate the light at 300 Hz. Lens "B" collects the chopped light and focuses it through prism C to a 1 x 5-mm aperture "D." Lens "E" collects the aperture light and focuses it through prism "F" to a 10X enlargement at aperture "G." Lens "H" collects the aperture "G" light and focuses it on photocell "I" and the induced voltage is amplified by circuitboard "J." The amplified voltage of 6.5 volts is then rectified and read out on the microampere meter on the front panel. When a photographic negative is placed in the path of the light at aperture "D" the reduction in the modulated light intensity produced reduces the total amplified voltage and the meter reads lower. The densitometer is calibrated with Eastman Kodak neutral density gelatin film to give meter readings that correspond to densities of 0 to 2 density units or from 100% to 1%.

Build a densitometer

I built my densitometer in three major sections. I tackled the base of the chopper/amplifier section first. Here the chopper motor and light source are mounted. A 1-inch hole in the front panel permits the chopped light to reach collecting lens "A." The only critical requirement in the chopper circuit is that the chopper wheel completely blocks the filament with

Density	Percent Transmission	Density	Percent Transmission
0.05	90.0	-.80	16.0
0.10	80.0	0.90	13.0
0.20	63.0	1.00	10.0
0.30	50.0	2.00	1.0
0.40	40.0	3.00	0.10
0.50	32.0	4.00	0.010
0.60	25.0	5.00	0.0010
0.70	20.0	6.00	0.00010

PARTS LIST

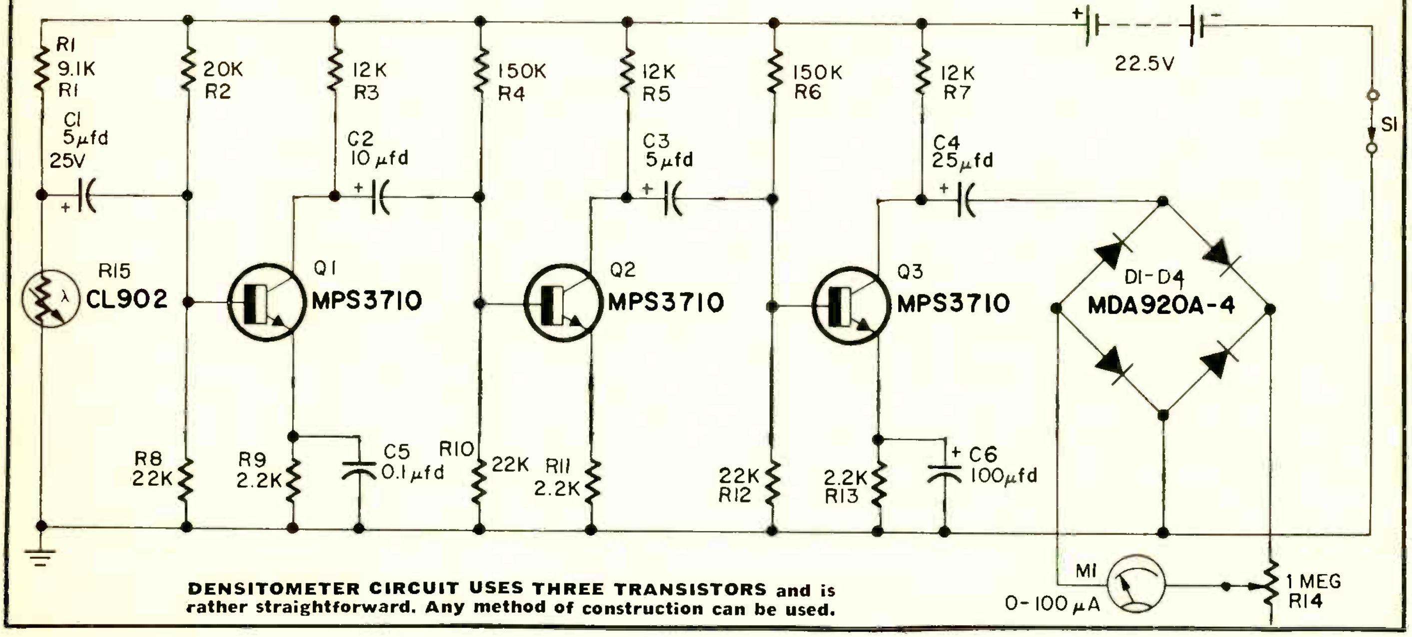
All resistors ¼-watt 10% unless noted
R1—9100 ohms
R2—20,000 ohms, 5%
R3, R5, R7—12,000 ohms
R4, R6—150,000 ohms
R8, R10, R12—22,000 ohms
R9, R11, R13—2200 ohms
R14—potentiometer, 1 megohm
R15—photoresistor, CL902
All capacitors 25 V or higher
C1, C3—5 μF, electrolytic
C2—10 μF, electrolytic
C4—25 μF, electrolytic
C5—0.1 μF disc
C6—100 μF, electrolytic

BATT—22.5 V
D1, D2, D3, D4—MDA920A-4
M1—meter, 0–100 μA
Q1, Q2, Q3—MPS3710
S1—spst toggle switch

The following parts are available from Edmund Scientific Co., 555 Edscorp Bldg., Barrington, N. J. 08007

50mm lens
(55mm F.L.; 10mm dia.) No. 30,562 $3.25
35mm lens (2 required)
(35mm F.L.; 16mm dia.) No. 5206 $4.50
or (36mm F.L.; 18mm dia.) No. 5186 $3.75
Prism
(21 x 15 x 15mm; silvered) No. 3309 $3.00
Prism
(54 x 38 x 28mm; silvered) No. 3274 $1.50

Other Parts
Chopper Motor, 115 Vac, 3600 rpm no load, open frame CCW rotation with built-in cooling fan
Micro DeC breadboard BB041
Spst switch
Lamp transformer, Triad F-25-X or equal
Lamp, GE 50, 7.5 V.
Lamp socket, bayonet type



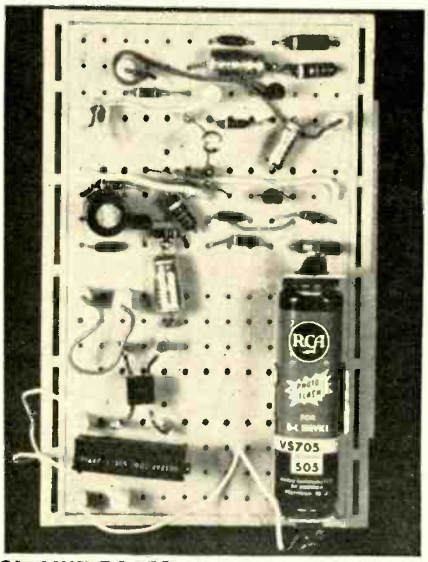
DENSITOMETER CIRCUIT USES THREE TRANSISTORS and is rather straightforward. Any method of construction can be used.

one of the blades and when rotating at 3600 rpm turns the filament light on and off 300 times per second.

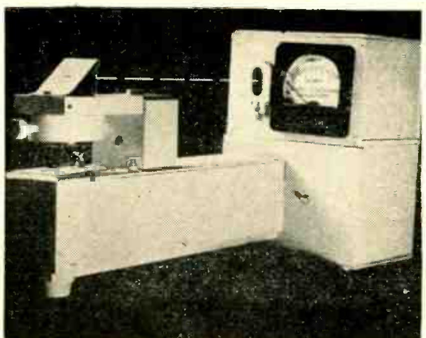
I built the light tunnel next. The tunnel is bolted to the chopper panel and the position of lens and prism arranged to provide *MAXIMUM* light intensity at the aperture slot. The 1 x 5 mm slot was worked into a plate of aluminum with a 0.040-inch drill then dressed free of burrs with a jewelers file. The light tunnel projects the filament at the aperture.

The projection bridge may offer a little trouble. It must be rigid and contain a means of focusing aperture "D" onto aperture "G." I found an ideal circular section of aluminum of just the right thickness and drilled a 1-inch center hole. This is a perfect fit for a small circular lens tube and needs only a 6-32 tapped hole to insert a knurled knob locking screw. The aluminum disc is bolted to the top member of the projection bridge so its hole lines up with a corresponding 1-inch opening. The projection prism is held in place with a formed section of aluminum sheet.

The amplifier section is made with the front panel cut out for the meter. Aperture "G" was originally drilled to a 0.040 diameter but later enlarged to 0.062 diameter to permit more light to enter. The 10X projection magnification permits a resolution of 0.0002 inch when a 0.040 aperture is used at "G," but at some sacrifice in light intensity. Collecting lens "H" focus the light onto the photocell "I." Vary the position of the photocell to get maximum light on the active area. This can be easily determined by noting the meter current while positioning the photocell.



CIRCUIT-BOARD closeup shows how the author assembled his electronics.



THREE-QUARTER VIEW shows the construction of the photo densitometer.

The amplifier circuit (above) is unusual as it is built on a new form of solderless breadboard. Use any circuit construction you wish, but the Micro-DeC circuit board means no soldering as components simply "plug-in."

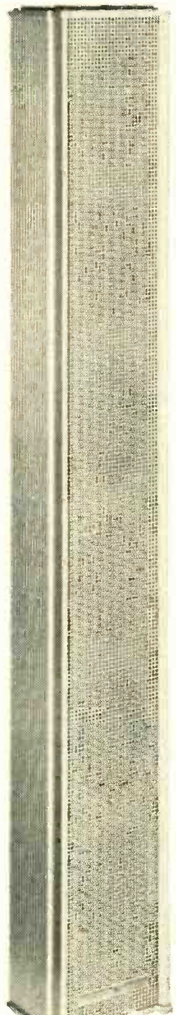
The amplifier is battery powered to reduce cost and size. The low current drain of the MPS3710 transistors assures long battery life. The METER ADJUST is the 1 megohm potentiometer and is used only to set full scale meter indication (which limits the meter current to 100 μA).

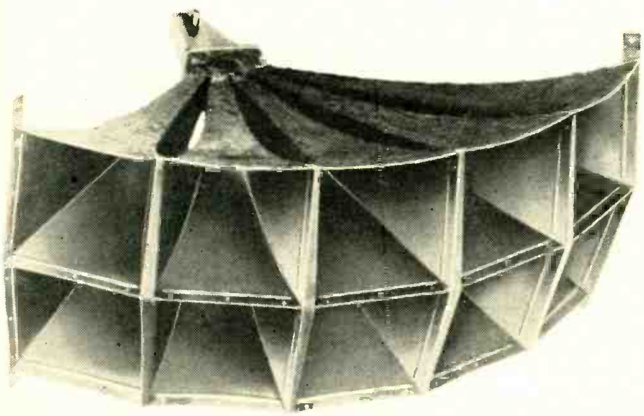
Final calibration is made with neutral density filters over aperture "G." I used the 0.30 density filter, and by increasing the number of filter sections over the aperature, was able to obtain up to 1.5 density units with no problem. These filters are available from your dealer; just ask for Kodak Wratten Neutral Density filter No. 96 at 0.3 density. The circuit and parts list provide sources and catalog numbers for all the components you need to construct this densitometer. **R-E**

Speakers for PA

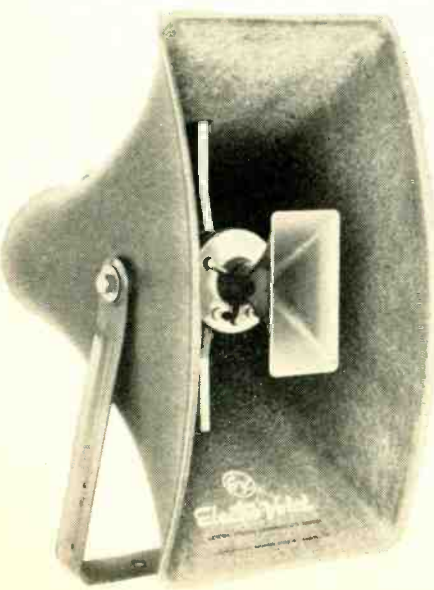
by BILL RAVENTOS
Electro-Voice

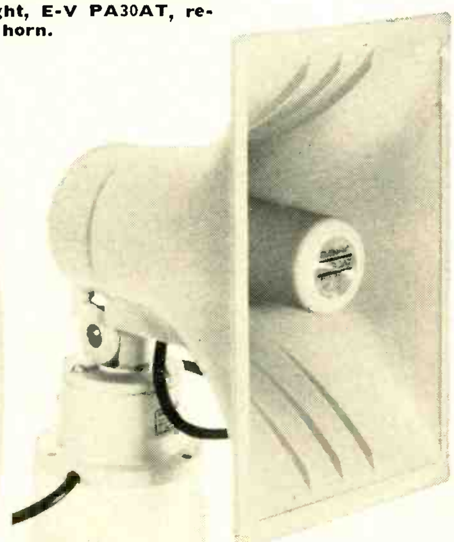
To choose the proper speaker you first have to know how they differ





FOUR MAJOR SPEAKER TYPES. Above, E-V M253 multicellular horn. Top right, typical column. Below right, E-V PA30AT, re-entrant horn. Below, E-V FC100 compound horn.





THIS ARTICLE DEALS MAINLY WITH types of PA speakers, rather than going into the details of PA speaker application techniques. Another article in a future issue discusses specific applications of the various techniques available to the user.

Public address vs. sound reinforcement?

We often hear the terms "public address" and "sound reinforcement" used synonymously. Though definitions may vary individually, and from region to region, there is a basic difference between public address and sound reinforcement. The definition is really implied in the terms themselves: Public address is the broader term. It indicates any system designed to amplify the natural program source (talker or entertainer) so that a larger number of people can hear. A *public address system* might also be used so that people in other parts of the building, or in totally different locations could simultaneously hear the same thing. The *sound reinforcement system* is designed and installed to create the illusion that the sound (the amplified sound) is really coming from the performer. Public address systems, then, might be associated with stadiums, arenas, race tracks, parking lots sound systems, etc., where sound reinforcement is either impractical, or unnecessary. A good example of an indoor public address system would be a distributed ceiling system where speakers are arranged throughout the ceiling. This may be totally adequate for background music, etc., but when a live person tries to present a message to a group of people in the room, they are subconsciously distracted because the sound no longer is coming from his mouth, but rather from a speaker located someplace above the listener. A typical sound reinforcement system might be found in a theater or other place where live performances are common. Here, it is much more appealing to the observer, and easier to pay attention, when the sound appears to come from the performer.

Perhaps the best way to look at the various types of public address and sound reinforcement speakers is chronologically. All public address and sound reinforcement speakers have operated on the same basic principle since the beginning. An electrical signal is applied to a copper coil in a magnetic field. Some sort of cone or diaphragm is attached to the copper coil, and as the electricity causes the coil to move in the magnetic field, the coil in turn moves a cone or diaphragm which acoustically excites the air surrounding it.

In the 1920's speakers were available, but because they had extremely broad polar patterns and low power handling capabilities, they could not be adapted for high level public address or sound reinforcement. Someone got the bright idea of directly coupling the front of the speaker to a large horn. The horn concentrated the energy in one direction, and thus the first successful sound reinforcement horn or speaker was developed. The straight horn had some physical problems, however, that weren't always easy to live with. They were big (4 to 6 feet long) and cumbersome, and they weighed a lot because they were made of metal. The idea of a portable public address system really wasn't practical with this kind of speaker! In addition, they suffered from some acoustical problems. The horn design did not allow for uniform dispersion over the whole frequency range. Because the high frequencies were only affected by the narrow part of the throat of the horn, their dispersion was a great deal narrower than the dispersion of the lower frequencies. This created a "hot spot" directly on axis of the horn where intelligibility and level was at its greatest. Outside the "hot spot" the sound pressure level may have been adequate. but there was not enough high-frequency information to make the program material intelligible. To combat this. a great number of horns had to be used aimed so the low-frequency distribution from each of the horns would overlap in order to allow for adequate high frequency dispersion.

Multicellular horns

The multicellular horn is simply another version of the straight horn. In this horn a number of very small straight horns (18 to 24 inches) are married into a single unit becoming a multicellular horn. The advantages of the multicellular horn include nicely controlled dispersion and ruggedness. Each of those little straight horns or "cells" has the same characteristic of the larger horn. A concentration of high frequencies directly on axis disproportionate to the dispersion of the low frequencies. However, the multicellular horn is a well accepted tool in the industry today and has a number of advantages to trade for its disadvantages.

The re-entrant horn

About 1935 another discovery was made. Obeying some simple laws of physics, there is a practical way to shorten the straight horn. The re-entrant horn simply bends the path of the sound from the driver or speaker unit making it go around a few corners. By "folding" the long straight horn using the re-entrant principle (the sound re-enters the horn) it was possible to shorten the length of the horn dramatically. In addition, the discovery of new materials (fiberglass and plastics) enables the construction of much lighter devices. Physically, the re-entrant horn was a great improvement over the straight horn. Indeed, many. many installations today use the re-entrant horn. A typical re-entrant is shown on page 52.

However, the re-entrant has its problems. Dispersion characteristics are much the same as the old straight horn; highs are still narrow, while lows are wider spread, and as frequency goes up dispersion goes down. All that sound path bending was not without some effect and it was noticed that even on axis, the high frequencies didn't seem to have the same "sizzle" that was available in the straight horn. The reason becomes evident when examining the physical characteristics of high-frequency waveforms. A high-frequency waveform with its very short wavelength has a great deal more difficulty negotiating the turns and bends in the re-entrant horn wavepath than do the low frequencies. The high frequencies bounce around in the relatively cavernous insides of the horn (a 10,000 Hz waveform is only about 1.3 inches long). The result is that some high-frequency energy gets lost before it ever leaves the horn. Thus, the high-frequency response is rolled off or attenuated. An obvious advantage of the re-entrant horn over the multicellular horn is that. thanks to its unfolded length, it can reproduce relatively low frequencies (usually down to about 200 cycles).

