20 experimenters' SCR circuits

How to make etched circuits

Last-Word IC stereo tuner

Inside Vackar oscillator

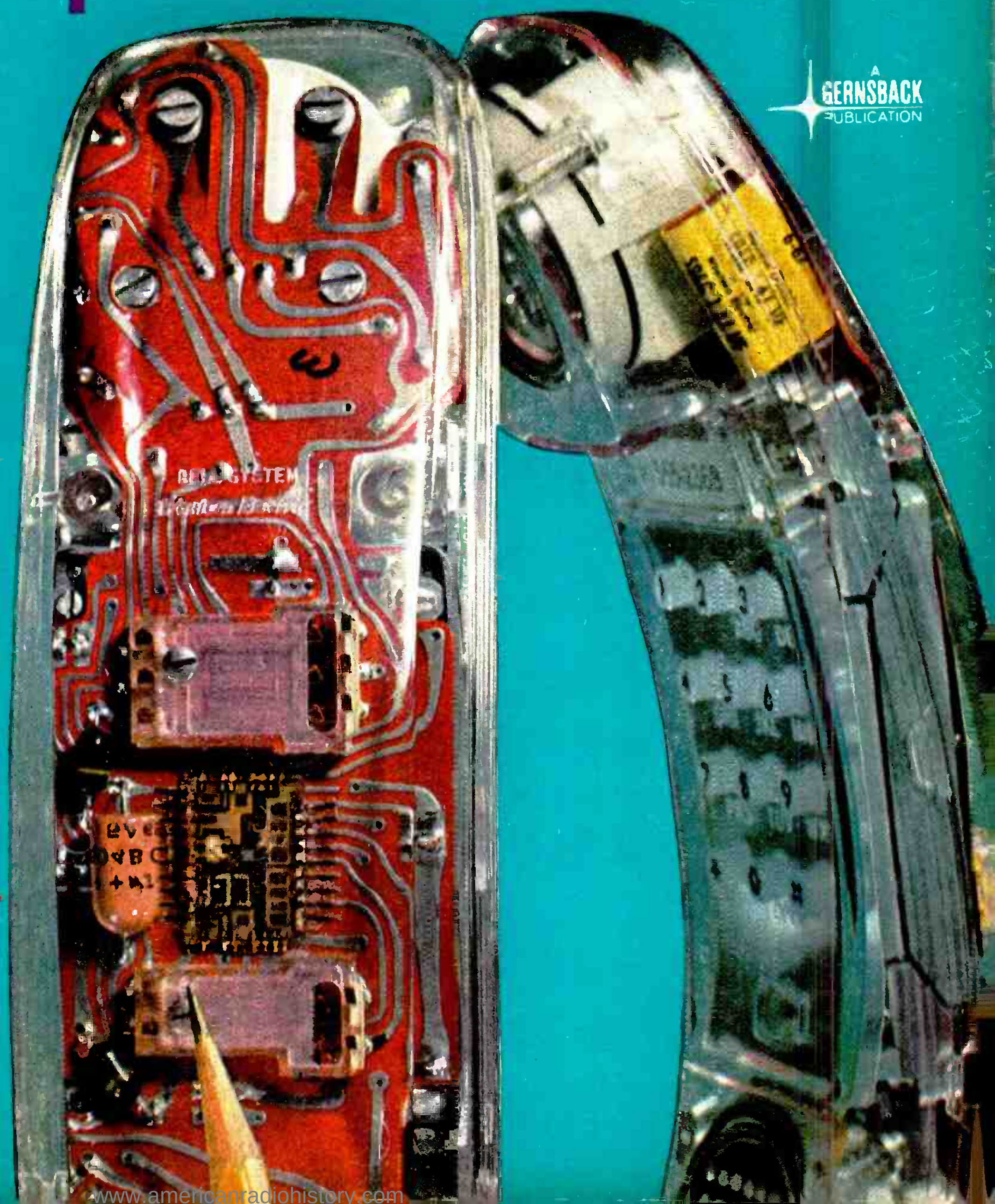
60¢ ■ JUNE 1969

Radio-Electronics®

Fix TV's Fast

NEW R-E EXCLUSIVE

Kwik-Fix™ picture and waveform charts



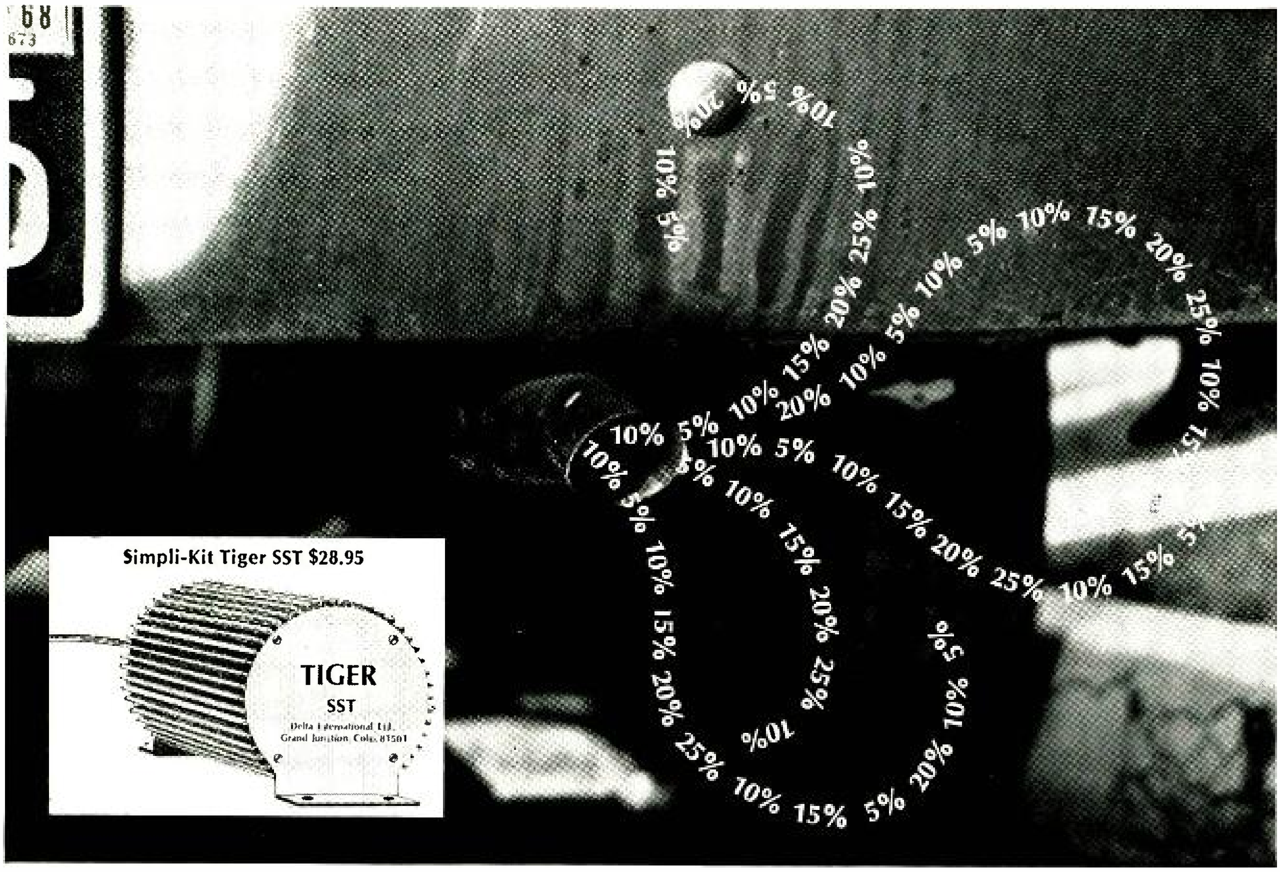
A GERNSBACK PUBLICATION

Build IC Tach For Your Car

NEW!

IC's In Today's Push-button Phones

All About IC's- What Makes Them Tick?



Capture that top 10% (at least) engine performance you're now blowing out the exhaust!

Announcing a new generation C. D. Ignition System—the Tiger SST.

Here, in a compact new unit, are all of the advantages of previous capacitive discharge systems that have been chalking up such impressive performance records the past several years—plus a good deal more. The dramatic results:

- gas mileage is increased up to 25%
- points and spark plugs last up to 5 times longer
- you go up to 5 times longer between tune-ups

The added performance your engine delivers with the Tiger SST is the fun part. You'll enjoy sharper acceleration to higher speeds—a smoother running engine at **all** speeds. And your engine will last longer.

Our new Tiger C. D. System is compatible with all domestic and foreign cars and trucks with 12 volt, negative ground systems. In Simpli-Kit form, the unit is easy to assemble and install in less than 60 minutes—no special skills or tools required. The unit is moisture proof and is not affected by underhood temperatures.

Order your Tiger SST today. It's the latest, most advanced C. D. System available. And, if you do an average amount of driving, it should pay for itself in less than two months. You'll be satisfied. Guaranteed. Money back.

Dealer/Distributor inquiries invited.

Special free offer!

Order now and receive a convenient to have, ruggedly built rechargeable flashlight **free.** It's a $4.95 value that can put an end to the annoyance of dead batteries. Your order must be received within 30 days from date of this publication.

Delta International, Ltd.
Box 1946C, Grand Junction, Colo. 81501
Enclosed is my check (or money order) for $______
Please send prepaid:

☐ **Simpli-Kit Tiger SST @ $28.95**
☐ Assembled Tiger SST unit @ $39.95

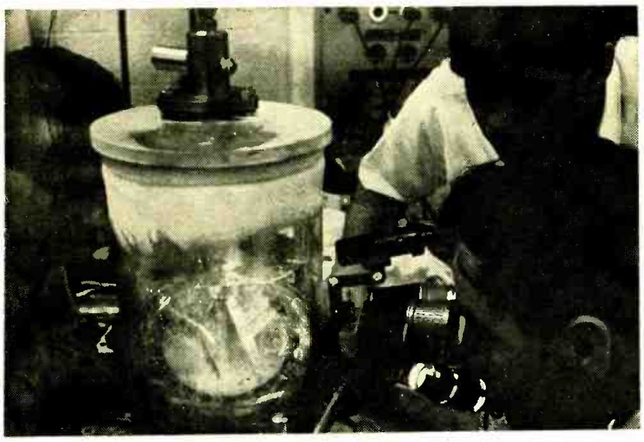
Make of car: ______ Year: ______
Name: ______
Address: ______
City/State: ______ Zip: ______

Circle 8 on reader service card

NEW & TIMELY

Volume 40 Number 6 RADIO-ELECTRONICS June 1969

NEURISTOR 'GRAY MATTER' AHEAD?



Cryogenic neuristor in its liquid helium bath is studied at U of W.

MADISON, WIS.—A superdense electronic brain using cryogenic tunnel junction neuristors is feasible according to three University of Wisconsin electrical engineers now investigating "synthetic gray matter."

In liquid helium. neuristors work similarly to the 10 billion neurons of the human brain. Insulating material sandwiched between two strips of superconducting metals breaks down when a pulse is applied across one end of the strip. The pulse travels to the opposite end much like a nerve impulse.

With IC techniques, component densities of 200 million per square foot are economically possible, the engineers believe. Since neuristors draw no current in the resting state, a brain-size system would not require excessive power.

Profs. A.C. Scott. R.D. Parmentier and J.E. Nordman feel the nearly impossible task of connecting individual neuristors could be overcome by "teaching" neuristors into a pattern, imitating the brain's organization of its neurons.

This might be done by adding bits of ferromagnetic material between each neuristor. When information is programmed in. the bits would become increasingly magnetized, gradually establishing preferential neuristor current paths.

SOLID-STATE VIDICON USES PHOTODIODES

NEW YORK—Among the new products unveiled at the IEEE Show here was a solid-state TV vidicon tube made by RCA. Although a vacuum tube, the target of the new device is an integrated mosaic pattern of several hundred thousand silicon photodiodes. The photodiode technique was first developed at Bell Labs.

The new vidicon is designed for closed-circuit TV cameras, but later versions are expected to be adapted to b-w and color broadcasting systems.

LOOKING AHEAD

By DAVID LACHENBRUCH
CONTRIBUTING EDITOR

Flat-screen breakthrough?

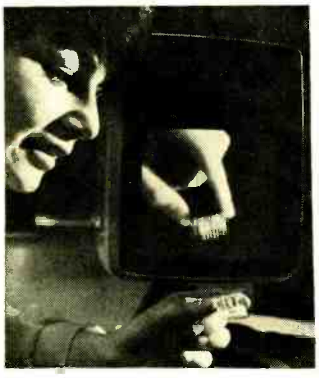
Although many American companies in the last 20 years have claimed progress toward an electroluminescent picture-on-the-wall flat TV display, none is believed to have progressed to the point where an actual off-the-air television picture could be shown. Now, at almost exactly the same time, two Japanese firms have actually shown recognizable pictures on experimental display panels. Both Matsushita Corp. (parent company of Panasonic) and Mitsubishi Corp., developers of these flat-screen approaches, say their use for television is still some time off.

In the U.S., attention appears to be shifting from electroluminescent panels to plasma devices in research looking toward elimination of the picture tube. Several projects are under way to develop color displays utilizing trapped ionized gases which glow in different colors.

Off-color commercials

The continuing television industry study of the lack of color uniformity in broadcast transmissions (Looking Ahead, April 1969) has come up with an interesting reason why commercials often show up poorly on color TV: It's not your set or the transmitter; nearly 40% of filmed commercials may have bad color in the first place. In subjective and objective evaluations of a large number of films shown on television, an engineering task force found that 35mm films had less color variations than 16mm, and that program and news films varied less than commercials.

Then 180 commercials were tested, and the task force concluded that "30 would not look good to any observer on TV or direct projection," while another 40 were rated "questionable." (continued on page 12)



600-COMPONENT IC CONTROLS TV PHONE

MURRAY HILL, N.J.—Through its closeup lens this Picturephone displays one of the key IC's that controls its timing circuits. The Bell Labs-produced IC has some 600 components in less than a square inch. It controls the TV telephone's CRT scan rate, frames per second and interlacing—to sharpen the picture and eliminate flickering. The Picturephone, currently being trial-tested between the New York City and Pittsburgh offices of Westinghouse Electric Corp., is expected to be put into nationwide service within a few years.

LASER SCAN PROVIDES HIGH-QUALITY PHOTOS

A radically new technique for transmitting high-resolution pictures via satellite is being used to send reconnaissance photos of North Vietnam to the Pentagon within minutes after a reconnaissance aircraft lands.

The device scans a photographic image with a laser beam, converting variations in tone to electronic impulses. The signal obtained is then transmitted to Washington through a military satellite, and reconverted by another laser scanner and developing equipment into a picture very close in quality to the original photograph.

Resolution of the image is reportedly several times high- (continued on page 6)

Radio-Electronics

June 1969 • Over 60 Years of Electronics Publishing

BUILD ONE OF THESE

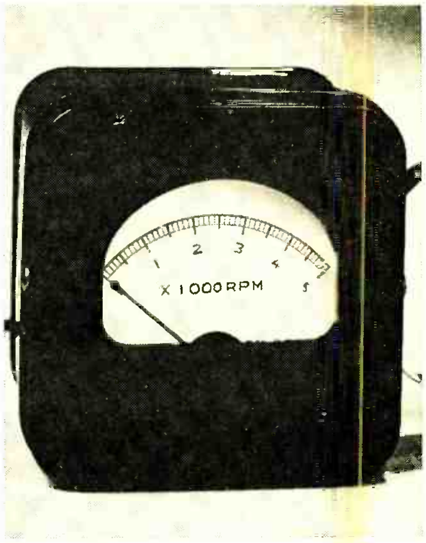
TELEVISION

AUDIO—HI-FI—STEREO

FOR THE EXPERIMENTER

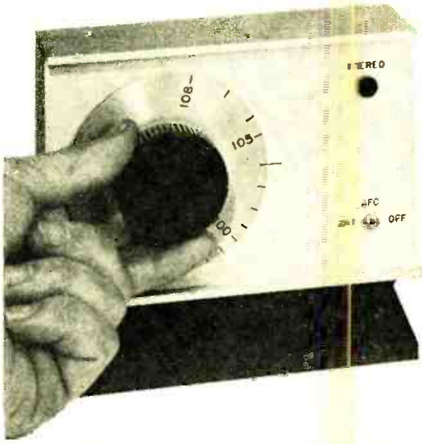
GENERAL ELECTRONICS

It's our anniversary! This month Radio-Electronics is 40 years old. Our first issue was published in June 1929 under the Radio-Craft masthead. We know our readers have enjoyed those first forty years and we are doing our best to make the years to come just as much fun.



IC Tachometer can help you get better performance from your car. The IC makes it easy to build by cutting down the number of needed parts.

see page 52



Stereo Tuner is a prize package. Uses VVC diodes instead of variable capacitors, has an IC i.f. strip and you can remote the front end. Build it!

see page 36

DEPARTMENTS

RADIO-ELECTRONICS, JUNE 1969, Vol. 40, No. 6
Published monthly by Gernsback Publications, Inc., at Ferry St., Concord, N. H. 03302
Editorial, Advertising, and Executive offices: 200 Park Ave. S., New York, N.Y. 10003. Subscription Service: Boulder, Colo. 80302.
Second-class postage paid at Concord, N. H. Printed in U.S.A. One-year subscription rate: U.S. and possessions, Canada, $6. Pan-American countries, $7. Other countries, $7.50. Single copies, 60¢.

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

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

FLAT-SCREEN TV HAS 52,900 PICTURE ELEMENTS

Experimental flat-screen set is checked by project director Yoshiyama. Model uses some 8600 components.

NEW YORK—Curious visitors jammed the darkened interior of Panasonic's booth at the March IEEE Show to view TV programs on a screen no thicker than this magazine. The 50-lb experimental set is likely to be a forerunner of flat-screen models that can be hung on walls.

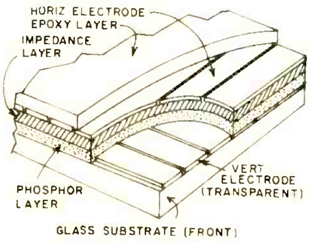
The 8 x 10.7-inch electroluminescent screen has 230 vertical and 230 horizontal electrode strips. A phosphor layer between these strips (diagram, right) provides 52,900 picture elements. The 0.04 x 0.03-inch size of each element maintains the standard 4:3 picture ratio.

Resolution is fair, but the phosphor has a distinct green hue and contrast and brightness are low. Writing in *Electronics*, project director Masami Yoshiyama (photo above) compares the image detail to that obtained from some low-cost video tape recorders. Instead of the odd–even scan pattern used in conventional receivers, both fields are successively displayed on the same horizontal lines. This boosts brightness but cuts resolution.

Lumped video delay

Here is how a single horizontal line of the 230 x 230 matrix is scanned. The horizontal electrode receives a negative selecting pulse, while blanking pulses dim the lines not being scanned. Simultaneously, a sampled video signal for the entire line is applied to all the vertical electrodes. This is accomplished with a 50.6-μsec lumped delay line, which holds the video for the scan line until it can be displayed simultaneously when the horizontal pulse is applied.

The brightness of each element is a function of the video pulse amplitude on the vertical strips, varying exponentially, within limits, with the pulse width. The input transistor to each vertical strip serves as a variable resistor, its collector resistance modulated by the sampled video from the delay line.



Then, after one line has been scanned, a counter, triggered by the horizontal sync signal, steps the horizontal pulse distributor to the next line. A second horizontal pulse generator simultaneously delivers blanking pulses to all other lines.

Improved phosphor

The cutaway drawing of the matrix display panel shows an impedance layer between the horizontal electrodes and the phosphor layer. This reflective coating of barium titanate improves brightness and contrast because of its nonlinear characteristics. The vertical strips are transparent, and the horizontal electrodes are aluminum evaporated.

Panasonic plans to test a display panel with an improved phosphor coating shortly. The zinc sulphide compound used now requires dim lighting for comfortable viewing.

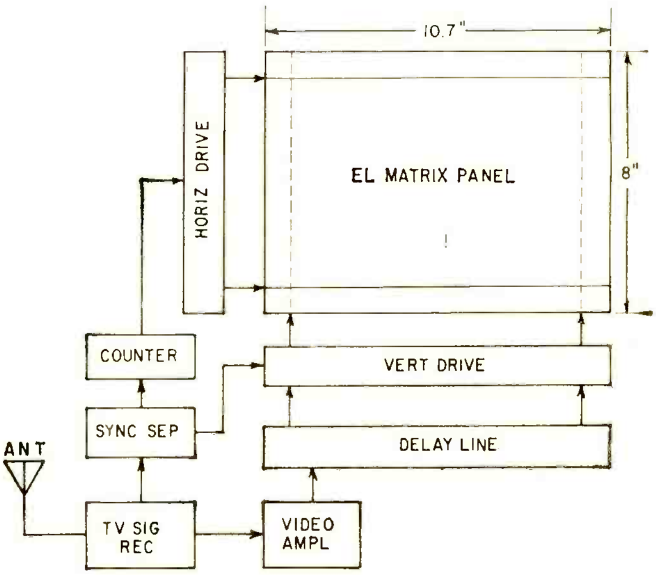
The prototype model demonstrated at the Show was equipped with provisions for video tape recorders and closed-circuit cameras in addition to VHF reception. With circuit modifications, the display system could be adapted for graphic and alphanumeric readouts.

IC's are used in the counter circuits and could simplify the brightness circuits.

Some 8600 components are used in the set, comparable to the number in a desk-top electronic calculator. Power consumption is about 100 watts.

(continued on page 6)

Screen photo made during IEEE show. Image is a dark green color.



(continued from page 4)

er than the French 809-line TV standard, and better than that obtainable with the best printing techniques available.

Dr. Peter C. Goldberg, president of CBS Labs, developer of the technique, indicated in a *New York Times* story that 15 similar high-quality pictures could be distributed globally within 5 seconds if the system is adopted for civilian applications.

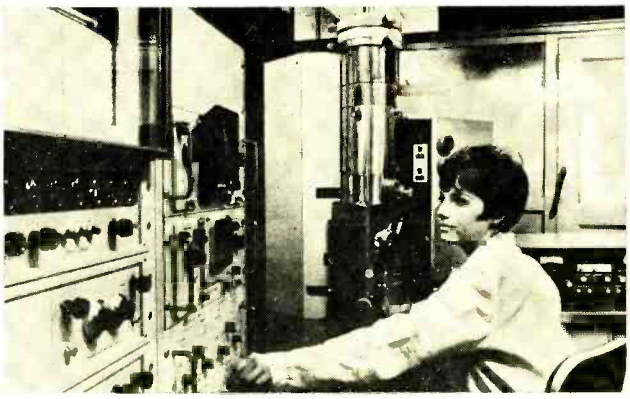
REVISED SIGNAL CODE HAS MEDICAL SYMBOLS

"Oo-nah-won. ok-to-ait" might mean a broken thumb at sea. This code word pronounciation for the number 18, code for a thumb, is part of a revised International Code of Signals that went into effect April 1.

The new code contains a detailed list of diseases and parts of the body by number, and is meant to improve medical communications over marine radiotelephones.

Alfa, Bravo, Charlie, Delta alphabet designations that replaced the Able, Baker, Charlie, Dog code in the 1950's have been retained in the code revisions. But the syllables that should be stressed have been emphasized. In "November," the code word for "N," the "vem" should be stressed, for example.

NEW SCOPE SPOTS ELEMENTS



MOUNT VERNON, N.Y.—Researchers now have a new tool to identify the chemical composition of microscopic samples. Called the electron probe micro-analyzer, the new instrument looks and works like an electron microscope.

When the 50,000-volt electron beam is focused on unknown samples, X-rays radiate from the substance. Each element emits its characteristic X-ray wavelength.

These wavelengths then pass through a rotating lithium fluoride crystal, which separates the X-rays like a glass prism separates light wavelengths. An X-ray counter tube registers each of the spectrum bands, and a computer tied to the crystal motor and counter determines the various angles of the radiation passing through the crystal. The computer then prints out a report of the specimen's composition. The micro-analyzer, selling for up to $100,000, is made by Philips Electronic Instruments.

IHF MAY BAR RATING ABUSERS FROM SHOWS

NEW YORK—To help combat the misuse of hi-fi amplifier wattage ratings (New & Timely, April 1969), the Institute of High Fidelity has indicated it may bar abusers of its standards from IHF hi-fi shows. John Koss, IHF president, also suggested legal action might be taken against manufacturers who deviate from IHF standards while using its identifying initials.

A typical abuse is the use of rating formulas expressed as "IHF (watts) ± dB."

NEW X-RAY DETECTORS ON THE MARKET

Two new do-it-yourself x-ray detectors for checking out color TV sets have cropped up. One tester is a plastic pod that is intended to be fastened to the TV screen. It contains a ⅛-inch square crystal of calcium fluoride doped with manganese phosphor. The set is turned on for 10 hours and the pod is then sent to the manufacturer for analysis. Set owner gets a card telling him satisfactory, marginal or excessive.

Another tester is a plastic device said to contain "electrostatically charged beads." With the set on you shake the container until the beads float in mid-air. To read radiation level you time how long it takes beads to fall to the bottom of their container.

The worth of either devices may be open to question. Measuring the extremely small amounts of radiation a TV emits, usually requires special sensitive instruments to get precise readings. It only takes a tiny error to cause extremely erroneous readings.

One city (New York) looks askance upon do-it-yourself testers. They have barred them, claiming they violate the city health code provision that forbids radiation surveys not conducted by qualified experts.

(continued on page 12)

Radio-Electronics

HUGO GERNSBACK (1884-1967) founder

M. HARVEY GERNSBACK, *editor and publisher*

LARRY STECKLER, *managing editor*

Robert F. Scott, *W2PWG senior technical editor*

John R. Free, *associate editor*

Jack Darr, *service editor*

I. Queen, *editorial associate*

Matthew Mandl, *contributing editor*

David Lachenbruch, *contributing editor*

Carrie Ng, *editorial assistant*

Vincent P. Cicenia, *production manager*

Elizabeth Shincel, *production assistant*

G. Aliquo, *circulation manager*

Cover by Harry Schlack

RADIO-ELECTRONICS is published by Gernsback Publications, Inc.
200 Park Ave. South
New York, N.Y. 10003
(212) 777-6400

President: M. Harvey Gernsback
Vice President-Secretary: G. Aliquo

ADVERTISING REPRESENTATIVES

EAST
John J. Lamson, Eastern Sales Mgr.

MIDWEST/N.&S. Car., Ga., Tenn.
Robert Pattis, the Bill Pattis Co.,
4761 West Touhy Ave.,
Lincolnwood, Ill. 60646
(312) 679-1100

W. COAST/Texas/Arkansas/Oklahoma
J. E. Publishers Representative Co.,
8380 Melrose Ave., Los Angeles,
Calif. 90069, (213) 653-5841;
420 Market St. San Francisco, Calif.
94111, (415) 981-4527

UNITED KINGDOM
Publishing & Distributing Co., Ltd.,
Mitre House, 177 Regent St.,
London W.1, England
RE 6534,5

SUBSCRIPTION SERVICE: Send all subscription orders and correspondence to RADIO-ELECTRONICS, Subscription Department, Boulder, Colo. 80302.

MOVING? For change of address, allow six weeks, furnishing both the old and new addresses and if possible attaching label from a recent issue below. Otherwise please print clearly your name and address exactly as it appears on your label.

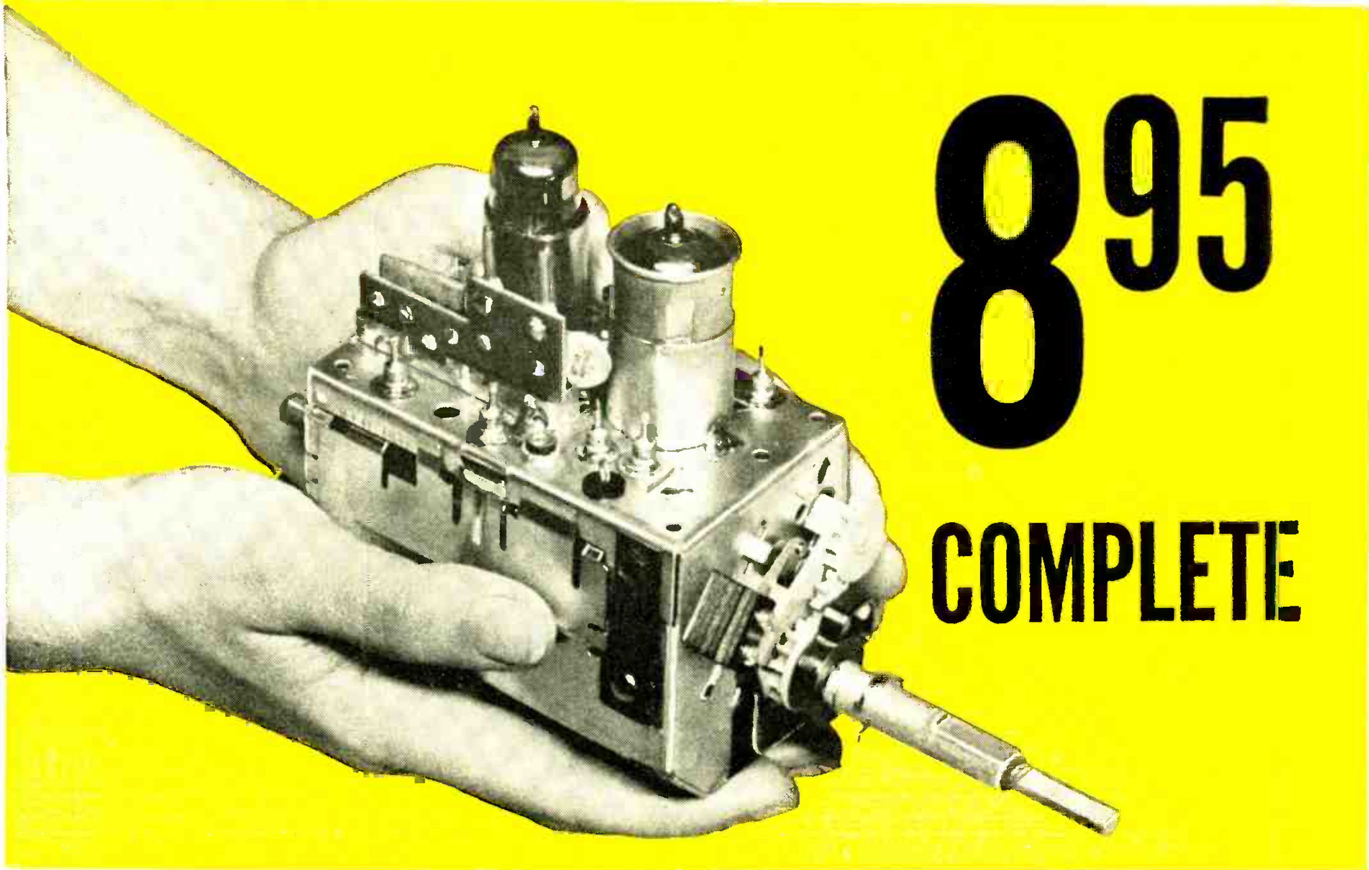
ATTACH LABEL HERE

name (please print)

address

city state zip code

Mail to: RADIO-ELECTRONICS
SUBSCRIPTION DEPT., BOULDER, COLO. 80302



Castle, the pioneer of television tuner overhauling, offers the following services to solve ALL your television tuner problems.

● OVERHAUL SERVICE — All makes and models.

VHF or UHF tuner	$9.95
UHF-VHF combination (one piece chassis)	$9.95
TRANSISTOR tuner	$9.95
COLOR tuner (Guaranteed color alignment . . . no additional charge)	$9.95

Overhaul includes parts, except tubes and transistors.

Simply send us the defective tuner complete; include tubes, shield cover and any damaged parts with model number and complaint. Your tuner will be expertly overhauled and returned promptly, performance restored, aligned to original standards and warranted for 90 days.

UV combination tuner must be single chassis type; dismantle tandem UHF and VHF tuners and send in the defective unit only.

And remember—for over a decade Castle has been the leader in this specialized field . . . your assurance of the best in TV tuner overhauling.

● CUSTOM REPLACEMENTS

Exact replacements are available for tuners that our inspection reveals are unfit for overhaul. As low as $12.95 exchange. (Replacements are new or rebuilt.)

● UNIVERSAL REPLACEMENTS

Prefer to do it yourself?

Castle universal replacement tuners are available with the following specifications.

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

*Selector shaft length measured from tuner front apron to extreme tip of shaft.

These Castle replacement tuners are all equipped with memory fine tuning, UHF position with plug input for UHF tuner, rear shaft extension and switch for remote control motor drive . . . they come complete with hardware and component kit to adapt for use in thousands of popular TV receivers.

Order universal replacements out of Main Plant (Chicago) only.

CASTLE TV TUNER SERVICE, INC.

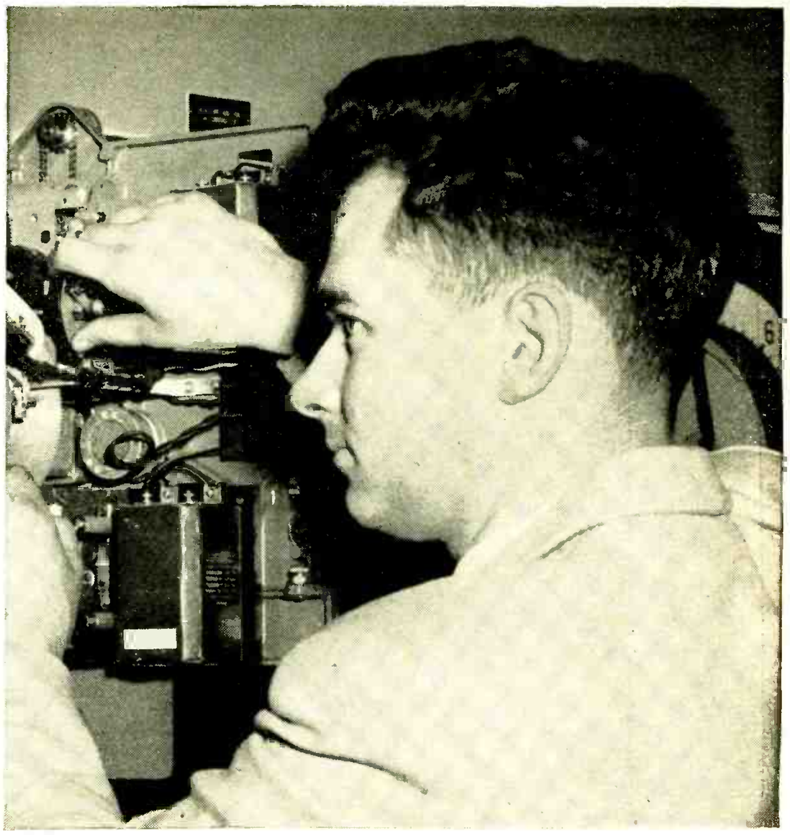
MAIN PLANT: 5715 N. Western Ave., Chicago, Illinois 60645
EAST: 41-96 Vernon Blvd., Long Island City, N.Y. 11101

Circle 11 on reader service card

With his NRI home training

as a solid base for success, graduate W. Gerald Kallies of Elliott Lake, Ontario, Canada, has branched into three different areas of Electronics. He is in charge of the complete Electronic automatic control system at Rio Algom Nordic, Ltd., a uranium mining company. Also, he handles operations at CKSO-TV, a satellite station in Elliott Lake, and he owns Gerol TV Sales & Service, which grosses $60,000 a year.

How did Gerald Kallies launch his career? While a high school senior, he faced the fact that college was beyond his financial reach. So he wrote to ten Electronics training schools. He chose NRI. Why? Because, he says, it appeared to be complete training with no short cuts . . . because courses were offered at very reasonable prices . . . and because he was convinced NRI would take a personal interest in him. The results of his training speak for themselves.



Experience Most in Color TV Communications Electronics

Designed-for-training equipment makes learning at home fast and fascinating—builds priceless confidence—as theory you learn comes alive.

There is an all-important reason why NRI has invested so heavily in the development of equipment for learning Electronics at home. With more than 55 years of home education experience, NRI is convinced that theory alone is not enough. Your hands must be trained as well as your head. To get ahead fast you must have "hands-on" experience as well as "book" knowledge . . . and, you get *both* in NRI home training programs.

Learning becomes an absorbing adventure as you get your hands on professional parts and demonstrate theory you read in "bite-size" texts carefully programmed with NRI designed-for-learning equipment. You'll *prove* theory by

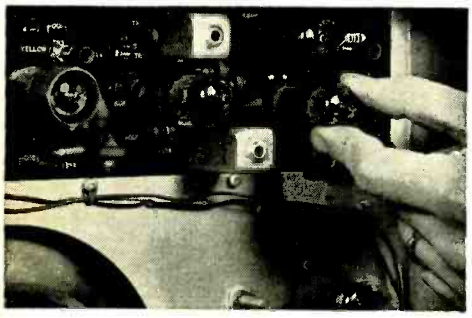
Counts

experimentation with the type of solid-state, transistorized and tube circuits you'll find on the job today — not hardware or breadboard hobby kits. Almost without realizing it, the NRI discovery method prepares you for your choice of careers in Color TV Servicing, Communications, Industrial Electronics. With your NRI diploma, you can confidently fill full-time openings in the TV-Radio Servicing business; become a part of the glamorous communication industry; have an important role in business, military or space Electronics or even launch your own full-time business. Many NRI graduates start earning $5 to $7 an hour extra soon after they enroll, fixing home Electronics equipment for friends and neighbors in spare time. NRI's remarkable teaching method simplifies, organizes, dramatizes subject matter so that any ambitious man — regardless of his education — can effectively learn and profit from the Electronics course of his choice.

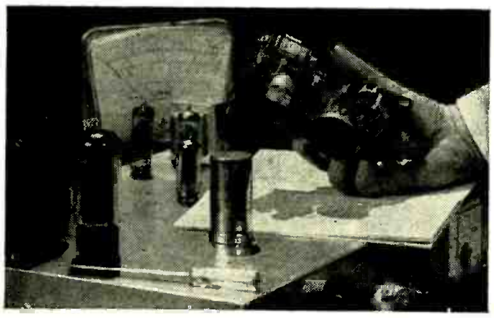
You get your FCC License or your money back NRI is so confident of the effectiveness of its training programs that all Communications courses include a special money-back agreement. You *must* qualify for a Commercial Radiotelephone License issued by the FCC, after successfully completing your training program, or NRI refunds your tuition in full. Here is just one more example of the value you get when you choose NRI for your Electronics training . . . one more example of why NRI continues to be the country's leading Electronics home-study school. Over three-quarters of a million have enrolled since 1914. Discover for yourself how easy it is to move into Electronics — America's fastest growing industry — with NRI home training. Mail the postage-free card for the new NRI Catalog. There is no obligation. No salesman will call. NRI does not employ salesmen. NATIONAL RADIO INSTITUTE, Washington, D.C. 20016.

Approved under GI Bill

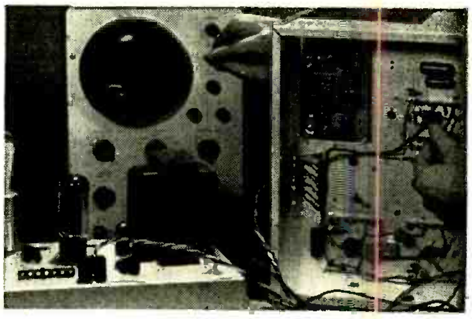
If you have served since January 31, 1955, or are in service now, check GI line on postage-free card.



Color TV circuitry is easy
to learn as you build the only Color TV set custom-designed for training purposes. The result is your own high-quality set you keep for years of viewing pleasure. NRI TV-Radio Servicing course includes your choice of color or black-and-white training equipment.



Communications experience
equal to as much as two years of on-the-job training is yours as you build and use equipment like this phone-cw transmitter suitable for the 80-meter amateur band. You also perform experiments on transmission lines and antenna systems. No other home-study school offers this equipment.



Competent technical ability
so necessary for careers in Industrial Electronics is easily acquired through NRI training. As you learn, you actually build and use your own motor control circuits, telemetering devices and even digital computer circuits. All major NRI courses include transistors, solid-state devices, printed circuits.

(continued from page 6)

TV X-RAYS ARE BACK

SUFFOLK COUNTY (LONG ISLAND), NEW YORK—A 14-month study of 5000 color sets conducted by the Suffold County Health Department indicates that 20% of the sets were delivering excessive x-rays.

The study covered sets from 37 manufacturers, and at least one color receiver of each brand was found to be emitting radiation in excess of the danger level (0.5 milliroentgens an hour at a distance of two inches from the surface of the set).

The door-to-door survey was conducted by Seymour Becker, a physicist with the County Public Health Service. Using these figures in an extrapolation, three million of the 15-million color sets now in use in the United States are emitting excessive x-rays.

Mr. Becker reports he found 15 separate causes for the excessive radiation, which was being emitted in all directions. Mr. Becker said that all x-ray emissions, even non-harmful ones "technically can be reduced to zero."

The amounts of radiation measured varied from 0.5 mR at 5 cm to as much as 150 mR. The average offender emitted 2 to 5 mR.

Power supply voltages in the malfunctioning sets ran as high as 40,000 volts with an average of 32,000 to 38,000. Normal high voltage is about 25,000 volts.

Editors Note: *An excessive high voltage is almost always accompanied by x-ray emission we recommend all technicians to check the high voltage of every color set they service and make any needed repairs. To the set owner we urge that you look at your picture carefully. If it is out of focus or narrow (black edges at the right and left) have your set's high voltage checked immediately. The troubles just described are often produced by excessive high voltage. And excessive high voltage is often accompanied by excessive x-rays.*

LOOKING AHEAD

(continued from page 2)

Pictures from space

A space broadcasting experiment in India may eventually bring a new kind of television service to the United States. NASA and the Indian Government are planning to test a low-cost method of mass education by satellite TV in 1972. Some 80% of India's population lives in 568,000 villages. The goal of the joint space venture is to reach these villages with educational telecasts from space.

Each community TV receiver, which can be watched by as many as 300 people at a time, will have its special 5-foot parabolic antenna and FM-to-AM converter to translate direct satellite signals into a standard TV set waveform.

Although direct satellite-to-home TV broadcasting won't be economically feasible before the 1980's at the earliest, NASA officials think the Indian project could lead to new TV services in the U.S. Low-cost ground stations could supplement regular TV service by filling in isolated areas which currently aren't covered by television stations. Another system could cover the U.S. with non-entertainment programing for specialized groups. For example, special programs for doctors, lawyers or scholars in certain fields—prohibitive in cost if beamed from a network of ground transmitters—could be transmitted from a single satellite, picked up by mass-pro-

(continued on page 14)

New & Timely

LOOKING AHEAD

(continued from page 12)

duced ground stations and distributed to offices or homes by existing cable TV systems, or piped directly to receivers in colleges or assembly halls.

FM's landmark

If you're old enough, you'll remember that FM radio was once given up for dead—but it refused to be buried. Well, FM reached a happy milestone in 1968. After all sales figures had been tallied, it turned out that exactly 50% of all radios sold last year contained FM. Americans bought 36 million table, clock, portable, auto and phono and/or TV combination radios—and 18 million of them had FM. A lively corpse, indeed.

TV prices down

While we're on statistics, perhaps you'd like to know that despite the rising cost of living, TV set prices hit an all-time low in 1968. At the factory level, the average American-brand color set sold for $342.88, down more than $19 from the 1967 level, while the average black-and-white set dropped $2 to $92.24. In both cases, the decline apparently is due to a higher proportion of small-screen set sales rather than to any major reductions on specific models.

Quick-change artist

Latest gadget for television broadcasters: a video tape cartridge recorder. Designed for automatically playing commercials and other short selections on the air, the RCA device can accommodate 18 cartridges on an endless oval belt. Each cartridge holds up to three minutes of color video material on two-inch-wide broadcast video tape. The cartridges play automatically in sequence to provide as many commercials in a row as desired, untouched by human hands.

If you're interested, the automatic color video machine will sell for about $89,500. But before you can operate it, you must have a broadcast color video recorder to attach it to (costing as much as $100,000 or more). Don't run out to buy one, production models won't be available until mid-1970.

'Brownie' color camera

Color cameras continue to shrink in size and price. Although TV studio versions still sell as high as $90,000, new developments are now bringing color within price and operational simplicity ranges of educational and industrial closed-circuit installations, and, at the present rate of progress, they'll soon be aimed at home color video recording hobbyists.

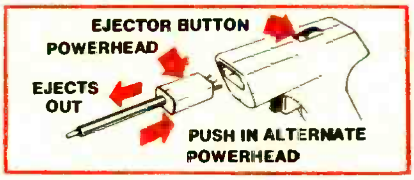
By far the smallest and cheapest color camera has just been announced by Toshiba. Weighing only 10 pounds and about the size of a cigar box, the new camera is expected to sell at around $1000, perhaps below. It's designed to plug into any household electrical outlet and can be connected directly to a conventional color set with a single cable. The control unit is mounted inside the camera head. The camera uses two pickup tubes, one for color, the other for luminance (b-w signals). **R-E**

Now one tool combines all the advantages of a lightweight pencil type iron, a fast heating soldering gun, and tip temperature control.

