Electronics World

AUGUST, 1970
60 CENTS

ARE OMNIDIRECTIONAL LOUDSPEAKERS DESIRABLE?

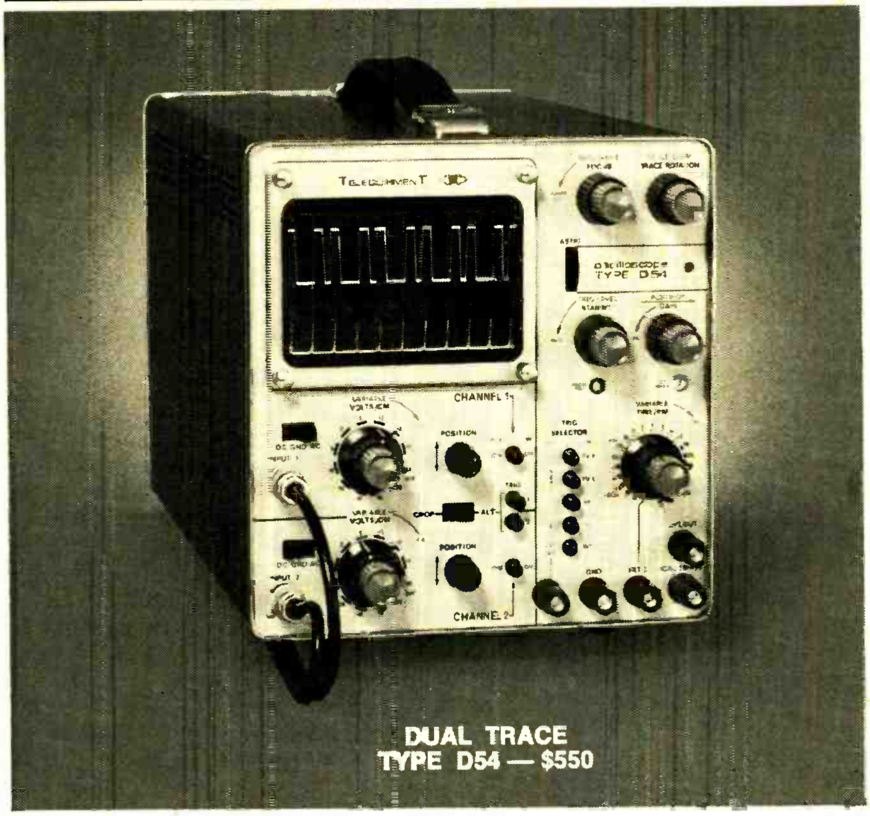
DIGITAL INSTRUMENTS YOU CAN BUILD—Counting and Decoding Circuits

NEW TEST SIGNAL FOR COLOR TV

DELAYS & ECHOES IN SATELLITE COMMUNICATIONS

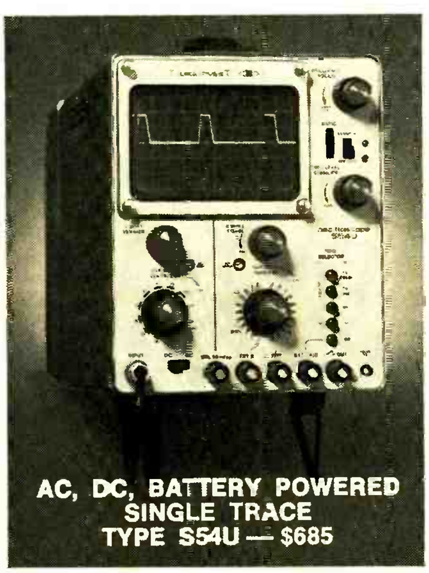
MICROWAVE OVENS–
A Revolution in Cooking

New oscilloscopes from TELEQUIPMENT



DUAL TRACE
TYPE D54 — $550

The 54 Series represents a new standard of performance for low priced oscilloscopes.



AC, DC, BATTERY POWERED
SINGLE TRACE
TYPE S54U — $685

SINGLE TRACE
TYPE S54A — $435

- **10 mV/cm DEFLECTION FACTOR and 10 MHz BANDWIDTH** permit viewing of low level high frequency signals with good vertical resolution.
- **FET INPUTS** minimize vertical trace drift.
- **TRIGGERED SWEEP,** including TV field or line, so that signals remain stationary with changes in sweep speed.
- **22 CALIBRATED SWEEP SPEEDS** from 0.2 μs/cm to 2 s/cm permit analysis of a wide range of frequencies.
- **4-kV CRT HIGH VOLTAGE** which means that the trace is bright.
- **VOLTAGE CALIBRATOR** for verification of the vertical gain.
- **SOLID STATE** for reliability.

The 54 Series are only three of the low-cost Telequipment Oscilloscopes. Many other models are available (priced from $225), designed by Telequipment specifically for applications where price is a prime consideration.

U.S. Sales Prices FOB Beaverton, Oregon

Telequipment products are backed by a one year warranty, parts support, 26 Tektronix service centers and marketed through 57 Tektronix Field Offices.