The re-entrant horn is found today in many configurations, some with built-in drivers, and others with facilities for adding external drivers of varying power and frequency response characteristics. The smaller re-entrant horns generally have integral drivers and are used in a number of applications including everything from paging in parking lots to announcing systems in factories, at race tracks, to sirens on automobiles, etc. The larger re-entrant horns with their higher power detachable drivers are most of-

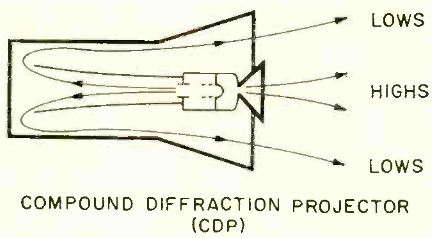


FIG. 1—CLOSEUP OF CDP type horn speaker. Rear opening is coupled to a folded wave path.

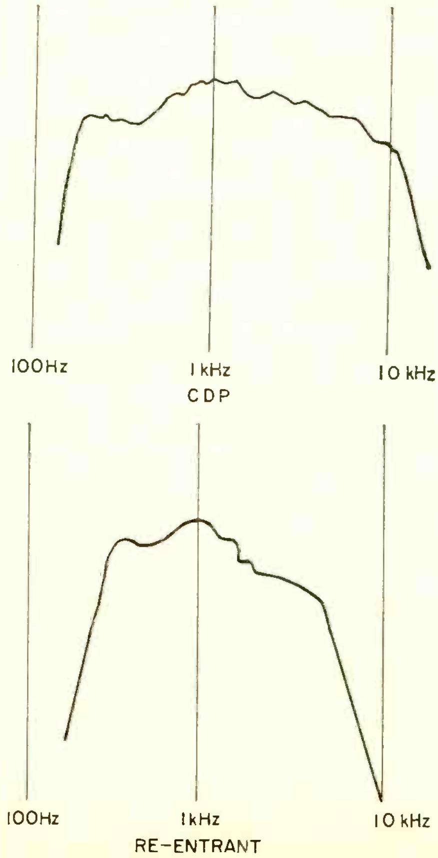


FIG. 2—FREQUENCY RESPONSE comparison between CDP and re-entrant horns.

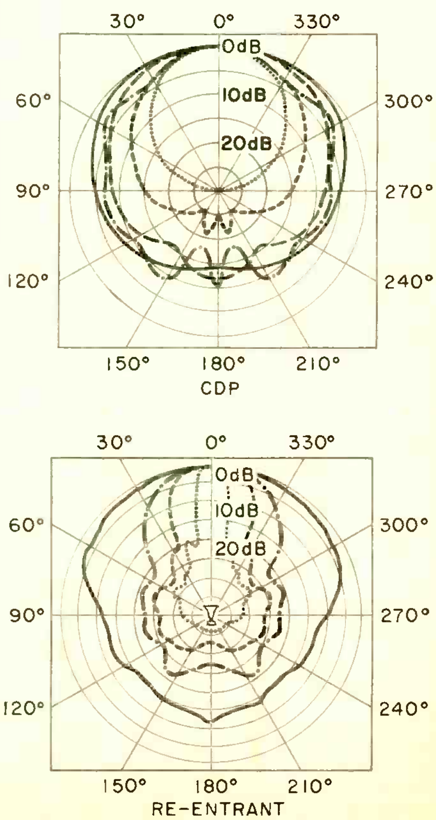


FIG. 3—HORIZONTAL DISTRIBUTION comparison between CDP and re-entrant horns. Curves represent response at frequencies between 500 and 5000 Hz.

ten found in stadiums and arenas and other large outdoor or indoor installations where intelligible vocal sound is the most important goal.

CDP horns

The story of public address horns does not end with the re-entrant horn. In the 1940's a new type of horn was developed (using an external driver) that did away with some of the disadvantages of the re-entrant horn. It combines some of the desirable features of the re-entrant horn with new additions of its own and is called the Compound Diffraction Projector (CDP). The driver for the CDP horn has an opening at the back and in the front. The rear opening is coupled, like the re-entrant horn, to a folded wavepath that effectively increases the length of the horn. Low frequencies, then, are primarily handled through the entrance of the driver which is coupled to the re-entrant horn. The front opening of the driver is coupled directly to the smaller horn which more adequately disperses the high frequencies over a wider area. Fig. 1 shows a typical CDP horn.

Because the high frequencies are no longer impeded by having to negotiate sharp turns as in the re-entrant horn, they no longer suffer from the attenuation previously endured. As well, the small horn at the front of the driver allows for much better high frequency dispersion. In effect, the CDP horn follows the compact and lightweight approach of the re-entrant horn, while doing away with the major disadvantages of narrow high frequency dispersion and attenuated high frequency response. (Figure 2 compares the typical frequency response characteristics of a re-entrant horn with a CDP horn. Figure 3 compares the horizontal distribution of a typical re-entrant with that of a typical CDP.)

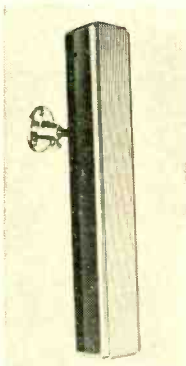
Sectoral horns

So far, most of the horns and speakers discussed have been designed for outdoor high-level public address. Another horn which is very popular today, especially in systems which require wide-range frequency reproduction for high-quality indoor sound reinforcement and public address many times involving music playback, is the sectoral horn. Properly designed, the sectoral horn can operate over a wide frequency range (depending on the driver) while maintaining very adequate horizontal dispersion. Sectoral horn and driver are usually coupled by a crossover with a low-frequency unit consisting of either a bass reflex type box or folded horn type box, with cone woofers. A properly designed system of this sort can provide extremely wide range, flat reproduction of sound and is very often used in theates, auditoriums, etc.

Sound columns

Column speakers are also used when wide range sound is needed. Some columns are almost as wide in range as the sectoral horn/woofer combination. The advantage of the column is usually its physical size and configuration.

Some columns are also line radiators. The line radiator offers a very wide horizontal dispersion (with speaker oriented vertically) while maintaining narrow vertical dispersion. The name "line radiator" stems from the principle used to get the narrow vertical coverage. Using an electrical or acoustic filter, the speakers near the ends of the column have rolled-off high frequency response. The "line" or column becomes shorter as frequency becomes higher. The shorter the line, the better we're able to control the response at progressively higher frequencies.

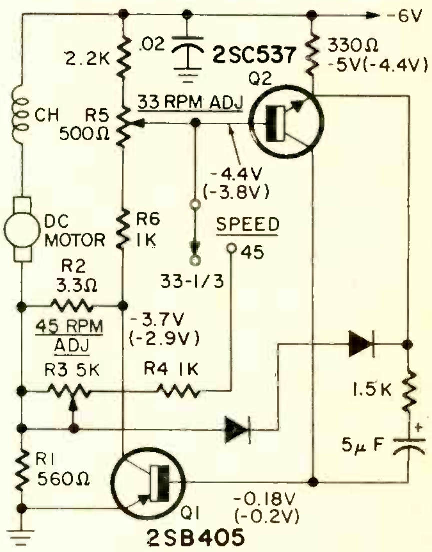


COLUMN SPEAKER is intended to mount on swivel on wall or post. This unit is made by American Geloso Electronics.

When choosing the proper speaker for a given application in either public address or sound reinforcement, certain things must first be known. Among the most important is the type of program material that is intended to be used. Usually wide-range program material such as recorded music playback, or symphony orchestra type reinforcement offers the greatest challenge in providing a system that can adequately cover the audience (power handling capacity) while maintaining the high quality of sound. The narrower range requirements of stadium and arena public address systems may not create great problems in dispersion, but the challenges come when considering system design and transducer placement and power handling. Perhaps an even greater challenge faces the user of small re-entrant public-address horns who is confronted with an ever-varying demand with regards to placement, installation, selection of horn and dispersion, etc. **R-E**

Phono Motor Control

In nearly all record turntables and changers, record speeds are selected by changing the position of a drive or intermediate pulley on a stepped shaft. Until now, electronic speed-change systems have been found on only the most expensive and sophisticated turntables. A unique electronic speed selection and control system (see diagram) is used in the Magnavox 1P2504, a 2-speed portable monaural phonograph that operates



from the ac power lines or a 6-volt battery.

The circuit holds motor speed at the selected speed by sensing changes in the voltage at Q2's base and using the change to control the conduction of Q1, shunted across a portion of the motor circuit.

The motor is connected between the −6-volt line and ground through R1 which is, in turn, shunted by R2 and the emitter-collector resistance of Q1. A change in the voltage on Q2's base produces a corresponding change in the bias on Q1.

A drop in supply voltage tends to reduce motor speed. At the same time, it reduces Q2's base bias, causing collector current to drop and collector voltage to rise. This increase in collector voltage drives Q1 to greater conduction. There is less voltage drop across R1 (shunted by R2 and Q1 in series) so the motor voltage rises to bring speed back to normal.

When the SPEED switch is in the 45-rpm position, resistors R3 and R4 are shunted across R2, R6 and R5; thus decreasing the resistance and increasing the voltage drop across the motor. Pots R5 and R3 are used, along with a strobe disc, to set the motor speed to 33-⅓ and 45 rpm, respectively. Transistor terminal voltages in parenthesis are for 45-rpm operation, others are for 33⅓ rpm. **R-E**

SERVICE NOTES

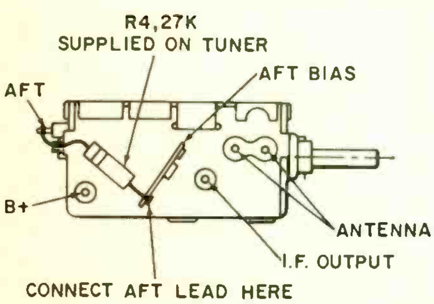
OLYMPIC CT-400

For complaints of intermittent color sync or no color sync, check C621, the .033-μF, 400-volt cathode bypass at pin 6 of the 8JV8 (V19) burst and second bandpass amplifier. It may have opened. Also check C633, the .01-μF, 400-volt cathode bypass for V20-A, the 6GH8-A reactance control as it may cause reactance control drift. This capacitor is located near L605 (top front corner of the board).

For intermittent color or no color (screen may appear predominantly green), check the 6GH8-A 3.58-MHz oscillator and replace, if defective. Also check C635 (.01, 400 volts) located near top center of the board. Replace if necessary.—*Olympic Service Bulletin*

MAGNAVOX T933, T939 AND T940 CHASSIS

The type 340129-2 uhf tuner in these chassis has been produced with three possible locations of R4, the resistor connected to the automatic fine tuning terminal. In the initial version, the resistor is located inside the tuner and has a value of 150,000 ohms. In later versions, R4 is moved to the outside of the tuner and its value changed



to 27,000 ohms. In first version incorporating the change, the resistor is connected directly between the aft lead from the main chassis and the aft terminal on the tuner. Current versions have the 27,000-ohm resistor connected between the aft terminal on the tuner and a terminal strip mounted on top of the tuner.

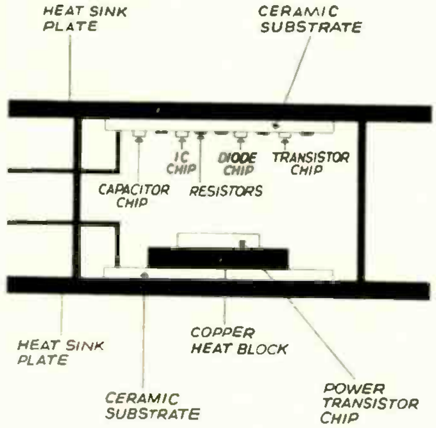
All replacement tuners will be the current version (see diagram). When replacing earlier versions with the current type, the aft lead must be connected directly to the terminal-strip end of R4 on the tuner. — *Magnavox Service News Letter*

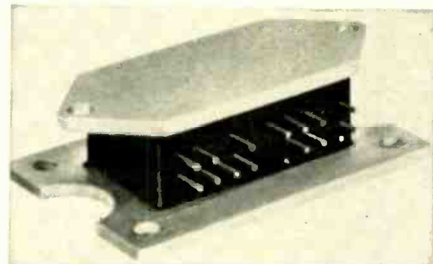
ADMIRAL K10 COLOR CHASSIS

When you service this chassis for a "no color" complaint, turn up the COLOR KILLER control (maximum clockwise). This may help to localize the problem more quickly.—*Admiral Service News Letter* **R-E**

New in power supplies: Hybrid IC regulator

Control, signal and power circuits in one little box





PRECISION POWER SUPPLIES ARE A VItal part of many different kinds of electronic instrumentation. A key section of any precision power supply is the voltage and current regulator. For the most part, this circuit is made up of descrete electronic components.

Recently, for low-power applications, some IC manufacturers have developed monolythic IC voltage regulators. The only problem is that these monolythic units have limited power capability. To solve this problem Lambda Electronics has devised an 85-watt hybrid voltage regulator to use with their power supplies and to sell to others who want to use the device in their own power supplies.

The new hybrid regulator combines all of the components beyond the filter capacitor in one small module that take up a mere 2.5 cubic inches of space. These regulators are available in 22 models with 5-volt to 18-volt outputs, and up to 5 amperes of current handling capability. The module provide 0.2% line or load regulation.

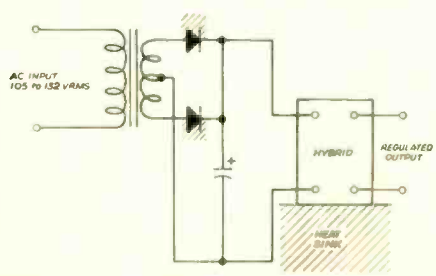
The heart of the power section of the hybrid unit is the power transistor chip (see diagram above) which is the series-pass element in the regulator. This chip is soldered directly to a copper block which is in turn soldered to an alumina ceramic substrate, and then to a steel plate.

All of the low-level control elements are mounted on a separate alumina ceramic substrate that is prepared by a screen printing process. The inks are, of course, cermets used to form capacitors and resistors at the same time as the interconnections between circuit components.

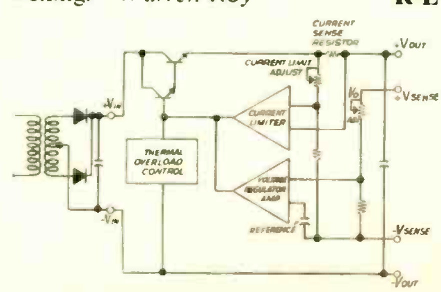
The completed control circuit consists of a monolythic IC chip that is a low-level voltage regulator, plus 13 screen-printed resistors, a diode, a transistor, and a capacitor.

This hybrid approach offers several advantages to the user. These include lower cost (the modules go for $20 each in quantities of 100), and greater reliability than equivalent regulators built on conventional printed-circuit boards with conventional components.

The user gets greater reliability for two reasons. First, the hybrid assembly requires many fewer soldered connections than the same circuit built on a printed-circuit board. In this particular module, 46 solder connections are eliminated, and as you may already know, solder connections are one of the major causes of circuit failure. Second, the printed circuit board is eliminated, together with its problems of cracking because of thermal flexing.—*Warren Roy* **R-E**



BASIC BLOCK DIAGRAM shows how the hybrid unit is added into a power supply.



INSIDE THE MODULE are all the components to right of the filter capacitor.

Design for STEREO

how to design your own solid-state audio amplifier

by MANNIE HOROWITZ*

Part VI: Bias circuits for bipolar circuits are important. Here's how they work and what they do

THE BIAS CIRCUITS DESIGNED FOR BIPOLAR transistors serve two primary functions. The first is to set the quiescent base current with the ultimate goal of establishing a specific collector idling current. The second and equally essential intent, is to stabilize the quiescent collector current against changes due to temperature variations, supply-voltage fluctuations and parameter tolerances in specific transistor categories. The FET bias circuits perform similar functions.

This discussion will deal primarily with biasing the JFET although many of the characteristics and procedures can also be applied to the IGFET. The partiality to the JFET here, and in future discussions, is due to the predominance of this type of FET in audio applications.

Only n-channel JFET's will be discussed here. Everything said about this device can be applied to the p-channel JFET when supply voltage polarities are reversed.

As for the bias mechanism of the JFET, the gate-to-source idling voltage, V_{GS}, is set to establish a desirable quiescent drain current, I_D, in the output circuit. Stability of the required drain current must be maintained against variables similar, in some respects, to those plaguing the bipolar devices.

JFET characteristics

A typical n-channel transistor and a display of drain characteristic curves are in Fig. 1. The curves resemble those of the pentode vacuum tube. The display can conveniently and functionally be divided into two basic sections—the ohmic or ON region and the pinch-off or OFF region. In audio amplifier applications, the ohmic region is just about ignored.

The curves are essentially horizontal for all gate-to-source voltages, V_{GS}, in the pinch-off region. It can be stated with reasonable accuracy that the drain current is virtually independent of the drain-to-source voltage, V_{DS}, although the current does increase slightly with the voltage. The drain current, I_D, flowing when V_{GS} is equal to zero is assigned the symbol I_{DSS}—the zero-gate-voltage drain current.

It is obvious from the curve that the gate of the n-channel JFET is made negative with respect to the source. The gate-source junction is reverse biased. As you may recall, a reverse biased junction of any diode conducts practically no current. From Ohm's law, the impedance of any device is the voltage across the device divided by the current flowing through it. Because the current flowing through a reverse biased junction is just about zero, the impedance of the junction, by Ohm's law, approaches infinity. The impedance of the reverse biased gate-source junction similarly approaches infinity.

Despite not being shown on the graph, positive V_{GS} curves are applicable up to about +0.5 volts. The impedance remains high despite the forward bias voltage applied to the junction. This follows from the diode characteristic where the forward biased silicon junction does not conduct until that voltage exceeds about +0.5 volts.

As the gate-to-source voltage is made more negative, the collector current becomes very small, approaching infinitesimal proportions. The gate-to-source voltage generating this condition is referred to as the pinch-off voltage, V_P, of the transistor. This is similar to the concept of cut-off voltage when applied to the vacuum tube. As an acceptable standard, the gate–source voltage is considered at pinch-off when the drain current is 1/1000 to 1/100 of I_{DSS}, or less than 50 microamperes.

