60¢ ■ SEPT. 1972

# Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

## BUILD THIS $40 IC FUNCTION GENERATOR

**ELECTRONIC WATCHDOGS**
To Protect Your Home

**EXORCISE TV GHOSTS**
Caused By Mismatch

**IC DUO-TROUBLESHOOTER**
Generator—Tracer

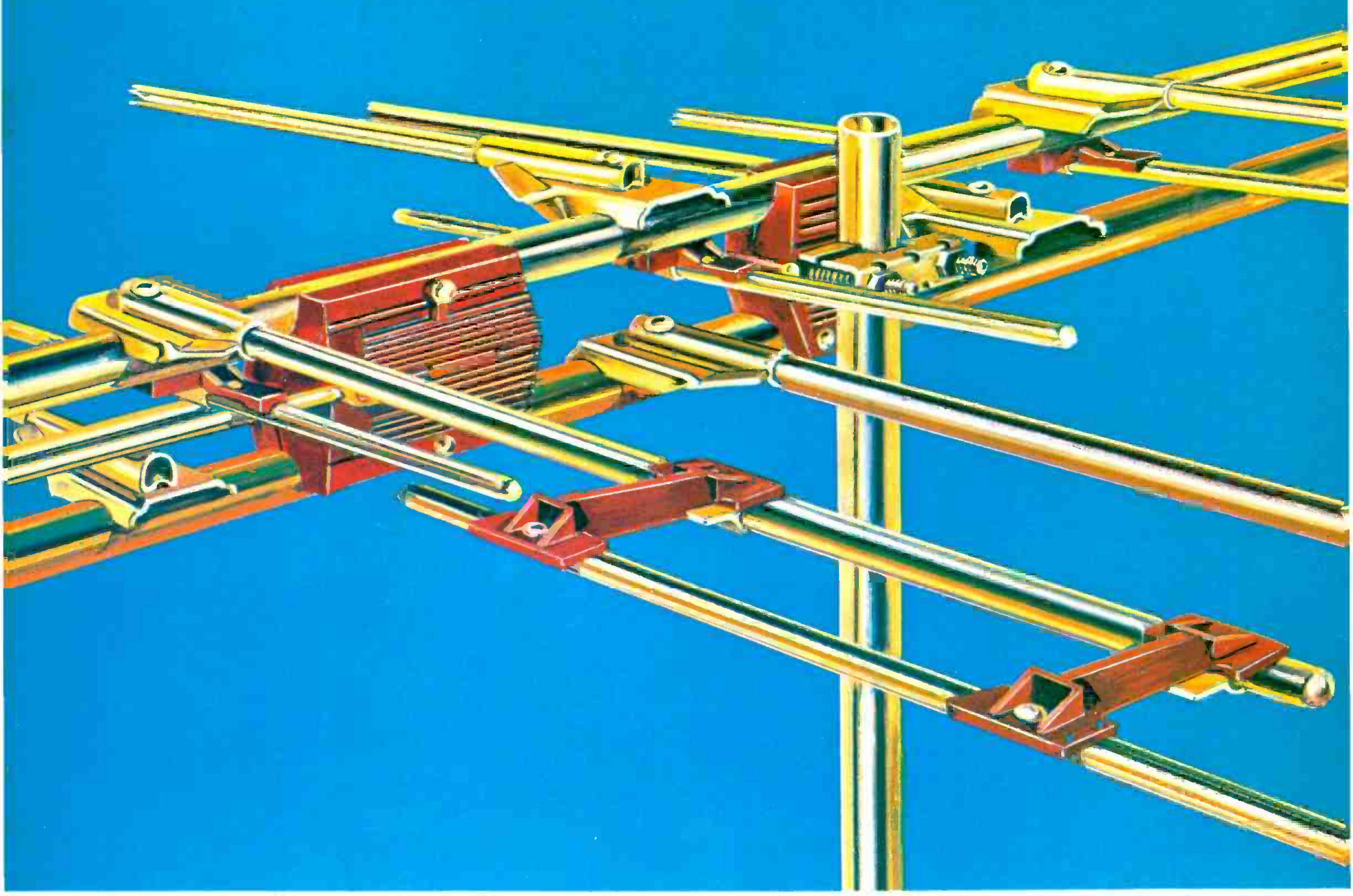
**NEW TV SERVICE SERIES**
Step-By-Step Fix-It Guide
This Month Art Margolis
Probes The AGC Keyer

**OP-AMPS AT WORK**
Using The 709


**PLUS**
State Of Solid State
TV Service Clinic
Solid-State Amplifier Design
Appliance Clinic

A GERNSBACK PUBLICATION

# Get less for your money!



## ...less ghosting ...less herringbone ...less snow

The radical new Channel Master Quantum Antennas give you less of today's major TV reception problem---interference. It's the most highly directive broadband antenna series the industry has ever seen, Front-to-back ratios are up to 50% better than the nearest competitor.

That means a lot less problems with FM, co-channel, adjacent channel, power line...or any other electrical interference.

And that's not all. The Quantum is loaded with features that can't be matched. Like a weather-proof terminal housing---a tunable UHF section that gives you the highest UHF gain you can get in a UHF/VHF antenna. Plus construction so rugged that it survived hurricane force wind-tunnel testing at the University of Maryland.

So if your customers want better color TV reception---check the new Quantum. It's the antenna that solves the problems ordinary antennas only magnify.

*Circle 1 on reader service card*

WEATHER PROOF TERMINAL HOUSING

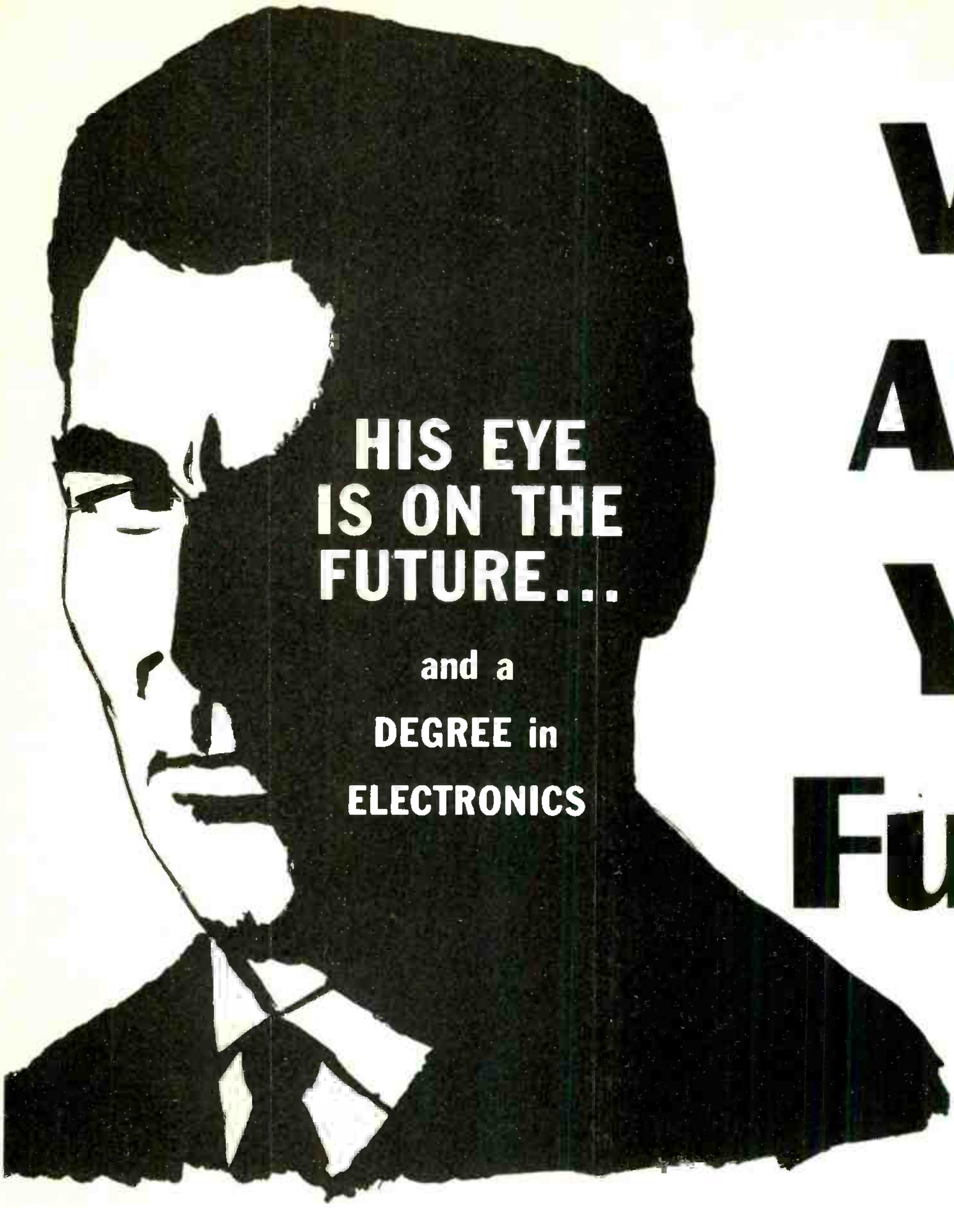
TUNABLE UHF DIRECTORS

**CHANNEL MASTER**

**QUANTUM**

BROADBAND ANTENNAS for VHF/FM and UHF/VHF/FM

**CHANNEL MASTER** Division of Avnet Inc., Ellenville, N.Y. 12428




# What About YOUR Future?

In planning your career, ask the following questions about the field you are considering, and decide whether you are willing to "live with" the true answers to these questions:

(1) Is this the kind of work I really enjoy doing, and do I have an aptitude for such work?

(2) For those who properly apply themselves, do average salaries in this field meet my financial needs and expectations?

(3) Is there reasonable opportunity in this field for advancement to higher-level positions?

If you decide that *electronics* is your field, you'll need *continuing education* for career advancement. We believe you should consider what Grantham School of Engineering has to offer. We may be the school that best fills your needs.

Grantham offers a college-level program mainly

## BY CORRESPONDENCE

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Please send me your free Bulletin which explains how the Grantham educational program can prepare me for a *degree* in electronics.

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Address ______________________

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*Circle 2 on reader service card*

# There's an Amperex replacement tube for any socket in any set you're likely to service...

TV, HiFi, FM or AM, House Radio, Car Radio, P.A. System or Tape Recorder. Imported or Domestic!

AMPEREX ELECTRONIC CORPORATION, DISTRIBUTOR SALES, HICKSVILLE, NEW YORK 11802

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**Amperex®**

TOMORROW'S THINKING IN TODAY'S PRODUCTS

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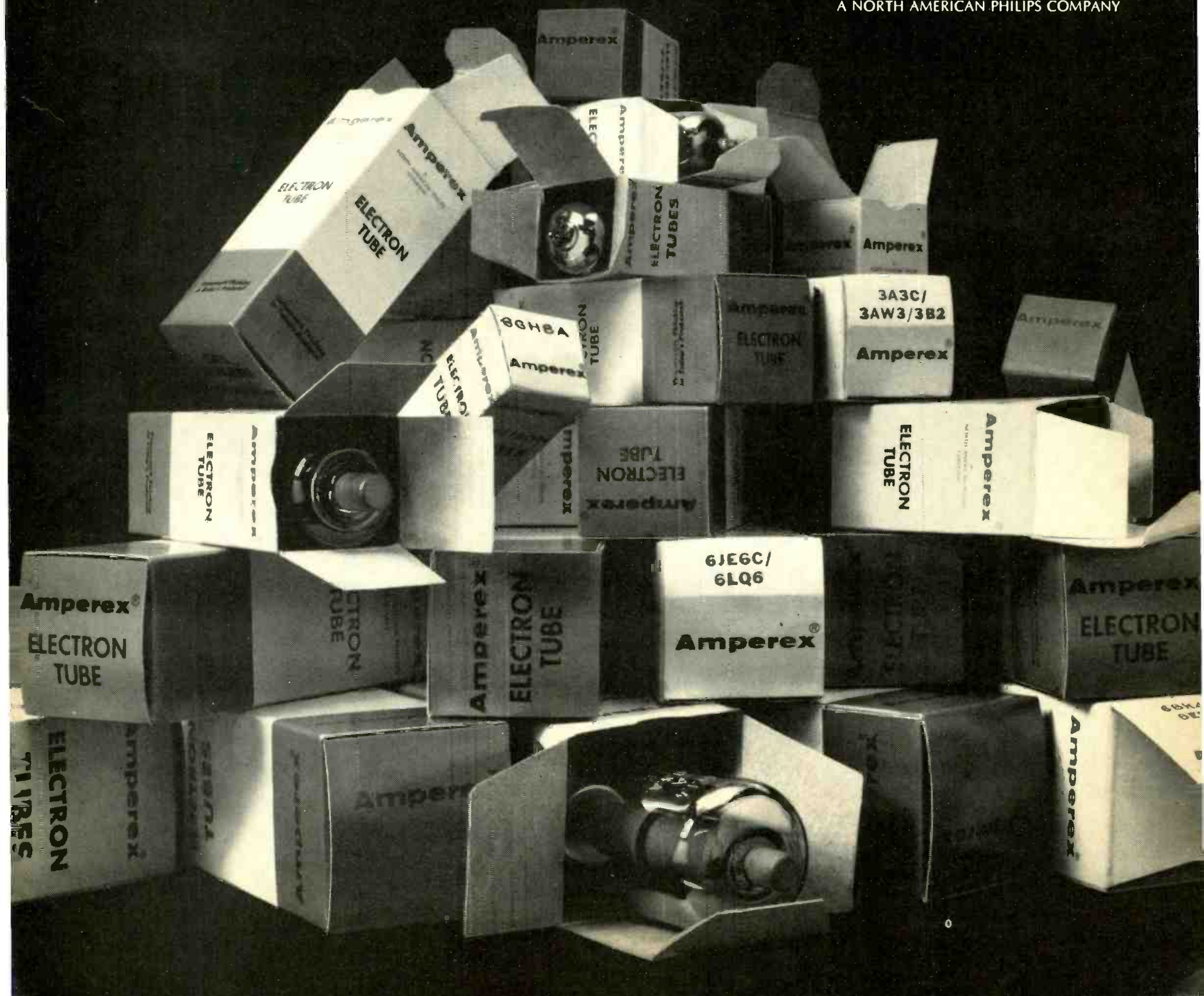


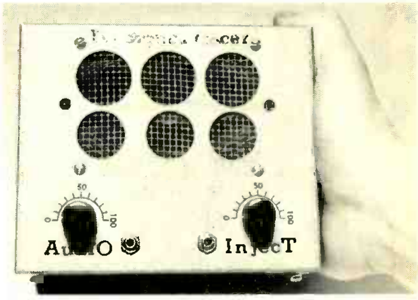
# Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

September 1972



**ALARM SYSTEMS protect you and your belongings against both fire and theft. Take a look at all the different kinds of protection that are available now.** **...............................see page 33**



**IC DUO TROUBLESHOOTER is a handy little tester everyone should own. It's easy to build too.** **...............................see page 59**


**Hugo Gernsback** (1884-1967) founder
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**Larry Steckler,** editor
**Robert F. Scott,** W2PWG technical editor, CET
**Jack Darr,** service editor
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Cover photograph by Walter Herstatt
Cover design by Marius Trinque

**Radio-Electronics** is indexed in *Applied Science & Technology Index and Readers Guide to Periodical Literature.*

**Radio-Electronics,** September 1972. Vol. 43, No. 9. Published monthly by Gernsback Publication, Inc., 200 Park Avenue South, New York City 10003. Second-class postage paid at New York, N.Y. and additional mailing office. One-year subscription rate: U.S.A., U.S. possessions and Canada, $7. Pan-American countries, $8. Other countries, $8.50. Single copies 60¢.




**Subscription Service:** Mail all subscription orders, changes, correspondence and Postmaster Notices of undelivered copies (Form 3579) to Radio-Electronics Subscription Service, Boulder, Colo. 80302

# looking ahead

## Matrix peace pact

The two major four-channel matrix record systems—CBS's SQ and Electro-Voice's Stereo-4—are now blending into a single system, and others are expected to join them. It always was possible to interchange SQ and Stereo-4 discs on the same decoder-equipped record-playing equipment and receive fairly satisfactory results. But now both CBS and Electro-Voice say their systems will use special decoders that will give optimum performance with either type of record, and CBS has recognized the basic matrix disc patent which was granted to Peter Scheiber, now an Electro-Voice consultant.

What is actually happening is that the matrix disc proponents have stopped squabbling among themselves to face the common enemy—the discrete disc, which RCA calls Quadradisc and which Panasonic and Japan Victor call CD-4. Because few discs are available and little equipment is yet on the market to play them, RCA hasn't yet unleashed the big guns in its battle for the discrete record system.

## New RCA Color Tube

RCA was the principal developer and the first to produce the standard shadow-mask color tube, that, with refinements and improvements, has been made since 1954. Now RCA has come up with a new design that it hopes will become the industry standard for all screen sizes of 19 inches and less, and perhaps later move into the larger sizes as well. The major improvement in the new tube, according to RCA's claims, is that it will never require any dynamic convergence adjustments—in the TV set factory, in the service shop, or in the consumer's home. The new development, says RCA, makes picture tube installation as easy in a color set as in a black-and-white receiver.

The new tube combines a number of principles already adopted by tube manufacturers in the United States and Japan, plus one new one—a yoke that is permanently cemented to the neck of the tube and pre-adjusted in the picture tube factory. The tube is of the slotted-mask variety *(Looking Ahead,* **Radio-Electronics,** July 1972)—that is, instead of the conventional round holes in the shadow mask, there are vertical oblong slots. The screen contains vertical phosphor stripes of alternating red, blue and green colors in place of the conventional phosphor dots. The gun structure is one "unitized" piece containing red, blue and green guns side-by-side on a horizontal plane instead of in a triangular (delta) configuration. This in-line-gun technique has been used by General Electric in its Porta Color tubes since 1965.

For lower deflection power requirements, as well as improved convergence and registration, the tube has a narrow neck (29 mm as opposed to the conventional 36). The new yoke is toroidal type, said to be extremely simple to produce and to use only 20% as much copper as the conventional saddle yoke. Many other neck components are eliminated, including the 12 convergence adjustments. The yoke can be salvaged and re-used in tube-rebuilding operations. The tube itself, with standard 90-degree deflection, is 1.8 inches shorter than a comparable old-type tube, and the tube and neck components remove 2½ pounds from the total weight of a color set. The new tube (excluding cost of the yoke) will be made available to set manufacturers at the same price as a conventional color tube of the same size and type, resulting in a factory cost saving said to be in the neighborhood of five dollars—plus obvious savings to the consumer in convergence costs. Since the set requires no convergence, technicians working on a set with this type of tube need not bring along their convergence equipment.

The new tube will be produced initially in a 15-inch size in the fourth quarter of this year, to be followed by 17- and 19-inch versions early next year, and possibly a 13-incher later. In the 19-inch size, it will be produced in a black-matrix negative-guardband version. The tube is designed for operation with a solid-state chassis. It appears to be RCA's answer to Sony's Trinitron—and then some. (For further details, see New and Timely, page 6.)

If the new RCA tube system meets the acceptance of set manufacturers, other tube makers are expected to manufacture similar tubes. But meanwhile, some other new designs are being demonstrated. Sylvania has a more conventional tube, with standard wide neck diameter, but with an in-line gun structure and toroidal yoke, that reduces the convergence adjustments from the standard 12 to four. GE says its new 10- and 16-inch Porta Color tubes require no convergence adjustments, and GE is also planning a slotted-mask version. And Zenith has introduced "Super-Chromacolor," which is said to have a much brighter, sharper picture than its predecessor, resulting from a new gun system, new phosphors and larger holes in the center portion of the shadow mask.

## Video discography

Television manufacturers are more excited about video discs than they are about video tape. The disc medium promises to be a lower-cost system, and a format with which all consumers are familiar. So you can look for competition on the video disc front between those two long-time antagonists, RCA and Zenith.

Zenith fired the first salvo in a closed-door demonstration to its distributors at a recent company convention in Chicago. The color TV disc Zenith demonstrated is its own adaptation of the one developed by A.E.G. Telefunken of Germany and Decca of the United Kingdom (Looking Ahead, December 1971). Enthusiastically received by the distributors, the showing was billed as a "technological progress report" and it's speculated that Zenith would like to introduce the disc by late 1974. By coincidence, that seems to be the target date for a super-secret video disc under development by RCA. Other than to confirm it's working on a video disc, RCA has made no public statements about the project. But there's one thing you can be sure of—the RCA and Zenith discs will be incompatible.

## Stereo AM?

Don't laugh. The idea is getting serious consideration, and is due for a test in the New York metropolitan area this fall. The system was developed by Kahn Research Laboratories and first proposed to the FCC in 1959.

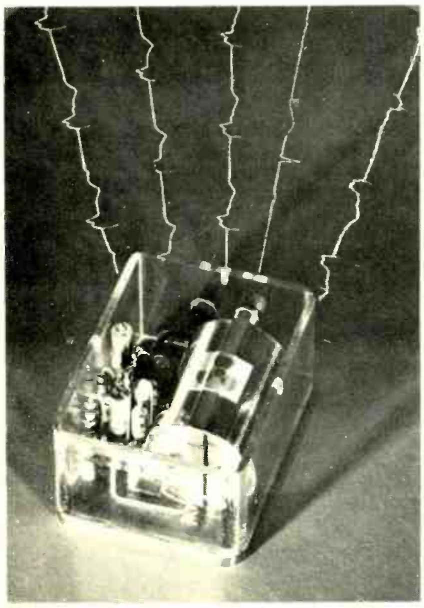
Improved since its first introduction, the Kahn system puts left-channel information on the left sideband, right-channel on the right sideband. A radio tuned to the center frequency of the AM station receives the full signal. To receive AM stereo, all you need is two cheap radios. Tune one slightly below, the other slightly above the station.

**by DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

# new & timely

## New nuclear-powered pacemaker has 10-year life

A new power source for a pacemaker, using the energy given off by a radioactive isotope, is under development in the Siemens research laboratory in Germany.



Pacemakers, which supply timing pulses to the heart, are now powered by batteries that have to be replaced by a surgical operation every two years or so. The new model is expected to last for at least 10 years. This will not only make life much easier for the patient, but will also reduce the work load on the specialized clinics that perform these operations.

The source of power for the new pacemaker is a little ball of plutonium 238, only 1 centimeter—less than half an inch—in diameter. The plutonium emits alpha rays, which are completely absorbed by even a thin metal layer. Radioactive decay of the Pu 238 produces heat, which is turned into electricity by thermocouples. These are vapor-deposited in narrow strips across a tape, the strips being alternately of *p* and *n* semiconducting material. About 700 of them are applied to the tape which is wound up in a coil around the heat-releasing ball. Output is in the order of 200 microwatts.

## RCA comes up with a new kind of color pix tube

A new color television picture tube that abandons the dot mask and phosphor in favor of slits in the mask and color strips on the phosphor, uses a three-in-line electron gun array and has the deflection yoke permanently bonded to the tube, has been announced by RCA. Dynamic convergence is eliminated and static convergence and purity adjustments are fixed in the bonded deflection yoke.

The new unitized triple-beam in-line gun structure and the line-focus type yoke (called PST for *precision static toroidal*) make dynamic correction unnecessary. Control, screen and focus grids and the anode are unitized flat planar triple-aperture electrodes. The gun is about half the size of the present triangular gun array, making it possible to reduce the neck diameter from 36 to 29 millimeters (1.42 to 1.14 inches). This results in better convergence and register, and reduces deflection power requirements.

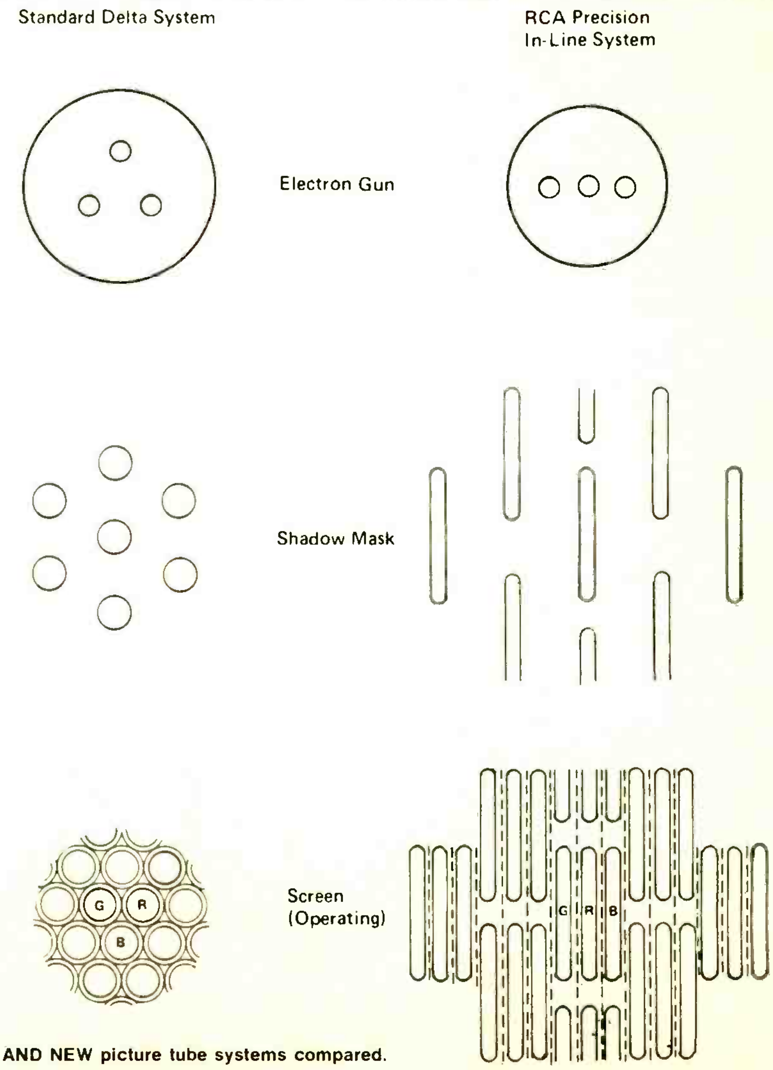
The vertical and horizontal deflection coils of the new PST yoke are precisely placed in winding grooves molded into plastic rings, which are cemented to each end of the ferrite core. A single static convergence and purity device is included in the system. The PST deflection yoke and convergence/purity assembly can be bonded to the neck of the tube, forming an integral tube-component assembly. This new assembly feature—plus the absence of dynamic convergence—makes installation and setup of a color tube assembly comparable to that of a black-and-white tube.

The new tube is designed for 19-inch V (viewable diagonal) and smaller sets. Advantages claimed by RCA are:

Tube (overall length) is 1.8 inches shorter than present 90-degree tubes.

Weight of the tube assembly is 2.5

*(continued on page 12)*




**OLD AND NEW picture tube systems compared.**

# What do RCA SK series devices have that other replacements don't?


## QUALITY PRODUCT

- Top-of-the-line quality
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- 23 new types
- Now 120 SKs replace more than 46,000 devices

## SOLID-STATE HARDWARE

- 10 sockets for transistors and IC's
- 15 heat sinks from TO-18 to TO-3 package styles

## INFORMATION SUPPORT

- Accurate • Comprehensive
- New SK Replacement Guide
- New SK Wall Chart
- Transistor Tape/Slide Educational Shows
- Manuals

All three make up the RCA Solid-State System — a product and back-up approach to a replacement line of devices with the professional technician and service dealers' needs in mind. You put the elements together — and they work. Product is top-of-the-line. Literature is accurate and comprehensive, and hardware helps in your day-to-day servicing.

Remember, RCA's Solid-State System is based on premium product — more than 120 different devices (including 23 brand new ones) that can replace more than 46,000 units, both foreign and domestic. They cover the full range of replacement needs — from small signal types, integrated circuits, insulated gate and junction type FET's, to the newest silicon audio 100-watt output types.

Designed especially for replacement use, RCA SK units are backed by electrical characteristics that make them comparable to or better than original devices. There are no cast-offs or factory seconds.

All units and the types they replace are cross-referenced in the RCA Replacement Guide, SPG-202M. There's a Quick-Selection Wall Chart, too, 1L1367A, and new Audio-Visual service aids. These spell the industry's finest informational backup for replacements — all SK, all available from your RCA Distributor. See him today for your copies.

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

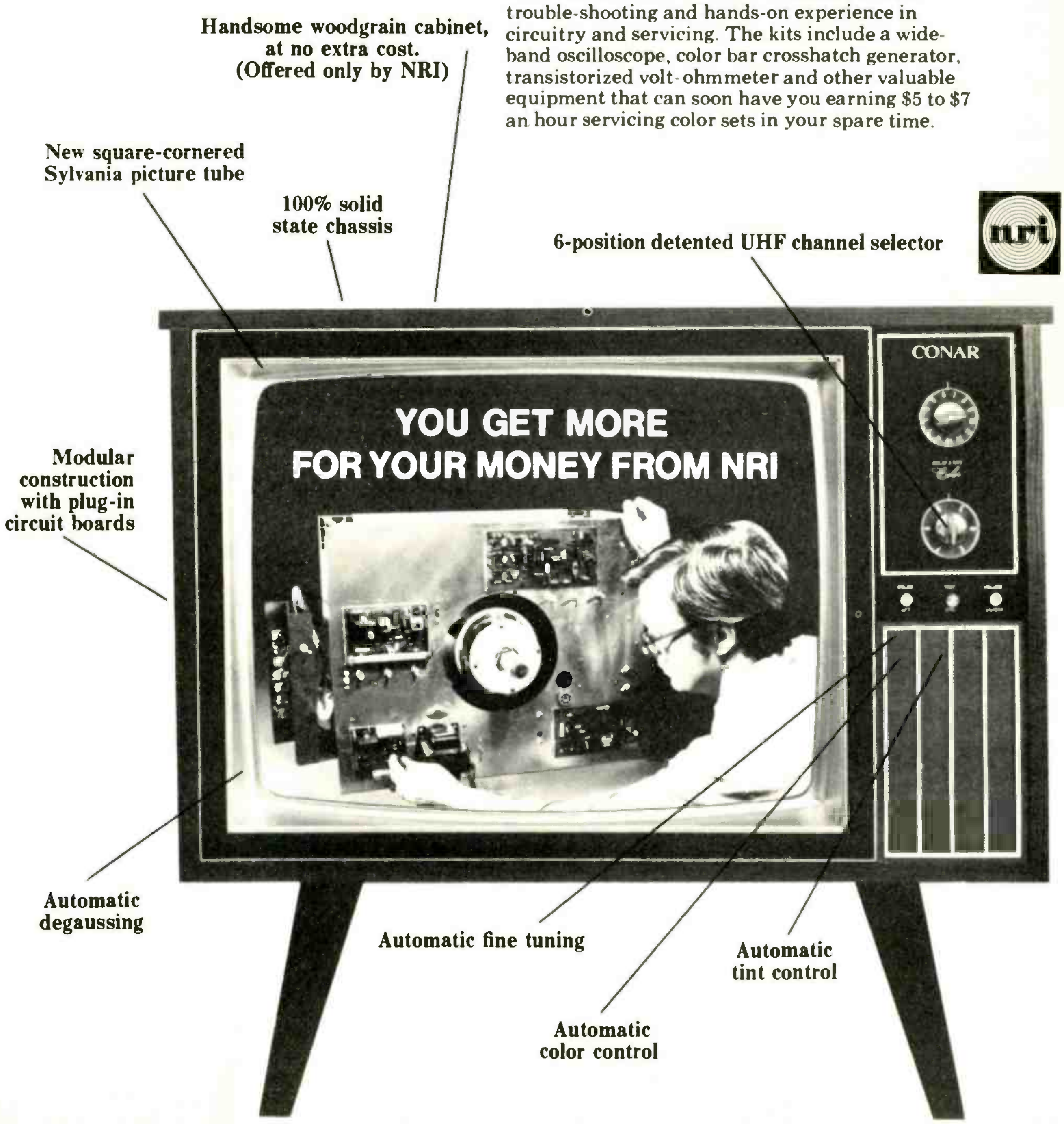
RCA Electronic Components

*Circle 4 on reader service card*

# NOW you can train at home building a NEW 25″ Solid State Color TV engineered by NRI for learning and trouble-shooting

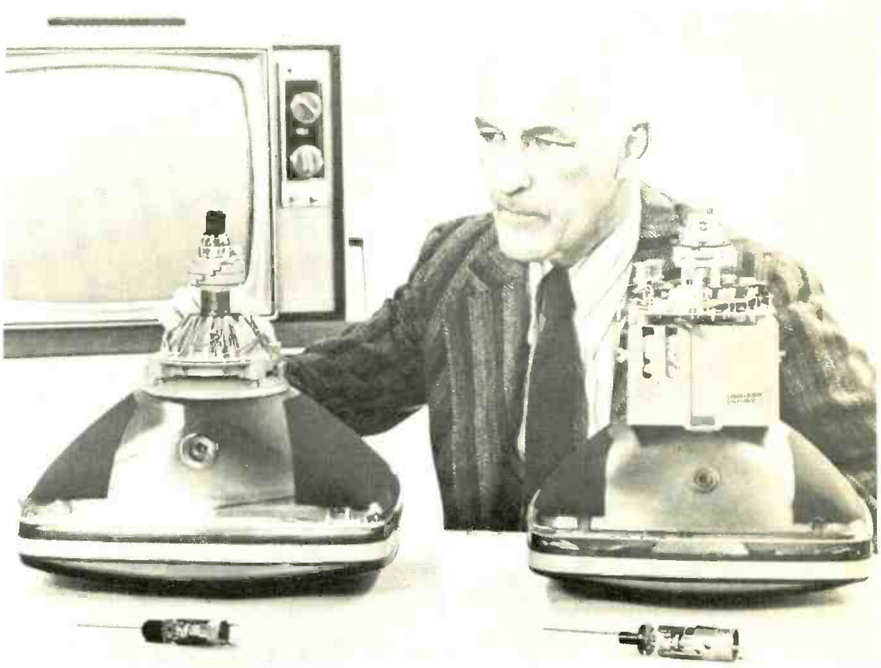
*So much better for learning TV servicing than any hobby kit, because NRI designed and created it as an educational tool.*

Unlike hobby kits which are designed for creating a TV set as the end product, NRI built its exclusive 25″ Solid State Color TV kit as a real training kit. You can introduce and correct defects . . . for trouble-shooting and hands-on experience in circuitry and servicing. The kits include a wide-band oscilloscope, color bar crosshatch generator, transistorized volt-ohmmeter and other valuable equipment that can soon have you earning $5 to $7 an hour servicing color sets in your spare time.



# new & timely

*(continued from page 6)*



**SIMPLIFIED color tube system on left compared with the older tube and its deflection yoke. Note that new tube is shorter than old one.**

pounds less than that of present 90-degree systems.

Installation and setups are greatly simplified, with consequent reduction of labor time.

Line type screen and mask reduces registration problems, improving performance and white uniformity.

## New television receiver has pictorial "memory"

Hitachi has come up with a new television receiver that lets you "freeze" the action at any desired point while continuing to watch the main program. This is done by adding a second 9-inch tube alongside the set's regular 13-inch one. When the viewer wishes to hold or preserve a frame, he simply pushes a button. The image on the main screen at the instant is transferred electronically to the second screen and frozen into place, while the program continues uninterrupted on the main screen. Even if the set is turned off, the frozen picture reappears when it is turned on again, and remains till the button is pushed again.

*(continued on page 14)*

**STOP-ACTION TELEVISION lets you watch the main show while holding any desired frame.**

# 7 NEW RATINGS (in 1000, 1600, and 2000V) ADDED

## *to world's broadest line of dipped tubulars!*

## SPRAGUE DIFILM® ORANGE DROP® CAPACITORS


- Designed to provide the electronics industry with compact capacitors with outstanding dependability under conditions of high heat and humidity.
- Dual dielectric—combines the best features of both polyester film and special capacitor tissue.
- Impregnated with HCX®, an exclusive Sprague synthetic hydrocarbon material which fills every void in the paper, every pinhole in the film *before it polymerizes*, resulting in a solid, rock-hard capacitor section.
- Double dipped in bright orange epoxy resin for moisture and mechanical protection.
- Leakproof—because impregnant is solid, there is no oil to leak, no wax to drip.
- Designed for operation at temperatures to +125 C.
- Capacitance tolerance, ±10%.

### 200 VOLTS D-C

| µF | D. x L. | Sprague Products Cat. No. |
|---|---|---|
| .02 | 29/64 x 15/16 | 2PS-S20 |
| .022 | 29/64 x 15/16 | 2PS-S22 |
| .047 | 33/64 x 15/16 | 2PS-S47 |
| .05 | 33/64 x 15/16 | 2PS-S50 |
| .1 | 35/64 x 1 1/4 | 2PS-P10 |
| .15 | 5/8 x 1 1/4 | 2PS-P15 |
| .2 | 43/64 x 1 3/8 | 2PS-P20 |
| .22 | 43/64 x 1 3/8 | 2PS-P22 |
| .25 | 43/64 x 1 3/8 | 2PS-P25 |
| .33 | 11/16 x 1 11/16 | 2PS-P33 |
| .47 | 49/64 x 1 11/16 | 2PS-P47 |
| .5 | 49/64 x 1 11/16 | 2PS-P50 |

### 400 VOLTS D-C

| µF | D. x L. | Sprague Products Cat. No. |
|---|---|---|
| .01 | 15/32 x 3/4 | 4PS-S10 |
| .015 | 33/64 x 3/4 | 4PS-S15 |
| .02 | 31/64 x 15/16 | 4PS-S20 |
| .022 | 31/64 x 15/16 | 4PS-S22 |
| .025 | 31/64 x 15/16 | 4PS-S25 |
| .03 | 17/32 x 15/16 | 4PS-S30 |
| .033 | 17/32 x 15/16 | 4PS-S33 |
| .04 | 33/64 x 1 1/4 | 4PS-S40 |
| .047 | 33/64 x 1 1/4 | 4PS-S47 |
| .05 | 33/64 x 1 1/4 | 4PS-S50 |
| .056 | 37/64 x 1 1/4 | 4PS-S56 |
| .068 | 37/64 x 1 1/4 | 4PS-S68 |
| .075 | 37/64 x 1 1/4 | 4PS-S75 |
| .1 | 41/64 x 1 1/4 | 4PS-P10 |
| .15 | 43/64 x 1 3/8 | 4PS-P15 |
| .2 | 43/64 x 1 11/16 | 4PS-P20 |
| .22 | 43/64 x 1 11/16 | 4PS-P22 |
| .25 | 43/64 x 1 11/16 | 4PS-P25 |

### 600 VOLTS D-C

| µF | D. x L. | Sprague Products Cat. No. |
|---|---|---|
| .001 | 25/64 x 3/4 | 6PS-D10 |
| .0012 | 25/64 x 3/4 | 6PS-D12 |
| .0015 | 25/64 x 3/4 | 6PS-D15 |
| .0018 | 25/64 x 3/4 | 6PS-D18 |
| .002 | 25/64 x 3/4 | 6PS-D20 |
| .0022 | 25/64 x 3/4 | 6PS-D22 |
| .0025 | 27/64 x 3/4 | 6PS-D25 |
| .0027 | 27/64 x 3/4 | 6PS-D27 |
| .003 | 27/64 x 3/4 | 6PS-D30 |
| .0033 | 27/64 x 3/4 | 6PS-D33 |
| .0039 | 29/64 x 3/4 | 6PS-D39 |
| .004 | 29/64 x 3/4 | 6PS-D40 |
| .0047 | 29/64 x 3/4 | 6PS-D47 |

### 600 VOLTS D-C (cont.)

| µF | D. x L. | Sprague Products Cat. No. |
|---|---|---|
| .005 | 29/64 x 3/4 | 6PS-D50 |
| .0056 | 15/32 x 3/4 | 6PS-D56 |
| .006 | 15/32 x 3/4 | 6PS-D60 |
| .0068 | 15/32 x 3/4 | 6PS-D68 |
| .0075 | 15/32 x 3/4 | 6PS-D75 |
| .008 | 29/64 x 15/16 | 6PS-D80 |
| .0082 | 29/64 x 15/16 | 6PS-D82 |
| .01 | 29/64 x 15/16 | 6PS-S10 |
| .012 | 31/64 x 15/16 | 6PS-S12 |
| .015 | 31/64 x 15/16 | 6PS-S15 |
| .02 | 35/64 x 15/16 | 6PS-S20 |
| .022 | 35/64 x 15/16 | 6PS-S22 |
| .025 | 35/64 x 15/16 | 6PS-S25 |
| .027 | 17/32 x 1 1/4 | 6PS-S27 |
| .03 | 17/32 x 1 1/4 | 6PS-S30 |
| .033 | 17/32 x 1 1/4 | 6PS-S33 |
| .035 | 17/32 x 1 1/4 | 6PS-S35 |
| .039 | 19/32 x 1 1/4 | 6PS-S39 |
| .04 | 19/32 x 1 1/4 | 6PS-S40 |
| .047 | 19/32 x 1 1/4 | 6PS-S47 |
| .05 | 19/32 x 1 1/4 | 6PS-S50 |
| .056 | 41/64 x 1 1/4 | 6PS-S56 |
| .06 | 41/64 x 1 1/4 | 6PS-S60 |
| .068 | 41/64 x 1 1/4 | 6PS-S68 |
| .075 | 41/64 x 1 1/4 | 6PS-S75 |
| .082 | 11/16 x 1 3/8 | 6PS-S82 |
| .1 | 11/16 x 1 3/8 | 6PS-P10 |
| .15 | 47/64 x 1 11/16 | 6PS-P15 |
| .2 | 27/32 x 1 11/16 | 6PS-P20 |
| .22 | 27/32 x 1 11/16 | 6PS-P22 |
| .25 | 27/32 x 1 11/16 | 6PS-P25 |
| .33 | 59/64 x 1 11/16 | 6PS-P33 |
| .47 | 1 1/64 x 1 11/16 | 6PS-P47 |

### 1000 VOLTS D-C

| µF | D. x L. | Sprague Products Cat. No. |
|---|---|---|
| .001 | 25/64 x 3/4 | 10PS-D10 |
| .0015 | 13/32 x 3/4 | 10PS-D15 |
| .002 | 7/16 x 3/4 | 10PS-D20 |
| .0022 | 7/16 x 3/4 | 10PS-D22 |
| .003 | 7/16 x 15/16 | 10PS-D30 |
| .0033 | 7/16 x 15/16 | 10PS-D33 |
| .004 | 15/32 x 15/16 | 10PS-D40 |
| .0047 | 15/32 x 15/16 | 10PS-D47 |
| .005 | 15/32 x 15/16 | 10PS-D50 |
| .0068 | 31/64 x 15/16 | 10PS-D68 |
| .01 | 35/64 x 15/16 | 10PS-S10 |
| .015 | 17/32 x 1 1/4 | 10PS-S15 |

### 1000 VOLTS D-C (cont.)

| µF | D. x L. | Sprague Products Cat. No. |
|---|---|---|
| .022 | 37/64 x 1 3/8 | 10PS-S22 |
| .033 | 19/32 x 1 3/8 | 10PS-S33 |
| **★.039** | **43/64 x 1 3/8** | **10PS-S39** |
| .047 | 43/64 x 1 3/8 | 10PS-S47 |
| **★.056** | **47/64 x 1 11/16** | **10PS-S56** |
| .068 | 47/64 x 1 11/16 | 10PS-S68 |
| **★.082** | **49/64 x 1 11/16** | **10PS-S82** |
| .1 | 49/64 x 1 11/16 | 10PS-P10 |

### 1600 VOLTS D-C

| µF | D. x L. | Sprague Products Cat. No. |
|---|---|---|
| .0005 | 1/2 x 7/8 | 16PS-T50 |
| .001 | 13/32 x 7/8 | 16PS-D10 |
| .0015 | 7/16 x 7/8 | 16PS-D15 |
| .002 | 1/2 x 7/8 | 16PS-D20 |
| .0022 | 1/2 x 7/8 | 16PS-D22 |
| .003 | 7/16 x 1 1/8 | 16PS-D30 |
| .0033 | 7/16 x 1 1/8 | 16PS-D33 |
| **★.0039** | **31/64 x 1 1/8** | **16PS-D39** |
| .004 | 31/64 x 1 1/8 | 16PS-D40 |
| .0047 | 31/64 x 1 1/8 | 16PS-D47 |
| .005 | 31/64 x 1 1/8 | 16PS-D50 |
| .006 | 17/32 x 1 1/8 | 16PS-D60 |
| .0068 | 17/32 x 1 1/8 | 16PS-D68 |
| .007 | 17/32 x 1 1/8 | 16PS-D70 |
| .0075 | 17/32 x 1 1/8 | 16PS-D75 |
| .008 | 5/8 x 1 5/32 | 16PS-D80 |
| .01 | 5/8 x 1 5/32 | 16PS-S10 |
| .015 | 21/32 x 1 19/64 | 16PS-S15 |
| **★.018** | **3/4 x 1 19/64** | **16PS-S18** |
| .02 | 3/4 x 1 19/64 | 16PS-S20 |
| .022 | 3/4 x 1 19/64 | 16PS-S22 |
| .03 | 3/4 x 1 39/64 | 16PS-S30 |
| .033 | 3/4 x 1 39/64 | 16PS-S33 |
| .04 | 27/32 x 1 39/64 | 16PS-S40 |
| .047 | 27/32 x 1 39/64 | 16PS-S47 |
| .05 | 27/32 x 1 39/64 | 16PS-S50 |

### 2000 VOLTS D-C

| µF | D. x L. | Sprague Products Cat. No. |
|---|---|---|
| .001 | 3/8 x 1 1/4 | 20PS-D10 |
| .0015 | 27/64 x 1 1/8 | 20PS-D15 |
| .0022 | 15/32 x 1 1/8 | 20PS-D22 |
| .0033 | 33/64 x 1 1/8 | 20PS-D33 |
| .0047 | 1/2 x 1 3/8 | 20PS-D47 |
| .0056 | 37/64 x 1 3/8 | 20PS-D56 |
| .0068 | 37/64 x 1 3/8 | 20PS-D68 |
| **★.0082** | **39/64 x 1 3/8** | **20PS-D82** |
| **★.027** | **51/64 x 1 11/16** | **20PS-S27** |

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# new & timely

*(continued from page 12)*

The applications are numerous: A viewer may wish to hold a frame for closer study or a better look at a performer. For sports fans or coaches, it's the next best thing to slow-motion replay. The frozen picture can be photographed without the problems that sometimes arise when taking pictures of a live program. In medical study—where television is often used—a critical point in an operation can be held and explained to students while the operation proceeds. One of the more interesting suggested uses is for holding that last frame of a commercial, the one that gives an address and telephone number, while the viewer searches for pencil and paper.