For a demonstration or more information call your local Tektronix Field Engineer or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

TELEQUIPMENT

. . . . a subsidiary of ***Tektronix, Inc.***

CIRCLE NO. 118 ON READER SERVICE CARD

Best values

Here are really high-capacity, low-voltage capacitors at great competitive prices.

MTA, MTV—From 1 microfarad to 1000 microfarads. Tubular aluminum units that are fully molded in moistureproof polypropylene plastic. All-welded construction. MTA axial lead and MTV single-ended lead capacitors are perfect for printed-circuit applications. MTV's also feature molded standoffs for good solder flow and board washing.

SX Polystyrene Capacitors—Available in 73 ratings from 5 picofarads to .01 microfarads . . . with the utmost stability. Exceptionally high insulation resistance, greater than 100,000 megohms . . . low power factor less than .05%. Temperature coefficient −150 ppm/°C ±60 ppm/°C . . . rated 600 WVDC.

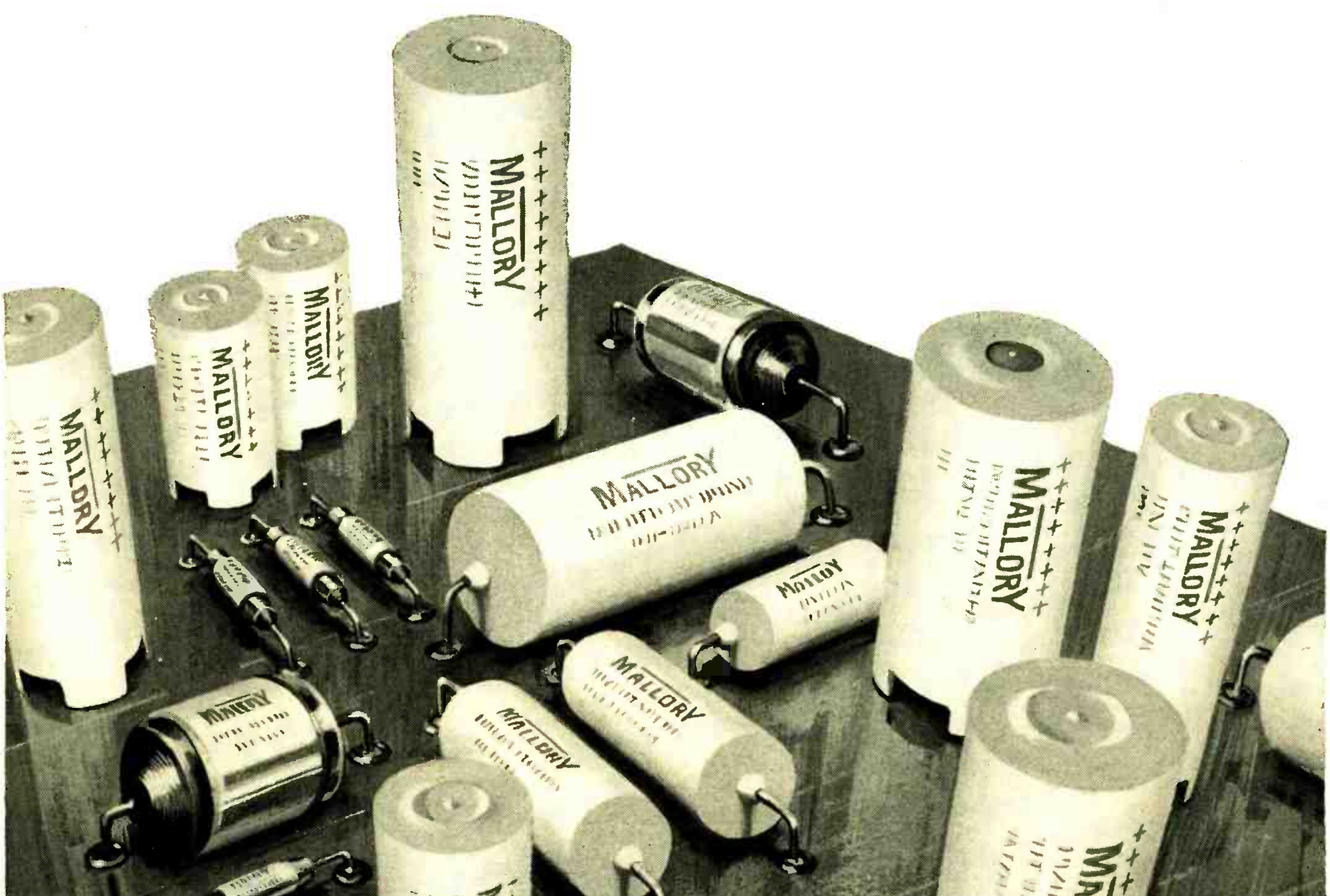
And you can get all you need right now . . . from a few to production quantities.

But if you want high-value capacitors, we have them, too. In fact, we can supply just about any kind you need.