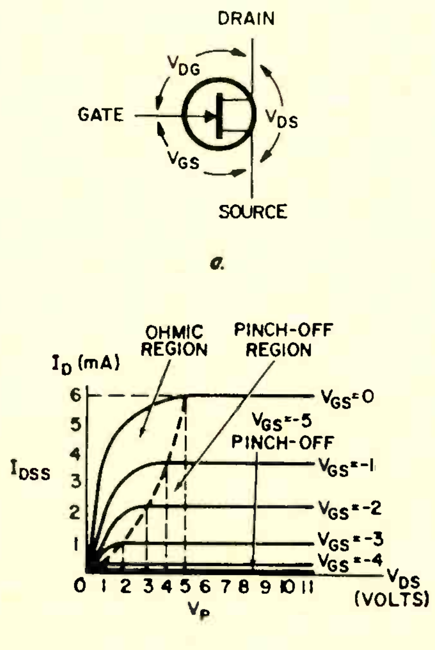


FIG. 1—THE N-CHANNEL TRANSISTOR and associated voltages are shown in (a). A set of characteristic curves is drawn in (b).

A dark broken-line curve is superimposed on the graph in Fig. 1. This trace is the sum of the drain-to-source voltage, V_{DS}, and the gate-to-source voltage, V_{GS}, with the polarity of both values ignored. The sum is equal to the pinch-off voltage. The mathematical statement for this curve is $V_P = V_{DS} + V_{GS}$.

It is obvious from the equation that when V_{GS} is equal to zero, $V_P = V_{DS}$. This is a point on the $V_{GS} = 0$ curve at the start of the horizontal pinch-off region. Pinch-off voltage can then be determined from this curve, as shown in Fig. 1, as well as from the value of V_{GS} which causes I_D to be very small.

Earlier, it was noted that the set of drain characteristics are separated into two regions. This broken-line plot of the equation is the dividing line. To be certain that you are designing audio amplifiers well within the linear pinch-off region of the plot, it is conventional that the minimum drain-to-source voltage be made 1½ times the specified pinch-off voltage.

The ohmic region to the left of this line is very valuable in some applications for each curve is a plot of a distinct drain resistance. The resistance is equal to the ratio of the change in drain-to-source voltage, ΔV_{DS}, to the change in drain current, ΔI_{DS}. As this resistance is different for each V_{GS} display, the drain resistance of the JFET will vary with the gate-to-source voltage. This characteristic is very useful should you wish to design a circuit such as a volume compressor utilizing the JFET resistance change.

Getting back to the pinch-off region, it is obvious from the drawing that the quiescent drain current I_D, is dependent upon V_{GS}. Although not equally as evident, drain current is related to V_P and I_{DSS}. The important relationship is

$$I_D = I_{DSS}\left(1 - \frac{|V_{GS}|}{|V_P|}\right)^2 \qquad \text{Eq. 1}$$

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

where $|V_{GS}|$ is the absolute value of V_{GS} and $|V_P|$ is the absolute value of V_P. As you know, absolute numbers disregard the + or − signs in front of the numbers.

Bias circuits

The quiescent drain or bias current can be calculated using Equation 1. I_{DSS} and V_P depend upon the particular transistor used. As these factors remain relatively constant for any one transistor, the drain current will depend only upon specific values of V_{GS}. It is then necessary to find circuits to set the required V_{GS} to establish the desired drain current. The self-bias circuit in Fig. 2 performs this function simply.

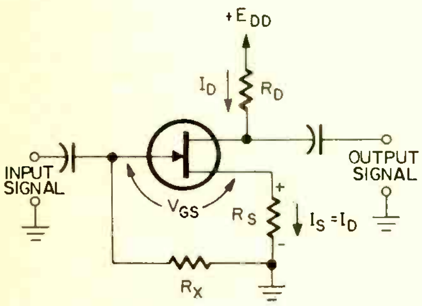


FIG. 2—SELF-BIAS CIRCUIT for the JFET.

The circuit is similar to the one most commonly used for vacuum tube bias. The drain current flows from $+E_{DD}$ through R_D, through the transistor and R_S, on to the negative ground side of the supply. Source and drain currents are essentially equal. A voltage with the polarity shown is developed across R_S equal to I_DR_S. No voltage appears across R_X (a statement to be modified below). The only voltage between the source and gate is across R_S. Considering this, V_{GS} is equal to I_DR_S.

For stability considerations, it is desirable to make R_S large. A voltage supply bucking that developed across R_S can be placed in series with R_X, as shown in Fig. 3. The voltage between

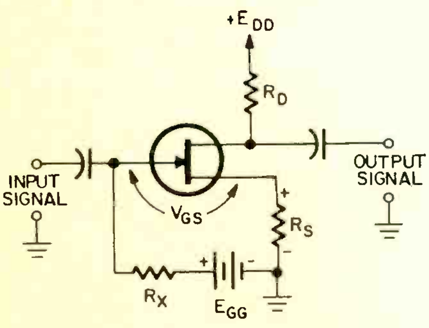


FIG. 3—COMBINED FIXED and self-bias circuit designed so that R_S can be made large.

the gate and source is about equal to $V_{GS} = I_DR_S - E_{GG}$. As the gate-to-source voltage and the drain current must be identical here to that determined for the previous circuit, the only variable factor in the equation is R_S. R_S must be larger in value here than it was for the circuit in Fig. 2 to compensate for the effect of the additional E_{GG} supply.

This circuit is not practical because a second power supply must be used for the E_{GG} voltage. An arrangement using but one supply is shown in Fig. 4. Volt-

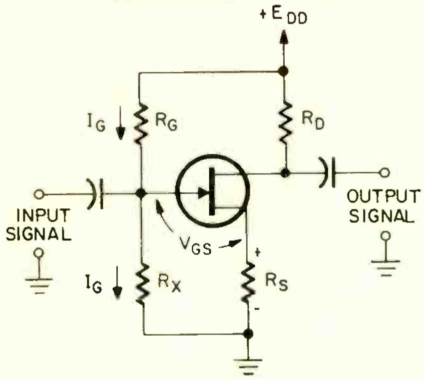


FIG. 4—PRACTICAL VERSION of circuit in Fig. 3 using only one power supply.

age is developed across R_X due to the current, I_G, generated by $+E_{DD}$, that flows through R_G and R_X. It is of the proper polarity to buck the I_DR_S voltage. The circuit is frequently designed so that I_G is equal to 1/10 of the drain current. The gate-to-source voltage then becomes $V_{GS} = I_DR_S - I_GR_X = I_DR_S - 0.1\ I_DR_X = I_D(R_S - 0.1\ R_X)$. I_G may be much less than the 1/10 of the drain current, but it must be at least 10 times the leakage current to be discussed below.

Resistors R_G and R_X may, at times, be too low in value to satisfy the requirements of an input signal source feeding the transistor. The input impedance is the parallel combination of R_G and R_X or $R_GR_X/(R_G + R_X)$. Should the circuit be modified to that in Fig. 5, the

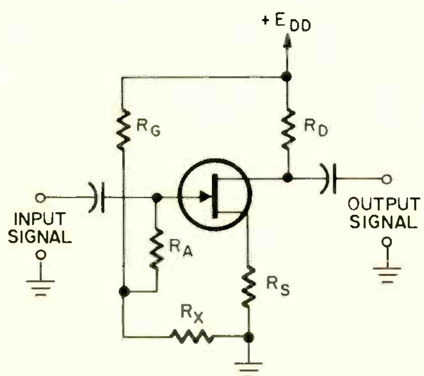


FIG. 5—MODIFIED CIRCUIT is based on Fig. 4. This one presents a higher impedance to the input signal.

input signal will see a load equal to R_A in series with the parallel combination. As no current we have discussed so far flows through R_A, it is not a factor in determining the bias voltage.

One additional change in the interest of stability, is frequently added to the circuit in Fig. 4. Instead of connecting R_G to the power supply, it is connected to the drain as in Fig. 6. Any advantages are due to the dc voltage feedback from the drain to the gate through R_G. Of course, R_A can be added here as it was in Fig. 5 should additional resistance be required to increase the input impedance presented to a source.

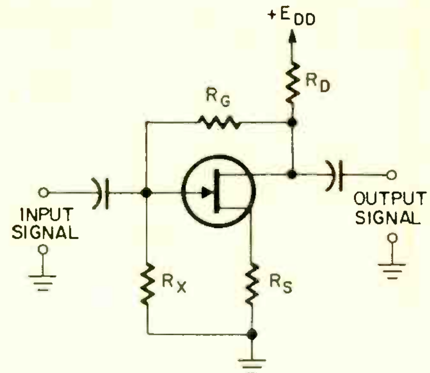


FIG. 6—THE BIAS CIRCUIT is improved by adding dc feedback from the drain to the gate of the FET.

Leakage Current

In the bipolar transistor discussion, we encountered a leakage current flowing in reverse-biased junctions. One leakage current is I_{CBO} due to the reverse current flowing between the collector and base. As for the JFET, the channel encompasses both the source and drain. The channel is reverse biased with respect to the gate. A leakage current flows between the channel and gate. This leakage current, I_{GSS}, is defined as the reverse current flowing into the gate when the source and drain are connected to each other. The current is proportional to the square of the voltage applied between the elements.

As is characteristic of all leakage currents, I_{GSS} increases with temperature. Depending upon the particular transistor, I_{GSS} doubles with every 6°C to 15°C temperature elevation. In this series of articles, we will use 10°C as a good average for all JFET's.

The leakage current of a JFET is usually very low. For example, at 25°C, it can range from 0.1 nanoamperes (0.1×10^{-9} amperes) for a 2N5558 up to 1 nanoampere for a 2N4303. It is, however, significant at high temperatures—especially if R_X in the gate circuit is large.

This can be illustrated using the bias circuit in Fig. 2. The bias voltage, V_{GS} was defined as equal to I_DR_S. A voltage is developed across R_X due to I_{GSS} equal to $I_{GSS}R_X$. To calculate V_{GS} more precisely than before, $I_{GSS}R_X$ must be subtracted from the originally determined bias voltage.

Transconductance

Among the important JFET parameters that change with temperature are I_{DSS}, I_{GSS} and g_m. The first two items were just discussed in detail while g_m, the ac transconductance, was defined in a previous article.

Transconductance relates the output current to the input voltage by the equation

$$g_m = \left(\frac{\Delta I_D \text{ ampere}}{\Delta V_{GS} \text{ volt}}\right) \text{(or mhos)} \qquad \text{Eq. 2}$$

where ΔI_D is a change in drain current due to ΔV_{GS}, a change in gate-to-source voltage. This can be shown graphically with the help of Figs. 7 and 8. In Fig. 7, the plot of drain current against the gate-

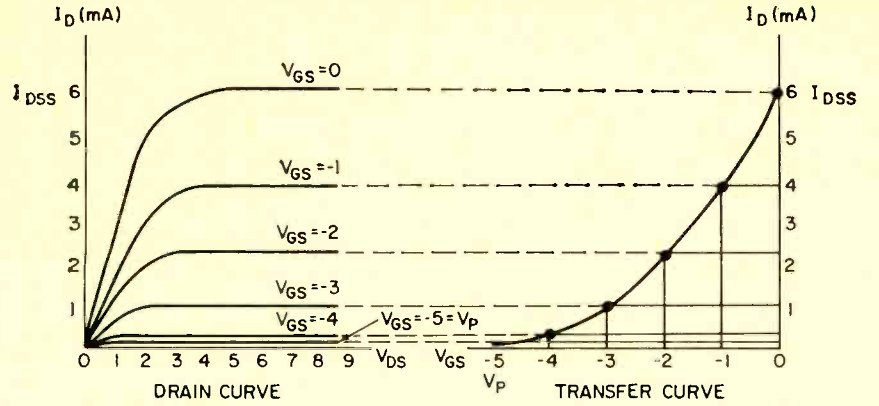


FIG. 7—THE TRANSFER CHARACTERISTIC CURVE is derived from the drain characteristic display of Fig. 1.

to-source voltage (the transfer characteristic curve) is derived from the drain characteristic curves.

At the left hand side of Fig. 7, the drain characteristic curves of Fig. 1 have been redrawn. The horizontal drain current lines for each value of gate-to-source voltage have been extended to the vertical drain current axis in the graph at the right of the figure. The horizontal axis of the second graph is calibrated in gate-to-source voltage. A vertical line is drawn from the gate-to-source voltage on the horizontal axis up to the horizontal current line which represents the drain current that flows for the specific V_{GS}. This procedure is repeated for each discrete value of V_{GS}. All necessary information is available in the original drain characteristic plot at the left. A dot is placed at the point where the related curves cross. All dots are connected to form the transfer characteristic curve.

Because the curve is a plot of the drain current against the gate-to-source voltage, the slope of the curve at any one point is the transconductance of the JFET for that particular current value. The variation of the slope from point to point on the curve indicates that the g_m varies with drain current.

Initially, two ac transconductance values are of interest to us. The first, referred to as g_{mo}, is the transconductance at I_{DSS}, where the gate-to-source voltage is zero (see Fig. 8).

FIG. 8—PLOT OF TRANSCONDUCTANCES on transfer characteristic curve. Slopes of tangential lines are transconductances at various points on curve. Slope of line connecting I_{DSS} and I_D is average transconductance.

Assume the transistor is biased so that the quiescent drain current is I_D. Put a dot on the curve at this drain current. This is the second significant point at which the transconductance must be determined. Refer to this transconductance simply as g_m.

An average value of transconductance, $\overline{g_m}$, is $(g_m + g_{mo})/2$, the mean value of the two transconductances. An equation can be derived from Fig. 8 to determine $\overline{g_m}$ from other circuit and transistor characteristics. It requires that I_{DSS} be connected to I_D in Fig. 8, with a straight line. Applying Equation 2,

$$\overline{g_m} = \frac{I_{DSS} - I_D}{V_{GS} - 0} \qquad \text{Eq. 3}$$

or stated in a more useful form

$$I_D = I_{DSS} - \overline{g_m}\, V_{GS} \qquad \text{Eq. 3-a}$$

We have now defined all the transistor parameters necessary to design a stable circuit. It is necessary to stabilize the transistor against the wide tolerances that exist in the specifications of any type as well as against parameter variations with temperature and drain current.

Let us note the parameters that do concern us. They vary with temperature in the following manner.

1. For the JFET, I_{DSS} increases as the temperature decreases. As for the IGFET, it doubles for every 10°C rise in temperature.

2. g_m is an inverse function of temperature. It also changes with drain current.

3. V_P increases at about 2.2 millivolts for each degree Celcius that the temperature increases.

4. I_{GSS} doubles for about every 10°C rise of the JFET's temperature. As for the IGFET, I_{GSS} is minute and the change with temperature is negligible.

5. r_{DS} (ON) is the resistance from the drain to the source when the transistor is biased in the pinch-off region. It increases with temperature.

Now let us turn to the specified transistor tolerances. Parameters such as I_{DSS}, V_P and g_{mo} are specified as having a range of values for any transistor type, rather than a specific value. For example, the I_{DSS} of a 2N4303 can be anywhere between 4 and 10 mA, and still be specified as a standard 2N4303.

Applying these facts, we can now establish two procedures which can be used to design stable circuits. The first assumes a thoughtful manufacturer who provides the designer with all pertinent information and limits. In this case, the paper design will usually suffice.

The second design procedure assumes that you have been provided with a minimum of detailed information. Many approximations must be made. The end result using any procedure should be checked in the laboratory. This is especially true of the latter, more inexact approach.

Stabilizing a design

The exact method assumes the semiconductor manufacturer supplied the data for, or the curve in Fig. 9. As ex-

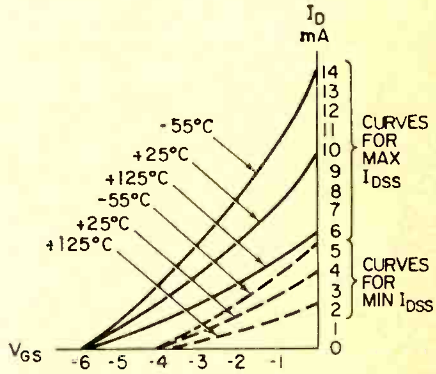


FIG. 9—THE SOLID LINE 25°C plot is the transfer characteristic curve for the maximum value of I_{DSS} of a hypothetical JFET. The broken line 25°C curve represents the transfer characteristic for the minimum value of I_{DSS}. The other curves are maximum and minimum values at extreme temperatures.

plained in the figure, transistors are specified to be within any one category if their characteristics fall within a specific set of limiting values. The curves marked 25°C are the plot of the two extremes within which all transistors of a particular type must fall when the ambient temperature is 25°C. Should the ambient temperature change, the curves are displaced accordingly.

The plots show the transfer characteristic curves within specific I_{DSS} limits at various temperatures. If these curves are not presented as such in the manufacturer's data, the plots at 25°C may usually be derived from the drain characteristic curves using the procedures exercised in Fig. 7.

The design procedure is based upon transistor operation limited within the boundaries of two of the curves. It can best be illustrated using a practical example. Assume that a circuit such as that in Fig. 3 is to be designed. The required output from the circuit is a minimum of 6 volts peak-to-peak across a 5600-ohm load resistor. The transistor must operate properly from +25°C to +125°C.

The temperature range is the first item to be considered. From the plots in Fig. 9, choose the 125°C broken line curve from the lower extreme characteristics and the 25°C solid line curve for the second limiting factor. All plots defining the characteristics of the particular transistor type between +25°C and +125°C are included between these curves. Hence, these curves as boundaries satisfy all temperature requirements. Redraw the limiting curves in Fig. 10.