Features Weller's exclusive new POWERHEAD

The heart of this new tool is its long-life, high efficiency POWERHEAD . . . another great innovation from Weller. The POWERHEAD contains Weller's temperature control system (which has been so successful in Weller temperature controlled soldering irons). The result is maximum protection of components even in the most delicate work situations.

The integral points of the POWERHEAD have made over 30,000 solder connections in lab tests.



The points have a special premium plating which vastly extends life. And the POWERHEAD completely eliminates filing and frequent tip changes as encountered with conventional non-temperature controlled tools.

Two POWERHEADS are available: A 700°F. 3/16″ chisel point POWERHEAD or a 600°F. 1/8″ conical point POWERHEAD. A convenient ejector button makes switching POWERHEADS easy.

The entire tool weighs only 7 ounces. Its trigger turns heat on and off. And the stainless steel barrel has long reach.

Ideal for service, repairs, PC boards, models and hobbies. Order these new Weller TEMPMATIC models now.

Weller®

WELLER ELECTRIC CORP., Easton, Pa. World leader in soldering tools

Circle 17 on reader service card

Correspondence

BOOST HURTS LOUDNESS

In the January 1969 issue of RADIO-ELECTRONICS there is a Technote concerning the Dynaco SCA-35 amplifier. The writer shows a suggested way to add high-frequency boost as part of the loudness circuit.

The circuit shown will give increasing treble as the volume control is turned down, and it will do this without causing any problems. However, I want to point out that this type of correction should not be part of accurate loudness compensation.

The familiar loudness contours show that the ear is not so sensitive to high frequencies as to middle frequencies. However, this phenomenon is true at almost all levels, and the treble contours are quite parallel. Therefore, there should not be any compensation for level. This merely indicates that at all levels we do not hear highs as well as we hear middle frequencies. This is true for original sounds as well as for reproduced sounds. A "correction" of reproduced sounds based on level would make them most unnatural. On the other hand, the same contours indicate that bass frequencies require augmentation when played at reduced levels if the original tonal balance is to be maintained at the lower level. Therefore, bass correction has some validity, but treble correction of the scale indicated in the Technote has none.

DAVID HAFLER
Dynaco Div.
Philadelphia, Pa.

CORRECTION

Bug in electronic photoflash: In the class-II trigger circuit (page 26 of the February issue) the cathode of the 5823 thyratron is marked as pin 5. It should be pin 3 as on the PC board. R1 is marked 4.7 megohms. It should be 4.3 megohms.

FM STEREO VS STEREO FM

Now that the word "monaural" is nearly completely eliminated from the audio vocabulary (only a few recalcitrant retailers and advertisers are still using this incorrect and obsolete

(*continued on page 22*)

Here's where we can save you time.

Every minute is longer up there.

You can save as many as 20 or 30 of those long minutes when you put up one of our larger antennas, because they're pre-assembled. Our snap-joints take only seconds to lock in place.

Sylvania antennas are equipped with a double boom (for strength and rigidity).

All have strong, seamless, half-inch tubular elements (not rolled-over strips of aluminum).

All aluminum parts are gold-alodized inside and out (not sprayed, but dipped).

Even more care goes into the electronics.

We've peaked our antennas for flat response over the entire 6 MHz bandwidth of each TV channel. Flat response is absolutely necessary for good color reception. Otherwise, color rendition may be lost.

You also need high gain—that's obvious. But coupled with high directivity to knock out interference. Polar patterns from our antennas show almost complete rejection of signals from the rear and sides.

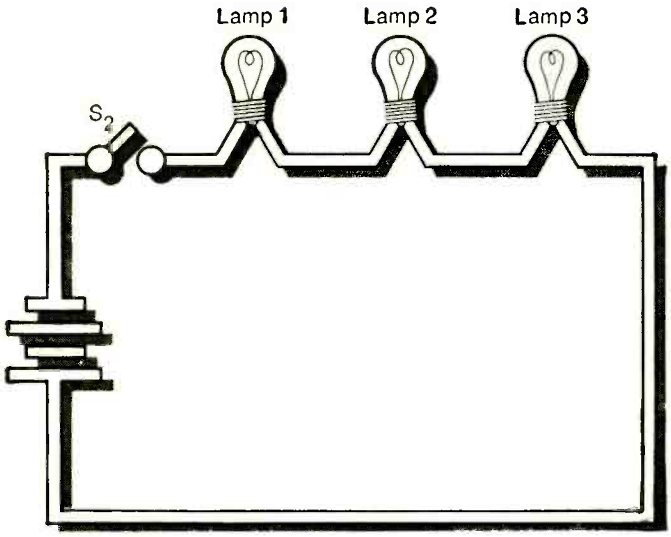
We designed our antennas so you wouldn't have to (1) climb back up there or (2) fiddle around up there.

We know that the fiddler on the roof is just fiddling his own money away.

For more information on our line of antennas see your Sylvania distributor.

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

Can you solve these two basic problems in electronics?

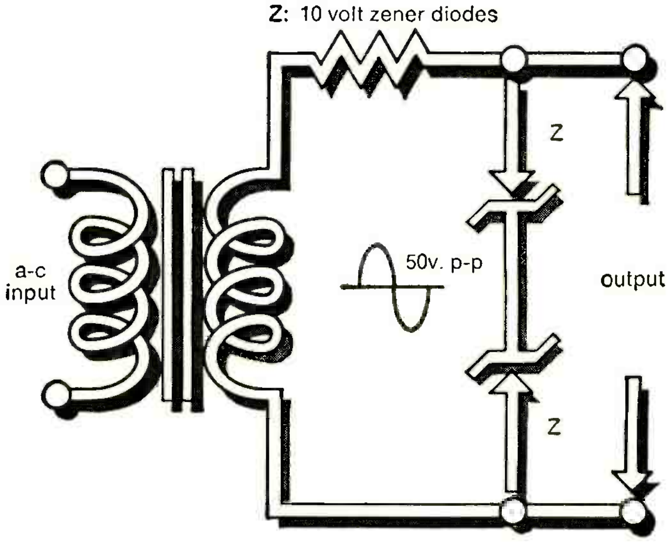


This one is relatively simple:

When Switch S_2 is closed, which lamp bulbs light up?

Note: If you had completed only the first lesson of any of the RCA Institutes Home Study programs, you could have solved this problem.

ANSWERS: Problem 1—they all light up
Problem 2—20 Volts (p-p)



This one's a little more difficult:

What is the output voltage (p–p)?

Note: If you had completed the first lesson in the new courses in Solid State Electronics, you could have easily solved this problem.

These new courses include the latest findings and techniques in this field. *Information you must have if you are to service today's expanding multitude of solid state instruments and devices used in Television, Digital, and Communications Equipment.*

If you had completed an entire RCA Institutes Home Study Course in Semiconductor Electronics, Digital Electronics, or Solid State Electronics, you should now be qualified for a good paying position in the field you choose. Send for complete information. Take that first essential step now by mailing the attached card.

CORRESPONDENCE
(*continued from page 16*)

word), it is time that we do something about that other piece of jargon, "FM stereo," that has become noticeable recently.

The term "FM stereo" is backwards. It should be *stereo FM*. The contrast is between mono FM and stereo FM, monophonic frequency modulation and stereophonic frequency modulation, not "frequency modulated stereophony" as implied by "FM stereo." The complete phrase is, "stereo multiplex FM radio receiver/tuner/broadcast": any of these words can be used *in this same order*, as in "stereo multiplex," "stereo FM receiver," "multiplex FM," "multiplex FM tuner," and so on. Any other word order violates the normal word relationships, the order of modifiers and subordinates, of the English language.

Now is the time for the audio field to eliminate the jargon of "FM stereo" in favor of the good English of *stereo FM*. Let us begin.

PHILIP N. BRIDGES
Ashton, Md.

OK, let's take a vote. Send in your postcards and simply write FM Stereo or Stereo FM on the back. We'll print the totals in a month or two.

NOTE TO ELECTRONIC SHUTTERBUGS

The exhaustive article on Integrated Circuit Electronics for Shutterbugs in the February issue of RADIO-ELECTRONICS was exceptionally informative and well written.

On behalf of Honeywell Photographic Products, I would like to extend my sincere thanks for including the information in the text and the photographs showing the Rolleiflex camera and our Auto/Strobonar.

There is one inaccuracy that I would like to point out to you. In the next to the last paragraph on page 42, the article states that Honeywell has a patent agreement to make automatic electronic flash units with Mecablitz. That statement is in error. Honeywell's only licensing agreement for automatic flash units is with Rollei-Werke of Braunschweig, West Germany.

To enter into a patent agreement with any other European manufacturer would be a violation of the existing licensing agreement with Rollei, whom Honeywell represents exclusively in the United States. **R-E**

R. L. PENNOCK
Vice President and General Manager
Honeywell Inc.
Littleton, Colo.

HOW TO MAKE ETCHED CIRCUITS

Three easy steps can speed schematics into working circuits

by JAMES A. GUPTON JR.

AN IMPORTANT DEVELOPMENT IN modern electronics has been the growth of chemical etching. The process was a major factor in the expansion of the printed circuit industry.

There are three major areas of printboard construction:

- Initial artwork transforms the circuit diagram into the physical circuit.
- Application of a chemical resist permits removal of unwanted metal, retaining metal where needed.
- A suitable etchant must be selected for the type of work to be done.

Preparing artwork

Can you imagine a drafting teacher asking his students to "draw a 0.100-inch line width," or "make all circles 0.287-inch diameter and maintain 0.025-inch clearance?" Of course not. Yet this is a daily requirement in the preparation of PC artwork. How is this done? By means of precision transfer materials and by making very large drawings and reducing them photographically to the desired size.

Fig. 1 illustrates a number of these readymade precision artwork symbols. Produced to a tolerance of 0.002-inch, the standard circuit symbols are available in sizes as small as 0.050-inch diameter to as much as 1.500-inches. Precision-width tapes are produced in 20-yard rolls in 0.015–2.000-inch widths.

To illustrate artwork preparation, we'll use a motor speed control circuit (Fig. 2). The schematic diagram can be completely laid out with transfer symbols and tapes. To make this drawing entirely by conventional means could take some time, plus the use of drafting devices. But with the use of transfer materials and a standard 10 x 10-division grid pad, the circuit was completed in a matter of minutes.

The "art" in printboard artwork is the ability to *locate* the components. Working from either component specification or from the actual component, I prepare a scale of dimensions for the components required for the circuit. Again using the standard 10 x 10-division grid pad, I cover the grid with a clear or translucent acetate sheet.

When ink letters are needed I use a matte-finished acetate that accepts ink without difficulty. My component-size scale and a pencil sketch of the master artwork are used as a guide in placing diecut transfer symbols on the acetate sheet.

A rule of thumb for pad dimensions is: 'Pad diameter equal to 3 times the diameter of the drill hole.' This assures ample copper around the component lead hole. Table I lists the current capacity for various size path widths. Path separation is governed by current capacity, but should never be less than 0.025 inch.

There are two types of artwork. Positive artwork is obtained by the use of black transfer artwork symbols on clear, matte, or translucent acetate. Negative artwork is generally made photographically from positive artwork, or by applying the transfer symbols directly onto the printboard copper surface.

Fig. 3 illustrates the actual-size original artwork as it appears on acetate. To make a film negative, the original artwork is contact printed onto Kodak Kodalith Estar Base film and then processed.

The contact printing process is very inexpensive as there is no need for a camera. Only a few simple items are required and the process can be carried on in the light of a red safelight. The Kodalith film produces a very dense black, which blocks ultraviolet light as required for photosensitive resist exposure.

The three-step contact printing process is illustrated in Fig. 4. The original artwork is placed with the symbol side down on the emulsion side of the film. (There are two ways of determining the emulsion side of the film: its color is lighter than the base side and the base side is glossy slick as compared to the dull, flat finish of the emulsion side.)

Next a plate of clean glass is used to cover the artwork-film sandwich and maintain flat contact of the film to artwork. To make the exposure I use a 15-watt white lamp placed 4 feet from the film and by varying the exposure time I can control the negative density. I find 1 to 5 seconds ample for the density required. The proper density will produce total transparency of the artwork symbol areas and a totally opaque black area.

TABLE I—Current Capacity vs. PC Path Width

PATH WIDTH	CURRENT CAPACITY (AMPERES) 1 ounce copper	2 ounce copper
0.015 (1/64")	0.480	0.840
0.025	0.800	1.400
0.032 (1/32")	1.025	1.790
0.063 (1/16")	2.015	3.525
0.125 (1/8")	4.000	7.000
0.156 (5/32")	4.990	8.735
0.187 (3/16")	5.985	10.475
0.250 (1/4")	8.000	1[illegible].000

After making the exposure, the film is removed from the artwork-film-glass plate sandwich and developed 1 to 2 minutes in a 1-part Kodak Dektol Developer to 2-part water solution. Development can be stopped anytime by placing the film in an acetic acid solution known as acid stop bath.

The film is then placed into Kodak Fixer solution until the whitish background disappears and the film becomes clear. Clearing time generally takes 3 to 4 minutes.

The final step is to wash in running water and dry. Water spotting of the negative can be reduced by dipping it in a solution of Kodak Foto-Flo. This is a wetting agent that reduces the surface tension of the water thus permitting rapid draining. The total expense of the setup to make film negatives will not exceed $5, excluding the film.

A negative resist can be made by applying artwork symbols and tape directly on the printboard copper surface. For a quick one-shot PC, this method is cheapest but far from the best. To prove this point I made two sample circuit boards, one with negative film and the other by direct application of the artwork to the copper surface.

For those who still wish to use this method, however, there's one way to improve your etching. After applying the stick-on resist, heat the circuitboard to approximately 150° F and roll down the resist with a hard-rubber roller.

The latest development in PC artwork eliminates registration problems encountered by the necessity of producing two separate drawings. Fig. 5 illustrates the use of red and blue transparent symbols and tapes in conjunction with standard black materials. Black symbols and tapes are used for circuitry common to both sides, while red transparent symbols are used for circuits common only to the top side. Blue transparent symbols and tapes apply only to the circuitry for the back. Thus the artwork for both sides of a PC board can be made with a single drawing.

To drop the red and retain the blue circuitry, the artwork must be photographed on Kodak Kadalith Estar Base Pan film with a No. 29 Kodak-Wratten filter over the lens. To hold the red and drop the blue circuitry, the artwork is photographed on Eastman Type 3 Estar Base film with a No. 47 Kodak-Wratten filter over the lens. The end result is two negatives in perfect registration.

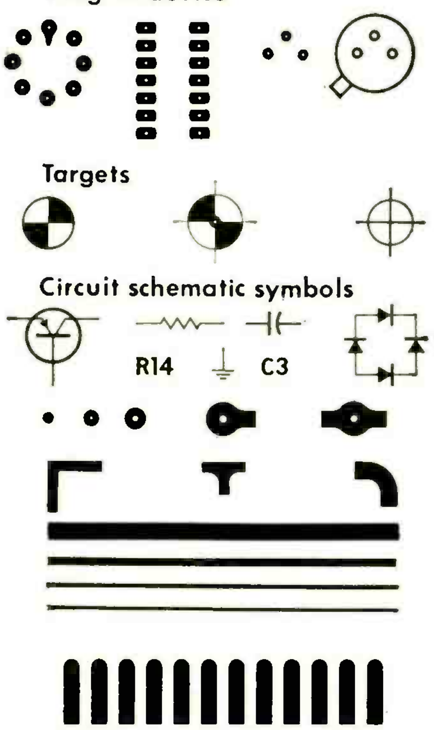
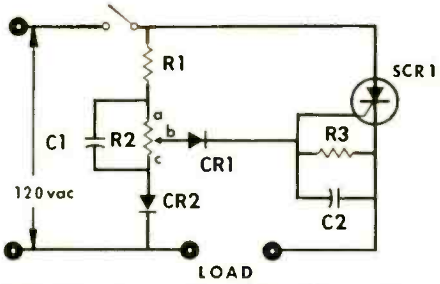
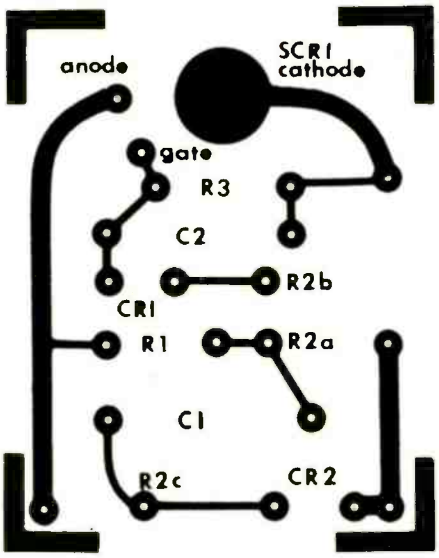


Fig. 1—(above) A sample of diecut precision artwork symbols used for PC construction. (DieKut StikOn, by Bishop Industries Corp.) Fig. 2—(top right) Schematic for motor speed control can be drawn on grid pad using standard transfer symbols. Fig. 3—(right) Completed artwork for motor speed control

PARTS LIST

R1—47,000-ohm, ½-watt potentiometer
R2—10,000-ohm, 1-watt resistor
R3—1000-ohm, 1-watt resistor
C1—0.5-μF, 50-volt capacitor
C2—0.1-μF, 10-volt capacitor
D1, D2—1.5 amp, 300-PIV diode (G-E A14C)
SCR1—2-amp, 200-PIV silicon controlled rectifier (G-E C106B1)





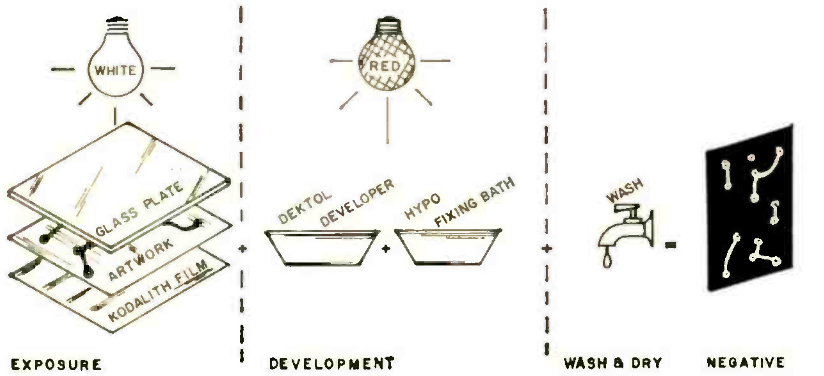


Fig. 4—(below) Three-step process used to make artwork film negative. Artwork symbol areas are transparent other areas black.

How to make a resist

Of the methods described for applying artwork to PC's, the film negative technique requires a photosensitive resist applied to the copper laminated board. The *negative* photosensitive resist hardens where exposed to ultraviolet light.

When developed properly the exposed area is fixed to the copper while the unexposed areas are washed away, leaving the copper exposed and subject to attack by an etchant.

There is a *positive* resist that works just the opposite. The exposed areas are not hardened in the development process and are washed clear of the resist.

All work involving application, drying, and development of photosensitive resist be performed under a safelight. Two types of safelights that can be used are the incadescent yellow "Buglights" or the G-E gold fluorescent lamps.

There are four methods by which the photosensitive resist may be applied to the circuit boards. It can be sprayed on like paint, dipped on, spun on, or rolled on by machine. Only the dip-on and spin-on processes will be described.

The dip-on process is perhaps the least complicated and inexpensive method for applying photosensitive resist. Eastman Kodak produces Photo Resist Type 3, better shown as KPR-3, for this application. The secret of applying the resist through the dip-on process is proper viscosity and controlled withdrawal from the resist solution. KPR-3 is supplied in the proper viscosity and I solved the withdrawal control by using my rotisserie motor from the charcoal grill.

This neat little 6-rpm motor is ideal for both controlling the withdrawal as well as rotating the circuitboard during the exposure. Fig. 6 shows the motor lifting a circuit board out of the dip tank. Two small holes were drilled at the edge of the circuit board through which thread is tied and connected to the rotating shaft of the motor. The thread is handy for hanging the circuit board during initial drying, but should be replaced with wire for the oven-bake cycles.

I fabricated a plastic dip tank to illustrate the circuit board in the resist solution, but I recommend either glass or metal for your dip tank, since the resist thinner will dissolve the plastic and make a mess of the tank and resist.

The resist is highly volatile and will thicken rapidly when exposed to air. It can be returned to the proper dip-on viscosity by adding Kodak Ortho Resist thinner. Always work in a well-ventilated area and avoid prolonged breathing of the resist, thinner and developer vapors as they are toxic.

The spin-on process is capable of producing very good resist coats. To achieve the best coating, the resist is usually thinned with 2 parts thinner to 1 part resist. In Fig. 7 construction details for a spin-on coater are shown. Sears and Roebuck Co. has an ideal aluminum dish pan for the coater costing less than $2. A small electric motor serves as the drive unit; it must be variable in speed and can be controlled with the motor speed-control circuit described in this article.

The best table speed for KPR3 is around 70 rpm. Be sure the resist is applied before starting circuitboard rotation, otherwise an uneven coating will result. Applying the resist while spinning the circuit board not only wastes resist, but causes gaps in the coating.

The complete photoresist process is illustrated in Fig. 8. In each of the resist application processes described, a 10-minute bake at approximately 200°F should be made prior to ultraviolet exposure. This bake removes any remaining vapors that could react with the film negative.

After the 10 minute prebake, the negative is positioned emulsion side down on the resist-coated circuitboard. To maintain complete contact between the negative and the resist, a cover glass is taped on to form a glass-negative-resist package. The assembly is then attached to the 6-rpm motor by dual gummed-surface tape and placed 3 inches from the ultraviolet light source.

Rotating the circuit board during exposure assures uniform exposure over the entire area and eliminates any hot spots or underexposed areas. I use a 6-watt fluorescent "blacklight" fixture available from Edmund Scientific Co. This wattage requires an 8 minute exposure. Shorter exposure can be achieved with G-E F20BL ultraviolet fluorescent lamps in a standard 20-inch fluorescent fixture.

Remember all operations involving the photoresist are conducted under a yellow incadescent lamp or a G-E gold fluorescent lamp. This includes the ultraviolet exposure cycle.

After the exposure, the glass cover and negative are removed from the exposure package and the circuit board is placed in the developer. Both tray and vapor development is satisfactory. Normal development time is 1–3 minutes, then the circuit board is removed and washed in hot water.

Using copper etchants

From Table II, ferric chloride was selected as the suitable etchant for our printed circuits. Although it's messy and stains the fingers, it is still the best etchant for reduced undercutting and maintaining fine detail.

For economy, the tray etching method is recommended. It requires longer to complete the etching process, but reduces the amount of solution

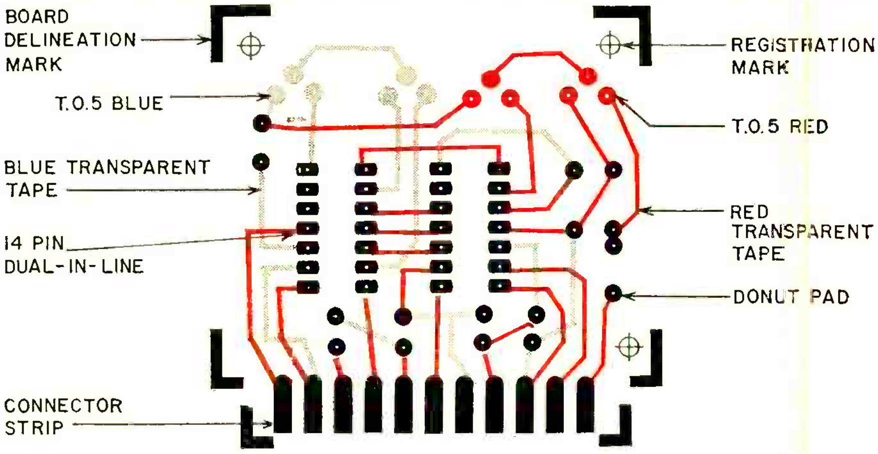


Fig. 5—Use of red and blue transparent symbols and tapes enables a single drawing to be used to make front and back of a PC board. Filters drop out one circuit.

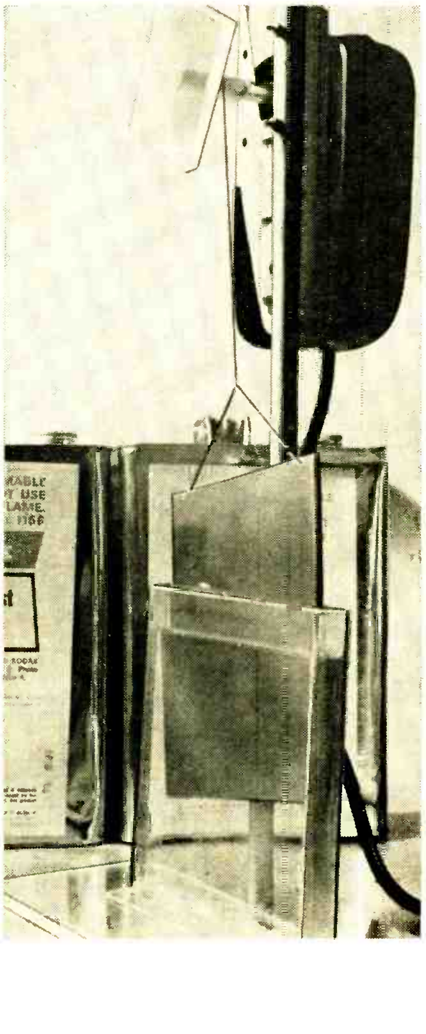


Fig. 6—(below left) Six-rpm motor withdraws circuit board from the resist solution. Fig. 7—(below) Spin-on process of applying the photo resist can be used with this spin coater. Resist is applied before the rotation starts.

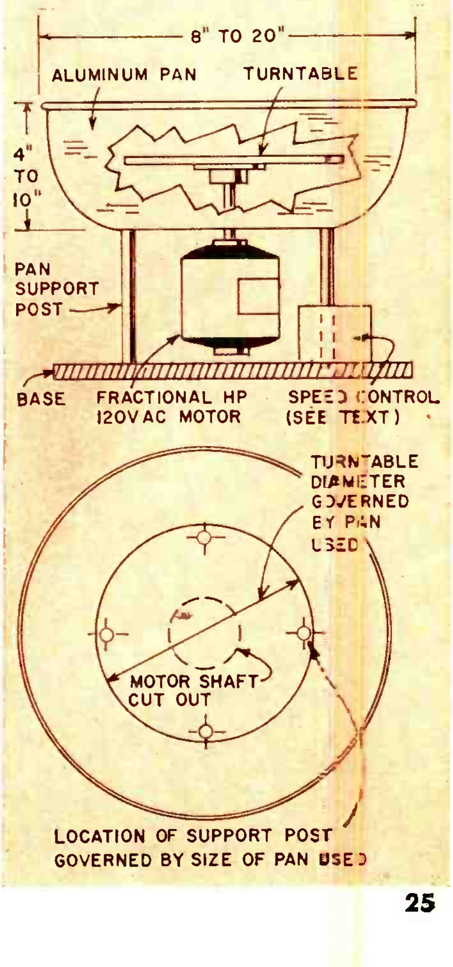


TABLE II
COPPER CHEMICAL ETCHANTS*

FERRIC CHLORIDE: Probably the most generally used etchant for printed circuits. Produces less undercutting, a faster etch, more uniformity, and absorbs more copper than other type etchants.

AMMONIUM PERSULFATE: 20% solution made by adding 2 pounds ammonium persulfate to one gallon water. Clean clear solution etches copper rapidly and uniformly. Can be disposed of in sewer system without fear of contamination. Does not attract solder. Very short life of solution.

CUPRIC CHLORIDE: Low undercutting, long life and capable of being regenerated by adding hydrochloric acid. Slow etching and messy, absorbs less than 30% the copper absorbed by ferric chloride.

CHROMIC-SULFURIC ACID: Strong, long life etchant. Difficult to dispose of. Messy. Does not attack tin-solder resist.

**For information on etchants for metals and glass ceramics other than copper and copper alloys, refer to Eastman Kodak publication No. P-91, "Application Data for Kodak Photosensitive Resist."*

tion required. The tray process requires only enough ferric chloride to fully cover the circuit board when placed circuit side down in the tray. The etchant solution is kept in constant motion by rocking the tray until the etch process is complete. Etch time may be reduced by heating the ferric chloride to approximately 150° F. provided adequate ventilation is available.

Tank etching requires sufficient etchant solution to completely cover a circuit board in a vertical position. A means of circulating the etchant is needed to provide constant fluid movement around the board. Etching time is approximately half that of the tray-etching method.

Spray etching needs a constant fine spray of ferric chloride directed across the circuit board. It is the fastest etching process using ferric chloride, but the circuit board should be rotated to prevent uneven etching.

In each of the three etching methods note that the etchant solution must be in constant motion. The reason is that ferric chloride molecules combine with copper and immediately become inactive. If allowed to remain in contact with the copper in an inactive state, the etch process would stop. By maintaining constant circulation of the etchant solution, a constant supply of active solution is always in contact with the copper.

After completing the etching of the two sample boards, a comparison was made of the etched results. Fig. 9 shows part of the press-on resist printboard. Note the severe undercutting and incomplete paths that terminate at a pad. This is typical when insufficient heat or roller pressure has been applied to the press-on resist. On the other hand, the photoresist printboard had very clean-cut paths and pads with little or no undercutting. The superiority of the photosensitive resist is obvious.

There are other circuit-board processes worthy of noting: "through hole plating," "electroless metal plating" and "electroplating." But any one of these processes would be an article in itself. Detailed information on these processes is in the $1 Eastman Kodak publication, "Photofabrication of Printed Circuits."

As a final step in the etching process of circuit boards, protection from corrosion is necessary. Copper oxidizes very rapidly, degrading the appearance of the circuit board and causing difficulty in applying solder to the paths or pads.

The best way to prevent oxidation is to seal the copper by applying electroless tin, electroplating solder-tin, dip-solder or pen solder over the copper, or spray with a lacquer. All serve the same purpose: to prevent oxygen from acting on the copper. For circuit boards containing finger contacts, gold plating should be applied to at least half of the finger-contact lengths. This reduces abrasion and provides the best electrical contact to the connecting plug. **R-E**

SUGGESTED READING

Printed and Integrated Circuitry, Materials and Processes, by Sclaback and Rider. McGraw-Hill Inc., New York, N.Y. 1963.

Kodak Ortho Resist, Kodak publication No. P-83 (1966)

Kodak Photo Resist, Type 3, Kodak publication No. P-86 (1966) Department 454, Eastman Kodak Company, Rochester, N.Y. 14650.

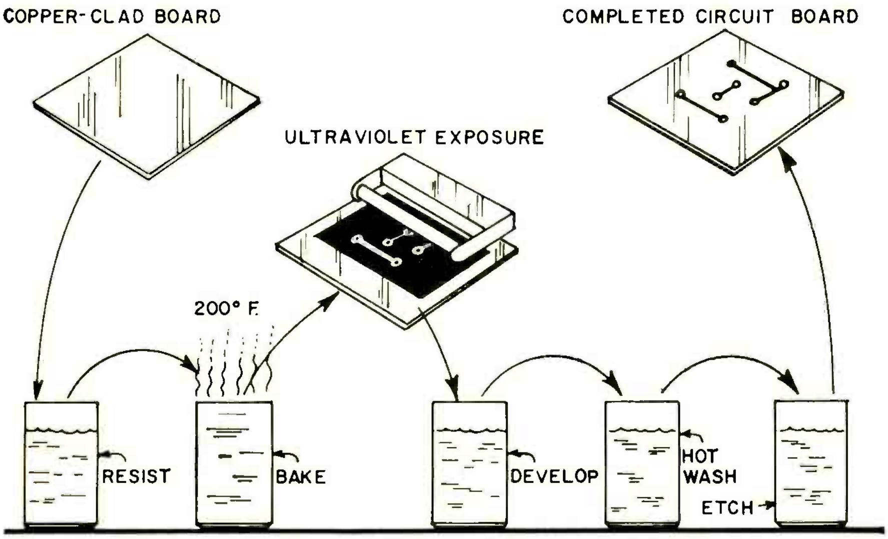


Fig. 8—Diagram of the complete photo-resist process. Baking resist-coated board removes vapors that might react with film negative. Exposure to ultraviolet light varies, but the final results should be uniform.

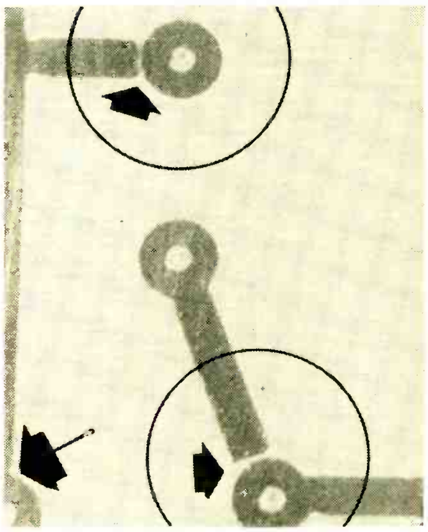
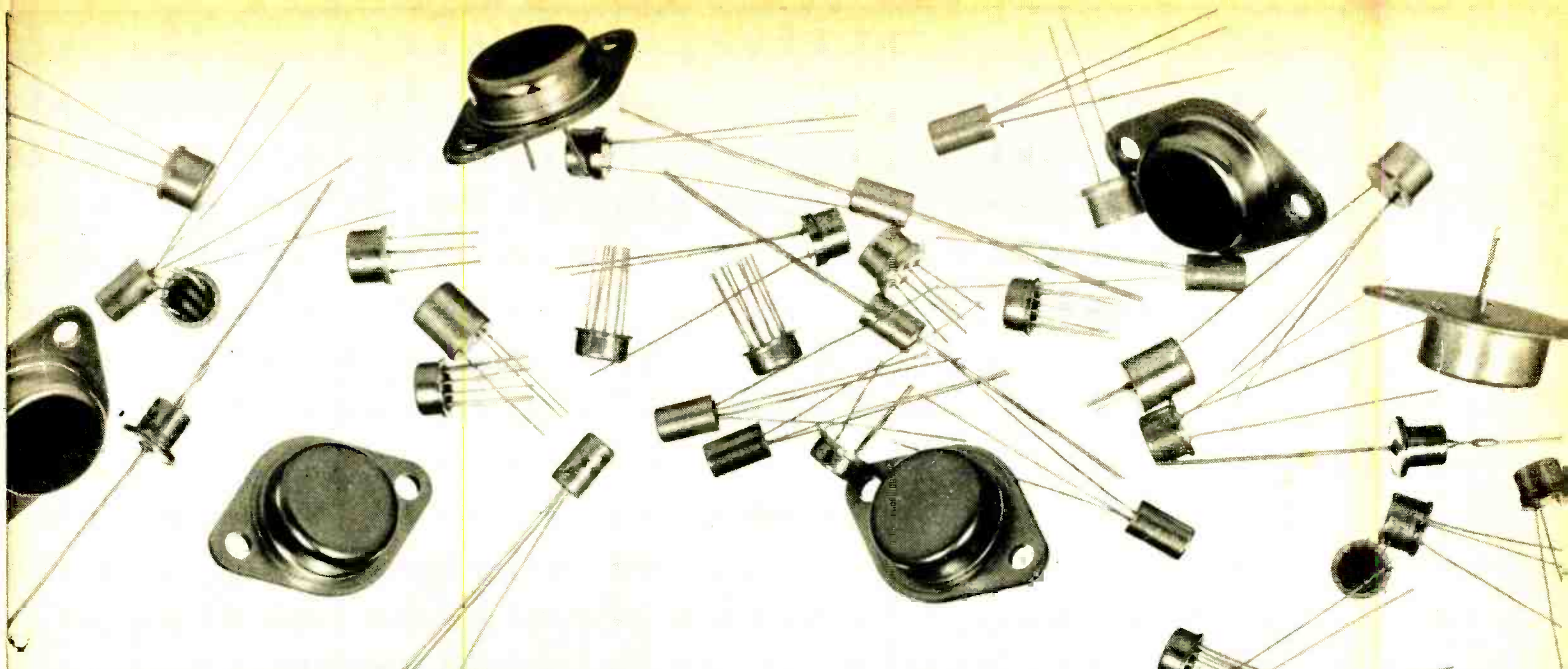
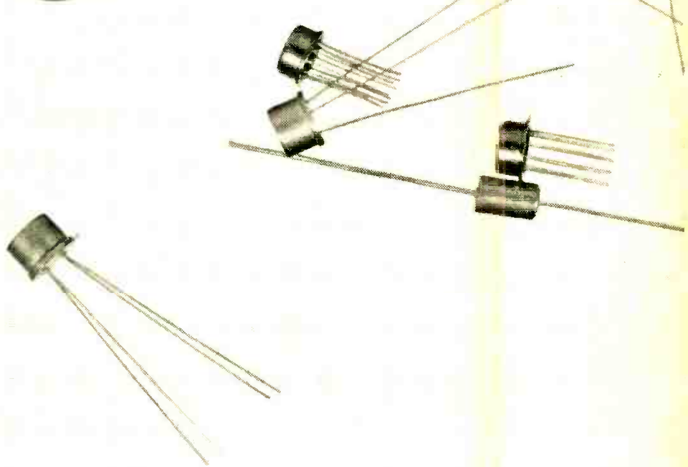


Fig. 9—Applying transfer letters directly to copper printboard can result in undercutting at conductor junctions.

Circle 22 on reader service card ➔





No More Room at the Top?

There's always room . . . for improvement! And, because RCA understands this, the SK Series solid-state replacement line is constantly updated to meet your growing needs.

Backed by production excellence and premium specifications, RCA's "Top-of-the-Line" series—transistors, rectifiers, integrated circuits—is precisely engineered, manufactured, and tested for use specifically as replacements.

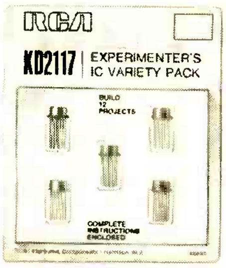
If you're building a name for yourself in solid-state servicing, your solid-state replacements should be RCA SK "Top-of-the-Line" devices. They are top-quality units—no cast-offs, no factory seconds, no unbranded culls.

The line is comprehensive—39 devices that can do the work of almost 13,000 others. Each unit has electrical characteristics comparable to or better than originally designed-in devices. RCA's SK series can be your answer for any needs from small signal to the newest in silicon audio output applications.

RCA SK Series and the types they replace are cross-referenced in the RCA Solid-State Replacement Guide—SPG-202G. Get your copy at your RCA Distributor. Today.

RCA

And, if you want an inexpensive way to extend your integrated circuit skill, try RCA's KD2117 Linear IC Variety Pack . . . includes 5 integrated circuits:



two KD2114 transistor arrays
one KD2115 audio amplifier
two KD2116 transistor arrays
plus
instructions for 12 useful circuits, schematics, parts lists, etc.

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

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

Could they be talking about you?

You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

But you can build a rewarding career if you supplement your experience with specialized knowledge of one of the key areas of electronics. As a specialist, you will enjoy security, excellent pay, and the kind of future you want for yourself and your family.

Going back to school isn't easy for a man with a full-time job and family obligations. But CREI Home Study Programs make it possible for you to get the additional education you need without attending classes. You study at home, at your own pace, on your own schedule. You study with the assurance that what you learn can be applied to the job immediately.

CREI Programs cover all important areas of electronics including communications, radar and sonar, even missile and spacecraft guidance. You're sure to find a program that fits your career objectives.

NEW!

Expanded coverage of solid state electronics including integrated circuits!

CREI, Home Study Division
McGraw-Hill Book Company
Dept.1406H,3224 Sixteenth Street, N.W.
Washington, D.C. 20010

Please send me FREE book describing CREI Programs. I am employed in electronics and have a high school education.

NAME__________ AGE_____

ADDRESS__________

CITY______ STATE_____ ZIP CODE_____

EMPLOYED BY__________

TYPE OF PRESENT WORK________ ☐ G.I. BILL

I am interested in ☐ Electronic Engineering Technology ☐ Space Electronics ☐ Nuclear Engineering Technology ☐ **NEW!** Digital Communications

APPROVED FOR TRAINING UNDER NEW G.I. BILL

You're eligible for a CREI Program if you work in electronics and have a high school education. Our FREE book gives complete information. Mail postpaid card for your copy. If card is detached, use coupon at right or write: CREI, Dept.1406-H,3224 16th St., N.W., Washington, D.C. 20010.

Founded 1927

CREI

Accredited Member of the National Home Study Council

NEW FOR YOU

Allied Model 395
Solid-State Stereo AM/FM Receiver

For manufacturer's literature, circle No. 32 on Reader Service Card.

HERE IS A STEREO RECEIVER THAT really delivers. One way to put it would be to say it performs as well as it looks. Several built-in features make it work.

The front-end, like all modern front ends, uses an FBT. The result is no audible cross modulation (the manufacturer says there's none at all), no discernible drift, high sensitivity (without making any antenna changes this receiver pulled in FM stations I had never heard with my older unit), low noise and an excellent spurious rejection characteristic.

In the i.f. and limiter stages four μA703E integrated circuits are used. The result is great performance.

A muting circuit which is by no means a must, makes tuning a station quieter. It completely knocks out interstation noise when selecting a new station. But you do have to remember to switch the muting out when you want to listen to weak stations.

The amplifier section's power output stages are single-ended push-pull that do not require output transformers. Triple-diffused mesa power transistors are used. To protect the transformerless circuit against burnout, an electronic switching circuit is incorporated into the amplifier. To give this circuit a test I tried two approaches. First, with the gain turned up to the ear-splitting level I shorted the output terminals. Sound output vanished. But when I removed the short everything returned to normal.

Next I tried operating the unit at full output with no load attached. Again I could do no harm.

A full range of inputs and controls makes the Model 395 a very convenient unit. There are even two magnetic phono inputs which permit easy switching between a turntable and a record changer.

Another convenient feature is the plug-in set-up for speakers. Wire the plugs (supplied with the receiver) to the speaker cables and just plug them in or out.

Two sets of speaker connections are provided. So you can have one set of speakers in some other room of the house and not require an added switch to permit convenient switching. All the controls you need are right on the front panel.

A last point of comment is the manual that accompanies the unit. Although labeled as an installation and operating manual, it contains other vital data too. Details on aligning the AM and FM sections as well as the stereo multiplex circuits for example. Make sure you hang onto this data. If you ever have to take the set in for repairs, take the manual along. It will help insure proper performance and probably will speed the repair too.—*Chester H. Lawrence* **R-E**

SPECIFICATIONS

AMPLIFIER CIRCUIT:
Power Output: 160 Watts IHFM at 4 ohms
Response: ±1.5 dB, 15—100,000 Hz
Harmonic Distortion: 1%
Hum & Noise:
  Magnetic Phono: −80 dB
  Auxiliary: −90 dB
Inputs: magnetic phono (2), ceramic phono, tape head, tape monitor, auxiliary
Outputs: 4–16 ohms, headphones, recorder
TUNER CIRCUIT: (FM section)
IHF Sensitivity: 1.4 μV
Harmonic distorion: 0.8%
Separation: over 35 dB
Signal-to-Noise Ratio: 69 dB
Capture Ratio: 0.95 dB

ALL ABOUT IC'S

What Makes Them Tick

Learn how solid-state integrated circuits are made—Part 1

by **BOB HIBBERD**
TEXAS INSTRUMENTS, DALLAS, TEXAS

THE POTENTIAL OF INTEGRATED CIRCUITS is so wide that in addition to replacing similar discrete component circuits, they are responsible for creating a completely new technology of circuit design.

To get the full implication of integrated circuits, you must have a general basic understanding of solid-state technology and its application. We'll start with a general introduction covering the basic principles of solid-state semiconductor devices. Then we will review the processes used to form the solid-state structures used in integrated circuits.

Basic solid-state principles

In a *conductor*, electric current flow is a movement of free electrons. The outer or valence electrons of a good conductor such as copper are so loosely bound to the atom that at room temperature the thermal energy causes approximately one electron to detach from each atom and become free to move and result in a current flow when an electric potential is applied.

Insulators are materials in which the outer electrons are tightly bound to the atom and no electrons are free to move. Thus, no current can flow when a voltage is applied.

Between these two major categories is a class of materials called *semiconductors*. As the name implies, a semiconductor is a material with conductivity roughly midway between conductors and insulators. However, a semiconductor is not just a poor conductor; it has two other very important properties. First, its resistance normally decreases with increase of temperature, as opposed to conductors such as metals in which the resistance increases slightly with temperature. Secondly, flow of current in a semiconductor can be by two mechanisms, either by a flow of negative electrons similar to current flow in conductors, or by a movement of missing electron sites in the opposite direction. If an atom has one outer electron missing, a loosely bound electron from a neighboring atom can jump into it, leaving behind a new vacant site; this in turn can be filled by an electron from a third atom and so on. It then appears as if the vacant site has moved. Such vacant sites are called "holes" and since a negative electron is missing the hole can be considered as a positive charge.

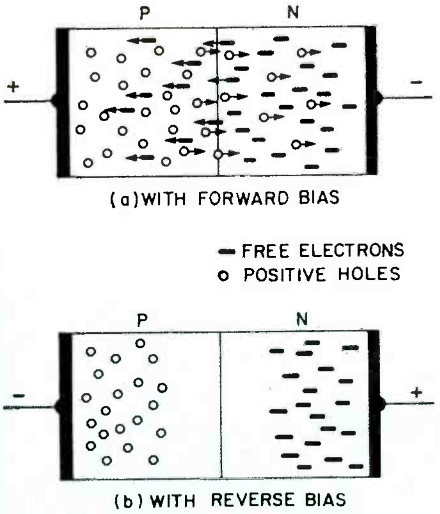


Fig. 1—Electron and hole movement; forward bias (a) *and reverse bias* (b).