The memory component of the system is a 4-inch magnetic disc, which records the program continuously. When the stop-motion button is pressed, it stops recording and applies its output to the second screen, scanning it repeatedly with the last frame that was recorded before the stop-motion button was pressed.

## New bright-beam glass laser works with moderate power

A new family of glass lasers, called the Mini-Face Pumped laser or Mini-FPL produce a high brightness beam in high and moderate power operation. Complementing the Zig-Zag FPL announced by General Electric last year, the new devices differ from it in that instead of having slabs of glass set in a zigzag line, the Mini-FPL uses a solid slab of neodymium glass with a rectangular cross-section. Instead of going in a straight line through the zigzag plates of glass, the beam in the new laser zigzags down the length of the slab, being internally reflected off the two opposing faces. Flash tubes on both sides of the slab pump energy into it.

The advantage of the Mini-FPL concept is its ability to keep the optical distortion caused by heat in the glass to an extremely low level. The two large opposing faces of the slab are cooled and the side faces are thermally insulated, keeping temperature gradients low.

Narrow-slab models have been operated as oscillators, producing 15 to 20 watts average power at 20 pulses per second. The wide-slab Mini-Face Pumped laser, although designed primarily as an amplifier, has as an oscillator produced an average power of 105 watts in three-pulse-per-second operation. **R-E**

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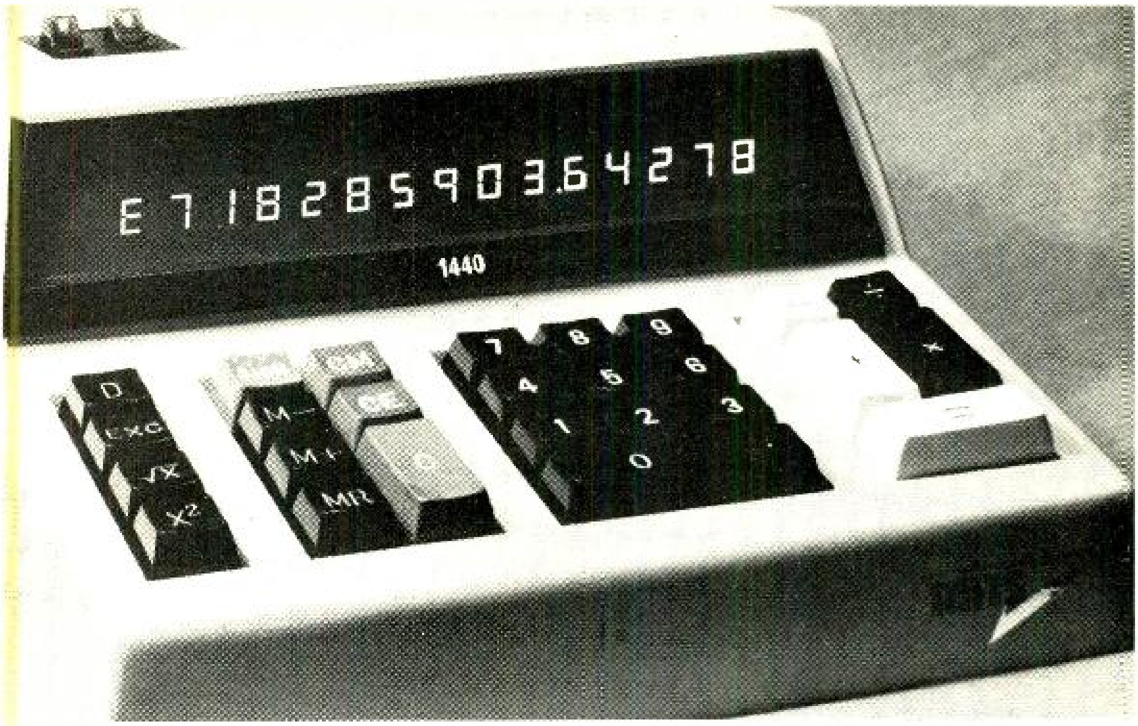
# MITS announces...




# our fourth generation.

Buying an electronic calculator is a lot like buying anything else today; you have to choose the right product for a given use and be sure that the product you buy performs as well as you expect it to. That's why MITS — the original kit calculator company — in order to answer the need for a high caliber calculator at an easily affordable price, has developed the 1440.

Just like the other members of the MITS family (the 808, 816A, and 816B), the 1440 uses only the highest quality components available from such American companies as National Semiconductor, AMP, TI, Sprague, and IRC. Special attention was given to its 'state of the art' design, assuring customer satisfaction by the establishment of standards like: 5% resistors; fully interconnected, double sided, plated through PC boards; extra large LED's; individual mounting sockets for all integrated circuits; precut, stripped, and tinned wire; and double injected, feather touch keyboards.

Put this much engineering effort into a case of 'designer's piece' quality, provide comprehensive detailed instructions covering Theory of Operation (with complete schematics and logic diagrams), Step by Step Assembly, Troubleshooting, and Applications, then stand behind it with a full 90 day warranty (1 year on assembled units), and you've got something you'll rarely find — a product you can count on long after you buy it.

But this alone wasn't enough. So, because we hope your needs will never outgrow the 1440's six function - memorizing† capability, we incorporated two interfaces for completely compatible printing and programming units (available summer 1972) which can increase its functional capacity to that of a small desktop computer.

The only remaining factor was a reasonable price. We think that $199.95 (assembled $249.95) is fair, and that's the only way we'd like to sell you one.

Our four function 816's (with 'computerizing' interfaces) and the 808 have undergone design improvement too. They're available at $129.95 (808); $149.95 (816A); and $159.95 (816B).

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the functions are ( +, , ×, —, √x, [illegible])
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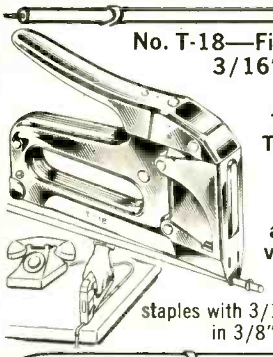

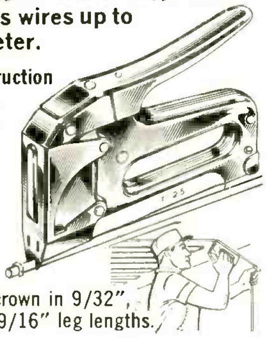

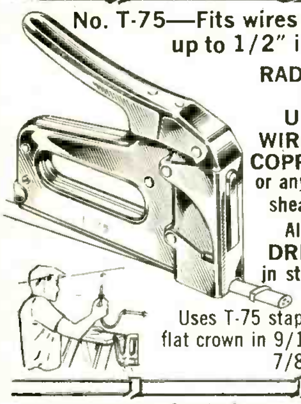

# letters

### CORRECTION

Several errors crept into the frequency-time conversion table on page 40 of the July issue.

In the second column from the left (headed msec), the 4th and 5th lines down should read .0007 and .0009, respectively. The frequency in kHz corresponding to 0.7 μsec is 1,429, not 1.429. Also in the kHz column, the frequency corresponding to 5000 μsec is 0.200, not 0.500.

### MORE 4-CHANNEL COMMENTS

Peter Scheiber's comments on the frequency response and signal-to-noise ratio of the new 4-channel discrete disc recordings (**Radio-Electronics,** June, 1972) are both realistic and well-founded.

It has been demonstrated that a trained human ear can detect the difference in transients reproduced through a 20-kHz bandwidth vs. a 50-kHz bandwidth; moreover, the human ear accepts a dynamic range of 120 dB. The fact that present day recording media do not meet such standards is made painfully evident by modern headphones. The discerning audiophile today is not interested in systems inherently limited to 15-kHz bandwidth and 50-dB dynamic range.

In fact, I would prefer to carry the argument a step further. Although the disc recordings are capable of 70-dB signal-to-noise ratio with a perfectly clean surface, no record I have ever bought even approaches such a standard. Random dust and surface flaws cause sporadic "shot" noise of 10 to 30 dB above the background hiss level. Such noise is not bad enough to be considered defective manufacture, but it makes me wish there were a viable alternative.

The only viable alternative at present is reel-to-reel tape. Unfortunately, the recording companies seem to have decided that reel-to-reel is a dying format which isn't worth saving. If this attitude persists, you can be sure it *will* die.

But it is worth saving. State-of-the-art dynamic range is an *honest* 70 decibels (no shot noise on top of that), and bandwidth need not be compromised to achieve 4 discrete channels.

Matrix networks provide an excellent, low-cost means of converting from 2 to 4 channels. By all means, let's have as much matrix hardware and software as the market will bear. But please don't forget the purists. Discrete 4 channel sound is the medium serious audiophiles want, but a serious audiophile is not willing to compromise on sound quality.

The present market in 4-channel reel-to-reel tapes is limited, but it should be noted that these tapes can be reproduced almost as cheaply in small quantities as in large. I look forward to the day when the entire present-day disc repertoire becomes available in 4-channel reel-to-reel format.

Remember the lesson that stereo taught us: the purist's standards of today are the consumer's standards of tomorrow.

G. H. Toole
*Ontario, Canada*

### GFI

I read with interest the article concerning ground fault interrupters in your July issue. I do feel however, that the article was incomplete in that it discussed only the differential transformer ground fault interrupter and made no mention of the isolation gfi. A comparison of both types was contained in an article which was published in the March issue of *Consumer Reports*.

Quoting from your article, ". . . the gfi does not limit the current that can flow through the fault. It limits the time during which it can flow. So the total energy fed through the fault (human body, or whatever else) is limited by limiting the pulse width." The foregoing statements are true only for the differential transformer gfi.

The isolation gfi operates at a trip current of only 0.2 milliampers, (adjustable), and trips within 15 milliseconds. The circuit is designed such that current flow to ground is limited to several milliamperes. Also, nuisance tripping is not a problem even at this small current.

Additionally, my company is presently developing a new and similar device which has just been invented by the inventor of the isolation gfi.

E. M. Bolin
*Charlston, SC*

*Our thanks to Mr. Bolin for his elaboration on the GFI Appliance Clinic. We have presented his comments here as we feel they will be of interest to the many readers who wrote to us about this article.*

*As many readers have told us we omitted the two diagrams that should have appeared in the GFI Appliance Clinic. Therefore, we are printing both diagrams on page 22.*

(continued on page 22)


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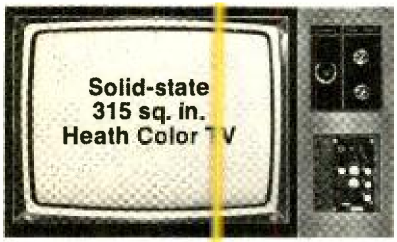

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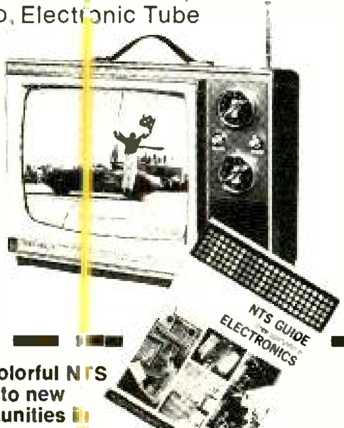

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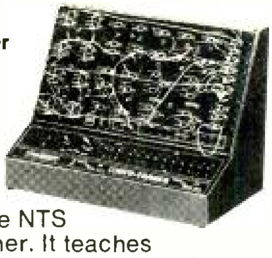

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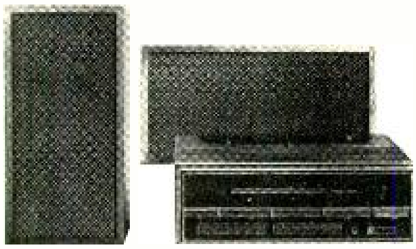

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**LETTERS**
*(continued from page 16)*

*We will be happy to hear from any readers with further experience with GFI circuits.*

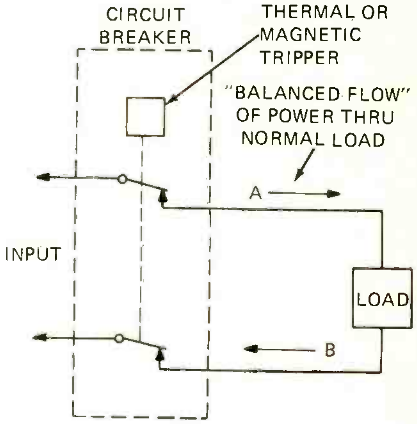


FIG. 1

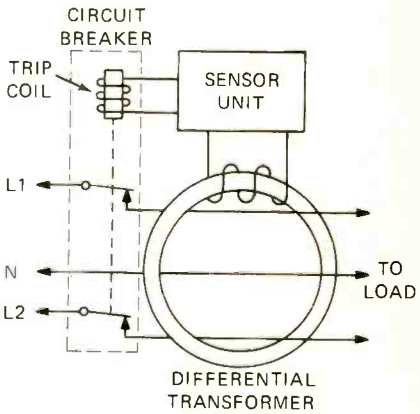


FIG. 2

*Our thanks to those who brought the missing illustrations to our attention.—Editor*

# next month

Three new articles on the exciting new world of four-channel sound will appear in the October 1972 issue of **Radio-Electronics.**

- **Electro-Voice & Four-Channel Stereo** takes a careful look at EV's new "compatible" 4-channel matrix adapter.
- **Four-Channel Recording Techniques** goes behind the scenes at the recording studio to see how a four-channel record is made.
- **R-E Tests 4-Channel Headphones** describes the Koss and Superex new 4-channel headphones. Find out how they work and how well they work.

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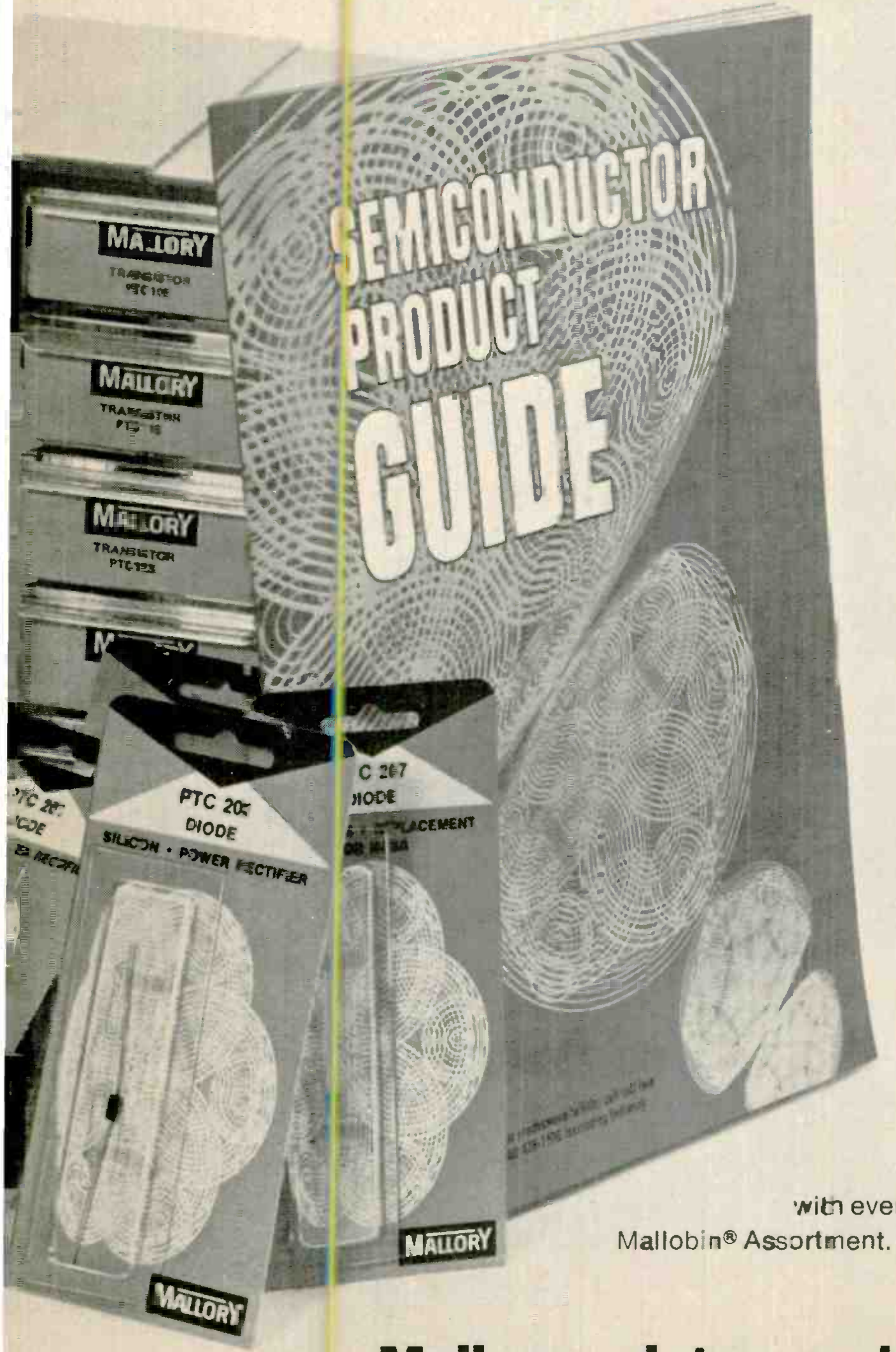


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# appliance clinic

### IS THE GROUND GROUNDED OR UNGROUNDED?

**by JACK DARR**
SERVICE EDITOR

IN THE JANUARY 1972 APPLIANCE Clinic, I mentioned that the white wire in home wiring and some industrial circuits. was always grounded. I drew a small amount of flak on this from a few sharp-eyed readers, who claimed that this was not *always* true. However, since I had sneakily specified that I was referring only to two-wire 117-volt home wiring, and *single-phase* 240-volt systems. also found in home wiring, this time I was correct.

The National Electrical Code (NEC for short) for 1971 specifies "All interior wiring systems shall have a grounded conductor which is continuously indentified throughout the system" (except for certain specialized cases like hospital operating rooms, etc. where an intentionally-ungrounded system is used). Also, "Identification of grounded conductors shall be as follows:—shall have an outer identification of white or natural gray." Later. "Conductors of white or natural gray shall not be used other than as conductors for which identification is required" etc. meaning that a white wire must never be used as the hot wire! Article 200-2, 200-3. 200-6. NEC 1971

The Code also provides that the secondary supply to the home, meaning the service wires from the transformer on the pole, shall be grounded on the *supply side* of the overcurrent protection device or disconnect, and that the home wiring must not be grounded after it leaves the disconnect. This is a free-hand translation of Art. 250-23.

One of my correspondents, a Professor of Electrical Engineering at a Northern University, brought out an interesting point, which could stand a bit of clarification, for which I thank him. This is the somewhat confusing difference between ground*ed* and ground*ing* conductors. Unless you watch closely, the Code can be just a little ambiguous along in here!

While both of the "ground" conductors mentioned, the white wire and the green, *are grounded,* there is a difference in their function. The white wire is a "current-carrying conductor, grounded," and a part of the power circuit. The green wire, on the other hand, is a "grounded, non-current carrying conductor." It *is not* a part of the power circuits, and is merely a safety feature!

The Code says "Grounding conductors—shall be arranged so that there is no objectionable (sic) passage of current . . ." It goes on to say that fault-currents set up in the grounding conductor under accidental conditions aren't objectionable!" (That's nice of 'em.) The aim of this Article, as it looks to me, is that there should be no normal current-flow in the safety ground, but that it must be capable of carrying enough current to trip the circuit-breaker if a fault does occur.

Strangely enough (to electronics types) the Code *does not* provide for color-coding of *any wires* other than the two ground wires. You can use any colors you want; provisions apply mainly to flexible cords and wires (Art.'s 400-13, 400-14). The white (or "natural gray") *is always* the one used as the grounded conductor, and the green wire *is always* the ground*ing* conductor. This provision has been in effect as far back as the 1965 Code, which is the oldest one I could find; don't know exactly when it was started. So, what we get out of this is one fact: outside of the white and green wires, All wires must be considered as "hot". (See Fig. 1)

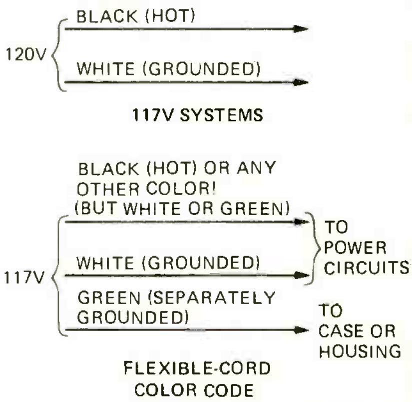


**FIG. 1—ONLY THE GROUNDED WIRES must be identified!**

To clear up one more point, the new type 3-prong plug/socket combinations, with the round-ground pin.

*(continued on page 98)*

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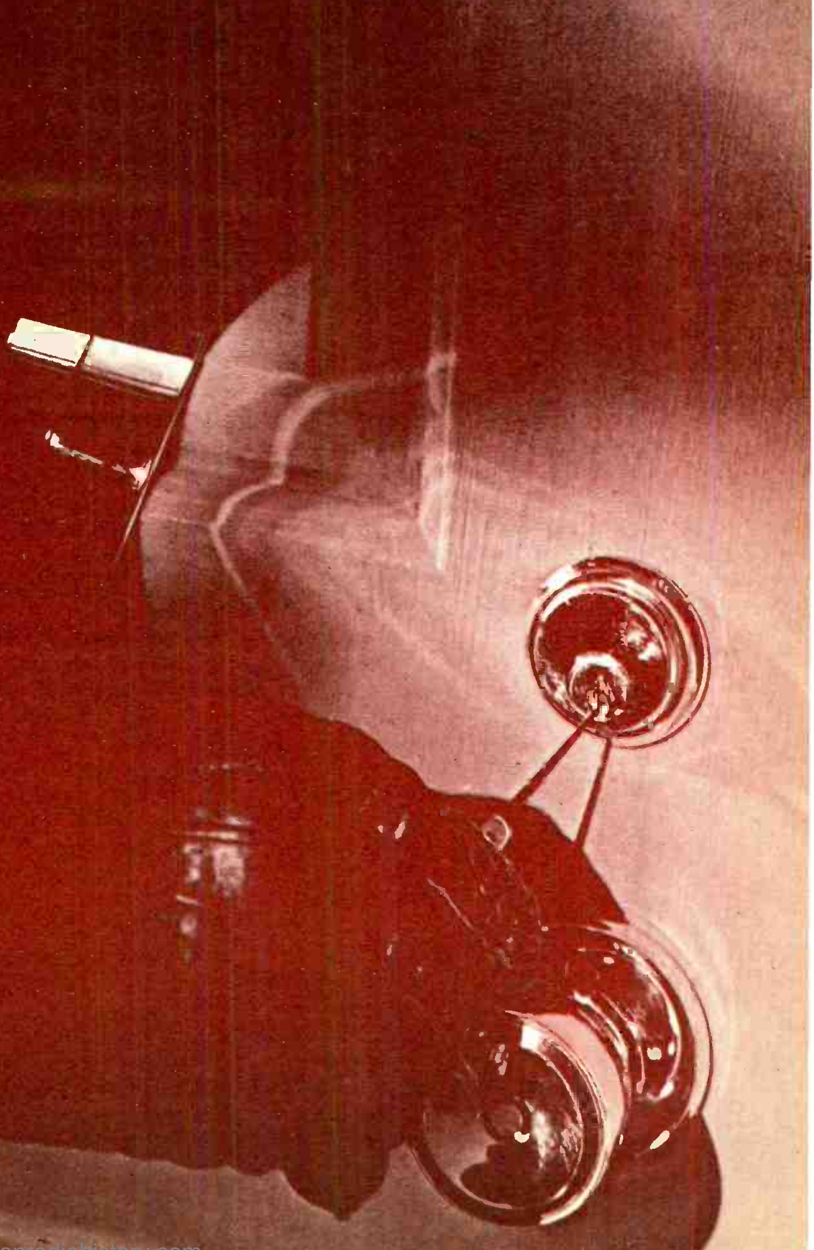

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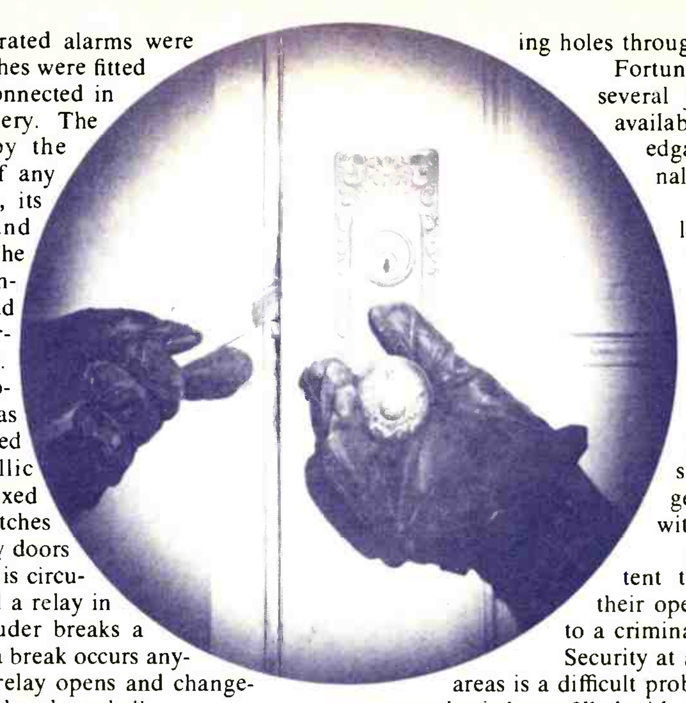
**Equipment should match the risk**

**The protection required from an alarm system must be related to the risk involved. An intruder alarm suitable for a suburban grocery store would not be adequate for a city jeweller. The jeweller's system would not suit the Reserve Bank.**

**It's very much a matter of horses for courses—and a wide variety of horses are available from the security industry.**

**In the beginning . . .** **(turn page)**



The first electrically operated alarms were simple. Normally-closed switches were fitted to doors and windows and connected in parallel to a bell and battery. The switches were held open by the closed doors and windows. If any door or window was opened, its associated switch closed and completed the bell circuit. The system had failings. Switch contacts tarnished, wires broke, bad joints were not detected, burglars traced and severed leads.

To overcome these problems the closed-loop system was devised. A series loop is formed around the building. Metallic tape is glued to areas of fixed glass, and normally open switches held in their closed position by doors and windows. A small current is circulated through the loop to hold a relay in its closed position. If an intruder breaks a window or opens a door, or if a break occurs anywhere in the series loop, the relay opens and changeover contacts apply power to the alarm bell.

The system is relatively cheap and simple. It is still widely used. Providing it is properly engineered and installed, it provides adequate protection for houses and low-risk to medium-risk business premises.

Closed-loop protection may not be adequate if the guarded premises contain high-risk goods. A truly professional criminal will locate and tape down microswitches. He will detect magnetic reed switches with a pocket compass and disable them with magnets he carries for the purpose. He will bridge tape loops with jumper leads, and so on. In extreme cases he will not open any doors or windows. He will enter through the floor or roof and move between rooms by smashing holes through adjoining walls.

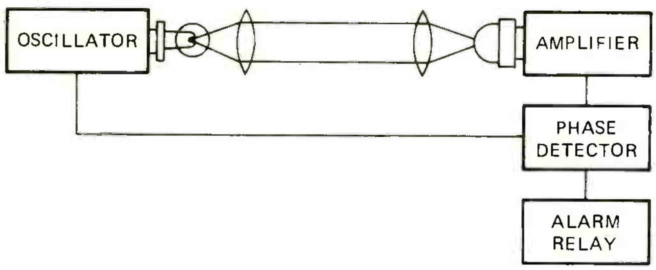
Fortunately the security industry keeps several jumps ahead, and systems are available to detect the most knowledgable and determined of criminals.

The arsenal includes phase-locked infra-red beams, ultrasonic and microwave motion detectors, proximity alarms, strain-gauge bridges sensitive to the weight of one cigarette packet on a warehouse shelf, footstep detectors and closed-circuit television with pattern recognition facilities. Systems more sensitive than a cage of uptight geese—and less easy to tamper with.

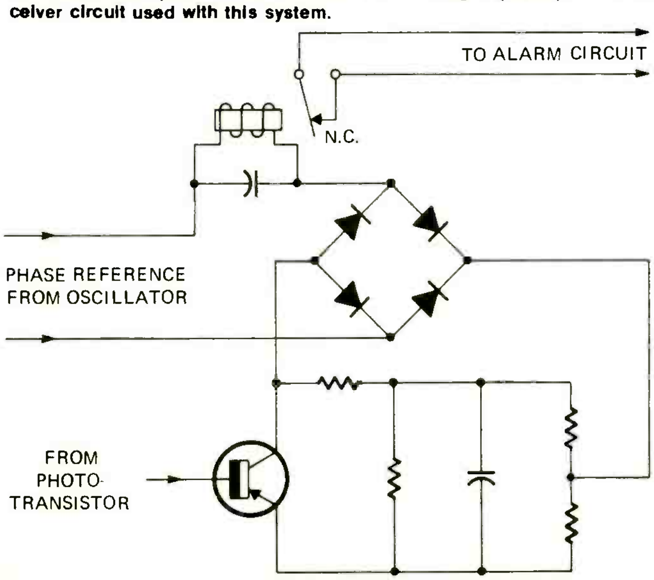
All are tamper-proof to the extent that a thorough knowledge of their operating principle is no assistance to a criminal. If anything it will deter him.

Security at airfields and other large exposed areas is a difficult problem. One ingenious system uses two plastic hoses filled with glycerine and water spaced a few feet apart and buried beneath the surface. Pressure transducers are attached to one end of each hose and the transducer outputs connected to a differential amplifier. A person walking towards the line of hoses causes pressure fluctuations in the hoses. The fluctuations are larger in the nearer hose. The difference signal is amplified and used to operate an alarm. Fluctuations caused by rain or thunder cause equal pressures in the hoses and no output is produced by the differential amplifier, so the alarm is not triggered.

This kind of system is often installed between two lines of perimeter fencing and detects only people who have already scaled the first fence, preventing false alarms.




**PHOTOELECTRIC BEAMS are a basic form of intruder protection. Fig. 1 (above) shows a phase-locked modulated beam. Fig. 2 (below) is the receiver circuit used with this system.**




## Perimeter fences

Perimeter fences can be protected by photo-electric and strain-gauge systems. Photo-electric systems are described in greater detail later on in this article.

A strain-gauge is a transducer that changes in resistance when subjected to mechanical strain. The gauge is simply a length of resistance wire glued onto backing material. Signals are obtained by bonding one gauge onto a section where strain can be expected (e.g., a fence upright) and a second identical gauge as close as possible to the first but in a position where there can be no strain. The first gauge responds to all strain-producing signals—temperature, humidity, mechanical loading. The second gauge is backed off against the first and all variations except the required signal are cancelled out.

The gauges and appropriate resistances are connected in a Wheatstone bridge. An intruder climbing the fence varies the resistance of one strain gauge, unbalance the bridge and trigger the alarm.

## Photoelectric beams

One of the simplest electronic alarms is the photocell and its associated light source. It is frequently used as a door monitor in small shops. With the light source covered by an infrared filter, making the beam invisible, the system can be used as a simple intruder alarm.

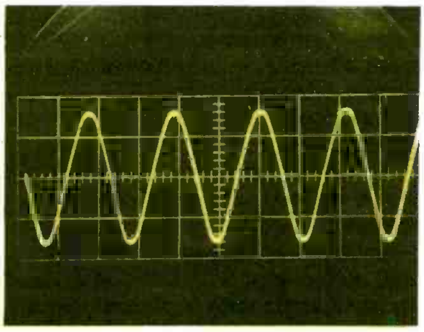
In its basic form the photoelectric beam can be bypassed by shining a light onto the photocell. To overcome this, the majority of beams used in security applications use a modulating technique in which the light beam is chopped electronically or by a motor-driven vane. A bandpass filter in the receiver passes only the modulated signal.

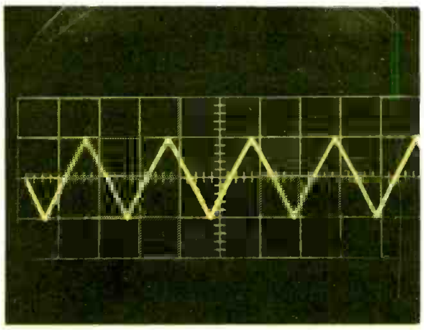
Photo this page courtesy Northern Intruder Alarm
Photo at right courtesy General Ordnance Equipment

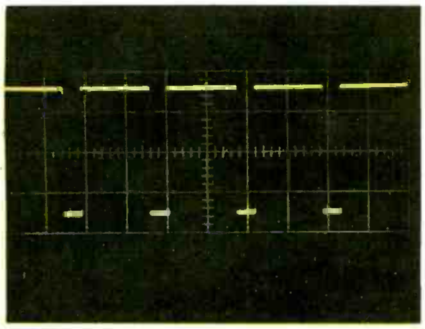
# BUILD THIS $40 IC

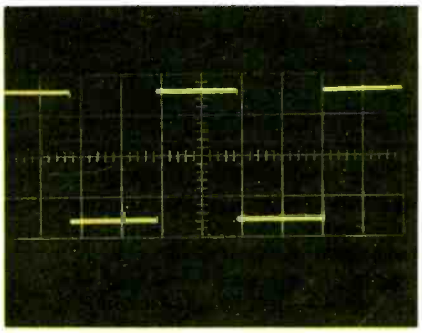
*Build this 30-range universal signal square, pulse, and ramp*

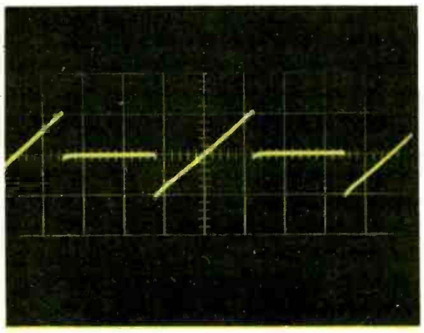
THESE FIVE WAVEFORMS, all at 1 kHz, are typical of the kinds of outputs the generator will deliver. From top to bottom they are, obviously; sine wave, triangle wave, pulses, square wave, and at the bottom, a ramp. While the patterns shown are at 1 kHz, all of these signals are available over the full range of the generator—1 Hz to 1 MHz.











ASK ANYONE WHO'S EVER BEEN ABLE TO afford one, and they'll tell you that a function generator is the handiest and most versatile signal source you can own, regardless of your particular electronic interest. Function generators produce various test waveforms—sine, triangle, and square at the very least, and sometimes much more. Function generators are often the number one choice for digital logic testing and experiments, electronic music, radio, TV, and hi-fi service, servo experiments, network synthesis, general electronics service and repair, ultrasonics, analog computation, and virtually anywhere else you need a flexible and stable wide-range signal source.

The problem is that today's function generators cost at least $400, and sometimes much more. This puts them beyond the range of the student, service technician, experimenter, or serious electronic hobbiest. But, thanks to a brand new $15 integrated circuit and some simplified switching circuitry, you can now duplicate most, if not all, the capabilities of a commercial function generator for less than $40.

The **Radio-Electronics** function generator has 30 pushbutton ranges that give you sine, triangle, square, pulse, and ramp outputs over a six-decade frequency range from 1 hertz to 1 megahertz. Output amplitude is adjustable from 0 to 2 volts and may be either ac coupled, or dc coupled with an adjustable offset from −2 to +2 volts, nicely giving you pulses and other test signals of either polarity. Output impedance is around 70 ohms, and the circuit drives TTL directly.

The complete specs appear in the table. Complete kits and any and all individual parts are commercially available and you can put this instrument together in a few evenings. Thanks to special printed-circuit boards, switch wiring is greatly simplified, eliminating one of the biggest assembly headaches on any piece of test equipment. An unbreakable impact plastic case is used. If you like, you can easily add external AM, FM, pulse modulation as well as voltage control, remote gating, the whole bit. You can also use two generators—one to control the other one for really wild waveforms. Typical waveform photos of the basic instrument appear in Fig. 1.

## How it works

A single function-generator integrated circuit does the whole job practically by itself, helped along only with a transistor used to compensate amplitudes. Fig. 2 shows us, in simplified form, that we can think of the circuit as made up of seven blocks. The four most complicated ones are inside the IC. The basic object of the game is to generate a waveform of the desired frequency. Then you select or alter its shape, control its amplitude, and then you control its offset, or how much dc there is to be in the output. Finally, you amplify it so it will drive a low-impedance output.

Fig. 5 shows us more details on each block. In Fig. 5-a, we see that the waveform generator is a fancy version of a multivibrator called an *emitter-coupled astable.* It has two stable states, one with Q3 conducting heavily and one with Q3 off and Q4 conducting heavily. Let's say that Q3 has just turned on, conducting heavily. Its collector voltage is low. This in turn holds the base voltage of Q4 low, temporarily insuring that Q4 is indeed off. If Q4 is off, all of the available current that normally flows through Q4 goes into the capacitor instead, charging the right end of the capacitor *negatively.* Since the charging takes place from a current source instead of a resistor, the charge on the capacitor is constantly changing with time, resulting in a *linear* ramp or a straight-line charging action.

The capacitor keeps charging until it gets to −1.2 volts. At this point, Q4 will begin to conduct, and through snap-action feedback, the circuit will flip over, and Q4 snaps ON and Q3 snaps OFF.

Now things have reversed, and the capacitor starts charging in the *other* direction. It does so until the left side goes negative enough to flip things back the way they initially were, and you have a continuous back and forth oscillation.

## Phase-locked beams

A refinement of this technique is the phase-locked modulated beam. An example of this approach is shown in Fig. 1.

In this system a transistor oscillator modulates the filament of a tungsten lamp at a frequency slightly lower than the 50-Hz or 60-Hz ac supply.

An electrical reference of phase is supplied to a phase-sensitive detector in the receiver (Fig. 2). This circuit compares the relative phases of the reference signal and the modulated infrared beam and holds the alarm relay closed while the two signals are in phase. If the beam is broken or any attempt is made to defeat the system (by cutting the phase-reference leads, or by shining a stroboscope into the receiver) the output from the phase-sensitive detector is reduced and the alarm relay is released.

## Developments in photoelectric beams

Incandescent lamps are commonly used in infrared beams. With their input voltage reduced, their output is almost entirely infrared. The reduced operating voltage lengthens their useful life by many times.

Their limitation is filament size. The divergence of an optical system is ultimately a function of the size of the light source, and using conventional incandescent globes it is not easy to produce the low-divergence beam required for long-distance operation.

The recently introduced gallium-arsenide electroluminescent diode is virtually a point source and reduces the problem of divergence. These diodes are available with their entire energy output in the infrared part of the spectrum. They are being increasingly used in optical beams despite the difficulty of aligning the totally invisible beams.

## Ultrasonic beams

Ultrasonic beams are frequently used where their ruggedness and ability to operate in dirty environments justifies their cost. Their operating frequency is generally 40 kHz. They are rarely used for intruder detection as their reliable operating range seldom exceeds 12 to 15 feet.

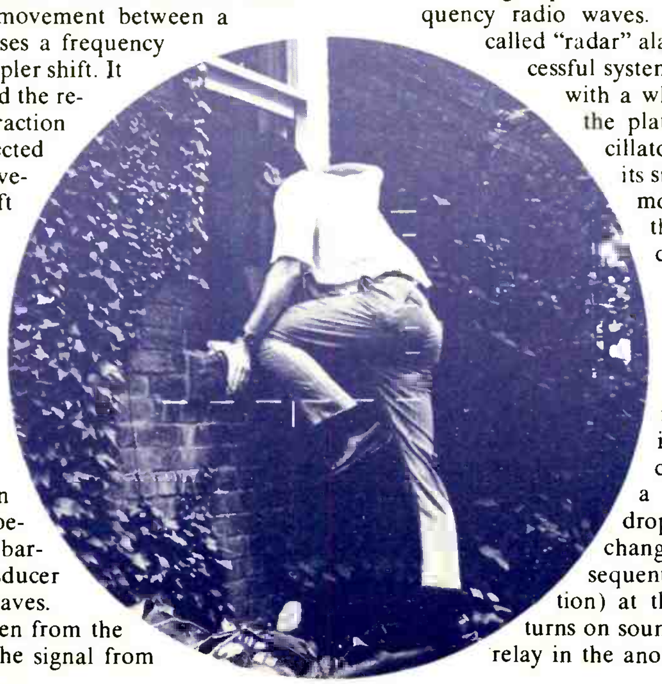
## Motion detectors

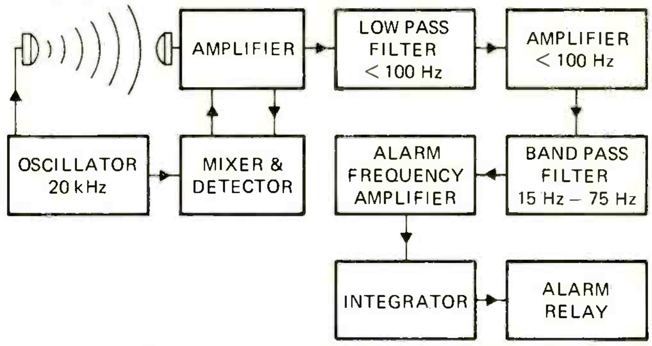
Thieves frequently conceal themselves inside buildings during working hours, to emerge later when work has stopped for the day. To counter this alarm systems have been developed that detect the presence of an intruder inside the protected area.

The first commercially successful motion detector used the principle that any relative movement between a sound source and a receiver causes a frequency shift. This effect is known as Doppler shift. It also occurs if the sound source and the receiver are stationary and some fraction of the transmitted energy is reflected from a moving object. Air movement also causes a Doppler shift in the transmitted energy, so unless special filtering techniques are used, ultrasonic Doppler-effect systems are prone to false triggering. A block diagram of a typical system is in Fig. 3.

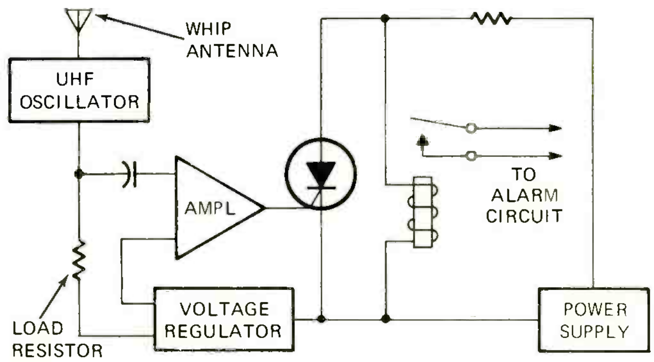
A 20-kHz oscillator energizes a transducer. It may be a magnetostrictive type in which a coil surrounds an armature of nickel alloy rods fastened to an aluminum diaphragm, or a piezoelectric device often made from barium titanate. The energized transducer floods the area with ultrasonic waves.

A frequency reference is taken from the transmitter and compared with the signal from






**MOTION DETECTORS are another common type of intruder detector. Fig. 3 (above) is an ultrasonic Doppler-shift system. Fig. 4 (below) is an rf or "radar" approach to the motion detector.**




the receiving transducer (mechanically and electrically similar to the transmitting unit). An intruder moving in the area shifts the acoustically received signal by an amount between 15 and 75 Hz. Thus two different frequencies are received—a 20-kHz signal directly from the transmitter and a 20-kHz plus the Doppler shift signal (of, say 70 Hz) from the receiving transducer. The two signals are mixed and a low-pass filter extracts any component below 75 Hz. Additional filters are used to remove extraneous signals caused by fan and thermal turbulence (occurring mainly below 10 Hz).

Under ideal conditions of low ambient noise and attenuation, a radiated power of 1/10th watt is enough to detect movement of a 0.03 sq. ft. object in an enclosed space of 200,000 cubic ft. In premises which have absorbent fittings considerably more power is required.

Another group of motion detectors uses ultra-high-frequency radio waves. These systems are sometimes called "radar" alarms, a misnomer. One very successful system uses a one tube uhf oscillator with a whip antenna directly coupled to the plate circuit (see Fig. 4). The oscillator load is both the antenna and its surrounding space. If there is any movement within this local space, there will be a change in oscillator loading.