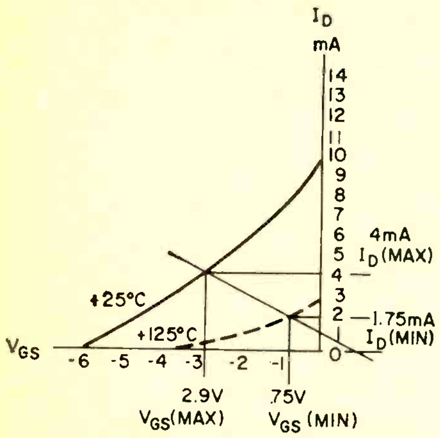


FIG. 10—CURVE DESCRIBING LIMITS for solution to problem using exact method.

Now, place a 5600-ohm resistor in the drain circuit so that the output load will be the specified value. The 6 volts peak-to-peak requirement dictates a minimum drain current swing of 6 volts/ 5600 ohms = 1.07 mA.

We proceed to plot a bias point on each of the two curves and set the extremes in idling current. It is undesirable to bias the transistor at or near pinch-off because this region is non-linear and the transconductance is low. If we place the bias on the lower I_{DSS} curve at approximately 1.75 mA, we will operate at a reasonably linear portion of the curve. It will also allow the 1.07-mA peak-to-peak swing the maximum range without hitting into pinch-off at one end nor the zero V_{GS} limit at the other extreme. Call this point I_D(min) and plot it on the broken line curve. Drop a vertical line from this point to the axis. The line crosses the axis at 0.75-volt gate-to-source voltage. Refer to this as V_{GS}(min) = 0.75 volt.

As the required 1.07-mA excursion is a small portion of the possible transistor current variation, we have wide latitude in choosing the maximum value of drain current on the upper limiting curve. Select I_D = 4 mA and plot it on the solid line curve. Extend lines to the vertical and horizontal axis. The vertical line crosses the gate to source axis at 2.9 volts. The point on the upper curve is then defined by I_D(max) = mA and V_{GS}(max) = 2.9 volts. Connect the points plotted on the two limiting curves with a straight line.

In the next step, the source resistor, R_S, is to be calculated for Fig. 3. It is the slope of the line connecting the two points on the graph. R_S is equal to the difference in the gate to source voltages divided by the difference in the drain currents, or

$$R_S = \frac{2.9 - 0.75}{4 \times 10^{-3} - 1.75 \times 10^{-3}}$$

$$= \frac{2.15}{2.25 \times 10^{-3}} = 955 \text{ ohms}$$

Use the next higher EIA 10% resistor value of 1000 ohms.

The next task is to determine E_{GG} from the plot. Circuit theory dictates the relationship

$$E_{GG} = I_D R_S - V_{GS} \qquad \text{Eq. 4}$$

Using the minimum values of V_{GS} and I_D (V_{GS}(max) and I_D(max) can be used instead), we find

$$E_{GG} = (1.75 \times 10^{-3})\ (1000) - 0.75 = 1 \text{volt}$$

R_X is chosen so that the voltage developed across it by I_{GSS} at the highest temperature is negligible compared to the E_{GG} of 1 volt. Assume 1/10 of E_{GG} or 0.1 volt is a negligible value. If it were specified that I_{GSS} = 1 nanoampere (10^{-9} ampere) at 25°C, and that it doubles for every 10°C rise in temperature up to 125°C, the maximum I_{GSS} is 1 microampere or 10^{-6} ampere. Then the maximum R_X may be is R_X = 0.1 volt/10^{-6} ampere = 100,000 ohms.

The minimum drain supply voltage must still be determined. It is equal to the sum of three factors: the maximum voltage across R_S, or $I_D(\text{max})R_S$; the minimum voltage across the transistor, $1.5V_P$, where V_P is the maximum pinch-off voltage for the transistor (V_P should be multiplied by about 1.5 to be certain that the transistor is operating in the linear portion of the pinch-off region); the maximum voltage across R_D, or $I_D(\text{max})R_D$. Note that since R_D and R_S are 10% resistors, the value referred to above are 10% *above* the nominal values of both resistors. Thus the R_S in question is 1000 ohms + 10% of 1000 ohms or 1100 ohms and R_D is 5600 ohms + 10% of 5600 ohms or 6160 ohms. In our example, the minimum supply voltage is

$$E_{DD} = (4 \times 10^{-3}\text{mA})\ \ (1100 \text{ ohms}) + 1.5(6) + (4 \times 10^{-3}\text{mA})\ (6160 \text{ ohms})$$
$$= 4.4 + 9 + 24.64$$
$$= 38.04 \text{ volts}$$

Use a 40-volt supply.

Should you wish to use the circuit in Fig. 4 instead of that in Fig. 3, and eliminate the second supply, the E_{GG} voltage must be developed across R_X. Assuming that I_G is about ten times the maximum I_{GSS} determined above, or 10 × 10^{-6} = 10^{-5} amperes, and that E_{GG} is the 1 volt as previously calculated, then R_X is 1 volt/10^{-5} ampere = 100,000 ohms. As E_{DD} is 40 volts, the remaining 39 volts must be developed across R_G. The same 10^{-5} ampere that flows through R_X flows through R_G. This makes R_G = 39 volts/10^{-5} ampere = 3.9 megohms, a standard 10% EIA resistor value.

In all honesty, the simple circuit in Fig. 2 can be used successfully to fulfill all stability requirements. Bias points on the two curves can be chosen to determine only a value for R_S, and the E_{GG} supply is unnecessary. However, the complication was added to indicate a procedure rather than to solve a tight problem.

Stabilizing shortcut

Let us now turn to a second method of determining the components in the circuits. This time assume that the manufacturer was not kind enough to present us with the curves in Fig. 9. To come up with a solution, we start with the assumption that all temperature variations with the possible exception of I_{GSS} have little effect on determining the circuit components. Actually, changes with temperature are usually negligible when compared to the variations in I_{DSS} due to transistor tolerances.

Several pertinent relationships should now be established. From Fig. 8, we evolved Equation 3-a to state a relationship between drain current, I_{DSS}, V_{GS}, and the average transconductance, $\bar{g}_m$. This equation, repeated here for convenience, is

$$I_D = I_{DSS} - \bar{g}_m V_{GS} \qquad \text{Eq. 3-a}$$

In many instances, we do not know the actual transconductance, g_m, at a particular quiescent current. It can be determined mathematically, for it is related to g_{mo}, the transconductance at I_{DSS} by the equation

$$g_m = g_{mo}\left(\frac{I_D}{I_{DSS}}\right)^{1/2} \qquad \text{Eq. 4}$$

Equation 5 relates $\bar{g}_m$ to g_{mo} and g_m.

$$\bar{g}_m = \tfrac{1}{2}\ (g_{mo} + g_m) \qquad \text{Eq. 5}$$

for as an average value, g_m is midway between the values of g_m and g_{mo}. It should also be noted that g_{mo}, V_P and I_{DSS} are related to each other by the equation

$$g_{mo} = \frac{2\ I_{DSS}}{|V_P|} \qquad \text{Eq. 6}$$

where $|V_P|$ is the absolute pinch-off voltage, disregarding polarity.

All factors in Equations 3-a, 4, 5 and 6 are assumed to be average values. To apply these equations properly, the average values for the various parameters must be calculated from the limited data supplied by the manufacturer of the device. Initially, we must also assume that all operations take place at a 25°C ambient temperature.

We will apply the approximate method to the problem solved above using the complete data. In the problem, we assumed a transistor with a minimum I_{DSS} of 4 mA and a maximum of 10 mA. Both currents are specified at 25°C. The average current is midway between the two limits, or ½ (4 + 10) = 7 mA = $\bar{I}_{DSS}$.

From the curves in Fig. 9, we note that the pinch-off voltages range from 4 to 6. The average is V_P = 5 volts.

V_{GS} should never be allowed to swing to pinch-off to avoid the crowded region of the display and the consequent distortion. As a rule of thumb, V_{GS} should not be more than ¾ of the minimum value of V_P. In this case, V_{GS} should be less than 3 volts. It may, however, be allowed to swing somewhat beyond zero volts at the other extreme, for the transistor will not conduct until V_{GS} is more than +0.5 volts. An average gate-to-source voltage, V_{GS}, would then be ½ (3 − 0) = 1.5 volts. Substituting this into Equation 1, the average drain current is

$$I_D = 7 \times 10^{-3}\ (1 - 1.5/5)^2 = 3.43 \times 10^{-3} \text{ ampere.}$$

If gain is important, I_D should be determined from Equation 3-a using the $\bar{g}_m$ term rather than from Equation 1 as above.

(continued on page 76)

TECHNICAL TOPICS

All about new no-switch, no-button TV tuning—more on selectivity.

by ROBERT F. SCOTT
SENIOR TECHNICAL EDITOR

LAST TIME AROUND, WE SAW HOW THE intermediate frequency and the number of tuned circuits affect the selectivity of a receiver. Ideally, the i.f. amplifier must pass *only* the sidebands of the desired signal and reject all others, no matter how close these unwanted signals may be to the limits of the lower and upper sidebands.

Thus, if a station transmits a signal with modulation up to 5 kHz, the 6-dB bandwidth would be 10 kHz. And, to eliminate all off-channel interference, the ideal i.f. response would have a 10-kHz wide flat top and perpendicular sides.

(Actually, as we will see later in this discussion on receivers, only the carrier and *one* sideband are needed for adequate reception and the overall bandwidth of the i.f. can be limited to that of one sideband.)

We recall that the slope of a response curve steepens as we increase the Q and also as we increase the number of tuned circuits. It is impossible to obtain a flat-topped straight-sided ideal response with any practical number of tuned circuits—the law of diminishing returns sets in and there is little or nothing to be gained in using more than 5-6 critically coupled pairs.

Engineers have settled on a compromise design that gives the steepest slope between frequencies at the −6 and −60-dB points. This results in a curve with the narrowest possible bandwidth at 60 dB down without reducing the 6-dB bandwidth. The ratio of bandwidth at −6 dB to that at −60 dB is the *shape factor*. The shape factor of an ideal rectangular response curve is 1.0. The shape factor of a communications receiver may run from about 1.5 to 5.0, depending on the design and on whether it incorporates such features as crystal, ceramic or mechanical filters.

One of the most common methods of obtaining a good shape factor is to increase the number of tuned circuits or critically coupled pairs. Bandwidth decreases only slightly while the shape factor is greatly improved. Figure 1 shows how two i.f. transformers are connected back-to-back through a small capacitor to provide a good shape factor in the Sonar J-23 CB transceiver. Figure 2 shows a similar approach used in the Pace model Plus-23 transceiver. Similar but more complex arrangements are used for a good shape factor and to provide variable selectivity in some of the more advanced communication receivers. We saw earlier that the response of tuned circuits depends on the Q and the degree of coupling between them. In most rf and i.f. transformers, the two coils are wound on the same form or on two separate forms in the same or in parallel planes. The coupling factor (k) is the linkage between the coils and is governed by the spacing between them.

Figure 3 shows the response of a transformer as k is varied by changing the spacing. When the coils are far apart, the curve (1) has a very sharp, low-amplitude peak. As spacing is decreased, the bandwidth and amplitude increase (2). Finally a point is reached (3) where a further decrease in spacing causes the center of the peak to sag so two humps or peaks (4) begin to develop. This point, corresponding to maximum gain, is *critical coupling* (3). Beyond critical coupling, the dip and twin peaks grow more pronounced (4 and 5) and we have an *overcoupled* circuit. If a stage is heavily overcoupled, the signal amplitude drops and the lower frequencies in the sidebands are severely attenuated. If we need the extra wide bandpass available from overcoupling, the top of the curve can be flattened out—roughly to the level at the dip—by shunting each coil with a resistor.

Some of the early Hammarlund Super Pro receivers provided varying degrees of selectivity by using a cam arrangement that permitted varying the spacing between coils in three i.f. transformers by rotating a SELECTIVITY control on the front panel. Figure 4 shows how the selectivity varies with spacing between the coils. Spacing varies from about one-third critical coupling in the narrow (3-kHz) setting to about 3 times critical coupling in the 16-kHz position.

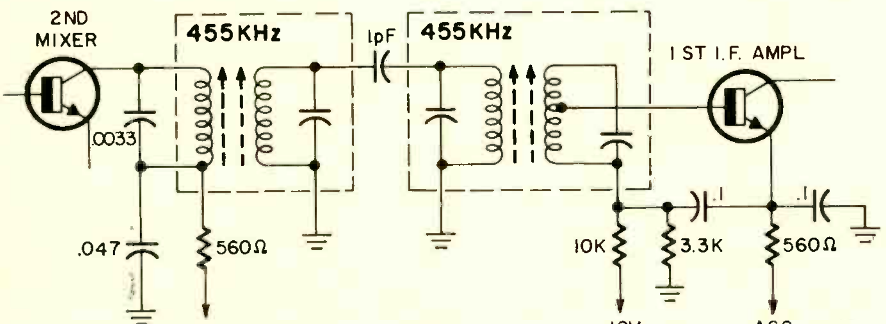


FIG.1

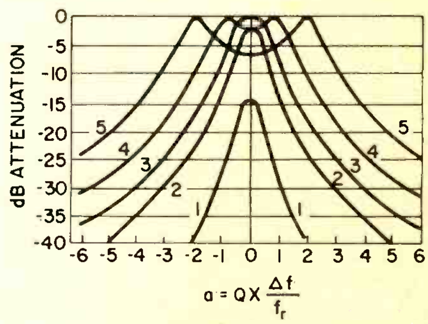


FIG. 3

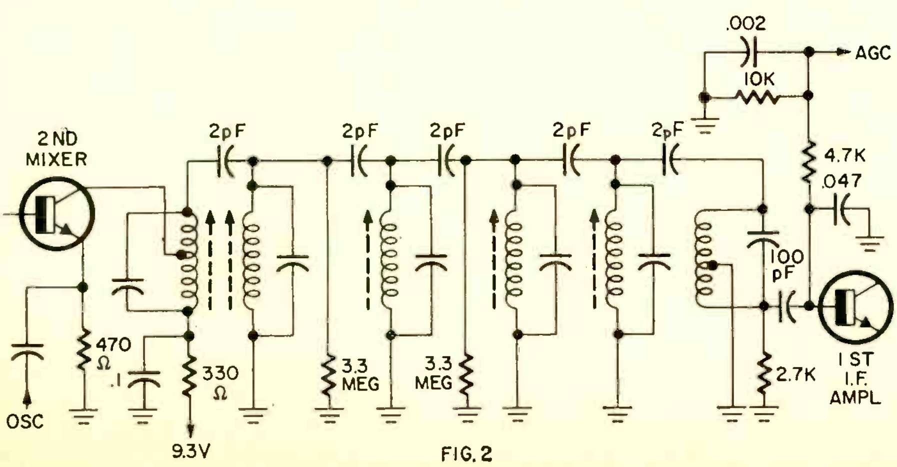


FIG. 2

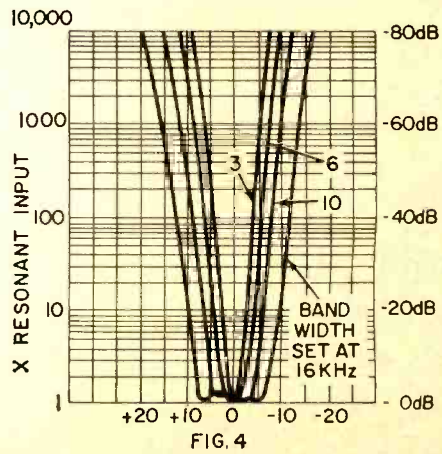


FIG. 4

Electronic touch tuning

Electronic touch tuning—no push buttons or mechanical switches—is now a feature of some new FM and TV receivers. In the Electrohome C-8 color TV chassis, channels are selected by bridging the appropriate touch contact and the common touch bar with a fingertip. The conductivity of the skin (9 megohms or less) activates a transistor circuit that tunes in the selected channel and turns on the channel indicating light. The electronic tuning system covers 18 channels, 12 vhf and 6 uhf. Varactor diodes (VVC's or voltage-variable capacitors) are used for channel tuning.

Each of the 18 channel-selector circuits consists of three transistors, two diodes, a channel-indicating lamp, control pot and the usual biasing networks. The vhf band is covered in two sections; channels 2-6 and 7-13 with electronic bandswitching. Figure 5, a simplified diagram, shows the complete selector circuits for one low vhf channel, one high vhf channel and one uhf channel. The circuits for the remaining channels in each band duplicate those shown.

Figure 6 shows the rf amplifier and channel-selection tuned circuits in the vhf tuner. Transistors Q1-Q2 and Q3-Q4 are the electronic vhf low- and high-band switches, respectively.

When one of the channel-selector contacts (Fig. 5) is bridged, transistors Q1, Q2 and Q3 are turned on and held in the conducting state by positive feedback from Q3 to Q1. The three transistors, operating in the common-emitter mode, form a dc amplifier. The increase in collector current flowing through 3300 ohms—common to the emitters of the eighteen Q1 transistors—turns off any other channel-selector circuit that was previously turned on.

A regulated +30 volts appears between the collector of Q2 and ground. A portion of this voltage appears across the 10,000-ohm PRESET TUNING pot and the wiper of the pot is adjusted to select the desired channel. Resistors R3 and R5 are selected to limit the voltage across R4 for easier channel selection.