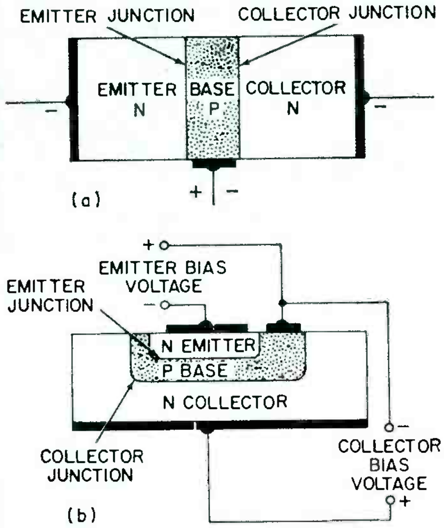


Fig. 2-a—Diagram of npn transistor, and (b) *practical arrangement.*

Semiconductor material in which conduction is by a flow of electrons is called n-type material (n for negative carriers) and material in which conduction is due to the movement of positive holes is called p-type.

From the viewpoint of monolithic integrated circuits, the most important semiconductor material is silicon. Silicon has four outer or valence electrons. If we add a small amount of an impurity element with five valence electrons, such as phosphorus, one electron per impurity atom will be free and we have *n-type silicon*. Similarly, if we add an impurity with only three valence electrons such as boron, there will be one missing electron or hole per boron atom and we have *p-type silicon*.

The operation of most solid state devices depends on the properties of one or more p-n junctions. A p-n junction is a transition from a p-type semiconductor to an n-type semiconductor within a piece of material. Alone, a piece of n-type or p-type semiconductor is purely resistive. Reversing a battery connected across it will reverse the direction of current flow, but will not affect the magnitude of the current. By contrast, a piece of semiconductor material with a p-n junction in it has rectifying properties. When the positive terminal of a battery is connected to the p-type side and the negative terminal to the n-type side, the free negative electrons in the n-type side are attracted across the junction to the positive contact, and the positive holes in the p-type side are attracted across the junction in the opposite direction to the negative contact (Fig. 1-a). This is called the forward or conducting direction. A high current flows with only a small applied voltage, and the forward resistance is very low. Now if the battery connections are reversed (Fig. 1-b) the holes in the p-type side are attracted away from the junction toward the negative terminal and the electrons in the n-type side are attracted away from the junction to the positive terminal and so no current flows across the junction. This is called the reverse or nonconducting direction and no current flows even with a high voltage applied. (In practice a very small leakage current does flow, due to free electrons and holes being generated near the junction by the thermal energy.) So a single p-n junction can be used as a rectifying diode.

An important point to observe is that when forward current is flowing through a p-n junction (Fig. 1-a) electrons are flowing through p-type material in which there are normally no free electrons, and also some holes are flowing through n-type material. The electrons are said to have been injected across the p-n junction into the p-type material. It is this situation that leads to the operation of the junction transistor.

The npn junction transistor

A junction transistor consists of two p-n junctions formed in a piece of semiconductor material with a very small separation, only of the order of one-tenth of a mil. A diagramatic npn transistor with its operating voltages is shown in Fig. 2. The first n-type region is called the *emitter* since it emits or injects electrons into the center p-type region which is called the *base*. The second n-type region is called the *collector* as it collects electrons from the base region. The junction between emitter and base is called the *emitter junction* and that between collector and base the *collector junction*. As mentioned above, in practice, the width of the base region is only of the order of a tenth of a mil.

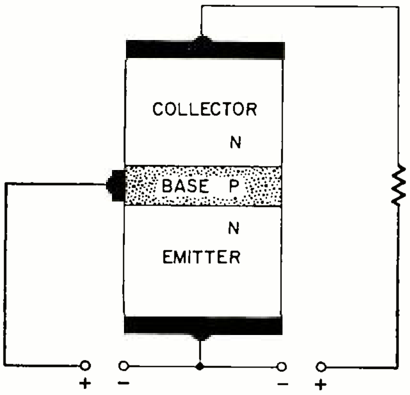


Fig. 3—Common-emitter circuit has both the input and output common to emitter.

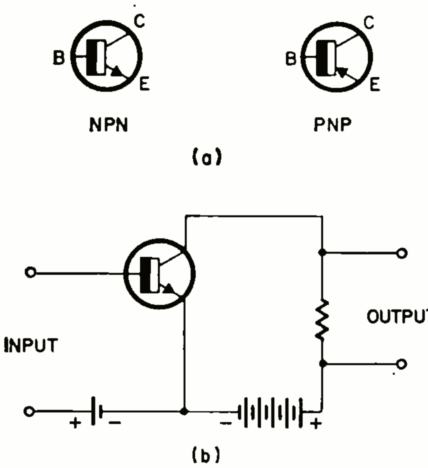


Fig. 4—Symbols for npn and pnp transistors (a), *and common-emitter circuit* (b).

The collector junction is biased with a high voltage in the reverse direction (positive to the n-type collector, negative to p-type base) and so, considering the collector junction by itself, no current flows across it. Now suppose the emitter junction is biased in the forward direction (negative to the n-type emitter and positive to the p-type base). A forward current flows across the emitter junction and electrons are injected into the p-type base region. If there were no voltage applied to the collector junction, these electrons would flow out of the base contact, but with the collector reverse-biased, as soon as the electrons in the base region flow near the collector junction, they are attracted across it by the positive potential on the collector side. Thus most of the current crossing the emitter junction continues on across the collector junction. The current across the emitter junction was produced by a very low forward voltage (less than 1 volt) and this current now flows in the collector circuit, which is biased with a voltage, providing power amplification.

As the electrons injected across the emitter junction flow through the base region, some of them fill holes in the p-type material. Thus the electron current crossing the collector junction is slightly less than the emitter current. The ratio of collector current divided by emitter current $\left(\frac{I_C}{I_E}\right)$ is called the current transfer ratio and is designated by the symbol α, i.e. $\alpha = \frac{I_C}{I_E}$. A typical value for α is 0.98.

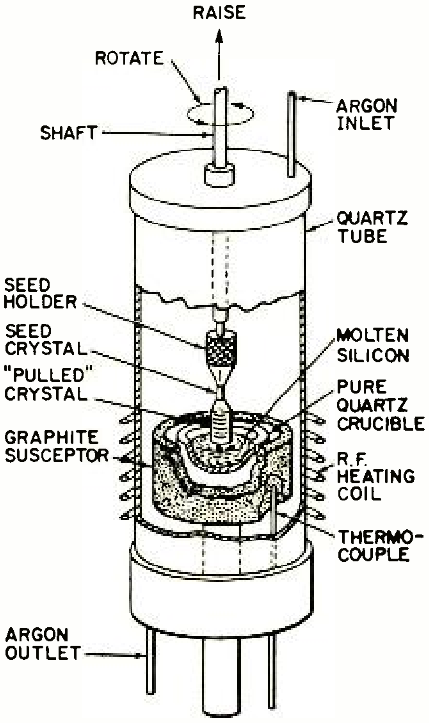


Fig. 5—Crystal-pulling device uses seed crystal rotating in polycrystalline silicon.

A current equal to the difference between the emitter current and the collector current flows in the base lead so that

$$I_E = I_C + I_B$$

with $\alpha = 0.98$, the base current I_B will only be 0.02 times the emitter current.

In the description of transistor action above, current through the collector is controlled by the emitter current, and the arrangement is called the *common-base circuit* since the base electrode is common to both input and output circuits. A more convenient arrangement is with the input fed to the base and the emitter common to both input and output as shown in Fig. 3. This is called a *common-emitter circuit*. The collector current is now effectively controlled by base current I_B and the ratio of collector current to base current has a high value, equal to $\frac{\alpha}{1-\alpha}$.

If $\alpha = 0.98$ as above, $\frac{I_C}{I_B} = \frac{\alpha}{1-\alpha} = 49$

Thus we have a current gain from the input to the collector of 49 times, and if the collector current flows through a load resistance to give a voltage output from the collector, a voltage gain results.

The pnp junction transistor

A pnp structure operates in a similar way to the npn transistor. There are two points to observe. First, to bias the emitter junction in the forward direction, the emitter must be made positive with respect to the base. To bias the collector junction in the reverse direction, the collector must be made negative with respect to the base. Secondly, the p-type emitter injects positive holes into the n-type base region, and they are subsequently attracted across the collector junction by the negative potential.

To represent the transistor graphically, the symbols shown in Fig. 4-a are used. The emitter is shown as an arrow pointing in the direction of positive current flow (opposite to the direction of electron flow). This device in a common-emitter circuit is shown in Fig. 4-b.

So far we have shown the importance of the pn junction. The technology of fabricating solid-state devices and integrated circuits has evolved around the development of methods of producing pn junctions in silicon material. The following sections are devoted to a general description of the basic processes involved in solid state technology.

Silicon preparation

Silicon is a metallic element with a light gray appearance. It occurs in nature as silicon dioxide (silica) and as various silicate compounds. To prepare silicon for solid state devices. there are two main requirements. First. extremely high purity is required. with unwanted impurities down to a level of one part in 10^{10}. Second. for a pn junction to operate as described earlier, the silicon must have a continuous regular crystal structure. and so the silicon must be converted into what is called *single crystal form*.

The first step in the preparation of semiconductor grade silicon is to reduce silica by heating it with carbon (coke) in an electric furnace. The resulting silicon is about 98% pure. The next step is to purify this material. It is converted to a compound such as a halide (silicon tetrachloride) which is purified by repeated distillation. Then the purified halide is converted back to silicon by hydrogen reduction. In this process. the silicon is deposited onto the surface of a high-purity silicon rod. building it up to a diameter between 1 and 4 inches. Using this chemical method of purification. we get the required purity level of one part in 10^{10}.

The silicon deposits onto the rod in polycrystalline form and must now be converted to single crystal form. The process generally used to produce single crystal silicon for transistors and integrated circuits is called *crystal pulling*. The general arrangement is shown in Fig. 5. Solid polycrystalline silicon is placed in a pure quartz crucible supported inside a translucent quartz chamber, through which a flow of an inert gas such as argon is maintained. The quartz crucible is located in a graphite susceptor, which is heated by rf induction. When the silicon is all molten. its temperature is lowered to a value just above its melting point. and a seed crystal—a small piece of single crystal silicon—is lowered until it just enters the melt. The seed crystal is rotated (about 60 rpm) and slowly raised (about 1 inch per hour), growing larger as more silicon solidifies onto it. Typical pulled silicon crystals are cylindrical in shape between 1 and 2 inches diameter by about 12 inches long.

The dopant to give n-type or p-type silicon is added to the silicon during the initial melting process so that the crystal has required conduction properties.

Epitaxial growth

In the fabrication of solid state structures. we often want to form a thin film of single crystal silicon with certain conduction properties on the surface of another silicon slice. The process used is called *epitaxial growth* and films up to a few tenths of a mil can conveniently be formed. The starting slice must be single crystal with the required crystal orientation and is called the substrate.

Hydrogen gas is bubbled through a volatile silicon compound such as silicon tetrachloride. causing it to vaporize. The mixture of vapor plus hydrogen is fed to a reaction chamber where the silicon substrate slice is heated to about 1200°C. The silicon tetrachloride dissociates and silicon is deposited onto the surface of the heated slice to form the epitaxial layer. which grows at about micron (0.04 mil) per minute. The conductivity of the epitaxial layer is controlled and arranged to be either p-type or n-type by introducing the requisite amount of a suitable dopant vapor into the hydrogen stream with the silicon tetrachloride vapor.

Solid state diffusion

Solid state diffusion is a process involving the movement of n-type or p-type impurity atoms into the solid silicon slice. To do this. the slice is heated to a high temperature. between 800 and 1250° C. in the presence of a controlled density of the impurity atoms.

In practice. the process is often carried out in two steps. The first step consists of heating the silicon slice in the impurity dopant vapor to form a high concentration of dopant on the surface. This step is called *deposition*. The slice is then removed to another furnace where it is heated to a higher temperature so that the dopant atoms on the surface move. or diffuse, into the silicon. This is called the *diffusion* step.

If a p-type impurity is diffused into the surface of an n-type slice such that the density of p-type atoms then exceeds the original density of n-type atoms in the slice. the surface will be changed the p-type and a p-n junction will be formed a small distance in from the surface where the density of the diffuse p-type atoms equals the original n-type density.

Convenient diffusant impurities for silicon are boron as a p-type impurity and phosphorus as an n-type impurity.

A most important and significant fact is that a layer of silicon oxide on the surface of a silicon slice will prevent the diffusion of certain elements. including boron and phosphorus. into the silicon. Also important is that silicon oxide can readily be removed from the surface of the silicon slice by etching with a hydrofluoric acid solution without etching the silicon. Thus. if we oxidize a slice of silicon by heating it in a flow of oxygen to form a layer of silicon dioxide on the surface, and then remove the oxide from selected regions by etching. we can arrange to diffuse impurities into these selected regions only. This selective diffusion is the basis of all silicon monolithic integrated circuit fabrication—it allows the simultaneous formation of a number of separate components in a single slice of silicon.

The selective removal of silicon dioxide is carried out by a photolithographic process using photoresist material. The several steps in the process are illustrated in Fig. 6. After oxidation (a). the oxidized surface of the slice is coated with a thin layer of photoresist lacquer (b). This is an organic substance which polymerizes when exposed to ultraviolet light. and then. in that form it resists attack by acids and solvents. A photographic mask. with opaque regions located where it is required to remove the silicon oxide, is placed over the slice and illuminated with ultraviolet light (c). The photoresist under the opaque regions of the photomask is unaffected and can be removed with a solvent. the exposed photoresist remaining in the other regions. The slice is baked to harden the photoresist and then immersed in a hydrofluoric acid solution to etch away the silicon oxide where it is not protected by the polymerized photoresist (d). Finally the photoresist is removed from the surface (e). and the slice is thoroughly washed. It is now ready for diffusion which will only occur through the open-

(*continued on page 60*)

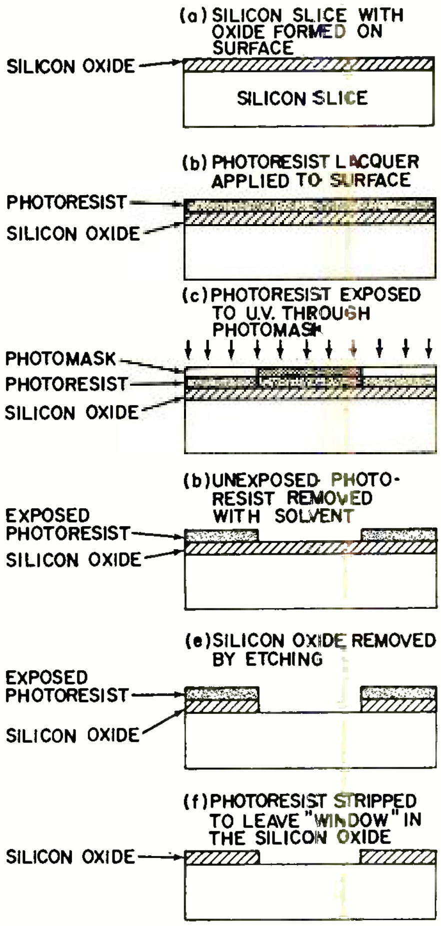
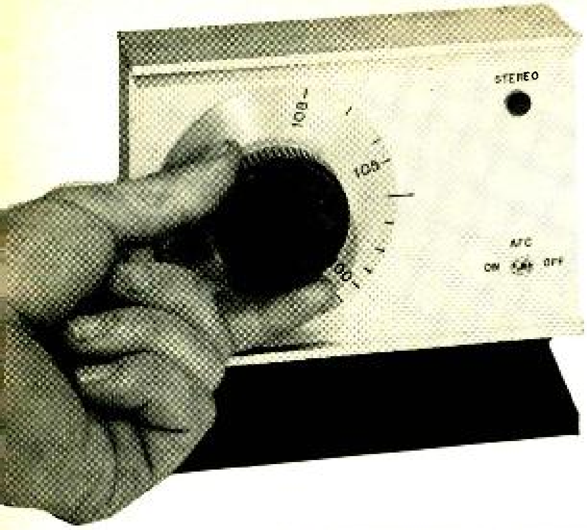


Fig. 6—Step-by-step photoresist process for removing selected silicon dioxide areas.



Last-Word—

IC STEREO TUNER

Diode tuning, MOSFET'S, all IC i.f. . . .

by KENNETH F. BUEGEL

THIS IS THE LAST OF THREE ARTICLES THAT PROVIDE COMplete construction details for a modern stereo hi-fi system. The April issue of RADIO-ELECTRONICS presented a stereo power amplifier capable of delivering 125 watts continuous rms per channel. Last month a compact IC stereo preamplifier—designed to operate with the power amp—was described.

To complement the quality of these amplifiers, you'll want to build this variable-voltage FM stereo tuner. The tuner design takes advantage of the newer breed of variable-voltage capacitor diodes (VVC's) that exhibit Q values of 150 or more at FM broadcast frequencies. [For details of VVC theory and operation, see "Variable-Voltage Tuning" by R-E's Senior Technical Editor, Robert Scott, in the April RADIO-ELECTRONICS, page 58.]

These diodes eliminate the traditional variable capacitor used in most broadcast receivers. Instead, the unit is tuned by adjusting a potentiometer in a small remote-control unit (photo above), and the circuitry—rf section, i.f. strip, power supply and multiplex adapter—can be concealed. To increase tuner sensitivity, details for mounting the rf head at the antenna are included.

Dual-gate field-effect transistors (FET's) are used as the rf amplifier and mixer in the rf head. Integrated circuits are used for each stage of the i.f. strip. Voltages are tightly regulated and temperature compensation is provided in the regulator circuit.

Transistor Q1 is a metal oxide silicon FET (MOSFET) with the incoming rf signal applied to gate 1 and agc voltages applied to gate 2 (Fig. 1). A dual-gate FET is essentially two FET's in series. Gate 2 is biased at about +4 volts when weak signals are present. At this bias voltage, FET gain is highest. As stronger signals are received, bias voltage moves toward zero and may become negative with a very strong input signal. Agc power required is negligible and cross-modulation capability of the FET is excellent.

The 40604 (Q2) is a dual-gate mixer. The amplified rf signal is applied to gate 1 and the local oscillator output is applied to gate 2. The mixing function does not depend on a square-law characteristic, and consequently the dual-gate mixer is remarkably free from cross-modulation.

Transistor Q4 is a 13-volt regulator that furnishes positive supply voltage to the local oscillator, the i.f. strip and the tuning-control pots. Transistor Q3 operates as a common-base oscillator. The first i.f. transformer, T1, is mounted on the rf board and a short length of shielded cable carries the low-impedance secondary output of T1 to the i.f. strip.

All four i.f. stages (Fig. 2) use CA3028 IC's operating in a differential mode. Limiting characteristics are superb since the transistors do not operate at saturation.

The output voltage of IC3 is coupled to agc detectors D6 and D7 through a 1.5-pF capacitor. Due to current flow through D6, D7, R36, R4 and R7, the agc output voltage is at +0.5V without a signal. As the signal level increases, output voltage at this point becomes negative, lowering the gain of Q1.

Transistor Q5 is an isolation amplifier for the tuning voltage developed at the junction of R43 and R44. It is not necessary to install Q5 if a vtvm (for meter readout) is used to measure this voltage at the base end of R45. Components R47, R48, C49 and C50 filter the audio elements from the dc output of the discriminator.

Power supply output voltage is regulated to +15 volts. Diode D10 (Fig. 3) furnishes temperature compensation to hold the output voltage constant. The +15 volts is directly applied only to Q1 and Q2 in the rf head. Transistor Q4 regulates this voltage to +13 volts.

The Zener diodes listed in the parts list are 2% types. Other types may be used if they are closely selected. The +15-volt diode must furnish an output of at least +14.6 volts; the +13-volt diode must not exceed 13.4 volts. (Note that 10% tolerance units can overlap, causing all temperature compensation and stability to be lost on the 13-volt output.)

The tuning voltage is heavily filtered at all levels by C26, C57, C58 and C13. Any ripple or noise on this line will appear as FM modulation of the 10.7-MHz i.f. signal.

The rf head, i.f. strip, power supply and multiplex adapter are housed in an 8 x 10 x 2½-inch aluminum chassis. It is feasible to mount this unit up to 300 feet from the control unit. For special applications you may want to mount only the rf head on or near an antenna. In this case, dc power and tuning voltage are supplied to the rf head. Signals returning from the rf head are the low-impedance i.f. signal and the +13-volt regulated voltage.

The +13-volt regulator has been placed on the rf circuit board to keep temperature-compensating diode D4 at the ambient temperature of the rf head. This minimizes tuning-dial offsets. A block diagram detailing the changes required when the rf head is antenna-mounted as in Fig. 4. The i.f. output cable must not have the shield grounded at either end.

The photographs show only one possible component arrangement. Use the PC boards as templates to mark mounting hole locations before parts are added.

On the rf head, mount all resistors first, then T1, C1, C9 and C22. A dot of solder should be placed behind one of the mounting points on each of these trimmers to prevent rotation after mounting. The mounting washer should not be tightened excessively or tuning will be difficult. One end of C2, C8 and C23 is soldered to the foil; the other

TUNER SECTION PARTS LIST

C1, C9, C22—1–6 pF tubular ceramic trimmer (Centralab 829-6)
C2, C8, C23, C45—15 pF silver mica
C3, C19—5 pF NPO disc ceramic
C4, C5, C10, C11, C12, C16, C20, C21—0.001 μF disc ceramic
C6, C7, C14, C28–C31, C33—C36, C38–C44, C48, C53—0.01 μF, 50V disc ceramic
C17, C27—0.05 μF, 20V disc ceramic
C18—3.3 pF NPO disc ceramic
C32, C37, C51—1.5 pF NPO tubular or disc ceramic
C46, C47—330 pF disc ceramic
C13, C23, C49, C50—0.1 μF, 16V disc ceramic
C25, C26—35 μF, 15V electrolytic
C52—1 μF, 25V electrolytic
C54—500 μF, 50V electrolytic
C55—200 μF, 25V electrolytic
C56—0.22 μF, 100V paper or wrapped Mylar
C57—100 μF, 15V electrolytic
C58—5 μF, 25V electrolytic
All fixed resistors ½W, 10% except as noted
R1—10,000 ohms
R2, R7, R8, R16—470,000 ohms
R3, R4, R14, R45—100,000 ohms
R5, R15—220 ohms
R6, R10—180 ohms
R9, R19—47,000 ohms
R11—150,000 ohms
R12—12,000 ohms
R13—100 ohms
R17, R46—1500 ohms
R18—22,000 ohms
R20—270 ohms
R21—330 ohms
R22, R27, R32, R38—1200 ohms, 5%
R23, R28, R33, R39—2400 ohms, 5%
R24, R26, R29, R31, R34, R37, R40, R42—150 ohms
R25, R30, R35, R41—220 ohms, ¼W
R43, R44—5600 ohms, 5%
R47, R48—330,000 ohms
R36—6800 ohms
R49—47 ohms, 2W
R50—1000 ohms
R51, R52—1000-ohm linear potentiometer
R53—dual 10,000-ohm linear potentiometer, single shaft
R54—2200 ohms
L1—2 turns No. 26, ¼" dia. (space to fit between turns of L2. Insert 1/3 dia. into L2)
L2—4 turns No. 20, ¼" dia., 0.4" length
L3—4 turns No. 20, ¼" dia., 0.4" length, tap @ 2 turns
L4—3 turns No. 20, ¼" dia., 0.4" length, tap 2 turns from cold end
RFC1–RFC3—Wind ½W resistor, 33,000 ohms or larger with No. 30 enamel wire
T1–T4—J. W. Miller 8851A
T5—J. W. Miller—8850
T6—Triad F91X or equivalent
CR1—0.2 amp., 100V bridge rectifier
Q1—3N140 (RCA)
Q2—40604 (RCA)
Q3—2N3856 (G-E)
Q4—2N3405 (G-E)
Q5—2N3860 (G-E)
Q6—40250 (RCA)
IC1–IC4—CA3028 (RCA)
D1–D3—Matched set BA141 diodes (ITT, or see below)
D4, D10—silicon signal diode, 1N645 or equivalent
D5—13V, 2% Zener diode selected 1N4743-A or Schauer Corp. SZ13.0 (2%) Newark Catalog No. 69, p. 121)
D6–D9—1N295
D11—15V, 2% Zener diode Schauer Corp. SZ15.0 (2%) (see D5 above)
1 set (3)—Matched BA141 tuner diodes. $4.60 postpaid, Transitek Co.
1 set—Tuner PC boards, etched, drilled & tin plated. No. VVT-2, $10.60 postpaid, Transitek Co.
1 Multiplex PC board—No. MD1, $4.35 postpaid, Transitek Co., P.O. Box 98[illegible]05, Des Moines, Wash. 98016 (Wash. residents add 4.5% tax for all parts)

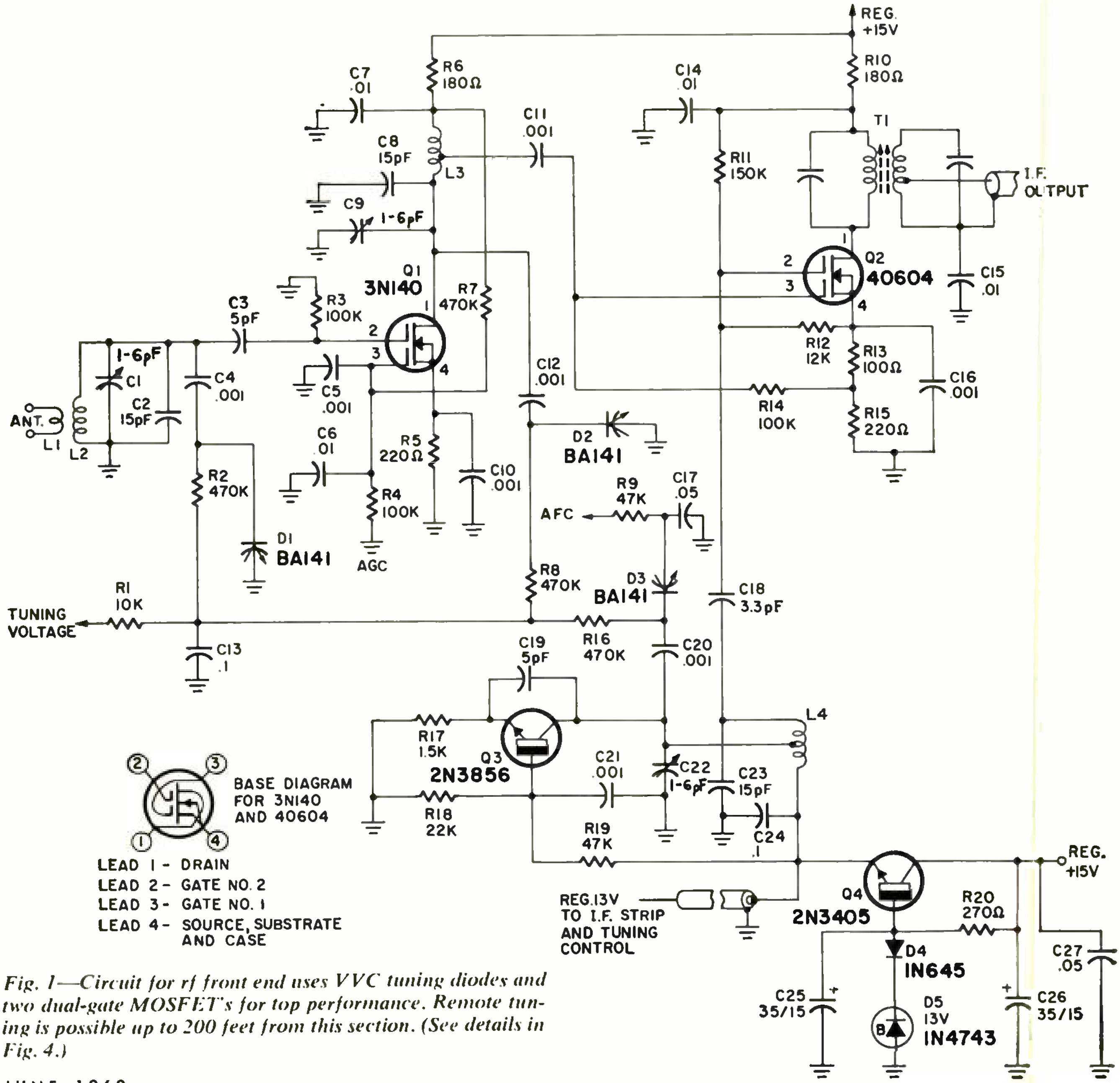
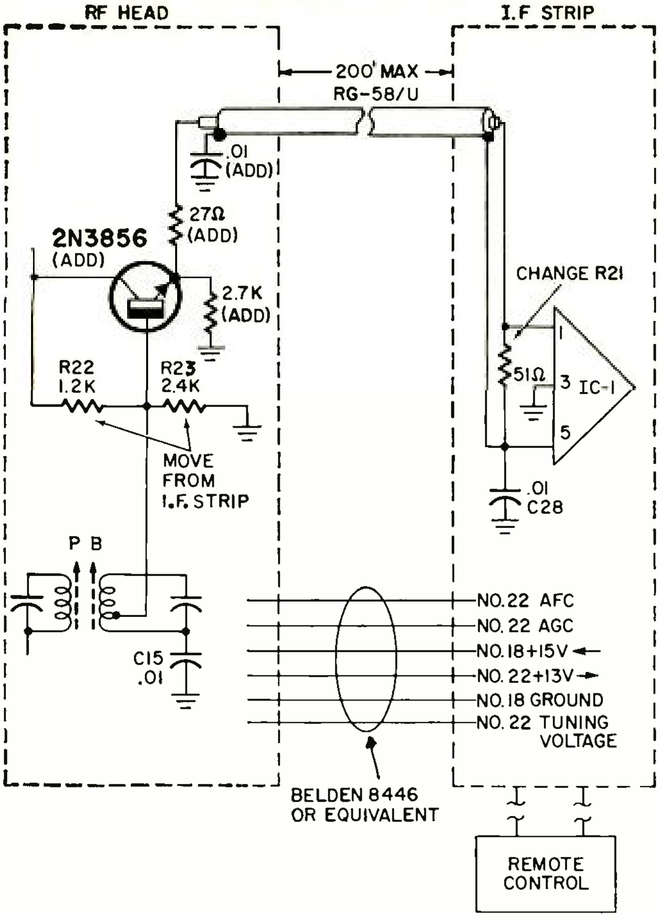


Fig. 1—Circuit for rf front end uses VVC tuning diodes and two dual-gate MOSFET's for top performance. Remote tuning is possible up to 200 feet from this section. (See details in Fig. 4.)



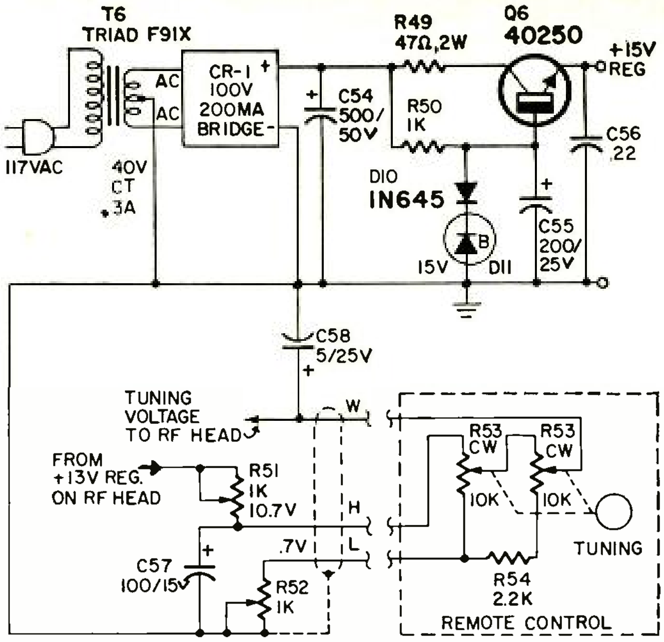
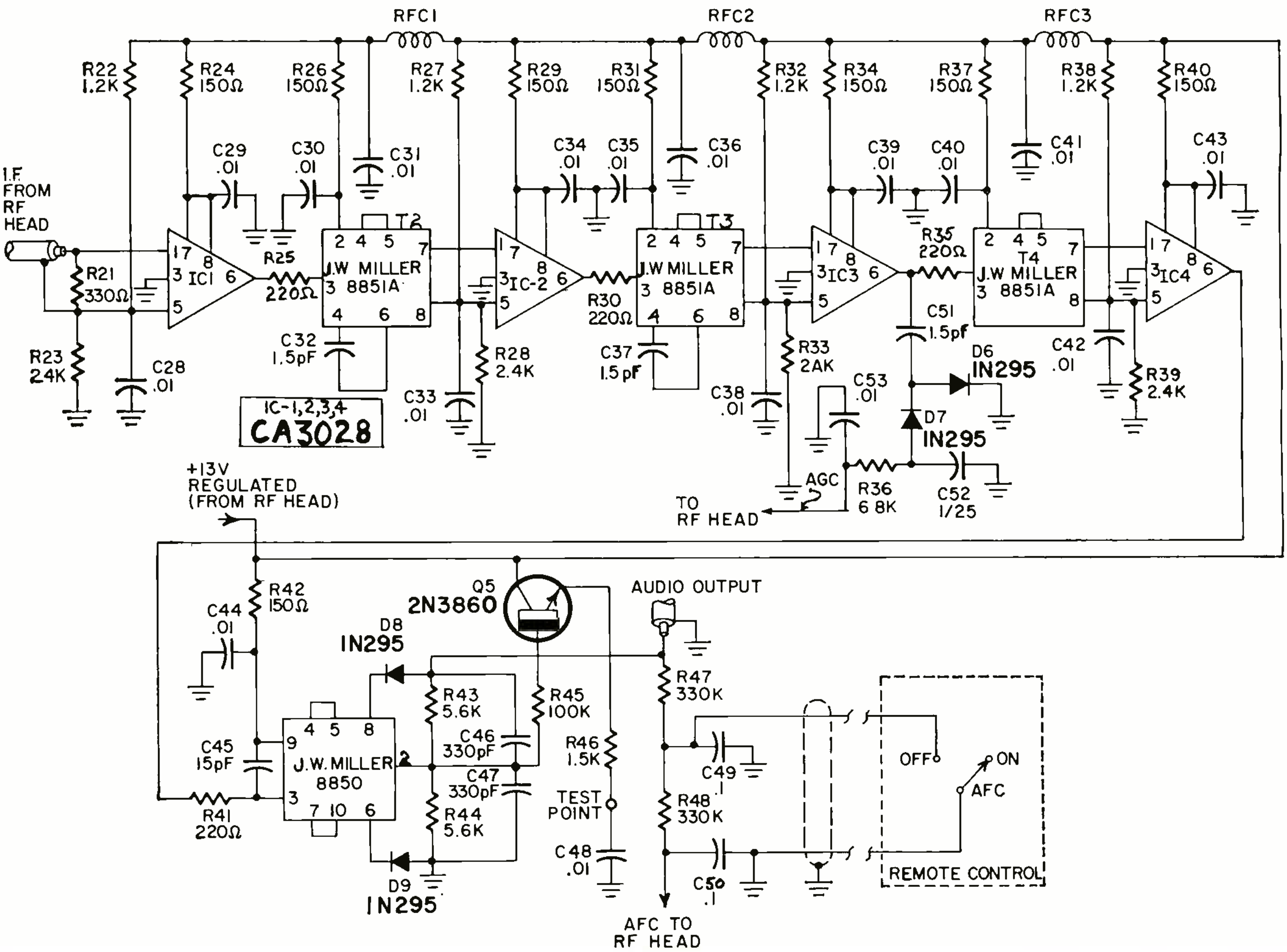


Fig. 3—Circuit for the tuner power supply provides 15-volt source for direct application to Q1 and Q2 in the rf head.

Fig. 4 (left)—Block diagram shows necessary circuit changes if you decide to mount the rf head at or near your FM antenna.

Fig. 2 (below)—Four i.f. stages operate with CA3028 IC's for excellent overall limiting of the i.f. strip.



end is soldered to the lead of the variable ceramic trimmer.

Attach all external wires to the board before soldering in Q1 and Q2. Like all MOSFET's, Q1 and Q2 are sensitive to transient voltages and static charges. Before removing the eyelet on each FET, grasp the case firmly with one hand. Then pull off the eyelet, touching the grounded foil surface BEFORE allowing any lead of the FET to touch the foil. Insert the FET and, *with the soldering-iron tip connected by a clip lead to the foil surface*, solder all four leads.

No special requirements exist for the i.f. strip except the diode leads should have small clips attached for heat sinks during the soldering operation.

In this version a planetary reduction drive was connected to R53. A 3½-inch aluminum circle was used as a dial scale. The frequency calibration is quite linear over the dial scale. Any planetary mechanism with a suitable ratio may be used.

After all units are completed and mounted, the tuner is ready for checkout. First check the +15- and +13-volt regulated outputs. Before the +13-volt output will regulate properly, the +15-volt output must be correct.

The i.f. strip should be aligned before adjustments are attempted on the rf head. Inject a 10.7-MHz signal through a 0.001-μF capacitor to pin 1 of IC3. Connect a 0–1-mA meter to the test point (or a dc vtvm to the base end of R45). Set the output for a tuning indication of 10% of full scale. Peak the pink and blue slugs in T4 for maximum meter indication.

Inject the signal at pin 1 of IC1 and peak the adjustments of T2, T3, T4 and the pink slug of T5 for maximum. Reduce generator output for the sharpest tuning response as alignment proceeds. Finally, clip the generator output lead to the case of C14 and peak T1. Increase generator output until the af output is fairly quiet, then connect a dc vtvm on the lowest voltage range to the af output, and carefully set the blue slug in T5 for a zero-volt indication. This completes i.f. alignment.

The AFC switch must be OFF for all rf alignment steps unless specifically stated otherwise.

Turn the tuning knob to the lowest frequency and adjust R52 for a reading of +0.7 volt at L on the power-

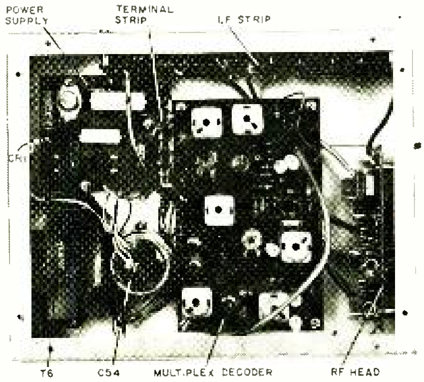
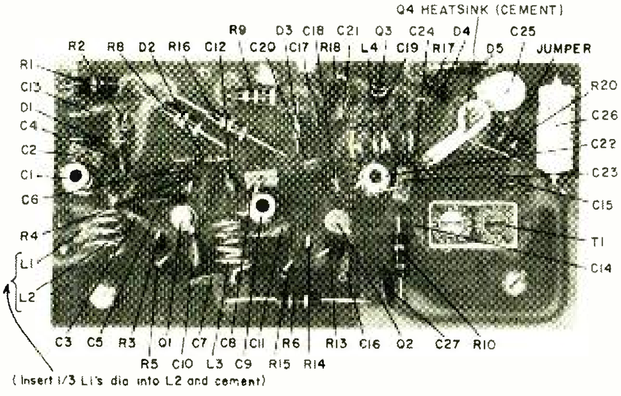


Photo on left shows layout of boards used by author. If you use this arrangement, cut holes in the chassis for transformer and capacitor adjustments. Below is the rf-head board.



MULTIPLEX ALIGNMENT

EDITOR'S NOTE: The multiplex section of this stereo tuner was described by the author in the August 1967 RADIO-ELECTRONICS ("A Modern FM Stereo Adapter," page 32.) Only a few preliminary construction details and all alignment procedures are presented here. The schematic of the multiplex decoder is shown in Fig. 5 and the PC pattern is included. Separation on a properly constructed unit will exceed 30 dB from 50 Hz to 14 kHz, and 40 dB from 100 Hz to 10 kHz.

In mounting parts to the wiring board, first install the transformers, then R3, R22, all other resistors and capacitors (except R2 and R11), and finally the transistors and polystyrene capacitors. The photograph shows all parts clearly.

The first step in alignment is to measure the multiplex output level of the tuner with an oscilloscope. Use the highest peak-to-peak reading as a reference. Use an output level from an audio generator to the decoder, 25% higher than this reference level. (Use any convenient frequency in the audio range.) Choose a value for R2 between 3900 ohms and 12,000 ohms (larger input, larger value), which allows undistorted reproduction of the input signal as seen on a scope at the emitter of Q2.

Next insert a 67-kHz signal (this should be accurate) and tune L for **minimum** signal at Q2's emitter. Insert a 19-kHz signal at one-fourth reference level and tune T1 for **maximum** voltage across its winding. Reduce the input signal and tune T4 and T5, with R22 at maximum, for maximum voltage across R24. During tuning reduce the input level until the voltage across R24 starts to decrease; at this point the tuning effect is most pronounced.

Tack in a 470-ohm resistor for R11 and temporarily ground the collector of Q7. Tune T3 for maximum amplitude of the 38-kHz waveform at Q4's collector. Then tune T2 until any jitter in the waveform disappears, indicating synchronization with the input signal. Continue to retune T1, T2 and T3, while reducing the input level until oscillator is synchronized with a 19-kHz input signal at least 26 dB (one-twentieth) below reference.

Select a value for R11 between 200 and 1000 ohms that provides maximum undistorted 38-kHz output. Too low a value will give lower-amplitude switching voltages and reduced separation. Adjacent cycles of the switching waveform will not have identical height (this is normal) but should be within 20%.

If you have access to a stereo multiplex generator, remove the ground at Q7's collector and inject a composite signal at reference level. Set R22 to place Q7 in saturation and adjust R3 for maximum separation.

If such a generator is not available, run through the procedure just described with the decoder connected to a tuner receiving a stereo transmission. Connect a potentiometer (about 100,000 ohms) to the tuner output to allow reduction of the decoder input during alignment.

After preliminary adjustments, remove the potentiometer from the circuit. Connect outputs A and B to the vertical and horizontal inputs of an oscilloscope. Tune to a station known to be transmitting a stereophonic broadcast. Adjust R22 until PL lights. The scope pattern will probably resemble Fig. 6-a. Adjust R3 until the scope display looks like Fig. 6-b. A slight touchup of T1 and resetting of R3 will result in best separation. If the separation seems poor, try another stereo station or broadcast.

To identify outputs A and B as to left and right, try to find a test transmission (many stations make them) in which the channels are identified. Some broadcasters make all voice announcements on a single channel during regular programing. Of course a stereo multiplex generator will instantly identify the channels.

supply board. Turn the dial to the highest frequency and adjust R51 for +10.5 volts at H on the power-supply board. The voltages at L and H change with the tuning knob position: this is normal, so be sure you set the knob correctly before adjusting the pots. Repeat adjustments.

Pre-position the flat portion of the tuning screws as follows: C1, 0.4 inch from foil: C9, 0.45 inch from foil; C22, 0.55 inch from foil. Turn the dial fixed to R53 to both stops and mark the end points. Make another mark 45° above the counterclockwise end and a mark 30° below the fully clockwise limit. These will be the alignment points for 88 and 108 MHz.

Set the dial to 88 MHz and squeeze or spread the turns of L4 until 88 MHz is received at this point. Coils L2 and L3 should be adjusted for maximum signal. Reduce generator output as alignment proceeds. Now tune the dial to the 108-MHz point, set the generator to 108 MHz and adjust C22 until the signal is received at this point. Peak C1 and C9 for maximum indication.

Recheck the 88-MHz alignment, which probably will have moved slightly. Remember, adjust inductance at 88 MHz, and tune with the capacitors at 108 MHz. Go from one end to the other until no further peaking is possible. If you have trouble getting to these points, it is entirely possible that the H and L voltages are off. If you can't get the dial to track at these points, increase the H voltage to 10.9 volts by setting R51.