Power for the uhf oscillator is supplied—via a load resistor—from a regulated dc supply. The load resistor and an associated capacitor form a differentiating network. Thus a sudden change in the local field causes a sudden change in oscillator loading and a reflected change in the voltage drop across the load resistor. This change is differentiated and the subsequent pulse appears (after amplification) at the gate of an SCR. The SCR turns on sounding the alarm operated by the relay in the anode circuit.

*(continued on page 96)*

We note there are three outputs available. A ramp output from Q4, an out-of-phase ramp output from Q3 and a square wave from Q6. If we take the Q6 output, we have our square wave. If we take either the Q3 or Q4 output, we have our ramp. Now, if we take the *difference* between Q3 and Q4, we get a triangle wave. And finally, if we take the difference between Q3 and Q4 and round off the sharp corners, we come up with a sinewave.

### Changing frequency

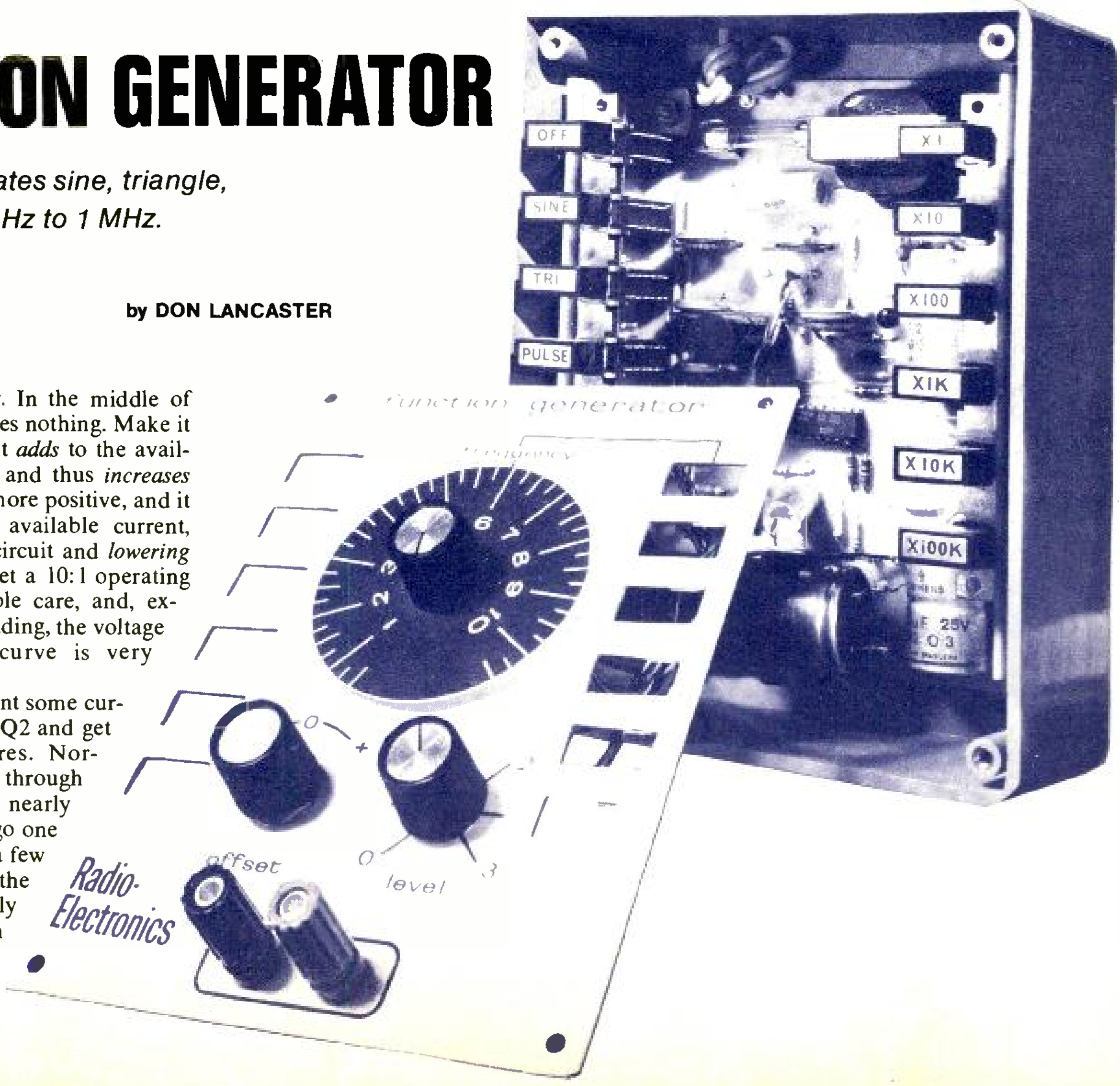
We can obviously change frequency by changing capacitor values, for the charging time for a constant current is directly proportional to how big a capacitor you hang on the circuit. So, looking at Fig. 3, we switch select a series of capacitors that are decade multiples (10X) of each other. This takes care of range switching.

To get a 10:1 vernier range, we have to somehow change the value of the current source at the bottom of the circuit. We can't change what's inside an IC, but we can add to or subtract from this current by sourcing or sinking some extra current at pin 13. We do this with an external potentiometer and cur-

# FUNCTION GENERATOR

*source that generates sine, triangle, waveforms from 1 Hz to 1 MHz.*

**by DON LANCASTER**




rent-limiting resistor. In the middle of the range, the pot does nothing. Make it more negative, and it *adds* to the available circuit current, and thus *increases* frequency. Make it more positive, and it steals some of the available current, leaving *less* for the circuit and *lowering* the frequency. We get a 10:1 operating range with reasonable care, and, except for some pot loading, the voltage versus frequency curve is very linear.

We can also shunt some current around Q1 and Q2 and get some added features. Normally the currents through Q1 and Q2 are very nearly 50-50, but they can go one way or the other by a few percent. This makes the square wave slightly asymmetrical, which isn't too bad. Trouble is that when we get to the sinewave output, anything but a 50-50 duty cycle will give us a bunch of second harmonic distortion in a hurry. So, we set up a high impedance pot and some big resistors (R21,R22,R23 of Fig. 6) around Q1 and Q2 to give us a symmetry control that lets us touch things up to an exactly 50-50 duty cycle.

If we shunt a bunch of current around one side, we get a very low duty cycle. This is how we get our pulse waveform. We use the square-wave output, but we unbalance things badly enough to get a 1:5 or 20:80 duty cycle. By the way, this also changes frequency, so the dial readings for the pulse output will be around half the actual pulse repetition rate.

So, the wave generator directly generates a square wave and a pair of out-of-phase ramp waveforms. If we take the difference between the ramps, we get a triangle wave. If we polish the tops of the triangle wave, we get a sinewave. Finally, if we pick the squarewave and unbalance the symmetry, we get a pulse output.

### Wave shaping

The shaping circuit of Fig. 5-b is called a *variable-gain differential amplifier*. The gain is controlled by resistor $R_x$, and the *difference* between the two input signals gets amplified and appears as an output. A differential amplifier is a linear amplifier for small input signals or low gains. Its also a limiter or clipper for large input signals or high gains, for you can get no more current out than is available at the bottom of the circuit, nor less than zero. Converted to voltages across the load resistor, this means you get a smooth clipping or clamping action for high input levels or high gains.

So, we change both the gain and drive level to improve upon our basic waveforms. Triangle and ramp are sent through at low level and low gain; they come out the way they went in. The differential amplifier nicely converts the two out-of-phase ramps into a uniform triangular wave. For square and pulse, we heavily overdrive the differential amplifier and run the gain up very high. This gives us a constant amplitude, lots of output, and sharp rise and fall times for these waveforms.

For the sine wave, we use a moderate amount of gain and start with a triangle wave generated as the difference between the two ramps. What this does is knock the sharp corners off the triangle waveshape, giving us the familiar sinewave shape, with a distortion typically around 2%. This technique is far simpler than those normally used in function generators, and this level of distortion is not even noticeable for anything but critical audio testing.

Biasing is critical on any differential amplifier. Both *inputs must be returned to the same dc level,* or the circuit goes into limiting and ignores the input signal due to the unbalance in currents caused by improper biasing.

There are two ways we use the differential amplifier in the **Radio-Electronics** function generator. For triangle and sine, we connect the inputs directly to the ramp and out-of-phase ramp outputs. These are both at the same dc level and thus give us proper bias. At the same time, the differential amplifier takes the *difference* between these two waveforms, generating a triangle wave at low gain and a rounded top triangle approximation to a sine wave at higher gain.

The rest of the waveshapes must be capacitor-coupled. To do this, we return both inputs of the differential amplifier to ground and bypass one input. This gives us a single-ended amplifier into which we can couple these square, pulse, and ramp inputs. We run the ramp at low gain, so the same signal comes out we put in. In square and pulse, we run very high gain by shorting $R_x$. This gives us a bigger output with completely flat tops and fast risetimes. Two small refinements complete the square and pulse coupling. The coupling capacitor is a compromise, since one that gives no droop on the 1-Hz range also gives objectionably long transients on the higher ranges as frequency is suddenly changed. To beat this, we use a relatively small coupling capacitor C6 for the higher ranges and switch in a larger C10 for the 1-Hz range. The pulse waveform has a large dc component due to its duty cycle. If we capacitor-couple, we end up with linear amplification on the bottom of the pulse and limiting on the top. This reduces pulse amplitude, but worse yet, it makes the bottom noisy and rounds the edges of the rise and fall times. To beat this, we purposely unbalance the differential amplifier slightly with R27, but *only during pulse operation.* This nicely limits both the bottom and the top of the pulse, giving us an output as big and as clean as the square-wave.

### Amplitude compensation

There is a slight change of wave generator output amplitude when we operate over a 10:1 current range. Most obvious is a dropoff at the high current, high frequency and caused by larger drops in Q3 and Q4. The high-end voltage drop gets eliminated automatically in the square and pulse modes since the shaper heavily limits, and you get a constant output level. The problem isn't too bad in triangle and ramp, but in the sine position, the waveshape changes pretty drastically as you reduce the amplitude, giving you "pointy" sinewaves at the high end of any frequency range. To beat this, we raise the gain of the shaper slightly at the far end of the frequency pot. The drop in input amplitude gets made up by the increase in shaper gain, and the output sine wave amplitude and waveshape stays constant over the pot's range.

Since the pot's going the wrong

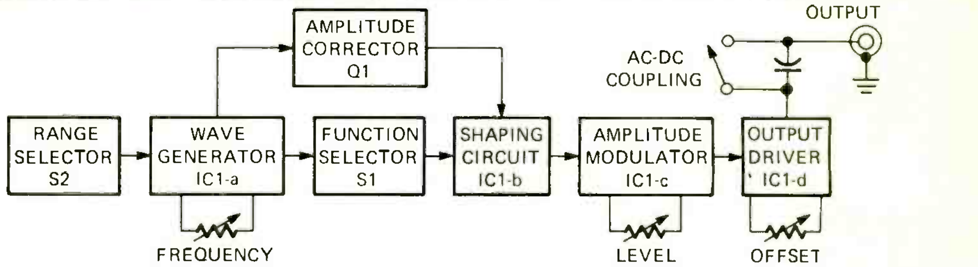
## SPECIFICATIONS

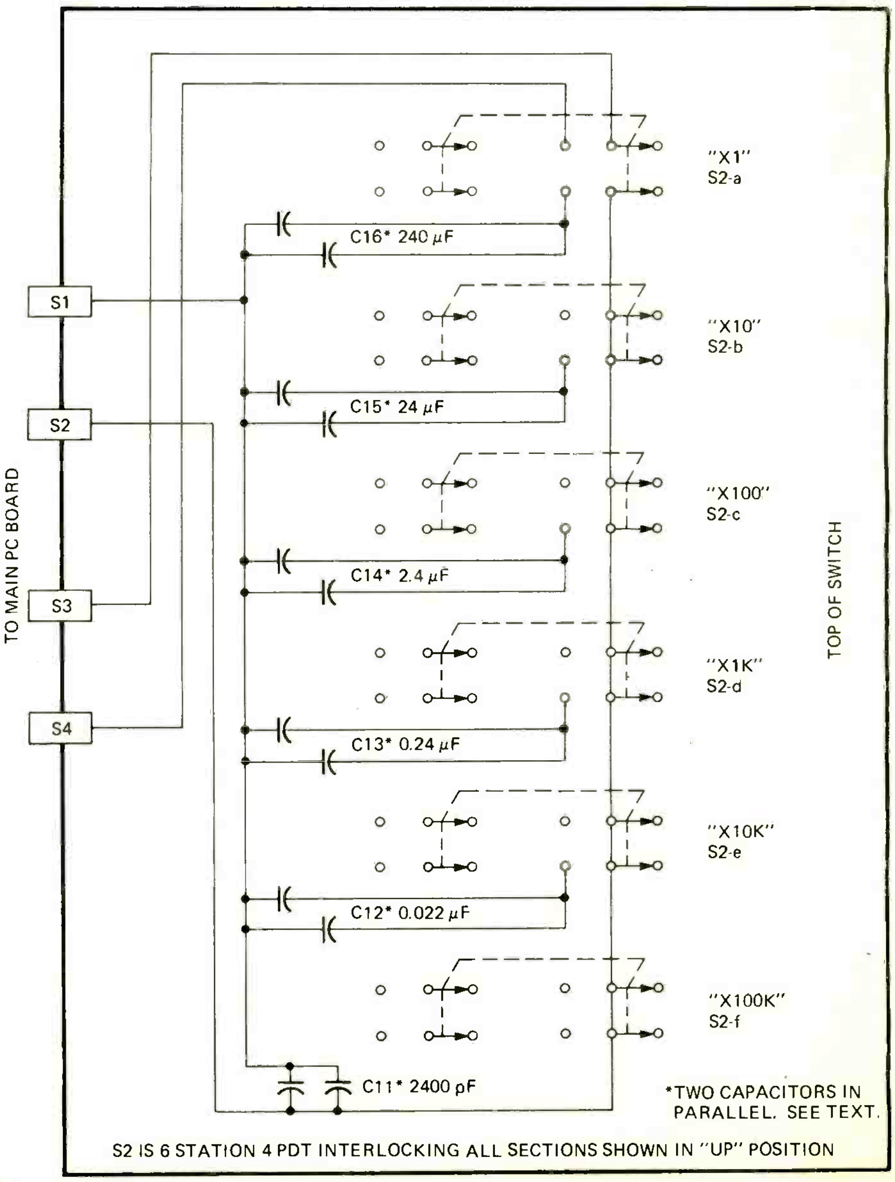
**FREQUENCY RANGE:** 1 Hz to 1 Mhz, pushbutton selected by decades and vernier adjusted over any one decade. Overall accuracy 2-5%

**FUNCTIONS:** Sine, Triangle, Square, Pulse, and Ramp

**AMPLITUDE:** Variable 0-2 volts Sine, Square, Pulse; 0-1.75 volts Triangle and Ramp. TTL compatable output using +0.6-volt baseline offset.

**OFFSET:** In DC Mode, adjustable from -2 to +2 volts giving high, centered, or low baseline. Capacitor coupled in ac mode.



**SPECIFIC…NS**

**DISTORTION:** S 2%; 3% over vernier frequency sine wave, less … range.

**DUTY CYCLES:** Pulse 20% typical; Square adjustable to 50%. Dial calibration not accurate on pulse range.

**OUTPUT IMPEDANCE:** 70 Ohms, Zener protected

**SIZE:** 2½" x 5" x 6½"; grey impact plastic case.

**WEIGHT:** 2 pounds

**MODULATION:** None in basic unit; AM, FM, VCO, remote gain, keying, etc. are easily added to the basic circuit.

way to do us any good, we invert it with a transistor and use this control voltage to steal a small amount of the shaper's current source. This increases the shaper gain as $R_x$ is now smaller with respect to the circuit currents than it was before. By keeping the transistor saturated for part of the pot's range, we don't start any correction till we need it. More and more gain is added as we get to the end of the pot. Looking ahead at Fig. 6, we see that R31 and R32 decide *how much* gain we add at the high end, while the *ratio* of R29 to R30 decides *when* in the pot's rotation the gain correction is to begin.

We control the gain with an electronic modulator as shown in Fig. 5-c. We can also inject signals here for amplitude modulation, remote volume control, keying, etc. If we like. The circuit is a true multiplier, which means it doubles as a balanced modulator. The circuit works by letting both the input and the control provide only a fraction of the available current to the output. Since the two fractions are cascaded, the *product* of the input and control appears at the output. Polarity may be controlled by reversing the difference in voltage on the control inputs. Zero difference gives zero gain, and one volt gives full gain, the polarity of the input determining which side of the waveshape ends up on top. The electronic gain control is internally directly connected to the shaper; all we have to do is connect up an external gain control or signal. Note that no waveforms have to travel through the pot and we can easily and safely use long leads without worrying about high frequency response falling off and causing misleading conclusions from the tests you are performing.

### Output buffer

A Darlington differential amplifier converts the output signal to one with enough current drive to handle a short circuit or another low-impedance load without damage. To adjust the offset, or how much dc we get out in addition to the waveshape, we capacitor-couple the buffer's input and add a variable bias that we control with the offset potentiometer. We also provide an output coupling capacitor that we short out when we want variable offset and insert for ac work.

### Circuit of the generator

The complete schematic is shown in Figs. 3, 4 and 6. Capacitors C11 to C16 select the decade frequency ranges, while R17 selects the vernier frequency and drives amplitude compensator Q1. Pots R9 and R11 put limits on the frequency control, so we can calibrate the upper and lower frequencies on the dial. Selector S1 picks the function we want and controls power to the +10,−10 volt conventional Zener supply.

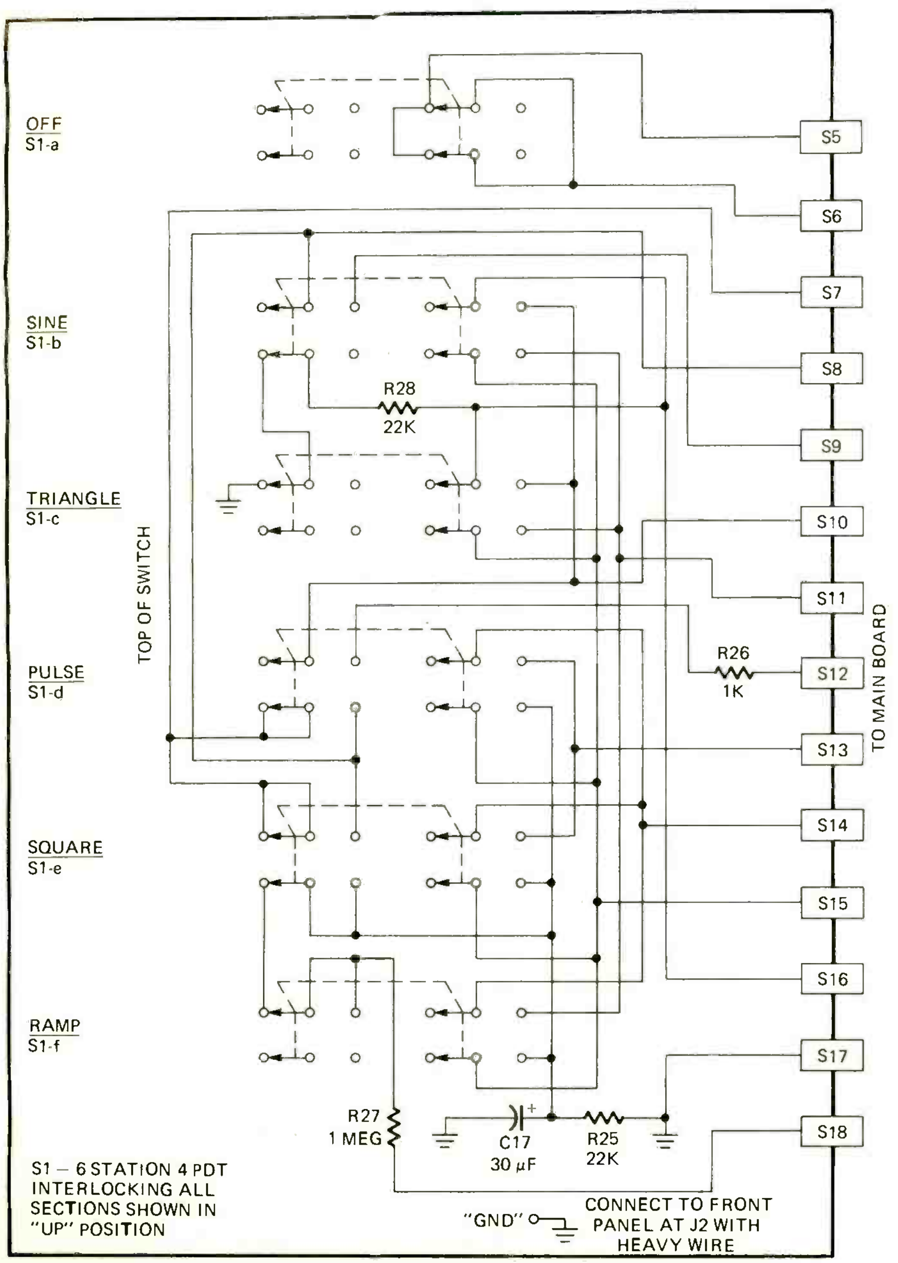
R19 controls the triangle waveshape, while R19 and R20 together control the sine waveshape. R21 to R23 provide the symmetry control, while R13 controls offset. Square, pulse, and ramp coupling is handled by C6, helped along C10 on the 1-Hz range. R27 switches in only during pulse operation to give a good pulse waveform.

The switching may seem complicated, but its really simple, particularly since the switches mount directly on the board, S1-a controls the ac power. If this button is *up,* the power is on. S1-b handles the sine wave. It first connects the shaper differentially to the

**FIG. 2—(left) BLOCK DIAGRAM OF GENERATOR gives an overall look at how the unit operates. The one IC does the lion's share of the work.**

**FIG. 3—(bottom left) RANGE-SWITCHING CIRCUIT Is on a separate printed-circuit board. An interlocking push-button switch, that mounts on this board, Is used.**

**FIG. 4—(below) FUNCTION-SELECTOR SWITCH forms another subassembly on a separate circuit board. Again an Interlocking pushbutton switch is used and is mounted on the board.**



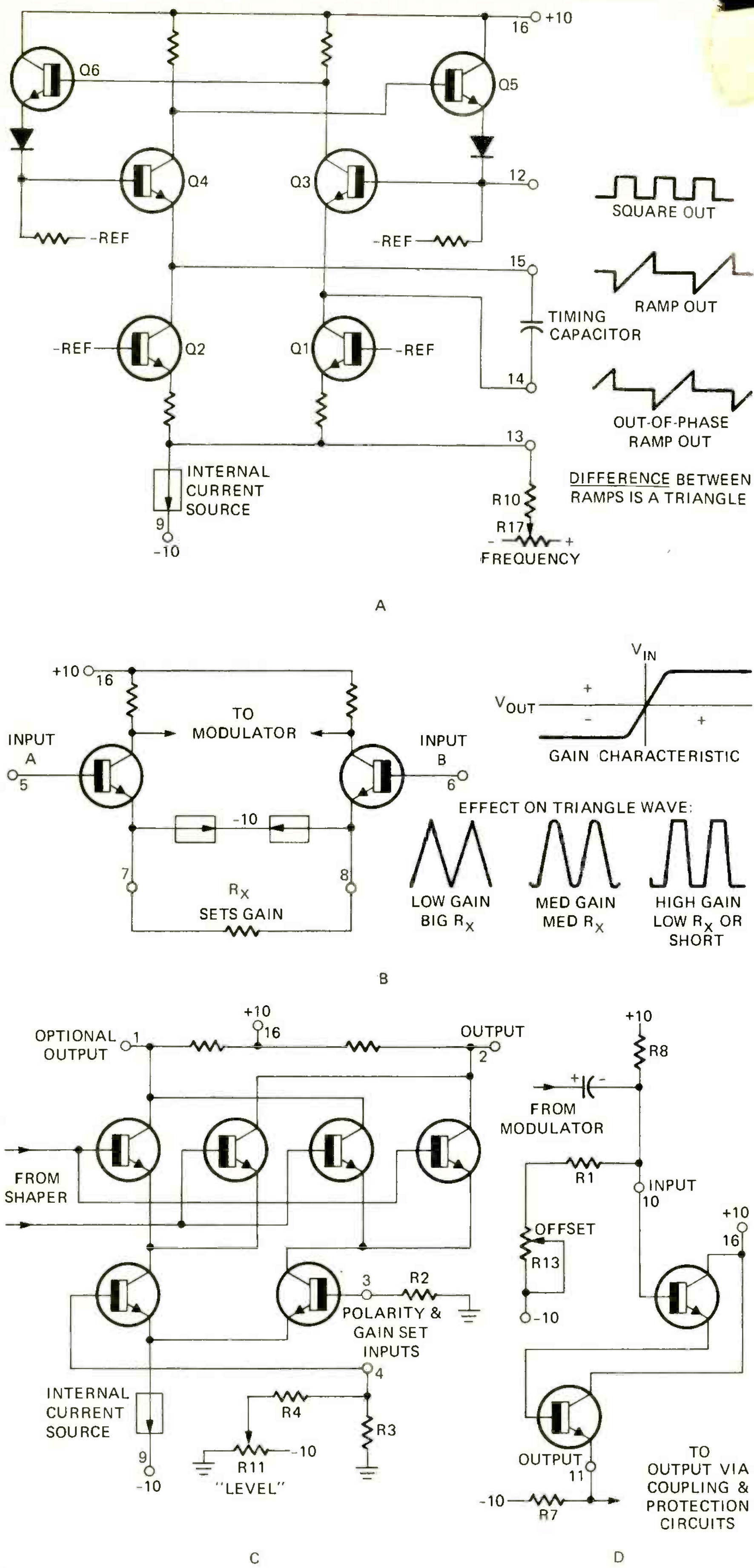



**FIG. 5—SIMPLIFIED DIAGRAMS OF PORTIONS of the waveform generator's circuitry. a—basic emitter-coupled astable multivibrator. b—shaping circuit is called a variable-gain differential amplifier. c—electronic modulator controls the gain. d—output driver.**

...d o... ...rate a trnhase ramp outputs to switches in enough wave. Then it shaper with R20 to give increase in the output. Finally, it prevents the sine wave getting into the circuit. R22 is used to bias the shape.

**That's all we have room for in this issue. Next month we will conclude the story by presenting the remaining text on construction and operation along with a complete set of circuit-board patterns, both foil and parts placement diagrams.**

**R-E**

### PARTS LIST

C1—1 μF, 400 volts, mylar
C2,C7—0.22 μF, mylar
C3,C9—500 μF, 12-volt electrolytic
C4,C5—1000 μF, 25-volt electrolytic
C6—3 μF, 6-volt tantalum
C8—6000 μF, 10-volt electrolytic
C10—50 μF, 6-volt tantalum
C11—Two parallel capacitors, 2400 pF, 2%
C12—Two parallel capacitors, .022 μF, 2%
C12—Two parallel capacitors, 0.24 μF, 2%
C14—Two parallel capacitors, 2.4 μF, 2%
C15—Two parallel capacitors, 24 μF, 2%
C16—Two parallel capacitors, 240 μF, 2%
C11—C16 Value shown is total capacitance
See October issue for capacitor selection details
C17—30-μF, 12-volt electrolytic
C18—0.1 μF, disc ceramic
D1,D2—Silicon power diode, 1 amp, 50 PIV, 1N4001 or equiv.
D3,D4—10-volt Zener, 1N4740 or equivalent
D5—15- to 20-volt Zener, 1N4744 or equivalent
F1—0.1-ampere fuse
IC1—XR-205 Function Generator IC (Exar)
J1,J2—5-way binding posts, 1 black, 1 blue
Q1—2N5129 transistor, silicon npn
R1,R25,R28—22,000 ohms, ¼ watt
R2,R3,R29—4700 ohms
R4,R31,R32—47,000 ohms
R5,R21,R22,R30—10,000 ohms
R6,R24—12 ohms
R7—1500 ohms
R8—33,000 ohms
R9—1000 ohms upright PC potentiometer
R10—680 ohms, ¼ watt
R11—1000 ohms upright PC potentiometer
R12,R18—330 ohms, ¼ watt
R13—50,000 ohms linear potentiometer with spst pull switch
R14—5000 ohms linear potentiometer
R15,R16—100 ohms, ½ watt
R17—1000 ohms linear potentiometer
R19—5000 ohms upright PC potentiometer
R20—5000 ohms upright PC potentiometer
R23—250,000 upright PC potentiometer
R26—1000 ohms, ¼ watt
R27—1 megohm, ¼ watt
S1,S2—six station, 4PDT interlocking
S3—spst pull switch on R13
T1—Power transformer: 20 Vct @ 60 mA, PC mount, *Signal* PC-20-60

**MISC: Main, Selector, and Range PC boards, punched front panel; Impact plastic case; line cord; ¾" knobs (2); skirted 2¼" knob with special calibration; flat cable or wiring harness; capacitor clip; no skid feet; fuse clips; PC terminals; angle brackets (4); mounting hardware; plastic machine screws for front panel; mylar button callouts; ground lug; wire; sleeving; solder.**

**NOTE: The following are available from Southwest Technical Products, 219 West Rhapsody, San Antonio, Texas, 78216**
**Set of three PC boards, etched and drilled FGb, $8.25**
**Complete kit of all above parts FG-1, $39.95**

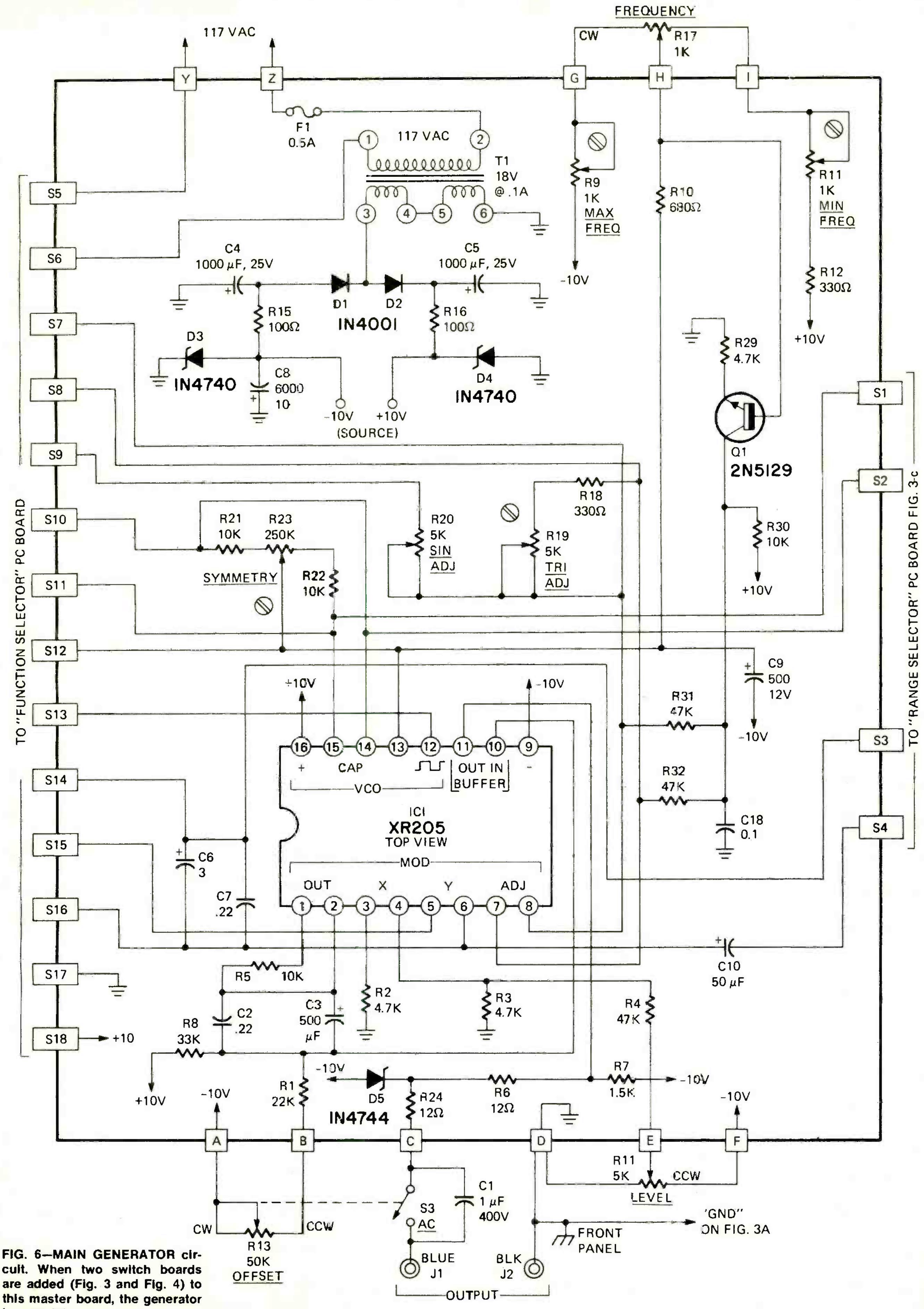



**FIG. 6—MAIN GENERATOR circuit. When two switch boards are added (Fig. 3 and Fig. 4) to this master board, the generator is complete.**

# GHOSTS due to mismatches

*This common type of interference—most often mistaken for smear—is easy to identify and eliminate by proper impedance matching.*

by FRED J. SHULTZ*

TV GHOSTS ARE USUALLY THOUGHT OF as those caused by reflections in the receiving path, between transmitter and antenna. But in this article we shall examine ghosts caused between antenna and TV set.

First let's look at the well matched installation in Fig. 1. In such an installation all the signal picked up by the antenna "flows" to the TV set (except for signal dissipated in the twin lead due to its loss).

However, if the TV set does not have an impedance of 300 ohms some of the signal is reflected as shown in Fig. 2.

It is obvious that the mismatched TV set "receives" less signal if some of

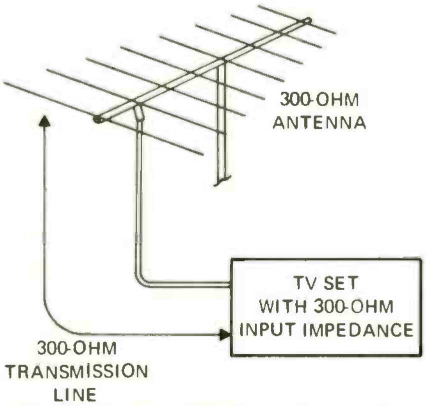



**FIG. 1—IN A WELL MATCHED INSTALLATION the antenna, lead-in or transmission line and the receiver all have identical impedances.**

it is reflected back towards the antenna. This loss of signal is not too serious as we shall see later. The reflected signal returns to the antenna and is radiated by it if the antenna has a 300-ohm impedance, some of the reflected signal is *re-reflected* toward the TV set. This is when we are in trouble (Fig. 3).

Figure 3 shows that the original signal traveled only once thru the lead-in. However, you will notice that the re-reflected signal traveled through the lead-in *three* times. Since it takes time for a signal to travel thru space or a transmission line, the re-reflected signal will arrive later than the original signal. On the TV screen, the main TV picture

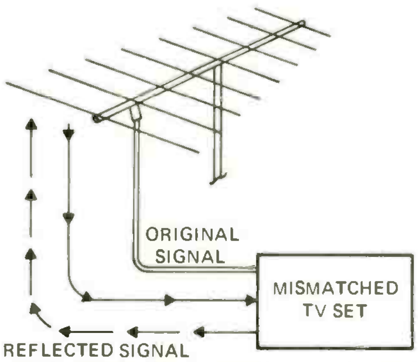



**FIG. 2—MISMATCH AT INPUT TO TV TUNER causes incoming signal to be reflected back toward antenna where it may be re-radiated.**

will be followed by a second weaker image. This is what we call a ghost. The same thing will happen if the lead-in is not of constant impedance throughout its full length.

Before we can talk about cures for mismatches we should know what

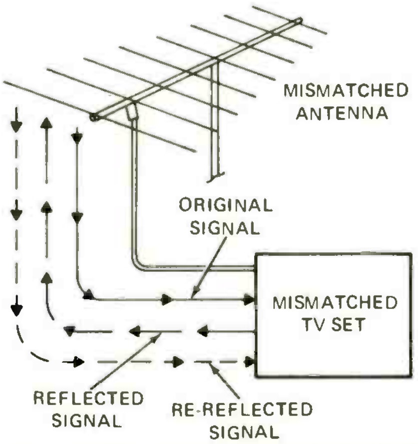



**FIG. 3—WHEN ANTENNA DOES NOT MATCH the lead-in's impedance, signal re-reflected from antenna to set causes weak ghosts.**

causes them. Let's look at the antenna.

Most antennas are designed for 300-or 75-ohm impedances. However, there are badly mismatched antennas on the market. In addition, a well-matched antenna can lose its good

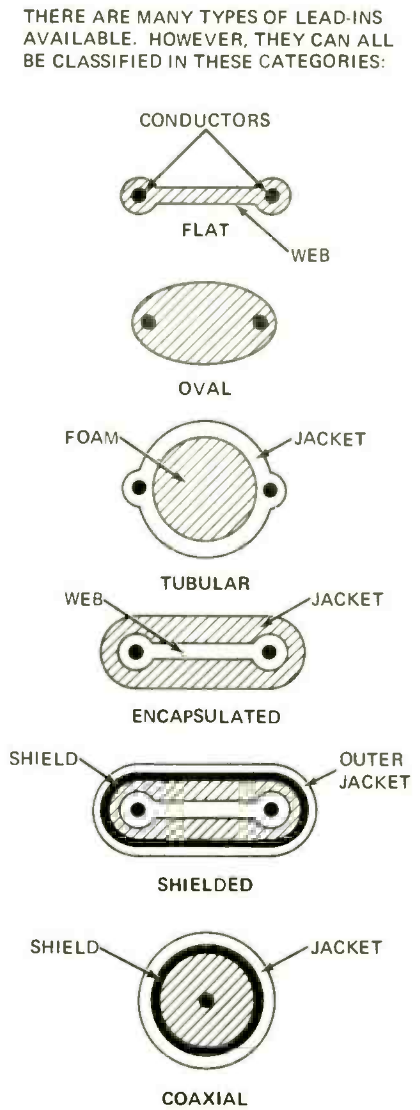



**FIG. 4—CROSS-SECTION of the most popular types of transmission line. Not shown are the perforated flat and open-wire lead-ins.**

*Reprinted from "Solution 3," Copyright Blonder-Tongue, 1969 match if its elements are bent or missing. Also, an antenna that is exposed to salt spray can become mismatched because of conductive brine. These mismatches often occur on certain channels only.

Another source of mismatch that can cause reflections is a badly aligned TV tuner. Only a complete realignment can cure this type of problem. Sometimes the lead-in itself is a prime cause of the mismatch.

Let's examine the different types of lead-ins now available and see how they can contribute to the problem. All these lead-ins consist of two separate conductors (see Fig. 4). In twin lead, the two parallel wires serve as the conductors. In coaxial cable, the center-conductor and the shield are the conductors.

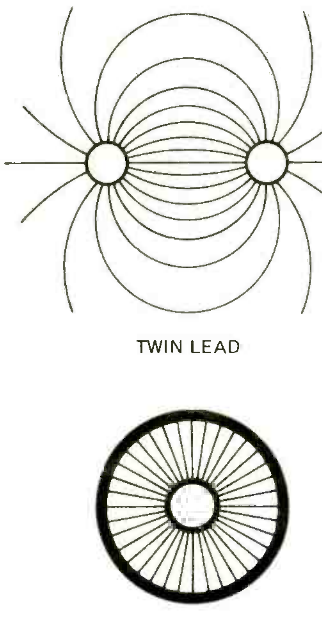



**FIG. 5—ELECTRICAL FIELD around twin-lead extends into space. In coax the field is confined by the outer conductor or shield.**

Unlike 60-Hz power or low-frequency ac where the electrical energy flows in the conductor, rf energy is contained in the field surrounding the two conductors. The impedance of twin lead depends on the size and spacing of the two conductors as well as the material between the conductors. For coaxial cable, the impedance is determined by the outside diameter of the center conductor, the inside diameter of the shield, and the dielectric between them.

The electric field surrounding a section of twin lead and a section of coaxial cable can be visualized as in Fig. 5. If we disturb the field, we alter the impedance of the cable and therefore cause a mismatch. In coaxial cable it is very hard to disturb the field since it is contained within the shield. However, the field can be disturbed by squashing the cable, making a very sharp bend in it, or by driving a nail through it. With flat twin lead it is very easy to disturb the field and cause a mismatch. If we bring a piece of metal near to it, we can create a beautiful ghost. Therefore, always keep twin lead away from metal or other conductors.

Less obvious is the effect of dirt on twin lead. This dirt can cause a greater loss which results in snowy pictures on the TV screen. In addition, dirt is a conductor particularly when wet. As a conductor, it creates a shorting loop around the twin lead and in turn changes the characteristic impedance all along the cable. The resulting mismatches cause many reflections and re-reflections. These closely spaced reflections are seen on the TV screen as smear.

How can we find out if ghosts are caused by mismatches or by other means? To do this we need an attenuator. A 12-dB pad as shown in Fig. 6.

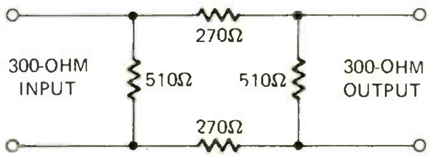



**FIG. 6—ATTENUATOR PAD is handy when analyzing ghosts to see if they come from antenna mismatch or from other causes.**

Insert the pad between the TV set and the input line. If the ghost gets weaker compared to the main image, you have mismatch ghost (or smear); if it stays the same, look for other causes.

Of course it is assumed that you already made the obvious test of checking the signal quality on a well aligned portable receiver to make sure the ghost or smear is not caused by a defective (usually misaligned) TV set. If the ghost changes when the fine tuning is operated, the tuner itself needs servicing.

Also keep in mind that ghosts are a lot more annoying on a color picture than on a black and white one. The ghosts, which are delayed signals, can create "colorful fringes" on objects. For this and for other reasons, color pictures are less forgiving than black and white. This is one of the major reasons some manufacturers make a point of calling coaxial cable a must for color TV installations. Strictly speaking, this is not so; what must be done is to make a mismatch free installation. If 300-ohm lead-in is chosen, one should use encapsulated twin lead and good standoffs throughout the system.

To this day, 300-ohm line is still very popular, since most antennas and TV sets have a 300-ohm impedance. Therefore, when using coaxial cable with 300-ohm antennas and 300-ohm sets, make sure that matching transformers are used. If you don't you can cause severe ghosting. **R-E**

**STATE OF SOLID STATE**
*(continued from page 52)*

multiplexer with a 3-line binary decode input for channel selection; it features a ± 15 V analog signal range and an $r_{ON}$ of less than 500 ohms over its full temperature and signal range, requiring standby power of only 36 mW (typical). The unit is housed in a 28-pin dual in-line package. The DG511, shown in Fig. 7-b, is a 4-channel differential analog multiplexer with a 1-out-of-4 decoder which features a ± 10 V analog signal range and less than 250 ohms $r_{ON}$. The device is offered in a 16-pin ceramic DIP.

A seven-segment LED numeric display that includes an integral MSI BCD counter, 4-bit latch, and a decoder/driver in a single 16-pin package is now available from the Dialight Corporation (60 Stewart Ave., Brooklyn, NY 11237). Illustrated in Fig. 8, the new display, model 745-0009, is completely TTL/DTL compatible, with its buffered inputs implemented by relatively large resistors in series with the bases of the input transistors to lower drive-current requirements to half of that required for a conventional series 54/74 TTL input; the serial-carry input, then, actually two internal loads, is rated as one standard series 54/74 load. The unit's driver outputs are designed to maintain a relatively constant on-level current of approximately 15 mA for all LED segments and 7 mA through the decimal point. Inputs are diode-clamped to minimize transmission-line effects. With a character height of 0.270 inch, the 745-0009 has a maximum clock frequency of 18 MHz, while its power dissipation is typically 825 mW when all segments are on.

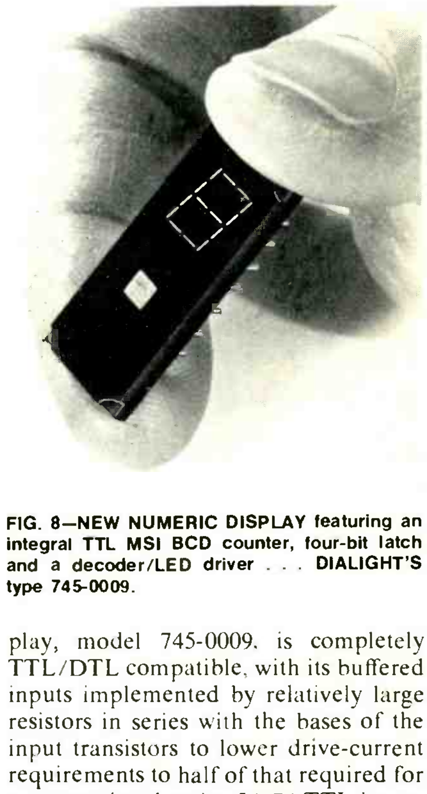


**FIG. 8—NEW NUMERIC DISPLAY featuring an integral TTL MSI BCD counter, four-bit latch and a decoder/LED driver . . . DIALIGHT'S type 745-0009.**

That's all for this issue. Be seeing you again—with more late news. **R-E**

# OP-AMPS AT WORK using the 709

by B.R. ROGEN

ONE OF THE MOST COMMON OPERATIONAL amplifiers available to the experimenter is the 709 in its various forms. This small, but powerful package of gain is low in cost, and is obtainable through a host of suppliers (see the rear pages of electronics magazines).