The voltage selected is fed through isolating diode D2 to the VVC diodes in the tuner (Fig. 6). The emitter current of Q3 flows through a channel indicator lamp and turns it on. The voltage across the lamp (8 volts) is fed through isolat-

(continued on page 68)

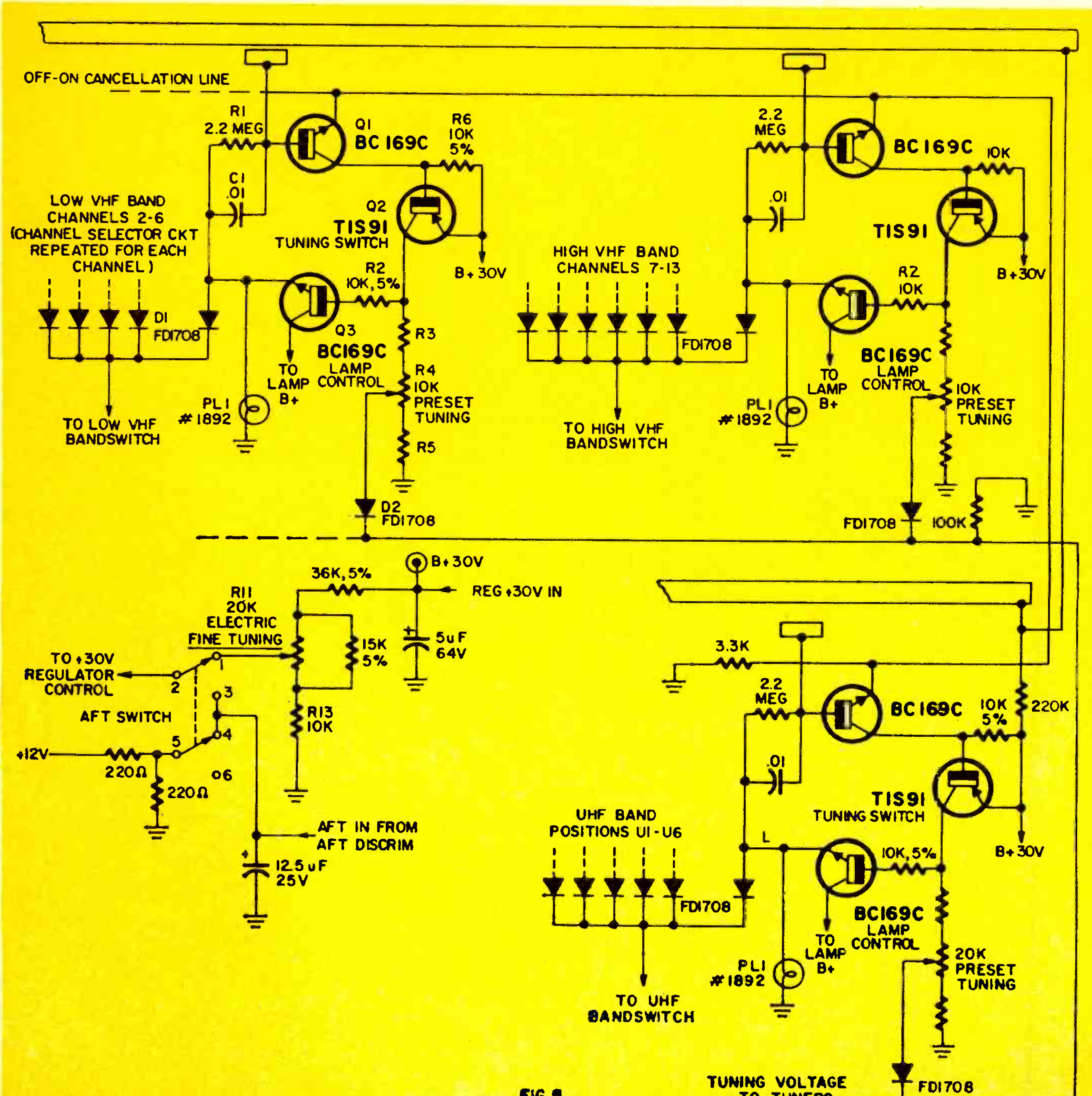


FIG. 5

You can advance

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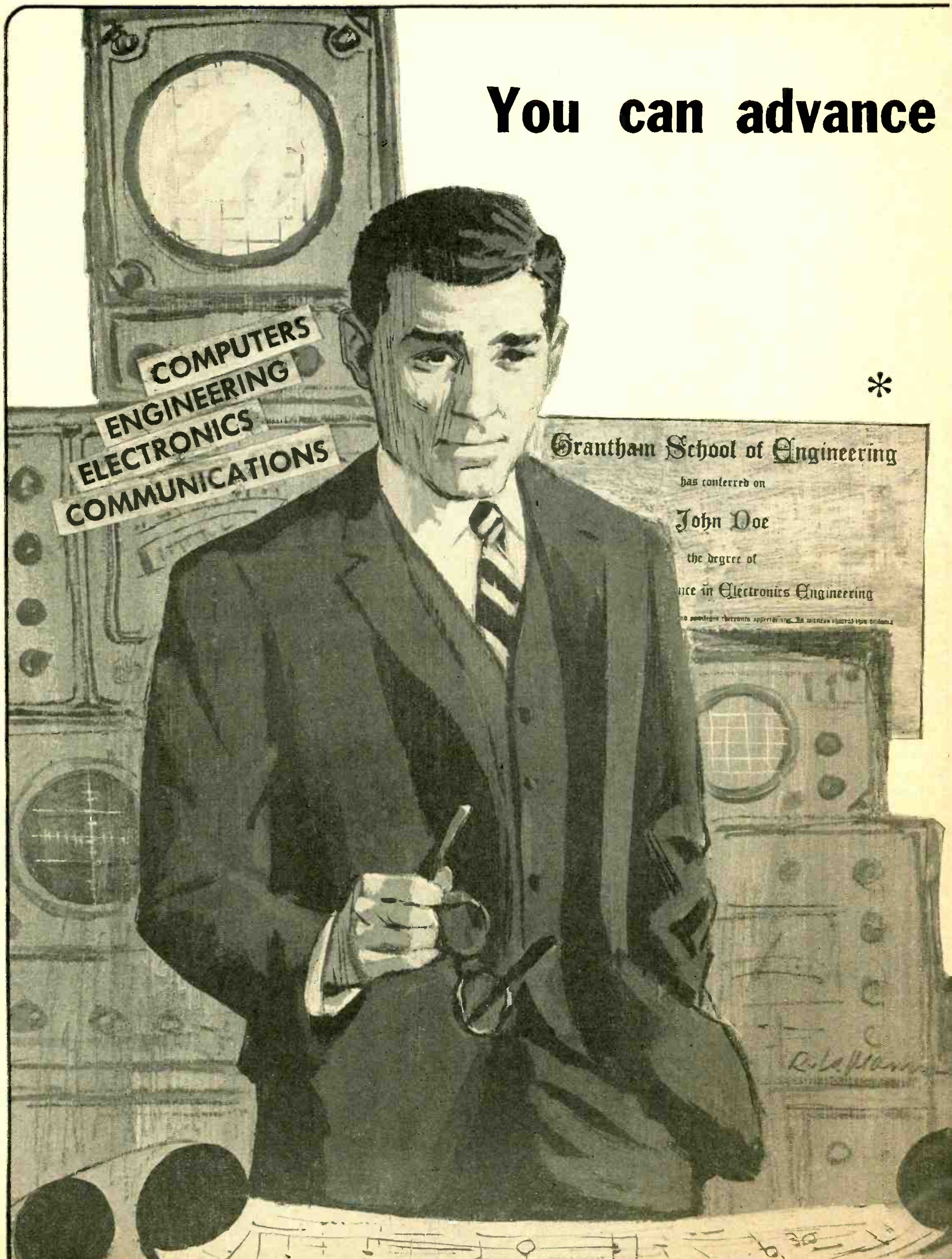


ing diode D1 to one of the three electronic bandswitches.

Two of the bandswitch circuits (Q1-Q2 and Q3-Q4) are shown in Fig. 6. The uhf band switch, identical to the vhf circuits, has been omitted for simplicity. An input voltage from one of the channel-selector circuits turns on Q1 and Q2 (or Q3 and Q4) and drives the output transistor to saturation. The +12 volts applied to the emitter of Q2 (or Q4) appears at the collector and is fed to the "switching line" in the tuner.

In the vhf tuner (Fig. 6) coil networks L2-L3-L4-L5, L6-L8, L7-L10-L9 and L11-L12 are tuned by VVC diodes D10, D1 and D5, respectively. (The vhf oscillator, not shown, is tuned by a VVC diode tied to the "tuning line".) Diodes D9, D12, D2, D3 and D4 connect or isolate tuning coils as needed.

When a low vhf channel is selected, a tuning voltage—ranging from 0 to +30 volts, as selected by one of the twelve preset vhf tuning pots—is applied to tuning diodes D10, D1 and D5. The +12 volts at Q2's collector is fed—as a padding or bias voltage—to the anodes of the VVC diodes. At the same time, this voltage is fed through D13 to the vhf oscillator and through D13 and D14 to the rf amplifier.

Switch Q3-Q4 is turned off and the −12 volts on Q4's collector is fed to the "switching line" so D9, D12, D2, D3 and D4 are reverse biased. With these diodes turned off, all the coils are in the tuning circuits and the tuner is set for selecting a channel from 2 through 6. The tuning voltage on the VVC's, adjusts the circuit capacitance as needed.

When one of the high vhf channels is selected, Q3 and Q4 are turned on. Q4's collector switches from −12 to +12 volts. This voltage is fed to the vhf oscillator—through D15—and to the rf amplifier through D15 and D14. Diode D13 is back-biased and the padding voltage drops to zero volts to provide a lower capacitance for the VVC's. With a positive voltage on the "switching line", the switching diodes are forward biased. (When the switching diodes are forward biased they conduct and act as closed switches.) Thus C3 is shunted across L5 and L3 is switched in parallel with L2, reducing the effective inductance of the antenna circuit for the high vhf band.

D2, D3, D4 and the oscillator switching diode are forward biased so the effective inductances of rf amplifier output, mixer input and oscillator circuits are reduced for channels 7–13.

An electronic bandswitch similar to Q1-Q2 applies +12 volts to the uhf oscillator when one of the uhf selector contacts is closed. The vhf bandswitch transistors (Q1-Q2 and Q3-Q4) are turned off so the vhf rf amplifier and oscillator are disabled. Tuning voltage from one of the preset uhf pots is applied to the antenna, mixer input, mixer output and oscillator circuits in the uhf tuner. The i.f. signal from the uhf tuner is amplified by the vhf mixer stage and then fed to the i.f. stages.

The channel-selector circuits (Fig. 5) are fed from a regulated +30-volt line. When the set's aft circuit is activated, the output of the aft discriminator is fed to the 30-volt regulator transistor so the regulated +30-volt line varies in accordance with the variation of the video carrier from the correct tuning point. The fine-tuning control is a pot that varies the +30-volt line from +26 to +31 volts. **R-E**

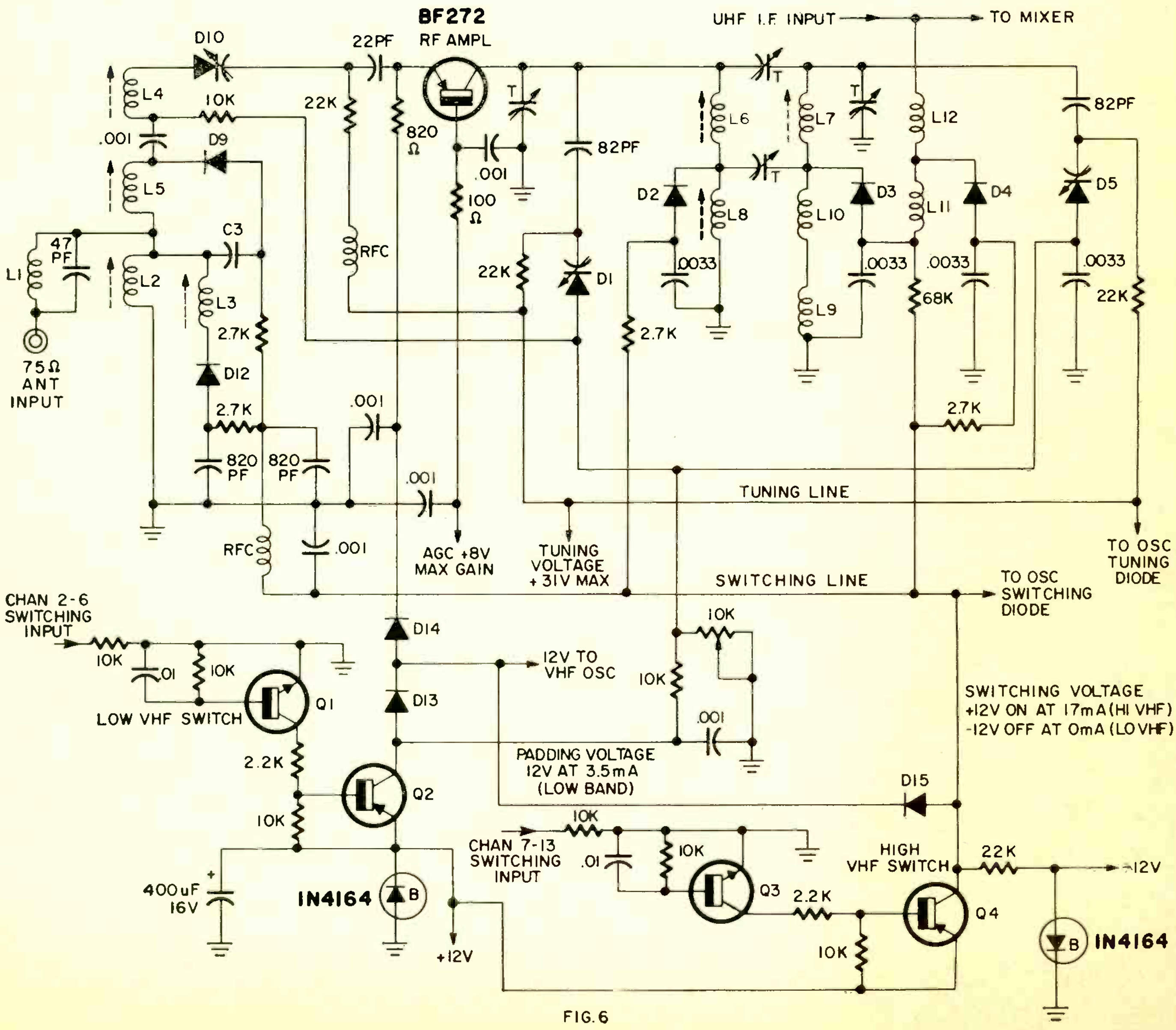


FIG. 6

THE LASER

by U.S. BUREAU OF RADIOLOGICAL HEALTH

This month we take a look at the ways that laser beam parameters affect exposure levels.

AT THE CLOSE OF THE LAST ARTICLE IN THIS CONTINUING series on the laser (March, page 61) we were discussing biological hazards produced by different types of lasers. Particular attention was paid to possible damage to the eye. We continue by describing how skin may be damaged and then proceed to show how exposure levels can be measured.

The skin hazard

The other area of concern is the skin. It is not as sensitive as the eye, and if damaged, most injuries are more easily repaired. However, it too is subject to great damage from laser impact when energy densities approach several J/cm^2. *Descriptions of skin damage are included for general interest but are probably not applicable in hazard considerations for He-Ne lasers.*

The skin is not a homogeneous mixture. It is a specialized, layered structure with numerous odd inclusions, such as blood vessels and hair follicles. Like most other tissues, the skin is composed principally of water, and the laser beams interact as if skin were sea water containing a number of inclusions. Consequently, the skin is relatively transparent to laser light.

Absorption of light in the skin occurs, for the most part, in the pigment granules and the blood vessels. The skin contains numerous pigments, the most common being melanin, which determine the color of the skin. Visible laser light is selectively absorbed by the melanin granule, causing it to rise in temperature at a rapid rate, and causing cavitation around or bursting of the granule at high energy density exposure. Blood vessels are also quite susceptible to laser damage and are easily occluded or cauterized by a laser hit.

Under some circumstances, the concern is not for the skin, but for the underlying organs. Skin is so transparent, that the visible light may pass through it to be absorbed by an internal organ. For example, the liver in mice is especially subject to this type of damage, lying close beneath the skin and being dark in color.

Laser damage to the skin ranges from a mild erythema to a surface charring, to a deep hole literally burned and blown into the skin. One rather sensational aspect is the plume, a kickback of debris present in high energy impacts. This plume may scatter tissue quite some distance from the point of impact.

Visible lesions may not be true threshold lesions because more sensitive processes may detect permanent damage at exposure levels well below those producing visible lesions. Histochemical methods can be used to detect permanent enzyme inactivation at exposure levels 10 to 15% lower than those resulting in visible lesions. Electroretinography can be used to detect some permanent changes at exposure levels 50% below visible lesion levels. Permanent damage may result at even lower levels.

Exposure standards are of little value unless used. Proper use of exposure standards includes an estimate of the hazard presented by the beam from your laser. Let us take a brief look at how to determine what hazards exist.

An accurate determination of the hazards posed by a laser requires measurement of several beam parameters. Many methods for measuring or defining the beam parameters are in common use, all requiring the use of calibrated and costly electronic gear. However, an approximate idea of the hazard posed by a laser can be gained by using the manufacturer's specifications.

One note of caution: The specifications listed by a laser manufacturer are likely to be minimum guaranteed levels for a particular model, and an individual laser may exceed these specifications. A nominal 2-mW laser will usually have an actual output greater than 2 mW. A laser with a nominal divergence of 1.0 milliradians may have a divergence of 0.8 milliradians. The supplied figures can provide a general idea of the power densities involved. However, this can lead to a serious underestimate of the hazards involved. Use of nominal specifications to calculate the power density leads to a nominal calculated value which may be considerably less than that determined by direct measurement.

Exposure levels which are listed as "safe" or "tolerable" are given in units of irradiance, mW/cm^2. Therefore, the output of your laser must be expressed in similar units. The usual information given by a laser manufacturer, and typical values for a classroom type He-Ne laser are:

Power output	1.0 milliwatts
Beam diameter at aperture	1.5 millimeters
Beam divergence	1.0 milliradian

The irradiance at the aperture is given by the following formula:

$$P_a = \frac{P}{\text{area}} = \frac{P}{\pi(D_a/2)^2}$$

where:

P_a = irradiance at aperture
P = power output
D_a = Beam diameter at aperture in cm

For the laser listed above

$$P_a = \frac{1.0 \text{ mW}}{3.14\ (0.15 \text{ cm}/2)^2}$$
$$= 57.1 \text{ mW/cm}^2$$
$$= 5.7 \times 10^{-2} \text{ W/cm}^2$$

This laser, therefore, has an output irradiance of approximately 6×10^{-2} W/cm^2 at the aperture. If we compare this with the "safe" value of 5×10^{-5} W/cm^2 recommended by the American Conference on Government Industrial Hygienists (1968) for daylight illumination, it is approximately 1000 greater than the "safe" value.