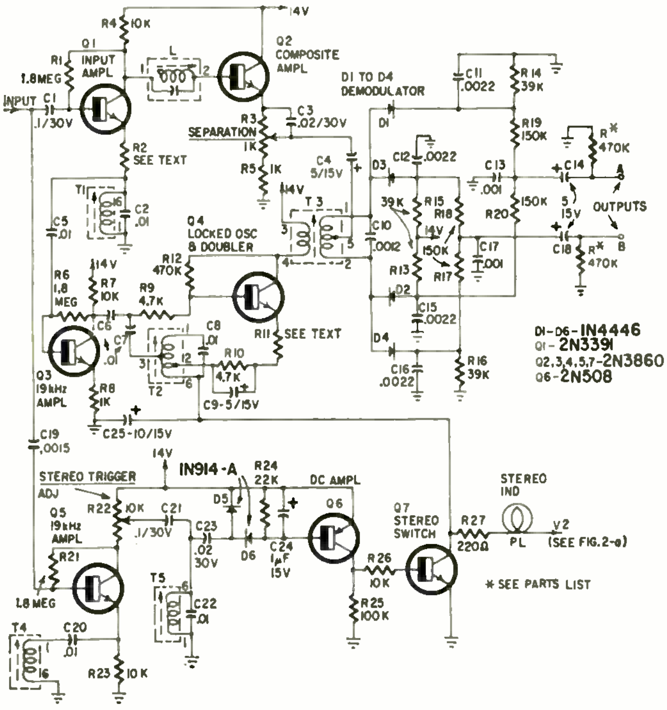
The rf alignment is now complete. Depending on the linearity of R53, it may be possible to separate the 88- and 108-MHz end points farther. (Some potentiometers have a considerable amount of end resistance and tuning becomes very broad at the ends.) To lower the 88-MHz point, increase the L voltage slightly; at the same time move R53 more counterclockwise. To raise the 108-MHz point, decrease the H voltage, moving R53 clockwise at the same time.

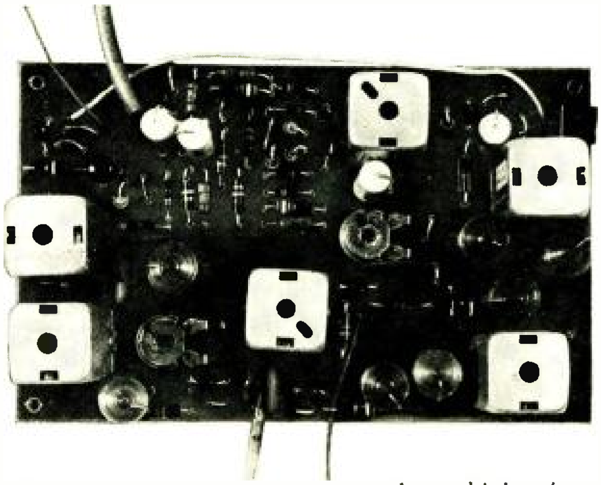
After a satisfactorily linear dial is calibrated, it is wise to record the H and L voltages at the mechanical extremes of R53 for future reference. **R-E**

If you want a complete set of printed circuit layout diagrams for this tuner send a stamped, self-addressed envelope to: Tuner Diagrams, c/o Radio-Electronics, 200 Park Avenue South, New York, N. Y. 10003.

PARTS LIST
MULTIPLEX DECODER

C1, C21—0.1 μF, 30V, ceramic
C2, C5, C6, C7, C8, C20, C22—0.01 μF, polystyrene
C3, C23—0.02 μF, 30V, ceramic
C4, C9, C14, C18—5 μF, 15V electrolytic
C11, C12 C15, C16—0.002 μF (Sprague 192P or equivalent)
C13, C17—0.001 μF (Sprague 192P or equivalent)
C10—0.0012 μF, polystyrene
C19—0.0015 μF, disc ceramic
C24—1 μF, 15V, electrolytic
C25—10 μF, 15V, electrolytic
Capacitors specified as polystyrene are Mallory type SX, listed on p. 331 of Allied's Catalog 280 (1969 general catalog)
Ceramic capacitors can be Sprague's low-voltage type, although higher-voltage capacitors are of course equally usable.
D1–D6—IN4446 (G-E) (1N914A is also usable)
Q1—2N3391 (G-E)
Q2, Q3, Q4, Q5, Q7—2N3860 (G-E)
Q6—2N508 (G-E)
PL—16-volt indicator lamp (15–20 mA) (Sylvania 16CSB—p. 508 of Newark Catalog 69)
Resistors R—470,000 ohms to 1 megohm to prevent multiplex switching click (equal values)
R1, R6, R21—1.8 megohm
R2, R11—see text
R3—trimmer resistor, 1000 ohms (Mallory type MTC-4)
R4, F7, R23, R26—10,000 ohms
R5, R8—1000 ohms
R9, R10—4700 ohms
R12—470,000 ohms
R13, R14, R15, R16—39,000 ohms, 5%
R17, R18, R19, R20—150,000 ohms, 5%
R22—trimmer resistor, 10,000 ohms (Mallory type MTC-4)
R24—22,000 ohms
R25—100,000 ohms
R27—220 ohms
All resistors ½ watt, 10% unless otherwise specified
T1, T2, T4, T-5—19-kHz tank (J. W. Miller 1354-PC)
T3—38-kHz output transformer (J. W. Miller 1355-PC)
L—series bandpass filter (J. W. Miller 1352-PC)
For chassis construction instead of PC board, order Miller units without PC suffix





Positioning of major components on the multiplex decoder board. The decoder used by the author was detailed in the August 1967 R-E.

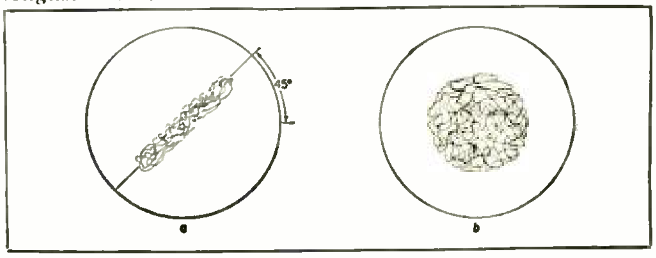


Fig. 5 (above)—Schematic for the multiplex decoder circuit. Figs. 6-a, b (right) shows scope display during separation adjustment.

horizontal-oscillator, afc cathode-coupled multivibrator and back-to-back diode

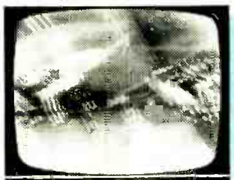
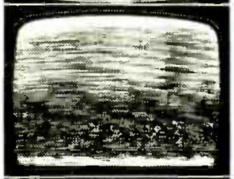
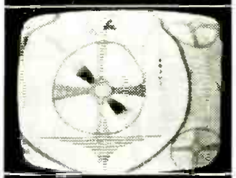
NEW R-E EXCLUSIVE

Kwik-Fix™ picture and waveform charts

HORIZONTAL SWEEP CIRCUITS

by Forest H. Belt & Associates*

SCREEN SYMPTOMS AS GUIDES

SYMPTOM PIC	DESCRIPTION	VOLTAGE (WHERE TO CHECK FIRST)	WAVEFORM (WHERE TO CHECK FIRST)	PART (WHERE TO CHECK FIRST)
	Pic jittery or sliding sideways. Hold can't steady it.	diode-pin-2	WF3 WF1	D1 C4 C1
	Severe bending and waving.	not much help	not much help	R4-C5 R5-C6
	Off-frequency slightly beyond range of hold.	diode-pin-2 grid-pin-7	WF5	R7 C7 C8
	Flagwaving at top.	not much help	not much help	R4 R5
	Far, far off-frequency screen almost dark.	cathode-pin-8 grid-pin-7	WF4	R6
	Blank bar visible. Pic jittery, but not bent very much.	plate-pin-6	WF5	R9 D1
	Way off-frequency. Screeching, sometimes.	grid-pin-7	WF5	R11 C8
	Scallops at top. Also called piecrusting. May wiggle.	little help	little help	R5 C6
	Osc stopped or 'way off-frequency	plate-pin-1 plate-pin-6	WF5	R6-R7 R9 C8 C10

* an Easy-Read™ feature by FOREST H. BELT & Associates © 1969

Use this guide to help you find which key voltage or waveform to check first.
Study the screen and the action of the Hold control.
Most helpful clues to fault are found at key test points indicated.

Make voltage or waveform checks as indicated for screen symptoms.
Use voltage guide *and* waveform guide *to analyze results.*
For quick check, test or substitute parts shown as most likely cause of symptom.

The Circuit

THIS IS THE POPULAR WAY TO GENERATE AND CONTROL a horizontal sweep signal. For automatic frequency control (afc), the sync signal, coming from the sync separator through C1, is compared with a signal from the output stage (WF2). If the oscillator moves off-frequency, pulses in the flyback signal don't coincide with sync pulses: the comparison diodes produce a dc correction voltage, which is applied to the pin-2 grid, adjusting oscillator frequency.

The two triodes are a multivibrator: feedback is by common-cathode connection across R6. Free-running frequency (without afc) is set mainly by the time constant of C8, R10, and R11.

Signal Behavior

The multivibrator produces a sawtooth. But outside forces affect it: horizontal sync applied through C1, and output sample (WF2) coming through R3. Pulses are phase-compared in the balanced diode circuit. Dc voltage at diode-pin-1 depends on the phase difference between the two pulses. It's near zero as long as the output and sync pulses are alike in frequency and phase. If either pulse shifts, the dc voltage changes enough to alter the multivibrator frequency and make the output pulse match the sync again. Filter R4-C5 smooths dc control voltage.

Capacitor C8 couples signal from first half to second half of the multivibrator. Charge/discharge time of C8 is set by R10-R11, and that sets the basic frequency. Tuned tank L1-C9 is a "flywheel" circuit to stabilize the signal; notice how the bottom of WF4 is rounded. R8 keeps L1-C9 from tuning too sahrply.

Network R12-C11 gives the signal a trapezoid shape. C10 couples it to the output stage.

DC Distribution

Plate-supply path for V1A is through L1, R7, the tube, and R6. Almost no voltage drops across L1, but about 60 volts drops across R7, leaving 200 at plate-pin-1. Voltage at grid-pin-2 stays fairly constant during normal operation. Bias for V1A is the 6 volts across the cathode resistor. Dc return for grid-pin-2 is roundabout: R4, R1, R2, R3, and the flyback sampling winding.

Plate current for V1B flows through R6, the tube, and R9. Besides cathode bias from R6, some grid bias develops across R10-R11. R9 usually drops about 135 volts, leaving 125 at plate-pin-6. The exact voltage depends on bias at grid-pin-7, and the hold control sets that.

With both cathodes connected across R6, a change in plate current in either tube-half can affect bias on the other. A bad tube can give some odd effects.

Signal and Control Effects

Stage operation doesn't change much when a station is tuned in. The only change in most waveforms is a tiny amplitude increase and a little "grass" (caused by video leaking into the stage).

Most noticeable change with station signal is the effect of the Hold control on dc voltages. Without a station, voltage at grid-pin-7 is the only one that varies much when you turn the Hold control; it swings between −3 and −8 volts. With station signal, when you twist the Hold: grid-pin-2 varies 0.5 volt either way; plate-pin-1 varies, but not far; cathode-pin-3 (and −8) varies between 6 and 8 volts; plate-pin-6 varies between 115 and 145 volts; diode-pin-2 swings between 4 and 8 volts.

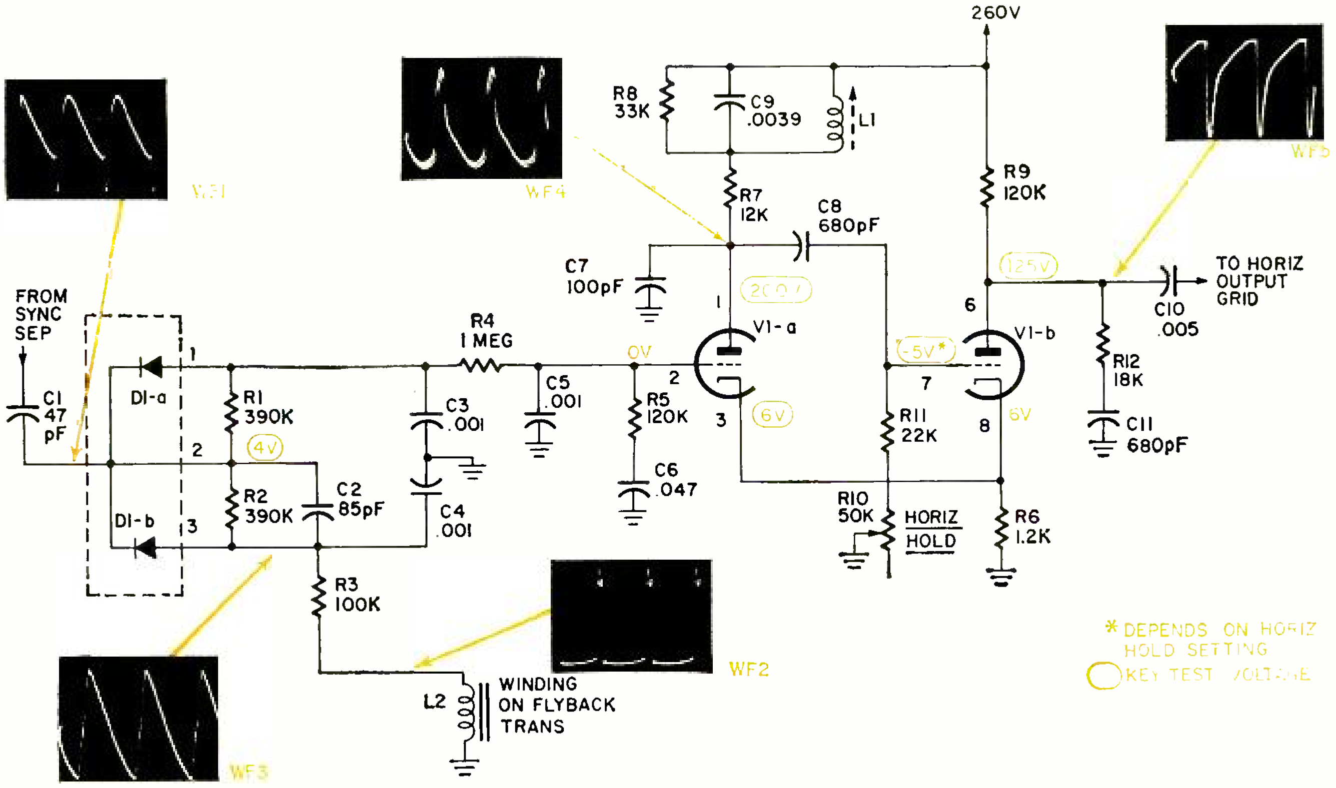
If you turn the Hold control so far that you hear the oscillator screeching, with or without station signal, none of the voltages are consistent.

Quick Troubleshooting

First, clip a jumper between diode-pin-1 and ground; that separates oscillator from afc. Rotate Hold from end to end. If the oscillator screeches, you know it's running. If there's video on the screen, stop the control where it keeps the picture as still as possible, although the jumper is blocking sync.

Check dc voltages at plate-pin-1 and plate-pin-6. If

(continued on page 45)



DC VOLTAGES AS GUIDES

VOLTAGE CHANGE →	TO ZERO	VERY LOW	LOW	SLIGHTLY LOW	SLIGHTLY HIGH	HIGH
Diode-pin-2 Normal is about 4 volts. Is developed mainly from rectified flyback pulse.	R7 open R9 open R11 open C1 shorted C8 shorted C10 open C11 shorted		R1 shorted R2 open R3 open/hi R6 open/hi R9 shorted R11 high C1 open D1B open D1A shorted	R1 low R2 high R3 high R5 open/hi R6 high R9 low C5 open C7 open	R1 high R2 low R3 low R4 shorted R5 short/lo R6 low R11 short/lo C1 leaky C2 leaky C2 open D1A open	R1 open R2 shorted R3 short/lo R6 short/lo C1 shorted C1 leaky C2 shorted D1B shorted
Cathode-pin-3 Cathode-pin-8 Normal 6 volts. Varies a volt or two with Hold, if station is tuned in.		R6 short/lo R7 open/hi C7 shorted D1B open	R6 low C7 leaky L1 open C11 shorted	R1 shorted R2 open R9 open R11 open C10 open C11 leaky D1A shorted	R1 open R2 shorted R3 low (5k) R4 open R7 short/lo R9 low C2 shorted C6 open C7 open D1B shorted	R3 shorted R6 open/hi R9 short/lo C1 shorted C1 leaky C8 shorted D1A open
Plate-pin-1 Normal 200 volts. Varies with Hold setting or station signal.	R7 open C7 shorted	R7 high C7 shorted C7 leaky C8 shorted	R1 open R2 shorted R3 shorted R3 open R6 shorted R7 high(50k) R9 open C1 shorted C7 leaky C8 leaky D1A open L1 open	R6 low R8 very low R10 open/worn R11 open/hi R12 open/hi C1 leaky C2 shorted C7 leaky C8 leaky C8 open C10 open C11 shorted	R1 shorted R2 open R5 open R8 shorted R8 open R9 short/lo R11 short/lo C4 open C6 open C11 open D1A shorted	R6 open/hi R7 short/lo D1B open
Grid-pin-7 Normal varies from —3 to —8 with Hold Control. For tests, set Hold for as near-normal pix as possible.	(or goes positive) C8 leaky C8 shorted C8 open	C8 leaky	R3 short/lo R4 short/lo R5 shorted R6 faulty R7 faulty R9 faulty R11 short/lo C1 shorted C2 open C5 open C7 shorted C7 leaky C8 leaky C11 shorted D1B open	R5 low R6 low R11 low C9 open C10 leaky C11 leaky D1A open	R1 short R1 open R5 high R11 high C4 shorted C4 leaky C10 open C11 open D1A shorted	R4 open R5 open R11 open/hi
Plate-pin-6 Normal 125 volts. With station, Hold can vary it from 115 to 145. For tests, set Hold for as near-normal pix as possible.		R6 shorted R9 open C8 shorted C11 shorted	R6 low R7 open R9 high R12 short/lo C6 shorted C6 leaky C8 leaky C11 leaky D1B open	R6 low R7 short/lo C5 open C6 shorted C6 leaky C10 shorted C10 leaky C11 open L1 shorted	R1 open R2 shorted R3 open/lo R4 open R6 high R9 low R11 high C1 leaky C2 shorted C8 open C10 open D1B shorted D1A open	R3 short/lo R6 open R9 short/lo R11 open C1 shorted

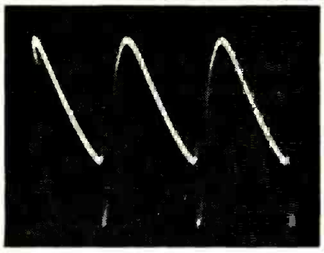
Use this guide to help you pinpoint the faulty part.
Measure each of the five key voltages with a vtvm.
For each, move across to the column that describes the change you find.
Notice which parts might cause that change.
Finally, notice which parts are repeated in the combination of changes you found.

Test those parts individually for the fault described.

NOTE: For more guides to narrow down the faulty part further, see waveform guide.

NOTE: Dc voltages at diode-pin-1, diode-pin-3, and grid-pin-2 are misleading for diagnosis, so are not a part of this guide.

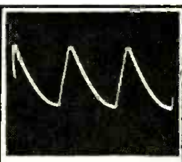
WAVEFORMS AS GUIDES



WF1 Normal 3.0V p-p

Taken at diode-pin-2, this waveform is combination of input sync pulse and sampling pulse from flyback transformer. Sawtooth shape of flyback pulse dominates; sync pulse forms downward spike. If oscillator goes off-frequency, sync pip jitters around and makes waveform very unstable. This waveform is good check point for judging operation of afc network. Before condemning WF1, however, make sure WF2 is normal; if it isn't, WF1 will be incorrect and unstable.

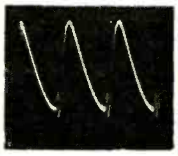
Shape okay V p-p low	Shape okay V p-p high	V p-p zero
R3 high	R3 short/lo	R6 faulty
R7 high	R7 short/lo	R7 open
R9 high	R9 low	R9 open
R11 faulty	R11 s. low	C7 shorted
C4 shorted	C1 shorted	C8 open
C7 leaky	C1 leaky	C8 shorted
C8 faulty	C2 open	C10 open
C11 leaky	C3 faulty	C11 shorted
D1 faulty	C4 open	
	C5 lky/short	
	D1 faulty	



C1 open

R2 high

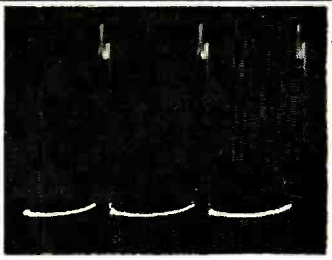
R1 shorted
D1 faulty



R1 low

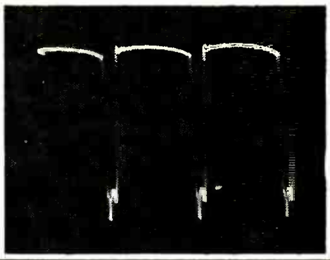
R2 low
D1 faulty

R2 shorted
C2 shorted
D1 faulty

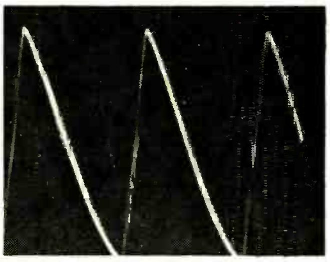


WF2 Normal 100V p-p

This is the afc sampling pulse. Usually, it comes from an extra winding on the flyback transformer; in a few chassis, it comes from elsewhere in the horizontal output stage. It represents oscillator frequency and phase, and is compared with station sync by the afc diode. Amplitude is not critical, unless it becomes very low. Polarity *is* critical. Most common trouble is faulty flyback transformer, or new one wired up wrong.



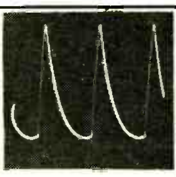
Other than reversed polarity, shown here, there are few faults. The waveform shown here is from the winding being wired up in reverse at the flyback transformer, when a new one was being installed.



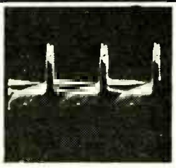
WF3 Normal 3.5V p-p

This is the sampling pulse after it is influenced by R3 and C4. Note the sawtooth shape. R3-C4 have an integrating effect on the sharp pulses that originate in the horizontal output stage. You can see in WF1 how this sawtooth shape dominates. The afc diode compares phase of this waveform with that of the incoming sync-pulse waveform. The two of them form WF1.

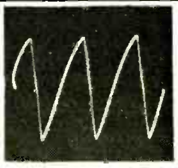
Shape okay V p-p low	Shape okay V p-p high	V p-p zero
R3 open/hi	R3 low	
C4 leaky	C4 open	
R7 short/lo	C1 shorted	
R11 shorted	D6	
C10 open		



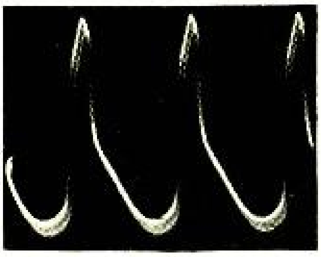
R3 low



R3 open
D1 faulty



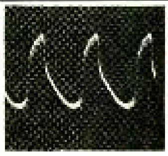
Winding reversed



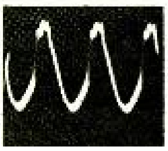
WF4 Normal 10V p-p

The oscillator's own waveform, but its shape is influenced by some afc parts. Mainly, though, shape and frequency depend on time constants of capacitors and resistors in oscillator stage. Natural waveshape in multi-vibrator like this is sawtooth. Amplitude depends mostly on plate dc voltage; frequency depends mostly on dc bias at grid-pin-2 and on values of components coupling this waveform to grid-pin-7.

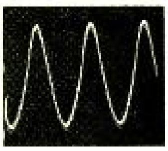
V p-p low	V p-p high	V p-p zero
R2 open	R9 short/lo	R6 shorted
R6 high/low	R11 open/hi	R6 open
R7 low	C1 s. leaky	R7 open
R9 high		R9 open
R11 low		R11 shorted
C1 shorted		C7 shorted
C7 leaky		C11 shorted
C11 leaky		
D1B open		



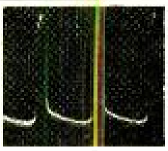
R2 open



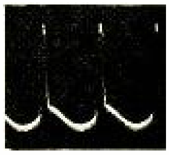
R7 low



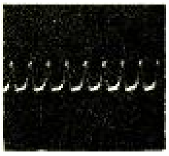
R7 shorted



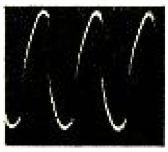
C9 shorted
R8 low
L1 open



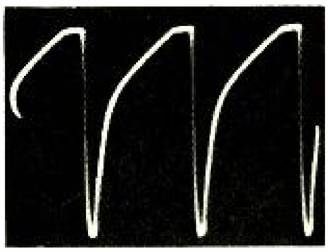
R6 low



R6 very low



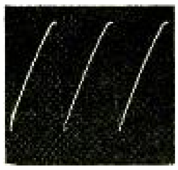
R9 low



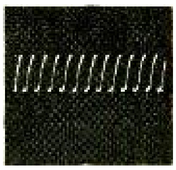
WF5 Normal 35V p-p

Output waveform, ready to be fed to horizontal-output stage. Similar in some ways to WF4, but inverted and nearer trapezoid shape ultimately needed by horizontal yoke. Would be saw-shaped, except for R12-C11. Its amplitude is affected mainly by waveform fed from V1A; frequency mainly by components in grid circuit, shape by other parts in V1B stage.

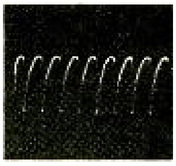
V p-p low	V p-p high
R6 high	R11 high/open
R7 faulty	D1A open
R11 low	
C7 leaky	
C8 leaky	
C11 leaky	
D1B open	
L1 open	



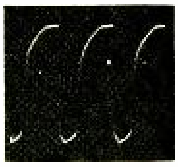
R12 low



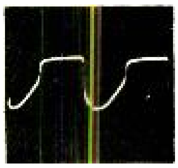
C8 leaky



R6 very low



R9 low



R9 very low

Use this guide and the voltages guide *to help pin down the fault possibilities.*

With the direct probe of the scope, check the five key waveforms. Scope set at H or at about 5 kHz.

Note amplitude. If it's low or high, check parts under those descriptions.
Note waveshape. If there's a change, check those parts.

NOTE: Only waveforms that help most with diagnosis are included in this guide.

both are within 30% of normal, the oscillator should run. If they are too high, too low, or missing, check the supply path. Measure bias on grid-pin-7, and on cathode-pin-3. If either voltage is far wrong, check related components (including C8).

With the oscillator running, jumper across L1. Steady the picture with the Hold control. Remove the jumper and tune L1 to again steady the picture. Then unclip the jumper between diode-pin-1 and ground. If the oscillator jumps off-frequency or quits, there's a fault in the afc.

Now use the scope. Check WF1 first, then WF2 and WF3. If WF1 is without a strong sync pip hold becomes touchy. WF2 can be down nearly half without losing horizontal hold. Polarity of WF2 and WF3 is critical. If WF1 is okay, but sync is poor, check R3 and C4.

A bad WF1 is hard to analyze. Instead of trying, if WF2 and WF3 are okay, check or replace the diode. Finally, check C3, R4, and C5. These three also affect the dc control voltage, and therefore frequency slightly.

If bending or piecrusting is a trouble, work on anti-hunt circuit R5-C6. Also, suspect C3, C5, R1, R2, and R4.

TECHNICAL TOPICS

Starting this month here's a new department you can contribute to. Read and write.

by **ROBERT F. SCOTT**
SENIOR TECHNICAL EDITOR

THIS MONTH WE ARE INTRODUCING "Tech Topics," a column in which we plan to discuss new circuits and components, keep you up to date on the latest technical developments, provide background material on some common but not-well-understood circuits and serve as a clearing house for those of you with circuits, techniques and technical information you feel will interest fellow readers. We are particularly interested in dope you may pick up from foreign radio and electronics publications and manufacturers' application notes.

Consider "Tech Topics" as your personal sounding board and feel free to let off steam about a particular circuit, device or technique: be it audio, radio, ham operating or what have you. Let us know what you would like to see in this column. We may not have the necessary info but we'll pass the word to your fellow readers and see what they come up with in the way of good solid answers.

An old but little-known vfo

Good frequency stability is a prime requisite of variable-frequency oscillators used in receivers and transmitters and in such test instruments as signal generators and frequency meters. For the last twenty years, the Clapp/Gouriet oscillator (Fig. 1) has been considered the ultimate in stable vfo's. It has been widely used in ham transmitters but is seldom seen in other applications because its tuning range is much, much smaller than the 3:1 frequency ratio possible with most other LC circuits.

A second disadvantage of the Clapp is that its rf output voltage is not constant. It drops off drastically as the circuit is tuned toward the high-frequency end of any given band. The wider the band, the greater the fall off in output voltage. When the band has a frequency ratio greater than around 1.2:1, the output drops to the point where there is not enough feedback to sustain oscillations. This results in uneven excitation of mixers in superhet circuits and in the following stages in transmitters.

Another drawback of the Clapp is that its "hot" cathode (the cathode is above ground for rf) is subject to hum modulation when the heater is operated from an ac power supply.

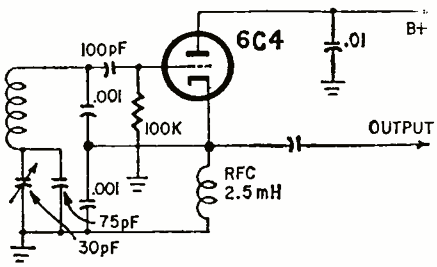
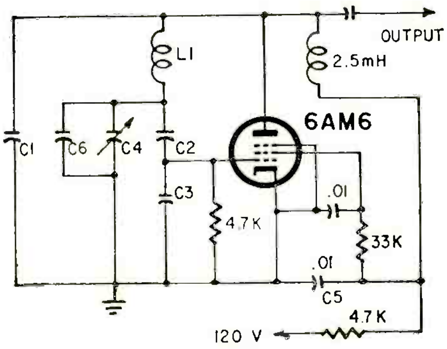


Fig. 1—The Clapp/Gouriet oscillator shown here has gained the reputation of the ultimate in stable vfo's from ham transmitters.

The Vackar oscillator (some call it the Tesla oscillator) in Fig. 2 overcomes the aforementioned disadvantages of the Clapp. It was developed during World War II by Jiri Vackar at the Czechoslovak Tesla laboratories but was not described in the technical press until 1949.

Both the Clapp and Vackar oscillators are series tuned with the tube tapped down on the tank through two large series-connected capacitors. Too, all the tube interelectrode capacitances are shunted by large external capacitors. However, in the Vackar, the external capacitances are much larger. This results in greater stability by further reducing the effects of changes in interelectrode capacitances and electrode voltages. The Vackar can provide a constant output voltage over a frequency range as high as 2.5:1. In addition, the Vackar's cathode may be grounded so it can in no way affect the tuned circuit or the feedback path.

Various articles on the Vackar lead us to believe that Vackar's original paper did not include full details on circuit values. For this reason, hams had to develop constants for their circuits. This resulted in considerable differences in the values of corresponding parts used by different constructors. Consequently, there have been many arguments pro and con on the relative merits of various versions of the Vackar.



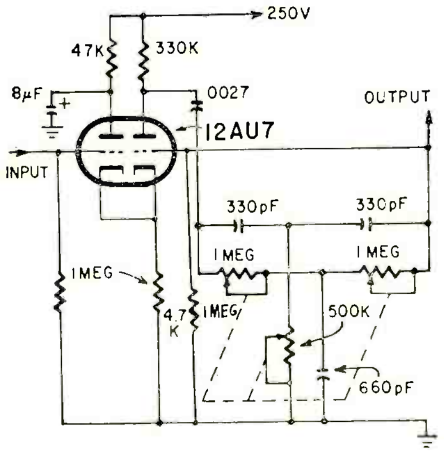


Fig. 2—Vackar oscillator is series tuned with the tube tapped down like the Clapp. But external capacitances are larger.

Fig. 3—Audio filter circuit consists of two-stage cathode-coupled amplifier with a twin-T filter as feedback network.

In the March 1965 issue of *RSGB Bulletin* (now *Radio Communications*, the Journal of the Radio Society of Great Britain) T. Lyell Herdman, G6HD, points out that for the circuit in Fig. 2, Vackar recommends the following relationships:

C2 is much smaller than the sum of C4 and C6.

The sum of C4 and C6 is much smaller than C1.

C2 is much smaller than C3.

$C1/C4+C6=C3/C2=6$.

In a circuit tuning from 1.7 to 2.0 MHz, C1 is .0072 μF, C2 is 100 pF, C3 is 600 pF, C4 is 100 pF and C6 is .0011 μF.

A high-Q coil is essential to the operation of the Vackar but the dynamic resistance of the tuned circuit must be held down to a reasonable value. If it is too high, the voltage across C2 and C3 will not be high enough to sustain oscillations. Thus, the inductance of the coil should not be made too high and the maximum value of C4 should be selected for the lowest operating frequency.

In some applications, the performance of the Vackar can be improved by using a two-gang variable capacitor for C4 with the second section of the same value connected across C1.

Super-sharp heterodyne filter

Heterodynes or whistles often take the joy out of AM broadcast and shortwave listening. They are generally the result of beats between the desired signal and (a) a station on an adjacent channel (b) a distant station on the same frequency or channel (c) a station on a frequency two times the set's i.f. away from the desired station or (d) a strong station operating on or very close to the set's i.f.

An audio filter can be used to eliminate whistles if it is tunable with a very narrow passband and a high attenuation at the interference frequency. A whistle frequency with these characteristics is used in the Philips model B5X35A receiver and described in *R.G.T. Monitor,* a publication of the Philips organization in the Netherlands.

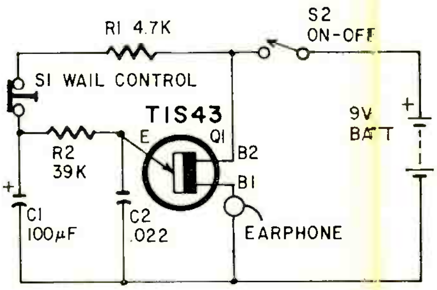
The filter circuit (Fig. 3) consists of a two-stage cathode-coupled amplifier with a Twin-T filter as a feedback network between plate and grid of the output stage. A three-gang potentiometer tunes the filter from around 800 Hz to about 20 kHz. Attenuation is 100 dB down at the whistle frequency and only about 5 dB down at frequencies 0.8 and 1.2 times the filter frequency.

A solid state version of this filter may be just what you need for your receiver. If you can develop a transistor or IC model, send it to us along with the circuit and performance figures. The many other readers of this column will enjoy hearing about it. If we use it, you'll be paid at our regular rates. **R-E**

SIREN FOR TOY AMBULANCE OR FIRE ENGINE

Want to give your young son a real thrill, and at the same time give him reason to boast that his Daddy is the greatest? Then build a real-sounding siren into his toy ambulance or fire engine! All you need is an old high-impedance magnetic earphone and a few other inexpensive parts, as shown in the accompanying schematic.

In this circuit, a unijunction transistor, Q1 (Texas Instruments TIS 43), operates as a relaxation oscillator, with resistor R2 and capacitor C2 in the emitter circuit determining the approximate operating frequency—approximate because the operating frequency is also determined by the voltage supplied to the R2-C2 combination. This voltage comes from



the charge stored in electrolytic capacitor C1.

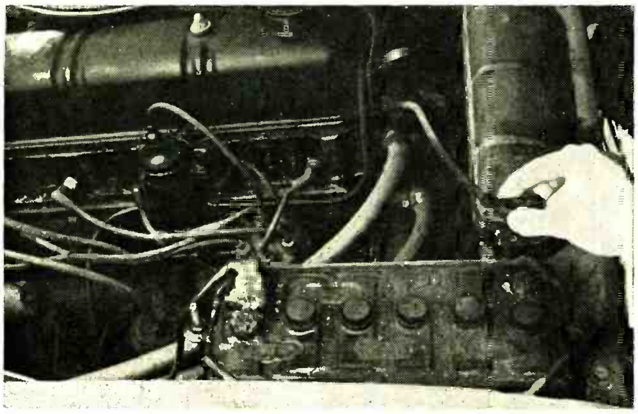
When on-off switch S2 is turned on, capacitor C1 charges through resistor R1, increasing the potential across the R2-C2 combination. As a consequence, the sound coming from the earphone rises in frequency. When S1 is pressed, the emitter-supply circuit is opened, capacitor C1 slowly discharges, the potential across the R2-C2 combination decreases, and the frequency falls. Component values have been chosen so that, when S1 is alternately pressed and released at approximately 2-second intervals, the rate of rise and fall, as well as the pitch, imitates the wail of a siren very realistically.

With a 9-volt battery and the average old high-impedance magnetic earphone, the sound is loud enough to satisfy the youngster, but not as loud as to disturb everyone in the household. The use of a pushbutton switch with normally closed contacts for S1 keeps the wail going as long as the circuit is energized, thus serving as a reminder to switch S2 off when the toy is not in use.

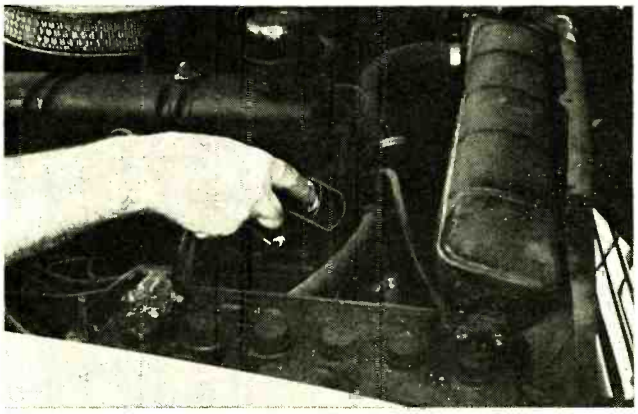
—Frank H. Tooker

4 SAFETY TIPS FOR AUTO WORK

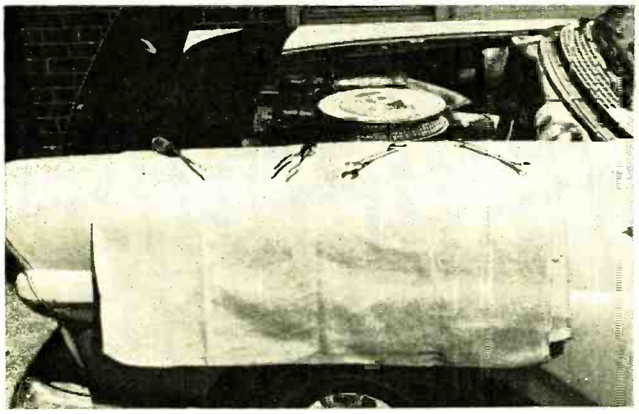
by CHARLES E. COHN



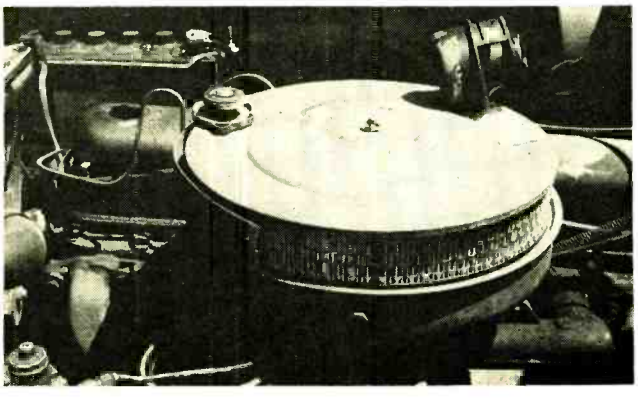
1. Disconnect the battery ground cable to eliminate the risk of short circuits.



2. Make ignition timing easier and safer by removing the fan belt.



3. Clear away loose tools before starting the engine, to avoid the hazard of their falling into the engine fan.



4. Be sure to replace all filler caps and other loose parts before closing the hood on a job.

Observing a few simple safety precautions can cut the hazards of working on a "live" engine to an absolute minimum. Working on a car can be safer than driving it.

Disconnect the battery ground cable whenever you work on the electrical system or whenever there is a possibility of causing a short circuit. The main electrical circuits in a car are not ordinarily protected by fuses. There is nothing to prevent a short circuit from causing extensive damage and serious burns. Interrupt the battery circuit in *any* situation where there is a chance of a tool or other metal object accidentally touching an exposed terminal.

Disconnect the *ground* cable. If you pull the hot cable first, accidental contact of the wrench with a metal part of the car would cause a short circuit. You might also do this when the car is to be left idle and unattended for several days or weeks. De-energizing the electrical system this way prevents a hidden defect in the car wiring from developing into a short circuit and causing fire.

The rotating engine fan is an extreme hazard and should be treated with as much respect as a circular saw. It has a similar appetite for fingers. **Don't put your hands anywhere near the fan when the engine is running.** Sometimes this rule must be violated, as in timing the ignition with a timing light. Then remove the fan belt so that the fan will not turn. This not only removes the hazard, but also makes the job much easier, since it allows the light to be held closer to the timing mark.

An innocent-looking group of tools lying on a fender cover can present a hazard. If the work is being done outdoors, a gust of wind can catch the fender cover and spill the tools into the engine compartment. If a tool falls against the fan while the engine is running, it can be hurled with great force and cause considerably injury and damage. Therefore, **remove loose tools from the fenders before starting the engine.** Similarly, **filler caps and other parts should not be left lying loose,** when the hood is closed. They can fly about and do damage. **RE**

NEW FOR YOU

20 SCR CIRCUITS YOU CAN MAKE

By R. M. MARSTON

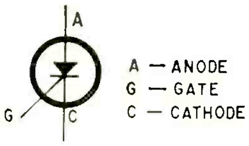
ONE OF THE MOST IMPORTANT SEMICONDUCTOR DEvices developed in recent years is the silicon controlled rectifier or SCR. Basically it acts as a unidirectional semiconductor switch that is normally off, but which can be turned on with a suitable trigger signal.

SCR's can handle currents up to several amps and operate at ac line voltages. Consequently, they can be used in many high-power switching applications. They can control electric motors, heaters, lamps, relays and sirens.

In this article we'll introduce you to the basic characteristics of the SCR, and then we'll show you 20 circuits you can build around this amazing device.

SCR characteristics

The SCR symbol is shown in Fig. 1. It resembles that of a normal rectifier, but has an additional terminal (G) known as a gate. The SCR can be made to act like either a normal silicon rectifier or an open-circuit switch, depending on how its gate is used; hence the name silicon controlled rectifier. Their basic characteristics are:



- Normally, with no bias or signal applied to the gate, the SCR is off, or "blocked," and acts (between anode and cathode) like an open circuit switch.
- When a positive bias or pulse is fed to the gate, the SCR turns on and acts like a normal silicon rectifier: it conducts (between anode and cathode) in the forward direction (with positive anode to cathode voltage), but blocks in the reverse direction (negative anode to cathode voltage).
- Once the SCR is on and is conducting, the gate loses control, and the SCR stays on even if the gate bias is removed. Thus, only a brief positive gate pulse can turn the SCR on.
- The SCR's gate-to-cathode junction has the characteristics of a simple silicon diode, and presents a low impedance when forward-biased. Typically, gate potentials of only 1 or 2 volts and currents of only a few tens of mA are needed to trigger a 5-amp SCR.
- Once the SCR is on, it can only be turned off again by momentarily reducing its anode-to-cathode currents to near zero. In ac circuits, turnoff occurs automatically at the zero crossing point at the end of each positive half-cycle. The SCR can *not* be turned off via its gate.
- Since the SCR turns off automatically when its anode-to-cathode current falls to near zero, there is a minimum anode current at which the device can be reliably operated. This minimum current, which typically has a value of a few mA, is known as the *minimum holding current*, and its practical effect is to place a limit on the maximum value of anode load resistance that can be reliably used with the SCR.

SCR's can be used in both ac and dc circuits, and are usually wired in series with an external load connected to a suitable power supply. When the SCR is off, negligible power is dissipated in either the load or the SCR. When the SCR is on, a large amount of power is dissipated in the load, but only a small amount of power is dissipated in the SCR. Less than 2 volts is usually developed across the SCR when it is on; so, if a 100-ohm load is used with a 200-volt dc supply, 396 watts is developed in the load and only 4 watts in the SCR. Typically, less than 20 mW of gate power is needed to trigger a 2-amp SCR, so in this case a power gain (between gate and load) of about 20,000 takes place.

Now let's look at a few basic circuits that help demonstrate these characteristics in a practical fashion.

Basic dc on/off circuits

A basic SCR dc on/off circuit driving a 12-volt, 500-mA lamp load is shown in Fig. 2. Normally, with S2 closed and S1 open, the SCR and lamp are off but the SCR and lamp can be turned on with a positive gate bias by briefly closing S1. Resistor R1 limits the gate current to a safe value. The circuit is self-latching, and the gate bias need be applied for a few microseconds to insure full turn-on. The turn-on gate pulse can be applied, if preferred, from a pulse generator. The SCR and lamp are turned off by momentarily breaking the supply connections via S2.

An alternate method of turning off the SCR is shown in Fig. 2-b. Here, the SCR anode is shorted to the cathode when S2 is momentarily operated, so the SCR anode-to-cathode current is briefly reduced to zero.

A variation of this switchoff theme is shown in Fig. 3. Here, with the SCR on, C1 charges via R3. When fully charged, the SCR1–anode end of C1 is a couple of volts above ground potential, and the R3 end is at full positive voltage, giving a capacitor charge of about 10 volts.

When S2 is operated, the positive end of C1 is clamped to ground, and the capacitor charge forces the SCR anode to momentarily swing negative, thereby reverse-biasing the SCR to cutoff. The capacitor charge leaks away rapidly under this condition, but has to hold the SCR anode negative for only a few tens of microseconds to insure complete switchoff. Note that if S2 is held down after the charge has leaked away, the capacitor then starts to charge in the reverse direction via LM1. Therefore C1 must be a reversible (nonpolarized or paper) type, although its value is not critical.