The basing diagrams for the TO-5 and DIP package have been defined in previous articles of this series. Table I spells out the electrical characteristics that can be used when designing a circuit.

One of the major problems when using the 709—which must be compensated—is to decide just how much resistance and capacitance is required in the input circuit, and how much capacitance in the output circuit. To save a lot of trouble, refer to Fig. 1 for closed-loop response (that is when some type of feedback is used). If you are going to use the 709 in an open-loop circuit, use Fig. 2 to calculate the compensation required. Note that in both cases, the value of components used is a function of the gain required at some frequency. Both these graphs are calculated with a ±15-volt power source, and at 25°C. (room temperature).

**General precautions.** Like all other semiconductors, the op amp can fail catastrophically under certain conditions, or abnormal performance can result from some simple electrical condition. Fig. 3 shows a number of precautions that can be taken to insure long life for your op amp. Obviously, the first thing that can go wrong is to use too high a dc power supply. In the case of the 709, ±15 volts is the recommended maximum. The differential voltage (that is, the voltage between the inverting and non-inverting inputs) should not exceed ±5 volts maximum.

**Latch-up.** The common-mode voltages for the 709 are determined for negative inputs by saturation of the current source transistor, and for positive inputs by saturation of the input transistors. Exceeding the positive common-mode limit of the device may damage the inputs by excessive current. Even if the current is limited to a safe value, erratic operation can still result. If the transistor saturates on inverting input, it no longer acts like an inverting amplifier but makes a direct connection between the input and base of the second stage transistor, thus becoming a non-inverting input. This results in positive feedback, and the amplifier will latch up if it is possible for the output voltage to hold the input stage in saturation through the feedback network.

One way to overcome this is shown

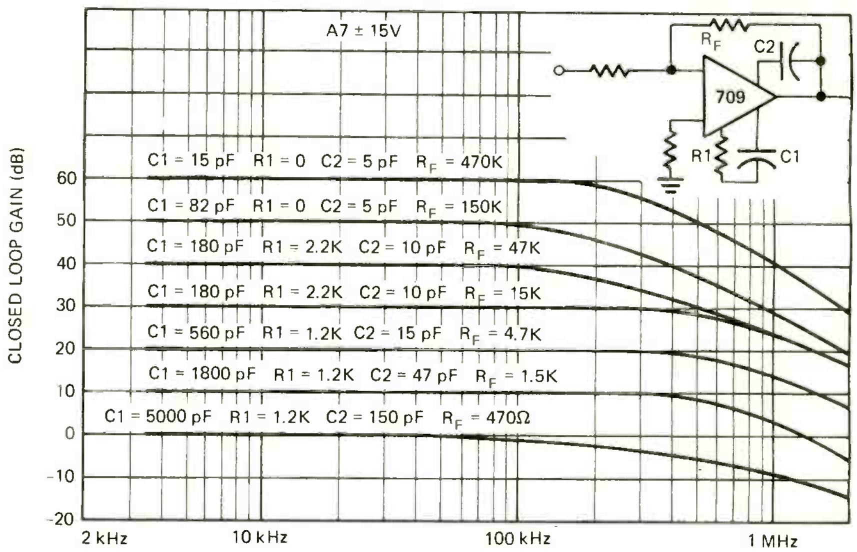



FIG. 1—COMPENSATION for closed loop.

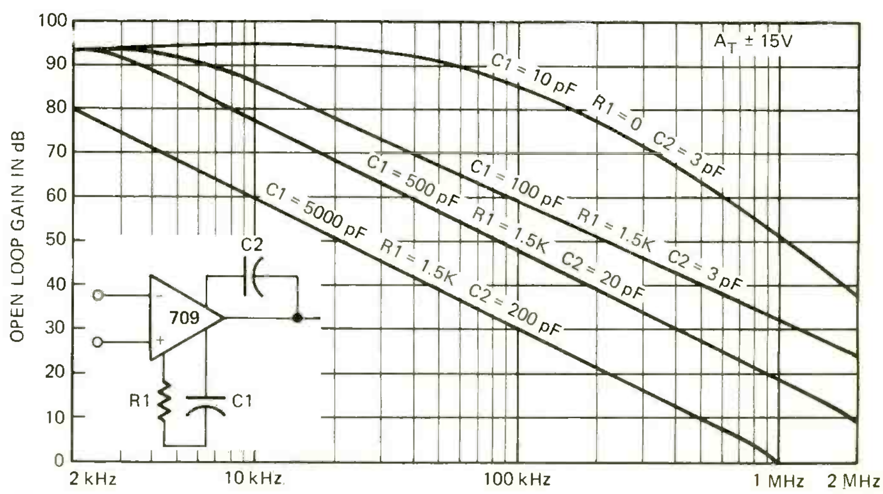



FIG. 2—OPEN-LOOP compensation values.

*A very common, but powerful package of gain that can be a most valuable building block in all kinds of practical everyday applications*

| | |
|---|---|
| Gain | 45,000 |
| Input Offset Voltage | 1 mV |
| Input Offset Current | 50 nA |
| Input Bias Current | 200 nA |
| Input Resistance | 400,000 ohms |
| Output Resistance | 150 ohms |
| Common-Mode Rejection | 90 dB |
| Slow Rate | .25V/μsec |
| Differential Input Voltage | ±5 max. |
| Output Short Circuit | 5 seconds max. |
| Power Consumption | 80 mW |

Open-loop voltage gain increases by 8 dB from ±9 to ±15 volts applied dc.

in Fig. 3-a. The output voltage is prevented from rising higher than the common-mode limit by the diode clamp shown. This modification keeps the input transistor from going into saturation and latch-up cannot occur. Another method, shown in Fig. 3-b, uses a pnp transistor connected across the input terminals. In normal operation, the transistor is turned off because the voltage between the inputs is only a few millivolts. When a transient or the input signal exceeds the common-mode range, the output of the op amp goes into positive saturation. The amplifier does not remain latched up after the transient leaves; instead the transistor turns on and pulls the inverting input back to the common-mode range.

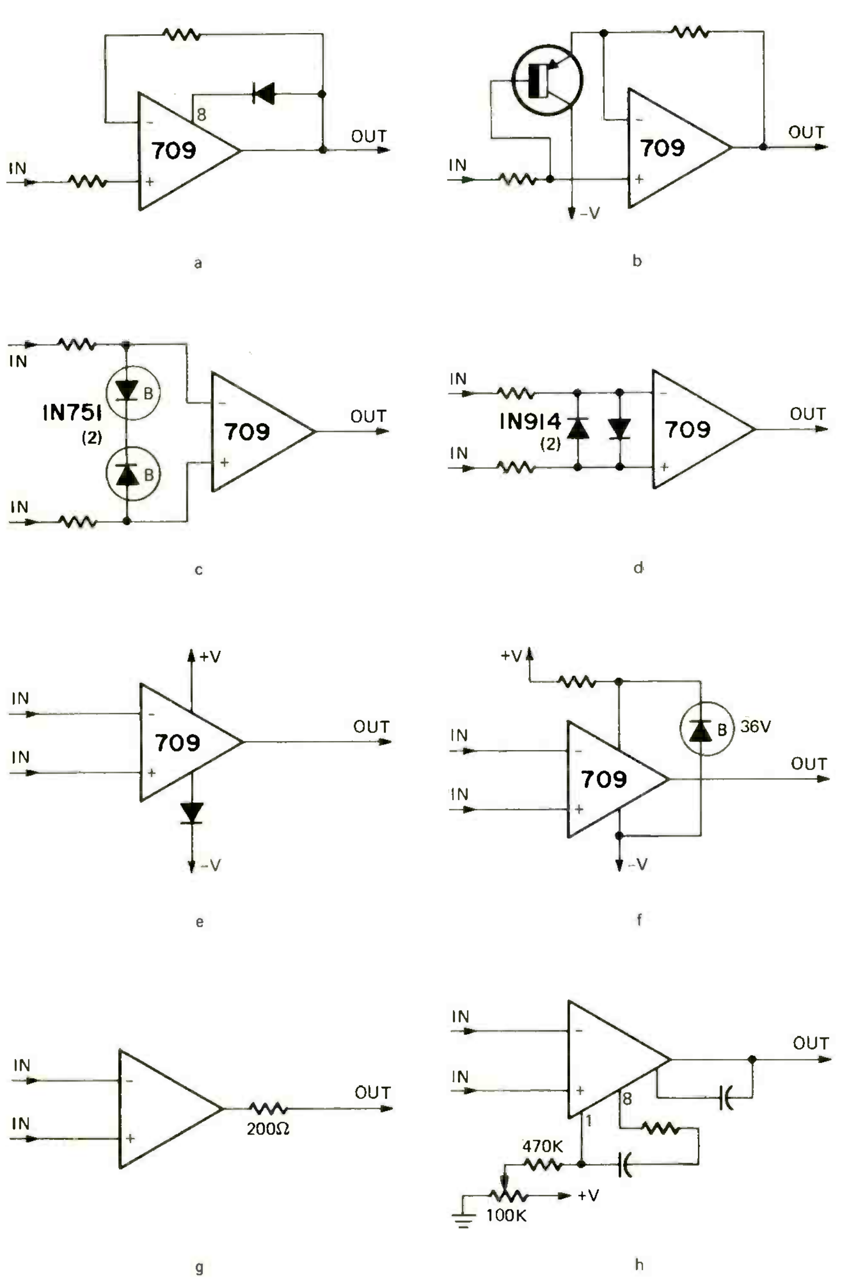



**FIG. 3—KEEPING YOUR 709 within safe limits: (a)—diode clamp holds the voltage down; (b)—transistor shorts on strong input signals; (c,d)—diodes can be used to protect the inputs; (e)—diode protects against reversal of voltage; (f)—a Zener diode regulates the power supply; (g)—resistor in output circuit holds within limits; (h)—an easy way to null the 709.**

**Differential damage.** We mentioned the damage that can be done by excessive differential voltage. If this voltage produces a current of about 50 mA, the op amp will be destroyed. The simplest protection is shown in Figs. 3-c and 3-d. Either a pair of ordinary diodes or Zeners can be used to protect the inputs. At low voltage levels, these diodes have no effect on the operation; they work only when their junction levels are exceeded.

**Polarity reversal.** Another easy way to "pop" an op amp is to reverse the polarity of the applied dc. The simplest approach to this problem is to insert a diode in the power line as shown in Fig. 3-e. The worst that can happen here is a low voltage drop (0.7 volt in a silicon diode) in the supply voltage.

**Maximum supply voltage.** The maximum steady-state dc voltage that can be applied across the op amp is 36 volts (±18 volts). If you have worries about your power supply, connect a 36-volt Zener across the op amp as shown in Fig. 3-f.

**Output shorting.** The 709 can tolerate an output short circuit for a couple of seconds or so, and can deliver up to 75 mA during this interval. Keep this current drain up too long, and the chip just plain melts. Fig. 3-g shows how to connect a low-value resistor in series with the output to keep the short-circuit current under control.

**Easy nulling.** A convenient and safe way to null a 709 is shown in Fig. 3-h. The 470,000-ohm resistor simulates a current source with the level adjusted by a potentiometer. The stability of the null depends on the stability of the power supply used. **R-E**

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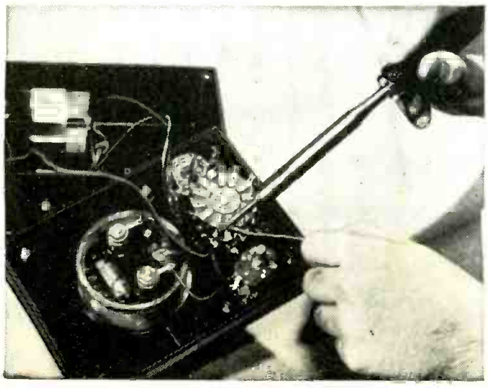
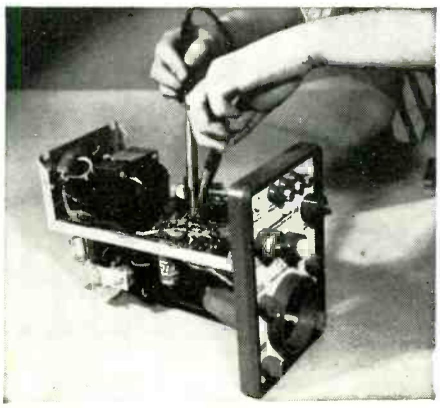
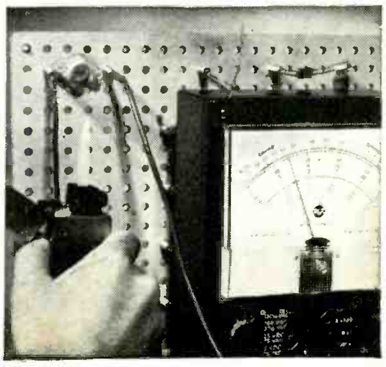
Construction of Multimeter.





Construction of Oscilloscope.

Temperature experiment with transistors.



# THE STATE OF

# SOLID STATE

*FET designs, solid-state triodes and pentodes, a complementary oscillator, and several other new semiconductors in the spotlight*

**by LOU GARNER**
SEMICONDUCTOR EDITOR

IF, FOR SOME OBSCURE REASON, you've been avoiding field-effect transistors and favoring the more familiar bipolar types, now's the time to put it all together. These valuable and versatile devices can be used variously in a variety of very exciting projects.

Two interesting and useful circuits are illustrated in Fig. 1. Both feature standard FET's in conjunction with a commercial IC operational amplifier and both were abstracted from *FET Design Ideas,* Bulletin CB-145, a 20-page booklet published by Texas Instruments, Inc. (P.O. Box 5812, Dallas, TX 75222). A number of other interesting circuits are featured in the booklet and we will examine some of these in future columns.

The Wien-bridge oscillator in Fig. 1-a uses a FET as one arm of the basic bridge, while an IC amplifier provides the feedback needed to initiate and maintain oscillation. The FET'a effective source-drain impedance is controlled by applying an adjustable signal to its gate electrode obtained from the output circuit through a 1 meg ohm potentiometer which serves as an AMPLITUDE CONTROL. In operation, the circuit's output frequency can be determined by the formula:

$$\frac{1}{2\pi RC}$$

where R and C are the values in megohms and $\mu$F, respectively, of the components in the series and parallel arms of the bridge. Normally, a matched dual 500,000-ohm to 1 megohm (or larger) potentiometer would be used as the circuit's FINE FREQUENCY CONTROL, while different C values would be selected by means of a suitable rotary switch to provide the desired number of ranges.

Featuring a high 10-megohm input impedance, a polarity reversing switch, and a zero adjustment control for maximum accuracy, the millivoltmeter circuit in Fig. 1-b uses two FET's and an IC amplifier in conjunction with an inexpensive 0-1 mA meter. Its input voltage divider permits full-scale measurements from 50 volts down to a minute 10 mV. Although precision resistors (1% tolerance, or better) should be used in the range-selection voltage divider circuit, the design is basically non-critical and can be duplicated easily in the home laboratory by the average technician or skilled hobbyist.

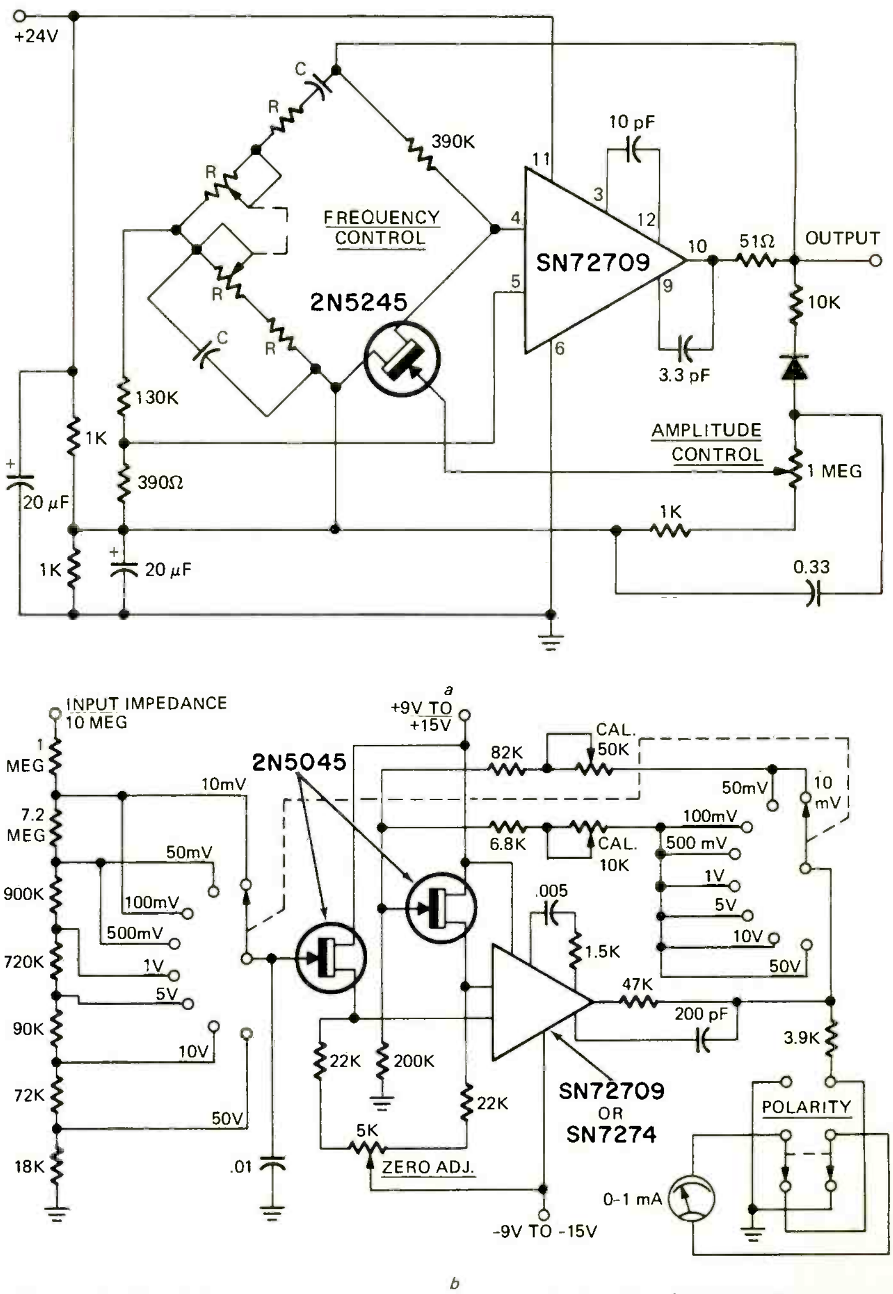



**FIG. 1—FET CIRCUITS suggested by Texas Instruments: (a) Wien-Bridge Oscillator; (b) Millivoltmeter.**

Electronic Devices Incorporated (21 Gray Oaks Ave., Yonkers, N.Y. 10710) International Rectifier Corporation (233 Kansas St., El Segundo, CA 90245) and Sarkes Tarzian, Inc. (415 North College, Bloomington, IN 47401) have all been offering solid-state plug-in replacements for common rectifier tubes for several years. But the *real news* is that one manufacturer is now offering solid state direct plug-in replacements (except for filaments or heaters) for popular pentode and twin triode vacuum tubes, while another is offering a solid-state replacement for a high-voltage, high-power mercury vapor rectifier.

Dubbed *Fetrons*, the solid state amplifier tube replacements are the products of Teledyne Semiconductor. For a list of distributors who sell these units, write Dick Kors, Director of Product Marketing, Teledyne Semiconductor, 1300 Parra Bella Ave., Mountain View, CA.

Vacuum tube characteristics have been achieved in a solid-state device by using special high-voltage JFET's (hence the name), cascaded as needed to obtain the desired electrical specifications. In most cases, except where series heater strings require the installation of an external voltage dropping resistor across the "heater" pins, the *Fetron* may be plugged in as a direct replacement for a vacuum tube within its "family."

Three *Fetron* types are in current production:( the TS6AK5, designed as a solid-state replacement for members of the 6AK5 vacuum tube family, such as the 6AK5, 5654, 6AG5, 6BC5, 6AU6, 12AU6, 7543, 6BH6, 6DT6-A, 12AW6, 3AU6, 3BC5, 3DT6, 4AU6, 4BC5, 408A, 6DC6, 6CE5, 1220 5591, 6AM6, and so on, as well as for such foreign tubes as the 6F32, DP61, E95F, EF905, EF96, 12F31, etc.; the TS6AK5-OSC, which is similar to the TS6AK5, but with internal feedback to improve its performance in oscillator applications; and, finally, the TS12AT7, intended as a direct replacement for members of the corresponding vacuum tube family, including the 12AT7, 12AU7, 6BC8, 6BQ7-A, 6CG7, 6J6, 7AU7, 9AU7, 8CG7, 12AV7, 6DT8, 6EV7, 12BZ7, 6201, 6679, 12AX7, 12AZ7, 6BZ8, and such foreign tubes as the B152, B309, ECC81, ECC82, E81CC, ECC801, and so on.

As might be expected, the solid-state devices are somewhat more expensive than the vacuum tubes which they replace, but, with no heater to burn out and virtually unlimited life, may be much cheaper in the long run. In addition, they offer the advantages of much lower shot noise and hum levels than tubes, a plus factor in hi-fi and critical instrumentation applications.

The TS6AK5 nets for $12.50 each in 1-99 quantities; the TS6AK5-OSC is $13.50; finally, the TS12AT7 is $15.60 each.

The Standard Rectifier Division of the Coherent Component Corporation (2200 South Fairview St., Santa Ana, CA 92704) is now offering a direct solid-state replacement for the GL-857B high-power mercury vapor rectifier tube and equivalent types. Illustrated in Fig. 2 along with the tube it replaces, the new device, type SRL 857B, consists of stacked silicon diodes, each with an integral heat sink assembly. It can be used with both convection and forced-air cooling.

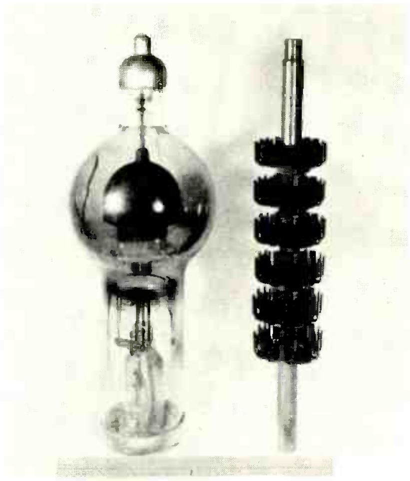


**FIG. 2—STANDARD RECTIFIER'S SRL 857B silicon solid state rectifier shown with the high power mercury vapor tube it replaces.**

With convection cooling, the SRL 857B has a PIV rating of 22,000 volts at 25°C and can supply currents of 8.0 amperes. It has a one-cycle surge current rating of 2500 amperes and can withstand overload currents of up to 300 amperes for up to 30 seconds. Its reverse leakage current at 8 amps, 9,000 volts is a tiny 10 ma. Currents of up to 16.0 amperes and a PIV of 32,000 volts can be handled when forced air cooling is used.

## A complementary oscillator

Designs using the opposite, but similar, dc polarity requirements of *p*-type and *n*-type devices are known, appropriately, as *complementary* circuits. One of the simplest is illustrated in Fig. 3-a, a two-stage direct-coupled amplifier using *npn* (Q1) and *pnp* (Q2) bipolar transistors in the common-emitter configuration. If desired, the two devices may be interchanged, provided the dc (B1) polarity is reversed.

In operation, R1 serves as Q1's base resistor and may be returned either to B1's positive or to circuit "ground," as shown by the dotted line, depending on the bias class desired and Q1's leakage characteristics. $R_L$ serves as Q2's output load and, in practice, may be a resistor, inductance, transformer primary, relay, solenoid, or even a loudspeaker or headphone voice coil.

At first glance, it may appear that Q1 lacks a collector load and source of collector bias and that, similarly, Q2 has no source of base bias. In reality, however, Q1's collector load is Q2's base-emitter impedance. Simply imagine a resistor symbol, representing this impedance, between Q2's base and emitter electrodes. By the same token, Q1 serves simultaneously as both a signal and base bias source for Q2. Again, simply imagine a resistor between Q1's collector and emitter electrodes, representing Q1's collector-emitter impedance.

Despite the circuit's simple arrangement and seeming lack of familiar load and bias components, each stage behaves as a conventional common-emitter amplifier. There is, therefore, a 180° signal phase shift between the base and collector of Q1, another between the input (base) and output of Q2. With a 360° phase shift between the amplifier's input (Q1's base) and output (Q2's collector) terminals, the circuit may be converted into an effective relaxation oscillator simply by adding a single feedback device, as capacitor C in Fig. 3-b.

As relaxation oscillators do, this circuit develops a pulse-like wave-form rather than a sine-wave. Its repetition rate (frequency) depends on its RC time constants and on the supply voltage.

Extremely versatile, the complementary oscillator circuit in Fig. 3-b may be used in a metronome, code-practice oscillator, ultrasonic generator, tone source, or periodic timer, depending on the choice of output loads, transistors, and component values. It can deliver modest amounts of power if Q2 is a power transistor rather than a small-signal type. All things considered, it is a fine circuit for experimental study and

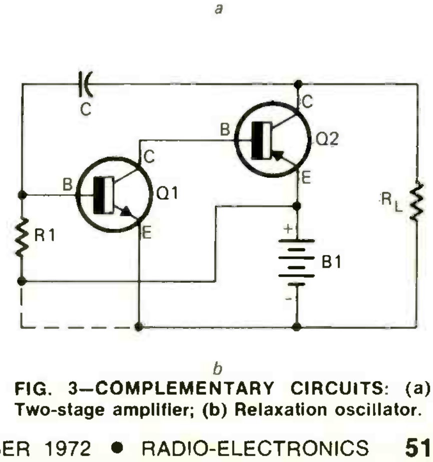



**FIG. 3—COMPLEMENTARY CIRCUITS: (a) Two-stage amplifier; (b) Relaxation oscillator.**

low-cost construction projects.

## Painless transistor training

A three-part training program that will enable distributors to hold impressive, ready-made seminars for their technician customers is now available from RCA/Electronic Components (415 South Fifth St., Harrison, NJ 07029).

Featuring audio-visual aids, the training program, designed to teach transistor servicing techniques, is divided into three parts: Part 1—*Basic Techniques For Transistor Servicing*, Part 2—*Identifying The Defective Stage*, and Part 3—*Identifying and Replacing The Defective Component*. Each part comprises a "Carousel-type" slide tray with color 35-mm slides, a cassette-tape with a prerecorded dialog keyed to the slides, and a printed lesson booklet for use by the instructor and students (Fig. 4).

Part 1 covers the selection of proper test equipment and tools, a quick test for open or shorted transistors and identification of the leads of unmarked transistors.

Part 2 includes a six-point "Quick Test" that covers visual inspection, battery voltage test, current drain measurements, speaker circuit click-test and local oscillator and agc tests. In addition, stage-by-stage voltage gain tests are outlined to pinpoint the defective stage.

Finally, Part 3 provides instructions for checking transistor voltage and current readings, checking capacitors for opens and in-circuit tests to determine defective transistors; also included is information on the use of transistor testers and instructions for assembling a "go/no-go" MOS/FET checker.

Each lesson part is about 25 minutes in duration.

## Device/product news

New items from RCA—the Solid State Division (Route 202, Somerville, NJ 08876) has introduced three new rf transistors plus a trio of medium high power SCRs, and has published revised editions of two of their special device catalogs.


FIG. 4—TECHNICIAN following RCA's new Transistor Servicing Course.

Described in their recently revised catalog-folder RFT-700J, *RF Power Transistors*, RCA's new rf devices are *npn* silicon overlay transistors designed for use in vhf marine transmitters and high-power class-C amplifiers. Designated types 40953, 40954 (Fig. 5), and


FIG. 5—NEW SILICON RF TRANSISTOR introduced by RCA . . . type 40954.

40955, the devices in cascade can provide 25 watts (minimum) output at 156 MHz when operated from a 12.5-V dc supply.

RCA's latest additions to their family of SCR's are 35-ampere 800-volt devides intended for applications in power switching, power-control, voltage-regulator, heating, lighting, and motor speed-control circuits. Identified as types 40937, 40938, and 40952, the units are basically similar except for packaging. All three devices are described in the firm's recently revised 28-page catalog THC-500B, *Thyristors/Rectifiers*. In addition to specifications and maximum rating data for RCA's line of Triacs, diacs, SCR's, and rectifiers, the catalog includes outline sketches, terminal connections, and a valuable "Designer's Guide For Rectifier Circuits."

Motorola Semiconductor Products, Inc. (P. O. Box 20912, Phoenix, Arizona 85036) has announced a new series of eight Thermowatt Triacs which can provide full wave ac control with rms currents of up to 12 amperes. Assembled in standard TO-66 plastic packages, as shown in Fig. 6, the new units are identified as types 2N6342 through 2N6349 with 8-ampere ratings and types 2N6342A through 2N6349A with a 12-ampere spec. Depending on type, blocking voltages range from 200 up to 800 volts. Maximum surge current ratings are 100 amperes for the standard units, 120 amperes for the "A" types.

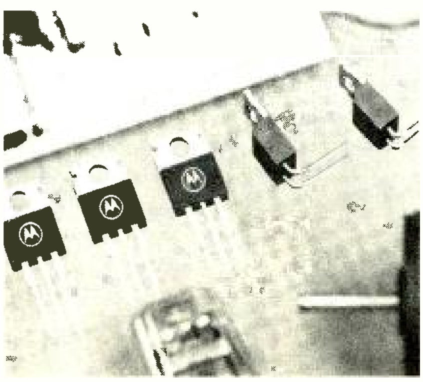


FIG. 6—MOTOROLA'S NEW Thermowatt triacs, types 2N6342 through 2N6349, are offered with both straight and formed leads, as shown above.

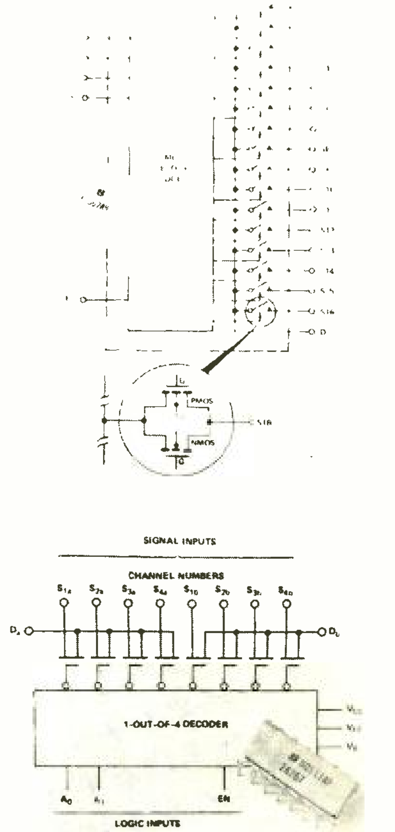


FIG. 7—SILICONIX'S NEW DG507 CMOS 8-channel differential analog multiplexer (a) and DG544 4-channel device (b).

Also from Motorola comes news of a hybrid IC device designed to interface TTL clocks with MOS systems. Designated the MPH401 clock driver, the new device is capable of sourcing and sinking the large peak currents necessary to achieve high clock rates when driving highly capacitive loads. When driving a 500 pF load and operating from +5 V and −12 V power sources, for example, the unit can supply clock pulses at rates of up to 5 MHz. The MPH401 is housed in a standard 14-pin plastic DIP.

Two new monolithic IC's have been introduced by Siliconix, Inc. (2201 Laurelwood Road, Santa Clara, CA 95054), the DG507 and DG511. Illustrated in Fig. 7-a, the DG507 is a CMOS 8-channel differential analog

*(continued on page 43)*

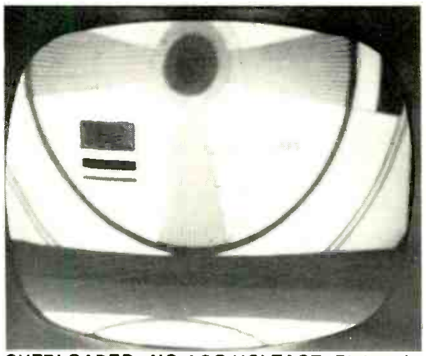
# STEP BY STEP

# TV troubleshooters guide

*Transistor agc circuits can be tricky when they don't work properly. Here are three step-by-step troubleshooting charts that lead you directly to the fault*

by ART MARGOLIS

THE PICTURE BENDS—NOT ENOUGH AGC. Video is too strong and beginning to overload.



OVERLOADED—NO AGC VOLTAGE. Picture is out of sync and shows signs of overload.

WASHED OUT—TOO MUCH AGC VOLTAGE. Rf and i.f. amplifiers are tending to cut off.

**Here is the first in a new series of television troubleshooting articles. Each month we will examine a different TV circuit and will present a complete step-by-step guide to finding problems in the circuit. Every technician should find these articles a valuable guide and reminder should he get hung up on a set in the shop.**

**Technicians who are just getting into bench work will find these articles a useful teacher and instructor.**

**As well as presenting older, more common circuits; we will bring a number of the newest solid-state circuits to our readers.**

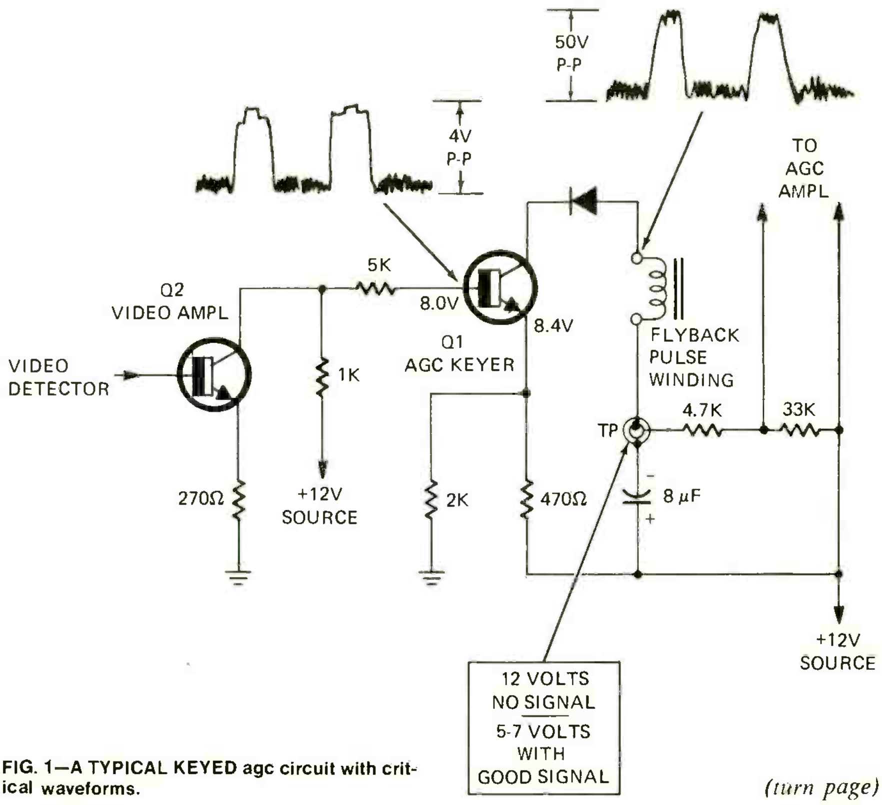



FIG. 1—A TYPICAL KEYED agc circuit with critical waveforms.

*(turn page)*

THE COMPLETE AUTOMATIC GAIN CONTROL system of a color TV receiver adjusts the rf and i.f. gain exactly opposite to the way that TV signal varies. As the signal gets stronger, the agc cuts down electron flow in the rf and i.f., reducing the gain. If the TV signal gets weaker, the agc permits more amplification for the signal. That way the total gain remains constant, even though the signal strength at the antenna is varying.

Keyed agc is preferred over simple agc since the agc keyer does not conduct between sync pulses. This prevents any noise pulses or rapid changes in video from affecting the agc control voltage.

In addition, the only frequency that has to be filtered is the 15,750-hertz flyback pulse. So the output filter has a relatively short time constant. This enables the filter to take out the quick change of signal caused by passing aircraft.

Simple agc, on the other hand, does not cut off during the video interval. A long time constant filter is needed to filter the 60-Hz vertical sync pulse, and the quick signal change of airplane interference hurts the steadiness of the display.

Even though keyed agc is a bit more expensive to produce, it is much preferred.

The typical transistor color TV agc system consists of three stages: the *agc keyer*, *agc amplifier* and agc *delay*. This month we'll discuss the keyer.

## Typical transistor agc keyer

The agc keyer gets its name from the fact that it won't operate unless the horizontal sync pulse arrives at the input simultaneously with a horizontal flyback pulse at the output. The two pulses "key" the transistor into conduction at that precise instant.

These electron bursts through the transistor are then filtered into a steady dc control voltage that varies with the size of the sync pulse, which is a function of the signal strength. This control voltage is sent to the rf and i.f. circuits where it controls the gain.

**Keyer dc setup:** The keyer is typically an npn transistor. Dc is applied to the collector. The emitter-to-base junction is slightly reverse-biased. There can be no conduction unless the signal is able to overcome the bias. Typically the bias is about 0.4-volt reversed.

Dc voltage arrives at the emitter from a 12-volt source. The emitter has a voltage divider (see Fig. 1) of 470 ohms in series and 2,000 ohms to ground. Electrons from ground are attracted to the 12-volt source. They pass through the 2,000 and 470-ohm resistors. The potential at the junction of the two resistors is the emitter voltage—about 8.4 V during operation.

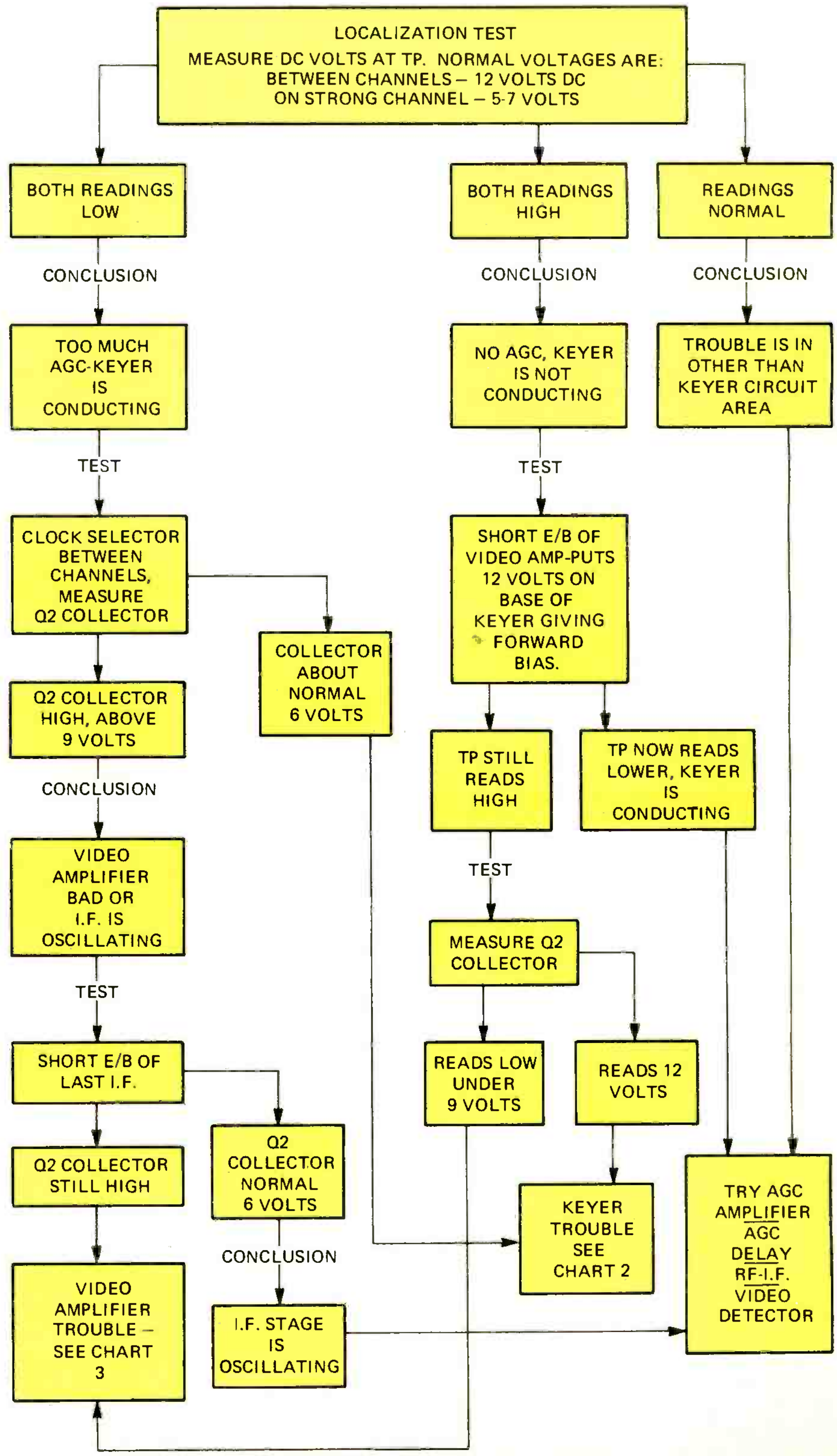
The base voltage is set by the amount of collector current in the video amplifier. The dc arrives also from the 12-volt source but must flow through the video collector resistor. During operation the base voltage is about 8.0 volts.

**Keyer ac setup:** The keyer's collector receives a steady stream of pulses of about 50 volts peak-to-peak from a flyback winding. These positive pulses on the diode's anode attract collector electrons to the winding through the diode. Any spurious pulses are rectified by the diode.

Meanwhile the video amplifier is feeding TV signal into the base of the keyer. As the video portion of the signal arrives at the base the peak-to-peak voltage is not high enough to overcome the reverse bias. Therefore no video passes through the keyer. But as the horizontal sync pulses arrive at the base,

## TROUBLESHOOTING CHART I

localizing agc trouble symptoms in a keyed agc system



they have enough peak-to-peak voltage to overcome the reverse bias. They turn the transistor on and pass through the keyer. They begin passage at the same time the flyback pulse applies 50 volts peak-to-peak to the collector. A burst of electrons passes through the keyer, the diode and the flyback winding.

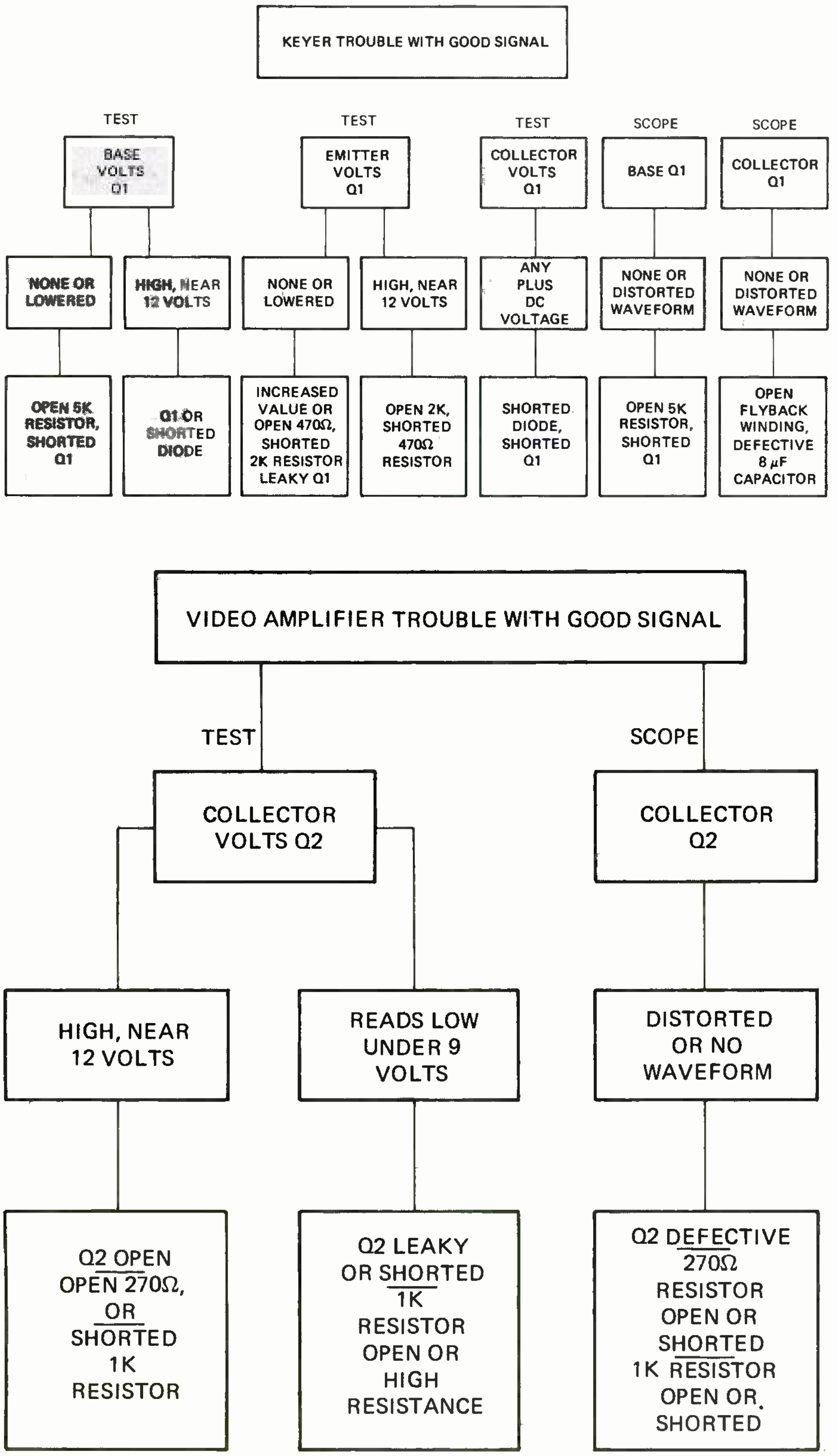
These electrons arrive at the negative side of the 8-$\mu$F filter and are changed to a steady dc that varies with the strength of the video signal as represented by the sync pulse.