As the laser beam travels beyond the aperture, it diverges slightly. At a distance of r meters, the beam will have diverged to a diameter D_r. This is shown in Fig. 14.

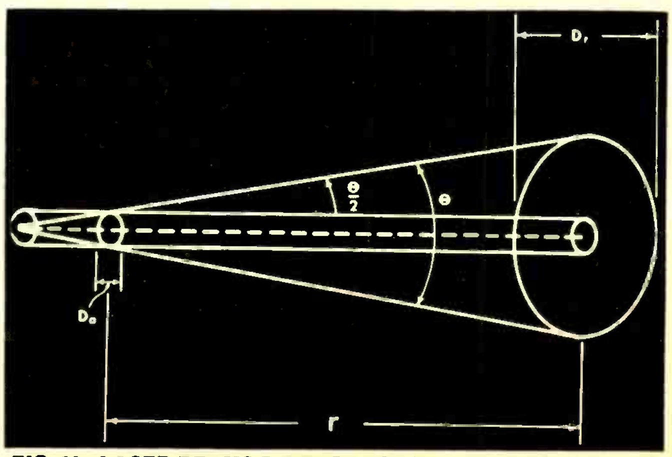


FIG. 14—LASER BEAMS DIVERGE slightly as they travel beyond the laser aperature. This diagram shows divergence characteristics

1. Work Area Controls

a. Use the laser away from areas where the uninformed and curious would be attracted by its operation.
b. Illuminate the area as brightly as possible to constrict the pupils of the observers.
c. Set up the laser so the beam path is not at normal eye level (i.e., below 3 feet or above 6½ feet).
d. Use shields to prevent both strong reflections and the direct beam from going beyond the area needed for the demonstration or experiment.
e. The target of the beam should be a diffuse, absorbing material to prevent reflection.
f. Remove all watches and rings before changing or altering the experimental setup. Shiny jewelry can cause hazardous reflections.
g. Cover all exposed wiring and glass on the laser with a shield to prevent shock and contain any explosions of the laser materials. All non-energized parts of the equipment should be grounded.
h. Signs indicating the laser is operating and that it may be hazardous should be placed in conspicuous locations both inside and outside the work area and on doors giving access to the area.
i. Whenever possible, the door(s) should be locked to keep out unwanted onlookers during laser use.
j. The laser should never be left unattended.
k. Good housekeeping should be practiced to insure that no device, tool, or other reflective material is left in the path of the beam.
l. A detailed operating procedure should be outlined beforehand for use during laser operation.
m. Whenever a laser is operated outside the visible range (such as a CO_2 laser), some warning device must be installed to indicate its operation.
n. Use a key switch to lock the high-voltage supply.

2. Personnel Control

a. Avoid looking into the primary beam **at all times.**
b. Do not aim the laser with the eye: direct reflection can cause eye damage.
c. Do not look at reflections of the beam: they can also cause retinal burns.
d. Avoid looking at the pump source **at all times.**
e. Clear all personnel from the anticipated path of the beam.
f. Do not depend on sunglasses to protect the eyes. If laser safety goggles are used, be certain they are designed for the laser being used.
g. Report any afterimage to a doctor, preferably an ophthalmologist who has had experience with retinal burns, as damage may have occurred.
h. Be very cautious around lasers which operate in invisible light frequencies.
i. Before operation, warn all personnel and visitors of the potential hazard. Remind them that they have only one set of eyes.

The formula for determining the irradiance at a distance r centimeters from the aperture is:

$$P_r = \frac{P}{\pi(D_r/2)^2} = \frac{4P}{\pi(D_r)^2}$$

where:

P_r = irradiance at distance r
D_r = diameter of beam at distance r in centimeters

The divergence of the beam in radians can be used to determine the beam diameter at distance r as follows:

$$D_r = r\phi + D_a$$

where:

r = distance in centimeters
ϕ = divergence in radians
D_a = aperture diameter in centimers

The irradiance can thus be determined at any point. Calculate, for example, the irradiance at a distance of about 40 feet or 13 meters (a reasonable distance from the front to the rear of a classroom).

$$D_r = (1300 \text{ cm} \times 1.0 \times 10^{-3} \text{ radians}) + (0.15 \text{ cm})$$
$$= (1.30 \text{ cm}) + (0.15 \text{ cm})$$
$$= 1.45 \text{ cm}$$

$$P_r = \frac{4(1.0 \text{ mW})}{3.14\,(1.45 \text{ cm})^2}$$
$$= \frac{4 \times 10^{-3} \text{ W}}{6.6 \text{ cm}^2}$$
$$= 6.06 \times 10^{-4} \text{ W/cm}^2$$

As you can see, even a small classroom type laser can emit enough power to be unsafe for direct viewing of either the primary beam or of specular reflection, even though the viewer may be seated some distance from the laser.

Safety aids

The laser can be used safely. Common sense and preplanning of experiments will point out the most obvious hazards. Safety aids will prevent injury even when the unexpected does occur. Let us look at some useful safety aids.

The beam shutter: Gas lasers are built to withstand continuous use. Their life span is actually shortened by intermittent use. Turning the laser on and off at short intervals is also inconvenient. One way to overcome this strain and inconvenience is to use a beam shutter.

The shutter can be a simple mechanical device fitted over the laser aperture. It allows the operator to cut off the laser beam without actually turning off the laser. The shutter should be made of black, non-reflective material and should completely stop the laser beam. One example is in Fig. 15.

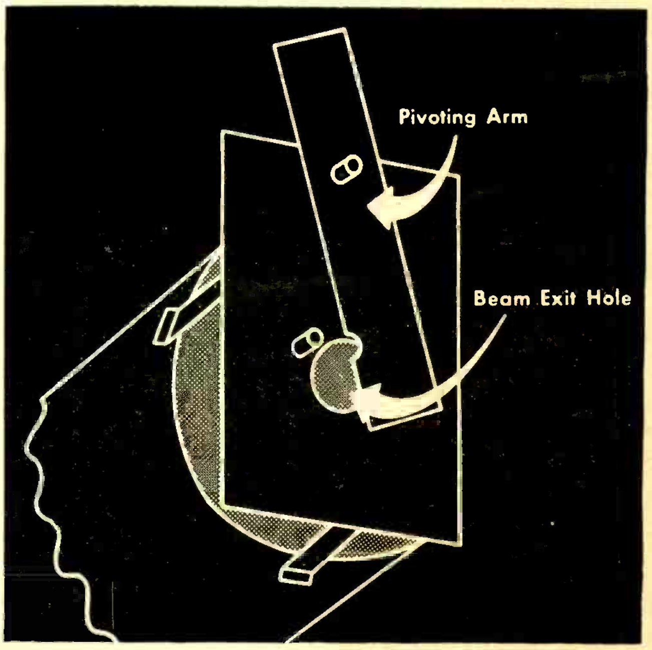


FIG. 15—SAFETY SHUTTER stops laser beam when laser is not in use. An easy way to avoid accidents.

Using the beam shutter can reduce the hazard to the operator whenever the experimental configuration in front of the laser is changed or altered. It eliminates the possibility of accidental reflection from a piece of equipment during the change. As with all safety aids, you must develop the *habit* of shuttering the beam at *all* times it is not actually needed.

The target: The laser beam will travel outward from the laser until it is absorbed or reflected. To prevent accidents a suitable target must be provided. This target should be made of a non-reflective material and should be large enough to stop the beam under a wide variety of experimental situations. Black foam rubber is one good beam target. Black ink on blotter paper also makes a good target.

(to be continued)

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.

IC DIGITAL COLOR GENERATORS, *models 1243 and 1246*. Both check convergence, color, linearity, size and focus. Flip-flop circuits used for all counting functions; precision crystals used in master countdown and color oscillators. *Model 1243* provides six patterns, is tun-

able to channel 3, 4 or 5, operates on 115 Vac. *Model 1246* has crystal-controlled picture carrier oscillators for channels 3 and 4; 4.5 MHz unmodulated carrier; provides nine patterns. $99.95 for the *1243*; $149.95 for the *1246*.—**Dynascan Corp.**, 1801 W. Belle Plaine Ave., Chicago, Ill. 60613.

Circle 31 on reader service card

COLOR TV VECTORSCOPE/GENERATOR, *model IO-101*. Combines conventional solid-state devices with computer-type integrated circuitry to provide visual readout of important characteristics of the chroma signal, produce standard 9 x 9 display of color bars, shading bars, dots,

cross hatch, vertical and horizontal lines. Features grid-cathode switch allowing display of vector pattern in same position regardless of the drive method used for the color CRT. $124.95 for the kit.—**Heath Company**, Benton Harbor, Mich. 49022.

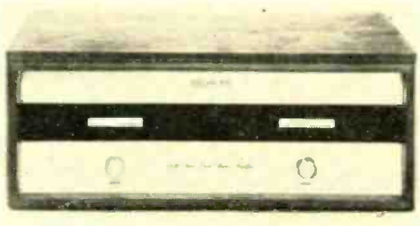
Circle 32 on reader service card

FM POCKET MONITOR, *Portamon models CRX-106 and CRX-107*. Solid-state portable receivers tunable over low band (27 MHz to 50 MHz) or high-band (144 to 174 MHz) respectively. Features include adjustable squelch control. Free from frequency drift, they have an rf stage, a tunable superhet circuit with 3 tuned i.f. stages for rejecting unwanted adjacent stations and rf signals, Class "B" push-pull power output. Automatic gain control. Also has a telescoping antenna, a built in jack which allows user to plug in an accessory ac power supply. Made with an 8-ohm speaker and precision slide rule front dial. The semiconductor complement

consists of 9 transistors and 2 diodes. Uses a 9 V battery. Earphone included. Weighs one pound. $39.95—**The Hallicrafters Co.** Dept. PR, 600 Hicks Road, Rolling Meadows, Ill. 60008

Circle 33 on reader service card

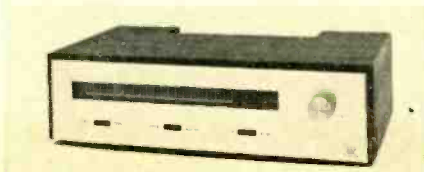
POWER AMPLIFIERS, *models Mark IIB, IIIA, and IVB*. Solid-state units featuring 12 output transistors with no driver or output transformers of any kind. Each channel has own power supply and gain control. The *IIB* power output is 90 watts per channel; the *IIIA*



120 watts per channel; the *IVB* 60 watts per channel. Both channels driven 20Hz to 20kHz. *IIB*, $450.00; *IIIA*, $550.00; *IVB*, $350.00.—**Scientific Audio Electronics**, P.O. Box 60271 Terminal Annex, Los Angeles, Calif. 90060.

Circle 34 on reader service card

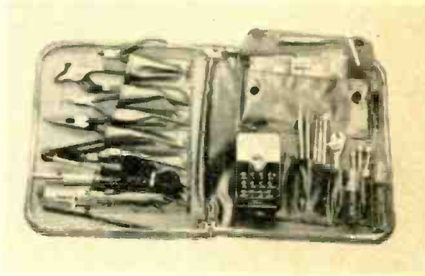
FM STEREO TUNER. All-silicon solid-state tuner: FET front end with 4-section variable capacitor, multisection phase-linear i.f. filter, integrated circuit



i.f. amplifiers. Distortion figure less than 0.5% IM or THD, mono or stereo; frequency response 20 Hz to 15 kHz, ± 1 dB. Other features include interstation hush, center channel tuning meter, and automatic stereo switching with indicator light. $210.00 with black aluminum cover. Optional oiled walnut cover, $15.00.—**Acoustic Research, Inc.**, 24 Thorndike St., Cambridge, Mass. 02141.

Circle 35 on reader service card

TOOL KIT, *JTK-16 "Detective" Kit*, provides screwdriver blades, Phillips-type blades, wrench, 10-piece Allen-hex wrench set, 10-piece Bristol-spline wrench set, pliers, wire stripper, handles, knife, sawblade, 6" scale, soldering iron,



solder, burnisher, alignment tool set, and needle file. *JTK-16* with Simpson No. 355, $104.50. Kit without tester, $54.50—**Jensen Tools & Alloys**, 4117 N. 44th St., Phoenix, Ariz. 85018.

Circle 36 on reader service card

TRANSVERTERS, *models 30-3120, 30-3131 and 30-3122*. Plug-in power transverters permit running portable electronic devices on automotive 12-volt negative-ground electrical systems. Transverter plugs into cigarette lighter

socket and gives required voltage: *30-3120*, 6-volt output; *30-3131*, 7.5-volt output; *30-3122*, 9-volt output. Maximum current output, 300 milliamps. All models are $6.85 each.—**GC Electronics**, Div. Hydrometals, 400 S. Wyman St., Rockford, Ill. 61101.

Circle 37 on reader service card

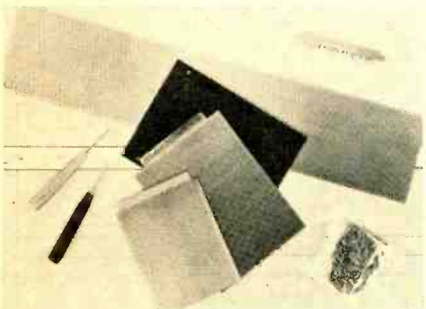
MONITOR RECEIVERS, *models UHF 800 and UHF 808*, scanning type 8-channel receivers. The *800* gives a duo-band uhf/vhf, selectivity of 15 kHz at 6 dB and vhf frequency ranges 150-170 MHz, uhf 450-470 MHz, any channels in a 10 MHz range. The *808* (illustrated) offers 8 uhf channels, selectivity of 30

KHz at 6 dB and frequency range of 450-470 MHz in 10 MHz spread. Both solid state receivers have automatic

search and manual push-button selection. *UHF 800* is $169.95, *UHF 808* is $149.95.—**Petersen Electronics, Inc.**, 1000 South Main St., Council Bluffs, Ia. 51501.

Circle 38 on reader service card

IC BOARDS KIT, *Vero MC-10*, for dual-in-line molded integrated circuits. All boards pierced on a 0.1" x 0.1" matrix. Included are a single-sided 18" long board with 34 copper strips on 0.1 centers; a plug-in single-sided board with 32 plated contacts; a double-sided plug-in



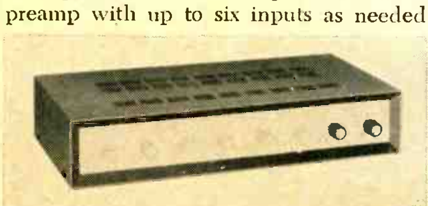
board with strips at right angles; an epoxy glass plain board pierced at 0.1 centers with 0.052 holes; 500 terminal pins; a pin insertion tool; a spot face cutter; a 0.1 reproducible design sheet and a 32 contact 0.1 edge connector. $29.95.—**Vero Electronics, Inc.**, 171 Bridge Rd., Hauppague, N.Y. 11787.

Circle 39 on reader service card

ELECTRONIC STROBE LIGHT, *model 3477*. Solid-state circuitry in walnut-grained cube shape with three color lens filters for home and commercial music systems. Plug-in xenon lamp gives kaleidoscopic effects, up to 2 watts per-second per-flash at one flash per second. Includes variable speed control. $29.95 wired.—**EICO Electronic Instrument Co.**, 283 Malta St., Brooklyn, N.Y. 11207.

Circle 40 on reader service card

PUBLIC ADDRESS MIXER, *MIX-6*. Unit permits custom design of a mixer/preamp with up to six inputs as needed

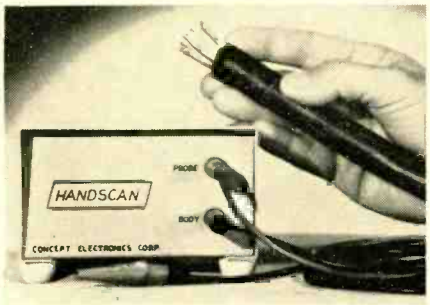


Circle 62 on reader service card

from standard P/A modules. Modular construction allows for integration of telephone, microphone, and program preamps with signalling or alarm tone generator. Control functions such as priority paging, remote volume control, or volume limiting also offered as standard plug-in modules.—**Bell P/A Products Corp.**, 1200 North 5th St., Columbus, Ohio 43201.

Circle 41 on reader service card

WIRE LOCATOR, *Handscan*, finds any wire in a bundle even if not color coded or otherwise identified, no matter how many in the bundle, whether terminated or loose. Also used for isolation testing of



transformers, capacitors, semiconductors, coaxial cable. The 22-ounce unit is portable and self-contained. $129.50.—**Electronic Tools Div., C. H. Mitchell Co.**, 18531 Ventura Blvd., Tarzana, Calif. 91356.

Circle 42 on reader service card

TAPE RECORDER ACCESSORIES. Microphones (*model 31802-D* shown), stereo headphones, cassette tapes, remote controls, foot controls, telephone pickups, car adaptors. The microphone line consists of twelve high- and low-impedance models with remote switches, voice-oper-

ated microphones, a cardioid mike, and a wireless mike with remote switch, all compatible with most modern tape recorders. The stereo headphone, 8 ohm impedance *model HP-10*, $19.95; *model HP-15* with separate volume controls for each channel, $24.95.—**Concord Electronics Corp.**, 1935 Armacost Ave., Los Angeles, Calif. 90025.