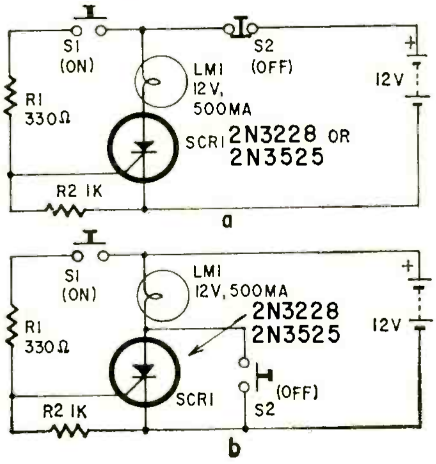


Fig. 2—Two basic SCR dc on/off circuits. The two different locations for S2 provide two different modes of circuit operation. Both work.

Fig. 4 is a modification of Fig. 3. It uses an additional SCR to enable switchoff via a low-current gate pulse. SCR1 and SCR2 act as a flip-flop or bistable arrangement in which SCR1 is on when SCR2 is off, and vice versa.

Thus, when a positive gate pulse is applied to SCR2, SCR2 switches on and pulls the R3 end of C1 to near ground potential. This drives the SCR1 anode negative, causing SCR1 to switch off. The cycle then repeats ad infinitum. Note that SCR2 has to carry a current of only $V_{SUPPLY}/R3$ amps in this circuit.

An interesting variation of the Fig. 4 bistable theme is in Fig. 5. Here, turnon and turnoff are controlled by a single pushbutton. The first push of the button turns the lamp on, the second push turns the lamp off again and the next push turns the lamp back on again, and so forth. Circuit operation relies on SCR2 not latching on properly, since it has a large anode load and its on current is lower than the SCR's minimum hold-on requirement.

Assume that both SCR's are off: both anodes are near positive supply voltage so zero charge is on C1. When S1 is pressed, SCR1 and LM1 are driven on via a brief positive pulse from C3, and SCR2 is momentarily driven on via a pulse from C2. At the end of this brief pulse, SCR2 turns off again through lack of holding current, but SCR1 and the lamp stay on. Capacitor C1 then charges via R1, and the SCR2 anode goes to positive supply potential. The next time S1 is operated, positive pulses are again fed to both SCR's, but those on SCR1's gate have no effect, since SCR1 is already on.

SCR2, on the other hand, is briefly driven on, and thus applies a reverse voltage to SCR1 via C1, so SCR1 and LM1 turn off. At the end of this pulse, SCR2 again turns off through lack of holding current, and the circuit is ready for the next operation of S1.

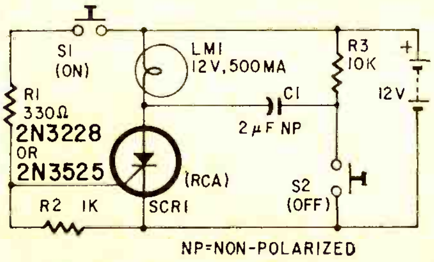


Fig. 3—Another variation of the circuits shown in Fig. 2. C1 must be a nonpolarized capacitor.

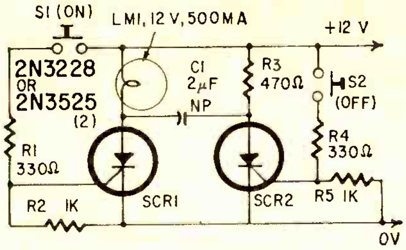


Fig. 4—An additional SCR enables switchoff via a low-current gate pulse. SCR1 & SCR2 act as a flip-flop.

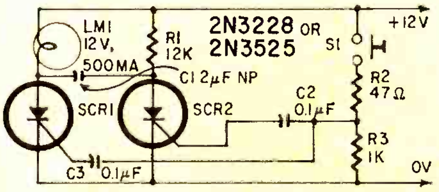


Fig. 5—Turnoff and turnon are both controlled with a single pushbutton. SCR2 does not latch on properly.

Basic ac on/off circuits

A basic ac on/off circuit driving a 100-watt lamp load from a 120- or 240-volt ac line supply is in Fig. 6. With S1 open, no bias is applied to the SCR's gate, so the SCR and lamp are off. But suppose S1 is closed. At the start of each positive half-cycle the SCR is off, so the full available positive voltage is applied to the gate via D1 and R1. Shortly after the start of the half-cycle sufficient voltage is available to trigger the SCR, and the SCR and lamp go on. As the SCR goes on, its anode voltage falls to near zero, removing the drive current to the gate. Since a large anode current is flowing in the SCR at this time, however, the SCR remains fully latched on for the duration of the half-cycle. It goes off only when the half-cycle ends and the anode current falls to zero.

This process repeats, with the SCR triggering on shortly after the start of each positive half-cycle, so long as S1 is closed. Diode 1 prevents reverse bias being applied to the gate on negative half-cycles.

Note that the SCR only conducts on positive half-cycles, and so acts as a half-wave rectifier. The lamp thus burns at only half brilliance when S1 is closed. Also note that, since the SCR turns off automatically at the end of each positive half-cycle, the circuit is not self-latching for most practical purposes.

A full-wave on/off circuit is in Fig. 7. The ac supply is converted to rough dc via the D1–D4 bridge rectifier. This dc is then applied to the SCR. With S1 open, the SCR is off, so no current flows through the bridge via LM1. When S1 is closed, the SCR is driven on shortly after the start of each half-cycle of rough dc, and the lamp goes on. As the SCR goes on in each half-cycle, the gate drive is automatically removed. But the SCR stays latched on for the duration of each half-cycle as described for Fig. 6. The SCR switches off automatically at

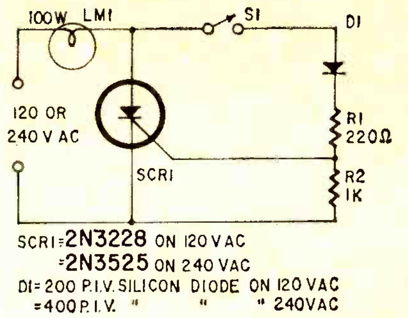


Fig. 6—Basic ac on/off circuit drives a 100-watt lamp from a 120 or 240 volt ac line supply.

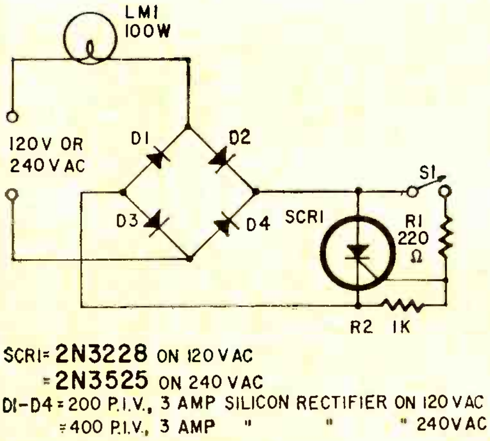


Fig. 7—Full-wave ac on/off circuit. Ac is converted to dc by diode bridge.

the end of each half-cycle as its anode current falls to zero.

Thus, when S1 is closed, the SCR is on for almost the full period of each half-cycle, and the lamp burns at almost full brilliance. The circuit is not, for most practical purposes, self-latching.

Notice in this circuit LM1 is on the ac side of the bridge, while the SCR is on the dc side. This design is used to control an ac load. Also note that if a bridge rectifier shorts out in this circuit, the short-circuit current is automatically limited by the lamp, so the circuit does not need fuse protection.

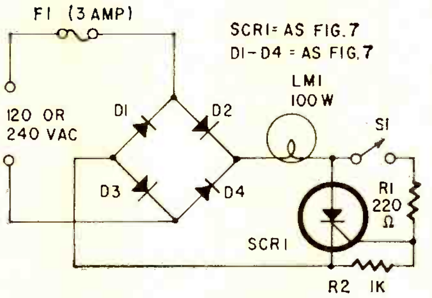


Fig. 8—Full-wave on/off circuit controlling a dc load. Note the similarity to Fig. 7.

A full-wave on/off circuit controlling a dc load is in Fig. 8. The circuit is similar to that of Fig. 7, except that the lamp is wired in series with the SCR anode on the dc side of the bridge, so the lamp is fed with dc rather than ac. In this case, however, if a bridge rectifier shorts out, the short appears directly across the ac line, so the circuit must be protected by fuse F1. Figure 9 shows how Fig. 8 can be modified to give self-latching operation.

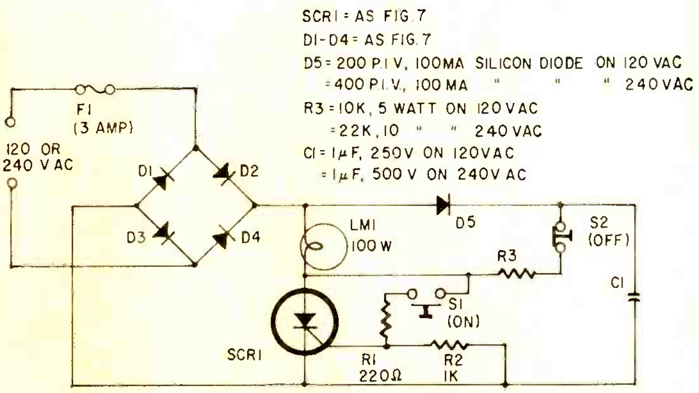
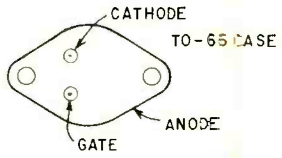


Fig. 9—Modification of the circuit shown in Fig. 8. New circuit gives self-latching operation. Opening S2 unlatches the SCR.

The nine circuits we have looked at so far use low-cost 2N3228 or 2N3525 SCR's. Fig. 10 shows the base connections of these types.



BASE CONNECTIONS OF 2N3228 AND 2N3525 SCR'S

12-volt lamp flasher

The circuit of the 12-volt lamp flasher is in Fig. 11. It has an operating rate variable between 25–150 flashes per minute, with equal on and off times. The design is a development of the single-button on/off circuit shown in Fig. 5. Here, the input pulses are provided from free-running unijunction (UJT) pulse generator Q1. SCR1 and the lamp change state each time the UJT fires, so the lamp is driven on by the first pulse, off by the second, on by the third, and so forth, the on and off times of the lamp being equal. Flashing rate can be varied by adjusting the UJT's operating frequency with R5.

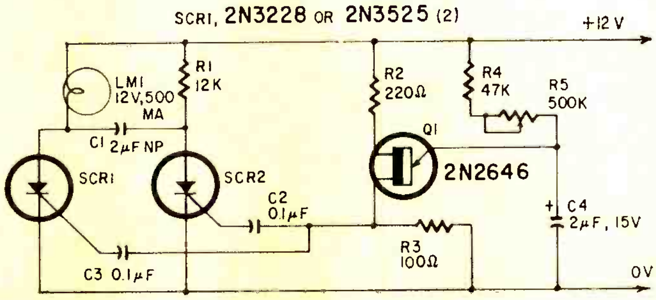


Fig. 11—Lamp flasher circuit operates off 12-volt supply. Operating rate is variable from 25-125 flashes per minute.

Automatic-turnoff lamp

A 12-volt automatic turnoff lamp driver is shown in Fig. 12. The lamp goes on as soon as S1 is closed, but goes off again automatically after a preset delay of 8–80 sec. The design is a development of the bistable circuit shown in Fig. 4, but in this case the anode of SCR2 is connected to UJT timer circuit Q1, and Q1's output is connected to SCR2's gate.

Normally, when the circuit is in the standby state, SCR1 and the lamp are off, and SCR2 is on. Since SCR2 is on, its anode is near ground potential, so the UJT circuit is inoperative. When S1 is momentarily operated, SCR1 and the lamp are driven on via the gate current of R1. As SCR1 goes on it turns SCR2 off via the discharge current of C1. As SCR2 turns off its anode rises toward positive supply potential, enabling power to flow to the UJT timer circuit, and a UJT timing cycle starts.

At the end of this timing cycle the UJT fires and applies a trigger pulse to SCR2's gate, and SCR2 goes on. As SCR2 goes on, its anode falls to near ground potential, making the UJT circuit inoperative again. At the same time it turns SCR1 and the lamp off via the discharge current of C1. The circuit is thus reset in its original standby state. The turnoff delay is varied with R7. Longer delays can be obtained by increasing the value of C2.

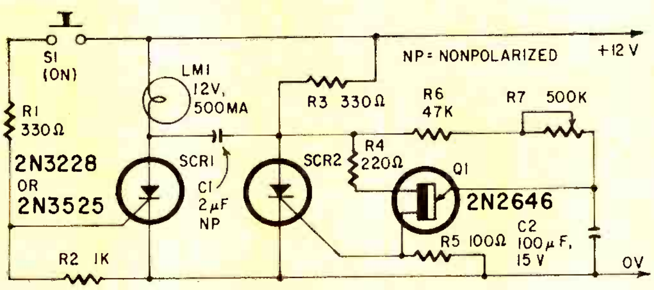


Fig. 12—An automatic lamp turnoff driver. The lamp goes on as soon as S1 is closed, and then off again after a preset delay.

We've looked at basic ac and dc SCR circuits and a few practical SCR applications. In the next article we'll show 10 more ac power circuits using SCR's—from light-operated switches to drill-speed controllers.

(Continued next month)

Build For Your Car—

ONE-IC TACHOMETER

by BENNETT C. GOLDBERG

A HIGH-ACCURACY TACHOMETER CAN be easily built using only one integrated circuit, a 1-mA meter and a few discrete components. It will measure the speed in rpm of six- or eight-cylinder automobile or boat engines, giving you an indication of your engine's performance when it is developing maximum horsepower.

The schematic diagram of the tachometer is shown in Fig. 1. Heart of the system is a dual two-input gate RTL (Resistor, Transistor, Logic) integrated circuit. But before describing how the tachometer works, a brief explanation of the two-input gate is needed.

When the two inputs of a single gate are low or at ground potential, the output of the gate is high or at some positive voltage described in logic terms as "1." When either gate input is high or logic "1," the output of the gate will be low or a logic "0."

IC tachometer operation

The schematic shows the gates connected externally to produce a one-shot pulse generator. The trigger input of the gate is connected to the breaker points of the engine distributor. Assuming initially the breaker points are closed or grounded, pin 5 is high and pins 1, 2 and 6 are low, forcing output pin 7 to go high. Due to this high output, C3 has the same potential on both sides—a no-charge condition on the capacitor.

When the breaker points open, pin 1 is returned to a high potential due to the ignition primary coil being connected to the positive battery voltage, thus requiring pin 7 to go low. Gate-input pin 5 is now low, and output pin 6 will remain high until C3 discharges at the 1-msec rate fixed by the R4–C3 time constant.

After C3 discharges, pin 5 returns to its high potential until the cycle is repeated. The output pulse from pin 6 is rectified and filtered by D2 and C4. The trigger input is applied to low-pass filter R5, R7 and C1.

The values of these filter components are chosen to attenuate above 360 HZ, corresponding to an eight-

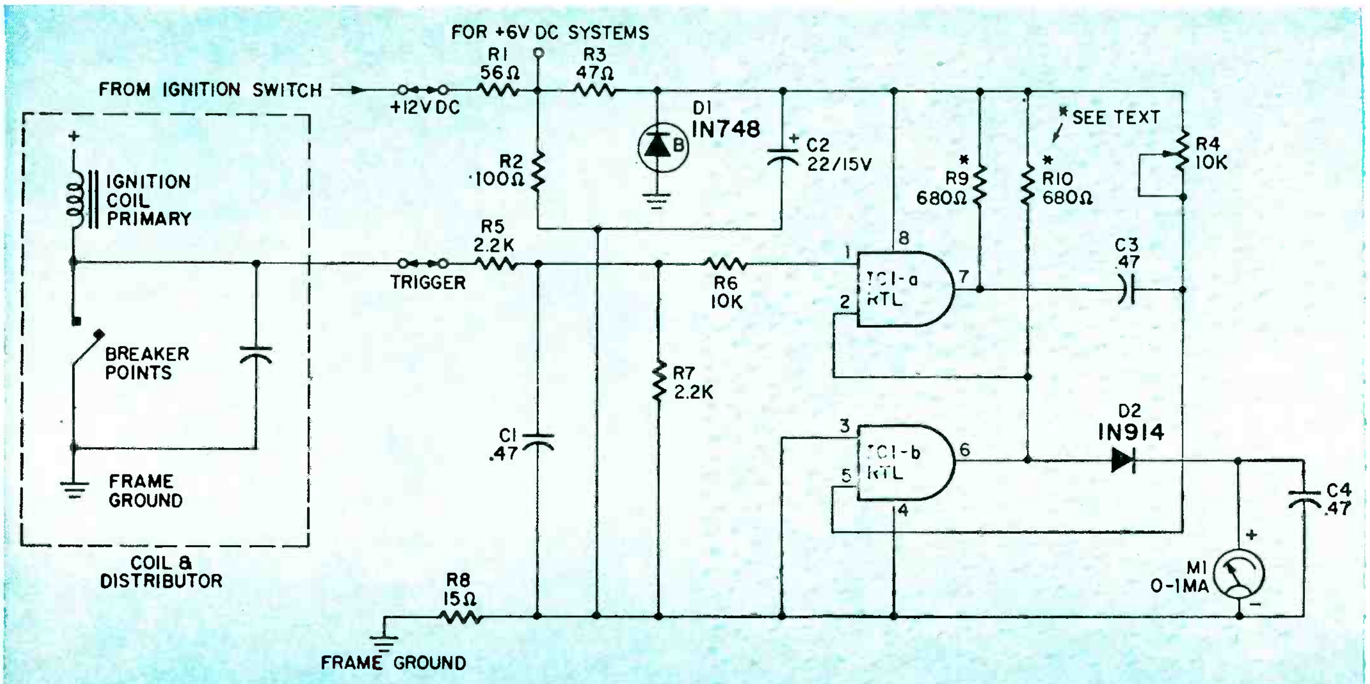
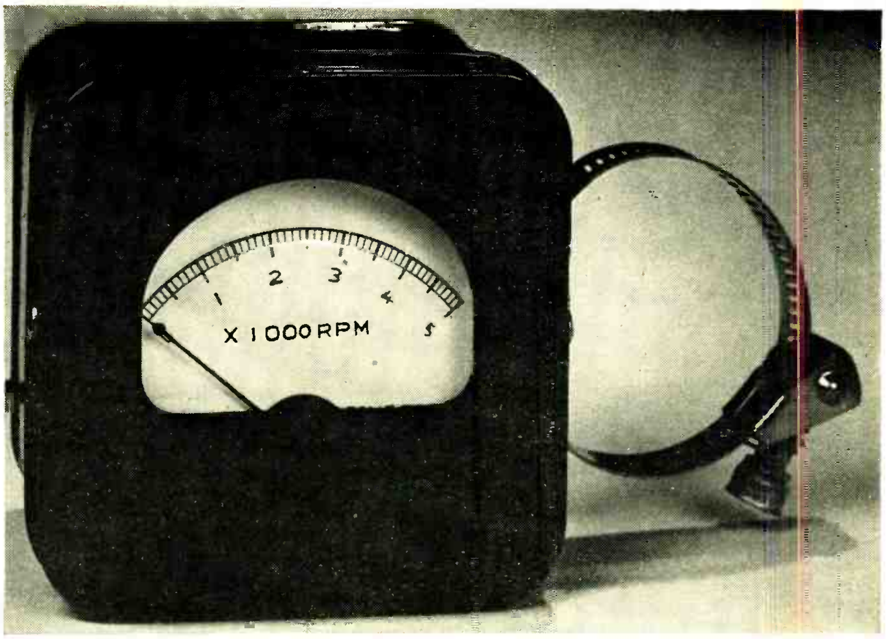


Fig. 1—IC gates are connected to output of the breaker points to form a one-shot pulse generator. Works with 6 or 12 volts.



Simple two-input gate circuit measures engine rpm's for top performance and best mileage

cylinder engine speed of 5400 rpm. If a maximum tachometer reading greater than 5000 rpm is desired, appropriate values should be chosen to provide a higher filter cutoff frequency for the circuit.

The +3.9-volt supply required by the IC is obtained by voltage-regulator components R1, R2, R3, R8, C2 and Zener diode D1.

Engines using a 6-volt battery will require bypassing R1. The voltage divider network consisting of R2 and R8 biases the gate inputs and ground at +1 volt. This prevents point bounce from the breaker points giving inaccurate readings.

Building your tach

Components used in the circuit are standard transistor circuit parts. The entire circuit was mounted on perforated board and fastened to the meter terminals.

Any standard dc 1-mA meter can be used. Mine was a surplus unit having an accuracy of ±5% at full-scale deflection. Because the meter must be recalibrated in rpm, almost any meter scale is acceptable. The IC leads may be wired directly to the components, or if preferred an eight- or ten-pin TO-5 IC socket may be used.

The RTL Dual two-input gate is manufactured by a number of companies. Any RTL 914 type may be used, such as the Fairchild μL914 or the Motorola HEP 584. A Motorola HEP 580 also may be used, but requires two additional resistors, R9 and R10. These resistors speed up the circuit, making it equal to the 914.

The meter movement was encased in a metal candy can and attached to the steering wheel column with an adjustable hose clamp.

Calibration and use

The unit may be calibrated so that the meter reads full scale for any desired input frequency. A very accurate calibration can be obtained with a sine-wave audio oscillator connected to the tach input. The output amplitude of the generator should be adjusted so that further increases in amplitude will not affect meter readings. Adjust potentiometer R4 to give the desired rpm readings.

If an audio generator is not available, connect a 100,000-ohm resistor to the trigger input of the tachometer, and using 117-volt, 60-Hz line voltage, adjust R4 to give a reading of 1200 rpm for six-cylinder or 900 rpm for eight-cylinder engines.

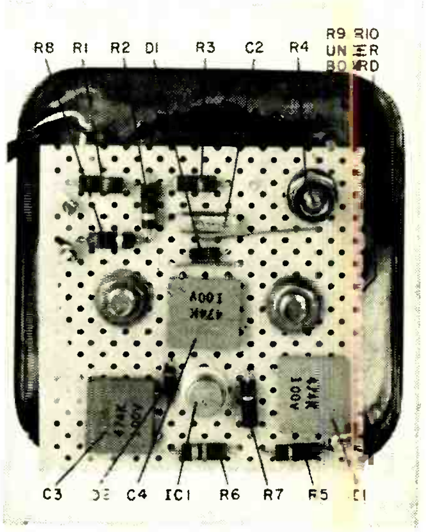
It's a simple matter to install the unit. The +12-volt lead is connected to the ignition switch, and the ground to the automobile frame. The third lead is the trigger to the primary terminal of the ignition coil, which also connects to the breaker points. The tachometer may be used with transistor or capacitor discharge ignition systems without modifications. The trigger is still connected to the breaker points. **R-E**

PARTS LIST

C1—0.47-μF, 100-V capacitor
C2—22-μF, 15-V electrolytic capacitor
C3, C4—0.47-μF, 10-V capacitor
R1—56 ohms
R2—100 ohms
R3—47 ohms
R4—10,000-ohm miniature linear potentiometer
R5, R7—2200 ohms
R6—10,000 ohms
R8—15 ohms
R9, R10—680 ohms (see text)
All resistors ½ watt, 10% or better
D1—¼-watt, 3.9-V Zener diode (IN748)
D2—IN914 silicon diode
IC1—RTL dual 2-input-gate integrated circuit (Fairchild μL914, Motorola HEP 584, HEP 580 with R9, R10)
M1—1-mA dc meter

CALIBRATION

FREQ.	RPM	
Hz.	6 CYL.	8 CYL.
30	600	450
60	1200	900
90	1800	1350
120	2400	1800
150	3000	2250
180	3600	2700
210	4200	3150
240	4800	3600
270	——	4050
300	——	4500
330	——	4950



Possible perforated board parts layout.

MAKE A TIME-TAPER

By **ALBERT L. SOHL**

IT'S A NEVER-TO-BE-REPEATED LIVE RECORDING session. Your level is perfect. All systems are "GO". You wander out of the room for a moment, carefree, in search of a cold beer. As you return, you hear the ominous slap-slap of an end of tape whipping wildly on the takeup reel. Oops!

Or have you ever made an educated guess at how much time you have left on a partially used reel, only to find out at the last crucial minute that you need about 10 more feet before the end of the disc you are copying?

Did I hear someone out there shout something about starting each recording stint with a fresh roll? Commercially the tape rolls may well be inexhaustible but not so most bank rolls. Granted, there are index counters or some form of time indicator on most tape recorders, but these are primarily for spotting previously taped material and vary from machine to machine. Furthermore, these systems never tell you the running time of a record, nor in most cases does the record manufacturer. This leaves you two choices:

1. Start each recording with a full, fresh reel of tape. Good, but expensive if you do much recording.

2. Start with a partially used roll and sweat it out. Economical, but nervewracking and not always wise.

There is a way out, with what I call the "Time-taper".

It's a time scalar rule for all discs and tapes, accurate enough for the average recordist. This handy little gadget can be used for tape timing, disk timing or program timing. It will indicate the amount of tape used, amount of tape to be used, time left and time used on any given part of a record disc. *It is applicable for all thicknesses of tape wound on the standard 7-inch reel.* All 33⅓-, 45- and 78-rpm discs can be timed at a glance with a tolerance of about 25%. (This rather wide margin is due to the varying widths of cuts on differently manufactured records, but is close enough to do a satisfactory job.)

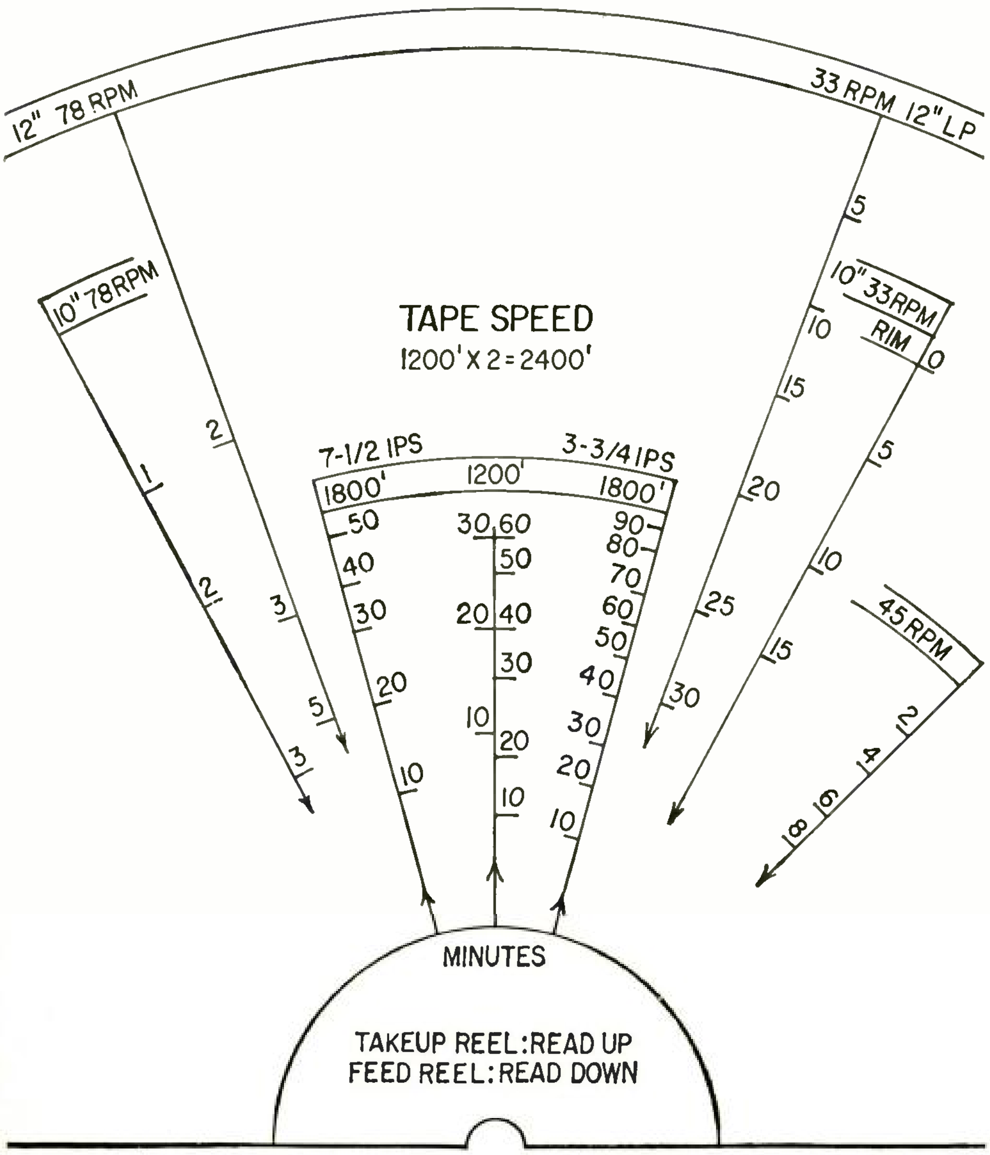
You can make your own Time-taper for less than $1 and about an hour's time. The materials are available in any art supply store. All you need is a 6 x 8-inch piece of clear *treated* acetate. (It's treated on one side to take India ink.) A bottle of black India ink, a fine pen point and holder, an ink drawing compass, a straightedge and four thumbtacks complete the list.

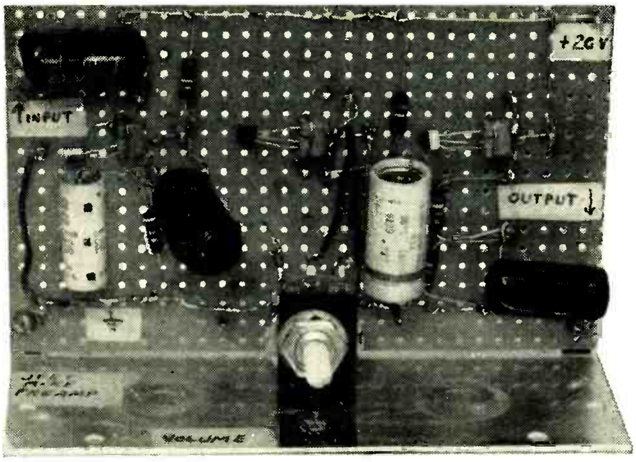
Tack the piece of acetate, *treated side up*, over drawing below and trace the scales. When all the lines are dry, you can print in the digits and necessary intelligence. Trim the outside curve with scissors. Cut a notch in the bottom of the Time-taper as shown and you've got it.

How to use with tape. Let's say you have just finished taping one side of a long-play record. You are using a roll of 1,800-ft tape at a speed of 7½ ips. You want to know how much time you have left on that reel. Without disturbing anything, slide the V-notch of the Time-taper over the hub of the *takeup* spindle and read up the left-hand (1,800) IPS scale. Through the acetate, the edge of the wound-up recorded tape lines up with the line marked "20". This means you have used (recorded) 20 minutes' worth and have approximately 28 minutes of virgin tape left. Prove this by placing the Time-taper on the *feed* reel and reading the same scale.

Depending on the speed, reel size and tape length, refer to the IPS scale in the central portion of the Time-taper. Exact time and amount of tape used may be read directly. For simplicity, only the two standard speeds are given on the scale, 7½ and 3¾. For slower or faster speeds, multiply or divide by 2 accordingly against the applicable length table.

How to use with records. Line up the outside margin of the Time-taper on the outer rim of the record. Refer to the applicable scale and read down to the end of the recorded grooves in the record. As an added refinement, the indicator lines on the record scales can be penned in with *white* ink for easier reading against the black disc. **R-E**





JFETS

Put last month's theory to work. Build these two useful field-effect transistor projects—Part 2

by RAY CLIFTON

LAST MONTH IN THE FIRST OF TWO articles we looked at the theory and operating characteristics of a few junction field-effect transistors (JFET's) costing under $2.50. Now you should be ready to experiment with and build some practical devices using JFET's.

Design a mike preamp

You'll need an assortment of ½-watt resistors, a few 25-volt electrolytics and some coupling capacitors. Choose part values around those shown in Figs. 2 and 3. For ease of breadboard experimenting, I recommend a few perforated boards with push-in terminals. A bias box is needed, since bias is dynamically determined. A simple arrangement using two 9-volt transistor-radio batteries across a 1-megohm linear-taper pot, with a switch to save the batteries, is shown in Fig. 1.

You'll also need a power supply capable of 20 volts and not more than 5 mA—batteries will do nicely. To test and design the circuit, you will need an audio generator. (A single frequency of between 400 and 2500 Hz is all you need, and output voltage can be quite low—50 mV rms.) An oscilloscope is essential to observe waveforms, but need not have high-frequency response, since you'll be observing only the frequency mentioned above. A high-impedance voltmeter (vacuum tube or transistor) is essential, and a milliammeter is nice, but not essential.

An easy but useful project is a simple preamplifier for a crystal or ceramic microphone. Fig. 2 shows the circuit, and here's how component values were selected and the first stage designed.

Assume a microphone output of about 30 mV rms: this calls for a fairly low-level input JFET. Among those listed in Table I (last month's issue), the D1102 isn't a bad choice. It has a low gate-to-source cutoff voltage (V_P) with reasonable transadmittance (y_{fs}) and drain-to-source current (I_{DSS}). The E102 and 2N5033 would also be good choices. (Even better small-signal JFET's are available, but they cost more than $2.50.)

Like vacuum tubes, most JFET's work well with a gate resistor of 470,000 ohms or 1 megohm. Remember that the gate circuit is high-impedance and normally doesn't draw current. Thus, R1 in the input stage is 1 megohm.

The drain-load resistor is also borrowed from vacuum-tube design. The greater the drain resistor, the higher the voltage gain (A_V) of the stage. But distortion also increases with greater load resistance, and after a certain point the increase in A_V is negligible. For the D1102 at Q1, 100,000 ohms is a reasonable compromise for R2.

Coupling capacitors C1 and C3 determine frequency response and, for 1-megohm gate resistors, 0.1 μF provides best low frequency response. You can use 0.05 or even 0.01 with little noticeable loss of low frequencies. If you want only speech-quality response, use 0.005 μF.

For source resistor R3, temporarily tack-solder in about 4700 ohms, and put the bias box in series (positive lead to source, negative lead to ground). This allows you to vary bias until you find the optimum value. Source-bypass capacitor C2 can be any value from about 10 to 50 μF, at 25 or 50 volts. It's simply a brute-force audio bypass around the source-bias resistor.

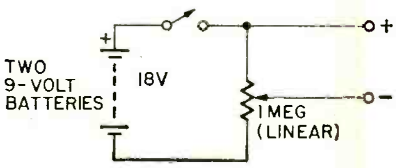
Setting bias dynamically

Couple 30 mV of rms audio into C1 and the gate circuit. Set the bias box at 5 volts or more, and tie a power supply to R2, as shown in Fig. 2. The supply should be 20 volts, ±2 volts. Hang a scope across the output. (You don't need a load resistor yet, for the output is high-impedance and the scope loads the circuit.

Note: Be very careful with JFET's. Use heat-sink pliers on the leads when soldering, and beware of transients, which can zap an FET in a millisecond. Normally a JFET shows resistance between drain and source, and vice versa. Between gate and either drain or source, it shows diode action (high resistance in one direction, low in the other). When zapped, the JFET loses its diode action from gate to channel, and shows similar resistance in both directions.

With all systems go, decrease source-to-ground bias below 4 volts and watch the sine wave coming out of the drain. (Use a fairly decent amplifier and speaker to monitor that sine wave.) Juggle the bias around and observe the scope.

Simple perf-board mounting of two 9-volt batteries, switch and 1-megohm pot provides a variable bias source. The circuit for this setup is in Fig. 1 below.



The JFET's listed in last month's Table I are inexpensive because their parameters aren't tightly specified. Thus the D1102 you use may have an I_{DSS} of anywhere from 0.2 to 1.0 mA; the bias you end up using may differ from mine. I found 0.5 volt a safe compromise, and at this bias value my D1102 drew about 100 μA of drain-source current. By Ohm's law, 5000 ohms is required to cause a drop of 0.5 volt with 100 μA flowing. I chose 4700 ohms as the nearest 10% value (R3). Drain current then became 115 μA, which had no ill effect on the stage operation.

The second stage—also common-source—can be designed the same as the first, but you must insert a volume control in the gate circuit or you'll overdrive Q2. More than about 70 mV rms into the gate circuit causes clipping in the output. The pot also allows you to increase or decrease gain to compensate for different microphones and distance between talker and mike. Fig. 2 shows values I obtained for the Q2 stage with an MPF105, which makes a fairly good medium-level amplifier. Other suitable devices are the 2N3819, 2N5163, MPF153 and TIS34.

Output stage Q3 is a simple source follower to provide fairly low-impedance output, which makes coupling to following amplifiers less critical than would a high-impedance drain follower. I used a 2N4304, but a D1201 would also be suitable. Both have a fairly high V_P of 10 volts, which you want in a source-follower output stage, to handle wide inputs.

The source follower is designed almost like the preceding common-source stages. The major difference is that load resistor R9 is in the source circuit, rather than in the drain. This being the case, and since it's desirable to have lower-impedance output, R9 is made 47,000 ohms instead of 100,000. This provides less voltage gain, but here you are working with a few volts, so gain is less important. When determining bias in this circuit, insert the bias box in series with R8 and R9, starting with about 4700 ohms for source resistor R8. Remember that the gain of a source follower is never greater than one.

By the way, use decoupling capacitor C8 even if you use a battery supply. It prevents undesirable interstage coupling.

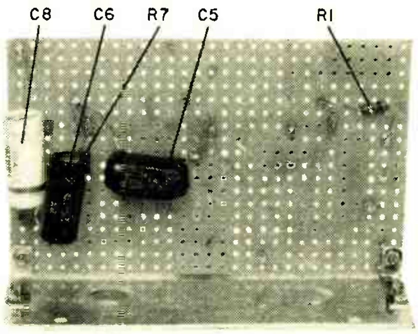
A simple audio oscillator

If you do any experimenting with audio circuits, a small oscillator is handy to have around. The circuit of Fig. 3 is the basic design for a phase-shift oscillator using JFET's. Design is fairly straightforward, and is built around the first stage. If you are willing to spend more money, you can buy a JFET with low V_P and high y_{fs} (the 2N4338, for instance, which costs $4.95) and build the oscillator with only two stages. (In this case, omit Q2 and Q3, and tie C1 directly to the drain of Q1.) Unfortunately, none of the devices listed in Table I have both low V_P and high y_{fs}, and none will sustain oscillation from drain to gate. Therefore two more stages are required to provide sufficient feedback.

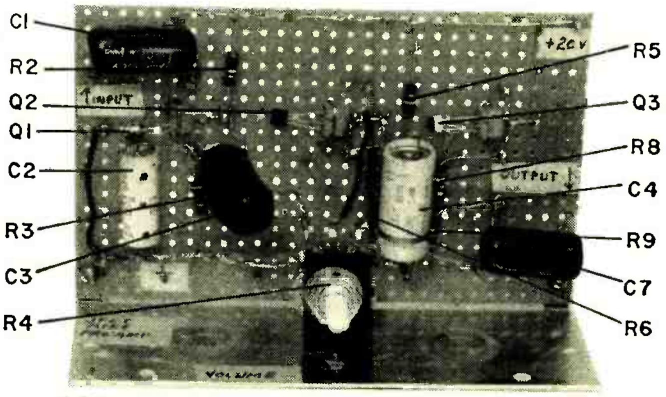
Here's how to design the circuit. Build stage Q1 first, temporarily using the values shown in Fig. 3 for feedback/phase-shift components C1, C2, C3 and R1, R2 and R3. (Do not connect R15 yet.) You can use 100,000 ohms for drain load R4 (I used 82,000 simply because I had run out of 100K's).

Use the method outlined above to determine bias. From an audio generator, feed about 1 volt rms into C1. Then provide drain-supply voltage and clamp a bias box to the source through any value from 1000 to 4700 ohms. Hang a scope and amplifier on the drain-output circuit and vary the bias until you get the most gain with the least distortion. Using Ohm's law, determine the value of source resistor R5. I used 41,000 ohms with the 2N4302. Other choices for this stage are the D1420 and E102.

The gain of the Q1 stage will be about 30 (too much output) so a pot is needed between Q1 and Q2. Use a 1-megohm audio-taper pot, to match Q2's input. For Q2 I used an MPF106, and by trial and error determined that 18,000 ohms was a workable value for the drain load. Set the bias here as you did before, but don't overdrive the stage. I found about 35 mV rms

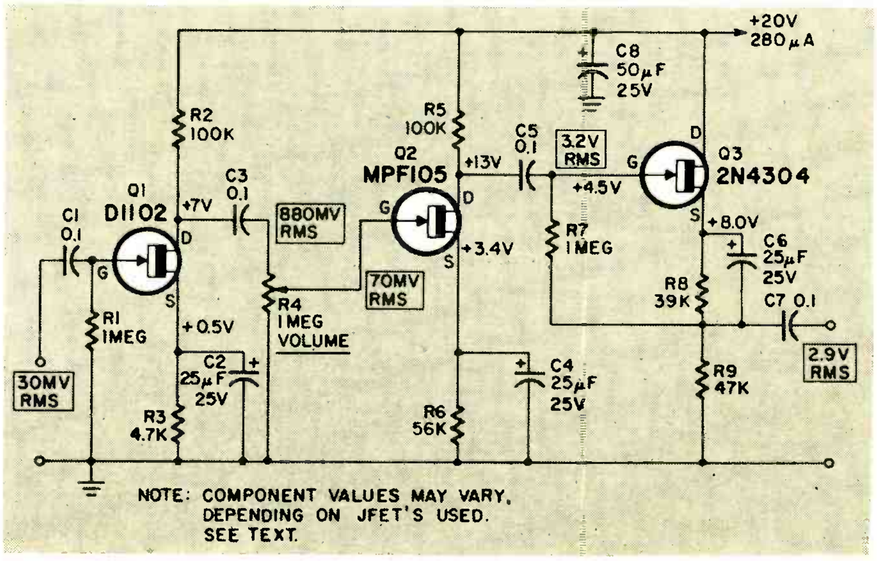


Rear-mounted components for mike preamp.



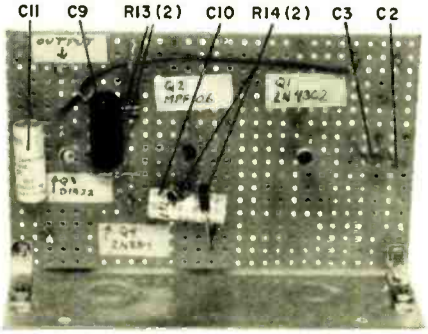
This perf-board arrangement lets you measure voltages and waveforms easily. Since component values vary, parts such as source-resistor R3 can be tack-soldered until the correct value is determined.

Fig. 2—Circuit for a JFET mike preamp, which operates with 30 mV input from crystal or ceramic mikes. Overall voltage gain of the circuit is about 97.



from the arm of R6 was about all the stage would tolerate. Later, this control is used to determine the cleanness of the oscillator waveform.

The Q3 stage operates as a split-load, providing one output (from the drain) for feedback and another output (from the source) for output coupling. I used a D1422, but the 2N4304 and E100 will also work. Try a load resistor of about 47,000 ohms or less to begin with. Then strap in the bias box and determine the source resistor. If it's less than 47,000 ohms, change R10 to match R11. I ended up with 39,000 ohms in both drain



Rear-mounted components for audio oscillator.

and source circuits. By the way, you should still be using the external oscillator signal for setting up these stages.

Now tie the output of Q3 to R12 —another 1-megohm audio-taper pot. Remove the external audio oscillator from Q1 and strap in feedback resistor R15. Try 47,000 ohms to start. You should already have set R6 so it's not overdriving Q2. Hang the scope across R12 and fire up the circuit. If the output waveform isn't clean, change R15. (But always turn off the power before you do!) Try less resistance, and if the waveform gets more distorted, you are going the wrong way. Cut and try until you find the optimum value. Don't use clip leads to try R15; the stray coupling will give you a false indication. Tack-solder each value of R15 in place, one by one.

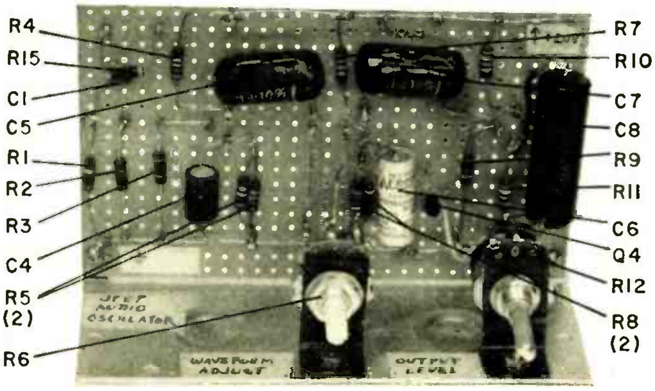
Once you get the oscillator itself working with a fairly clean waveform, build Q4. I used a 2N3819 because it has a high V_P and hence can accept a fairly high gate-input signal. The MPF105 and 2N5163 would also be good choices. Transistor Q4 is simply an isolation stage, and you can assume 100,000 ohms for drain load. Set the bias as before, being careful not to overdrive the stage with the setting of R12. I got about 4.5 volts rms out of Q4 with a clean waveform from the oscillator.