## Agc keyer trouble shooting

The agc keyer area includes all components immediately clustered around its inputs and output. This includes the video amplifier transistor and its emitter and collector circuits.

### TROUBLESHOOTING CHART II

finding the part when symptoms point to video amplifier trouble




The first step is to analyze the TV trouble. The agc system is suspect immediately if strong local channels are coming in overloaded or not at all, while weak distant channels are being displayed well. The agc is also suspect if the video and color are gone. With the latter trouble agc is not the primary suspect: the tuner, i.f.'s and video stages are first, with agc second.

A quick test pins the blame on or exonerates the keyer. Find the negative end of the 8-$\mu$F filter capacitor and take two dc readings there—one with a strong station tuned in and the other with the channel selector cocked between two channels.

The on-channel reading should be between 5 and 7 volts as the keyer conducts during pulse times. The off-channel reading should be 12 volts, since the transistor is shut off.

If the readings are both low—between 4 and 7 volts—something is wrong in the keyer. The agc is developing too much dc correction voltage off the rf and i.f.

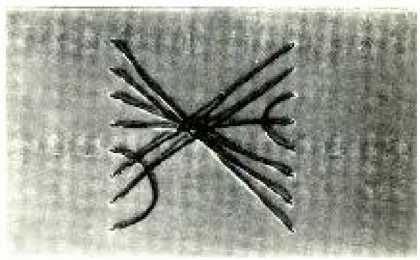
Should the readings both stay high at the 12-volt source level, something is wrong in the keyer and there is no conduction.

When the test point voltages read as prescribed the keyer is cleared and the trouble is further on in the agc amp, agc delay or the i.f. or video stages. These will be covered in coming articles.

Therefore, if the voltage stays high or stays low the keyer area has been localized as the trouble area. Next step is to pinpoint the component with the help of the trouble charts. Note that the charts are to be used with a good signal at the antenna (strong channel). **R-E**

## *magnet wire to replace hook-up wire*

When doing a lot of interconnecting wiring on a circuit board, try using magnet wire instead of hook-up wire. The thin-wall insulation allows



the wire to lie flatter and give a neater appearance. It's ideal for integrated circuit strapping. Use the smallest magnet wire consistent with circuit current requirements. You can speed up your wiring by using the heat-stripping type (Sodereze) wire.—*A. E. Plavcan*

# STEREO

## how to design your own solid-state audio amplifier

*Secrets of transformer-coupled audio circuits are explored in this article. These "rules" apply to both FETs and bipolar transistors*

by MANNIE HOROWITZ*

THE GAIN OF AN INDIVIDUAL TRANSISTOR circuit is limited primarily by device parameters, by the load it must feed, by the impedance of the input signal, and by the bias and bias stabilization components. Both JFET and bipolar devices are affected by all these factors, but to differing degrees. While the impedance of the input signal will probably have a severe effect on the gain of a circuit using a bipolar transistor as the input device, it will be relatively insignificant when facing the high input impedance of an FET.

Three arrangements are commonly used to couple several transistors into circuits designed to provide more gain than is possible with one device. All methods use the signal derived from one stage of amplification to drive a second stage of gain. The output from the second transistor may, in turn, drive a third device, and so on. The overall gain is the product of the gains of each individual amplifier circuit, remembering of course, that the gain of each circuit is affected by the circuit and components preceeding and following the one being analyzed.

Of the three circuits, capacitive coupling is probably most frequently used. Here, a capacitor couples the signals from the output of one stage to the input of the next, while all dc voltages are isolated within the individual neighboring stages. Although adequate in very many applications, it discriminates against dc and the lowest frequencies of the signal being reproduced. There is also a frequency dependent phase shift which many audio purists find objectionable.

The disadvantages are overcome by omitting the capacitor and using direct coupling. Circuits of this type are not free of drawbacks. Drain and collector current build-up due to instability in one stage is multiplied by the gain of succeeding stages. The current may build up to such proportions as to upset the quiescent conditions in the final stage of amplification. Furthermore, drift due to thermal causes can upset the balance of push-pull output stages allowing dc current to flow through speaker loads.

Transformer coupling, although frequently used due to convenience and circuit matching advantages, has many of the drawbacks exhibited by the capacitor coupling method. It is the subject of this article.

### The transformer

As you recall, a transformer consists of two or more windings placed in a common magnetic field. The signal appearing in one winding is coupled to

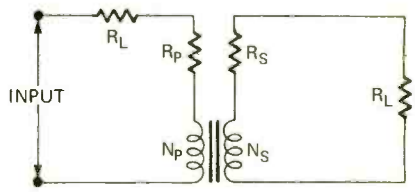



FIG. 1—OUTPUT LOAD is reflected into the primary side of the transformer as $R_L'$.

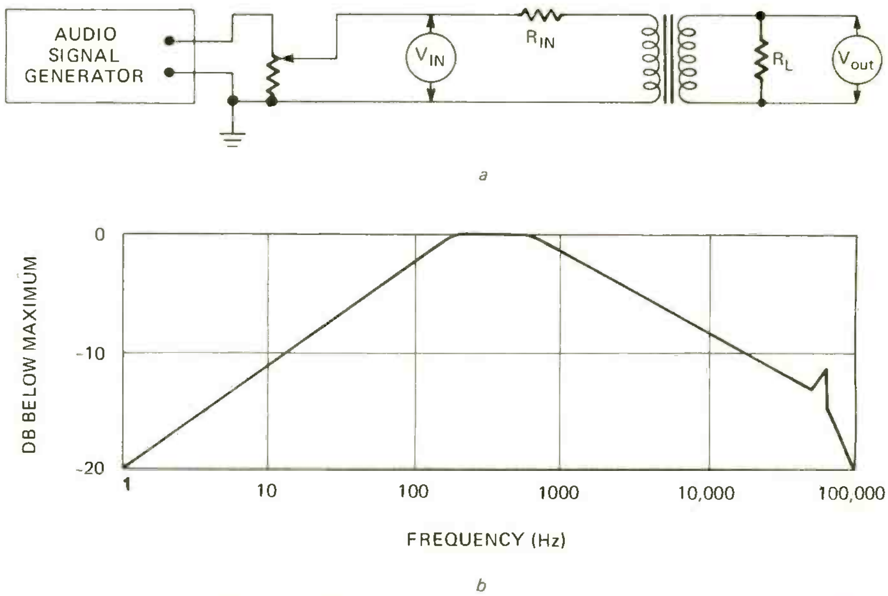



FIG. 2—OUTPUT TRANSFORMER FREQUENCY RESPONSE is measured with the set-up (a). Resistor $R_{in}$ is impedance or resistance of the circuit feeding the primary winding. The graph plots possible response of a small output transformer. The dB scale is ratio of $V_{in}$ to $V_{out}$.

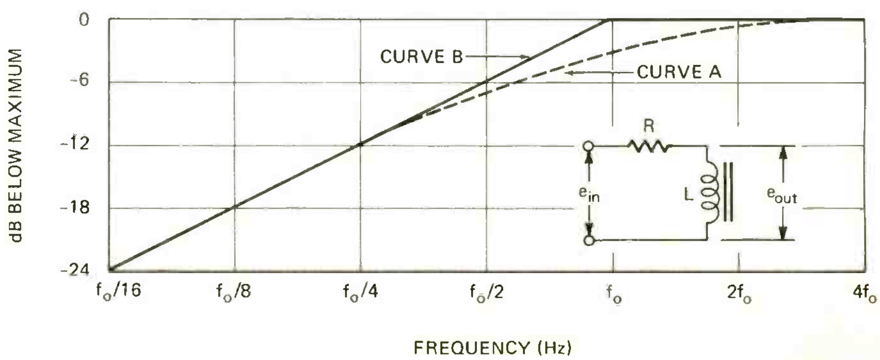



FIG. 3—HIGH-PASS FILTER CIRCUIT formed by the lumped resistances and inductances associated with transformer causes low-end rolloff. Curve A is actual response; curve B is theoretical.

*Chief Project Engineer, EICO Electronic Instrument Co.

the second and to any additional windings that may exist. Transformers with a single tapped winding (autotransformers), are seldom used in audio applications because there is no dc isolation possible between transformer coupled stages.

The impedance or resistance of the load ($R_L$) across the secondary winding is "reflected" into the primary winding; its initial value being multiplied by the *square* of the *turns ratio* of the two windings involved. In Fig. 1, $R_L$ is the resistor placed across the secondary winding of the transformer and $R_s$ is the dc resistance of that winding. With $N_P$ turns in the primary winding and $N_S$ in the secondary, $R_L'$, the resistance reflected in the primary is:

$$R_L{}^1 = \left(\frac{N_p}{N_s}\right)^2 (R_L + R_S) \qquad \text{Eq. 1}$$

A signal fed to the primary of the transformer sees $R_L'$ in series with the dc resistance of the primary winding, $R_p$. $R_p$ and $R_s$ are losses in the transformer. Good transformers are designed so that the resistances in the windings are negligible compared to the actual load placed across the windings. $R_s$ is consequently made much smaller than $R_L$. In Equation 1 $R_s$ is usually assumed equal to zero.

A 25% loss factor is usually included in designs to compensate or account for all inefficiencies of the transformer. The primary factor affecting efficiency is the copper used for the windings. The percent copper efficiency can be readily determined from the equation.

$$\%\ \text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}} = \frac{100}{1 + \left(\dfrac{R_p + n^2R_s}{n^2R_L}\right)} \qquad \text{Eq. 2}$$

where $n$ is equal to $N_p/N_s$, the turns ratio of the transformer. Being directly proportional to the voltage ratio, the turns ratio can be determined experimentally by placing a known 400-Hz voltage, $V_p$, across the primary and reading the voltage, $V_s$, across the secondary. The ratio $V_p{:}V_s = n$.

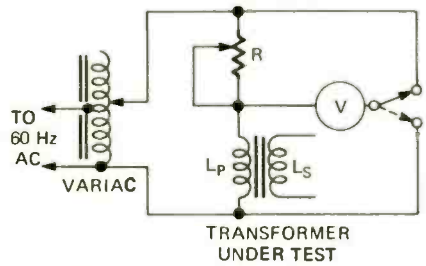



**FIG. 4—PRIMARY INDUCTANCE (approximate) of transformer can be measured with simple bridge set-up.**

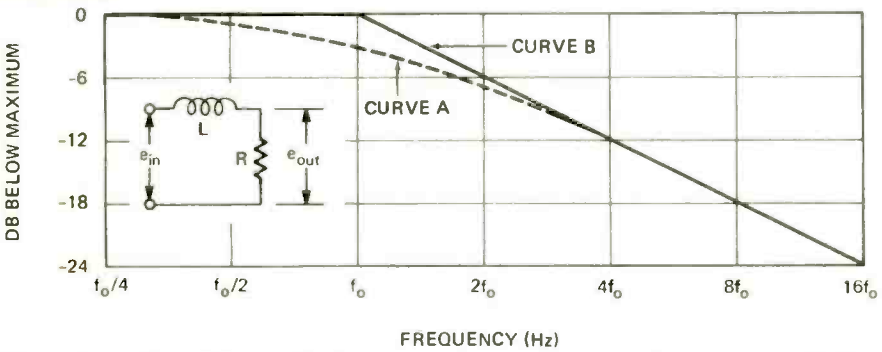
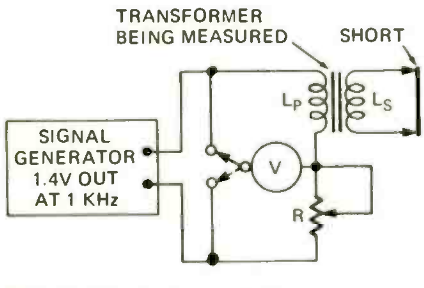



**FIG. 5—LOW-PASS FILTER formed by leakage inductance and lumped resistances cause rolloff indicated by curve A. The straight-line approximation (curve B) rolls off at 6 dB/octave.**



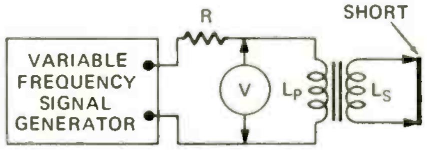




**FIG. 6—(left) MEASURING LEAKAGE inductance of transformer at audio frequencies.**

**FIG. 7—SET-UP FOR MEASURING winding capacitances.**

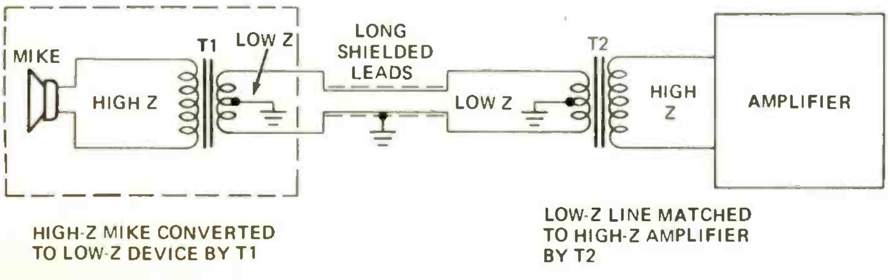



**FIG. 8—TRANSFORMER COUPLING AS USED AT THE INPUT of some PA amplifiers. Mike-to-line transformer T1 is step-down type. T2 provides step up to high-Z amplifier input.**

The efficiency is frequency dependent. Another way of saying this is that the frequency is limited by the presence of a transformer in a circuit. The circuit in Fig. 2-a can be used to measure the frequency response of a transformer. A curve similar to that in Fig. 2-b can be derived from the measurements. It shows the gain of a transformer circuit over a range of frequencies. The low-frequency roll-off is due to the incremental inductance of the primary winding of the transformer, while the high-frequency roll-off is due to the leakage inductance.

The basic low-frequency equivalent of a circuit using a transformer is a resistor in series with an inductor, as shown in Fig. 3. If the secondary of the transformer is open, R may simply be the sum of the primary winding resistance, $R_p$, and the collector or drain resistance of the transistor, usually $r_d$. When we load the secondary with $R_L$, R in the diagram becomes $R_p + r_d$ in parallel with $R_L'$, the value of the load resistor when reflected into the primary.

The L in the circuit is not simply the inductance of the primary winding of the transformer, $L_p$. It is the *incremental inductance*, or the inductance of the primary winding when dc is in the winding along with the audio.

The incremental inductance should be determined for a specific direct current through the winding while there is a 60-Hz ac voltage across the transformer. A bridge can be used for the measurement. The approximate inductance (not incremental) can be determined using a bridge or using the circuit in Fig. 4. Here, 60-Hz ac voltage is fed from the ac lines across a series R-L circuit. A voltmeter is used to measure the voltage across R and $L_p$. R is adjusted until both voltages are equal. Then $L_p = R/377$. (Note that when the voltages across R and $L_p$ are equal, the voltmeter will indicate more than one half the voltage of the supply due to phase shift in the R-$L_p$ circuit.)

The low-frequency response characteristics due to the circuit in Fig. 3 is shown by curve A with the approximation to the exact curve being drawn in curve B. Frequency $f_o$ is shown as the corner frequency and can be determined from

$$f_o = \frac{R}{6.28L} \qquad \text{Eq. 3}$$

At $f_o$, the true circuit gain (curve A) has decreased 3 dB from its mid-frequency value. Other important approximate points on this curve are at $2f_o$ where the gain has dropped 1 dB from that at mid-frequency, at $f_o/2$ where the roll-off is 7 dB, and the loss of gain at $f_o/4$ is 12 dB. Below $f_o/4$, the gain decreases at the rate of 6 dB per octave. Curve B has a 0 dB roll-off at $f_0$ and the gain decreases at the rate of 6 dB/octave below the corner frequency. When the gain drops at the rate of 6 dB/octave, it is identical to a 20 dB/decade rolloff.

At the high frequencies, the equivalent circuit, as shown in Fig. 5 is a resistor in series with an inductor. Here, R is the sum of the primary resistance of the transformer $R_p$, the load resistor reflected from the secondary winding into the primary $R_L'$, and the collector (or drain) resistance of the transistor, usually $r_d$. The leakage industance, $L_{leak}$, is the L in the circuit.

Leakage inductance is a stray inductance considered to be in series with the primary winding of the transformer. It is measured on a bridge by applying 1000 Hz at 1 volt across the primary of the transformer while the secondary winding is shorted.

Leakage inductance can also be measured using the circuit in Fig. 6. The secondary winding is shorted. A variable resistor is placed in series with the primary winding. About 1.4 volts is impressed across the series combination formed by the resistor and the primary of the transformer. The control is varied until the ac voltmeter indicates equal voltages across the transformer and resistor. At this resistance, $L_{leak} = R/6.28 \times 10^3$.

The actual high-frequency response curve for the circuit is shown curve A while the approximation is shown by curve B. As was the case for the low-frequency characteristic, the roll-off of the approximate curve is at the rate of 6 dB/octave or 10 dB/decade, starting at $f_o$. Once again $f_o$ is defined by Equation 3. At $f_o$, the actual gain is 3 dB down from the gain at the mid-frequency. Gain is 1 dB down at $f_o/2$, 7 dB down at $2f_o$, 12 dB down at $4f_o$ and it rolls off at the rate of 6 dB/octave thereafter.

Due to various stray capacitances, the high-frequency rolloff is not as smooth as depicted by the ideal situation described. There are various peaks in the response which cause bumps in the curve. Rolloff can proceed at the rate of 12 dB/octave. Winding capacitance producing the peaks can be found using the circuit in Fig. 7. Here, resistor R (a few thousand ohms) is placed in series with the primary winding of the transformer while the secondary is shorted. The signal generator frequency is varied until there is a peak voltage across the primary winding as read on the meter, V. The frequency $f_1$ is one of the frequencies at which a bump will occur on the response curve. The winding capacitance is $C = 1/(6.28f_1)^2 L_{leak}$. Several peaks may be noted for the various capacitances characteristic of transformers. Some peaks in the characteristics will be more pronounced than others.

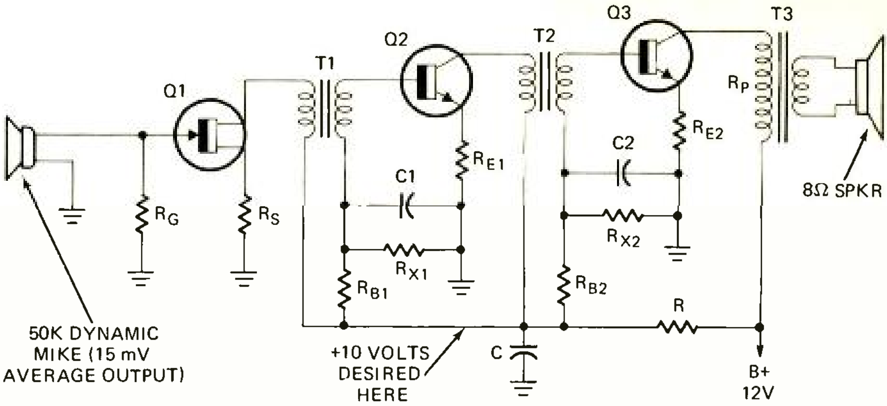



**FIG. 9—TRANSFORMER-COUPLED AMPLIFIER used in design problem. Large amounts of overall feedback—for extended bandwidth—cannot be used because of stability problems.**

## Using coupling transformers

In previous articles on power amplifiers, transformer coupling to output loads, was discussed. It was indicated that transformers are used to convert the low output impedance of a speaker load across the secondary to a high impedance in the primary winding. This relatively high impedance is to serve as the load for a transistor. In a similar manner, a transformer can be used to couple a high-impedance input source to the low impedance at the input of bipolar transistors. This impedance conversion is not generally required when feeding the high input impedance of a JFET.

The audio input to an amplifier may originate at a microphone. Because of long lines, it is frequently desirable that a balanced input be used, as shown in Fig. 8. While the low impedance in the long lines is less susceptible than a high impedance line to hum and noise pickup, the use of a transformer center-tapped to ground is an important asset in cancelling the in-phase hum and noise induced in the two "hot" leads of the connecting cable.

The signal fed through a low-impedance line may be applied directly to the input of an amplifier, or it may first be transformed so that it will appear at a higher impedance. Voltage gain is added as a fringe benefit. The transformer must be of the proper quality so as not to adversely affect the characteristics of the signal.

Interstage transformer coupling is commonly used in amplifiers. Although it limits bandwidth and the circuit flexibility—large amounts of feedback around transformer-coupled stages cause stability problems—many excellent designs still do include driver transformers. However they are applied primarily to public address and low-price hi-fi equipment.

## Example

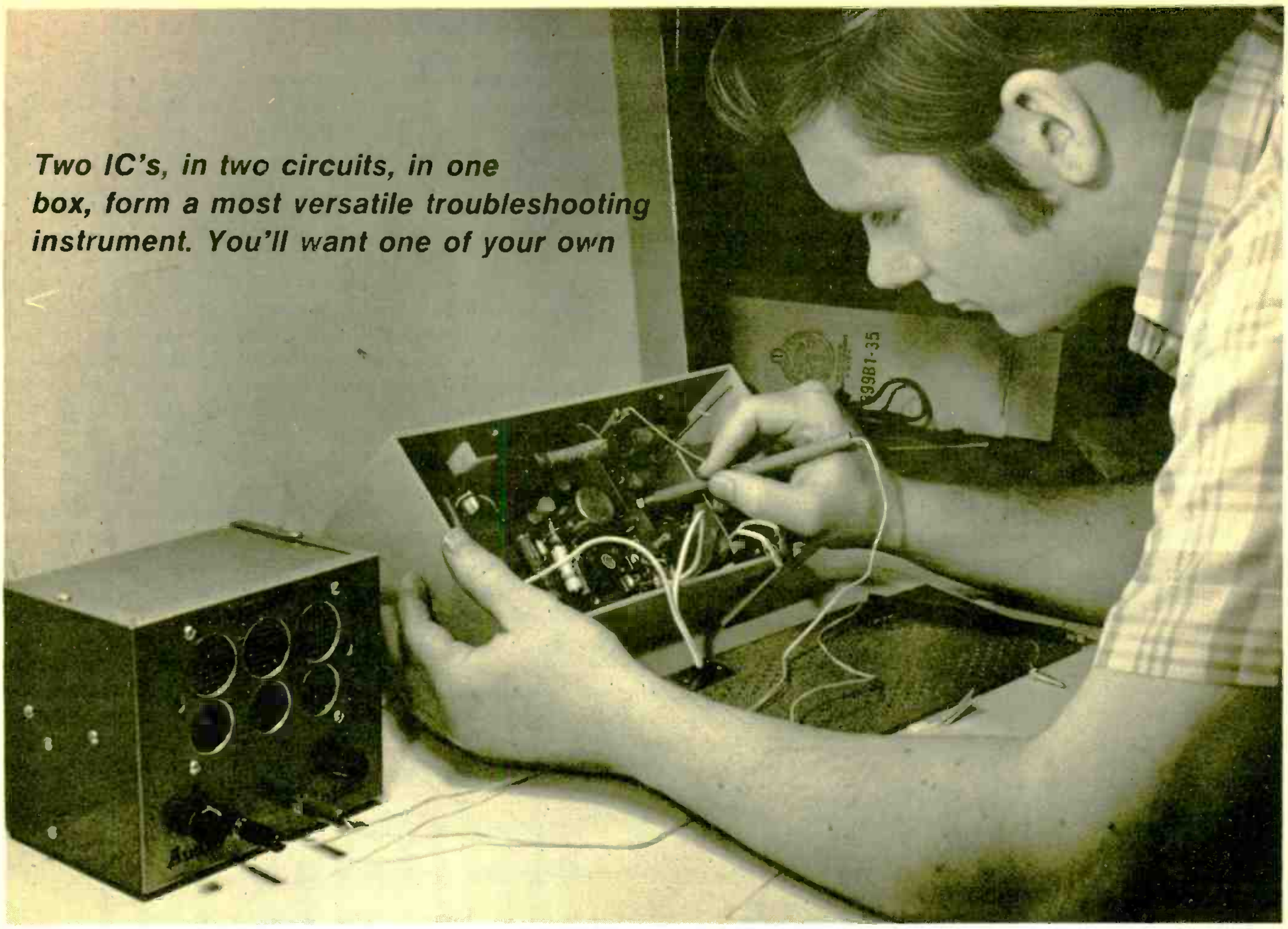
Let us now turn our attention to a circuit (Fig. 9) using a considerable amount of transformer coupling and see just what the component values and arrangements can be. More transformers than are normally used in any one design are shown here. The paper design should be checked in a laboratory for accuracy and reproducibility. On an actual chassis, care must be exercised to avoid magnetic coupling between transformers. Returns to B+ and ground should be made in the proper sequence to avoid coupling between stages due to resistance in the leads.

A 50,000-ohm dynamic microphone with 15-mV average output is used. The signal is amplified by three stages of gain consisting of an n-channel JFET and two npn bipolar devices. Each stage is transformer coupled to the preceeding and succeeding transistor. The required output is 1 watt delivered to an 8-ohm speaker. A 12-volt automobile battery is the source of power used directly as the B+ supply for the output stage, and it applied through a decoupling R-C network to feed the first two transistors. It is assumed that the first two devices require 10 volts as their B+ supply. This voltage is at the junction of R and C.

Starting with the final stage, let us first assume the output transformer is 75% efficient so that for 1 watt output, $1/0.75 = 1.33$ watts is required at the primary of the transformer. Sufficient leeway can be built into the design if it is assumed that about 3 volts are lost across the output transistor due to leakage current and saturation voltage. About 2 volts of this can be attributed to saturation voltage. Adding this to power losses across $R_{E2}$, we can expect an additional 25% loss of power at Q3. The total power the output stage must be capable of delivering becomes $1.33 + 0.25(1.33) = 1.66$ watts. We must now determine if the relatively inexpensive 2N3053 transistor in a TO-5 package can deliver this power.

As 1.66 watts are required across the primary winding, the transistor in the Class-A circuit must dissipate 3.32 watts or twice the power the device must deliver. If we assume 2 volts will be developed across the dc resistance in

*(continued on page 92)*




# BUILD IC DUO-TROUBLESHOOTER
## Generator—Tracer

by HOMER L. DAVIDSON

SOME TECHNICIANS LIKE TO USE THE actual signal to track down trouble. With a signal tracer—which is a sensitive radio receiver or audio amplifier, they start at the input stage (antenna or phono pickup) and assure themselves of a signal there. Then they work through the equipment stage by stage till the signal disappears. This, they say, is where the trouble starts and where they start checking parts. Often the tracer itself spots the faulty component. Normal signal at the input of a coupling capacitor and none at the output localizes the fault to three parts.

Others prefer to *inject* a controlled signal into the circuitry and listen for it from the equipment's own output. A strong audio signal is inserted at the input of the last stage, and the output from the equipment's speaker noted. Then the injector is moved back a stage at a time till the defective stage is located.

Each method has its advantages and disadvantages. But the *Duo-Troubleshooter* combines the advantages of both. It *is* both—a signal injector and an audio signal tracer. And it can be both at the same time—you can feed a signal into the circuit with the signal injector and pick it up further on with the audio signal tracer.

Here is a signal tracer that simultaneously doubles as a signal injector. The audio signal tracer sections easily track down a lost signal to locate the dead stage. You can inject a signal into any section of a radio, audio amplifier or your favorite electronic project and pinpoint the defective stage.

To locate a low-gain or weak stage, feed a signal into the circuit with the signal injector section and pick up the signal with the audio signal tracer.

The signal injector is a noise signal generator. The audio signal tracer is an audio IC that will pick up and amplify weak audio signals. Each section is built on a separate perforated board and both boards are in a single cabinet. Signal input jacks for each IC are on the front panel of the instrument.

### Signal tracer circuit

The audio signal tracer (Fig. 1) is built around an RCA CA3020 IC. The audio signal is fed through a .05-$\mu$F coupling capacitor to one end of R1. To protect the IC, a 600-volt capacitor is used at this point. Volume control R1 controls the level of the incoming signal fed to the IC.

An output transformer couples the IC to a small PM speaker. I used a 3.5-ohm, 3 x 5-inch speaker but just about any small PM speaker will work.

### Preparing the IC sound board

Select a piece of perforated board to mount all small parts. See Fig. 2. First, mark off the spot where the IC will go. Drill extra 1/16-inch holes between the holes already on the board, until there are twelve terminal holes.

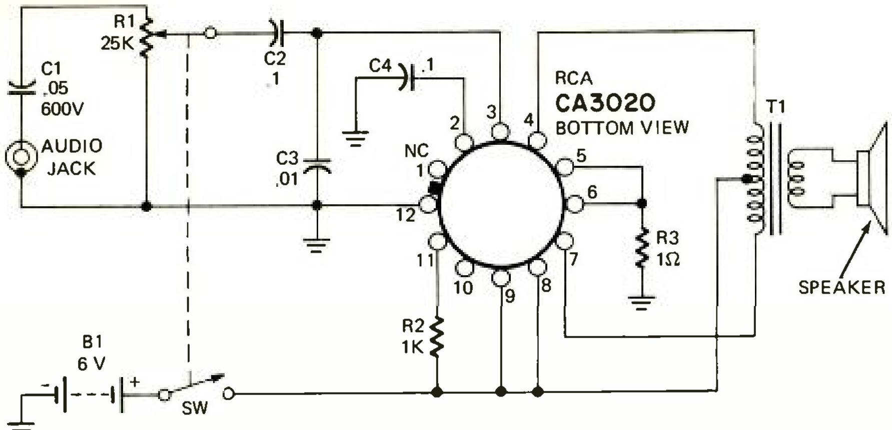



**FIG. 1—CIRCUIT DIAGRAM of the signal tracing section shows its economy of parts.**

**PARTS LIST**

**Audio Signal Tracer**

B1—4 1.5-volt penlight cells
C1—.05 μF, 600 volts
C2, C4—0.1 μF, 10 volts
C3—.01 μF, 10 volts
IC—RCA CA3020
R1—25,000-ohm pot with spst switch
R2—1,000 ohms, ¼ watt
R3—1 ohm, ½ watt
SPK—PM speaker, 4 or 8 ohms
Battery holder (for 4 cells), phone jack and plug, cabinet (Bud CU2107A or similar), hookup wire, nuts, bolts, test leads, knobs, perforated board, brackets, etc.

Now drill ⅛-inch mounting holes for the output transformer and mounting bracket.

The CA3020 IC is soldered directly in the circuit. No IC socket is used. First solder and connect the primary windings of the output transformer. Curl excess leads before soldering to IC terminals 4 and 7. Use a pair of long-nose pliers between solder joint and IC lead, to serve as a heat sink.

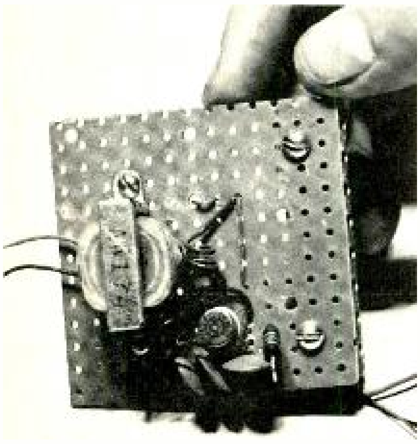


**FIG. 2—THE SIGNAL TRACER section of the tester.**

Use a small pencil-type soldering iron on the IC terminals. Make a good solder joint, but don't let the iron rest on the joint too long. Clamp your long-nose pliers to the soldered IC terminal until the joint becomes cool. A 12-terminal IC socket can be used to mount the IC component. But most commercial manufacturers solder the IC chip to the PC board, and you can do the same.

Mount all small components as they are soldered into the circuit. Solder the components to one another and then join them to the IC terminal. Be real careful not to apply too much heat or blob solder over other terminal leads. Use the blade of a pocket knife and dress each terminal lead away from other connections.

## Wiring the signal tracer

Before leaving the IC sound board give the wiring a "double once over." Make sure each component is soldered to the right terminal. After the IC sound board has been completed mount the small perforated board beside the PM speaker. Solder the secondary leads, of the output transformer to the small PM speaker voice coil terminals. Run a flexible wire from terminal 9 to one side of the ON-OFF switch. Connect the red (+) battery terminal to the remaining switch terminal. Solder the black battery terminal to ground lead on the IC perforated board.

Now connect C1, a .05-μF, 600-volt capacitor, from top terminal of the volume control to the input test jack. Connect a flexible lead from ground terminal of the test jack to ground terminal on the IC sound board. Solder one end of C2 to the volume control center terminal. Connect the other end of C2 to the input of the IC.

Before testing the IC circuit, go over all wiring connections. Check and double-check all connections. Make sure every wire and component is in its right place. It is very discouraging to crank up a project and not have it work properly. But it is a great joy and pride to have the project perform the very first time!

## The signal injector

The IC signal injector generator is constructed around a Motorola IC HEP 580 chip (Fig. 3). Again, the IC component is mounted through holes in the perforated board. Drill small 1/16-inch holes so the IC terminals will form a circle. Bend a couple of terminal leads, across from each other, to form feet and hold the IC in a rigid position. Then bend the remaining leads over and under the perforated board.

All small components can be mounted as they are soldered into the circuit. Mounting position of these small parts is not critical. Again, be careful not to overheat the IC terminals, and dress them away from each other. Solder 6-inch flexible leads to terminal 6, the battery connection, and the ground terminal of the IC. These extension leads can be soldered to their respective components when mounted in the metal cabinet. Now double-check all component leads and soldered joints. Be sure the leads are not touching and are soldered properly.

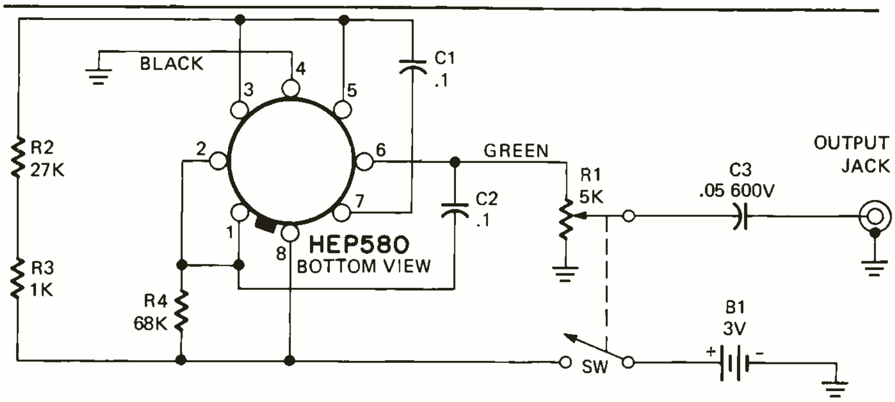



**FIG. 3—SIGNAL INJECTOR CIRCUIT.**

**PARTS LISTS**

**Signal Injector**

B1—2 penlight cells—see text
C1, C2—0.1 μF, 10 volts
C3—.05 μF, 600 volts
IC—Motorola HEP 580
R1—5,000-ohm pot with spst switch
R2—27,000 ohms, ¼ watt
R3—1,000 ohms—see text
R4—68,000 ohms, ½ watt
Battery holder (2-cell type), earphone jack and plug, hookup wire, perforated board, nuts, bolts, brackets, etc.

The audio frequency of the signal injector noise generator can be raised or lowered by changing the resistance of R3. For higher notes reduce the resistance of R3—to lower the frequency raise its resistance. A higher frequency can be obtained by eliminating R3 from the circuit and connecting R2 direct to R4.

### Cabinet construction

Remove the front panel of the mini-box, and Scotch-tape a piece of white paper over the panel area. Select and lay out all mounting holes and speaker openings. Fig. 4 is a good

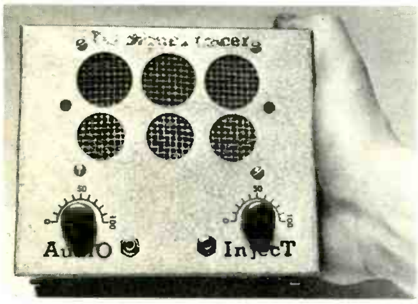


FIG. 4—THIS FRONT view can serve the constructor as a front panel layout guide.

guide. Lay the small PM speaker on the white paper and mark the outside dimension of the speaker. Circle all four speaker mounting holes. With a metal circle cutter cut out ¾-inch holes for the PM speaker opening. All front panel mounting component holes should be drilled before any boards or components are bolted in place. Drill ⅛-inch holes in the side panels to mount battery holders and IC circuit boards.

Before mounting the PM speaker place metal or plastic grille cloth over the speaker opening (Fig. 5). Next mount controls and input jacks in the front panel mounting holes. After all battery holders and front panel components are mounted bolt the two IC perforated boards in place (Fig. 6). You can make your own battery holders from scrap metal (Fig. 7). Now finish wiring the IC circuits to components on the front panel (Fig. 8).

### Testing

After both IC signal tracers have been wired they can be tested separately or can be checked against each other. First connect the battery cable to the IC audio signal tracer battery. When the unit is switched on a click or pop should be heard in the speaker. Open the volume control wide and touch and audio cable probe tip. A hum or noise should be heard.

If there is no sound at all, check the battery terminal and connections. Make sure the small penlight cells are inserted correctly. Still no sound: remove battery clip and clip up only one side of the battery, leaving the other battery terminal

FIG. 5—HOW SPEAKER AND GRILLE are mounted on the front-panel section of the box.

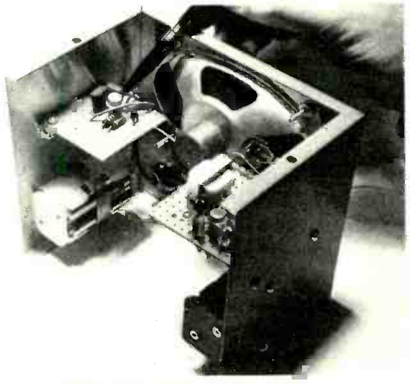


FIG. 6—THE TWO SECTIONS MOUNTED.

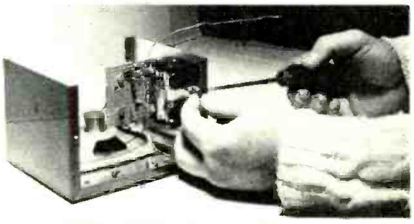


FIG. 7—THE BATTERY HOLDER can be home constructed from a piece of scrap metal.

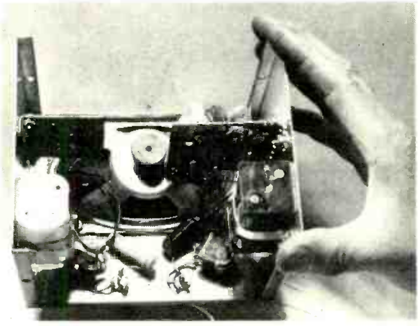


FIG. 8—TROUBLESHOOTER REAR VIEW shows connections to components on front panel

open. Now, insert a milliammeter in series with battery terminal and battery clip. You should measure 22 mA of current. In case of no current reading, recheck battery and switch connections. If the meter pulls more than 30 mA, the clip is wired up wrong—go over the complete circuit and check for wrong soldered connections.

If a hum is heard with volume wide open, check the IC audio signal tracer on a working radio. First, connect the input probe and ground connection to the radio's speaker terminals. The music should be loud and clear. Turn the volume down on the radio and check for music by grounding the clip to common ground; then touch the test probe to the high side of the radio's volume control. You should be able to control the volume of the radio with the volume control on the signal tracer.

Try to trace the audio signal from the detector in the radio to the second i.f. transformer. When tuned to a strong local station, the signal can be traced up to the collector terminal of the second i.f. stage. This audio signal tracer is ideal to check for loss of signal, weak reception, and distortion found in the audio stages.

The IC signal injector circuit can now be checked on the audio signal tracer. Fire up the signal injector circuit and clip the two ground terminals together. Touch the two test probes together and a loud tone should be heard. You can control the output signal from the signal injector with R1. Make sure R1 will lower and raise the output signal.

If the signal injector tracer does not produce an audible tone make a current check. Again, unclip the battery connection and clip one side of the battery into the circuit. Use the low milliampere scale. The correct current reading should be around 1.25 mA. If no current reading, check the battery connection and OFF-ON switch. Too much current will indicate improper wiring of the IC.

The signal injector tracer will check most rf, converter, i.f., and audio stages. Inject the signal at the collector of each transistor and see if signal gets through to the speaker. Now go to the base terminal of the transistor. You will notice a gain in each stage, as you go back through the circuit. When the signal is lost, the defective component is close at hand.

A weak transistor or coupling stage can be checked with both test units. Connect the audio generator to the collector terminal of the suspected stage and connect the signal injector noise generator to its base. Keep the injected signal as low as possible. You can uncover weak transistor stages, defective coupling capacitors, and distortion with the above method.

### Do's and Dont's

1. **Do** check the wiring diagram over at least three times before turning the signal generator on.

2. **Do** use a pencil type soldering iron when making connections to the IC circuit.

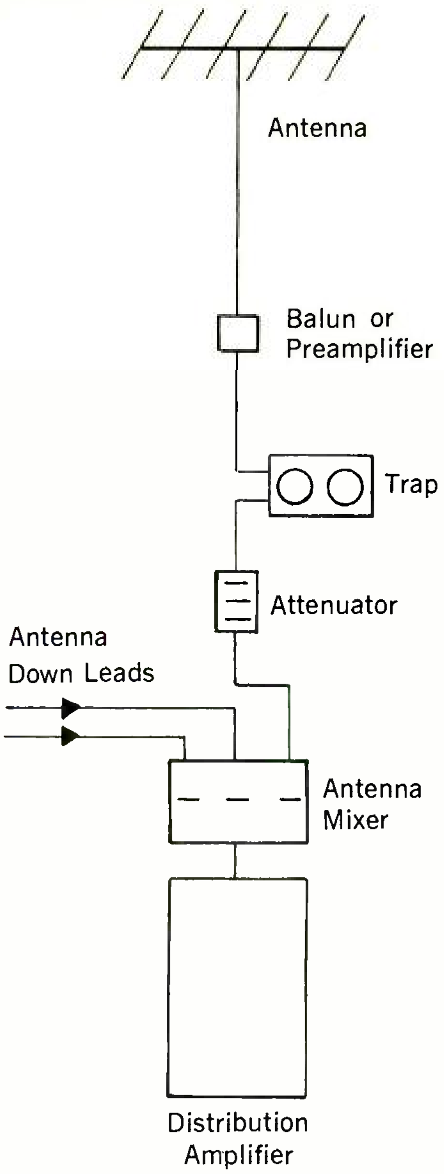
3. **Do** use alkaline or heavy-duty penlight cells for longer life.

4. **Don't** forget to make a current check if the signal tracer will not work at first.

5. **Don't** forget to dress down all terminal leads of the IC circuit. **R-E**

# MATV cookbook

TYPICAL HEAD END




THE PURPOSE OF A MASTER ANTENNA SYSTEM IS TO DELIVER clear television signals to every TV set connected to the system. The very fact that there is an MATV system presupposes that a large number of sets will be tapped in. There are many individual parts to any master antenna system. These divide into two major categories. They are the head end and the distribution system.

## The head end

The head end usually consists of the antenna installation. But in addition to receiving the desired signals it include amplifiers to boost those signal levels to a useable point. In addition, mixing networks, traps, filters and other equipment may also be used depending upon considerations, such as the number of channels being received, signal strength, the direction of the transmitters and interference problems.

A well-designed distribution system is needed to guarantee that adequate signals are delivered to every set connected to the system. Trunk lines, feeder lines and tap-offs must be carefully selected so that each TV set in the system, no matter how far it may be from the amplifier, receives a strong enough signal to deliver good pictures.

## The antenna is first

The first portion of any MATV system to receive the signal is, of course, the antenna and since reception can be no better than the quality of the signal at the antenna, the antenna must be selected and installed with great care.

Some MATV systems use a broadband antenna, but in areas where the stations to be received lie in different directions or where the signal from one station is much stronger than that of another, single-channel antenna installations may be required. When selecting an antenna, the number of channels to be received, the direction of the stations and the signal levels available must all be considered.

## Baluns for matching

Many antennas have a 300-ohm impedance, while most MATV equipment has a 75-ohm impedance. Therefore, the signal coming from the antenna must be converted from 300 ohms to 75 ohms. This is done with a matching transformer called a balun. The balun is normally mounted as close to the antenna as possible.

## Preamplifiers boost the signal

In weak signal areas, it may be necessary to amplify the signal right at the antenna to get acceptable reception. Any preamplifier must be a low-noise unit because in this type of arrangement the preamplifier determines the noise level. Excessive noise shows up as snow in the picture. Some preamplifiers, in addition to increasing the signal, will also match the 300-ohm antenna to the 75-ohm master antenna system.