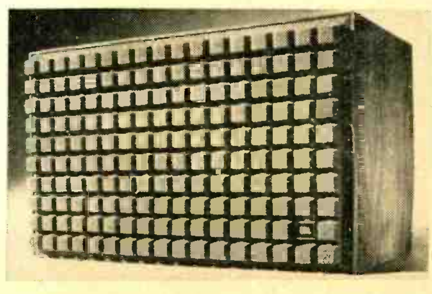
Circle 43 on reader service card

IMPEDANCE BRIDGE, *model 330A*, measures resistance, capacitance and inductance of electronic components. Solid-state, portable testing unit has direct digital readout, automatic decimal

placement and range-units display. Operates from battery or ac 50 to 400-Hz power. Accuracies of ±0.05% for resistance and ±0.2% for capacitance or inductance. $510.00.—**General Metrology Corp.**, Box 471, Edmonds, Wash. 98020.

Circle 44 on reader service card

BOOKSHELF SPEAKER SYSTEM, *L100 Century*, has a long-excursion 12" woofer; 6 pound magnetic assembly; low free-air cone resonance of 27 Hz. The system has power capacity of 50 watts continuous program, crossover 2500 and

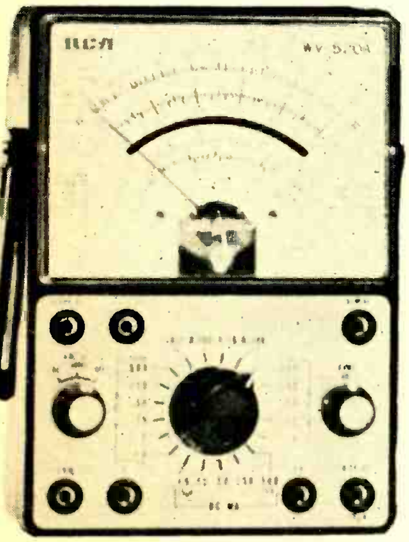


Circle 63 on reader service card

7000 Hz, nominal impedance 8 ohms, frequency response 40-15,000 Hz ±3 dB. Oiled walnut finish. 24" x 14" x 13" deep. $264.00.—**James B. Lansing Sound, Inc.**, 3249 Casitas Ave., Los Angeles, Calif. 90039.

Circle 45 on reader service card

VOM TEST INSTRUMENTS, *WV-516A, 517A, 518A, 519A and 520A*, all have meter movements with protection diodes, precision range resistors (±1%), 3-color meter scales, and blue plastic cases. Lowest price *model WV-516A* measures ac (rms) or dc voltage from 0.1 to 1,000 volts in 4 ranges; ac and dc sensitivity is 2,000 ohms-per-volt. Will fit in technician's pocket. *WV520A*, (illustrated) highest price model, has sensitivity of 100,000 ohms-per-volt for dc

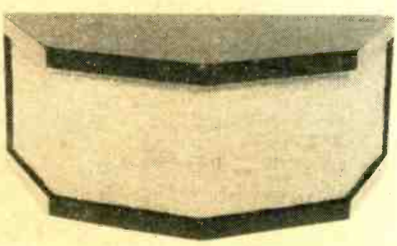


measurements and 10,000 ohms-per-volt for ac measurement; measures dc voltages from 10 mV to 1,500 volts; ac voltage (rms) from 100 mV to 1,500 V; dc current from 0.5 mA to 5 A; resistance from 0.05 ohm to 20 megohms, and decibels from −20 to +55.5. Prices are $9.95, $18.00, $28.50, $36.00, $48.00 respectively.—**RCA/Electronic Components**, 415 South 5th St., Harrison, N.J. 07029.

Circle 46 on reader service card

Write direct to the manufacturer for information on the following item.

HIGH-FREQUENCY SPEAKER SYSTEM, *Microstatic*, designed to be used with AR and KLH speakers. *Microstatic* has a 180° radiation pattern and flat frequency response in its operating range of 3.5 kHz to 25 kHz; harmonic distortion



less than 0.45% below 15 kHz at 20 watts input; 16 ohms. Weight 2 lbs. 5 oz., walnut finish, 8⅜" x 5⅞" x 3¾". $77.00.—**Micro/Acoustics Corp.**, Box 302, White Plains, N.Y. 10602.

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!

MARINE ELECTRONIC AIDS described and pictured in color in 20-page brochure. Line of products for pleasure boats and small commercial vessels features indicating and recording fathometer, depth sounders; radars; vhf/FM single sideband, CB, AM radio-telephones; direction finders; loran receivers; loud hailers and accessories.—**Raytheon Company Marine Products**, 676 Island Pond Rd., Manchester, N.H. 03103.

Circle 47 on reader service card

ANTENNA CATALOG, *No. 1270*. Five complete lines of outdoor vhf, uhf, FM and combination broadband antennas; single-channel Yagis; and fifteen types of uhf-only antennas; antenna rotators, uhf converters, and miscellaneous hardware.—**Channel Master Corp.**, Ellenville, N.Y. 12428.

Circle 48 on reader service card

SOUND PRODUCTS CATALOG, *1971*, is a complete listing, including photographs and specifications, of speakers, amplifiers, woofers, tweeters, speaker grilles, audio level controls, wall baffles, headsets, cabinets, and bookshelf enclosures.—**Components Specialties, Inc.**, 39 St. Mary's Place, Freeport, N.Y. 11520. **R-E**

Circle 49 on reader service card

Circle 64 on reader service card

DESIGN FOR STEREO

(continued from page 67)

The average transconductance should be calculated from g_m and g_{mo}. Use equation 6 to determine g_{mo}. It is $2I_{DSS}/|V_P| = 2(7\times10^{-3})/5 = 2.8\times10^{-3}$ ampere/volt. Equation 4 dictates that the transconductance at the average drain current is $g_m = (2.8\times10^{-3})(3.43\times10^{-3}/7\times10^{-3})^{1/2} = 1.96\times10^{-3}$ ampere/volt. Hence the average transconductance, $\bar{g}_m$, is $(g_{mo}+g_m)/2 = (2.8\times10^{-3} + 1.96\times10^{-3})/2 = 2.38\times10^{-3}$ ampere/volt from Equation 5.

To summarize the important data, $I_{DSS} = 7$ mA, $I_D = 3.43$ mA, $V_P = 5$ volts $\bar{g}_m = 2.38\times10^{-3}$ mhos, $V_{GS} = 1.5$ volts and $I_{GSS} = 10^{-6}$ ampere at 125°C. (I_{GSS} at the elevated temperature was calculated in the previously discussed procedure.)

Using the above data, initially design the simple self-bias circuit in Fig. 2. R_D is 5600 ohms as specified for all circuits. The entire gate-to-source voltage is developed across R_S and is equal to source currents to be equal. Since $V_{GS} = I_DR_S$, $R_S = V_{GS}/I_D = 1.5$ volts/3.43×10^{-3} ampere = 438 ohms. Use the standard 470-ohm resistor. As before, R_X = 100,000 ohms, for the considerations here are the same as they were in the example with the more exact solution.

The circuit in Fig. 3 is of greater interest for the E_{GG} voltage which bucks I_DR_S will permit R_S to be increased in size while retaining the desired V_{GS}. The equation for the gate current is

$$V_{GS} = I_DR_S - E_{GG} - I_{GSS}(\max)R_X$$

Substituting the calculated values into the equation yields

$$1.5 = (3.43\times10^{-3})R_S - E_{GG} - (10^{-6})(10^5)$$

so that the gate supply voltage is related to the source resistor by

$$E_{GG} = -1.4 + 3.43\times10^{-3}R_S \quad \text{Eq. 7}$$

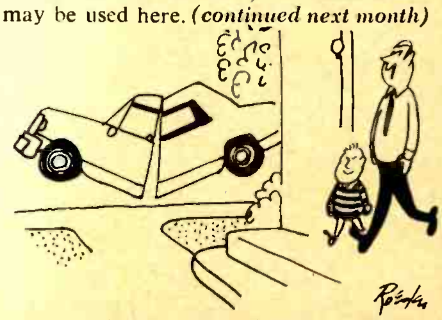
R_S must be bigger than determined for the circuit in Fig 2. Doubling the 470 ohms to the EIA resistor value of 1000 ohms, is a good estimate. Then E_{GG} will be $-1.4 + 3.43 = 2.03$ volts, from Equation 7. This is a logical solution not unlike that derived using the more exact methods. The results should be checked in the laboratory.

The required drain supply voltage should now be determined. The procedures used above also apply here.

The voltage across the drain resistor is $I_DR_D = 3.43\times10^{-3}\times5600$ ohms = 19.2 volts. The minimum voltage across the transistor is (1.5) V_P, as derived above, or 1.5 (5 volts) = 7.5 volts. The voltage across R_S must be at least that calculated for Fig. 2, or $I_DR_S = (3.43\times10^{-3})(438) + 1.5$ volts. The average supply voltage is the sum of these factors, or $19.2+7.5+1.5 = 28.2$ volts. Add about 30% to compensate for peak values in drain current and pinch-off voltage. The required supply will then be approximately 40 volts.

The practical circuit in Fig. 4 can be determined from the data which has already been accumulated. Although R_X remains at 100,000 ohms, R_G can be calculated as before. The voltage across R_G is E_{DD} less the voltage across R_X, or 40 volts − 2.03 volts ≈ 38 volts. (2.03 is E_{GG}, the voltage across R_X). As I_G, the current flowing through R_G is about the same as the current flowing through R_X, or $2.03/10^5 \approx 2\times10^{-5}$ ampere, R_G is 38 volts/2×10^{-5} ampere = 1.9 megohms. Use a standard EIA 1.8 megohm resistor.

Should the more stable circuit in Fig. 6 be desired, the quiescent voltage across R_G is that at the drain, V_D, less E_{GG}, the voltage across R_X. Because the quiescent drain current is 3.43×10^{-3} ampere and the resistor in the drain circuit is 5600 ohms, the voltage across R_D is (3.43×10^{-3}) (5600 ≈ 19 volts. The voltage across R_G is 19 − 2.03 ≈ 17 volts. Assuming that I_G is equal to the 2×10^{-5} ampere determined above, R_G for this circuit is $17/2\times10^{-5} = 8.5\times10^5$ ohms. The standard 820,000 ohm resistor may be used here. *(continued next month)*



"So you built a laser beam projector. What else is new?"

Service Clinic

By JACK DARR SERVICE EDITOR

VERTICAL OUTPUT CIRCUITS

THERE'S ONE IMPORTANT CIRCUIT, used in all TV sets, that can be confusing. It's actually very simple, but by the time the manufacturer gets through adding things to them, they don't *look* simple. This is the vertical oscillator and output stage. The one I'm refering to is the almost-standard multivibrator, using dissimilar triodes such as the 7GF7, and many others. One is a voltage amplifier, the other a power amplifier.

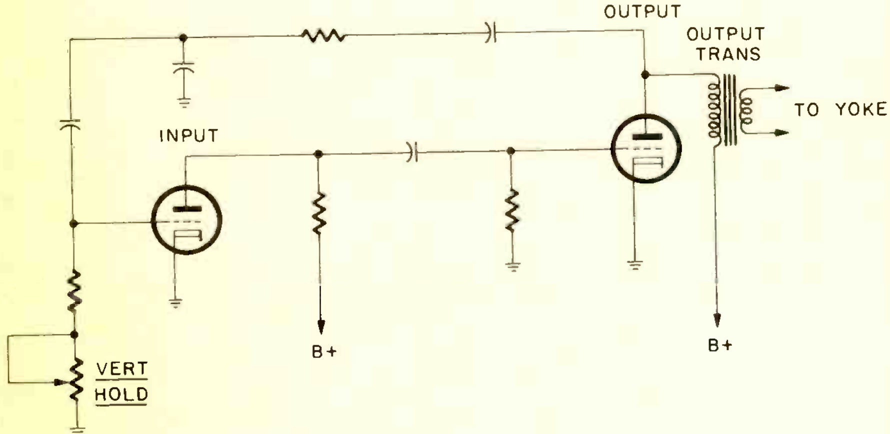


Fig. 1

Fig. 1 shows a simplified version of this—the bare bones of the MVB. Put your hand over the parts on top and what do you see? A plain R-C coupled audio amplifier. Now, uncover the top parts and you'll see that this is a *feedback* from output to input. In other words, almost 100% regenerative feedback (tending to cause oscillation.)

So if the parts in here, (all *nine* of them, plus the tube) are good, it *has* to oscillate! If it doesn't oscillate, one (or more) of the 9 parts is bad. All of them are critical. You can't take any dc leakage through the capacitors, or any drastic change in resistor values. This upsets the frequency. With such a small number of "active" parts, you can "shotgun" this circuit if you want to—replace *all* of the parts at once.

However! Before we start loading the shotgun let's look at some key symptoms. If you know how the thing works, and what it's *supposed* to do, it won't take long to find out if it's doing it. For example; "The picture rolls up or down, but it won't stop!" Do you check the vertical *oscillator?* If you do, you're wasting valuable time. This is a vertical sync problem! All the oscillator is supposed to do is "make the picture roll up or down." In plain words, run slightly faster or slower than the correct frequency. If it does that, forget the oscillator and go for the sync, which is obviously missing.

Ok, what *does* indicate oscillator trouble? When the picture *WILL NOT REVERSE* direction! It rolls down or up, at all times; or runs so fast that you can see only half a picture, or so slow that you see two complete pictures. Now you've got oscillator trouble. It is always directly related to the *quality* of the parts in the oscillator circuit. A very small leakage in a capacitor in the feedback loop and the oscillator frequency changes. A change in the value of a resistor in the hold control circuit, the plate circuit, or any other, also changes the operating frequency, and the hold control won't make it reverse, as it must.

The vertical output transformer

Before we leave this section for the moment, let's look at a part which is often replaced unnecessarily; the vertical output transformer. A careful analysis of the symptoms will show you that in most cases, it couldn't be bad. An output transformer can have two defects; it can be open, in which case you get no vertical sweep at all, and it can be checked with an ohmmeter. Or, it can have shorted turns. In this case, your linearity is badly upset, usually stretched out near the top of the picture. (Don't replace it yet. Look for a big electrolytic cathode bypass on the output tube. If it is open, you'll get very much the same symptoms. Bridge a new one across the original to find out.)

The yoke.

Yokes are another oft-replaced part, when they shouldn't be. Same as the output transformer. An open yoke can cause no vertical deflection at all, and can be caught with the ohmmeter. A badly shorted yoke shows you the old keystone raster. The narrow end of the wedge points toward the winding that is shorted.

There is one yoke defect that is quite rare, but possible. If you see a quite severe "bunching" or squeezing up of the scanning-lines, at or near the middle of the raster, (not at the very top, or the very bottom) look out. This is sometimes caused by a small short (only one or two turns) in one of the yoke windings. If you have this kind of symptom, and all of the coupling capacitors, bypass capacitors, etc. are good, look for it.

While not universally true, sometimes you can pin it down by checking the dc resistance of the two halves of the vertical yoke. They should match closely. If you find a difference of several ohms, there is a distinct possibility that the squeezing of lines means a shorted yoke winding. Try another yoke of about the same inductance. If you can get a *linear* raster, even though it falls short of filling the screen, a new yoke is indicated.

(More on vertical sweep next time)

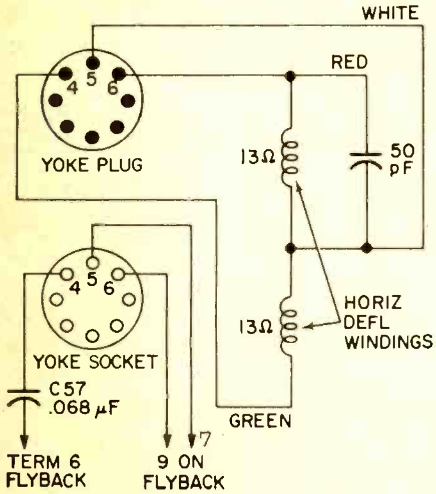
This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

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.

THIN WHITE LINE. (VERTICAL!)

I put a new yoke in an Airline GEN-1367A TV. In about a week it came back. Now I have a thin white vertical line on the screen and I think the new yoke is out!—H. V., Glen Burnie, Md.

Not too likely, although nothing is impossible. Check the dc resistance of the two halves of the horizontal deflection coil from the center tap. If they are *the same,* the chances are that the yoke is still OK. The presence of



the thin white vertical line shows that you are still getting high voltage, so this trouble is probably in some other part.

Check the horizontal deflection return capacitor, C57, the .068-μF from pin 4 of the yoke socket to terminal 6 of the flyback. If this is open you'll get exactly the symptom you have now.

OFF-COLOR CONDITION

I've got funny colors in a Zenith 20Y1C50 chassis. Looks very odd; Orange, heavy blues, and not much green. I've checked the bandpass amplifier and demodulator tubes, but no help. Any ideas?—D. E., Comnack, N.Y.

If you haven't replaced the 6JU8 triple-diode tube, try it. We have had some extremely odd color symptoms like this caused by leakage across the diodes in these tubes. While you are at it, check the voltages on the "deflection plates" of those 6ME8 demodulator tubes (pins 1 and 2). If these aren't exactly *equal,* they can cause some very peculiar color symptoms.

NO COLOR, MAGNAVOX T-940

I can't get any color on a Magnavox T940. This chassis has the TAC automatic color control. I can get the comb-pattern (color-bar) waveforms on my scope right up to the input of the TAC board, but none out. Switching the TAC out doesn't seem to have any effect. R.Q., Tulsa, Oklahoma.

You're losing it somewhere *in* the TAC circuit. Regardless of the position of the TAC switch, your color signals go *through* an amplifier transistor on this board. Check wiring, dc voltages, etc., and follow the color signal "comb" pattern through the TAC. You'll find out where it stops. **R-E**

EQUIPMENT REPORT
(continued from page 27)

410A probe fitted with extra-flexible cable and a BNC-type connector. A built-in switch sets up the probe for either dc or ac and ohms measurements. The WG-301A (accessory) crystal-diode probe extends WV-510A's frequency range to 250 MHz. It slips over the tip of the standard voltmeter probe and handles sine-wave rf voltages up to 20 V rms in the presence of dc up to 250 volts.