Set R6 for purest waveform, and after you build Q4 if you are doubtful of the oscillator, try another R15. You can vary R12 from zero output up to clipping, and you should find several volts of output. This output is fairly high-impedance, but if you prefer low impedance you can make Q4 a source-follower stage. You won't get as much output, but you'll be able to use a longer output line and match low-impedance inputs.

Oscillator frequency is determined by R1, R2, R3, C1, C2 and C3, and is about 600 Hz for the values I used. The exact frequency is given by the formula f = 1/10.88 RC, where f is the frequency in hertz. R is the resistance of R1, R2 or R3 (all equal value) in ohms, and C is the capacitance of C1, C2 or C3 (all equal value) in farads. *Note that this formula holds only if resistors and capacitors are 1% types.* I used 10% types and came up with 600 Hz, rather than the frequency that was originally computed: 920 Hz.

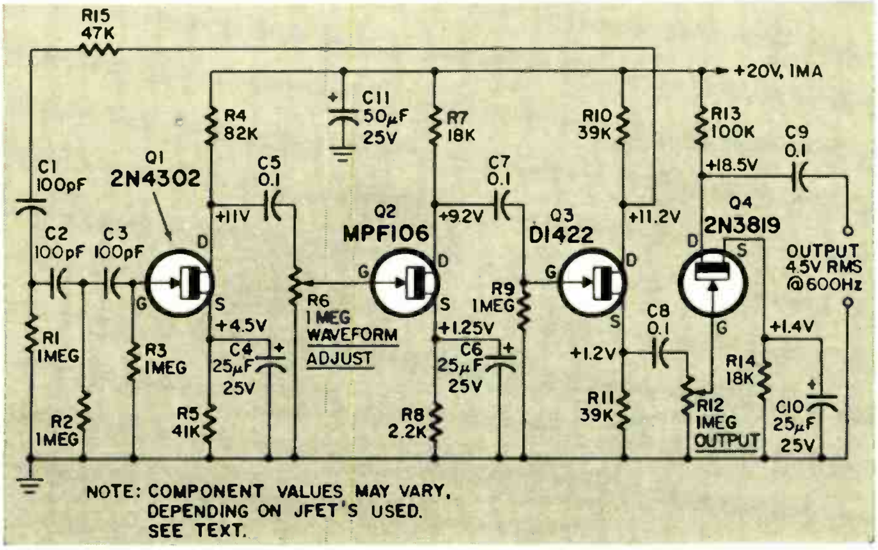
If you build this circuit on a metal chassis, use a single ground-return bus insulated from the chassis. Tie the bus to chassis at one point only—the junction of R1, R2 and R3.

If you want to make the oscillator variable in frequency, sharpen your pencil and compute the values of R1–R3 and C1–C3 for the frequencies you want. I suggest using a three-gang capacitor and switching in various resistors. Use straight-line parts layout and short leads, and put the circuit in a metal box where it won't be affected by stray capacitance that could alter the frequency.



To build the JFET audio oscillator, Q1 is mounted and its associated components temporarily soldered to the push-in terminals. Best bias for Q1 and remaining stages is determined with the bias box.

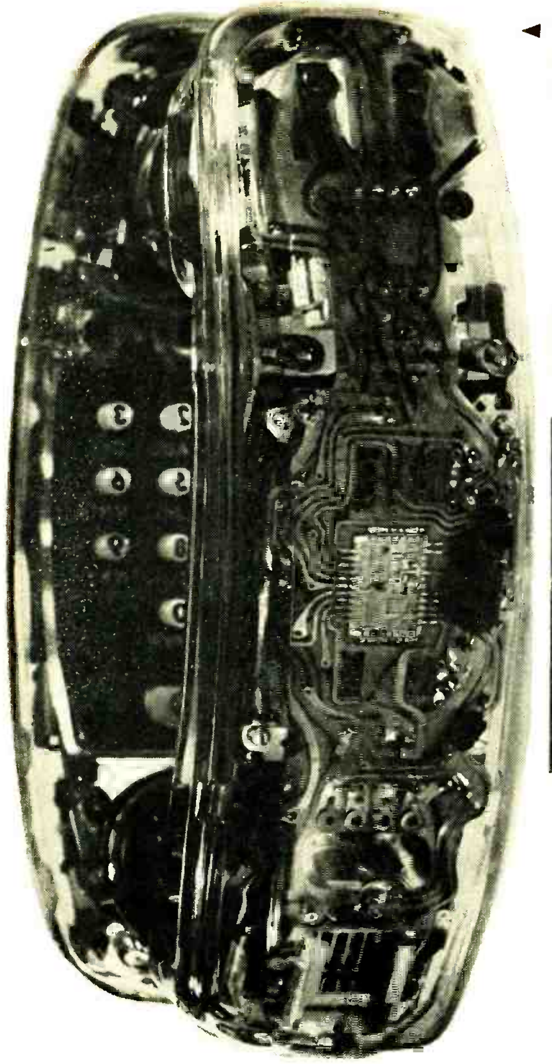
Fig. 3—This JFET audio oscillator produces clean single-frequency sinewave. The circuit can be made tunable by changing values of C1-C2-C3 and R1-R2-R3.



General design notes

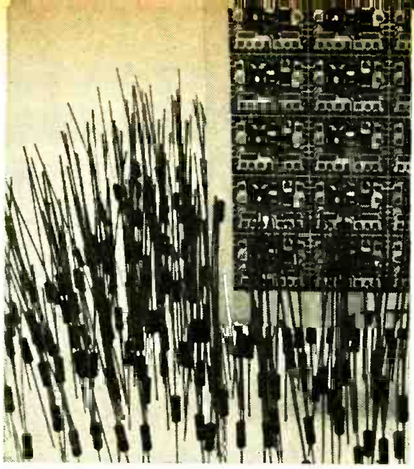
The methods outlined above are, of course, very simple. They are meant to show you how to use JFET's in construction projects. By experimenting with these devices, you will become familiar with them. Then you can go on to more sophisticated designing.

Because of the spread in JFET parameters, those who design circuits for production line use must safeguard against device-to-device variation in y_{fs}, I_{DSS} and V_P. They do this by using lots of feedback and sophisticated bias networks. They also compute drain loads and bias values more exactly, to allow for temperature and power-supply variations. After you get the feel of JFET's, you may want to collect some specification sheets on various devices and read up on more of their characteristics. **R-E**

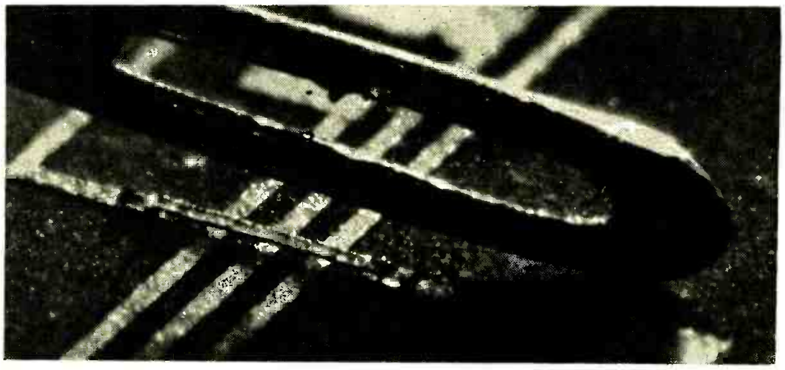


◄ *Trimline handset is a modern marvel of electronics. Contains all the electronics.*

Forest of 450 resistors is replaced by "thin film" circuits in background. ►



Gold bridge is 7/10,000-inch high. Replaces insulator in thin-film circuits. ▼



IC'S IN TODAY'S

It's amazing—but there's a lot of electronics inside

by LARRY STECKLER
MANAGING EDITOR

TELEPHONES ARE GOING "MOD". WITNESS THE BELL SYSTEM'S sleek new electronic pushbutton Trimline phone. A glance at this month's cover and the photos in this article reveals that the "modness" is more than just skin deep. Below the modern exterior is an electronic heart—a virtual maze of electronic components.

Let's take a closer look. Visible near the center of the handset is a rectangular-shaped tone-generating integrated circuit—the first application of integrated-circuit technology to the telephone handset. Twenty-six components—transistors, diodes and resistors—are contained in a single silicon chip about 1/16 inch square (in the very center of the integrated circuit). Gold-tape leads interconnect the tantalum thin-film resistor substrate and the tantalum thin-film capacitor substrate, which together comprise the passive network for controlling the Touch-Tone calling frequencies.

This move to electronics, specifically to integrated circuits, became a must when the dial-type telephone began to be replaced by the pushbutton phone. Why? Because the pushbutton phone doesn't use relays to determine the number you are calling. Instead, it is a frequency signaling system.

With this new system each phone number consists of a code made up of a string of specific audio frequencies. When a user punches out a number on a Touch-Tone phone he transmits this identification code to a central office where it triggers switching circuits that connect the caller to his party.

Two frequency generators produce the frequencies that make up this identification code. Each generator produces four specific signals. One oscillator generates 698-, 711-, 853.5- and 952.5-Hz signals. The other oscillator puts out 1211-, 1338-, 1479- and 1636-Hz signals. The numbers may seem unusual, but they were deliberately selected to insure that there is no harmonic relationship between the low-frequency and high-frequency groups, and to avoid frequencies that might be produced by the voice of a caller.

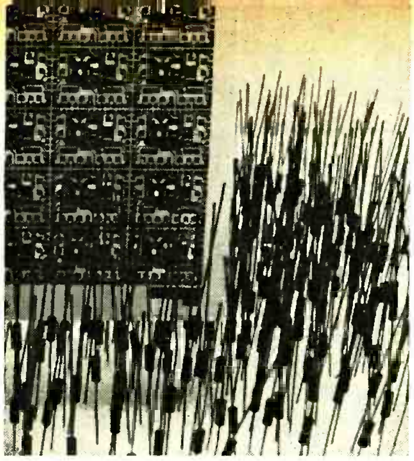
When you punch out a number on a Touch-Tone phone, two frequencies—one low and one high—are produced each time a button is depressed. The combination of these two tones is the code that represents the particular digit selected.

Obviously, this system makes available a total of 16 codes. Only 10 are needed for dialing a number. The 6 "spares" are available for other telephone services such as Picturephone and abbreviated dialing.

The physical arrangement of a Touch-Tone oscillator circuit consists of two tantalum integrated circuits on glass substrates, a silicon integrated-circuit chip, a silicon multidiode chip and two miniature thermistors. You can see these elements in the cover photo and the supplementary photos in this article.

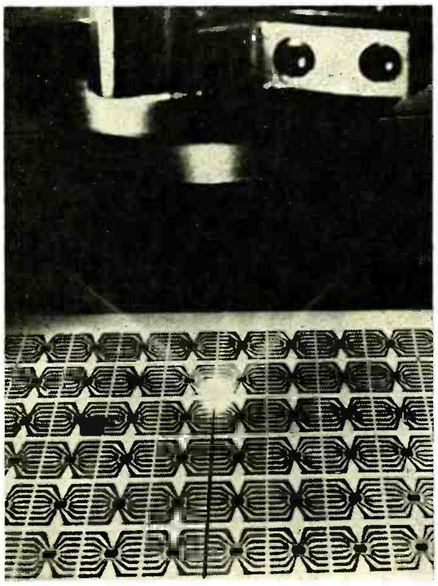
(*Please note: The phones in the clear plastic cases shown on these pages were specially made just for these photographs. They are not available for home use.*)

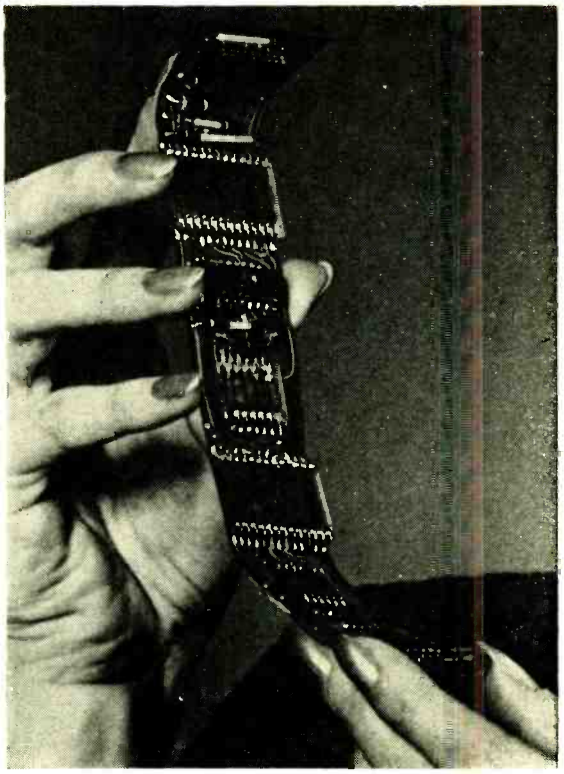
One of the glass substrates contains 19 thin-film resistors that are used in the notch filter, and buffer stages of the tone generators. The other substrate contains 10 thin-



Canadian experimental phones use this flexible circuit board and three ICs. ►

Laser separates thin-film circuits on a ceramic base at ▼ *Western Electric.*





PUSHBUTTON PHONES

film capacitors, 6 of which complete the notch filter and 4 of which are used for oscillator amplitude limiting and feedback coupling.

The frequency output of the generators must be very precise. Each of the eight signal frequencies used is adjusted within a tolerance of ±0.1%.

The two dc-coupled amplifiers and part of the buffer stage are on the integrated silicon chip, which contains 10 transistors, 12 resistors and 2 zener diodes. The diode chip contains 4 diodes, 2 for each of the oscillator amplitude-limiting circuits. Separate silicon chips are used to avoid the chance of the amplifier elements heating the diodes (the amplifier chip dissipates 0.4 watt).

Resistors for Touch-Tone circuits are made by sputtering a film of tantalum onto a glass substrate. Then the film is thermally oxidized to provide an underlay. Next a nitrided tantalum film is sputtered over the oxide. Conductor paths and terminations are formed on the tantalum by evaporating titanium and then gold.

Resistors and conductor paths are formed by a photoetching process. The resistors are adjusted to a precise value by electrochemical anodization. Leads for external connections are attached by thermocompression binding.

Thin-film capacitors used in the pushbotton phone start off the same way as resistors with a sputtered film of undoped tantalum. Then the tantalum film surface is electrochemically anodized to form tantalum pentoxide, which makes a good dielectric. A top electrode is then formed by evaporating a layer of Nichrome alloy, then a layer of gold over the oxide. Photoetching and external lead bonding complete the process.

North of the border

In Canada electronic telephones are being developed, too. Northern Electric Laboratories, Ottawa, recently revealed a new experimental handset using pushbuttons and integrated circuits. All the electronics are located inside the handset. It is made up of three silicon integrated circuits and five thin films, joined together by a double-sided flexible printed-circuit board. IC's are used as the active elements of the design, for amplifying and transmission, while tantalum thin-film circuits are employed for passive components and conducting paths.

Other features of the experimental telephone include a unique design of pushbutton dial mechanism, which electronically rather than mechanically switches the power from the network to the dial, and two new transducer devices in the ear and mouthpieces. A novel "electret" microphone and its associated electronic circuit in the mouthpiece weigh one-tenth as much as the conventional carbon-type microphone, while reducing size power and distortion sharply. In addition, an electronic tone ringer has been developed which is said to offer a more pleasant signal than the electromechanical bells now used.

Future telephone innovations will make the phone even easier and more convenient to use. Already under test are such special services as abbreviated dialing (you dial only two digits to get the number you want), and transferred calls (when you go visiting your calls are automatically switched to the phone at the home you are visiting). Yes, the telephone is better than ever and I wonder if Alexander Graham Bell ever anticipated a phone as convenient as the one we have today. **R-E**

HOW IC's WORK
(continued from page 35)

ings (sometimes called "windows") in the oxide. This complete photoresist process must be repeated each time the silicon oxide is selectively removed.

The planar process

The combination of oxidation, selective oxide removal and diffusion forms the basis of the *planar process*, which is now firmly established as the basic process of solid state technology. The sequence of processes used to fabricate a silicon planar n-p-n transistor will be described in some detail. The processes are carried out on whole silicon slices, about 1.5-inch diameter by 10 mils thick. Each slice normally contains a large number of individual device patterns, and at the end of the slice processing it is cut up into individual wafers.

Referring to Fig. 7, an n-type silicon slice is oxidized (a) and windows for the base diffusion are opened in the oxide (b) by the photoresist process as in Fig. 6. Boron is used as the p-type impurity for the base diffusion. Boron tribromide, a liquid, is vaporized, the vapor mixed with nitrogen, and passed over the silicon slice heated to a temperature of 850° C. During this process boron is deposited onto the surface of the silicon. The slice is then transferred to another furnace and heated at 1150°C in a flow of nitrogen for a sufficient time (about one hour) for the boron to diffuse in and form the p-n junction at the required depth. During the latter part of this diffusion, steam is mixed with the nitrogen so that a new layer of silicon dioxide forms on the surface of the diffused region (c). In addition to diffusing down into the silicon, the boron also diffuses sideways, and so the p-n junction is formed under the oxide and is protected against surface contamination. This is a very important feature of the planar process. A typical base diffusion depth is 0.1 mil.

The slice is now prepared for the emitter diffusion by etching windows in the new oxide grown over the base region (d), using the identical photoresist process as before. To form the n-type emitter region, phosphorus is diffused in. Liquid phosphorus oxychloride is vaporized and passed over the slice at 1000°C. This is usually a single step diffusion, and for the latter part of the cycle, steam is again introduced to form silicon oxide on the surface (e). The emitter diffusion depth is about 0.06 mil, resulting in a base width between the collector and emitter junctions of 0.04 mil.

The next process is to form metallized contacts to the base and emitter regions. Once more the photoresist process is used and contact windows are opened in the silicon oxide (f). Aluminum is now evaporated onto the whole surface of the slice, and a fourth photoresist sequence carried out with a "reverse" contact photomask to remove the aluminum from everywhere but in the contact windows. The aluminum remaining in the contact windows is then alloyed to the silicon to form a low resistance contact (g).

Finally the slice is cut into individual transistor elements by scribing between the rows of elements and breaking into wafers. The individual wafers are assembled into transistor units by fusing down to a header, which forms the collector contact, and bonding connections to the base and emitter contact areas (h).

It will be seen that all of the above processes are carried out on the top surface of the slice, and the three regions of the transistor—the emitter, base and collector—all come to this same plane surface and hence the name "planar." By changing the photomask details only, any size and shape can be given to the diffused regions, and so any desired ele-
(continued on page 91)

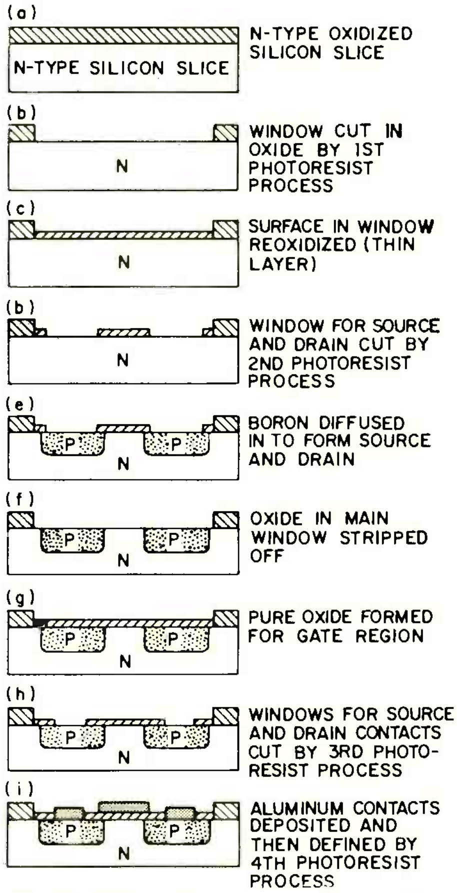


Fig. 7—Fabrication of a silicon npn transistor using the diffused planar process.

Our tubes have finally met their match.

We've been making power output tubes for a long time.

Now, we're matching them.

You can get the most popular output tubes—6BQ5, 7591A, 7868, and 8417—in carefully matched pairs.

Matched pairs that lower harmonic distortion, reduce hum.

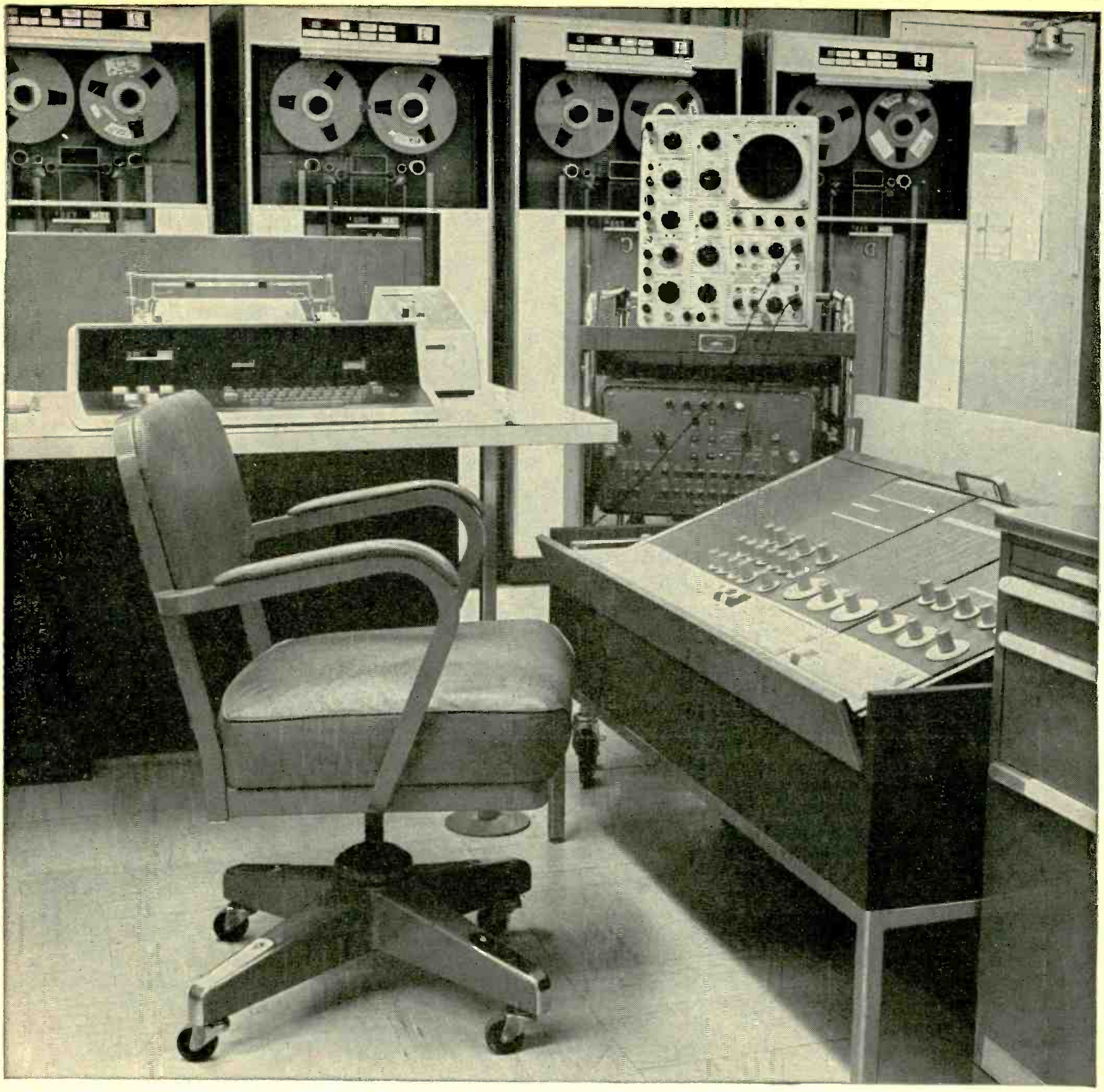
And give you more satisfied customers.

Sylvania is the only domestic brand that your distributor has in stock. Just ask for 6BQ5P, 7591P, 7868P, or 8417P. The suffix "P" assures you that you are getting a set of tubes factory-matched by Sylvania.

Sylvania Electronic Components, Electronic Tube Division, West Third St., Emporium, Pa. 15834.

SYLVANIA
A SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS

Circle 24 on reader service card



This important job (and its big salary) is reserved for a qualified electronics technician. It can be you!

It's a fact. There are *many thousands* of jobs like this available *right now* for skilled electronics technicians. What's more, these men are going to be in even *greater* demand in the years ahead. But how about you? Where do you fit into the picture? Your opportunity will never be greater...so act *now* to take advantage of it. The first step? Learn electronics fundamentals...develop a practical understanding of transistors, troubleshooting techniques, pulse circuitry, micro-electronics, computers and many other exciting new developments in this booming field. Prepare yourself now for a job with a bright future ...unlimited opportunity...lasting security...prestige... and a steadily-increasing salary.

Thousands of ambitious men are using Cleveland Institute of Electronics Training Programs as a stepping stone to the good jobs in Electronics. Why not join them? You will learn at home, in your spare time, and tuition is remarkably low. Read the important information on the facing page. Then fill out the postage-free reply card and drop it in the mail today. Without obligation we'll send you all the details. But act now...and get *your* high-paying job just that much sooner.

How You Can Succeed In Electronics

...Select Your Future From Six Career Programs

The "right" course for your career

Cleveland Institute offers not one, but six different and up-to-date Electronics Home Study Programs. Look them over. Pick the one that is "right" for you. Then mark your selection on the bound-in reply card and send it to us. In a few days you will have complete details...without obligation.

1. Electronics Technology

A comprehensive program covering Automation, Communications, Computers, Industrial Controls, Television, Transistors, and preparation for a 1st Class FCC License.

NEW!

2. Broadcast (Radio & TV) Engineering

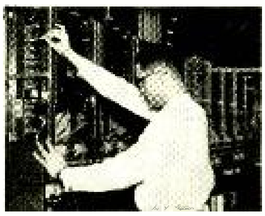
Here's an excellent studio engineering program which will get you a 1st Class FCC License. Now includes Video Systems, Monitors, FM Stereo Multiplex, Color Transmitter Operation, and CATV.

3. First Class FCC License

If you want a 1st Class FCC ticket *quickly,* this streamlined program will do the trick and enable you to maintain and service all types of transmitting equipment.

4. Electronic Communications

Mobile Radio, Microwave, and 2nd Class FCC preparation are just a few of the topics covered in this "compact" program...Carrier Telephony too, if you so desire.



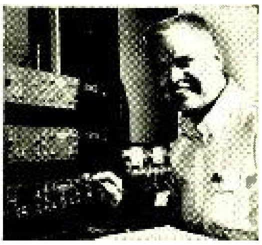
5. Industrial Electronics & Automation

This exciting program includes many important subjects such as Computers, Electronic Heating and Welding, Industrial Controls, Servomechanisms, and Solid State Devices.

NEW!

6. Electronics Engineering

A college-level course for men already working in Electronics...covers Steady State and Transient Network Theory, Solid State Physics and Circuitry, Pulse Techniques, Computer Logic, and Mathematics through Calculus.



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

An FCC License...or your money back!

In addition to providing you with comprehensive training in the area indicated, programs 1, 2, 3, and 4 will prepare you for a Commercial FCC License. In fact, we're so certain of their effectiveness, we make this *exclusive* offer:

> The training programs described will prepare you for the FCC License specified. Should you fail to pass the FCC examination after completing the course, we will refund all tuition payments. You get an FCC License... or your money back!

CIE's AUTO-PROGRAMMED® lessons help you learn faster and easier

Cleveland Institute uses the new programmed learning approach. Our AUTO-PROGRAMMED® lessons present facts and concepts in small, easy-to-understand bits...reinforce them with clear explanations and examples. Students learn more thoroughly and faster through this modern, simplified method. You, too, will absorb...retain...advance *at your own pace.*

Lifetime job placement service for every CIE graduate...at no extra cost

Once enrolled with CIE, you will get a bi-monthly listing of the many high-paying, interesting jobs available with top companies throughout the country. Many Cleveland Institute students and graduates hold such jobs with leading companies like these: American Airlines, American Telephone & Telegraph, General Electric, General Telephone and Electronics, IBM, Motorola, North American Aviation, New York Central Railroad, Raytheon, RCA, and Westinghouse.

CIE lessons are always up-to-date

Only CIE offers new, up-to-the-minute lessons in all of these subjects: Logical Troubleshooting, Laser Theory and Application, Microminiaturization, Single Sideband Techniques, Pulse Theory and Application, Boolean Algebra.

Full accreditation...your assurance of competence and integrity

Cleveland Institute of Electronics is accredited by the Accrediting Commission of the National Home Study Council. You can be assured of competent Electronics training by a staff of skilled Electronics instructors.

CIE Cleveland Institute of Electronics
1776 East 17th Street, Cleveland, Ohio 44114

If card has been removed, mail this coupon for 2 FREE BOOKS

Cleveland Institute of Electronics
1776 East 17th Street, Cleveland, Ohio 44114

Please send me without cost or obligation:
1. Your 44-page book "How To Succeed In Electronics" describing job opportunities in Electronics today, and how your courses can prepare me for them.
2. Your book on "How To Get A Commercial FCC License."

I am especially interested in:

- ☐ Electronics Technology
- ☐ Broadcast Engineering
- ☐ First Class FCC License
- ☐ Electronic Communications
- ☐ Industrial Electronics & Automation
- ☐ Electronics Engineering

Name ____________________ Age ____
(PLEASE PRINT)

Address ____________________

City ____________ State ______ Zip ______

☐ **Check here for G.I. Bill information** RE-6.

Circle 25 on reader service card

In the Shop . . . With Jack

By **JACK DARR**
SERVICE EDITOR

Testing with extension cables

THE "EXTENSION-CABLE METHOD" OF testing is handy for setting a CRT and cabinet far enough from a crowded chassis to let you get at the circuits. However, as usual, there are pitfalls along this easy path.

One often unsuspected problem is cable capacitance. On a little 110° portable a while ago, I used an old extension cable that I'd made up of 5 feet of eight-conductor rotator cable. All of a sudden the raster was narrow! Some investigation showed that I had added something like 150 pF of capacitance across the horizontal yoke winding. Each pair of wires in this extension read 150 pF on a capacitor bridge. Since the normal capacitance across the yoke was only about 82 pF, this was quite a bit.

Commercial yoke-extension cables are intentionally wired "loose"—the wires are not neatly tied together. This might look a little sloppy, but it works better.

You can get the reverse of this, too, of course. In some sets, the designer gets about 100 pF of "cheap" shunt capacitance by simply tying the horizontal yoke leads together. Watch out for this when a yoke is replaced.

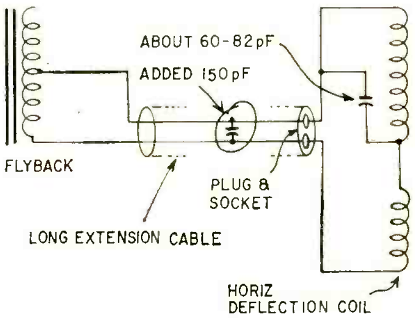
Other odd problems can be found in CRT extension cables. Be sure all wires are connected, and in the right places! A couple of oddball bases are used on 110° tubes. I had an adapter cable to convert the oddball to the standard base. You can really get confused if you get this one for use with a standard-base tube. The heater won't even light! (If you have any of these around, tie a *big* label to them, identifying them for what they are.)

Home-made adapter cables, although they're easy to make if you have the right plug and socket, are subject to this right-wire-in-the-wrong-place problem. (Don't ask me how I found out, it's embarrassing.) Just make sure when you build one to check it, recheck it, then check it again just to make sure.

Intermittents or loose wires are about the most common problems. I can still remember a set of cables I had long ago for use with the old Philco two-unit chassis. I don't think there was a time I used them when I didn't find at least one wire broken loose. Finally took the covers off the plugs and sockets so that I could at least see the wires.

Strangely enough, the one thing you'd think would be the most sensitive to being checked with long extension cables is the easiest—tuners. The answer is simple. The average tuner will have maybe four wires: two heaters, B+ and agc.

The tuner i.f. output can be connected to the chassis through a coaxial cable with plug and socket. This



can be 8 or 9 feet long without bothering anything too much. Of course, you don't want to make any *alignment* adjustments with this much added capacitance across the output. But for servicing, checking intermittents, replacing parts and typical tuner work, the longer length speeds up the job tremendously. The console cabinet can be left on the floor, and the tuner moved to the bench where you can get at it.

Modern TV's are coming up with the "theater" styles: color TV/phono–AM radio/FM radio, etc., all in one "box" and mostly with remote controls. They will all be interconnected with a positive maze of multiconductor cables.

For servicing this type of gear, a set of extension cables is almost essential. You can get out the unit that's giving trouble, leaving the rest in the box. These cables will usually have to be obtained from the factory, for the plugs and sockets are apt to be special types. However, they're cheap when you figure the cost of wasted time needed to pull all the "good pieces" to check the bad ones. **R-E**

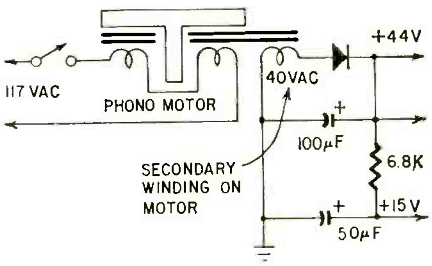
Service Clinic

By JACK DARR
SERVICE EDITOR

Transistor blows, motor slows

A Westinghouse V-2536-1 stereo record player is in for repair. The complaint was slow speed, and no sound in one channel. Changing a bad driver transistor fixed both of them! How come? Why would the transistor affect the motor? It's fed straight from the ac line.—L. O., Akron, Ohio.

I sat and looked at this for quite a while before I saw it! Notice that the "power transformer" for the low-



voltage supply (see diagram) is an extra winding on the phono motor! This isn't uncommon: it was used in a few tube amplifiers a while back.

When the driver went bad, it undoubtedly caused the output transistor to draw more than normal current. This caused a current overload on the power supply winding, which changed the magnetic fields in the motor itself. Since these little motors are pretty delicate as to their magnetic fields, this made the motor slow up.

A good while back, there was a similar unit, which used a low-voltage

(*continued on page 70*)

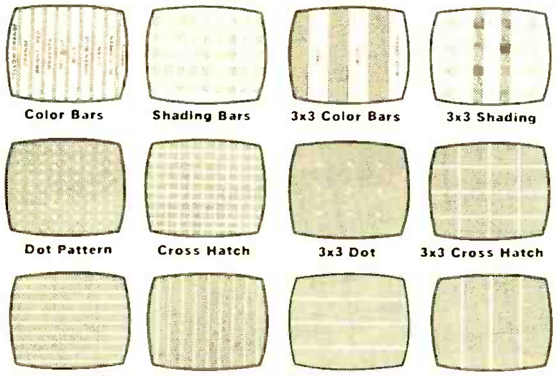
This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

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.

9 Exciting New Kits

NEW
Kit IG-28 $79.95*

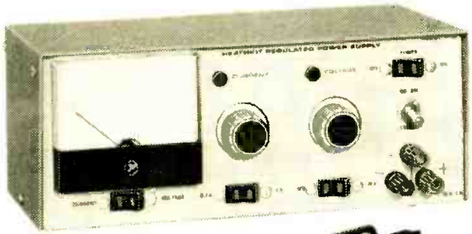
Standard 9 x 9 Display OR Exclusive Heath "3 x 3" Display



Color Bars | Shading Bars | 3x3 Color Bars | 3x3 Shading

Dot Pattern | Cross Hatch | 3x3 Dot | 3x3 Cross Hatch

Horizontal Bars | Vertical Bars | 3x3 Horizontal | 3x3 Vertical



NEW
Kit IP-28
$47.50*

NEW
Kit ID-29
$29.95*

NEW
Kit GR-88
$49.95*

NEW
Kit GR-98
$49.95*

NEW
Kit GD-48
$59.95*

NEW Heathkit Color Bar-Dot Generator... Advanced Integrated Circuitry Produces 12 Patterns Plus Clear Raster, Eliminates Divider Chain Instability Forever

The new IG-28 is the signal source for all color and B&W TV servicing. No other instrument at any price will give as much stable, versatile TV servicing capability. Its solid-state circuitry produces dots, cross hatch, vertical and horizontal bars, color bars, and shading bars in the familiar 9x9 display . . . plus exclusive Heath 3x3 display of all these patterns . . . plus a clear raster that lets you adjust purity without upsetting AGC adjustment. Fifteen J-K Flip-Flops and associated gates count down from a crystal controlled oscillator, eliminating divider chain instability and adjustments. And for time-saving convenience the IG-28 has variable front panel tuning for channels 2 through 6. Plus & minus going video signals at the turn of a front panel control . . . for sync, in-circuit video or chroma problems, use the front panel sync output. Two front panel AC outlets for test gear, TV set, etc. Built-in gun shorting circuits and grid jacks too. Add any service-type scope with horizontal input and you have vectorscope display capability as well. Fast, enjoyable circuit board-wiring harness construction. You can't beat the Heathkit IG-28 for versatility or value . . . put it on your bench now. 8 lbs.

NEW Heathkit 1-30 VDC Solid-State Regulated Power Supply

The new modestly priced IP-28 is an excellent power supply for anyone working with transistors. Compact Heathkit instrument styling with large, easy-to-read meter . . . two voltage ranges — 10 V., 30 V. . . . two current ranges — 100 mA, 1 A. External sensing permits regulation of load voltage rather than terminal voltage. Adjustable current limiting prevents supply overloads and excessive load current. Convenient standby switch. Fast, easy assembly with one circuit board and wiring harness. Order yours today! 9 lbs.

NEW Heathkit Solid-State Auto Tune-Up Meter ... Measures Dwell, RPM And DC Voltage

The new Heathkit ID-29 is most versatile . . . really three automotive test instruments in one. Measures Dwell on all 4-cycle, 3, 4, 6, or 8 cylinder engines . . . measures RPM in two ranges, 0-1500 and 0-4500 . . . measures DC voltage from 0 to 15 volts. And no batteries are needed . . . running engine provides both signal and power. Easy to use . . . on both 6 and 12 volt system without changing leads. Lightweight and easy to carry . . . its black polypropylene case has a built-in lead storage compartment and is resistant to virtually everything. Fast, simple assembly . . . only about 5 hours. The perfect accessory for the handyman, emergency road service personnel or shop mechanics . . . order your ID-29 now. 4 lbs.

NEW GR-88 Solid-State Portable VHF-FM Monitor Receiver

Tunes both narrow and wide band signals between 154-174 MHz . . . for police, fire, most any emergency service. Exceptional sensitivity and selectivity, will outperform other portable receivers. Smart compact styling, portable or fixed station capability with accessory AC power supply, variable tuning plus single channel crystal control, collapsible whip antenna, adjustable squelch control, easy circuit board construction. The new GR-88 receiver is an added safety precaution every family should have . . . get yours today! 5 lbs.

NEW GR-98 Solid-State Portable Aircraft Monitor Receiver

Tunes 108 through 136 MHz for monitoring commercial and private aircraft broadcasts, airport control towers, and many other aircraft related signals. Same exceptional features as the GR-88 above. The perfect receiver for aviation enthusiasts. 5 lbs. **GRA-88-1**, Accessory AC Power Supply...**$7.95***

NEW GD-48 Solid-State Metal Locator

A low cost, versatile, professional metal detector at one-third the cost of comparable detectors. Packed with features for long life, rugged reliability, and dozens of uses . . . battery operated, completely portable, weighs only 3 lbs. . . . highly sensitive, probes down to 7' depth . . . built-in speaker signals presence of metal, front panel meter gives visual indication, built-in headphone jack, telescoping shaft for height adjustment, easy-to-use and easy-to-assemble. Whether you're an amateur weekend hobbyist or a professional treasure hunter, the GD-48 is for you . . . also a great help to contractors, surveyors, Gas, Electric, Telephone and other public Utility Companies. 4 lbs.
GD-396, Headphones, 2000 ohm (Superex)...**$3.50***

From The Leader

NEW Heathkit Ultra-Deluxe "681" Color TV With AFT . . . Power Channel Selection & Built-In Cable-Type Remote Control

The new Heathkit GR-681 is the world's most advanced Color TV with more built-in features than any other set on the market. Automatic Fine Tuning on all 83 channels . . . eliminates touchy fine tuning forever, power push button VHF channel selection, built-in cable-type remote control . . . or you can add the optional GRA-681-6 Wireless Remote Control any time you wish . . . plus the built-in self-servicing aids that are standard on all Heathkit color TV's but can't be bought on any other set at any price. Other features include a bridge-type low voltage power supply for superior regulation; high & low AC taps to insure that the picture transmitted exactly fits the "681" screen. Automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs, top quality American brand color tube with 2-year warranty.

GRA-295-4, Mediterranean Cabinet shown **$119.50***

Heathkit "295" Color TV

Big, Bold, Beautiful . . . with the same high performance features and built-in servicing facilities as the GR-681 above . . . but less the Automatic Fine Tuning, push button VHF power tuning and built-in cable-type remote control. You can add the optional GRA-295-6 Wireless Remote Control at any time.

GRA-295-1, Contemporary Walnut Cabinet shown **$62.95***

Both the GR-681 and GR-295 fit into the same Heath factory assembled cabinets; not shown, Early American style at $99.95.*

NEW Deluxe Heathkit "581" Color TV With AFT

The new Heathkit GR-581 will add a new dimension to your TV viewing. Brings you color pictures so beautiful, so natural, so real . . . puts professional motion picture quality right into your living room. Has the same high performance features and exclusive self-servicing facilities as the GR-681, except with 227 sq. inch viewing area, and without power VHF tuning or built-in cable-type remote control. The optional GRA-227-6 Wireless Remote Control can be added any time you wish. And like all Heathkit Color TV's you have a choice of different installations . . . mount it in a wall, your own custom cabinet, your favorite B&W TV cabinet, or any one of the Heath factory assembled cabinets.

GRA-227-2, Mediterranean Oak Cabinet shown **$99.50***

Heathkit "227" Color TV

Same as the GR-581 above, but without Automatic Fine Tuning . . . same superlative performance, same remarkable color picture quality, same built-in servicing aids. Like all Heathkit Color TV's you can add optional Wireless Remote Control at any time (GRA-227-6). And the new Table Model TV Cabinet and roll around Cart is an economical way to house your "227" . . . just roll it anywhere, its rich appearance will enhance any room decor.

GRS-227-6, New Cart and Cabinet combo shown **$49.95***

Both the GR-581 and GR-227 fit into the same Heath factory assembled cabinets; not shown, Contemporary cabinet $59.95.*

NEW Heathkit Deluxe "481" Color TV With AFT

The new Heathkit GR-481 has all the same high performance features and exclusive self-servicing aids as the new GR-581, but with a smaller tube size . . . 180 sq. inches. And like all Heathkit Color TV's it's easy to assemble . . . no experience needed. The famous Heathkit Color TV Manual guides you every step of the way with simple to understand instructions, giant fold-out pictorials . . . even lets you do your own servicing for savings of over $200 throughout the life of your set. If you want a deluxe color TV at a budget price the new Heathkit GR-481 is for you.

GRA-180-1, Contemporary Walnut Cabinet shown **$49.95***

Heathkit "180" Color TV

Feature for feature the Heathkit "180" is your best buy in color TV viewing . . . has all the superlative performance characteristics of the GR-481, but less Automatic Fine Tuning. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart. Get the value-packed GR-180 today.

GRS-180-5, Table Model Cabinet & Cart combo **$39.95***

Both the GR-481 and GR-180 fit the same Heath factory assembled cabinets; GRA-180-2, Early American Cabinet $75.00.*

Add the Comfort And Convenience Of Full Color Wireless Remote Control To Any Rectangular Tube Heathkit Color TV . . . New Or Old!

Kit GRA-681-6, for Heathkit GR-681 Color TV's **$59.95***
Kit GRA-295-6, for Heathkit GR-295 & GR-25 TV's **$69.95***
Kit GRA-227-6, for Heathkit GR-581; GR-481 & GR-180 Color TV's **$69.95***

Now There Are 6 Heathkit® Color TV's To Choose From

2 Models In 295 Sq. Inch Size

NEW
Kit GR-681
With AFT
$499^95*
(less cabinet)

Kit GR-295
$449^95*
(less cabinet)

2 Models In 227 Sq. Inch Size

NEW
Kit GR-581
with AFT
$419^95*
(less cabinet)

Kit GR-227
NOW ONLY
$379^95*
(less cabinet & cart)

2 Models In 180 Sq. Inch Size

NEW
Kit GR-481
with AFT
$359^95*
(less cabinet)

Kit GR-180
NOW ONLY
$329^95*
(less cabinet & cart)

NEW

FREE 1969 CATALOG!

Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, electric guitar & amplifier, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

HEATHKIT®
a Schlumberger company

HEATH COMPANY, Dept. 20-6
Benton Harbor, Michigan 49022

☐ Enclosed is $________________, plus shipping.

Please send model (s)____________________
☐ Please send FREE Heathkit Catalog. ☐ Please send Credit Application.