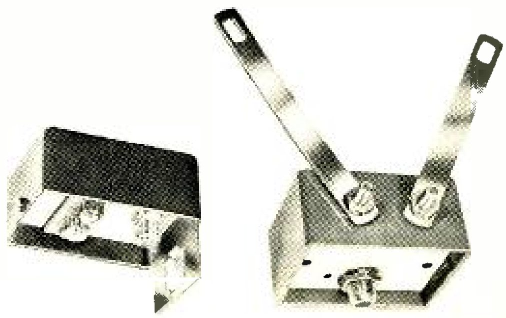
## Uhf converters

In many commercial MATV systems uhf signals are converted to vhf and then piped through an unoccupied channel. Since uhf converters convert to a single vhf channel, a separate converter is needed for each uhf station to be received.

Uhf converters contain a mixing network that permits vhf signals from another converter or a vhf antenna to be combined in a single cable before broadband amplification. In addition to converting uhf signals to vhf, converters usually amplify the signal they convert and this must be taken into account when equalizing signal levels.

## Filters and traps

Filters and traps are used in the head end of many systems to eliminate undesired frequencies and provide interference-free reception. Traps are either fixed or variable. Fixed traps are designed to cover a specific frequency range, such as FM or individual television channels. Variable traps can be tuned to any given frequency within their range.



**TWO ANTENNA BALUNS used to match an antenna with a 300-ohm impedance to a 72-ohm coaxial cable.**

*To use a cookbook you must first know the ingredients. Every part of an MATV system and what it does is detailed here*

**by JOE SHANE**

Bandpass filters permit the desired range of frequencies to pass through while greatly reducing (attenuating) all signals on either side of the desired range.

Traps are filters that are used to block an undesired frequency that is very close to the desired frequency. To be effective, a trap must have a very high Q (be very selective) so it can eliminate the undesired frequency without appreciably attenuating the desired frequency.

## Attenuators to equalize signal levels

As signals are picked up by a single antenna or combination of antennas, there may be a wide variation between the amplitude of the received signals. when this happens, the signal levels should be equalized to prevent the stronger signals from overriding the weaker ones. This is done by using attenuators to reduce the incoming signal by a specific ratio.

Attenuators are either fixed or variable. They are designed either to deliver a particular attenuation level or can be switched so that signals can be reduced to the exact level required.

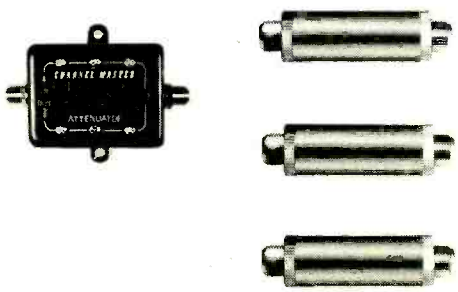
## Antenna mixers for multi-antenna hookups

If more than one antenna is used, the signals from the various antennas must be combined (mixed) before they reach the distribution amplifier (when broadband amplifiers are used). Antenna mixing units are usually a number of band pass filters covering either the low band (channels 2 through 6) or the high band (channels 7 through 13).

In addition to combining the signals from various antennas, the antenna mixing unit also filters out interfering frequencies. However, if the interfering frequency is very close to the desired frequency, a high-Q trap may also be required.

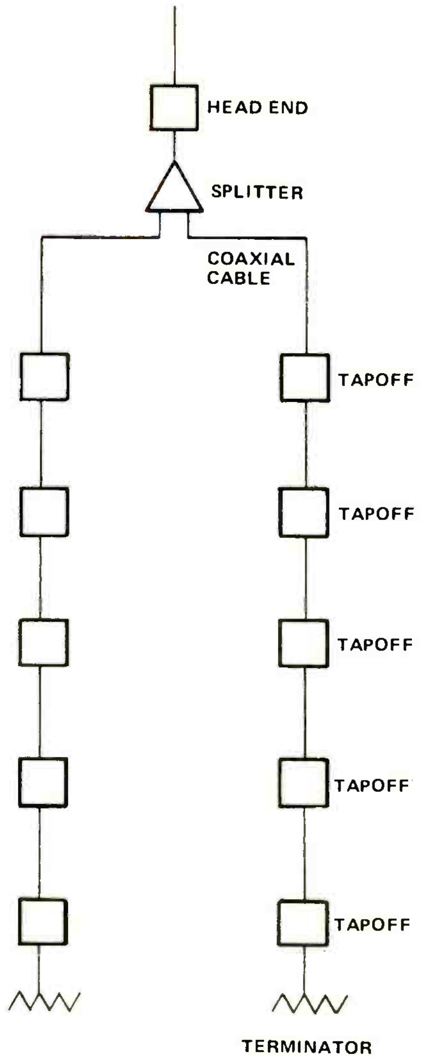
If both low-band and high-band channels are to be received, the signals from the low-band and high-band antenna mixers must be combined in a single line before broadband amplification. To do this, we normally use a band separator/mixer. This unit joins any vhf low-band signal to any vhf high-band signal to provide a single lead with a minimum interaction. The unit can also be used to separate vhf low-band and vhf high-band signals contained in a single lead.

If a broadband antenna is used, adjacent channel operation is not recommended. Where adjacent channels are to be received, use single-channel antennas. However, if adjacent channel operation from a broadband antenna is mandatory, use traps to attenuate sound carriers to prevent adjacent channel interference.



**TWO KINDS OF ATTENUATORS are commonly used in MATV systems. Unit on left is variable, those on right are fixed types.**

TYPICAL DISTRIBUTION SYSTEM




## Amplifiers in the system

Amplifiers are used to increase the signal strength received from the antenna to a level greater than the distribution system's losses while providing an acceptable signal to every set in the system. Although gain is important, the output capability is just as important and the amplifier specifications must be checked to insure that the output level is great enough to feed the system and that the signal input plus the gain of the amplifier does not exceed the amplifier's output capacity. If the amplifier's output capacity is exceeded, the result is overloading (cross modulation) and overall signal deterioration.

For the most economical installation, the amplifier should be centrally located in relation to the distribution lines. The longer the distribution lines, the more costly the system will be to install.

## Distributing the signal

As we enter the distribution system, the first piece of electronic equipment we encounter is the splitter. The coaxial cable that carries the signal from the distribution amplifier toward the sets is called the main trunk line. Some MATV systems have only a single trunk line, but it is more common and practical to separate the signal into separate lines for dis-

*(continued on page 68)*

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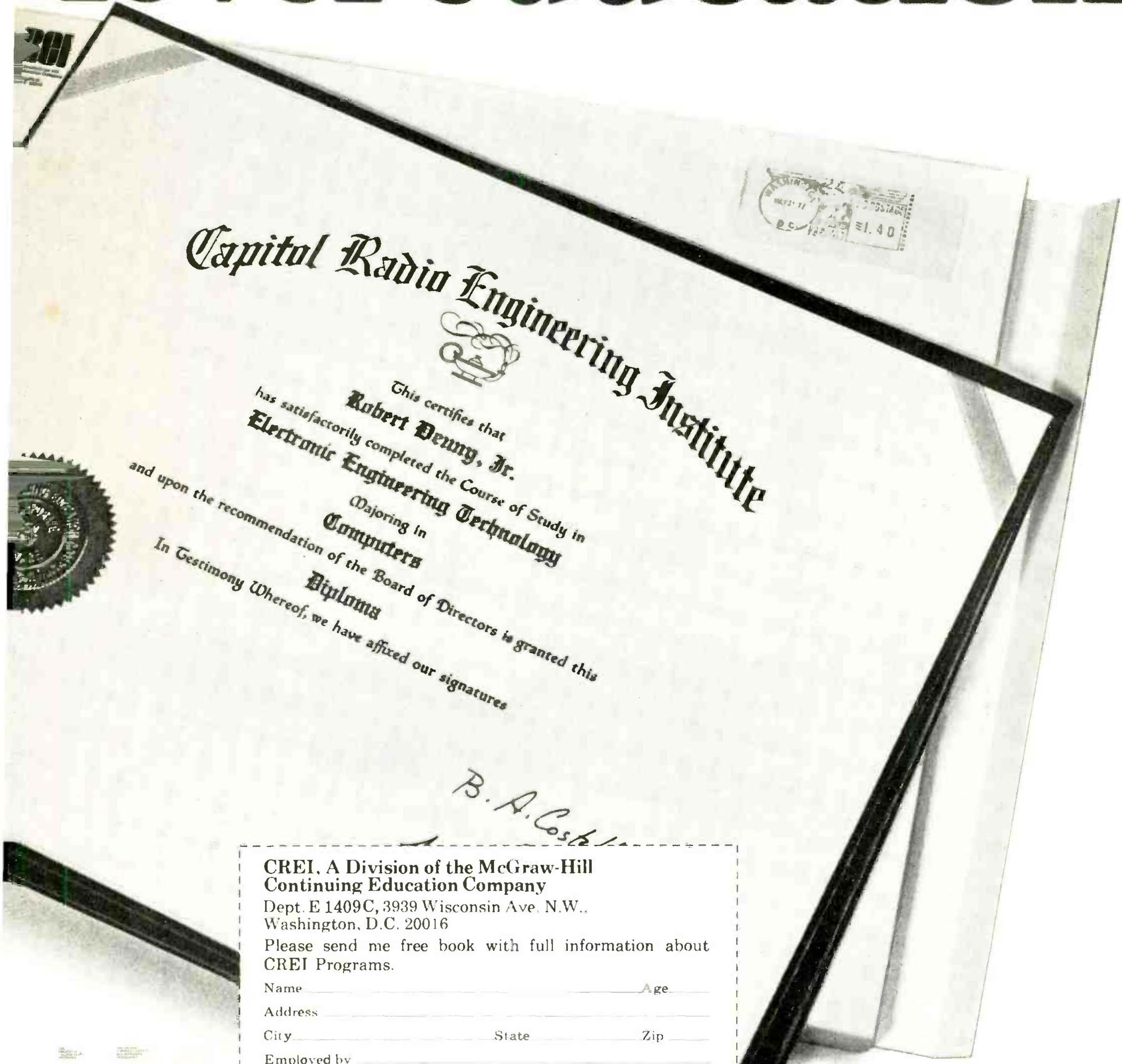


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**MATV COOKBOOK**
*(continued from page 63)*

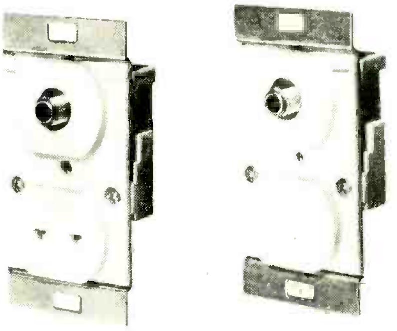
tribution to the sets. This is normally done with a two, three or four-way splitter. In strong signals areas it is important to use back matched splitter mixers. Backmatching provides a good match for reverse current flow, minimizing the possibility of signals re-entering the system, causing ghosts.

## Tapoffs come in different styles

The tapoff delivers signal from the distribution lines to the TV sets and at the same time provides enough isolation to prevent the sets on the same line from interfering with each other. Each set in a MATV system ideally gets approximately the same amount of signal, but there is more signal available in the distribution lines for sets closer to the amplifier than for sets further down the line. Variable isolation wall tapoffs are used to balance this signal difference out. These can be set to vary the percent of signal to be removed from the distribution line to gain a balanced signal output. Four types of tapoffs are commonly used: the wall tap, the line drop tap, the directional coupler tap and the pressure tap.

## The wall tap

This is the most commonly used tap in MATV. It is used in much the same way as an ac outlet. In a new building the distribution line runs inside the wall and the tap is mounted in a standard electrical outlet box in the wall. In existing buildings, it may not be possible to snake wiring through the walls and in these instances the distribution line is run along the baseboard or on the surface of the wall. The tapoff is then enclosed in a special surface-mounting housing for protection.



**WALL TAPS are the final connector between the MATV system and the TV set. Here are two types of units.**

There are three types of wall taps available: the 300-ohm output, the 75-ohm output and the dual output. The type used depends on two factors: the number of outlets required per room and the signal strength in the area. Generally, using a 75-ohm type with a matching transformer is recommended. In strong signal areas, 300-ohm twin lead tends to pick up signals directly from the air and can cause ghosts and interference. Using coaxial cable prevents this since it is shielded from direct signal pickup.

Some systems will require an outlet for both television and FM. In these instances dual 300/75-ohm tapoffs are employed. The 75-ohm section is used for TV and the 300-ohm section for FM.


**FOUR OUTPUT TAP coupler for apartment houses and other multiple dwelling buildings.**

## The line-drop tap

This type of tap is used in attics and crawl spaces. Each line-drop tap provides one to four drop lines to carry the signal to the set. The drop lines can be run directly to the set and matching transformers or they can be run to a 0-db wall tap. The linedrop tap is most commonly used in schools, motels and hospitals where the main cable is run down the hallway and feeder lines dropped down into each room.

## The pressure tap

This device is used outdoors when distribution lines are strung between poles, under the gables of apartments or other external systems.

## Directional couplers

The circuitry in these devices incorporates design techniques that assure excellent impedence matching at all terminals, high accuracy of coupling and low insertion loss. Directional coupler tapoffs provide attenuation of 40 to 60 db to signals leaving the line and returning because of receiver mismatch or disconnection. This virtually eliminates all problems such as ghosts and reflections producing noise, faze distortion and overload.

**MATCHING TRANSFORMER matches 300-ohm terminals at the rear of the TV set to the 72-ohm coaxial cable in the system.**

This directional coupler circuitry is available in line tapoff configurations with one, two or four taps to the droplines and with assorted isolation values.

## Band separators

Band separators are used in all channel (uhf/vhf) MATV systems to separate the uhf signal from the vhf signal before it is fed into the TV set. Unlike splitters that divide the signal equally, band separators contain circuitry to separate one band from another. In addition to uhf/vhf band separators, you may also have occasion to use vhf/FM band separators in vhf/FM systems.


**SPLITTER divides uhf/vhf signal.**

## Terminators

The end of each 75-ohm distribution cable must be terminated with a 75-ohm resistor to prevent signals from traveling back up the line and causing ghosts on the individual TV sets. These resistors are called terminators.

There you have all the ingredients that go into a MATV installation and a description of the part that they play in the system. **R-E**

The material in this article is based on information provided in the Channel-Master book "MATV Installation Guide."

# R-E's Service Clinic

## cable TV and you

*Is it the cable or is it the set? How does the technician know?*

by **JACK DARR**
SERVICE EDITOR

WITH THE RECENT FCC DECISION ON cable TV (CATV) systems, we may see a large increase in their number. So it behooves us to learn some of the peculiarities we'll run into, servicing TV sets hooked in to such systems. Personally, I like them. I did like to skin masts and run around roofs like a demented squirrel, but that was a long time ago. I leave the antenna work to the young bucks these days.

Like everything else, cable systems have their peculiarities. The first question, in most cases, is: "Is it the set or the cable?"

With the right tests, it's easy to find out. If the set seems to be in good working order, but there is no picture, a weak picture, etc. this is the point where the correct test methods can save a lot of work. It's no fun to haul a set all the way to the shop only to find it plays up a storm on your antenna.

The quickest and most definite test is a substitute signal. A bar-dot generator is ideal. It will tell you whether the set is working, whether it will make color and sound, etc. For the best results, measure the rf output of your bar-dot generator, on a field-strength meter. If yours has a variable rf output, get a rough idea of what the output level is at particular settings of the output control. If it doesn't have a variable rf output, find out what the output actually is. In a correctly set-up cable-system, *each* channel should have a signal strength of about 1,000 mV. This is more or less of a standard, although I don't know whether it's official or not. This will make a snow-free picture on any TV set even in fair working order.

You'll find some problems that are peculiar to CATV systems, if there actually is a fault in the system. One typical trouble is the case where the high channels will come in clearly, but the low channels are very weak. Or, vice versa. Or, all channels are weak and snowy. First check, hook up the bar-dot and see if the set will make a clean picture. If it will, then you have "cable trouble."

The most common cause of this is a defective balun at the cable outlet. If it has been visited by lightning, it could be partially open somewhere. Depending on exactly where it is open, you'll get this kind of symptom. By the way, you can usually check high and low channels on a set, even with a fixed-tuned bar-dot. For example, if yours is set on Channel 3 (60–66 MHz), you should be able to see a pattern on Channel 8 (180–186 MHz) on the 3rd harmonic. It will be only ⅓ the amplitude of the Channel 3 fundamental, of course, but enough to make a picture.

A field-strength meter, of course, will give you a definite answer as to signal strength on each channel used. If you get readings considerably less than 1,000 mV on any or all channels, *then* you call the cable company's technician, and tell him what you found, and why.

### Ghosts on the cable?

It *is* possible to get ghosts on a cable system. If any of the coaxial cable feed-lines aren't properly terminated, you get standing-waves. One cause of this is accidental damage to the coax during work on something else in the building. However, a properly designed and installed cable system will be free of ghosts. For a check, get out the bar-dot again. See if you can tune in a crosshatch pattern; this will tell you whether the ghost is in the set itself. Tune for the sharpest vertical lines in the pattern. If there is any tendency to ringing in the set, this will show it up.

### Lost the color

I have heard complaints that "the cable kills the color." On the face of it, this is mildly ridiculous. The line-amplifiers are extremely broad-band. To let the video signal get through, and trap out only the color, the response-curve of the line-amplifier would have to have a very sharp "notch" in it, exactly on the color subcarrier frequency. This is impossible. (I know: we tried to *make* one do it, some time ago, and couldn't.) It may be possible; but all I can say is that I have never yet seen a verified, proven case of it.

It *is* possible for line-amplifiers to add hum-bars to the rf signal. In vacuum-tube line amplifiers, heater-to-

*(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.

*(continued from page 69)*

cathode leakage in a tube will do this. Sometimes you'll see quite a bit of bending in the picture, too. An open filter capacitor in the dc power supply of either tube or solid-state line-amps will also make hum-bars. To find out whether it's "set or cable," haul out the bar-dot again. Put a crosshatch pattern on the set. If the hum is in the set, it'll show up as background shading, and/or bending of the vertical pattern lines.

Some TV sets will have agc problems on cable systems. These are mostly the cheaper models, without an agc control. Symptoms will be standard; overload in the picture, bending, buzz and so on. For a quick-check on this, disconnect the lead in, and hold it close to the antenna terminals. If you can find a point where the set will make a good clear picture, but it buzzes and overloads when the lead in is hooked up, that's it. In some cases, you can add a simple resistive attenuator to bring the signal down to a range where the reduced agc can handle it. Sensitivity of the set can be roughly checked by disconnecting the antenna. If you see a good deal of snow, the rf gain is usually OK. If you see a nice clean snow-free raster, look out. This normally means a loss of gain; some thing like a weak i.f. tube, etc.

### Cross-talk and "cable-bars"

In an improperly-adjusted CATV system, if the signal levels are too high, you *can* get cross-talk between channels. This will show up in most cases as floating blanking-bars on the screen; beats, ghosts, etc. If you see this, check the signal strength on all channels, with a field-strength meter. You'll probably find some channels running much too high. If your bar-dot will make a clean picture, then it's time to ask the cable technician for help. All properly designed CATV systems have agc control at the head-end amplifiers, and many use agc on all amplifiers, just for this purpose.

### "Cable-bars" on antennas

There is one more. Not too common any more, though we used to run into it now and then. This is the appearance of a white or black blanking-bar on the screen of a TV set working on an outside antenna, but close to one of the line-amplifiers of a CATV system. The cause is simple; the line-amp is leaking rf signal. When the set, on the antenna, is tuned to a channel being carried by the cable, it picks up the direct signal from the TV station. It also picks up the rf leakage of the same signal from the line-amp. Since this signal will be *delayed* from coming all the way down the hill from the head-end, the blanking-bar will show up in the picture. (Velocity of propagation in coax cable slower than free-space; delay). To find out, aim the antenna directly at the suspected line-amplifier, which will be on a nearby pole. If the interference gets worse, that's it.

This can be cross-checked by asking any of the neighbors who are also using outside antennas. If they all get the same kind of interference, it's time to call the cable technician and give him the word. This is usually due to someone leaving the lid off or loose on the line-amplifier housing. The FCC has set up a standard maximum for rf leakage from cables and/or line amplifiers, to prevent this kind of interference. This is very small.

That's about all there is to it. Easy if you know what to look for. **R-E**

# Reader Questions

**LOW VIDEO, BAD SMEAR**

***The picture comes on very slowly in an old Motorola TS-544. The raster lights up in the normal time, but it takes almost***

*(continued on page 72)*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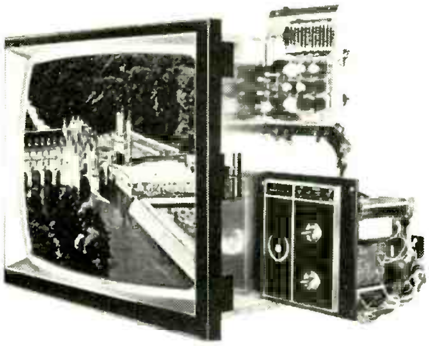

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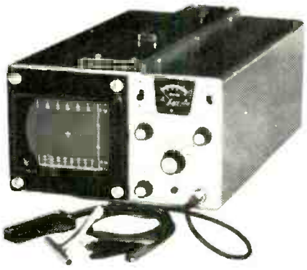

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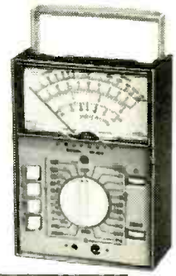

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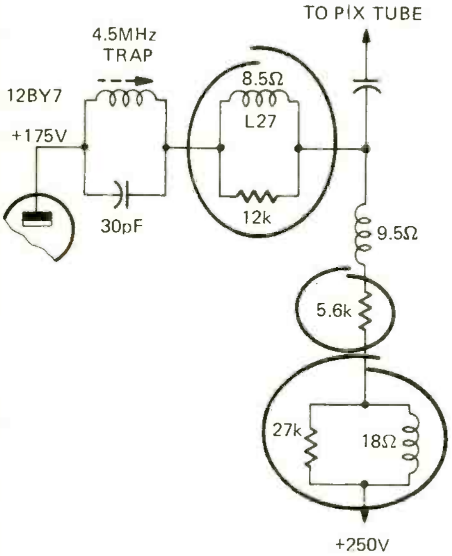
**SERVICE CLINIC**

*(continued from page 70)*

***a minute for the picture to show up. When it does, it is very badly smeared horizontally. Is this an agc problem?—J.G., Mena, Ark.***




Doubt it very much; not with these symptoms. Read the dc voltages on the plate and screen of the 12BY7 video amplifier. You'll probably find the plate voltage pretty low, say down around 75 to 80 volts (normal +175).

If this is the case, check all four peaking coils in the plate circuit, and that 5600-ohm resistor. If any of these coils read more than a very small resistance, the coil is open and you're reading the shunt resistor. Replace these. The 5600-ohm resistor has been known to go way up in value, also. Causes almost the same effect.

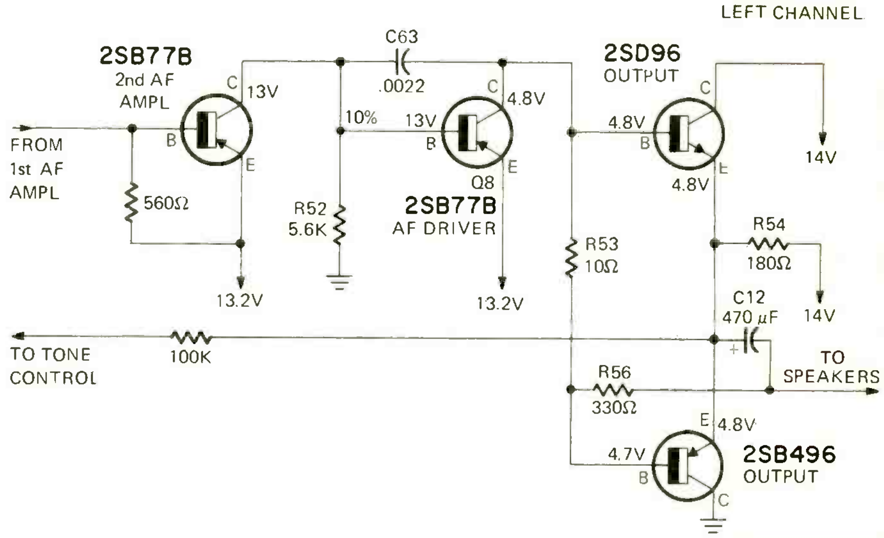
**CURRENT UNBALANCE IN OUTPUT**

***I've just replaced all four output transistors in a Truetone 4DC5929A-86 stereo amplifier. The top transistors in each channel had gone bad. Now, the right channel works nicely, but the left channel is distorted. New transistors were taken out and rechecked, but they were good.***

***I notice that at "no volume" (no input signal, volume off), the left channel output transistors get warm, and show too much bias voltage.—R.T., Tulsa, Oklahoma.***

Check the *driver* transistor. This is directly coupled to the base of the upper output transistor. So the collector current of this one sets the base bias of

*(continued on page 78)*



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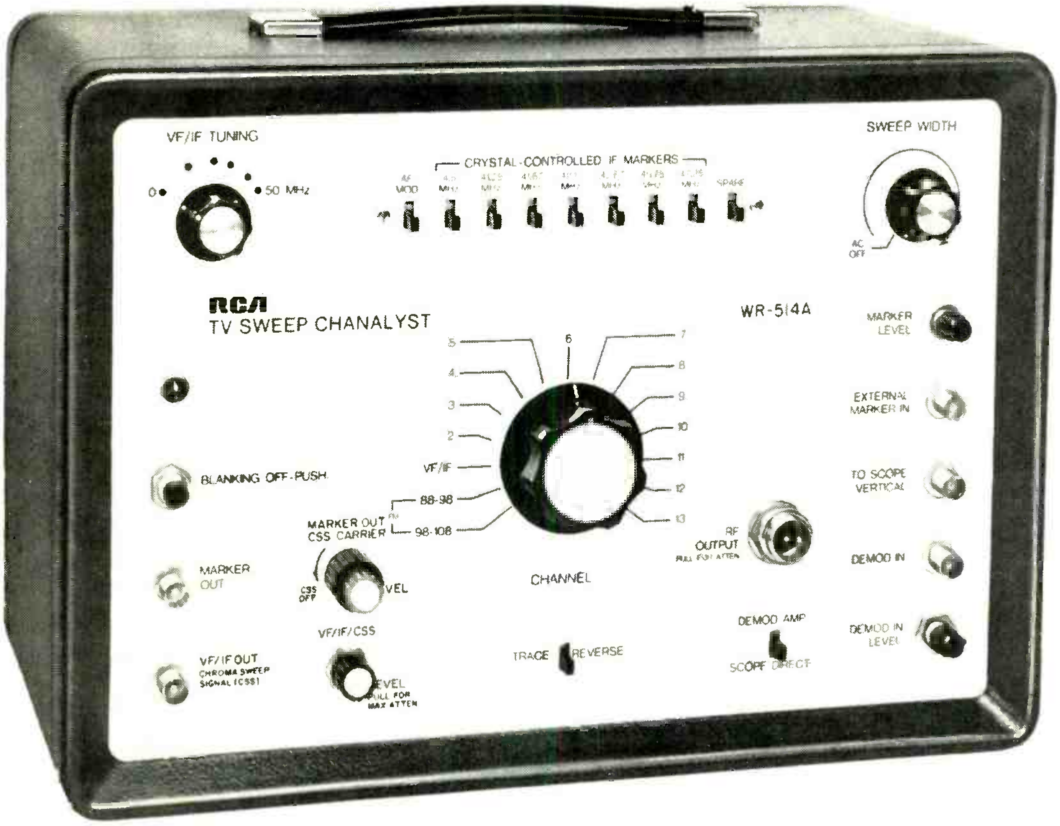


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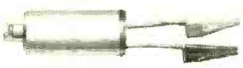

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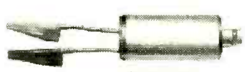

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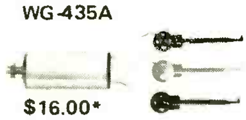

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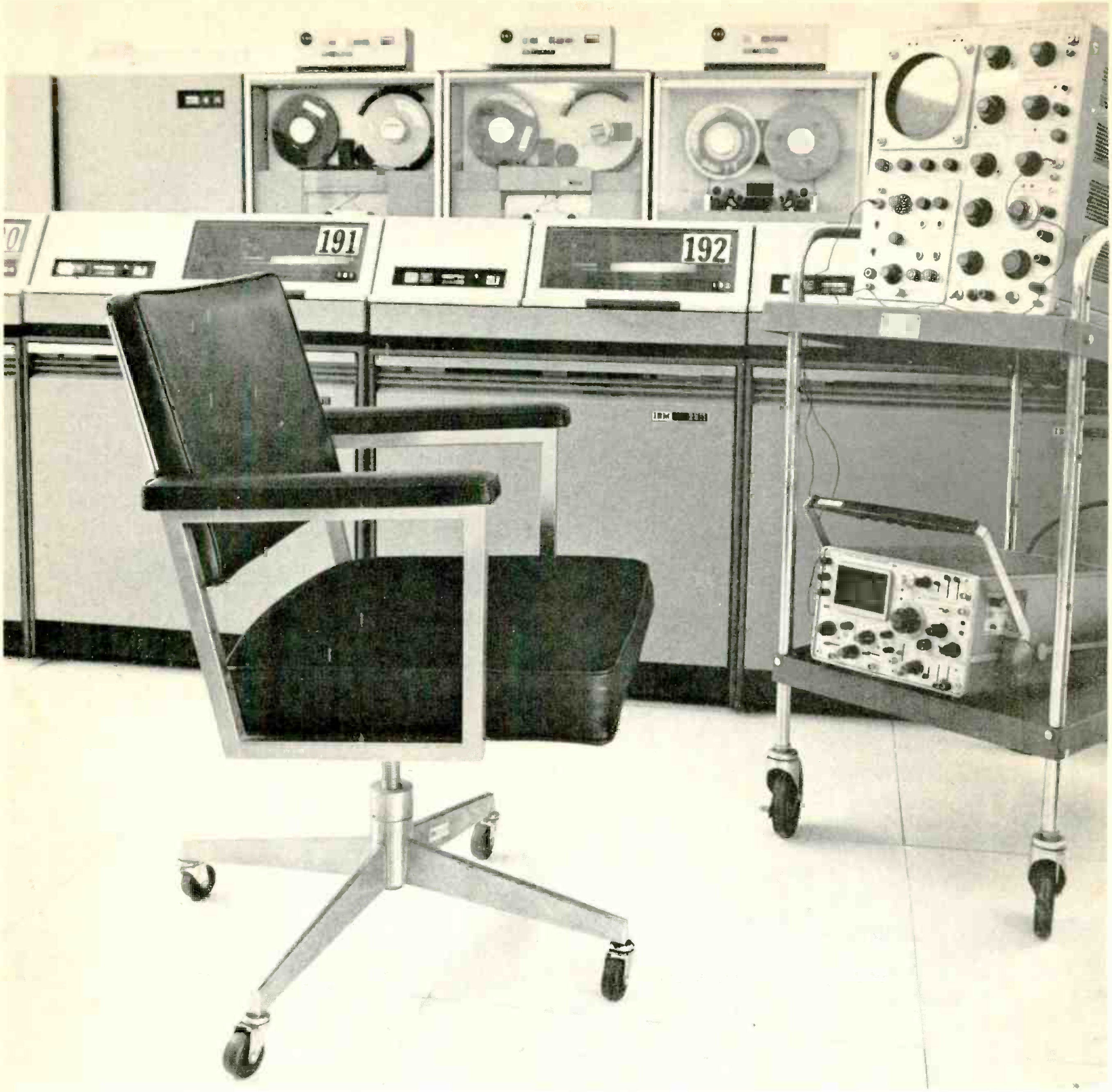


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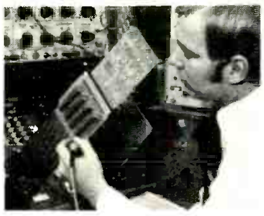

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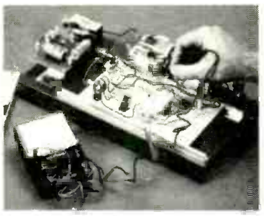

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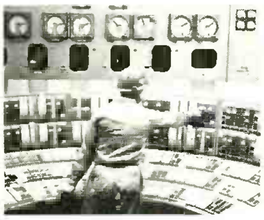

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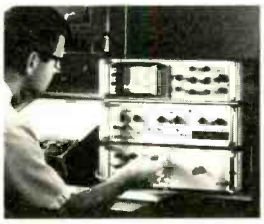

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*Circle 20 on reader service card*

**SERVICE CLINIC**
*(continued from page 72)*

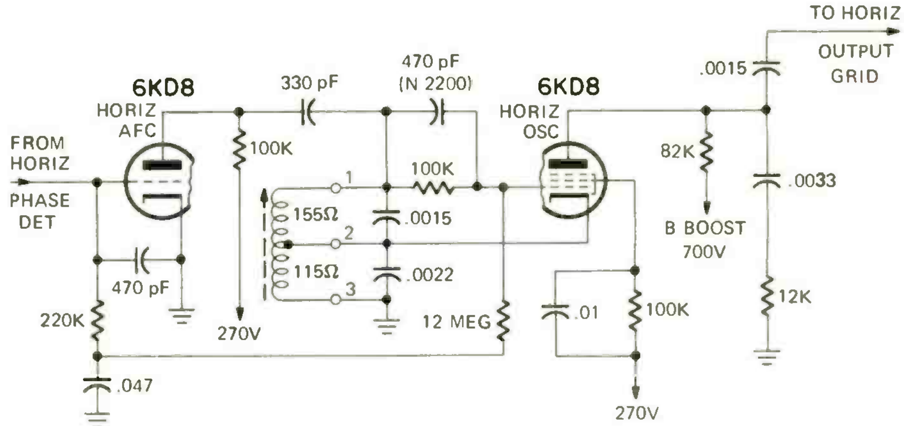
the larger output transistor. If this transistor has changed its characteristics, or if it doesn't exactly match the new output transistor, the bias will be off (just as you found it). This is a complementary-symmetry Class-B output stage. So, the "resting-current" (no-signal) should be practically zero. Or, at the very least, it should *match* that of the other channel.

Take the driver transistor out and check it; better still replace it.

The replacement transistors for this output stage could be RCA SK-3024/3025 (pnp/npn pair). A good replacement for the driver transistor could be another SK-3025. After replacing the driver, recheck the voltages, and the balance between R and L channels.

## HORIZONTAL OSCILLATOR TROUBLE

***No raster, no HV on a Zenith 14M28 chassis. No negative voltage or waveform on the grid of the horizontal output tube, either. Everything seems to check out, I just don't have any output.—R.H., Bergenfield, N.J.***



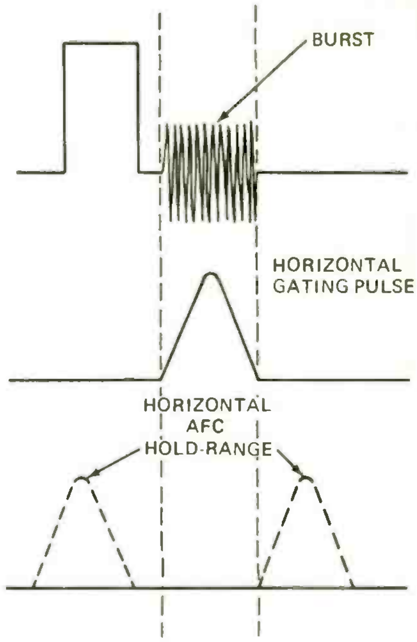

If "everything's all right and it just won't work", check the oscillator coil. It is Zenith's "sinewave" horizontal oscillator, that works a lot like the common ECO circuit used in so many radios, with 12BE6 tubes, etc.

The diagram shows how this coil is connected. If you replace it, be sure to get the two halves right! *They are not the same!* Reversing the connections will make the oscillator run far off-frequency. (And don't ask me how I found out.) The two capacitors are not the same either, so get them across the right part of the coil.

## HORIZONTAL HOLD VS. COLOR BURST

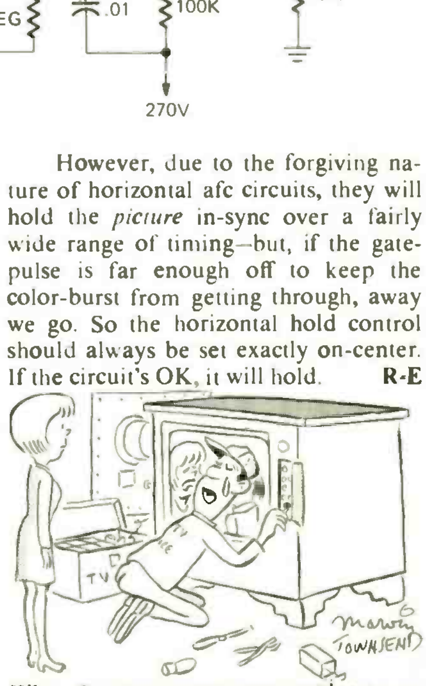
***Why does the horizontal hold control affect the color on my set, and on quite a few of those I work on? The picture will hold, but the color will fall completely out of sync.—J.W., Portland, Ore.***

This puzzles a lot of people, but it's normal. The color burst is *gated* by a pulse from the horizontal circuits. Un-




less this gating pulse is *exactly* (within about 5-7 μ sec.) in phase with the color burst, the gate won't open.

However, due to the forgiving nature of horizontal afc circuits, they will hold the *picture* in-sync over a fairly wide range of timing—but, if the gate-pulse is far enough off to keep the color-burst from getting through, away we go. So the horizontal hold control should always be set exactly on-center. If the circuit's OK, it will hold. **R-E**

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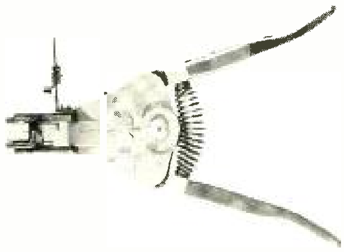
# new products

*More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card on page 127 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.*

**AUTOMATIC WIRE STRIPPER,** *Archer Automatic,* strips No. 24 to No. 12 wire in one second. Insulation is removed cleanly, without nicking or breaking the wire. A strip gage guides the wire to the correct position of the blade for a uniform stripped length every time. $4.95.—**Allied Radio Shack,** 2617 West Seventh St., Fort Worth, TX 76107.

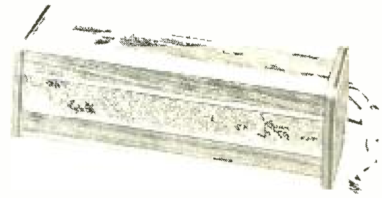


*Circle 31 on reader service card*

**IGNITION ANALYZER,** *model CO-1015.* An all-solid-state analyzer for servicing standard, transistor and capacitive-discharge ignition systems. Works with 2-, 4-, 6- or 8-cylinder engines. Detects shorted spark plugs, bad points, defective wiring, worn distributor parts, incorrect dwell time, coil, condenser or transistor problems. Features built-in tachometer with 0-1,000 and 0-5,000 ranges, for making carburetor adjustments. No need to adjust sweep width for changes in rpm—simply set it once and special circuitry holds it constant. Front panel controls for four patterns—primary or secondary in either parade or superimposed displays. Horizontal expansion 10 to 1; vertical 2 to 1. Built-in power supply for 117-volt ac operation; or can be used with optional COA-1015-1 12-volt inverter. $129.95 (inverter $24.95).—**Heath Company,** Benton Harbor, MI 49022.


*Circle 100 on reader service card*

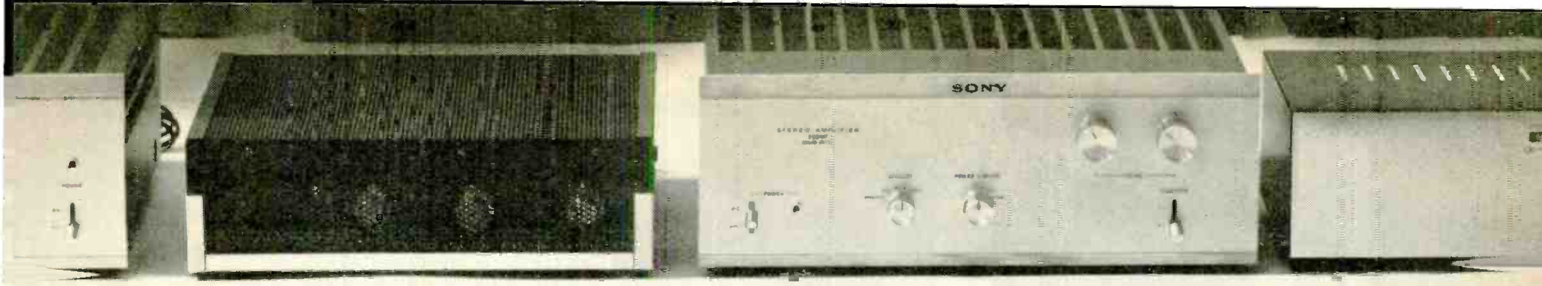
**INTRUSION DETECTOR,** *DeltAlert.* Uses ultrasonic frequencies to monitor up to 300 square feet of space. Has adjustable timing control; unit may remain activated from 10 seconds to 3 minutes, after which alarm is reset automatically. As long as activity continues in the monitored area, unit remains on indefinitely. Uses horn, lights, or both. Adjustable delay permits occupant to turn off system upon entry, before the horn sounds. Used with light only, the system may be used by legitimate occupants to turn lights on automatically in dark areas, hallways or stairways—an excellent safety feature. Available in 117- or 12-volt units. The 12-volt systems include a *Super DeltAlert Package* including an Alarm Alert—a red flashing light mounted outside the entrance, that warns that the area has been entered illegally—and a standby power supply, that switches the unit to batteries if power fails or is cut off. *DeltAlert,* $69.95; *DeltaHorn,* $24.95; *Super DeltAlert Package* (all parts but batteries included) $159.95, all postpaid—**Delta Products Inc.,** P.O. Box 1147, Grand Junction, CO 81501.



*Circle 32 on reader service card*

**ELECTRONIC MUSIC SYNTHESIZER,** *Synthi.* Low-cost instrument is built into a briefcase and is completely portable. Using internal speakers, it can set up almost any single sound effect. Three internal oscillators, noise generator and filter, can be made to interact with each other or with

*(continued on page 84)*

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All the convenience and compactness of ordinary receivers are still yours, vith your power amplifier neatly tucked out of sight. But the performance is any-hing but ordinary. Consider the impres-sive tuner specifications: 1.7uV IHF sen-sitivity, 100 dB selectivity, and a signal-to-noise ratio of 70 dB. And to make the most of that performance, the tuner facilities include switchable high-blend and muting, signal-input and center-channel tuning meters, a long, linear-spaced dial, rear-panel oscilloscope output jacks to help you aim your an-tenna for minimum multipath. There's also a coaxial connector for a 75-ohm shielded antenna lead.

The preamplifier is equal to the finest separate components. High voltage in-tegrated circuits and other advanced features give it sensitivity, overload resistance, wide dynamic range, and clean, quiet performance to match the high standards of the tuner: only 0.1% harmonic or IM distortion, with 10Hz to 100 kHz response, and a 90 dB signal-to-noise ratio. And its facilities are as complete as those on any separate preamplifier, including such unusual extras as rear-panel audio scope output jacks, dual tape monitors with direct tape-to-tape dubbing, front and rear panel Aux inputs, a microphone mixing input with shutoff, and sharp-cutting 12 dB/octave high and low filters.

Think of it as the finest, *most* powerful receiver you can buy — or the finest, least powerful. The choice is yours. The cost of this high quality component, $549.50* Sony Corporation of America, 47-47 Van Dam Street, Long Island City, New York 11101.*Suggested retail price.