Voltages up to 50 kV are measured using the WG-411A high-voltage probe (another clip-on accessory) with a 100X multiplying factor. The WG-411A, with its 2079-meg resistor increases input resistance to 2100 megohms. This very high input impedance is required when measuring high voltages on CRT's, G-M tubes, photo multipliers and other high-impedance circuits and is especially useful when checking low-voltage circuits.

The WV-510A metering circuit is shown in the schematic. Input from the ac or dc voltage dividers is applied across the bases of bridge preamplifier transistors Q3 and Q4—positive to Q3 and negative to Q4. These transistors provide nearly infinite input impedance and minimum load on the volt-
(continued on page 87)

TRY THIS ONE

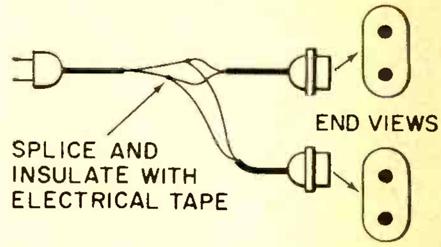
MARK RECORDING TAPE

One of the major problems in tape recording for your own use, is that tapes do come to an end, and at the most inconvenient times—just when you want to change them in a hurry. Another major problem is making sure which side of a tape you are on. To facilitate using recording tape, try this idea for marking the tapes.

Use two colors for leaders, red for side one, green for side two. Put a piece of Dymo Tape, punched with the tape number, at the start of the leader: this way you know both which tape you have out, since you can number-code them, and which side you are on, because either the red or green side is up. Using the Dymo tape for threading makes this simple, since it is stiff and yet flexible, and has adhesive backing so it may be turned and looped.—*Menno D. White*

DUAL CHEATER CORD

Most television and many radio sets are equipped with a safety interlock consisting of a power line disconnect that is riveted to the rear panel. Some of these interlocks are



polarized. This can pose a minor irritation to the service technician as he needs to apply power to these sets to check and adjust them, and may not have at hand a cheater cord with the proper receptacle (female end).

A simple answer to this problem is to parallel the female ends of both types (polarized and non-polarized) of connector cords as shown. In this way, the proper connector is always available with the first reach into the tool kit.—*Aaron W. Edwards*

TUBE LAYOUT UPSIDE DOWN

Place a carbon paper, *carbon side up*, under the paper on which you draw the tube layout for a TV set. This gives a top view on one side and a bottom view on the other, which is fine when working under the chassis.—*Harry J. Miller*

R-E

NEW BOOKS

ELECTRIC CIRCUITS. PART I; DIRECT CURRENT: PART II; ALTERNATING CURRENT by J. Richard Johnson. Holt, Rinehart & Winston Inc., 383 Madison Ave., New York, N.Y. 10017. 6 x 9¼ in. 556 pages. Hardcover, $9.95.

Thorough coverage is given to basic topics such as Ohm's Law, dc and ac networks, inductance, capacitance, reactance and transformers. Also included are electrical applications and characteristics of modern battery cells, fuel cells, effects of RC and RL circuits on non-sinusoidal voltages and currents and the phenomenon of superconductivity. Many completely worked out illustrative examples and problems are included. A high school background in mathematics is required. Calculus is not needed to use this book.

The second part of this two-volume set covers complex algebra and electric vectors, basic ac circuits, ac network theory and bridge circuits, resonance, polyphase circuits, transformers, and electrical measurements.

JACK DARR'S SERVICE CLINIC NO. 2, by Jack Darr. Tab Books, Blue Ridge Summit, Pa. 17214. 176 pages, 5⅝ x 8¾ in. Hardcover, $7.95, softcover, $3.95.

Here's more of Jack Darr's wisdom and wit in book form, a collection of timely service information and trouble solutions covering color and B&W TV, radio, stereo, recorders, CB gear, from RADIO-ELECTRONICS' monthly "Service Clinic" column. All new material—no repeats of Volume 1. Photographs and schematics, and a comprehensive index are added to material on electronic service problems, efficiency, tips on making tests and using test equipment, applications and modifications for existing instruments. A useful and practical book for the average technician.—*MCL*

DIGITAL SIMULATION OF CONTINUOUS SYSTEMS by Yaohcn Chu. McGraw-Hill, 330 W. 42nd St., New York, N. Y. 10036. 8 x 6½ in. 423 pages, hard cover. $14.50.

The purpose of this book is to teach engineering and scientific students how to use effectively a digital computer in solving problems which previously could be solved only by an analog computer. Since the subject matter involves the use of a digital computer, the book also teaches programming. However, the simulation of languages used are application-oriented, easy to learn and simple to use.

BETTER SHORTWAVE RECEPTION, by William I. Orr and Stuart D. Cowan. Radio Publications Inc., Box 149, Wilton, Conn. 06897. 160 pages, 8¼ x 5½ in. Softcover, $3.95.

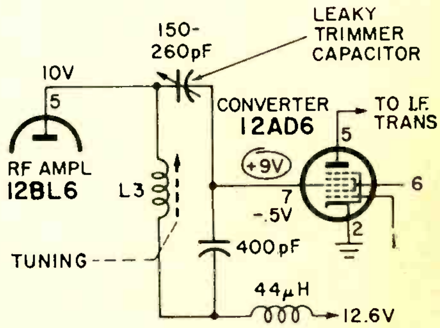
This is the second edition of this book, and has been revised and updated. In particular, the book has been expanded to cover the spectrum from long waves to microwaves. Of particular interest to the beginner and old-timer is the chapter on buying a used receiver and some of the pitfalls to avoid. The text also covers FM mobile service and Citizen's band radio. **R-E**

TECHNOTES

DEAD FORD RADIO

Not a peep could be heard from a Ford 14MF auto radio. Using a noise-type signal generator and working forward from the af output stage, the signal was traced to the grid section of the 12AD6 converter tube.

Voltage on the converter plate terminal was very low. Voltage on the 12AD6 signal grid (pin7) was +9 when it should have been −0.5. The rf amplifier plate voltage seemed to be normal. Either the trimmer or 400-pF capacitor was leaky (see diagram). A resistance measurement in-



dicated the trimmer capacitor was leaky.

The trimmer capacitor was a special type that would have to be ordered. Rather than tie up the radio we decided to repair the capacitor. Here is how it is done. Simply back out the small trimmer screw and check the position of the mica insulation. In most cases the break in insulation is where the screw head and washer tighten down against the first metal stator plate. Slip a piece of mica insulation between washer and stator plate.—*David Held*

SYLVANIA D-12011 CHASSIS

The symptom is intermittent loss of color with color returning when test equipment is touched to any part of the chassis. The coupling capacitor (C606) to the chorma amplifier base had 3 megs leakage and would heal intermittently. Replacing C606 cured the trouble.—*Sylvania Service Notebook*

MAGNAVOX T931, T933 and T940

Intermittent loss of color sync, poor color sync or even loss of color may be traced to the diodes in the color-killer detector or in the color-phase detector. Those diodes are specified as matched pairs. If one of the diodes should undergo a change in characteristics, circuit operation is impaired. Resistance checks will not enable you to determine if a suspected diode has changed characteristics. Use the following check if you suspect diodes:

Connect a color-bar generator to the receiver and set it for a normal color-bar display. Remove the 3.58-MHz oscillator tube (V708) and ground the junction of R756-a and R756-b in the color killer detector circuit. Use a vtvm and measure the dc voltage to ground from the outside end of each diode pair. For example, the cathode end of CR701-b and the anode of CR701-a. The voltage from ground to the cathode will be positive and from ground to anode will be negative. The exact value of the measured voltages will vary from set to set and also with the level of the burst signal. (Typical values may be −55 volts at the anode and +55 volts at the cathode.) The important factor is the difference, if any, in the voltages measured across each diode pair. Ideally, the voltages across a diode pair will be identical but a 10% variation is allowable. If a voltage difference of more than 10% is noted across either diode pair, replace that pair with a matched pair, part No. 170733-1. Do not replace just one diode of a pair.—*Magnavox Service News Letter* **R-E**

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HOME APPLIANCE ELECTRONICS
(continued from page 26)

lay RY2 closes, doing the same thing for tube V2, which in turn closes RY3 in its plate circuit. This controls the solenoid valve which actually switches the door-mechanism. It also starts a pump to supply the hydraulic pressure. All of this was obviously working very well, since the door did open and close. The problem was in the *timing.*

This is controlled by the grid voltage of V1. When the positive voltage is applied, it charges up capacitor C1, a 0.5-μF from grid to ground. When you step off the mat, opening the circuit, RY1 opens. The charge on C1 now leaks off through a big variable resistor, R1. The time needed for the grid voltage to drop to the point where the tube stops drawing current is determined by the setting of R1.

This is the "time constant" of this circuit. To find out exactly how much delay you'd get, simply multiply the capacitance of C1 in microfarads by the resistance of R1 in megohms, and you come out with the time, in seconds. Here, the resistor was 10 megohms and the capacitor 0.5 μF, so the maximum time constant should be 5 seconds. This, we didn't have, so we took the "electronics" out, and went to the bench with it.

Connecting it up, we turned it on, and jumpered the mat-switch contacts 1 and 2. The relays closed, and the grid voltage of each tube jumped up to about +15 volts. This was read with a 15-megohm input impedance TVM, since this is a pretty high-Z circuit. Tube V2 held as it should. However, the grid voltage of V1 dropped off very rapidly! When it got down to about a +3 volts, RY1 opened. Several seconds later, RY2 opened, after V2's grid had fallen to the same value.

"Well, that's what you said it was" said Friend. "Too short a time constant!" I smiled (very pleased also mildly astonished), and disconnected the charging capacitor on the grid of V1. Sure enough, this showed a fairly high leakage on the insulation resistance test of my capacitor tester. An ohmmeter wouldn't show this, since the total leakage was in the order of several megohms.

I replaced it, after carefully checking the new one for leakage. Now this tube would hold its grid voltage up for several seconds, and the variable resistor would adjust the time-constant between about 7 and 2 seconds. This was just what we wanted. So, I replaced the other one, too, just for luck. (The unit was mounted above a 30-foot ceiling, and pretty hard to get to!) and we re-checked circuit operation.

Taking it back and re-installing it, it worked just like new, and everyone was happy.

So, there you are. When you run into something like this, that you've never seen before, look it over carefully. The chances are that you'll find some "old friends" in the way of simple electronic circuits just like this. If so, by applying your basic knowledge of electronics, you'll be able to figure out just how they work.

In this application, of course, the actual time constant was not just the same as the one used in radio-TV circuits; this is the time it takes for a given percentage of the total charge to leak off; 70.7% of it, I think. Here, the time-constant would be the time it took for the positive voltage to leak off to the point where the tube was once more cut off. This would depend on the tube, the applied plate voltage, screen grid voltage, and so on. However, the principle is the same.

There's another familiar circuit in here; look at the dc power supply! Silicon diode half-wave rectifier (D1) with a 20-μF electrolytic filter capacitor. If the filter capacitor should open, the unit wouldn't work, because of low plate voltage. The diode could also open or short; in other words, same old type of trouble you'd find in any ac/dc radio! Dc voltage, by the way, is about +150 volts, dropping to about 50–60 volts under load.

You'll find this kind of application, of simple electronic circuitry, used in quite a few things. You can fix them with ease, if you'll look them over carefully, and make sure that all of the "necessaries" are present: dc voltage, good parts, tubes, transistors, etc. You won't find any new things; just the same old things used for different purposes. **R-E**

"I like to keep in constant contact with all my patients."

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EQUIPMENT REPORT
(continued from page 79)

age dividers by virtue of positive feedback networks consisting of R1 and R2 and pots R3 and R4. Transistors Q3 and Q4 drive the bases of Q1 and Q2, respectively. Negative feedback developed by unbypassed emitters for Q1 and Q2 gives these transistors a high input impedance to prevent loading the Q3 and Q4 emitters. Voltage is read on the meter connected between the collectors of Q1 and Q2. The bypass capacitors shown prevent ac signals from affecting the meter circuit. The front panel ZERO control balances the meter amplifier output with no signal applied.

Ac voltages being measured are applied to a full-wave peak-to-peak rectifier that charges a capacitor to the p-p value of the ac signal. This voltage, now dc, is fed to the amplifier through the range voltage divider network.

When measuring resistance, 1.5 volts dc is applied to the unknown resistor through one of the resistance-range resistors. The known and unknown resistances form a voltage divider whose output is fed to the amplifier and read out on the meter in terms of resistance.

The amplifier is not used when direct current is being measured. A current-range resistor is shunted across the meter and the current input is connected across this network. A pair of diodes—connected across the meter with opposite polarity—protect the meter against damage due to accidental overload.

WV-510A is easy on batteries but includes circuit for testing them. To check the 9-volt batteries just unplug the ac power cord and set the function switch first to BATT TEST A and then to B. The meter pointer should not read below the green area on the BATT TEST scale in either of the two positions.

As the schematic shows, the 9-volt batteries are used in series-connected pairs. One pair, (B+1 to Q1 and Q2) is checked in position BATT TEST A. The second pair (B+2 as bias for Q3 and Q4) is checked in BATT TEST B position. The 1.5-volt "D" cell should be replaced when it is no longer possible to adjust the OHMS control and bring the pointer to exactly full-scale.

Loosening four screws on the back lets you remove the case to expose the battery compartment. The 9-volt batteries (replaced in pairs) are inserted in brackets and the connectors snapped onto their terminals. The "D" cell is soldered in place after its positive and negative terminals have been tinned. **R-E**

"OOPS, SORRY! - I DIDN'T KNOW THIS SOLDER GUN WAS LOADED."

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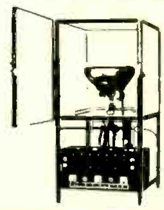

R-E ON FILM

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100	.40	.70	1.00
200	.70	1.10	1.40
300	.90	1.35	1.80
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400	.16	.35	.90
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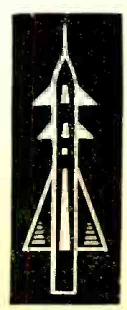

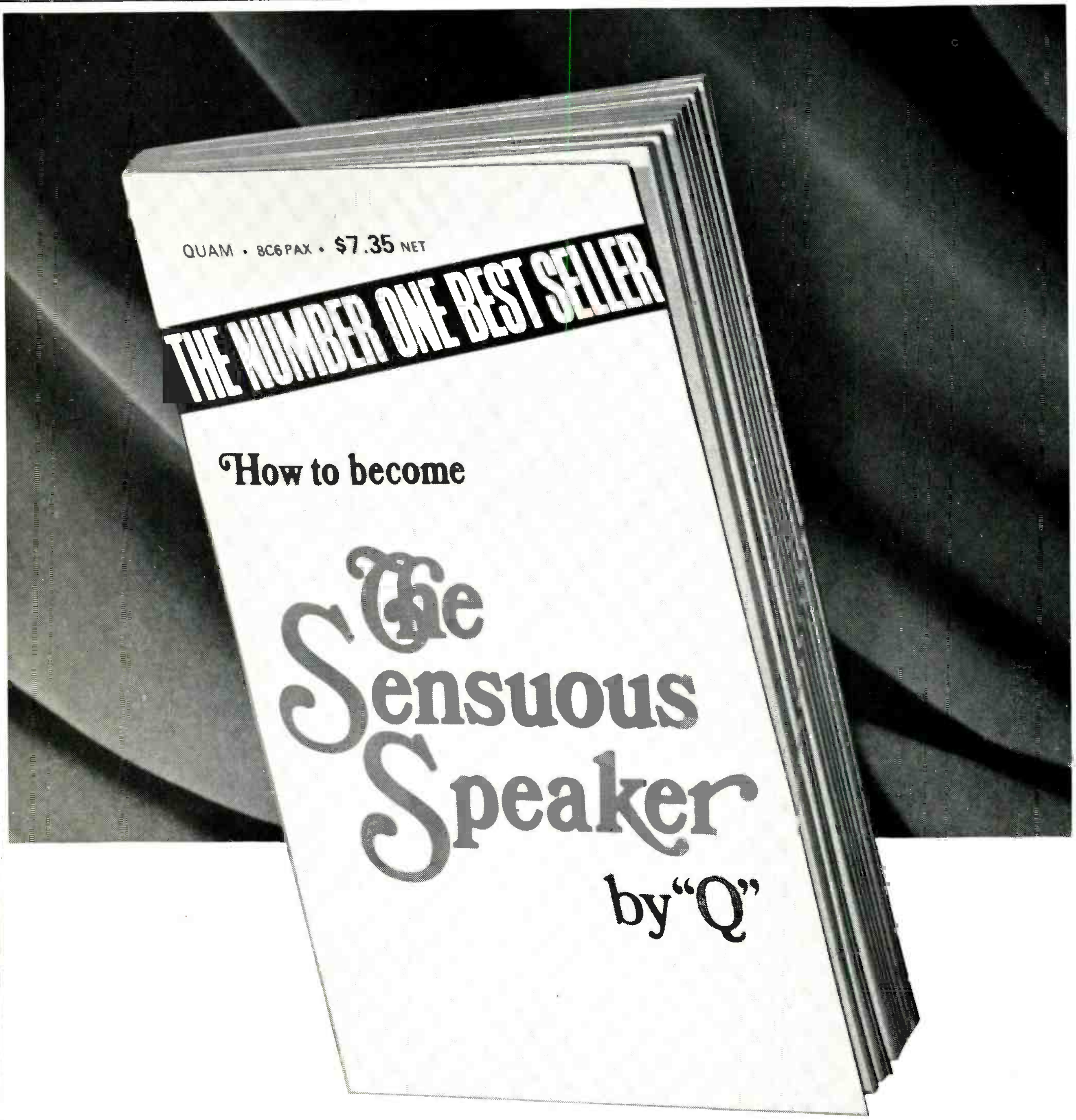

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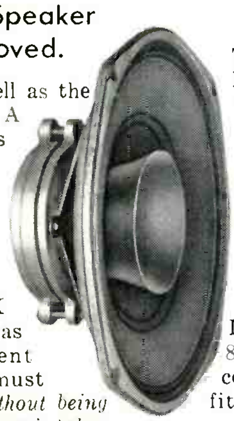

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