Name______________________________

Address____________________________

City______________State__________Zip________

*Mail order prices; F.O.B. factory. Prices & specifications subject to change without notice. CL-357

Circle 29 on reader service card

SERVICE CLINIC
(continued from page 67)

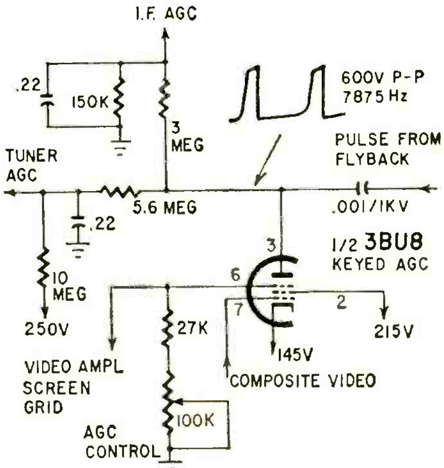
phono motor, in series with the heater of the single 25L6 amplifier tube. If the tube blew, everything went dead! This caused the replacement of a few perfectly good motors, then puzzlement as to "why it didn't work?"

Keyed AGC trouble

I've got a bad picture overload in an Admiral 17Y1X TV chassis. By feeding an external keying pulse into the 3BU8, it works fine. However, this is a 2,000-volt pulse, and the set's supposed to work with a 600-volt pulse; this checks out okay with a scope. What now?—J.G., St. Constant, Quebec.

An agc overload, black, bending picture with buzz, means too much *positive* voltage on the agc. A white-out, no sound no picture, blank screen, means too much *negative* agc voltage (plus the normal number of other possible causes, of course!)

The most common agc circuits used with this tube (3BU8) use a "bucking" or delay voltage taken from the B+ line through a very large resis-



tor, up into the 10-megohm or larger range. These resistors are far more critical than most technicians think! Only a small change in their rated value will cause the agc bus to go more positive or negative than it ought to be; so, we get agc trouble symptoms.

Since you can feed in a keying pulse and get good operation, I'd say that one of the two big resistors shown could be off-value. Check them, and also check your pulse-feed coupling capacitors for leakage. Also, check *all* of the operating voltages on the —BU8 tube. I had a case last week with almost identical symptoms, and found that the dropping resistor in the 145-volt line (feeding the *cathode* of the —BU8 tube, thus setting the bias and conduction level) was completely open! However, the "trouble" was "AGC symptoms," and you could override the agc and make it work!

Color change between TV stations?

In a perfectly tuned-up color TV set, should there be any change in color, hue, etc., when the set is switched from one channel to another?

Also, does the difference between a weak and a strong signal change the hue?—A. D. P., Des Moines, Iowa

To the first question, the answer is "theoretically no, practically, yes, quite often!" When you switch channels, you change TV transmitters! There is often a difference between stations as to color, and even a slight change in hue, although the last is very, very rare. There are two stations near my home, each of which gives me very good color pictures. However, when I change from one to the other, I have to reset my COLOR control! There is a *very* decided difference in the color-strength signal between the two!

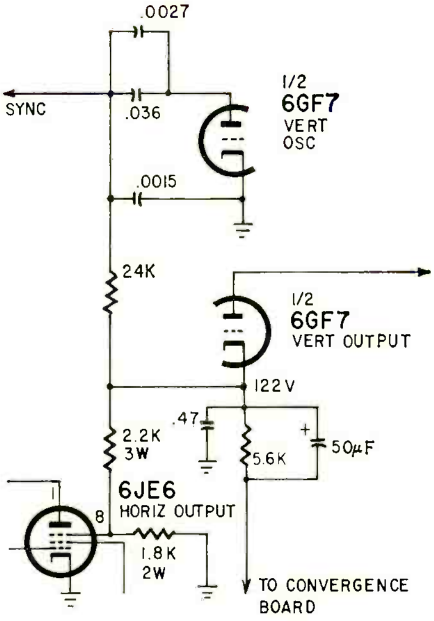
This can be caused by a slight difference in the response of the station video transmitters. As a rule, older transmitters can have a narrow bandwidth and attenuate the color-signal end of the response, which is, of course, out near the high-frequency end. If the station doesn't have enough bandpass, you'll get weak color or hard-to-tune color. A newer transmitter will give you bright vivid color on the same program.

Color should "hold" just the same on a weak signal as on a strong one. I've seen signals fade out completely to where there was no perceptible picture on the screen. The last thing that disappeared, like the Cheshire cat's grin, would be a red sweater or some bright-colored object in the picture! However, the presence of snow *in the color* of objects will make them *look* weak and washed-out.

Combination vertical–horizontal trouble

In an RCA CTC16 E color TV, the vertical and horizontal sweeps seem to be affected by the same trouble, whatever it is! After about a minute, the picture flips, loses contrast and shrinks horizontally. Voltages all seem to check okay. Cool it off and it does the same thing over again. I'm lost!—S. M., Dickson City, Pa.

One thing can cause such trouble, and has been known to do it. Check the schematic, and you'll see a circuit which starts at the vertical sync input, goes to the vertical output tube cathode, then on to the horizontal output tube's suppressor grid.



This acts as a sort of voltage divider. One purpose of this connection is to put a positive voltage on the 6JE6 suppressor grid to get rid of snivets on uhf.

At any rate, if one of these resistors opens up, it can affect the horizontal and vertical circuits at the same time. Check the 1800-ohm 2-watt resistor from the suppressor grid to ground at the 6JE6 tube socket. It has caused this kind of trouble in the past.

I.f. oscillation

I've got an RCA KCS-132AZ chassis, and I never saw such a violent oscillation! There seems to be a picture, but it's broken into parallel black-and-white bars about an inch wide! (Horizontal stripes or bars, that is.) The vertical sync is unstable, and all in all, the set's a mess!

I've bridged every filter and bypass capacitor in the thing, and all the tube shields are there. What's making this thing oscillate so badly?—R. D., Albuquerque, N. M.

You've had too much "help" on it sometime in the past! From these symptoms, which are all too familiar, some helpful soul has replaced all of the i.f. tubes before you got it. However, he's replaced them with the wrong ones!

The first i.f. is a 6BZ6, the second is a 6GM6 and the last is a 6EW6, and that's it! *Don't* substitute in this chassis! It's a very good set with the right tubes, but with the wrong types in the video i.f. it's as wild as a March hare! Check to be sure that the right tube types are in there and it'll work very nicely. Voice of Experience signing off! R-E

RADIO-ELECTRONICS READER SERVICE

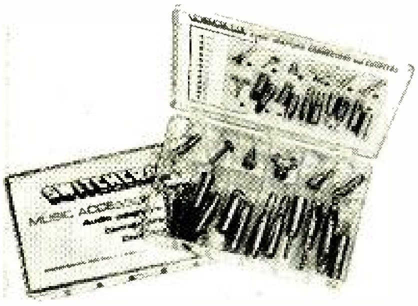
Here's how you can get manufacturers' literature fast:

1. Tear out the post card on the facing page. Clearly print or type your name and address. **Include zip code!**
2. Circle the number on the card that corresponds to the number appearing at the bottom of the **New Products, New Literature** or **Equipment Report** in which you are interested.
   For literature on products **advertised** in this issue, circle the number on the card that corresponds to the number appearing at the bottom of the advertisement in which you are interested. Use the convenient index below to locate quickly a particular advertisement.
3. Mail the card to us (no postage required in U.S.A.)

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 at the left and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

AUDIO CONNECTOR KIT, *Model K130*, contains 17 different connectors and adapters. Each one helps solve a particular mating problem. Also included



are special "Y" adapters and audio connectors. Unit makes it possible to interconnect guitars, mikes, electric organs, amplifiers, etc. $56.—**Switchcraft Inc.** Chicago, Ill.

Circle 46 on reader service card

STEREO HEADPHONE KIT, *Model KG-801*, lightweight with adjustable headband and padded ear-cushions. Reproduces stereo with frequency response

covering a range of 20-20,000 Hz. $5.95, with all parts, easy-to-follow instructions, a 6' cord and a standard ¼" plug.—**Allied Radio Corp.,** Chicago, Ill.

Circle 47 on reader service card

CRYSTALS called *Nystals*, meet the requirements of Method 213 of MIL-STD-202 for shock and Method 201 for vibration. Four Models, *HC-25/U*, *HC-18/U*, *HC-13/U* and *HC-6/U* (-18 and -25 are the same case, one with pins, the other with pigtails). Minimum frequency for

HC-13/U is 16 KHz and all sizes include crystals which resonate to 100 MHz. Standard frequency accuracy is 0.002% typical and temperature influence over the −55 to +105°C temperature range is 0.005% typical.—**Nytronics Inc.,** Pelham Manor, N.Y.

Circle 48 on reader service card

MOBILE ANTENNAS. Two models; *Racer 4* ($10.25) has a 48" shaft and *Racer 6* ($11.25) a 72" shaft made of fiberglass. Both have a stainless steel tip

incorporating a tuning device. Frequency, 26.6-27.3 MHz. Power capability, 100 watts.—**Avanti Research & Development Inc.,** Addison, Ill.

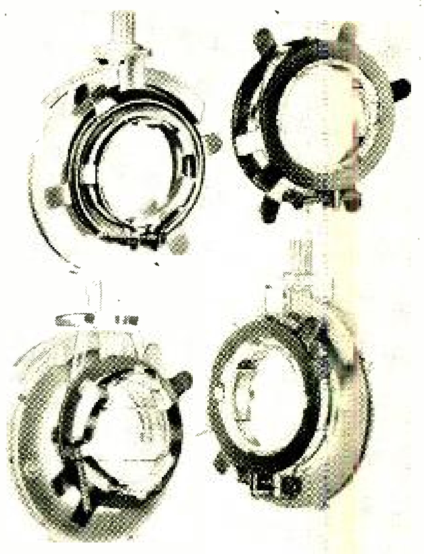
Circle 49 on reader service card

TRANSCRIPTION TURNTABLE, *Model TD-125*, has an electronic transistorized drive system to control drive motor speed. Has three speeds—16, 33, 45 rpm,

plus an electronic speed selector and pitch control. Replaceable tone-arm board permits mounting arm of choice.—**Elpa Marketing Industries,** New Hyde Park, N.Y.

Circle 50 on reader service card

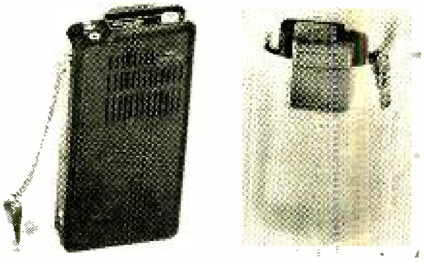
BLUE LATERAL MAGNET ASSEMBLIES, available in four models, *Mark I*, *Mark II*, *Mark IV* and *Mark V*, are compact, easy to install and may be adjusted in the field. Two sets of magnet-



ized rings for adjusting beam deflection on all 90° color TV picture tubes. Color purity is also obtained by two purity rings for centering the triad of beams.—**Fastex Div.,** Illinois Tool Works Inc., Des Plaines, Ill.

Circle 51 on reader service card

FM PAGING RECEIVER, *Model PR-150/2*, solid state, crystal controlled double superheterodyne. Operates on recently FCC-assigned 150-MHz band as well as low band, 30-50 MHz. Offers either beep-only or beep-plus-voice. Device measures 2½" x 5" x ⅞", is pow-



ered by rechargeable batteries or conventional dry cells. Under $200.—**Minilec Devices Inc.**, N.Y., N.Y.

Circle 52 on reader service card

TRANSISTOR/FET TESTER, *Model TF151*, tests high/low power transistors for ac beta and FET's for G_m, both in and out of circuit as well as checking for critical leakage in each device. Leakage cur-

rent (I_{CBO}) of any transistor in microamps is shown directly on the meter. Operates on 105/130 Vac, 50/60 Hz at 10 watts. Size, 9½" x 7½" x 6". $129.50—**Sencore, Inc.**, Addison, Ill.

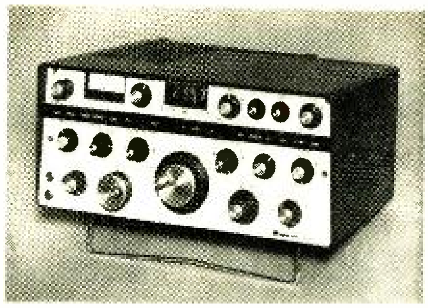
Circle 53 on reader service card

CAPTIVE FLOATING NUTS, *Type FLN*, correct hole misalignments in chassis and panels. Locking effect is achieved by distortion of the round extension above base. A dry, Teflon-type lubricant, Dupont *Vydax*, applied to the thread

simplifies insertion and removal of screw. Resistant to pull, push and torque-out and provides strong, wear-resistant threads in soft metals or thermoplastics. —**Precision Metal Products Co.**, Stoneham, Mass. 02180

Circle 54 on reader service card

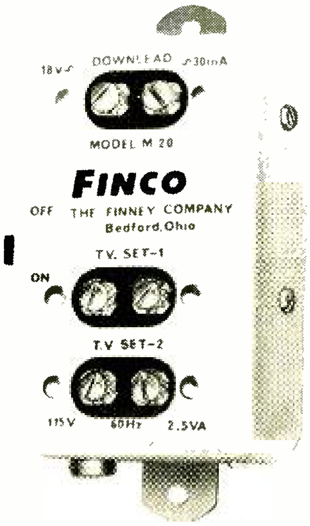
TRANSCEIVER, *Model CX7*, covers seven 1-mHz frequency bands in the 1.8–30mHz range, plus 50–51 mHz receive only, with counter readout to 100-Hz accuracy. An "auxiliary band" option permits coverage of any 1-mHz band in



1.8–30 and 50–54-mHz ranges. Solid-state except for a single power amplifier tube. Power supply, 115/230 Vac, 60 Hz. $1495.—**Electronic Communications Inc.**, St. Petersburg, Fla. 33733

Circle 55 on reader service card

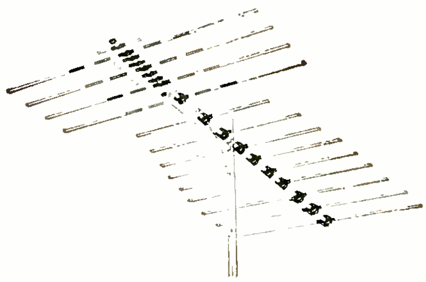
PREAMPLIFIERS, solid-state broadband, designed to prevent signal overloading. Mounts on antenna boom. Amplifies antenna signal 10 times with mini-



mum noise and lead loss. *Models M-10* and *M-11*, 300 ohms, have two outputs. *Model M-12*, 75 ohms, one output. 20 dB gain on both high and low bands.—**Finney Co.**, Bedford, Ohio.

Circle 56 on reader service card

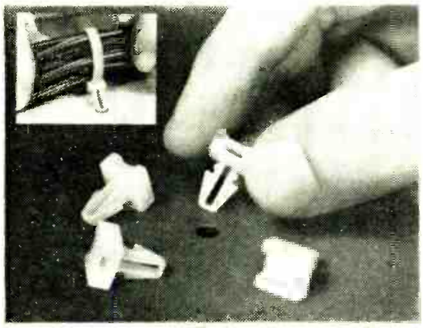
ANTENNAS in the *VUfinder Plus Series* come in 5 models. All provide improved color and monochrome reception on all TV channels and strong, clear radio re-



ception on FM band. Available for direct 300-ohm installation and instantly convertible to 75-ohm operation by snapon transformers. For areas classified from "local" to "deep fringe" in signal strength. Price range: $21.95–$64.95.—**Jerrold Electronics Corp.**, Philadelphia, Pa. 19105

Circle 57 on reader service card

PUSH-IN MOUNTING BASE. *Model TC823,* fits into a 0.250–0.265" diam hole in ⅛" max. thick panels. Accepts an assortment of T&B Ty-Rap cable ties up to 0.190" wide. Made of fabricated ny-



lon, the self-locking base provides easy installation of mounting plate by pushing the stud into the hole.—**Thomas & Betts Co.**, Elizabeth, N.J. 07207

Circle 58 on reader service card

AC VOLTMETER PLUG-IN. *Model DP130,* measures voltage from 10 μV to 1000 V with an accuracy of 0.1%. Frequency range: 22 Hz to 1 MHz. Input impedance: 1000 megohms. Provides

rms readings when measuring sine-wave ac signals; also rms value of square and triangular waveform inputs if specified correction factors are applied. $375.—**Hickok Electrical Instrument Co.**, Cleveland, Ohio 44108

Circle 59 on reader service card

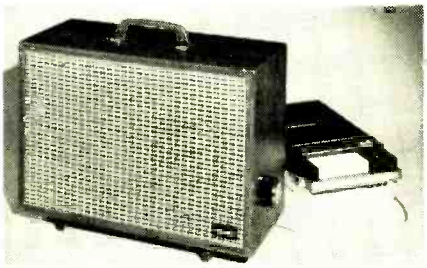
AM/FM STEREO RADIO SYSTEM, *Model LR-20,* solid-state, consists of a AM/FM stereo radio and two 6½" wide-

range speakers. Circuitry: 26 transistors, 19 diodes and 4 thermistors. Power: 12 watts. Tuning range: FM, 88–108 MHz, AM, 540–1600 kHz. Sensitivity: 7 μV.

Stereo separation: 30 dB @ 400 Hz. For 117-V, 50/60-Hz ac. Housed in a walnut metal enclosure. $99.95.—**Lafayette Radio Electronics**, Syosset, N.Y. 11791

Circle 60 on reader service card

AMPLIFIER/SPEAKER SYSTEM, solid-state, 4-watt, converts any cassette recorder to full-range sound with a 6" speaker, and into a PA system when cassette recorder is attached to a mike. Op-



erates on 9-volt radio battery. Frequency response, 40–10,000 Hz. Unit records on a cassette while being used as PA system at the same time. Measures 12" x 8¾" x 5" and weighs 4 lb. $34.95.—**Dynaphonics Inc.**, Dayton, Ohio 45419

Circle 61 on reader service card

CITIZENS TWO-WAY RADIO, *Messenger 123*, solid-state, 23-channel, features a special compression circuit for maximum voice intelligence. Power input: 5 watts. Sensitivity: 0.4 μV. Selec-

tivity: 7 kHz. Variable squelch control reduces background noise by silencing the receiver until a message is broadcast. $169.95.—**E. F. Johnson Co.**, Waseca, Minn. 56093

Circle 62 on reader service card

85-WATT STEREO AMPLIFIER, *Model LA-85TA*, solid-state, has a selector switch for any of 4 program sources. Harmonic distortion less than 1%. Frequency response: 22–20,000 Hz ±1 dB. Power bandwidth: 22–40,000 Hz. Inputs in-

clude aux, tape input and output, tuner, ceramic phono, magnetic phono and 2 ac outlets. Complete with walnut-grained metal enclosure. $99.95.—**Lafayette Radio Electronics**, Syosset, N.Y. 11791 ***R-E***

Circle 63 on reader service card

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 72 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

1969 TAPE RECORDER CATALOG, 16 pages illustrated, describes portable cassette and reel-to-reel models; cassette, 8-track and reel-to-reel tape decks, radiocorders and stereo tape systems for which applications, features and specs are included.—**Concord Electronics Corp.**, Los Angeles, Calif. 90025

Circle 76 on reader service card

COMMUNICATIONS/DICTATION HEADPHONES and other private listening devices plus accessories are illustrated with photos and charts in *Catalog B1-2166*. 8 pages. Information on applications, complete specs, new catalog numbers and prices also provided.—**Telex Communications Div.**, Minneapolis, Minn. 55420

Circle 77 on reader service card

TEMPMATIC SOLDERING TOOL handles light and heavy-duty soldering with tip temperature control. Points have premium plating. Trigger turns heat on and off. Ejector button makes for easy switching of power heads, which are available in two models: 700°F 3/16" chisel point, and 600°F ⅛" conical point. Device weighs 7 oz and comes in a color display package.—**Weller Electric Corp.**, Easton, Pa.

Circle 78 on reader service card

ABC'S OF NUT FASTENING. Application and requirements, purpose and reasons are outlined in a 12-page pocket-size booklet, *AS-1101*. Brief description on many nut products in a wide range of styles and sizes available.—**Shakeproof Div., Illinois Tool Works Inc.**, Elgin, Ill. 60120

Circle 79 on reader service card

CONTACT PLATING TAPE. Vinyl electroplater's tape with a "built-in" shorting bar offers significant advantages over other methods of contact finger plating. A 4-page bulletin includes comparison of production time and costs to other methods such as conductive paint, paste shorting bars, copper tapes with conductive pressure-sensitive adhesive, and shorting bars etched directly into a circuit board.—**Tapecon Inc.**, Rochester, N.Y. 14612

Circle 80 on reader service card

INDUSTRIAL AEROSOLS covering paints and protective coatings, lubricants, mold releases, solvents and cleaners, corrosion preventives, office supply aerosols, building maintenance aerosols and adhesives are described with suggestions of color coding for each application in a 39-page catalog, *F-2500-50*. Size and price list included.—**Crown Industrial Products Co.** Hebron, Ill. 60034

Circle 81 on reader service card

ELECTRONIC INSTRUMENTS, including dc, ac and ac/dc instruments, multirange precision milliohmmeter, chart recorders and digital systems are detailed with full specs, charts and photos in a 12-page *Bulletin 368A*. Price for each model given.—**Simpson Electric Co.**, Chicago, Ill. 60644

Circle 82 on reader service card

ELECTRONIC STROBOSCOPE, its fundamental concepts, its accessories and how it can be used with a simple camera for high-speed photography and a variety of other applications are described in a 24-page booklet titled *A Primer of Stroboscopy*.—**General Radio Co.**, West Concord, Mass. 01781 **R-E**

Circle 83 on reader service card

HOW TO REPAIR VTR'S

By VIC BELL

MANY SERVICE TECHNICIANS TURN down video tape recorder service jobs. Although you may have avoided audio tape recorder customers in the past, you'll find it difficult to ignore the fast-growing VTR (Video Tape Recorder) service market. More manufacturers will be marketing home entertainment centers that include VTR's and since this is a TV linked item they'll be coming to the TV service technician when repairs are needed.

Some technicians, bypassing audio tape recorders because of the mechanics involved, reason that VTR mechanisms must be much more complicated. But they're not. Actually, the transport mechanisms are so similar that at least one manufacturer uses a basic transport deck for both audio and video recorders.

Of course, VTR electronics *are* more involved. One imported model uses 76 transistors and numerous diodes. But the TV receiver—part of the system—accounts for about half of these transistors. About 10 of the remaining transistors are used in the VTR's audio section, which operates much like a regular audio recorder. So, if you've been working on solid-state TV and tape recorders, you already have about two-thirds of the system under your belt. Let's look at the remaining circuitry.

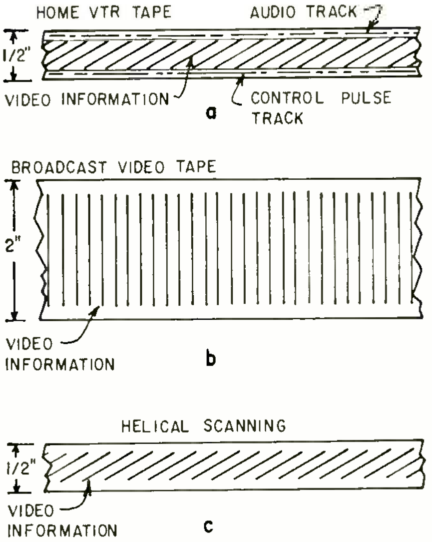


Fig. 1-a—Home-type VTR tape uses edges for audio and control tracks. b—Broadcast video tape (2-inch width) with vertical video. c—Helical scan.

1/2" tape

Home VTR's employ 1/2" tape compared to the 1/4" tape used in audio recorders. The reason is simple: More information must be put on tape by the VTR than in audio-only tape systems. So much more that a special method of recording is used to increase tape information density.

Audio is recorded on the edge of video tape in the same manner as in audio-only tape recorders (Fig. 1-a). Maximum frequency response from this recording method is about 15 kHz. Since video information contains frequencies from 0 to 3 MHz another method must be used to record video.

Generally, increased tape speed in an audio tape recorder increases frequency response. Professional audio recorders operate at 15 ips, 30 ips or even more. To record video, however, tape speeds far beyond 30 ips would be required.

An alternative to high tape speeds is to move the *tape heads* in relation to the tape. It's not important whether the tape or the heads move, so long as the *relative speed* between the tape and the head is sufficiently high. Broadcast VTR's move the tape at a relatively slow speed, but rotate the video head vertically so the recorded information is in a strip from one edge to another. (Fig. 1-b). VTR's using this method generally use 2" wide tape.

Slant or helical scanning, the method favored by many home-use VTR manufacturers, is shown in Fig. 1-c. Video is recorded on the relatively slow-moving tape with a fast-moving head rotating in a horizontal plane. To prevent information from being superimposed on recorded video from prior head revolutions, the tape is slanted and fed around the rotating head. Fig. 2 shows the application of this technique.

30-Hz field rate

The helical scanning head normally rotates at 1800 rpm (30 rps), which coincides with the 30-Hz field rate for standard TV. Understanding this, it's easy to see that each diagonal strip of information on the tape can correspond to one frame of video information.

Since the heads rotate, a slip-ring and brush is employed for record and playback connection to the heads.

Actually, alternate information fields are recorded with this scanning technique. This is called skip-field recording. During playback, the record head and an additional head are used so that recorded information is read twice. One head is mounted lower than the other. This compensates for tape movement between each revolution and allows head B to follow head A's path precisely.

Video information recorded on the tape is frequency-modulated. A center frequency of 1.7 MHz with 1-MHz deviation is employed. FM was chosen because amplitude changes would not affect the signal and because the signal-to-noise ratio would be improved since dc signal components would be preserved.

Servo-sync system

During TV recording, motor speed is regulated by comparing the TV sync pulse to a 30-Hz pulse generated by the 30-PG (Pulse Generator) pickup coil near the rotating head assembly (Fig. 3). This 30-Hz pulse is compared to alternate sync pulses. When the 30-Hz pickup-coil pulse is early, the coincidence circuits apply current to a magnetic brake and slow the motor. When the sync signal arrives late, the brake is relieved and the motor speeds up.

Since the drive mechanism is designed to constantly operate the motor slightly faster than necessary, the brake is always needed. The head-drum assembly is driven by an elastic belt and braking is easily achieved.

In the camera-record mode, a different sync system is used. A 60-Hz signal is taken from the power line, shaped and used a reference for the servo system. A signal from the 30-Hz pulse generator is recorded on the edge of the tape—much like the audio signal—for sync comparison during camera-recorded playback. This recorded signal is picked up by a control-pulse head during playback and used in the same manner as sync when an air-recorded signal is played back.

Both camera and broadcast-TV recording-sync systems are diagramed

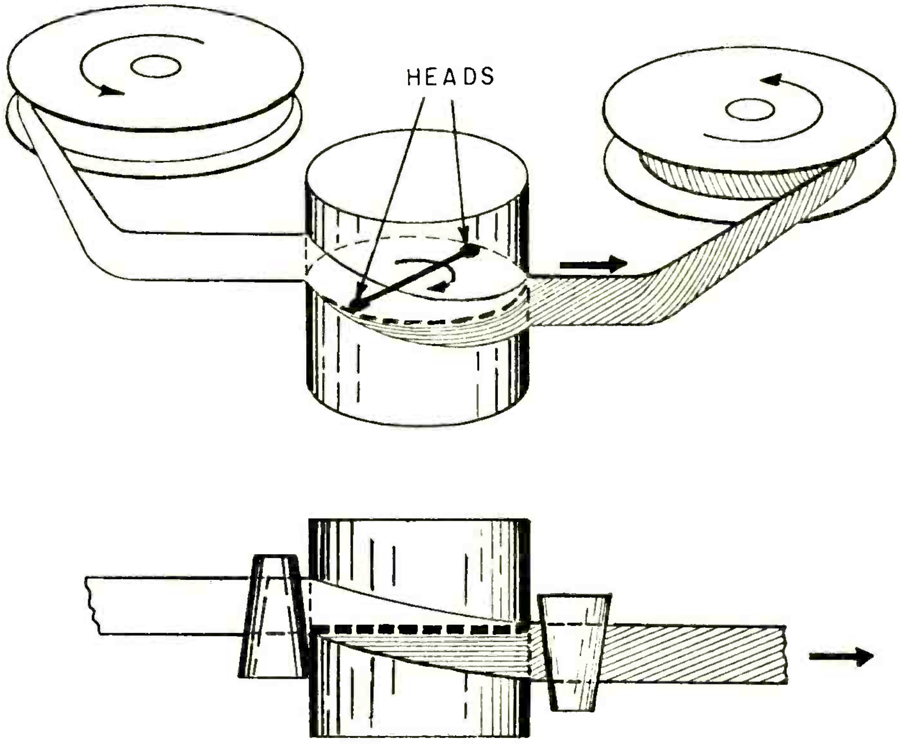


Fig. 2—For home VTR's slant or helical scanning is used. Tape moves slowly, heads spin in the horizontal plane. Tape and head positions are shown.

in Fig. 3. Vertical sync is reinserted into the video signal because interlace is lost in the skip-field recording method. This vertical sync signal is generated by the 60-Hz pickup coil near the head assembly, and reinserted in all modes when the head motor is running. The reinserted pulse can be seen on the VTR monitor by turning the vertical hold control to "roll" the picture down to the blanking bar. When the pulse is absent, the camera reverts to random interlace.

The pulse from the 60-PG coil is also used to synchronize the camera during the camera-record mode.

Interlace and stable horizontal sync are maintained for camera recording operation with a pickup coil positioned near a gear having 525 teeth. Note that two vertical pulses

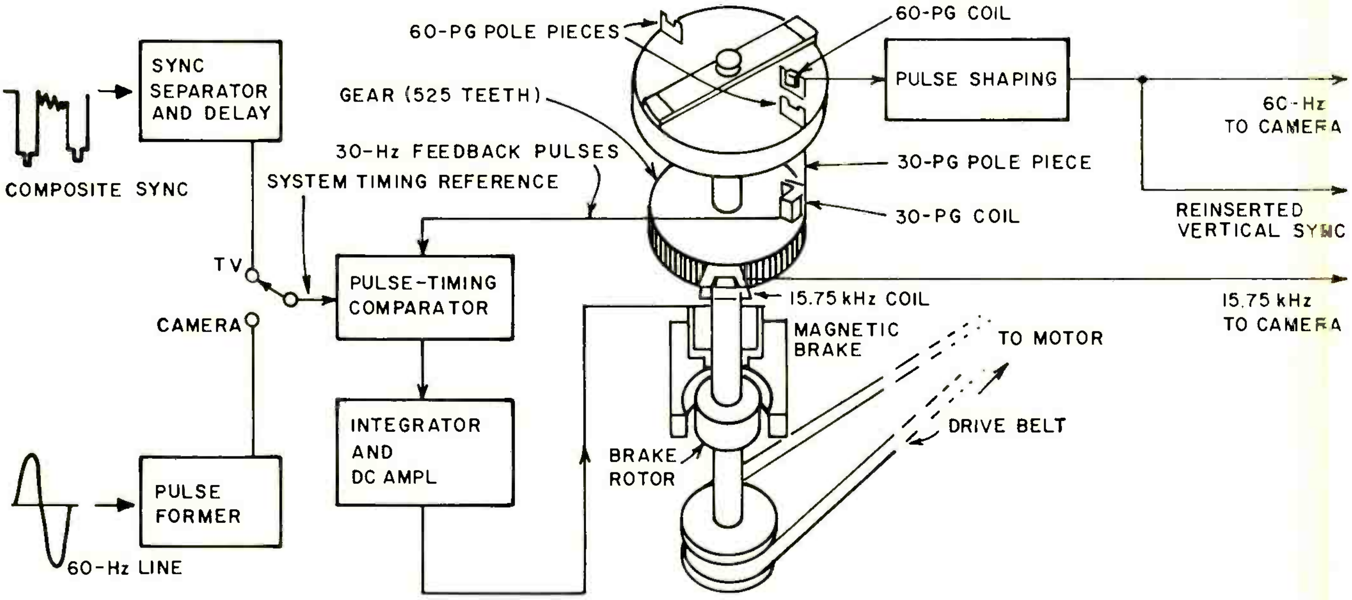


Fig. 3—Drive method and layout of rotating head and sync system. Motor speed is regulated by comparing TV sync to 30-Hz pulse from a pickup coil.

(from the 60-PG coil) are generated for each complete head revolution and one complete frame of horizontal sync pulses (525 lines), thus achieving 2:1 interlace.

General maintenance

Tolerances in the tape-path area of the video tape recorder are held to a minimum. Unless parts are removed, tape-path parts normally do not need to be adjusted.

Head replacement will probably be the most common exception. Video heads are fragile and can be broken by careless operation. Also, the heads wear rapidly. Poor recording tape will greatly accelerate head wear.

VTR manufacturers differ on cleaning the heads of their machines. In one VTR, head cleaning is made semi-automatic with a pushbutton. When the button is depressed, a small brush contacts the rotating heads and removes dirt.

Some companies warn that damage may result from contact with a moving head and suggest the following head-cleaning procedure: Stop the machine, and use a chamois-covered cleaning stick saturated with Methanol or tape-head cleaner to wipe each head side to side. Vertical movements may break the head.

Spray solutions made for head cleaning are also recommended. For all tape machines, this is probably the safest method.

The remaining tape path should be cleaned just as you would an audio recorder. Small oxide buildups on a VTR can cause severe tearing and streaking that would be unnoticed on an audio recorder, so clean carefully. Problems caused by dirty slip wings may be slight, such as a noisy picture, or may cause part or all of the picture to disappear.

An access door to the slip-ring is usually available. The instruction book usually outlines the proper cleaning method. Methanol or a similar cleaner should be used on slip rings. Be careful not to bend the brush springs when cleaning the rings. A change in brush pressure can cause loss of picture, a noisy picture or excessive wear.

VTR's require lubrication just as their audio counterparts do. Use a good grade of oil and lightly lubricate all metal-to-metal moving parts.

Machine tape compatability is determined by the care used when installing video heads. If care is used, tape from one machine can normally be played on another with acceptable results. Misaligned heads cause tearing.

If a tape-head assembly must be removed or replaced, exercise extreme care and proceed as follows:

Remove access panels necessary to uncover the heads or the top of the head-drum assembly. On some recorders a printed-circuit preamplifier will be found on this drum assembly. Some screws hold the drum lid on and others hold the PC board to the drum lid.

Carefully remove screws that hold the drum lid on the machine. Do not allow the lid to drop on the video heads. Note the drum lid is positioned against a template-like guide.

Next, fold the drum lid back on its wires. The head assembly is now accessible. Note that one end of the head assembly is different from the other. Generally, paint is applied to one end, but, if not, look for different colored wires or other obvious markings. Mark the table which holds the head so that this head or a replacement will not be reversed when installed. It is not generally necessary to remove the heads to replace the slip-ring assembly.

To install the heads or slip rings, use great care and reverse the above procedure. Tighten all screws alternately.

When slip rings must be replaced, make sure they are concentric with the rotating heads. If they are eccentric, they may damage the brushes, cause a noisy picture and quickly wear out.

Brush-pressure measurement is shown in Fig. 4 for the Sony VTR. Other machines may be adjusted similarly, but instruction books should be consulted for proper pressures. **R-E**

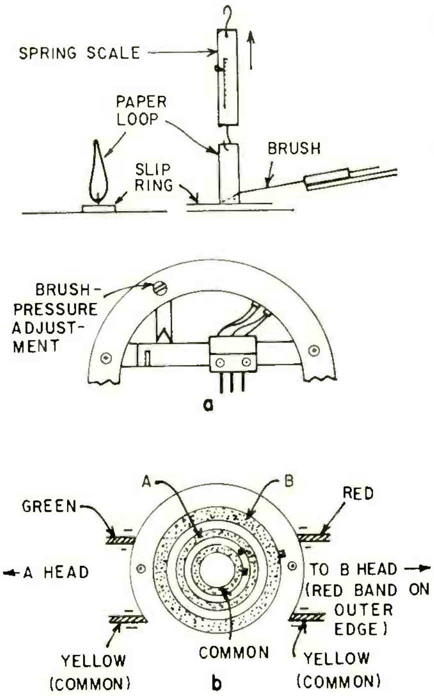
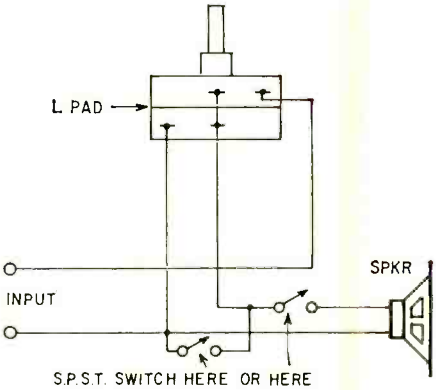


Fig. 4—Top drawings (a) *show technique for Sony VTR brush spring adjustment.* b*—Slip-ring connections.*

KILL EXTENSION-SPEAKER WHISPER

If you are bothered by the faint sound that can often be heard in a quiet room when an extension-speaker's L pad or T pad is turned fully off, there are two ways to solve the problem.

One is to short-circuit the shunt element of the pad with an spst switch (a), which must be opened when you turn the pad up. The other is to open the line between speaker and pad (but not between amplifier and pad) with a switch—which must of course be closed when you want to listen to the speaker.



The second method is guaranteed to attenuate the sound to zero.

It would be nice if manufacturers of L- and T pads would adapt them to take add-on switches; but since there are no such controls, you will have to use a separate switch.

For stereo, use a dpst switch to shush both channels at once —*James A. Fred*

COMING NEXT MONTH

JULY 1969

- **Lowdown On Intruder And Fire Alarms**
  What kind of protection do you need in your home? See what's available and how best to use it.

- **Fixing Car Tape Players—A Cinch**
  Programmed step-by-step picture of how they work and how to keep them going.

- **Build A TV Camera for $100**
  Closed circuit camera is all solid-state and easy to build. If you've got a well-stocked scrap box you can make it for less.

- **Make A 2-watt Hi-Fi**
  A new IC is what makes it possible. It's both a fun project and a quality amplifier.

- **Kwik-Fix™**
  Second article in this new series covers vertical sweep circuits. You won't want to miss this one.

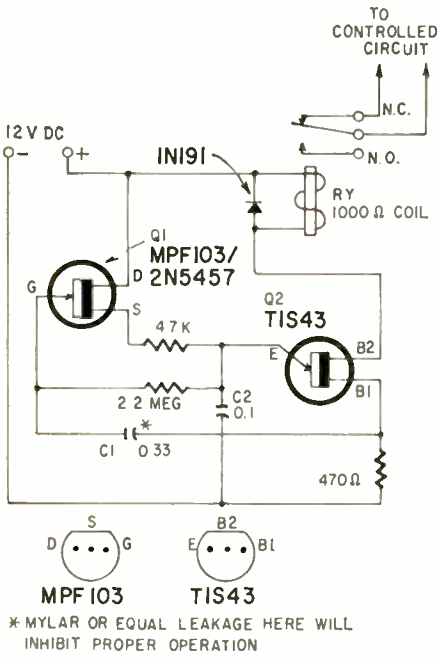
- **Bongo, Bongo, Bongo**
  Add four tones of electronic bongos to any power amplifier. Perf-board circuit is easy to duplicate, fun to use.

NOTEWORTHY CIRCUIT

VERSATILE REPEATING TIMER AND FLASHER

This circuit was designed originally to be used in a road emergency light. It blinked a couple of series-connected 6-volt bulbs on and off as a warning to oncoming motorists that a car was stalled on the road. The bulbs were mounted in reflectors equipped with red lenses and directed fore and aft.

The setup is actually a slow-running multivibrator, with the timing interval controlled by capacitor C1 and triggering performed by capacitor C2. A virtue of the circuit is that an on interval of 2.5 seconds and an off interval of 1 second is obtained with C1 having a value of only 0.33 μF. Ordi-



narily, large, expensive capacitors are required in slow-timing circuits. C1 can be made 0.25 μF if a faster blinking interval is desired. The value of capacitor C2 is not especially critical.

The off interval of the multivibrator is longer than the on interval, so the back (normally closed) contact of the relay is used to control the lights. Base 2 current of unijunction transistor Q2 (which operates the relay) swings from 1.75 to 4.5 milliamperes. Positive operation is therefore obtained when the relay is adjusted to pull in at 4 ma and drop out at 2. The relay-coil resistance should be no greater than 1000 ohms. A high-quality relay, such as the Sigma 4F-1000-S/SIL, is recommended for this circuit.

The original assembly was powered entirely from a pair of 6-volt lantern batteries connected in series. Later, an extension cord with husky clips was made up to power the unit from the 12-volt car battery. If you do this, be particularly careful to observe polarity. It's easy to make a mistake on a dark night, especially when you are ruffled because of a flat tire or a stalled engine.

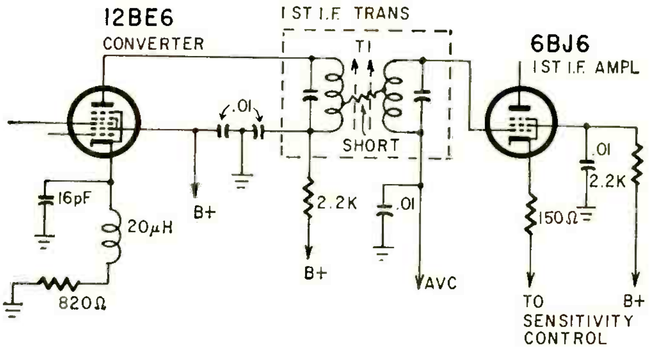
In addition to its use in an emergency warning light, this timer has a number of other applications, including winking Christmas lights, blinking illuminated signs, and a dock-locating light—if you're a boating enthusiast.—*Frank H. Tooker* **R-E**

CB Troubleshooter's Casebook

Compiled by Andrew J. Mueller*

Case 1: Distorted receive audio. Unit transmits OK.

Common to: Johnson Messenger II

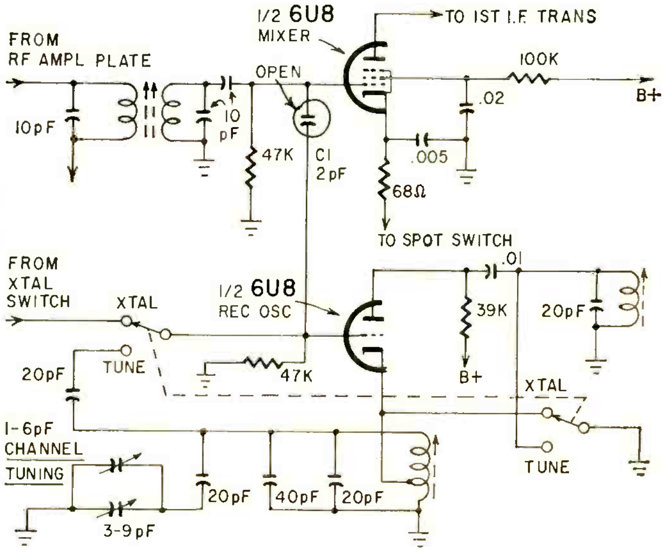


Remedy: Replace the first i.f. transformer.

Reasoning: The first i.f. transformer, T1, has developed leakage between primary and secondary. This places a positive voltage on the avc line which in turn increases the gain of the rf and i.f. stages to a point where the signal becomes distorted. Replacement of T1 is the only cure.

Case 2: Weak reception. Transmits OK.

Common to: Midland 13-160



Remedy: Replace C1.

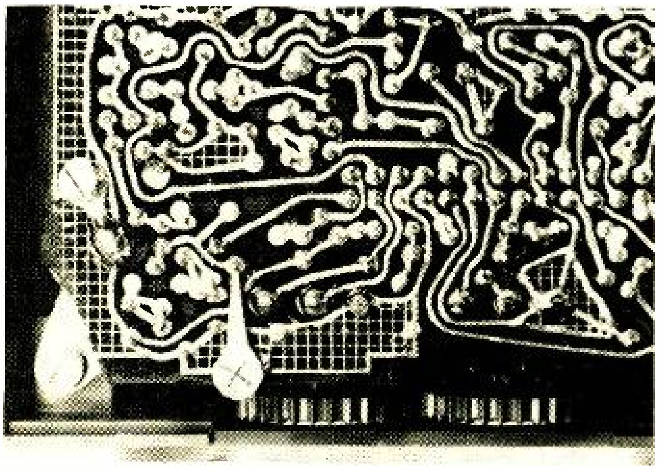
Reasoning: C1, the oscillator injection capacitor, is open. This produces a loss of receiver sensitivity because of a severe drop in oscillator injection voltage. The only way any injection voltage can get to the mixer is through the capacitance of the tube. Replacing C1 will bring the sensitivity back to normal. R-E

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

TECHNOTES

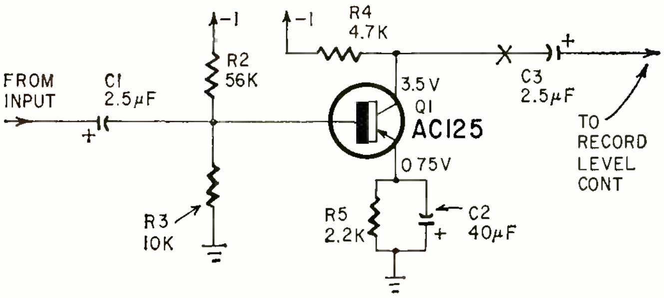
NORELCO CARRY-CORDER 150

A hard-to-find intermittent on record and playback was traced to a cold solder joint on the PC board between the pigtail of capacitor C3 and the copper strip to the collector of Q1 (see diagram). This capacitor is located behind and



adjacent to the record level control. When the three PC board mounting screws were removed, pressure on the control would cause C3 to move just enough to produce the intermittent condition.