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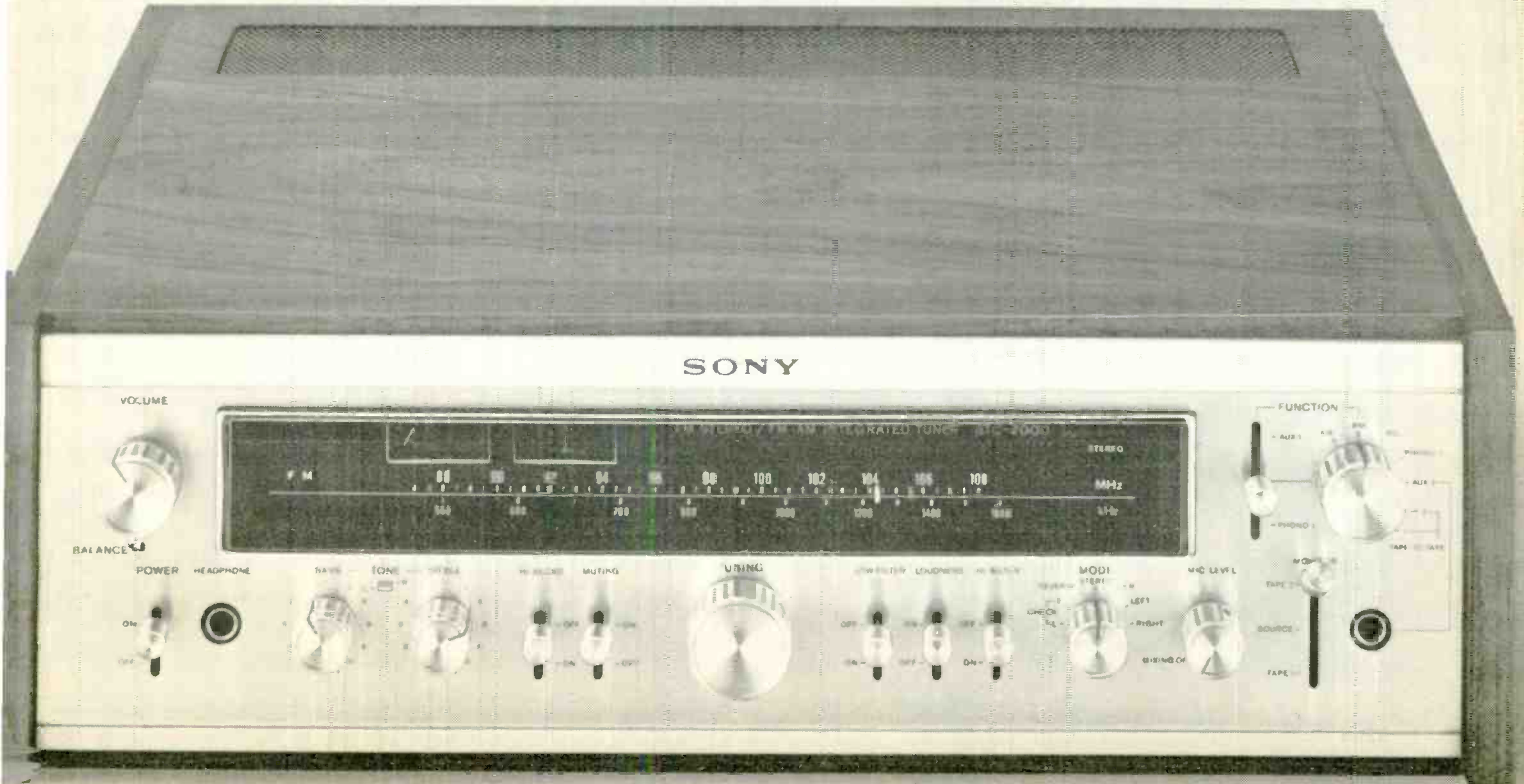


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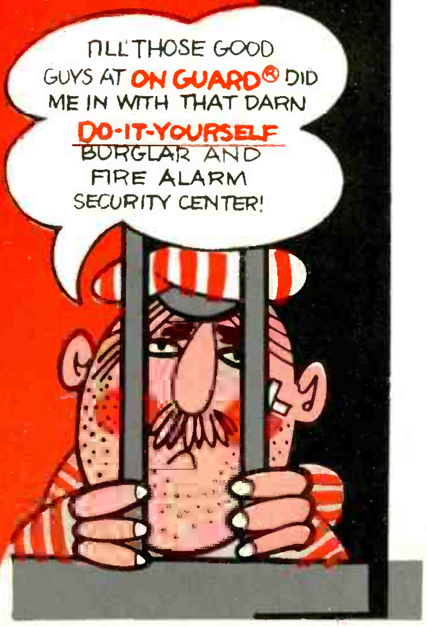


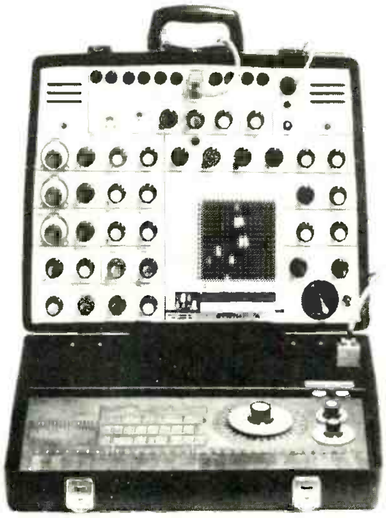

*Circle 25 on reader service card*




## NEW PRODUCTS

*(continued from page 80)*

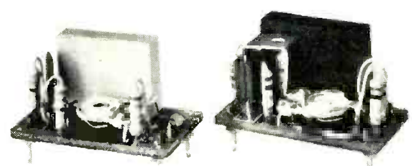
inputs from external sources, contributing to the unit's almost infinite variety of sound effects. Approximately 5½ x 4½ x 19 inches, weight 20 lb. Basic unit, $995. With keyboard $1,050. With keyboard and



computer-type memory component, $1,095.—**Electronic Music Studios (London) Ltd.,** 49 Deodar Rd., London SW15, England.

*Circle 33 on reader service card*

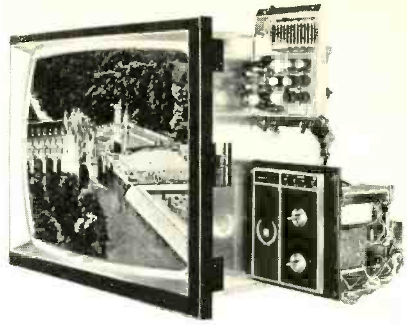
**BATTERY CHARGER,** *Panaquick*. Designed for recharging batteries in cordless equipment, the *Panaquick* uses an IC regulating device to detect changes in voltage as small as 50 mV. As a result, this system is said to charge from five to ten times faster than anything else available



today. Applicable to a wide range of industrial and consumer products, from battery-operated toys to video tape recorders, the *Panaquick* is maintenance-free, safe and easy to operate.—**Matsushita Electric Corp. of America.** 200 Park Ave., New York, N.Y. 10017.

*Circle 34 on reader service card*

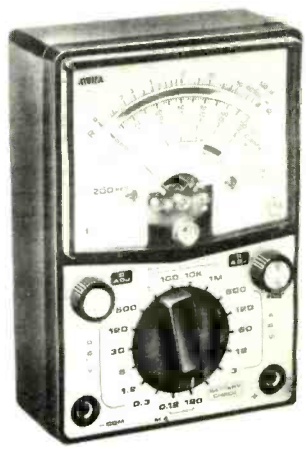
**25" COLOR TV KIT,** *model GR-900,* has a 25" diagonal screen and a uhf-vhf detent tuner that permits tuning uhf channels just like vhf channels. Pushbutton power tuning and wireless remote are also offered. Built-in angular tint switch selects either normal or wide angle color demodulation to reduce tint and flesh tone changes when switching channels. Instant-on operation with override, pushbutton automatic fine tuning and automatic tint control and adjustable tone control are also included. All solid-state circuitry uses



plug-in module boards. Factory prepared wiring harnesses and factory assembled and aligned tuners to simplify construction. $599.95.—**Heath Company,** Benton Harbor, MI 49022.

*Circle 100 on reader service card*

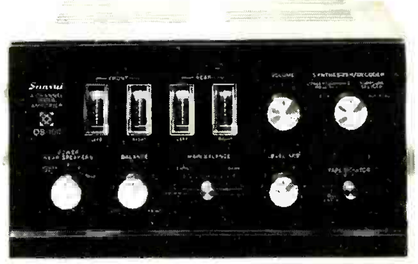
**SOLID STATE MULTITESTER,** *model FET-200.* Reads resistance up to 1 megohm, ac & dc volts to 600V; 300mV dc full-scale sensitivity. Zero-centering feature allows positive and negative readings without reversing leads. Three pound in-



strument measures 5" x 3-½" x 1-⅞", is battery-powered, has built-in battery check and all controls and jacks are on the front panel. Comes in a simulated leather carrying case. $54.95.—**Mura,** 50 S. Service Rd., Jericho, NY 11753.

*Circle 35 on reader service card*

**FOUR-CHANNEL CONVERTER,** *model QS100.* When used with two additional rear-channel speakers, converts existing 2-channel stereo systems into a 4-channel



sound synthesized matrix or discrete system. The unit combines a synthesizer, a matrix decoder, two channels of power

*(turn page)*

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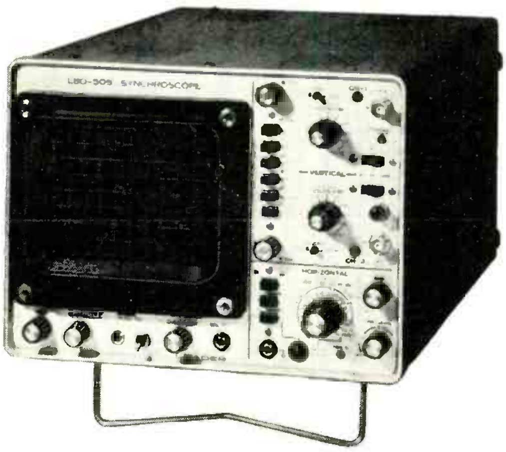

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*Circle 36 on reader service card*

**MATV ANTENNA CABLE JUMPERS,** *models CAD-6MF and CAD-6FF,* use tightly shielded coax cable with low loss on all uhf and vhf channels. The *CAD-6MF* is a 6-foot jumper with an autotype plug and an "F" fitting end. Typical application


would be from Jerrold's *Omni-Tap* wall outlet to a matching transformer with an "F" fitting input.

*CAD-6FF* is a 6-foot jumper with an "F" type male fittings at each end of the cable. *CAD-6MF* is $3.50; *CAD-6FF* is $3.15.—**Jerrold Electronics Corp.,** 401 Walnut St., Philadelphia, PA 19105.

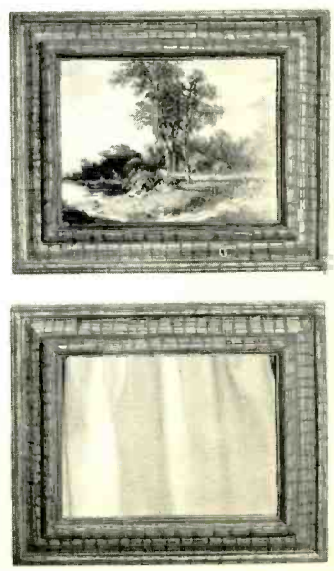
*Circle 37 on reader service card*

**SPEAKER SYSTEM,** *model FX-100A,* 2-speaker, 2-way system; ducted port design; heavy-duty 8" wide-range driver; special 3" tweeter; frequency response 32 to 20,000 Hz; 30-watt input; 8 ohm impedance; minimum power requirement 8

watts; 21" H x 12" W x 7-7/8"D. Oiled walnut veneer finish. $79.95.—**Fairfax Industries, Inc.,** 900 Passaic Ave., E. Norwark, NJ 07029.

*Circle 38 on reader service card*

**DECORATOR SPEAKER,** *Poly-Sonic Model DS4OP.* This looks like a painting, is actually a hi-fi speaker. The print is preselected, but can easily be replaced with one of your own choice. The super-thin



speaker hides behind the painting which functions as the basic sound-producing speaker surface. The unit handles 40

*(turn page)*



*Circle 63 on reader service card*

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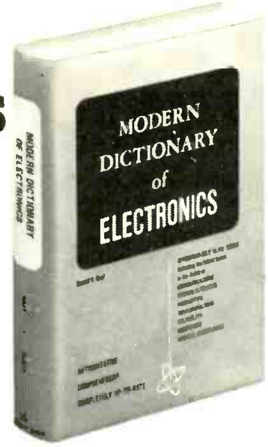


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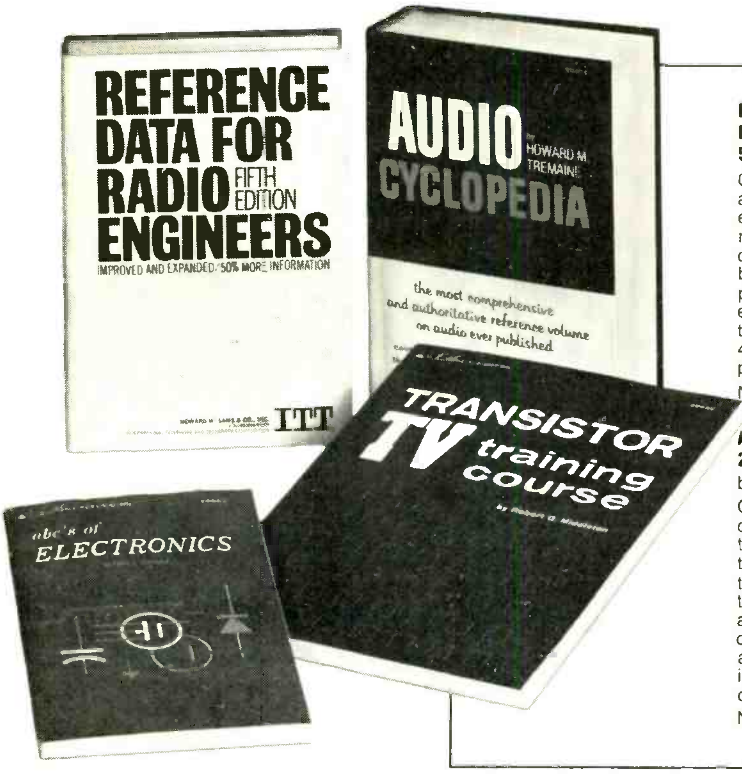


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watts, has 30 Hz to 20 kHz frequency range, 8 ohms imput impedance. 19⅞" x 16⅞" x 2⅛". $24.95—**Magitran Co.,** 311 East Park St., Moonachie, NJ 07074.

*Circle 39 on reader service card*

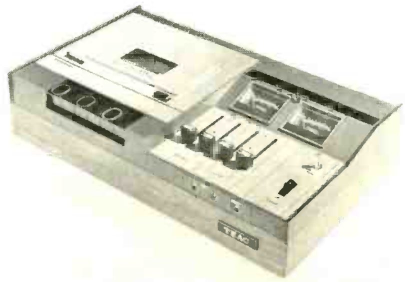
**SSB/AM CITIZEN TWO-WAY RADIO,** *Sidetalk 23.* A 46-channel sideband and 23-channel AM transceiver. Has adjustable squelch, plus fine tuning (clarifier) control of each channel. Noise blanker circuit with front control switch is provided for high noise conditions. Crystal-lattice filter provides 60 dB suppression of unwanted side bands. AM receiver section has dual conversion with ceramic filtering for better than 70 dB image rejection. Operates from 12V dc or—with power supply—from 117V ac.—**Pathcom, Inc.,** Pace Div., P.O. Box 306, Harbor City, CA 90710. R-E

*Circle 40 on reader service card*

**HIGH VOLTAGE SOCKETS,** *part No. S-104-C* shown. One of a series of five new high-voltage sockets that have been added to this tube socket line. Altogether, there are 74 different types of sockets available. All are replacements for sockets used in high-voltage power supplies of television receivers.—**Oneida Electronic Mfg., Inc.,** 843 N. Cottage St., Meadville, PA 16335.

*Circle 41 on reader service card*

**CASSETTE DECK,** *TEAC Model 220.* Luxury type deck that includes four separate preamps, two for record and two for playback. High-density ferrite heads bear an original owner lifetime warranty. Has a bias selector for the latest high-density ferrite oxide tapes and for chromium-dioxide tape. Four-pole hysterisis synchronous motor, speed 17/8 ips, headphone jack (for 8-ohm phones). Suited for use with the TEAC Model AN-60 Dolby noise reduction unit. $199.50.—**TEAC Corp. of America,** 7733 Telegraph Road, Montebello, CA 90640.



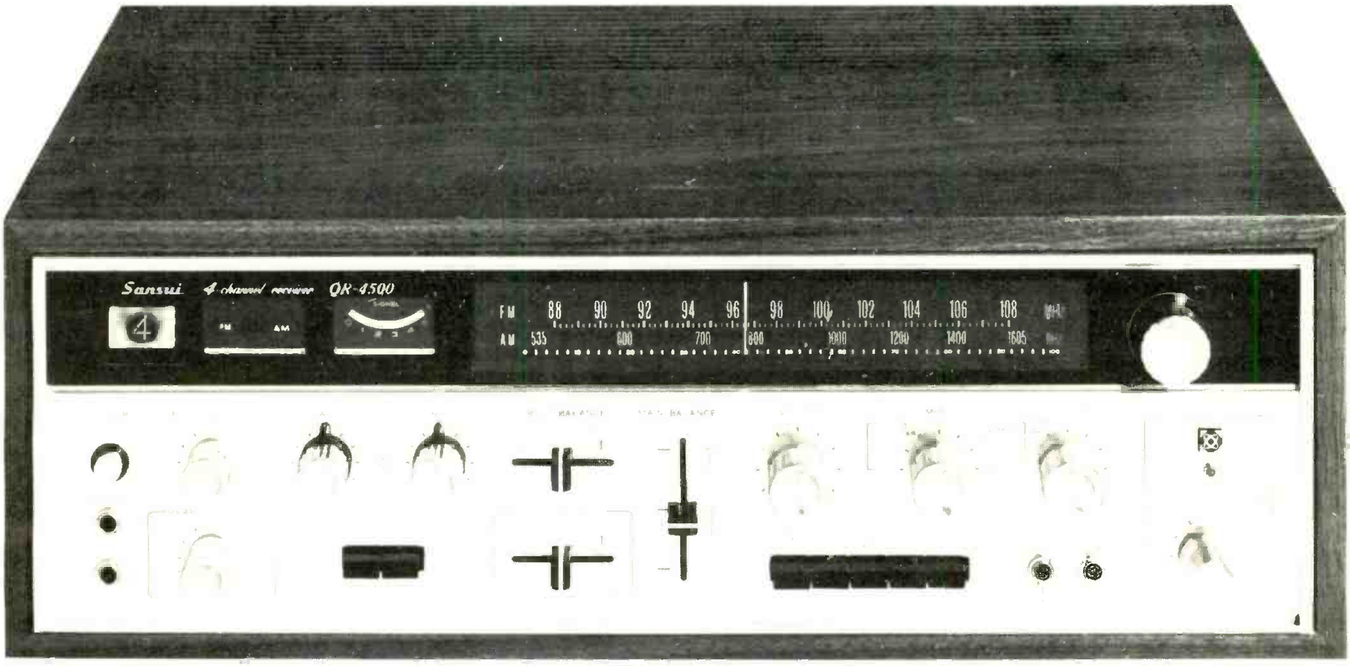
*Circle 42 on reader service card*

**CHEMICAL SPRAYS,** *Adjusta-Spray.* A new valve that permits adjusting the rate of chemical flow and a special spray nozzle that may be used with or without extender tubes are now available in this line of chemical sprays. With the adjustable nozzle it is possible to both put the spray exactly where you want it and regulare the amount of spray as well. *Adjusta-Spray* is available on 8-ounce cans of *Tun-O-Foam* tuner cleaner/lubricant and *Tun-O-Brite* tuner cleaner/polisher/lubricant.


The regulator feature will permit the service technician to select a heavy spray to blast loose gunk, or a light spray for small delicate jobs. It can also reduce the possibility of overspray, which can sometimes be messy.—**Chemtronics Inc.,** 1260 Ralph Ave., Brooklyn, NY 11236 R-E

*Circle 45 on reader service card*

# WHICH WAY FOUR CHANNEL ?




# THIS WAY

If the four-channel merry-go-round has you confused, you have lots of company. Discrete or matrixed. Compatible or non-compatible. This system or that one.

Now Sansui offers you total-capability QR Receivers that will transport you into the four-channel world to day and can handle every variation to the four-channel game that anyone's dreamed up for tomorrow.

Take the QR4500 AM/FM Two-Channel and Four-Channel Stereo Receiver-Synthesizer-Decoder-Amplifier-and-Control-Center. It can decode any compatibly matrixed four-channel recording or FM broadcast, or it can synthesize two rear channels from any two-channel source. Exclusive Sansui phase-shift matrixing prevents the sound dropouts and false dislocations that plague many matrixed systems. And exclusive phase modulators duplicate the live sound field.

It can handle any tape or other discrete source and accepts adaptors, converters or other accessories for any four-channel technique anyone's hinted at.

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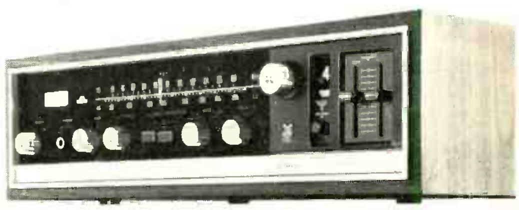
You'll find the same universal four-channel versatility in all Sansui QR Quadphonic Receivers, including the QR1500, with 100 watts of total IHF power (20 watts continuous per channel at 4 ohms). With walnut cabinet, $299.95.



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# new lit

*All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free for the asking. Turn to the Reader Service card on page 127 and circle the numbers of the items you want. Then mail the postage-paid card.*

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**BURGLAR AND FIRE ALARM EQUIPMENT** *1972 Catalog.* 12 pages filled with all kinds of fire and burglar alarm devices, bells, horns, sirens, complete systems, switches and key locks. Actuators of all types, alarm wire, fire alarm thermostats, and every other device needed to assemble an alarm system, are listed. One of the most comprehensive catalogs of its type.—**Universal Security Instruments, Inc.,** 29 Potee St., Baltimore, MD 21225

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*Write direct to the manufacturers for information on items listed below:*

**TECHNICAL BULLETIN** describes *RAECO-15* rare-earth cobalt permanent magnets with an energy product of 15 million gauss-oersteds, and a Curie temperature of 750°C.

The new magnets are an alloy of samarium and cobalt.—**Raytheon Co.,** Microwave and Power Tube Div., 190 Willow St., Waltham MA 02154.

**REACT TEAM DIRECTORY.** A listing of more than 600 REACT (Radio Emergency Associated Citizens Teams) who maintain a 24-hour watch on Citizens Band channel 9 for the purpose of giving aid to motorists and assisting in any kind of emergencies. Motorists who want to report emergencies or call for assistance simply give their call letters and call REACT, 10-46, for motorists assistance, or 10-33 for emergencies threatening the safety of life or property.—**REACT National Headquarters,** 111 E. Wacker Potee St., Baltimore, MD 21225

# The best time to upgrade your component system is before you buy it.

If you're a typical reader of this magazine, you most likely have a sizeable investment in a component system. So our advice about upgrading might come a little late.

What you might have overlooked, however, is the fact that your records are the costliest and most fragile component of all. As well as the only one you will continue to invest in.

And since your turntable is the only component that handles these valuable records, advice about upgrading your turntable is better late than never.

Any compromise here will be costly. And permanent. Because there is just no way to improve a damaged record.

If the stylus can't respond accurately and sensitively to the rapidly changing contours of the groove walls, especially the hazardous peaks and valleys of the high frequencies, there's trouble. Any curve the stylus can't negotiate, it may lop off. And with those little bits of vinyl go the high notes and part of your investment.

If the record doesn't rotate at precisely the correct speed, musical pitch will be distorted. No amplifier tone controls can correct this distortion.

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Experienced component owners know all this. Which is why so many of them, especially record reviewers and other music experts, won't play their records on anything but a Dual. From the first play on.

Now, if you'd like to know what several independent test labs say about Dual, we'll send you complete reprints of their reports. Plus a reprint of an article from a leading music magazine telling you what to look for in record playing equipment. Whether you're upgrading or not.

Better yet, just visit your franchised United Audio dealer and ask for a demonstration.

You'll find Dual automatic turntables priced from $109.50 to $199.50. That may be more than you spent on your present turntable, or more than you were intending to spend on your next one.

But think of it this way. It will be a long, long time before you'll need to upgrade your Dual. Dual®

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*Circle 68 on reader service card*

**SOLID-STATE DESIGN**
*(continued from page 58)*

the emitter circuit and the primary winding of transformer T3, 10 volts will be across the transistor in the quiescent state. The quiescent collector current is 3.32 watts/10 volts = 332 mA. The peak current, $I_{max}$ = 2 × 332 mA = 664 mA, which is within the 700 mA rating of the 2N3053. Draw the ac and dc load lines in Fig. 10.

The dc load resistance is (12 − 10) volts/332 mA = 6 ohms. The ac resistance is 20 volts/664 mA = 30 ohms. The resistance that is to be reflected from the secondary of the transformer to the primary is 30 ohms − 6 ohms = 24 ohms, so that the impedance ratio of T3 is 24 ohms to 8 ohms, or 3:1, and the turns ratio is $(24/8)^{1/2}$ = 1.73:1. This assumes the dc resistance in the secondary winding is negligible when compared to the resistance of the 8-ohm load.

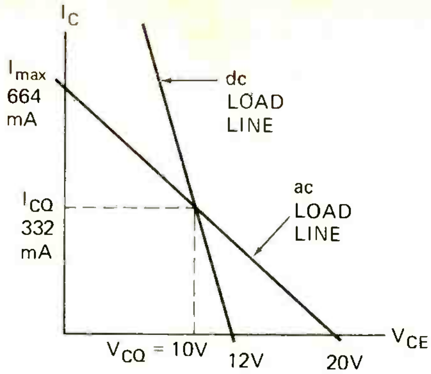


**FIG. 10—LOAD LINES used in design of power amplifier stage shown in Fig. 9.**

If we wish to design the transformer for a minimum of 25% efficiency, the maximum resistance of the primary winding can be determined from Equation 2.

$$25 = \frac{100}{1 + \frac{R_p + 3R_s}{3R_L}} = \frac{100}{1 + \frac{R_p + 0}{24}}$$

and $R_p$ = 72 ohms

As the dc design allows for a maximum of 6 ohms for the sum of the primary winding dc resistance and $R_{E2}$, the efficiency requirement will automatically be met in a proper design.

The voltage gain of an output stage is relatively unimportant when compared to its performance in delivering output power. Let us assume we would like a voltage gain of about 20 from this stage. As the ac output impedance in the collector circuit is 24 ohms, the resistor in the emitter should be about 1/10 this value. Use a standard 2.7 ohm resistor for $R_{E2}$. This will also conform with another rule of thumb stating that *about 1 volt should be across the emitter resistor of a power transistor when it is idling.* Here the voltage is (2.7 ohms) (332 mA) = 0.9 volts—a value close enough to 1 volt. The dc resistance of the primary winding, $R_p$ can then be specified at less than 6 ohms—2.7 ohms = 3.3 ohms.

1.33 watts must be delivered to the 24 ohms ac impedance across the primary of T3 if 1 watt is to be delivered to the load. For this output, the rms voltage across the primary of the transformer is $V = (R_L' P)^{1/2} = [(24)(1.33)]^{1/2}$ = 5.7 volts.

The emitter resistance, $r_e$, of the transistor is usually taken at $26/I_E$, where $I_E$ is the quiescent emitter current expressed in mA. For a current of 332 mA, this figure becomes too small to be reasonable. We assume a minimum dc emitter resistance of 1 ohm for most transistors.

The total ac resistance in the emitter circuit is this $r_e$ = 1 added to the $R_{E2}$ = 2.7 ohms, or 3.7 ohms. The calculated voltage gain of the output stage is the ratio of the 24 ohms at the primary of the output transformer to the 3.7 ohms just calculated, or 6.5. This differs from the approximate gain of 10 sought after above. More gain can be designed into the earlier stages.

The voltage at the input to the transistor must be the 5.7 volts at the output divided by the gain of 6.5, or 0.88 volts.

*(concluded next month)*





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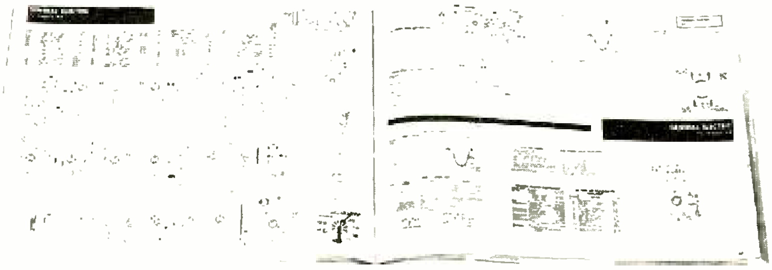

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*Circle 71 on reader service card*

## ELECTRONIC WATCHDOGS

*(continued from page 35)*

Other uhf systems operate in a similar fashion to the ultrasonic units and use Doppler shift as the detection method (Fig. 5).

Uhf motion detectors operating in the GHz part of the electromagnetic spectrum are less prone to false alarms caused by large objects moving outside the walls of the protected area. The Gunn diode is an ideal oscillator for this purpose, and now that it is commercially available, it is beginning to be used in low-cost compact uhf systems.

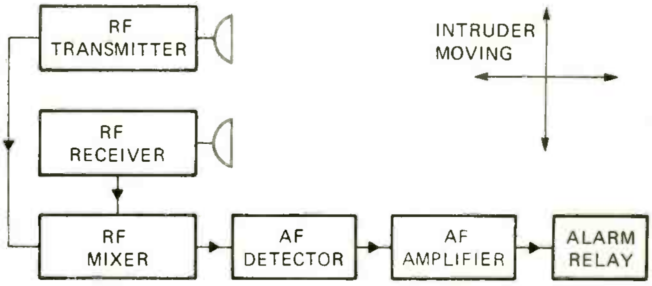


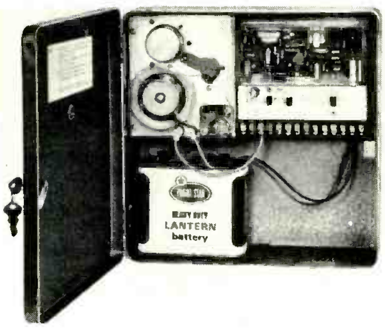

**FIG. 5—A UHF MOTION DETECTOR in block diagram form. These systems operate in the GHz portion of the spectrum.**

### Passive infrared

Every object whose temperature is above absolute zero radiates electromagnetic energy. Most of this radiated energy is in the infrared part of the spectrum and is directly related to temperature.

Infrared energy bridges the gap between visible light and the microwave frequencies used in radar. It starts at deep red and extends from 0.75 microns to about 1000 microns.

The human body radiates energy at wavelengths predominantly between 3 and 8 microns. Although the energy level is very low, special photoconductive cells can detect a moving human target at distances of 30 feet. A recently introduced system operating on this principle uses a single passive sensor to protect an area 20 feet by 20 feet. One amplifier and control unit serves up to eight sensors that can be placed in any location. It is claimed that the unit responds only to sudden changes in infrared radiation and is not affected by noise, air turbulence or rfi.




**TELEPHONE DIALER alarm calls police or fire department depending upon type of transducer activated. Ademco makes this unit.**

### The very candid camera

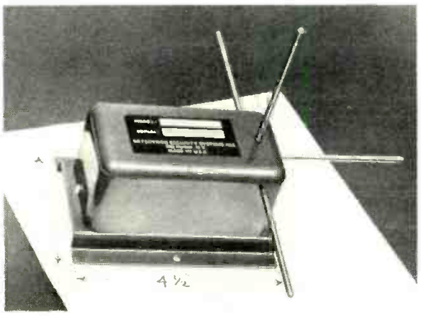
Closed-circuit television (CCTV) systems have been extensively promoted as the ultimate form of security. Experience has shown that it is not enough to use CCTV alone. It is necessary to use a primary detector—such as ultrasonics—and to use CCTV to view the area when an alarm is received; or to modify the receiver so an alarm is automatically triggered if the picture changes.

One CCTV system uses a digital memory and comparator to obviate the need for a primary detector. When the camera is switched on and stabilized, an analogue-to-digital converter translates "bits" of the scan (picture) into a digital code stored on a magnetic loop that is synchronized with the scan.

The stored data is compared with each subsequent scan. Any major change in the data between scans activates an alarm. Changes are detected by adding the "live" and the "stored" signal out of phase. If the picture changes, the two signals no longer cancel and the output activates the alarm.

### Electronic sniffer

Chromatography is a method of determining the constituents of a complex gas or vapor mixture. The method–it can be a continuous process–may be used to detect the presence of a human or animal intruder.

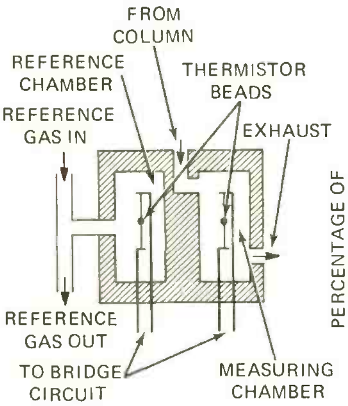


**TYPICAL "RADAR" type motion detector. This small unit is part of a system by Detectron Security.**

The human body effuses a significant amount of ammonia, and this is frequently increased under stress. As an intruder detector, the gas chromatograph is programmed to report any increase in the ammonia constituent.

A gas sample is taken at frequent intervals from the protected area. It is combined with an inert carrier gas and forced under pressure through a glass or metal column packed with activated carbon or similar absorbent. Constituents of the sample are retained for different periods by the absorbent and emerge from the column (together with the inert carrier) in inverse order of absorbence.

Various methods are used to determine the percentage of each constituent in the sample. The most common of these compares the thermal conductivity of each constituent plus the inert carrier against the carrier alone, and plots the result as percentage against time. A thermal conductivity cell is



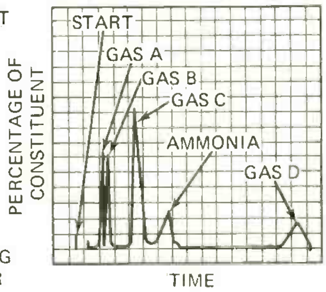




**FIG. 6—(above left) shows construction of a typical thermal conductivity cell. FIG. 7—(above right) is the plot produced by such a cell.**

shown in Fig. 6 and a typical plot in Fig. 7. Note that the graph is read from right to left.

Once calibrated for use, any ammonia content in the gas sample appears at the same known interval of time after the total sample has been introduced into the column. If a reading is obtained from the thermal conductivity cell at this time, exceeding the preset level, an alarm circuit is energised.

The gas chromatography system is virtually tamper-

*(continued on page 100)*

**APPLIANCE CLINIC**
*(continued from page 26)*

should not be used in wiring systems having only two wires. Not unless the wires are replaced, which could lead to quite a bit of "wire-pulling" through the walls in the typical home. In most places, you can use flexible conduit or "Romex" for this, if you use the 3-wire type. It has two insulated conductors, (usually black and white) and a bare wire. For a strictly Code job this bare wire, which is the groundING conductor, must be connected to the ground connection of the service wiring, at the service disconnect. It is for cases where new Romex is run to an additional outlet.

There is one exception noted in the Code: Art. 250-50, p. 74. I quote: "Exception: for branch-circuit extensions only in existing installations which do not have a groundING conductor, the grounding conductor of a grounding-type receptacle may be grounded to a grounded cold-water pipe near the equipment." unquote. This *would* allow the use of the "3-wire with one round pin" type of receptacles, in systems with only two wires; for laundry rooms, utility rooms, and such places, where a coldwater pipe is nearby for the ground. For this, the GREEN wire in the appliance line cord must be connected to the round pin of the plug; this is the safety ground. The round hole in the new receptacle *must* be wired to the cold-water pipe. Bare wire can be used here, of the same size as the conductors.

So, there you have the two types of "ground". The "power-circuit grounded conductor"—a part of the circuit carrying power, as in Fig. 1. As the Code says, p. 70, Art 250-25, "The identified conductor is commonly known as 'the white wire'." There is always current flowing in this, when a load is connected and turned on, although it is at ground potential.

The other one is the "green wire" and should be connected to the same ground-point as the white wire, at the service-disconnect unit. This is the point where the service wires enter the building. (Incidentally, this wire will be green only in flexible cords; in the branch wiring it'll probably be a bare wire). This wire *never* carries current, in normal operation. It carries current *only* when there is a "fault", meaning a short-circuit.

It is a good idea to check with your local wiring inspectors as to the ground connection of the safety ground. The Code recommends connecting this to the same ground as the white wire. In some cases, there may be different inter-



*Circle 74 on reader service card*



*Circle 75 on reader service card*

pretations, allowing the use of a different ground for the safety-ground. Art. 250-23, p. 70, says "Grounding connections shall not be made on the load-side of the service-disconnecting means." Then, they list three "Exceptions", one of which we mentioned.

You can install polarized plugs and sockets on the older two-wire systems, with which the majority of the homes in this country are wired. These have one wide blade and one narrow one, so that the plug can be inserted only one way

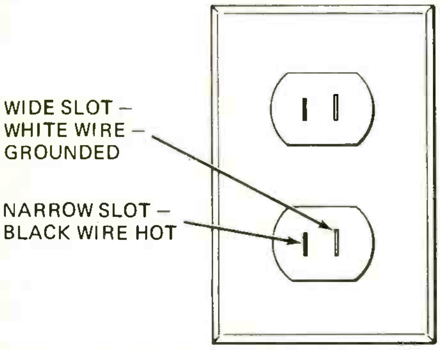



**FIG. 2—POLARIZED OUTLET suitable for use on older two-wire systems.**

(See Fig. 2) This is an old system, and has been used for years. The grounded (white) wire must be connected to the *wide* blade of the pin and the corresponding terminal in the receptacle. On the receptacle itself, the terminal screws will be coded; the ground side will be plated, with cadmium, etc. so that it looks "white" or silvery. The hot wire will be copper colored. In the new three-pin receptacles, the safety-ground screws will usually have a coating of green paint for identification.

Just remember the differences; a groundED, current-carrying conductor is always the "identified wire" white. The groundING conductor will be bare in the wiring, and green in the appliance line cord. Any other color of wire should always be considered as hot! **R-E**


***He won it in a raffle?—Well, tell him to buy another chance and maybe he can come up with a parts list!***

**NEXT MONTH**

**THREE NEW STORIES ON FOUR-CHANNEL STEREO**

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**ELECTRONIC WATCHDOGS**

*(continued from page 97)*

proof; however, the sampling speed is slow and a rapidly-moving intruder may not be detected until he has left the area. Recent development undertaken for the military is said to have overcome these problems.

The traditional alarm bell is still the best audible alarm for private and small-risk business use. Despite the folklaw that insists that the public does not pay attention to alarms of this nature, the type of criminal who attacks homes and small businesses most certainly does.

Alarm bells are essentially low-power devices and their effective range is less than 100 yards—but their abrupt onset attracts attention and their high-frequency components can be heard above normal background noise. Being a mechanically resonant device, the conversion efficiency of a bell is very high.

Sirens have the power-handling capability required for long-distance transmission and their distinctive sound is clearly differentiated from background noise. Their characteristic rise and fall in pitch is attention-producing. The vast majority of sirens are motor-driven. Some electronic sirens have been produced, but at the present time their power outputs cannot compete with the motor-driven types.

**ALARM INSTALLERS tool kit. A complete package of all the tools the installer needs. *Mountain West Alarm Systems***

A noise-making device **will deter the majority of intruders.** Nevertheless the really professional criminal will often disable a bell or siren before attempting entry. Some of the methods for doing this are most ingenious—and regrettably cannot be printed here.

Where such a risk exists, the alarm system is connected either by private telephone line or automatic dialling unit to a security company central bureau.

## What of the future?

Intruder detection systems are approaching the level of development where it is possible to almost totally secure an area against intrusion, and much current development has as its objective the production of existing systems which are cheaper to buy and simpler to install.

A major criticsim of many security systems is their high percentage of false alarms. This is typically 97 to 98%, and while quite a few of these are caused by the owner leaving doors and windows only partially closed, far too many are caused by substandard design and construction and/or poor installation. In some areas the problem has become so serious that the local police force has warned it will no longer answer alarm calls unless the number of false alarms is reduced.

As in so many fields, the quality of an installation is probably—but not necessarily—related to price. Look into what's available in your price range and see which system offers you the kind of protection you require. An alarm specialist that handles several lines of alarm systems can help you select a system that best fits your needs. **R-E**

This article reprinted from Electronics Today, April 1971

# next month

## OCTOBER 1972

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Topics included in this rather complete book on feedback systems are: uses of feedback, sensitivity analysis, nonlinear distortion in feedback systems, feedback control of large systems comparative sensitivity of optimal feedback control of systems with uncertain parameters, theory of general multiloop systems and applications of functional analysis to nonlinear systems with unknown plants.

Because of its orientation, practicing engineers as well as students will find the text a valuable reference for investigating tolerance problems in systems analysis and design.

***199 ELECTRONIC TEST & ALIGNMENT TECHNIQUES, by Art Margolis. TAB Books, Blue Ridge Summit, PA 17214. 5½ x 8½ in. 224 pp. Hardcover, $7.95.***

Here's a delightful quick reference guide of tests and adjustments to use in trouble shooting AM and FM radios, TV receivers, antenna systems, intercoms, electronic organs, garage-door openers, auto ignition systems and other electronic devices. These tests are broken down into appropriate categories, making it easy to find needed information. An important part of the book are tests for power supply and components including easy methods of checking transistors. A handy addition to any technician's shelf.

***RCA/COS MOS INTEGRATED CIRCUITS MANUAL, compiled by the RCA Solid State Div., Soverville, N.J. 08876, 5½ x 8 in., 160 pp. Softcover, $2.50.***

Prepared to give the reader an understanding of the basic principles of COS/MOS (Complementary-Symmetry/Metal-Oxide Semiconductor) devices, this book covers basic circuits, the CD4000 and CD4000A series, with complete handbook information and performance characteristics, COS/MOS logic-system design, counters and registers, adders, inverters and oscillators.—FS

***A CASEBOOK OF BASIC CIRCUITS FOR ELECTRONIC INSTRUMENTATION edited by George C. Stanley, Jr. Rinehart Press, Holt, Rinehart and Winston, Inc., 383 Madison Ave., New York, N.Y. 10017. 6 x 9¼ in. 216 pp. Hardcover, $9.95.***

Basic circuits are examined in terms of basic circuit description and trouble-shooting and failure patterns. Mathematics are kept to a minimum and explanations are in a language common to both engineers and technicians, although a knowledge of semiconductors and elementary circuitry is required.—LS

***FORTRAN IV AND THE IBM 360 by W. Wesley Peterson and Jean L. Holtz. McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. 10036. 7 x 10 in. 205 pp. Softcover, $5.95.***

This text explains more than just how to program. It also provides many interesting examples that illustrate important techniques, and yet can be understood without a great deal of technical background.—LS

***RADIO AND TELEVISION: PRINCIPLES AND APPLICATIONS, by J. P. Hawker. Hart Publishing Co., 510 Sixth Ave., New York, N.Y. 399 pp., 9¼ x 6¼ In. Hardcover, $12.50.***

Helps in understanding the principles and applications of radio and TV equipment used in the home. Focuses on major advances in the field of stereophonic sound and color TV, semiconductor devices, new construction techniques. **R-E**

# electronic photos

A NEW FORM OF "ELECTRIC PHOTOGRAPHY" has been invented by researchers at Sandia Labs, N.M. Images are stored

(a) STORED IMAGE
All-Electric Cerampic

(b) STORED IMAGE
Electric Storage/Thermal Erase Cerampic

(c) PHOTOGRAPHIC PRINT
from original photo negative

by projecting them on a thin sheet of a special ferroelectric ceramic, across which a voltage has been impressed. *(continued on page 106)*

# equipment report

## *B & K 1440 oscilloscope*

At first glance, the B & K 1440 oscilloscope looks just like any of the "New Generation" scopes. Compact case, flat-screen 5" crt, controls all neatly arranged for maximum ease of operation, and so on. However, B & K have added a feature to this one that can save you a great deal of time no matter what kind of electronics service work you do.

*Circle 26 on reader service card*

It is called *Cali-Brain*. Basically, it is a fast and easy method of reading the peak-to-peak voltage *of any signal* displayed on the screen. Locked on or unlocked, I might add. You do *not* have to sync the pattern. (For example, when looking for hash on a filter capacitor terminal, indicating that it is open.) The vertical attenuator is calibrated in 8 ranges, in 1-3-1-3 steps. The lowest range is 0.1 volt (and you *can* read a vertical deflection of about 0.05 volt), the next one 0.3 volt, then 1, 3, 10.0, 30, 100 and and 300 volts. A continuously-variable control is provided, if you want to set a waveform so that you can check some part of it. To calibrate the attenuator, just turn the variable control clockwise until you hear the switch click.

You can get a pretty good idea of the amplitude by looking at the waveform. For maximum accuracy, this is where the *Cali-Brain* comes in. Just pull out on the VERTICAL POSITION knob. This not only collapses the horizontal sweep, but moves the resulting vertical line either left or right until it is under one of the two scales on the graticule! "1" on the left, "3" on the right.

To make sure that you know which one you're on, a digital read-out just above the screen lights up. Three digits are used, and the decimal point *moves* as the VOLTS FULL SCALE selector switch is turned. Peak-to-peak voltages up to 300 volts can be read, in the DIRECT position of the probe. Set the probe to the 10:1 position, and this multiplies all ranges by 10, so that peak-to-peak voltages up to 3,000 volts are available. The 1440 uses the same light, handy dual probe that we discussed with the 1460 B & K scope; to change it from DIRECT to 10:1 LOW-CA-



*Circle 86 on reader service card*

PACITANCE, just pull out the tip, turn it halfway around and plug it back in.

The vertical amplifier in the 1440 is an all-solid-state type, with frequency response from dc up to 10.0 MHz. Either ac or dc input can be used. The selector switch has a center ground position, for positioning the trace in dc. Just be sure to move this off the GROUND position, or you'll have the same momentary difficulty I did!

The horizontal sweep goes from about 5 Hz up to 500 kHz, and has the very convenient preset TV-V and TV-H sync-separator circuit helps to give these waveforms maximum stability.

The regular INTERNAL, EXTERNAL and LINE syncs can be used, with a polarity selector to let you lock on either the positive-going or negative-going waveforms. A SYNC-PHASE control helps stabilize patterns. This is also used to phase the sweep when doing sweep alignment on INTERNAL LINE sweep. With the wideband amplifiers, the 1440 can also be used as a vectorscope, from the front panel jacks. An overlay is included to help locate the various key points on the "flower".