Be careful when making the repair. Wipe the tip of the hot iron clean and then touch the iron to the scraped



and cleaned junction of the pigtail and the copper strip. (The tiny pointer marked "X" shows the location of the bad connection.) This reduces the possibility of excess solder flowing to other conductors and causing an unwanted connection.—*Robert S. Havenhill*

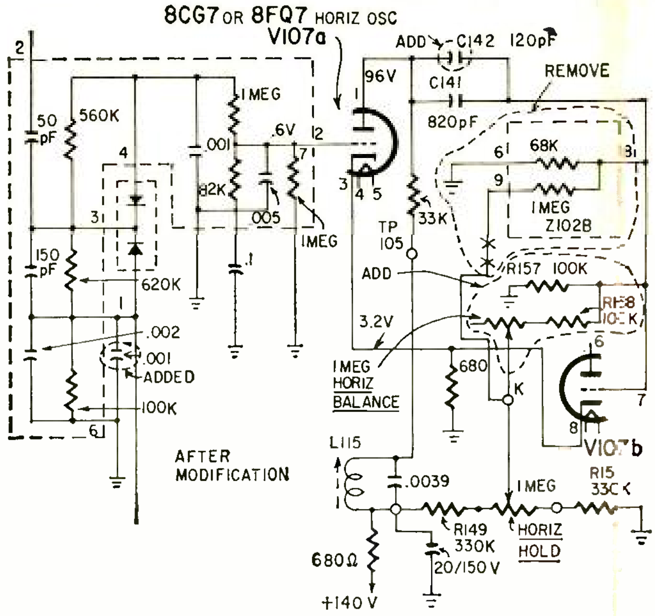
OLYMPIC HORIZONTAL OSCILLATORS

The 8FQ7 has a wide range of dynamic operation. When used as the horizontal oscillator in Olympic NCP and NDP chassis its operation is critical. The characteristics of a replacement tube often throw the horizontal frequency outside the control range. This has made it necessary to adjust the values of the two resistors (R149 and R151) in series with the hold control, to suit the tube being installed.

In *Service Bulletin 67-2*, Olympic recommends modifying the horizontal oscillator circuit by installing an additional control which will allow the oscillator to lock in with the horizontal hold control in the center of its range. The diagram shows the circuit with PC unit Z102B removed and the new control and two resistors and capacitors added.

After making the modifications, readjust the horizontal oscillator circuit:

1. Allow a 2-minute warmup and tune in a station. Short out horizontal frequency coil L115 with a jumper from test point TP105 to the +140-volt terminal.



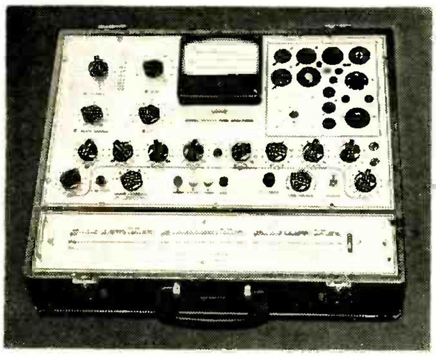
2. Disable the sync by connecting a jumper from test point TP104 (not shown) to ground.
3. Center the HORIZ HOLD control and adjust the new HORIZ BALANCE control until the picture is nearly in sync.
4. Remove the jumper from L115 and adjust the coil until the picture is in sync.
5. Remove the jumper between TP104 and ground to allow the station sync signal to reach horizontal circuits in the set.

R-E

EQUIPMENT REPORT

Triplett 3444-A Tube Analyzer

For manufacturer's literature, circle No. 88 on Reader Service Card.



TO A TEST-EQUIPMENT-HAPPY PERSON like me, it was a pleasure to check out the new Triplett 3444-A Tube Analyzer.

First I dug out my box of defective tubes, kept for just this purpose. The 3444 caught them all, including some tricky ones. This instrument is a "tube analyzer," not just a tube checker. By setting the controls, you can duplicate operating conditions in almost any kind of circuit. Results are claimed to be equal to laboratory type testers.

Dc voltages (regulated) are applied to all elements except the heater. The grid signal used in transconductance (G_m) testing is not 60 Hz, but a 5-kHz sine wave to duplicate conditions in amplifier circuitry.

Plate, screen and control-grid voltages can be set for "book" values on all elements. This allows testing new tube types by simply looking them up in a tube manual, and making the adjustments for rated operating voltages. Thus, actual G_m can be read on the meter and compared to the manual's value.

Grid current and actual plate cutoff can be checked for voltage amplifier tubes. Shorts or leakage can be read on the meter in ohms or megohms. The familiar neon lights are gone. You can read interelement leakage up to several megohms. These won't blink a neon lamp, but can be important in critical circuitry. Leakage currents as low as 1 μA can be read. Dc plate voltages can be used from 12 volts up to 250, at currents up to 150 mA. This plate current can be read directly on the meter.

The signal voltage applied to the grid in G_m testing can be set from 16–1000 mV. The G_m test uses five direct-reading ranges from 1000–60,000 μmhos full scale.

Power amplifier tubes can be tested at plate currents up to 150 mA. This has been a weak point in past versions of tube testers. Rectifier tubes can be measured for emission capability, and voltage regulators or thyratrons checked for firing point and cutoff voltage. Even electron-ray indicator tubes can be tested.

The roll chart gives the *limits* of transconductance instead of a single arbitrary value. Two figures are shown for each amplifier tube. For example, a 6L6 is listed as 2.4/4.7 (in thousands of μmhos). The first figure means 2400 μmhos; if it reads below that, the tube is about done for. The average value will be 4700 μmhos. The loading possible for high-current tubes makes it possible to match pairs of output tubes.

Ten 12-position selector switches on the panel allow connecting any pin on the tube socket to any element—plate, grid, filament, heater, etc. Fourteen separate sockets are provided on a removable panel. Some of these are multiple-purpose types, so 19 different bases can be tested.

Here's the good part: If you run into a tube not listed with the several thousand on the roll chart, just look up the base connections and set the selectors so each element is hooked to the right place. You won't know the rated G_m, of course, without a tube manual, but you can get a very good idea by noting what the tube is used for in the circuit.

Multiple-element tubes such as the compactrons are much easier to test. You can often check two sections without making a new switch setting. Triple types may need a reset adjustment for the third section.

Older tube testers have a couple of tubes inside. This has six transistors, including an FET for the sine-wave 5-kHz signal oscillator, and several Zeners for regulation of various voltages.

Accuracy of the G_m test can be checked when the G_m CHECK button is pushed, along with the No. 1 VALUE button, and the G_m check control adjusted until the meter reads full scale. This sets the 5-kHz oscillator output to exactly the right value.

The 3444-A is a high-quality test instrument that can be a decided asset to any TV repair shop, electronics laboratory, etc. A comprehensive instruction book gives full details of the many tests which can be made, including running characteristic curves for industrial tubes, checking cutoff, and many others.—*Jack Darr*

EQUIPMENT REPORT

Heathkit AA-15 Stereo Amplifier

For manufacturer's literature, circle No. 89 on Reader Service Card.

THE AMPLIFIER PORTION OF HEATHkit's AR-5 receiver was somewhat overwhelmed by the innovations and performance of the FM tuner portion of the unit. But the amplifier, now available separately as the AA15, contributed in no small way to the popularity of the AR-15 receiver's sound.

I undertook the construction of the AA-15 expecting it to bring about at least an audible improvement in the sound of my stereo system. But it was a pleasant surprise to hear a *dramatic* improvement in audio quality. My pre-AA-15 system used 20-watt amplifiers to drive a pair of notoriously inefficient acoustic suspension speakers (their minimum recommended driving power).

When the AA-15 was connected and a recording plugged into its phono inputs, the output from the speakers was clearly more brilliant and "crisp." Undoubtedly contributing to the improved sound was the 15's high damping factor (45 and up), its very high power (easily 60 watts rms into the speaker's 8 ohms), and its low distortion over the entire audio range.

This enormous reserve of power makes the AA-15 ideal for a number of top-rated speakers on the market today, some of which need that much power to be driven cleanly on audio peaks.

All inputs to the amplifier can be varied by adjusting pots behind a hinged front panel. A separate preamplifier consisting of two transistors per channel gives the phono input an excellent sensitivity over an extremely wide range (2.2–155 mV).

A front-panel source switch selects phono, tuner, tape and auxiliary inputs. The variable front-panel controls are: bass, treble, balance and volume. Seven rocker switches complete the panel controls. The MODE switch determines "stereo" or "mono" programing. A TAPE MON switch in the on position cuts off the input audio from the speakers, and instead plays the inputs to the tape monitor jacks on the rear panel. This permits rapid or constant monitoring of what is being recorded on a tape machine.

In the on position, the TONE FLAT switch bypasses both tone controls, giving the amplifier a flat frequency response. Two switches turn the main and remote speaker on or off, but do not influence the output signals at two separate phono jacks next to the power switch, which is black in contrast to the six white rockers.

With the LOUDNESS switch in the on position, the dual-tandem volume control provides continuous compensation for nonlinear hearing response at low audio levels.

Mounted on two of the output transistor heat sinks are two thermal circuit breakers. A temperature rise exceeding 60°C due to overload or a short circuit will open the circuit breaker, removing supply voltage to the output section and lighting a "hi temp" red light on the front panel. The breaker resets itself when the temperature is at a safe level.

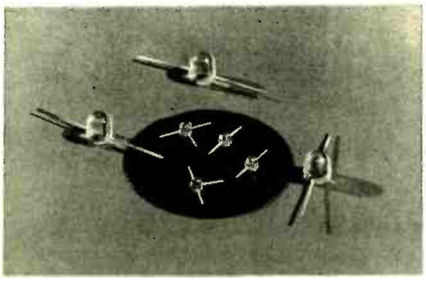
The amplifier goes together easily, requiring component installation on five PC boards, and a large cable harness to tie the boards to the many switches and jacks on the front and rear of the amplifier. It took about 24 hours of construction time.—*John R. Free* **R-E**

NEW TUBES AND SEMICONDUCTORS

LOW-COST PHOTOTRANSISTORS

Housed in unique plastic packages, the MRD450, MRD100 and MRD150 are Motorola's latest addition to its line of optoelectronic devices. They are low-cost phototransistors for use in sensing light and road conditions in automobiles, security, light control and fire sensing in the home and for such other applications as reading electric, water and gas meters and credit cards.

The MRD450 is housed in the 2-lead Mini-T package. The base lead is not used in most applications so it has been omitted for reliability. It is expected to find use in counters, sorters, switching, industrial control, signal and alarm systems and logic circuits. Minimum sensitivity is 0.2 $mA/mW/cm^2$.



The MRD100 and MRD150 are clear-plastic versions of Motorola's Micro-T package. Their small size (0.085" diameter) makes them ideal for high-density mounting in linear and planar arrays. Minimum sensitivity is 0.04 $mA/mW/cm^2$. The MRD-100 has a base lead, the MRD150 has not.

The photo shows some of these devices and a 1" diameter wafer containing 1,200 unseparated phototransistor dice.

IC FOR TWO-WAY RADIO

National Semiconductor's LM-370 audio, agc and squelch amplifier is basically an IC operational amplifier with gain controllable by a dc voltage, plus a built-in sensitive squelch threshold detector. The 10-pin circuit replaces entire sections in transmitters, receivers or transceivers and makes speech compression, VOX and receive squelch practical in even the simplest equipment.

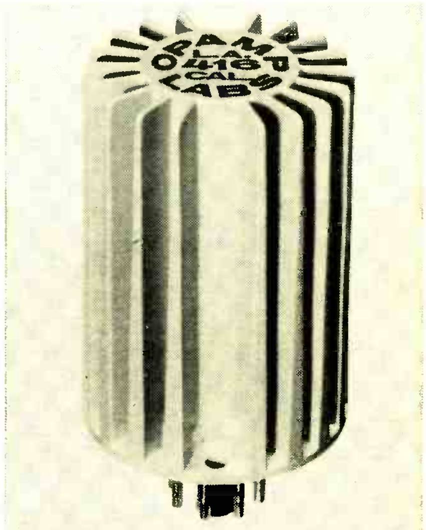
The IC device contains 36 transistors and diodes and 20 resistors. Its heart is a 4-transistor balanced series-shunt variable attenuator which allows a large gain control range with low distortion (for inputs less than 100 mV p-p). It can be direct-coupled to other circuits in the IC. When operated from a 12-volt supply, the gain vs control voltage is a smooth curve giving a constant 40 dB gain from 0 to 2 volts, 0 dB at 2.45 volts and cutoff (about −35 dB) at 2.5 volts.

A separate subsystem within the LM370 is a high-gain peak detector that responds to inputs as low as 1 mV (depending on the setting of an external threshold control) and rapidly discharges an external capacitor. In the absence of an input signal, the capacitor charges above 2.6 volts, which, when connected to the gain control input, keeps the output amplifier turned off. A momentary input pulse above the threshold causes the external capacitor to discharge and turn the amplifier full on. This arrangement provides a fast-attack, slow-release squelch. Price is $4.50 in lots of 1–24.

10-WATT AUDIO OP AMP

The type 416 differential dc operational power amplifier consists of the manufacturer's type 4009 driving a dual class-AB power amplifier. It is intended for use as a servo motor or dc through audio power amplifier and may be used with either single- or bi-polar power supply. It delivers up to 10 watts rms and is mounted in an octal-base plug-in 2" diam. x 3" heat sink.

Unity-gain bandwidth is 2 mHz, input offset voltage is ±100 mV, input impedance is 20,000 ohms, common-mode rejection ratio 80 dB, output impedance (open loop) is 0.5 ohm, full power output (−3 dB) is dc to 50 kHz.



For further technical details, contact B. Losmandy, Opamp Labs, 172 S. Alta Vista Blvd., Los Angeles, Calif. 90036. **R-E**

RADIO-ELECTRONICS
(*continued from page 60*)

ment can be produced with the same basic diffusion processes.

Mos transistors

So far, we have discussed only the "bipolar" junction transistor—bipolar because two types of carrier, the free electron and the positive hole, are involved in its operation. A more recently developed transistor, the metal-oxide-semiconductor field effect transistor (the MOS transistor) is of considerable importance in integrated circuits. The basic operation of this transistor is quite different from that of the bipolar transistor. In it, a conducting channel is induced between two very closely spaced electrode regions by increasing the electric field at the surface of the semiconductor between the electrodes.

The basic structure is shown in Fig. 8. The two electrode regions, called the source and drain, are formed by a p-type diffusion into an n-type silicon wafer. Between the source and drain are two pn junctions back to back, p_1n and np_2. With a voltage V_{DS} applied between the source (positive) and the drain (negative), the np_2 junction is reverse-biased and so no current will flow from source to drain. If now the gate electrode over the space between source and drain is made sufficiently negative with respect to the source, holes are attracted to the surface of the n-type region and cause it to change to p-type. Then we have two p-type electrodes with a p-type channel joining them and so a current can flow.

The steps in the fabrication of an MOS transistor are shown in Fig. 9. An n-type silicon slice is oxidized (a) and a photoresist sequence used to form a window in the oxide for the complete device (b). Now a new thin layer of oxide is formed in the window by oxidation in steam (c) and a second photoresist process used to open windows for the source and drain diffusion (d), and boron is diffused in (e). The thin oxide is then removed by immersing the slice in a hydrofluoric acid solution (f). Next a new very pure oxide layer is grown over the device region (g) and contact windows for the source and drain opened by another photoresist process (h). Finally aluminum is evaporated over the whole slice and removed everywhere but in the source and drain contact windows and in the gate electrode region by a fourth photoresist process (i).

The thickness of the pure oxide under the gate electrode is only of the order of 1000 angstroms and the spacing between the source and drain is typically 0.3 mil. The whole structure can be fabricated in an area about 3 mils by 1.5 mils and this makes the MOS transistor very suitable for use in integrated circuits where a high density of elements is desired. The fabrication of the MOS transistor in integrated circuits will be discussed in detail next month. R-E

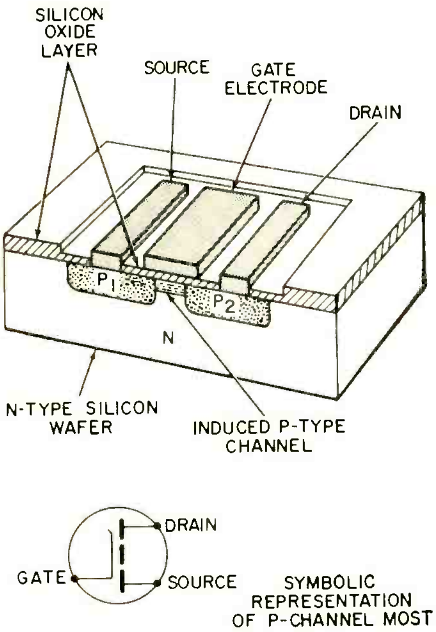


Fig. 8—Semiconductor structure of MOS transistor and symbol for p-channel type.

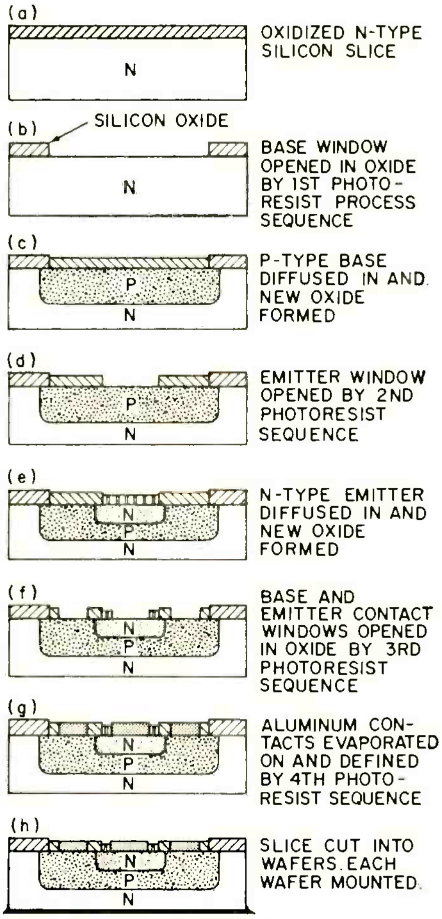


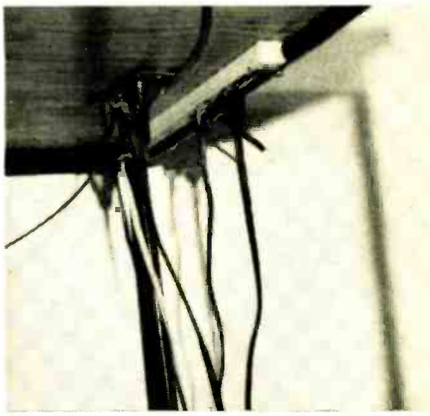
Fig. 9—Nine steps used in the fabrication of the metal-oxide-silicon transistor.

TRY THIS ONE

TV SERVICE TABLE

In addition to converting a bridge table by topping it with a sheet of ½-inch plywood, and adding large casters for moving a TV chassis easily, we have

also added underneath the table an outlet strip for 117 volts ac, and a strip which carries vhf at one end, uhf at



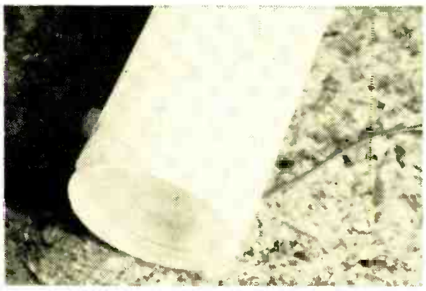
the other, with the middle terminals for our all-channel antenna lead-in.

Thus the table makes an all-around unit for faster servicing.—*Harry J. Miller*

IMPROVEMENTS FOR KNIGHT AUTO ANALYZER

On the Knight KG-375 Auto Analyzer the plastic battery tube sometimes cracks at the opening, as shown on next page. When this happens the threads no longer grip the cap securely, so cap and batteries fly out under spring pressure.

The crack can be repaired or prevented by reinforcing the tube. This is readily done with a coupling nut for 1¼-inch rigid conduit. The inside diameter of the nut is slightly too small, so file down the threads until the nut is a snug slip fit over the end of the tube. You'll have to file a flat on one side of the nut so it will clear the back of the cabinet when in-



stalled. Slide the nut over the end of the tube until it contacts the shoulder, as shown in photo at right. (The flat is not visible here.)

When the cap is tightened, the rivet in the cap must end up about ½ inch clockwise of the front terminal in the tube, so the spring in the cap makes good contact with the terminal. If the cap cannot be turned that far, sandpaper a little material from the front of the tube until the cap seats properly.

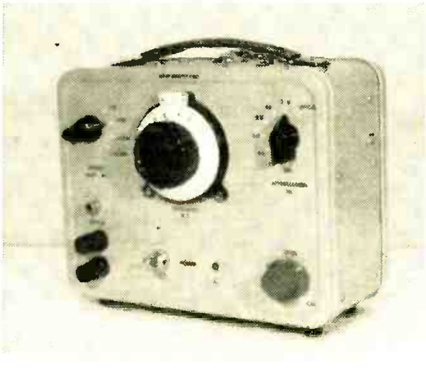
The tachometer function of the Auto Analyzer has a tendency to drift out of calibration, probably be-

cause of contact problems in the calibrating potentiometers. These should be given a thorough treatment with volume-control cleaner before calibrating.—*Charles Erwin Cohn*

INEXPENSIVE EQUIPMENT CABINETS

Anyone who has ever built a piece of electronic test equipment knows how expensive a commercially available cabinet can be, not to mention the "boxy" look it usually has. Here's an inexpensive substitute—a child's lunchbox—which offers several advantages over the more common aluminum box.

Test equipment looks better, and



comes complete with a useful handle. The steel case provides good shielding against stray magnetic fields, and the box can be opened quickly for access to the circuits inside. Finally, it definitely costs less. The oscillator shown was adapted from "IC Sine-Square-Saw Generator" (RADIO-ELECTRONICS, July 1967).—*Donald R. Hicke* **R-E**

TRY THIS ONE'S WANTED

Have you developed a new tool, a new use for an old tool, or a new or simpler way of doing a job around your shop or service bench? Your fellow readers can profit from your experience. We need good how-to-do-it hints for our Try This One column. Line drawings and photos make your item worth more.

MARKET CENTER

AUDIO — HI-FI

HI-FI COMPONENTS, Tape Recorders, at guaranteed "WE will not be undersold" prices. 15-day moneyback guarantee. Two-year warranty. NO Catalog. Quotations Free. **HI-FIDELITY CENTER,** 239R East 149th St., N.Y., N.Y. 10451

Tapemates makes available to you ALL 4-TRACK STEREO TAPES. All labels—postpaid to your door—at tremendous savings. For free brochure write: **TAPEMATES CLUB,** 5280 RE West Pico Blvd., Los Angeles, Calif. 90019.

TAPE RECORDER SALE. Brand new nationally advertised brands, $10.00 above cost. Amazing discounts on stereo components. **ARKAY ELECTRONICS,** 1028-E Commonwealth Avenue, Boston, Mass. 02215

ACOUSTIC RESEARCH, Dyna, Koss, Shure discount specialists. Free catalog and low Hi-Fi quotations available from **BOSTON AUDIO COMPANY,** 2 Common St., Waltham, Mass. 02154

RENT 4-track open reel tapes—all major labels—3,000 different—free brochure. **STEREO-PARTI,** 55 St. James Drive, Santa Rosa, Ca. 95401

WRITE for highest discounts on components, recorders, tapes, from franchised distributors. Send for FREE monthly specials. **CARSTON,** RFD #3, Route 7, Brookfield, Conn. 06804

RADIO TV TAPE RECORDER parts at low prices. List sent on request. **EFEMDE COMPONENTS,** Box 114, Commack, N.Y. 11787

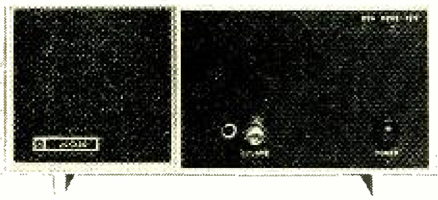
INVENTIONS & PATENTS

FREE "Directory of 500 Corporations Seeking New Products." For information regarding developments, sale, licensing of your patented/unpatented invention. Write: **RAYMOND LEE ORGANIZATION,** 230-U Park Avenue, New York City 10017.

MR. SCA OPERATOR

NEED A RELIABLE SOURCE FOR HIGH QUALITY, LOW COST SCA RECEIVERS, OR SCA DEMODULATOR UNITS?

A new and proven sub-carrier demodulation scheme using old established principles is now practical due to recent component developments and mass production. The resultant reduction in cost is passed on to you.



MODEL SCA-6137 SINGLE FREQUENCY FM RECEIVER. Size: 12" x 5½" x 4½". Price: $69.95 (Quantity 1-9)

SCA-6137 FM Receiver Features:

• Range: 88 to 108 MHz • Frequency Field Adjustable • All Solid State Devices • RF Stage • 3 IF Stages • Automatic Frequency Control • Two 67 KHz Amplifier Stages • 67 KHz Ratio Detector • Adjustable Muting • Main/Sub-Carrier Switch • One Watt Audio Output • 4" Monitor Speaker • Provision for External Speaker • 117 Volt AC Operated.

Also available: SCA-3 sub-carrier demodulator PC Card with muting control. Size: 2½" x 3" x 5/8". Operates on 6 to 12 Volts DC at 6 ma. **Available** from stock Price: $39.95 (Quantity 1-9)

Quantity discounts and detailed specifications **are** available to SCA operators.

Send orders and inquiries to:

JanZac Company; P.O. Box 177;
Stamford Conn. 06904
KenZac Company; P.O. Box 66251;
Houston, Texas 77006

ARCTURUS SALE

- **1700 transistor types at 39¢ each.**
- **40 watt germanium power transistor, same as Delco 501, 2N278 (etc.). Cat. #349. 59¢ each.**
- **Color TV cartridge focus rectifier 6.5 kv. Used in every color TV. Cat. #CFR-20. 79¢ each.**
- **Motorola 2500 ma. at 1000 piv. high voltage/current epoxy silicon rectifier, axial leads. Cat. #HEP-170. 49¢ each.**
- **2 Printed circuit I.F. transformers, 4 lug, 455 kc input and output. cat. #1909P4. 99¢ each.**
- **RCA UHF transistor type TV tuners. KRK-120 (long-shaft) cat. #UHF-20; KRK-120 (short-shaft). cat. #UHF-21. each $4.98.**
- **RCA VHF transistor type TV tuners. KRK-146. cat. #VHF-74. $9.99 each.**
- **Transistorized U.H.F. tuners used in 1965 to 1967 TV sets made by Admiral, RCA, Motorola, etc. Removable gearing may vary from one make to another. Need only 12 volts d.c. to function. No filament voltage needed. Easy replacement units. Cat. #UHF-567. $4.95.**
- **U.H.F. Tuner-original units as used in TV sets such as RCA, Admiral, etc. covering channels 14 through 82, as part #94D173-2. Complete with tube. Drive gearing is removable. Can be used in most sets. Cat. #UHF-3, $4.95.**
- **Color yokes. 70° for all round color CRT's. Cat. #XRC-70. $12.95. 90° for all rectangular 19 to 25" color CRT's. Cat. #XRC-90. $12.95.**
- **Kit of 30 tested germanium diodes. Cat. #100. 99¢.**
- **Silicon rectifier, octal based replacement for 5U4, 5Y3, 5AS4, 5AW4, 5T4, 5V4, 5Z4. With diagram. Cat. #Rect-1, 99¢ each.**
- **7", 90° TV bench test picture tube with adapter. No ion trap needed. Cat. #7BP7, $7.99.**
- **Tube cartons 6AU6 etc. size, $2.15 per 100. 6SN7 etc. size, $2.55 per 100. 5U4GB size, $2.95 per 100. 5U4G size. 4¢ each.**

Send for complete free catalog. Include 4% of dollar value of order for postage. $5 MINIMUM ORDER. Canadian check, 8% dollar differential.

ARCTURUS ELECTRONICS CORP.
502-22nd St., Union City, N.J. 07087
Dept. MRE
Phone: 201-864-5568

Circle 136 on reader service card

ADVERTISING INDEX

RADIO-ELECTRONICS does not assume responsibility for any errors which may appear in the index below.

SERVICEMEN • EXPERIMENTERS!
IF YOU WISH TO PURCHASE
BRAND NEW TUBES
WE HAVE THE MOST UP TO DATE TUBES LISTED PLUS THE HARD TO GET TYPES. DON'T CONFUSE OUR TUBES WHICH ARE NEW WITH THE PULLOUTS AND REJECTS. SEND FOR OUR CATALOG.
UNITED RADIO COMPANY • Estab. 1920
56 FERRY ST., NEWARK, N.J. 07105

INVENTORS: protect your Ideas! Free "recommended procedure". **WASHINGTON INVENTORS SERVICE,** 422X Washington Building, Washington, D.C. 20005

INVENTIONS WANTED. Patented; Unpatented. **GLOBAL MARKETING,** 2420-AE 77th Ave., Oakland, Calif. 94605

EDUCATION/ INSTRUCTION

FCC First Class License in six weeks—nation's highest success rate—approved for Veterans Training. Write **ELKINS INSTITUTE, 2603E** Inwood Road, Dallas, Texas 75235

REPAIR YOUR OWN TV TUNERS—Color—Transistor—VHF—UHF. Earn to $1,700. monthly. No customer headaches. Simple, complete course. First of its kind. Copyrighted. Years in preparation. Six sections, 33 chapters. All field-tested. Jigs—Fixtures—Adapters—"Setting-up". Special probes. Quick-checks. How alter and use test sets. Repairs WITHOUT EQUIPMENT. Unique power supplies. Fast-fix luxuries. Equipment you can build. Professional tricks. Illustrated schematics, pictures, drawings, sketches. Plans for all items. Troubleshooting. Alignment. All tests and adjustments. Common mistakes. How and where to buy parts. Specific repairs common problems. Index of all tuners. Much, much more. Programmed teaching. Introduction, plus two sample lessons $1.00. Optional condensed courses (complete in themselves): VHF $9.50. UHF $4.50, Transistor tuners $4.50. Details of major course, introduction, plus two sample lessons, $1., Refundable. **FRANK BOCEK,** Box 3236R, Redding, Calif., 96001

ELECTRONICS ENGINEERING. Day or evening classes. Bachelor of Science Program evenings. Associate in Science Program day or night. If you are married or if you must work for a living while obtaining your education, this is the college for you. Approved for Veterans. **WESTERN STATES COLLEGE OF ENGINEERING,** 970 West Manchester Avenue, Inglewood, California 90301.

ELECTRONICS

Ultra-sensitive and powerful METAL DETECTORS join the many who are finding buried coins, minerals, relics and artifacts. Don't buy till you see our free catalog of new models. Write **JETCO**—Box 132-RE, Huntsville, Texas 77340

SEMICONDUCTOR AND PARTS CATALOG over 100 pages free to Canadians. U.S. 50¢. **J & J ELECTRONICS,** Box 1437, Winnipeg, Manitoba, Canada

JAPAN DIRECTORY. Electronics products and parts. General merchandise and Asia trade information. Just $1.00 today. **IPPANO-KAISHA** LTD., Box 6266, Spokane, Washington 99207

INTEGRATED CIRCUIT KITS: computer, audio, others. New catalog free. **KAY ENGINEERING,** Box 3932-D, Long Beach, California 90803.

RECEIVING & INDUSTRIAL TUBES, TRANSISTORS, All Brands—Biggest Discounts. Technicians, Hobbyists, Experimenters—Request FREE Giant Catalog and SAVE! **ZALYTRON,** 469 Jericho Turnpike, Mineola, N.Y. 11501.

ELECTRONIC BARGAIN CATALOG on unusual kits, parts, do-it-yourself, stereo, intercoms. **ALCON,** P. O. Box 1348R, Lawrence, Mass. 01843

INTEGRATED CIRCUITS / RECTIFIERS
SEMICONDUCTORS / TRIACS

ER 900 TRIGGER DIODES These bidirectional trigger diodes are one of the best and cheapest methods of triggering SCR's and triacs. 3/$1.00

UNIJUNCTIONS
Similar to 2N2419 Rbb of 5-7, stand off ratio of .6 and Ip of 12, with data sheet $1.50

ZENERS
1 Watt 6.8-68V $.40
10 Watt 7-200V $.75

MOUNTING HDWE KITS
These kits are used to mount our SCR's, zeners, & rectifiers etc.
6 x 32 (3, 12 Amp rectifiers, 7 Amp SCR's) 6 sets/$1.00
¼ x 28 (20, 40 Amp rectifiers, 20 Amp SCR's) 4 sets/$1.00

EPOXY AND CONTROLLED AVALANCHE RECTIFIERS 1 AMP

PRV	AMP
100	.07
200	.09
400	.12
600	.18
800	.22
1000	.35

N-CHANNEL PLASTIC TO-18 FET'S. Low noise, low leakage, gate current, gain to 9000μ mhos. $ .80

☐ **2N1163 a TO-3 PNP GERMANIUM TRANSISTOR** rated at 35v and a gain of 50 at 25 amps. $1.75

TRIACS

PRV	5A	10A
100	.90	1.20
200	1.40	1.75
300	1.75	2.25
400	2.25	2.75
500	2.60	3.25

SQ-10A DISCRETE
OPER. AMPL. MODULE
Voltage Gain 60,000 Min.
$4.95 each

☐ **HIGH-VOLTAGE NPN 150V VBCBO** at 2.5A, hi gain in TO-66 pack $ .75

Silicon Power Rectifiers

PRV	3A	12A	40A
100	.09	.30	.75
200	.16	.50	1.25
400	.20	.70	1.50
600	.30	1.00	1.80
800	.40	1.25	
1000	.55	1.50	

9030 8 BIT MEMORIES $5.95

LINEAR CIRCUITS
FM IF AMPLIFIERS ...... $ .90
702C WIDE BAND DC AMP ... $2.75
709C OPERATIONAL AMP. ... $2.75
710C HI SPEED DIFF COMPARATOR $2.75
711C DUAL COMPARATOR ... $2.75

DIGITAL RTL CIRCUITS
2-914 QUAD 2 INPUT GATE $1.25
900 BUFFER $1.25
925 DUAL 2 INPUT GATE EXPANDER $1.25
923 JK FLIP FLOP $1.25

☐ **NEON LIGHT of BIK E TUBE DRIVERS.** An NPN TO-18, Si Transistor with a VCBO of 120 3/$1.00

Silicon Control Rectifiers
TO-66 pack Studs

PRV	3A	7A	20A	70A
50	.35	.45	.70	
100	.50	.65	1.00	4.00
200	.70	.95	1.30	8.00
300	.90	1.25	1.70	
400	1.20	1.60	2.10	12.00
500	1.50	2.00	2.50	
600	1.80	2.40	3.00	16.00
700	2.20	2.80	5.00	

Send for our latest catalog featuring Transistors and Rectifiers; 325 Elm St., Cambridge, Mass.

SOLID STATE SALES
Post Office Box 74D · Somerville, Mass. 02143 · Tel. (617) 547-4005

Circle 137 on reader service card

UNUSUAL BARGAINS BY MAIL

SHOPPING MART

GIANT FREE CATALOG! 148 — PAGES

A selection of products available by mail for readers of Radio Electronics. All merchandise sold on money-back guarantee. Order by No. Send check or M.O.

SEE MUSIC IN DAZZLING ACTION

MUSIC VISION DRAMATIC BREAKTHROUGH IN AUDIOVISUAL ENJOYMENT

See your favorite music translated into fantastically colorful patterns; each note creating its own unique, everchanging image in perfect time with the music. Easily attached to stereo, radio, tape recorder. Send 25¢ for 16-p. booklet #9096EH

BOY'S STARTER KIT
No. 71,095EH ...... $6.00 Ppd.
8" DO-IT-YOURSELF KIT
No. 71,009EH ...... $22.50 Ppd.
WALNUT CABINET MODEL
No. 85,181EH ...... $99.50 FOB

ASTRONOMICAL TELESCOPE KITS

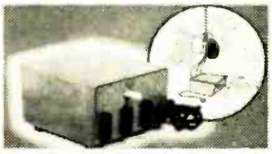
Kits contain fine annealed pyrex mirror blank, tool, abrasives, diagonal mirror, and eyepiece lenses. Instruments you build are valued up to $100's.

4¼" DIAMETER—¾" THICK
Stock No. 70,003EH $8.00 Ppd.
6" DIAMETER—1" THICK
Stock No. 70,004EH $13.95 Ppd.
8" DIAMETER—1⅜" THICK
Stock No. 70,005EH $21.00 Ppd.
10" DIAMETER—1¾" THICK
Stock No. 70,006EH $34.25 FOB

PROJECTION KALEIDOSCOPE

Infinite variety of brilliant color patterns which do not repeat. Specially designed, easily interchanged 9" diam. liquid wheel. 3" projection lens and Edmund Projector make it all possible. Easily operated. Large screen image at short projection distance perfect for backgrounds, light shows, parties, dances, etc. Front or rear proj.

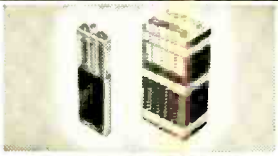
Stock No. 71,121EH $94.50 Ppd.
SOLID MULTI-COLORED GLASS ACCESSORY WHEEL (9" Diam.)
Stock No. 71,122EH $15.00 Ppd.



NEW! LOW COST COLOR ORGAN

Accompany music with colored lighting that creates tremendous variety of unusual and beautiful effects. Plug in 3 diff. sets of colored lights and place near audio source. Notes picked up by interior "mike" determine which colored lights go on—loudness determines intensity. Control lighting in pools; fountains, window and holiday decorations, great for parties. Tough, compact unit with light intensity control. 4-9/16" x 2¼" x 4½". 1 lb. 6 oz.

Stock No. 1900EH ...... $39.95 Ppd.
4 CHANNEL DE LUXE 2,000 watt
Stock No. 71,103EH $195.00 Ppd.



Ni-Cd BATTERY BARGAIN

Terrific value—slightly used gov't surplus. Lightweight cell, 6 volt, 4 Amp-hour battery with almost unlimited life. Extremely high current output. Recharges in 1 hour with Edmund kit. Won't deteriorate when left discharged. Minimum maintenance — few drops of water per year. Rugged, shock-and-vibration resistant nylon case. Delivered partially charged, filled with electrolyte. 3⅛" x 2" x 6" 2 lb.

BATTERY
Stock No. 70,942EH $15.00 Ppd.
CHARGER KIT
Stock No. 70,807EH $ 8.00 Ppd.

GIANT FREE CATALOG

Edmund, 300 Edscorp Building, Barrington, New Jersey 08007

148 PAGES — 1000's OF BARGAINS

Completely new 1969 edition. Dozens of electrical and electromagnetic parts, accessories. Enormous selection of Astronomical Telescopes, Microscopes, Binoculars, Magnifiers, Magnets, Lenses, Prisms. Many war surplus. Items for hobbyists, experimenters, workshops, factory. Mail coupon for FREE catalog "EH".

NAME............
ADDRESS............
CITY............
STATE............ZIP............

ORDER BY STOCK NUMBER • SEND CHECK OR MONEY ORDER • MONEY-BACK GUARANTEE
EDMUND SCIENTIFIC CO. 300 EDSCORP BUILDING BARRINGTON, NEW JERSEY 08007

Circle 138 on reader service card

MARKET CENTER

RADIO & TV TUBES 33¢ each. One year guaranteed. Plus many unusual electronic bargains. Free catalog. **CORNELL** 4217-E University, San Diego, California 92105

Discharge IGNITION, PHOTOFLASH. Free catalog parts, kits. **TRANSPARK,** Carlisle, Mass. 01741

BUILD several sensitive metal detectors from our 20 page book. Fully transistorized circuitry. Easily followed diagrams and instructions, $4.00. **TRIONICS,** Box 164J, Brewer, Maine 04412

CATHODIC PROTECTION INSTRUCTIONS $1.00. **F. F. KNAPP,** P.O. Box 854, Scottsdale, Arziona 85252

GENERAL

ROOM TO LIVE. Pleasant, peaceful, S. Utah Mtn. Valley. Hunting country. 40 ac. Level, rich soil $1600, $50 down, $31/mo., 6% int. • **WEST LANDS,** Dept. RE, P.O. Box 17407, Holladay, Utah 84117

JAPANESE NEW PRODUCTS MONTHLY! $1.00. Refundable. **DEERE,** 10639 Riverside, North Hollywood, Calif.

CONVERT any television to sensitive Big-Screen Oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans $2.00. **RELCO**-A25, Box 10563, Houston, Texas 77018

GOVERNMENT SURPLUS

WANTED

CLASSIFIED COMMERCIAL RATE (for firms or individuals offering commercial products or services). 70¢ per word . . . minimum 10 words.

NON-COMMERCIAL RATE (for individuals who want to buy or sell personal items) 30¢ per word . . . no minimum.

Payment must accompany all ads except those placed by accredited advertising agencies. 10% discount on 12 consecutive insertions, if paid in advance. Misleading or objectionable ads not accepted. Copy for August issue must reach us before June 13.

WORD COUNT: Include name and address. Name of city (Des Moines), or state (New York) counts as one word each. Zone or Zip Code numbers not counted. (We reserve the right to omit Zip Code if space does not permit.) Count each abbreviation, initial, single figure or group of figures or letters as a word. Symbols or groups such as 8-10, COD, AC, etc., count as one word. Hyphenated words count as two words. Minor over-wordage will be edited to match advance payment.

Circle 141 on reader service card

Outstanding Values from the Nation's Largest CCTV Supplier

GE VIDEO TAPE RECORDERS

(built by Sony for General Electric)

50% OFF
REGULAR GE PRICE
ONLY
$397.50

COMPATIBLE WITH ALL SONY 1/2" VIDEO TAPE RECORDERS INCLUDING BATTERY OPERATED PORTABLES

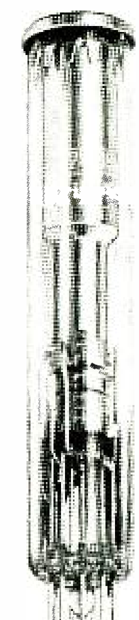
GBC spent half a million dollars to bring you this once-in-a-lifetime close-out price on quality video tape recorders. GE sold thousands of these units at $795. Now, you can buy them for under $400. You actually get a video *and* audio tape recorder for the price you'd expect to pay for a good audio tape recorder!

You can use your video tape recorder for educational TV, training, instruction, presentations, advertising, or instant home movies. Simple to operate, it tapes programs picked up by TV cameras or off-the-air, and plays them back through a standard TV monitor. Brand new, *FULLY GUARANTEED,* in original factory cartons. Order today, while they last.

This is a top quality camera built right into a rugged, enamel plated aircraft aluminum housing. Completely weatherproof, it accepts any lens, including a remote controlled zoom lens. Light enough to be used with any standard mount. Full year warranty. Only $495.00

VIDICONS

TOP QUALITY AT LOW, LOW PRICES.



The quality: brand-new Hitachi, fully guaranteed in factory-sealed cartons.

The price: (distributor cost)
Hitachi 7735-A vidicon **$34.50**
Toshiba 7038-H vidicon **$29.50**
Hitachi separate mesh vidicon 8507 **$74.50**
Hitachi 7262—replacement for Sony and Pansonic **$34.50**

All vidicons sold in lots of 5 (10% more for lesser quantities)

WHEN YOU NEED IT, WE GOT IT!

GBC maintains a hugh inventory of TV cameras, viewfinders, monitors and accessories of all kinds. Whatever you want, we probably have in stock right now. VIDICONS — TOP QUALITY AT LOW, LOW PRICES.

WRITE FOR THE FREE GBC ENCYCLOPEDIA OF CCTV

TERMS: Check with order — FREE delivery.
COD — 25% deposit, shipped F.O.B. N.Y.C.

GBC **GBC Closed Circuit TV Corp.**
74 Fifth Avenue, New York, N.Y. 10011 / Phone: (212) 989 4433

Circle 149 on reader service card

RCA's triple play
three terrific values free with your purchase of RCA entertainment receiving tubes

RCA

Precision® Gruen Wristwatches. Men's (1A1793) and Ladies' (1A1794)
Both have 17 jewels, Swiss movement, "Incabloc" protection with unbreakable main spring. Free with your purchase of 275 entertainment receiving tubes for each watch.

Black and Decker 1/4" Variable Speed Power Drill (1A1795)
Fully variable speed control. Finger pressure controls the speed which permits you to select the ideal RPM for every job. Free with your purchase of 200 RCA entertainment receiving tubes.

The Random House Dictionary (1A1796)
The most authoritative dictionary of its kind. Completely new and up-to-date, it is an indispensable reference book for the home, on the job and in school. Free with your purchase of 200 RCA entertainment receiving tubes.

Tube values are optional with your participating RCA Distributor. See him for complete information on how you can get in on the excitement of RCA's Triple Play. RCA Electronic Components, Harrison, N. J. 07029