This instrument uses all solid-state circuitry; only one tube, the 5DEP1 crt. A 1-volt peak-to-peak square wave for checking calibration is on a front-panel jack. Astigmatism can be adjusted, if necessary, with a screw-driver through a tiny hole in the front panel. The 35 ns rise-time of the vertical amplifier gives this scope high resolution, especially on steep-sided pulses, sync, and similar applications. R-E

## ELECTRONIC PHOTOS

*(continued from page 103)*

The images are immediately visible, need no developing or fixing, but become permanent with removal of the electric field. They can be erased by applying another voltage and flooding with light.

The pictures may be made by applying light through a photographic negative or by scanning the ceramic with an intensity-modulated beam of light. Researchers feel that it may become possible to form and erase images at rates up to 15,000 lines per second, making the device useful for television-like pictures.

The prototype Cerampic plate consists of a material called PLZT, a lanthanum-modified lead zirconate–lead titanate electro-optic ceramic plate with a photoconductive film (PVK polyvinyl carbazole) deposited on one surface. To make the necessary electrical contact to both surfaces, they are coated with tin oxide-doped indium oxide, forming transparent electrodes on both sides of the ceramic plate.

The principle of the Cerampic is that randomly oriented ferroelectric domains (microscopic regions in which all the molecules are polarized in one direction) in the material tend to scatter light applied to the ceramic while domains lined up with the electric field transmit more light.

An image is stored by first "prepoling" the ceramic by flooding it with light and applying a voltage of about 12 kV per centimeter of thickness. This makes the ceramic almost transparent. Then the pattern to be reproduced is applied, say by placing a photographic film over one of the photoconductive layers. A dc voltage is now applied to the photoconductive surfaces, in *the opposite direction* to the voltage that prepoled it.

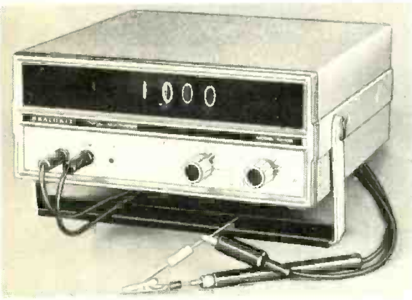
Since the photoconductive layer is an insulator in the absence of light, there is very little voltage across the ceramic under the darkest areas of the negative. Under the brighter areas, practically the whole applied voltage is across the ceramic, and the ferroelectric domains are scattered, reducing their transmission of light in proportion to the transparency of the negative. Thus the ceramic reproduces the detail of the negative in reverse: the lighter areas cause more scattering of light and make the ceramic appear darker, while the darker areas of the negative appear brighter in the ceramic "positive."

In its original unpoled state, the ceramic is even more transparent than when pre-poled. The ferroelectric domains are smaller and tend to be lined up "head-to-tail" with each other. Pic-

*(continued on page 110)*

# equipment report

## *Heathkit IM-102 digital multimeter*



*Circle 100 on reader service card*

THE LATEST THINGS IN THE HEATHkit line of test equipment are their digital display units. Several of their instruments (frequency counters) have used digital readouts, of course, but if I'm not mistaken, the IM-102 is the first "one piece" digital multimeter in kit form. The IM-102 can be used for service work or lab use with equal ease. It reads ac or dc volts and current as well as resistance. Voltage ranges run from 200 mV up to 1,000 volts. Both ac and dc current ranges from 200 μA to 2.0 A. Resistance from 200 ohms to 20 megohms (full-scale). (You can read as little as 0.1 ohm accurately.) A high-voltage probe can be used to read up to 30 kV.

A very high input impedance on the two low voltage ranges is handy; 100 megohms on the 200-mV range, and 1,000 megohms on the 2.0V range. The standard 10.0-megohm input applies to all others. The ohmmeter section has a current of only 100 μA on the 2K range, and 10.0 μA on the 20K and 200K ranges. This is low enough so it won't turn on transistor junctions while making in-circuit measurements.

The readout is 3½ digits. This caused some arguments when we first got it, but it was soon settled by reading the instructions. This means that there are 3 Nixie tubes, plus a "1" at the left, for readings over 999. So, it will count up to 999, then the 1 lights and you start over. So, maximum usable reading on the 200 volt range, for instance, is 199.9 volts. If the voltage goes above this, you see an OVER light, and switch to the next higher range. (The instrument has all kinds of overload protection, from Zener diodes to fuses, on all ranges.)

The accuracy of this instrument is something else for service work. With the special dc calibrator furnished, you can calibrate it to a minimum accuracy of 0.2%; 0.1% if you have access to a lab-standard ac/dc calibrator. That's *two-tenths of one percent.*

For old "needle-watchers", the digital display may be confusing for a little while, but you'll get used to it quickly. This is mainly due to the fact that we're used to reading voltages as "about 10.4 volts" instead of an indicated "10.36

*(turn page)*

**EQUIPMENT REPORT**
*(continued from page 107)*

volts". We just aren't used to being able to read to a hundredth of a volt, that's all.

The IM-102 is about 8" wide, 10" deep and 4" high. Inside this little box is a complete analog/digital readout system. There are 19 IC's, 18 transistors and a whole herd of assorted diodes. All of this is mounted on a heavy epoxy-glass PC board. Another, smaller board across the front carries the "ac converter" circuitry. This is a beautiful job of design and construction, too. Every part is numbered and marked on the boards, and assembly is really simple, if you follow the directions.

The front panel is deceptively plain. A dark plastic window lets the readouts be seen. Two selector switch knobs and three banana jacks complete the layout, and that's all there is. You don't need a pilot light since the readouts light as soon as it's turned on. The IM-102 draws so little power, despite the great number of components used, that it can be left on all day; nothing gets hot.

There is a bonus. The instruction and assembly manual that comes with the IM-102, if studied carefully, will get you well-started into basic *computer* circuitry and applications. Each circuit is drawn out separately, and its operation described in plain English.

That takes care of the technical stuff; now for the personal reactions.

The kit took about 15 hours to finish. I'd gone over and over the board, and no solder bridges that I could see. So I made the preliminary resistance tests given in the book, and I passed. No shorts in the dc power supply. I smirk and turn it on. The little lamps light up and say "1931". So, I start with the calibration procedure.

Nothing happens. It sits there and says "1931" at me. All right, knucklehead, you've done *something* wrong; what was it? The magnifying glass shows me that one of the pins of IC-8 has missed its socket. Hmm. Pull it, straighten the pin and put it back right this time.

Now the display works. At least it counts up all the time. The zero-adjust won't stop it. Now what? Turn it off and look up the "Troubleshooting" section of the manual. First step here, it says, is "Check all dc voltages". I do. There are two 12-volt supplies, one positive and one negative. The −12 is OK, but the +12 volts "sinks" gradually to about 6 volts.

Some little time later, I discovered a wee tantalum electrolytic capacitor on the +12 volt line installed *backward*. The reverse current through the capacitor was slowly dragging the +12 volts down. Fortunately for idiots, tantalum capacitors take this better than the stock low-voltage electrolytics.

Now everything looks a lot better. Both 12-volt supplies are OK, all of the calibration adjustments work, and I am red-faced but happy.

I'm entitled to one small gripe. On page 18, early in the assembly, they recommend installing Q16, a flat-pack power transistor similar to RCA's SK-3084; 3 legs and a flange. This has a good-sized heat-sink (it's the 3.5-volt line-voltage regulator). It's mounted on its own leads, standing free. During the rest of the assembly, I kept knocking this down as I turned the board, until I was afraid I'd break the legs off. I finally took it out; after I had all of the rest done, I put it back. This is easy, since it is on top of the board and very accessible.

It's finished, and occupies a place of honor on my bench. I've used it on a lot of different jobs, from TV to transistors, and found it to be an extremely handy and accurate instrument. It's nice to be able to look up and see a reading that tells you "in plain English" that you have 165.8 volts. **R-E**

### PECULIAR PURITY AND CUTE CURE

**Reader:** "I've got poor purity in my old RCA CTC-19. Adjustments don't seem to help much. Why."

**Service Editor:** "Check this, and that, and you might try a new set of purity rings as a last resort. Sometimes they lose magnetism."

**Reader:** (Second letter) "I tried your suggestions; yoke back, and so on. I had an *almost* red screen. The purity rings didn't seem to be doing anything. Remembering your suggestion, I *remagnetized* them with a permanent magnet and a couple of bars of iron. Now, they work beautifully, and I've got a pure red screen! Thanks."

### NO COLOR SYNC

***I've got a good black and white picture on this Zenith 20X1C38, but no color sync. Changed 3.58 MHz oscillator tube; no help. What's the most likely cause?—J.V. Youngstown, OH.***

Ground pin 8 of the 6JU8 tube, and adjust the color oscillator plate coil. See if you can get the color to straighten up and hold momentarily. If so, take the shunt off the 6JU8. If the color promptly falls out of sync again, you've got AFPC trouble.

One odd cause for this is "grid leakage" in the 6JU8 quadruple-diode tube. I know this one is a bit shy on grids, but you'll read this as grid emission on a tube tester capable of reading it. Actually, it seems to be a tiny leakage across the mount, or something. Upsets color sync wonderfully, though. Try a new 6JUB tube. **R-E**

**ELECTRONIC PHOTOS**
*(continued from page 106)*

tures with a little greater contrast can be made with unpoled ceramic. To restore the ceramic to its original state thermal depoling is necessary. Thus unpoled ceramic can be used only where permanent pictures are required, or in slow-switching electro-optic devices.

Negatives may also be made from negatives, or positives from positives, by a reverse process. After pre-poling, the Cerampic is switched to near the depoled state, scattering the domains and leaving the whole plate relatively opaque. Then, for example, a transparency can be placed on the Cerampic and light and voltage applied. The domains under the lighter parts of the transparency will line up, "erasing" the darker area and becoming brighter in the permanent picture, and areas under dark portions will remain opaque.

The resolution of stored images decreases with plate thickness, due to greater scattering of light. Contrast peaks at a thickness of 0.375 mm. Typical photosensitive plates now being produced measure 0.123 inch thick and 1 inch in diameter. **R-E**



# technote

**EMERGENCY MODIFICATION**

We had an Arvin model 65K8 TV portable come in for repair, just two days before the World Series. Its owner wanted it ready for that first game.

Right away, we located a cracked 34R3 damper tube. Yup, this was an easy one. What we didn't realize, at this time, there was not one 34R3 tube in town or at the three local electronic supply houses. We phoned two wholesale distributors ninety miles away. The tube was not made anymore!

How could this be? The set was hardly over three years old _ _ _ _ . According to Sams Photofact the portable was made in Japan. Maybe this could be the answer. Even the tube substitution manual was blank.

The set just rested on the service bench one whole day. Since all of the rental tv portables were reserved for the World Series, something had to be done—but, quick. Perhaps, the damper circuit could be modified?

This 34R3 damper tube was constructed quite differently than most American-made tubes. Yes, a little backwards. Instead of the top cap being the plate it turned out to be the cathode terminal (Fig. 1). Well, no American-made tube would easily fit in here.

Since the receiver was an ac-dc type we could use a dropping resistor in place of the 34R3 heater. A 75-ohm 10-watt resistor would work out at this

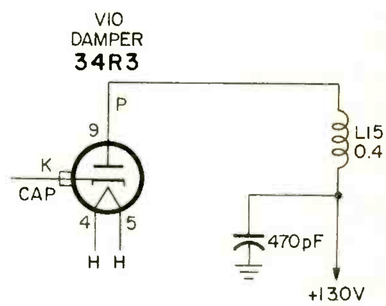



Fig. 1

point (Fig. 2) but, what can we use as a damper or rectifier?

You said it! A fixed diode or damper diode. Well, a focus diode or a regular diode could not possibly work in this damper circuit. Too much current drain and peak voltage. We remembered that RCA uses a solid-state damper diode in last year's 14-inch color receiver. Checking the CTC22 schematic diagram and parts list, we dug up a new damper diode, part number 120818.

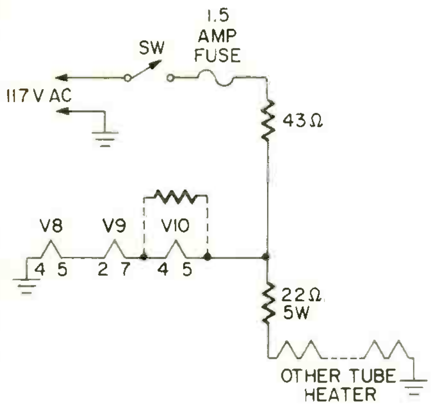



Fig. 2

Do you know something _ _ _ that cathode top cap plugged directly over the cathode end of the new damper diode. How lucky can you get. This, was our day after all. So why not take another horizontal output tube cap and fit over the other end? So be it.

The plate terminal cap was cut the right length and plugged directly through socket pin hole number nine and soldered to the corresponding terminal (Fig. 3). Both insulated caps were real snug and held the diode in place.

The portable TV was fired up and everything was GO. Better settle down and take a few ac voltage checks. We

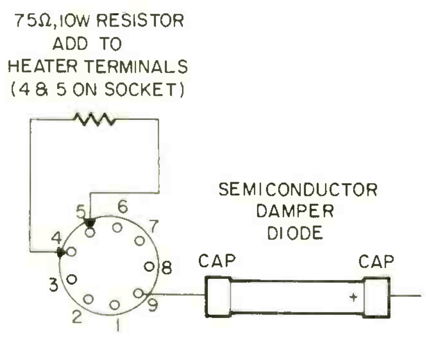



Fig. 3

measured 51 volts across the heater of V9, a 50JY6. Normal voltage across V8 is 17 vac and ours measured 17.5 volts.

After the portable TV played for sixty minutes we shut her down and checked the damper diode. Cool as a cucumber. The 10-watt resistor was a little warm but some ac dropping resistors run quite warm.—*David Mark* **R-E**

# try this

### HIGH QUALITY HOME BREW READOUT

Often, the experimenter has become interested in readout technology. Prices being what they are today limits the electronics buff in what he can do with readouts.

The purpose here is to convey ways and means, that cheap and high quality readouts can be made in the home.

The readout described here is a seven segment type. A large quantity can be manufactured for less than $6.00.

### LIST OF MATERIALS

1 pint of polyester resin and catalyst (use ventilation)
many Plexiglas strips 1/16 x ½ x 2 inches (use any color or clear)
1 small bottle of black painters pigment
mixing cups and mixing sticks
home made strip holder (see text)
1 polyethylene ice cube tray

Figure 1 shows what a finished home-brew readout looks like. Make

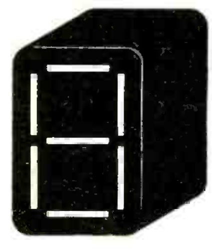


Fig. 1

the strip holder out of any hard wood that is knot free (oak will work very well). Figure 2 shows the dimensions of the holder. Use a planer blade in the saw when making the cuts.

After the strip holder has been made, then make the many Plexiglas strips using a band saw or other straight blade device. Make at least 50 strips.

After the strips have been made, steel wool the flat surfaces and leave the rough edges alone. The rough edge will provide a better grip for the strips.

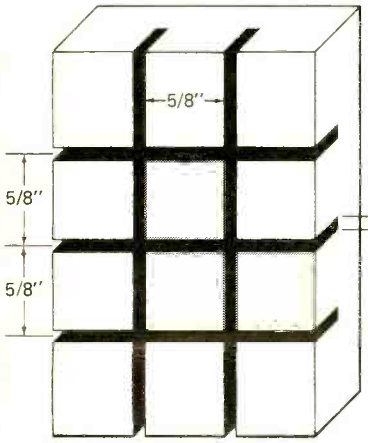



Fig. 2

After touching up the strips insert (seven) of them in the strip holder. If the strips do not fit snugly put a small piece of paper between the strip and the wood holder. The arrangement should look like Fig. 3.

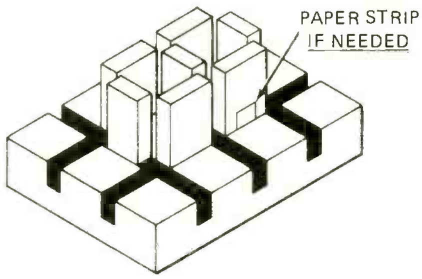



Fig. 3

Now you are ready to mix the polyester resin for the body of the readout. Do this as follows:

*(continued on page 114)*

**TRY THIS**
*(continued from page 113)*

Take the paper mixing cup and pour a quantity of resin into it. Judge how much resin will fill one space in the cube tray.

Then add just enough black pigment to the resin so that it turns opaque. After the resin has been mixed with the pigment then add the proper amount of hardener (catalyst).

After mixing the hardener with the resin and the pigment pour the contents into one cube portion of the cube tray. Pour only enough so that ¼ inch shows from the top of the mold. This allows for the mass of the plastic strips when they are inserted into the plastic.

Insert the strip holder (strips down) into the plastic in the tray. Center the strips as well as possible but take care not to disturb their position in the holder.

After positioning the strips in the plastic **do not move the tray or strip holder until the plastic has hardened.** The plastic will cure in about 1 to 2 hours. Some heat will be released by the chemical reaction of the curing plastic.

After the plastic has hardened it will easily come out of the cube tray. Saw off the protruding ends of strips and rough sand both front and rear surfaces of the readout. Wet or dry sand the front surface (smaller side) but do not polish.

Drill (seven) ¼ inch holes in the rear of the readout (large side) ½ inch in

—REAR OF READOUT—
(NOT TO SCALE)

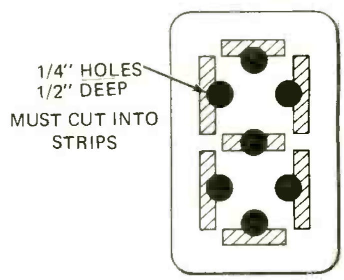



Fig. 4

depth (Fig. 4). These holes are for the appropriate lamps that you decide to use in the readout.

For all practical purposes you have made a top quality seven segment readout for about a quarter.—*R. E. Lukanen*

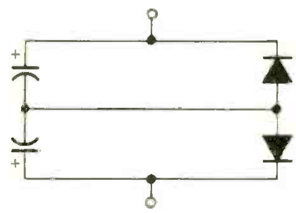
**OCTOBER FOR STEREO**

First there will be three new stories on 4-channel stereo covering 4-channel headphones, 4-channel recording techniques and new 4-channel equipment. Then you'll be reading about chromium-dioxide tape, three noise-supression circuits, and what's happening in hi-fi Repairs.

# circuits

### CHEAP COMMUTATION CAPACITORS

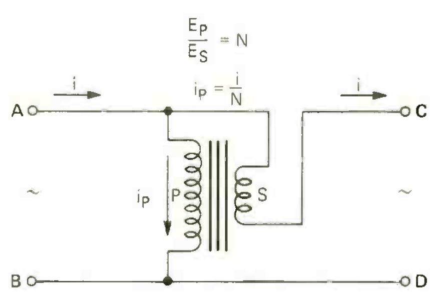
Expensive oil-filled capacitors are usually recommended for SCR commutation because in this application they must usually be unpolarized and carry appreciable ac. Ac motor electrolytics may heat in some SCR applications or have too much resistance in others, but you can connect two dc electrolytics in



series back-to-back and shunt each with a diode rectifier to carry the current that would otherwise go through the capacitor on reverse polarity. This worked well in an SCR circuit breaker with 105 amps surge current.—*A. H. Taylor*

### TOY TRANSFORMER ADJUSTS LINE VOLTAGE

To raise ac line voltage a little, connect one side of the low-voltage secondary of a toy or filament transformer to one side of the primary, say terminal **A,** and choose polarity so that the voltages add. The secondary must carry full load *current* but the transformer handles only a little power. Example: A 25-watt




toy transformer raised line voltage enough so a saturable-reactor regulator controlled by a lamp, a photocell and an amplifier could deliver 150 watts of regulated ac at normal (rms) line voltage.

To step line voltage *down* a little, you can buck the windings but it is better to use **C** and **D** as primary and take the output from **A** and **B.**—*Albert H. Taylor* **R-E**

# market center

## TAPE & RECORDERS

**RENT** 4-track open reel tapes—all major labels—3,000 different—free brochure. **STEREO-PARTI,** 55 St. James Drive, Santa Rosa, CA 95401

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**TRIGGERED SWEEP** Conversion kits for EICO 460 or HEATH IO-102. Details write: **HW ELECTRONICS,** Bloomfield, Ontario, Canada

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## COUNTER DISPLAY KIT-CD-2

This kit provides a highly sophisticated display section module for clocks, counter or other numerical display needs.

The RCA DR-2010 Numitron display tube supplied with this kit is an incandescent seven segment display tube. The .6" high number can be read at a distance of thirty feet. RCA specs. provide a minimum life for this tube of 100,000 hours (about 11 years of normal use).

A 7490 decade counter IC is used to give typical count rates of up to thirty MHz. A 7475 is used to store the BCD information during the counting period to ensure a non-blinking display. Stored BCD data from the 7475 is decoded using a 7447 seven segment decoder driver. The 7447 accomplishes blanking of leading edge zeroes, and has a lamp test input which causes all seven segments of the display tube to light.

Kit includes a two sided (with plated through holes) fiberglas printed circuit board, three IC's, DR-2010 (with decimal point) display tube, and enough Molex socket pins for the IC's . . .

Circuit board is .8" wide and 4⅜" long. A single 5 volt power source powers both the IC's and the display tube . . .


| | |
|---|---|
| Board only | $ 2.50 |
| CD-2 kit complete only | $10.95 |
| assembled and tested | $13.00 |

## SUPER DIGITAL SPECIAL

This has to be the greatest buy of IC's ever offered. These are brand new Signetic 8424 dual low power RS/T flip flops. These are first quality IC's, dual in line and packaged in the factory plastic carrier.

RS/T flip flop is a Signetics description of a latch which includes the steering logic to provide a toggle function. These IC's can divide by two with input frequencies of up to 12 MHz. (8 MHz. guaranteed minimum).

The Signetic low power 84xx series is fully compatible with other TTL lines and its low power consumption is a great help with large scale use (such as music synthesizers). Each package (two FF) operates at 5 volts and **5ma.** (typical—with 10ma maximum) . . .

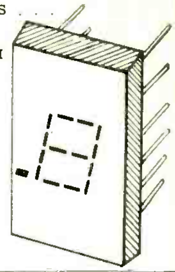
**With data sheets** and two pages of application notes.

| | |
|---|---|
| EACH | $ .35 |
| TEN | 3.00 |
| 100 | 25.00 |
| 1000 | 200.00 |

## LED DISPLAY

Seven segment diffused planar GaAsP light emitting diode array. It is mounted on a dual in line 14 pin substrate and then encapsulated in clear epoxy for protection. It is capable of displaying all digits and nine distinct letters . . .

FEATURES:
High brightness . . . typically 350ft-L @ 20ma
Single plane, wide angle viewing. . . . 150°
Unobstructed emitting surface
Standard 14 pin dual in line package
Long operating life . . . Solid state
Operates with IC voltage requirements



**ONLY**
**$4.25**
each

## DIODES BY THE FOOT

High quality Germanium signal diodes made by Transitron. These are brand new first quality devices on tape carrier.

These diodes are branded and banded at the cathode end, but do not have a 1Nxx marking, I checked and measured a forward voltage of .35 volts @ 20 ma., and .58 volts at a continuous 100ma. . . .

1 foot (60 diodes) only **$2.95**
less than **.05¢** each . . .

We have Silicon diodes (signal) at the same price as the above, please specify . . . . . . . . . .

## LM309K—5 volt regulator

This TO-3 device is a complete regulator on a chip. The 309 is virtually blowout proof, it is designed to shut itself off with overload of current drain or over temperature operation.

Input voltage (DC) can range from 10 to 30 volts and the output will be five volts (tolerance is worst case TTL requirement) at current of up to one ampere . . .

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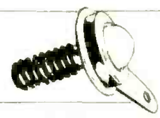
M-50 red emitting 10-40ma @ 2V **.60**
10 for **$5.00**

M-2 Invisible infrared emitter high power 1A @ 1.5V TO-5 **3.00**

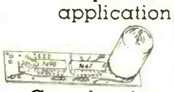


M-10B Visible red emitter 5-70ma @ 2V **.75**

## UNIVERSAL COUNTER DISPLAY KIT CD-3

This kit is similar to the CD-2 except for the following:

a. does not include the 7475 quad latch storage feature.
b. board is the same width but is 1" shorter.
c. five additional passive components are provided, which permit the user to program the count to **any** number from two to ten. Two kits may be interconnected to count to any number 2-99, three kits 2-999 etc.
d. complete instructions are provided to preset the modulus for your application.



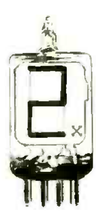
| | |
|---|---|
| CD-3 board only | $2.25 |
| IC's 7490, 7447 | 2.75 |
| RCA DR2010 tube | 5.00 |

Complete kit includes all of the above—plus, 5 programming parts, instructions, and molex pins for IC's
only **$9.25**

## 256 BIT BI-POLAR FIELD PROGRAMMABLE READ ONLY MEMORY

This Signetic #8223 IC operates at 5 volts and contains 32 x 8 bit wide ROM which can be field programmed.
Each **$10.00**

We can provide these devices programmed to your specifications @ **$5.00** for the first one and **$2.00** each additional one. Please allow one week for programmed units.



**RCA DR2010** Numitron digital display tube. This incandescent five volt seven segment device provides a .6" high numeral which can be seen at a distance of 30 feet. The tube has a standard nine pin base (solderable) and a left hand decimal point.

Each **$5.00** SPECIAL **5 for $20.**

## LSI-Calculator on a Chip

This 40 pin DIP device contains a complete 12 (twelve) digit calculator, Add, subtract, multiply, and divide. Outputs are multiplexed 7 segment MOS levels. Input is BCD MOS levels. External clock is required. Complete data is provided with chip (includes schematic for a complete calculator).
**$14.95** complete with data

Orders for $5.00 or more will be shipped prepaid. Orders over $25.00 will be shipped via AIR MAIL prepaid. IC and transistor orders are shipped within two workdays of receipt. Kit orders are shipped within ten days of receipt. Purchase orders accepted from rated firms and government agencies. Minimum open account order is **$25.00.**

—All goods described in this flyer are new unused surplus, unless described otherwise in special offerings. All goods are sold on a money back guarantee.

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*Circle 121 on reader service card*

## ADVERTISING INDEX

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*(continued on page 124)*

**IGNITION.** 250:1 Coil, Ballast $7.95. Free lists. **TRANSPARK,** Carlisle, MA, 01741

**ELECTRONIC** Ignition—Various Types. Information 10¢. **ANDERSON ENGINEERING,** Epsom, NH 03239

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*Circle 122 on reader service card*

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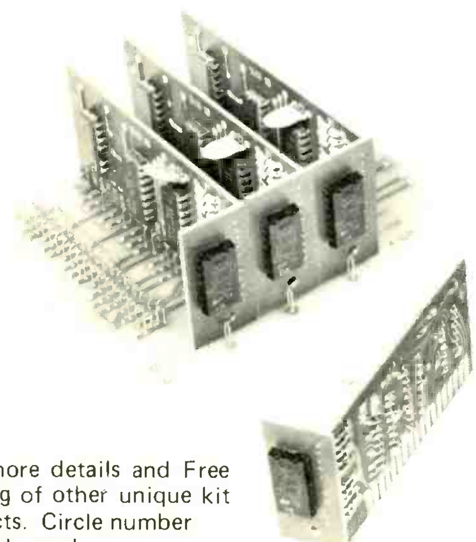

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*Circle 123 on reader service card*

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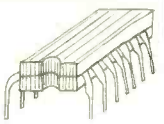

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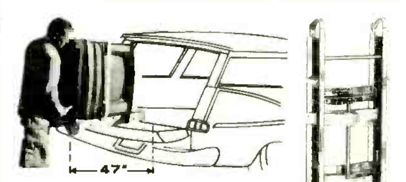


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- ☐ 40 - G-E MICRO MINI RECTIFIERS, silicon, porcelain to 1 KV* . . . $1
- ☐ 2 - G-E 2N5777 PHOTO TRANSISTORS, built-in Darlington amp . . . $1
- ☐ 40 - RECTIFIERS & ZENERS, 1W & 1A, bullets, assorted volts* . . . $1
- ☐ 30 - WORLD'S SMALLEST RECT. & zeners, 1W, assorted volts* . . . $1
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- ☐ 5 - 2N3638 PNP, silicon, TO-5 plastic transistors . . . $1
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| | H. x W. | Characters | Filament V. |
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| SLIM-7* | 1.6 x 0.375" | .40 x .20" | 1.5V AC/DC 42 mils |

*Compatible to 7-segment driver IC's.
All 3 have 0-9 numerals, decimals and letters.

MINI-7 SLIM-7

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| ☐ SN74S11 | Triple 3 input AND gate | 1.37 |
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| ☐ SN74S20 | Dual 4 input NAND gate | 1.37 |
| ☐ SN74S21 | Dual 4 input AND gate | 1.37 |
| ☐ SN74S22, | SN74S21 w/open collector | 1.37 |
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*(continued from page 120)*







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| 7407 | .52 | .50 | .47 | .44 | .42 | .39 | 7486 | .58 | .55 | .52 | .49 | .46 | .44 |
| 7408 | .32 | .30 | .29 | .27 | .26 | .24 | 7490 | .80 | .76 | .72 | .68 | .64 | .60 |
| 7409 | .32 | .30 | .29 | .27 | .26 | .24 | 7491 | 1.43 | 1.35 | 1.28 | 1.20 | 1.13 | 1.05 |
| 7410 | .26 | .25 | .23 | .22 | .21 | .20 | 7492 | .80 | .76 | .72 | .68 | .64 | .60 |
| 7411 | .28 | .27 | .25 | .24 | .22 | .21 | 7493 | .80 | .76 | .72 | .68 | .64 | .60 |
| 7413 | .58 | .55 | .52 | .49 | .46 | .44 | 7494 | 1.18 | 1.12 | 1.05 | .99 | .93 | .87 |
| 7416 | .52 | .50 | .47 | .44 | .42 | .39 | 7495 | 1.18 | 1.12 | 1.05 | .99 | .93 | .87 |
| 7417 | .52 | .50 | .47 | .44 | .42 | .39 | 7496 | 1.18 | 1.12 | 1.05 | .99 | .93 | .87 |
| 7420 | .26 | .25 | .23 | .22 | .21 | .20 | 74100 | 1.52 | 1.44 | 1.36 | 1.28 | 1.20 | 1.12 |
| 7421 | .26 | .25 | .23 | .22 | .21 | .20 | 74107 | .52 | .49 | .47 | .44 | .42 | .39 |
| 7423 | .80 | .76 | .72 | .68 | .64 | .60 | 74121 | .56 | .53 | .50 | .48 | .45 | .42 |
| 7425 | .50 | .48 | .45 | .43 | .40 | .38 | 74122 | .70 | .67 | .63 | .60 | .56 | .53 |
| 7426 | .34 | .32 | .31 | .29 | .27 | .26 | 74123 | 1.21 | 1.06 | 1.00 | .94 | .89 | .83 |
| 7430 | .26 | .25 | .23 | .22 | .21 | .20 | 74141 | 1.63 | 1.55 | 1.46 | 1.38 | 1.29 | 1.20 |
| 7437 | .56 | .53 | .50 | .48 | .45 | .42 | 74145 | 1.41 | 1.33 | 1.26 | 1.18 | 1.11 | 1.04 |
| 7438 | .56 | .53 | .50 | .48 | .45 | .42 | 74150 | 1.63 | 1.55 | 1.46 | 1.38 | 1.29 | 1.20 |
| 7440 | .26 | .25 | .23 | .22 | .21 | .20 | 74151 | 1.20 | 1.13 | 1.07 | 1.01 | .95 | .88 |
| 7441 | 1.73 | 1.64 | 1.55 | 1.46 | 1.37 | 1.27 | 74153 | 1.63 | 1.55 | 1.46 | 1.38 | 1.29 | 1.20 |
| 7442 | 1.27 | 1.21 | 1.14 | 1.07 | 1.01 | .94 | 74154 | 2.43 | 2.30 | 2.16 | 2.03 | 1.89 | 1.76 |
| 7443 | 1.27 | 1.21 | 1.14 | 1.07 | 1.01 | .94 | 74155 | 1.46 | 1.39 | 1.31 | 1.23 | 1.16 | 1.08 |
| 7444 | 1.27 | 1.21 | 1.14 | 1.07 | 1.01 | .94 | 74156 | 1.46 | 1.39 | 1.31 | 1.23 | 1.16 | 1.08 |
| 7445 | 1.71 | 1.62 | 1.53 | 1.44 | 1.35 | 1.26 | 74157 | 1.56 | 1.48 | 1.39 | 1.31 | 1.23 | 1.15 |
| 7446 | 1.24 | 1.17 | 1.11 | 1.04 | .98 | .91 | 74158 | 1.56 | 1.48 | 1.39 | 1.31 | 1.23 | 1.15 |
| 7447 | 1.16 | 1.10 | 1.04 | .98 | .92 | .85 | 74161 | 1.89 | 1.79 | 1.68 | 1.58 | 1.47 | 1.37 |
| 7448 | 1.44 | 1.37 | 1.29 | 1.22 | 1.14 | 1.06 | 74164 | 1.89 | 1.79 | 1.68 | 1.58 | 1.47 | 1.37 |
| 7450 | .26 | .25 | .23 | .22 | .21 | .20 | 74166 | 1.98 | 1.87 | 1.76 | 1.65 | 1.54 | 1.43 |
| 7451 | .26 | .25 | .23 | .22 | .21 | .20 | 74180 | 1.20 | 1.13 | 1.07 | 1.01 | .95 | .88 |
| 7453 | .26 | .25 | .23 | .22 | .21 | .20 | 74181 | 5.20 | 4.90 | 4.59 | 4.28 | 3.98 | 3.67 |
| 7454 | .26 | .25 | .23 | .22 | .21 | .20 | 74182 | 1.20 | 1.13 | 1.07 | 1.01 | .95 | .88 |
| 7460 | .26 | .25 | .23 | .22 | .21 | .20 | 74192 | 1.98 | 1.87 | 1.76 | 1.65 | 1.54 | 1.43 |
| 7470 | .42 | .40 | .38 | .36 | .34 | .32 | 74193 | 1.98 | 1.87 | 1.76 | 1.65 | 1.54 | 1.43 |
| 7472 | .38 | .36 | .34 | .32 | .30 | .29 | 74198 | 2.81 | 2.65 | 2.50 | 2.34 | 2.18 | 2.03 |
| 7473 | .50 | .48 | .45 | .43 | .40 | .38 | 74199 | 2.81 | 2.65 | 2.50 | 2.34 | 2.18 | 2.03 |

TRANSISTORS AND DIODES

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1N270 | .15 | .14 | .13 | .12 | .11 | .10 | 1N4003 | .13 | .12 | .11 | .10 | .09 | .08 |
| 1N751A | .30 | .28 | .26 | .24 | .22 | .20 | 1N4006 | .15 | .14 | .13 | .12 | .11 | .10 |
| 1N914 | .10 | .09 | .08 | .07 | .06 | .05 | 1N4154 | .15 | .14 | .13 | .12 | .11 | .10 |
| 1N4001 | .10 | .09 | .08 | .07 | .06 | .05 | 2N3860 | .25 | .23 | .21 | .19 | .17 | .15 |
| 1N4002 | .11 | .10 | .09 | .08 | .07 | .06 | | | | | | | |

SUPER FAST SCHOTTKY TTL

Types 74S00, 74S01, 74S03, 74S08, 74S09, 74S10, 74S15, (Three input AND with open collector), 74S20, 74S21, 74S50, 74S51, 74S60, 74S64, (4-2-3-2 input AND-OR-INVERT gate), 74S65 (open collector 74S64); your six column prices are:

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Types 74S04, 74S05, 74S40, 74S140 (Dual 4-input NAND line Driver); your six column prices are:

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ALL IC'S are supplied in 8-, 14-, 16-, or 24-pin DIP (Dual-in-Line) plastic package.
We give FREE data sheets upon request, so ask for those data sheets that you NEED, even for those listed IC that you are not buying.

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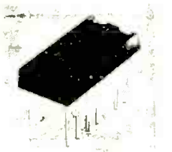

LED
7-SEGMENT
DISPLAY

$4.95 Each

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| 50-99 | $4.75 |
| 100-999 | $4.50 |
| 1000-70 | $4.25 |

Large ¼" 7-segment LED readout similar to the popular MAN-1 but with improved brightness. Has left-hand decimal point. Fits in a DIP socket. Expected life: Over 100 Yrs. Regularly $12.95 in single Lots. These are BRAND NEW with full data sheet and 4-page MULTIPLEXING Application Note. Needs a 7447 for driver and ONE CURRENT-LIMITING RESISTOR PER SEGMENT. We can supply you with one or ten thousand FROM STOCK. Also available, ±1 OVERFLOW digit at the same prices. Mixing of Regular & Overflow digit allowed.

Package of 8, ¼W Limiting R's .......... .30¢

Incandescent Type of 7-segment display. With right-hand decimal point. Rated 8mA per segment at TTL supply of 5V. Design life of 50,000 hours. Needs a 7447 as a driver. In DIP Package. Each $3.25

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100 for $1.00; 200 for $1.80; 300 for $2.60
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700 for $5.80; 800 for $6.60; 900 for $7.40
1000 for $8.20. Each Additional 1000 $7.50

CERAMIC DISC CAPACITORS. Type 5GA-10000WVDC.
5, 7.5, 10, 12, 15, 20, 22, 25, 27, 30, 33, 39, 50, 56, 68, 75, 82, 100, 120, 150, 180, 200, 220, 250, 270, 300, 330, 360, 390, 470, 500, 560, 680, 750, 820, 1000, 1200, 1500, 1800, 2000, 2200, 2500, 2700, 3000, 3300, 3900, 4700, 5000µµF.
EACH .......... 10¢
0.01µF. EACH .......... 11¢ 0.02µF. EACH .......... 12¢

LOW VOLTAGE DISCS, Type UK.

| | |
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| 1.0 µF, 3V .......... 25¢ | 2.2 µF, 3V .......... 30¢ |
| 1.0 µF, 10V .......... 12¢ | 0.2 µF, 10 .......... 20¢ |
| 0.47µF, 3V .......... 25¢ | 0.01µF, 16V .......... 10¢ |

ELECTROLYTIC CAPACITORS:
All values are available in both, axial or upright (PC Board) mount. PLEASE INDICATE YOUR CHOICE.

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| 30 µF, 15V .......... 10¢ | 1 µF, 50V .......... 10¢ |
| 50 µF, 15V .......... 10¢ | 2 µF, 50V .......... 10¢ |
| 100 µF, 15V .......... 10¢ | 3 µF, 50V .......... 10¢ |
| 220 µF, 15V .......... 15¢ | 5 µF, 50V .......... 10¢ |
| 500 µF, 15V .......... 20¢ | 10 µF, 50V .......... 15¢ |
| 1000 µF, 15V .......... 30¢ | 20 µF, 50V .......... 20¢ |
| 20 µF, 25V .......... 15¢ | 50 µF, 50V .......... 20¢ |
| 30 µF, 35V .......... 20¢ | 100 µF, 50V .......... 20¢ |
| 50 µF, 35V .......... 20¢ | 200 µF, 50V .......... 40¢ |
| 100 µF, 35V .......... 20¢ | 500 µF, 50V .......... 55¢ |
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STANCOR P-8180, 25.2 VCT, 1-Amp Transformer.
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DUAL-IN-LINE Wire-Wrap Type IC Sockets. BRAND NEW with gold plated pins.

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| 14-PINS | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 |
| 16-PINS | 0.75 | 0.70 | 0.65 | 0.60 | 0.55 |

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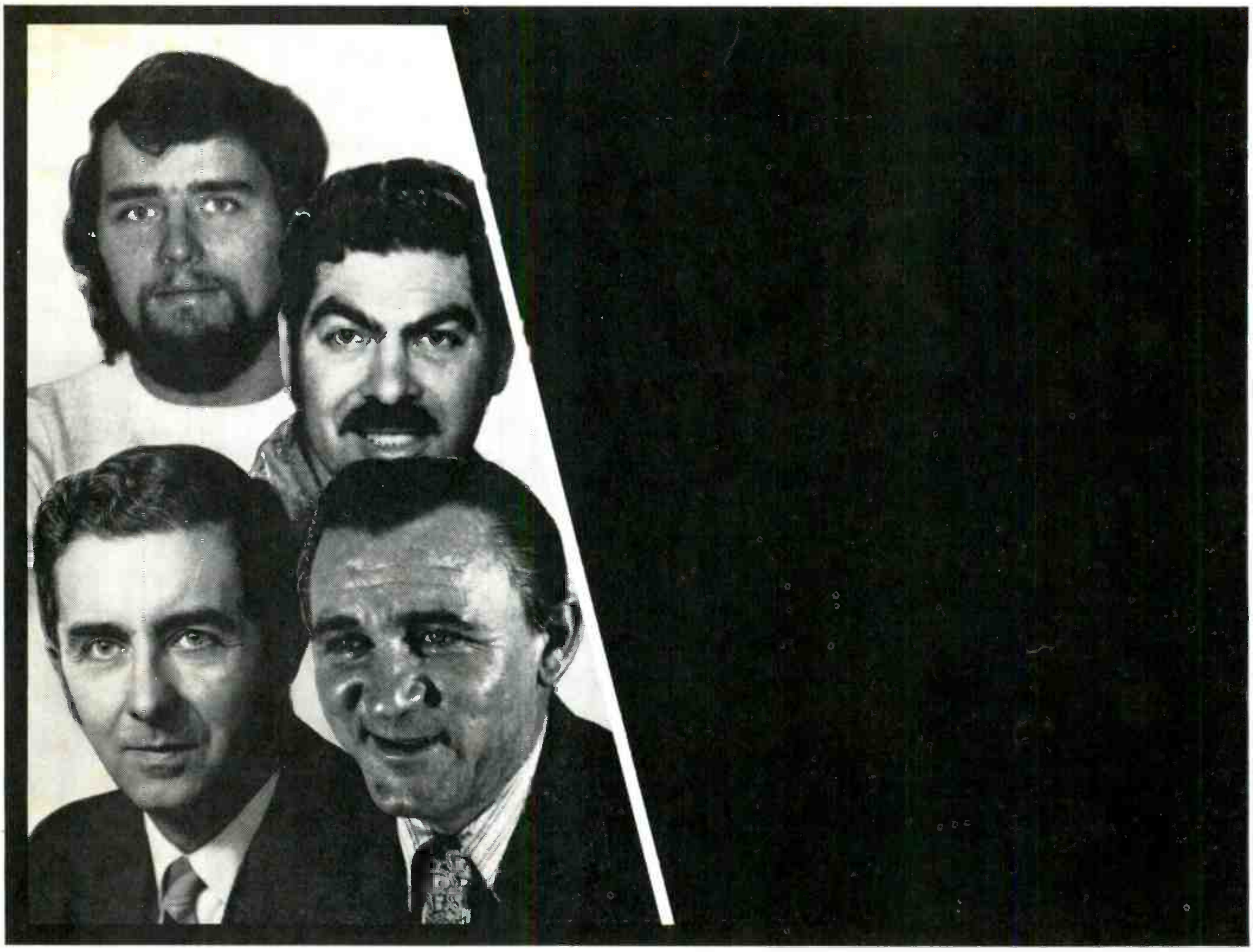
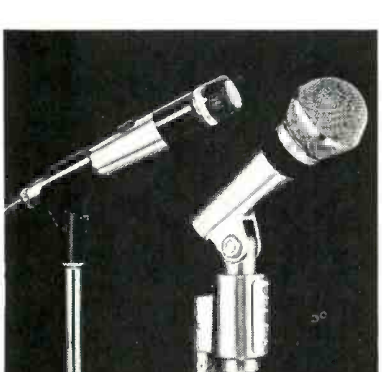


# Ask Bob. or Jerry. or Harry. or Harry



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*Circle 118 on reader service card*

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Pull enough to bring in those distant stations—those hard-to-get channels—pull enough to feed more than one set! Try Winegard's CW-980 Color-Wedge VHF-UHF-FM model, with its optional antenna-mounted solid state preamplifier, for the ultimate in TV reception.

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## Winegard Antennas For Trailers and Boats

**SR-20T**

Specially designed SENSAR solid-state antenna for boats & recreational vehicles—extra strong construction.

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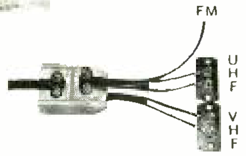
Winegard's new "Hideaway" Travel antenna for trailers, boats, campers, folds like an umbrella for travel!

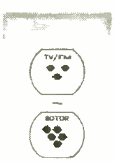
## Winegard Accessories For Complete Systems...

**BC-782 BOOSTER-COUPLER**
Solid-State Booster-Couplers for all-channel TV and FM signals to 2 to 4 sets.


**CC-282 COUPLER**
All-Channel non-amplified couplers to connect two sets to one antenna.




**CS-380 BAND SEPARATOR**
Band separators to connect 75 or 300 ohm download to 300 ohm UHF, VHF & FM terminals.

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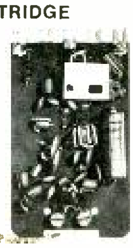
TV outlets in a variety of models for all-channel TV and FM reception plus rotor.



**AC-823B CARTRIDGE PRE-AMPLIFIER**
Antenna-mounted pre-amplifiers in 8 models for all-channel, UHF, VHF-FM and FM use, each in its own weather-proof housing.

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