MALLORY

MALLORY DISTRIBUTOR PRODUCTS COMPANY
a division of P. R. MALLORY & CO. INC.
Box 1558, Indianapolis, Indiana 46206; Telephone: 317-636-5353

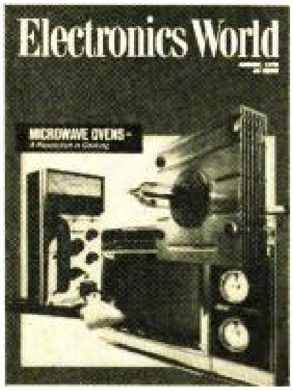
Batteries | Capacitors | Controls • CRIME ALERT® • DURATAPE® • Resistors • Semiconductors • Sonalert® • Switches • Timers • Vibrators • Tape Cassettes



CIRCLE NO. 129 ON READER SERVICE CARD

Electronics World
AUGUST 1970 VOL. 84 NO. 2

CONTENTS

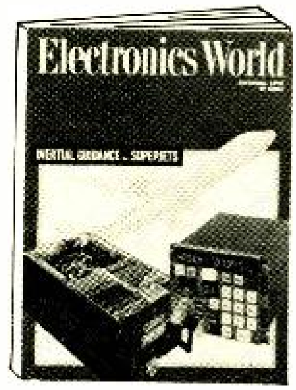


THIS MONTH'S COVER illustrates our two-part lead story on microwave ovens. The oven at the bottom right is an Amana Radarange (Model RR-2) designed for counter-top or table-top use. At the upper right is the Raytheon QK-1381 12-cavity magnetron tube that generates the r.f. energy used for cooking. Since user safety is such an important consideration with this appliance, we must have a method for measuring the r.f. leakage from the oven. This is done by means of the Narda Model 8100 electromagnetic radiation meter shown at the left along with its probe. Photograph: Dirone-Denner

MONTHLY FEATURES

Coming Next Month

Special Feature Article



INERTIAL GUIDANCE FOR SUPERJETS

Details on the "black boxes" that make up GM's "Carousel IV" inertial guidance navigation system for the Boeing 747 superjet. This navigator can steer the 747 across the continent or around the world—through the plane's autopilot. Completely self-contained and requiring no outside radio or radar contact, this is the first such system to be able to tell the pilot where he is at all times while providing other up-to-the-minute navigation information as well.

CAN YOU LEARN ELECTRONICS BY HOME STUDY?

How can you pick a course that will meet your needs and a school that can provide it? Louis E. Frenzel, Jr. offers seven important points for you to check regarding any school or course you are considering. With a proper match—you can get valuable training in your specific field of interest.

DIRECT VS REVERBERANT SOUND FOR STEREO SPEAKERS?

While controversy continues over the best type of speaker for home stereo systems, George Augspurger, Technical Director of J. B. Lansing, offers his reasons why reverberant sound wins his approval over a direct-sound system. See if you agree with his ideas.

ELECTRONIC FUEL-INJECTION REDUCES AIR POLLUTION

By doing away with the carburetor and injecting fuel directly into the intake manifold, auto exhaust emissions are reduced, thereby eliminating need for a smog-control device. Fred Holder describes a system that was developed by Bendix for use with U.S.-made cars.

DIGITAL INSTRUMENTS YOU CAN BUILD

Part 3 of this series covers four digital-IC families available to the design engineer and gives some of the salient features of each. Donald Steinbach explains how one manufacturer, Motorola, classifies these logic families by performance, packaging, and operating range.

*All these and many more interesting and informative articles will be yours in the **September** issue of ELECTRONICS WORLD . . . on sale **August 20th.***

ZIFF-DAVIS PUBLISHING COMPANY

William Ziff, President
W. Bradford Briggs, Executive Vice President
Hershel B. Sarbin, Senior Vice President
Stanley R. Greenfield, Senior Vice President
Philip Sine, Financial Vice President
Walter S. Mills, Jr., Vice President, Circulation
Phillip T. Heffernan, Vice President, Marketing
Frank Pomerantz, Vice President, Creative Services
Arthur W. Butzow, Vice President, Production
Edward D. Muhlfeld, Vice President, Aviation Division
Irwin Robinson, Vice President, Travel Division
George Morrissey, Vice President
Sydney H. Rogers, Vice President

Editorial and Executive Offices
One Park Avenue
New York, New York 10016
212 679-7200

NEW YORK OFFICE
212 679-7200
Joseph E. Halloran, Adv. Mgr.
Michael E. Kelman

MIDWESTERN OFFICE
307 North Michigan Avenue
Chicago, Illinois 60601 312 726-0892
George B. Mannion, Jr.

WESTERN OFFICE
9025 Wilshire Boulevard
Beverly Hills, California 90211
213 CRestview 4-0265: BRadshaw 2-1161
Western Advertising Manager, Bud Dean

JAPAN: James Yagi, Ishikawa Mansion, #4, Sakuragaoka Shibuya-ku, Tokyo 462-2911-3

CIRCULATION OFFICE
P.O. Box 1093, Flushing, N.Y. 11352

Member Audit Bureau of Circulations

Radio & TV News ● Radio News ● Radio-Electronic Engineering Trademarks Reg. U.S. Pat. Off.
SUBSCRIPTION SERVICE: Forms 3579 and all subscription correspondence should be addressed to Electronics World, Circulation Department, P.O. Box 1093, Flushing, N.Y. 11352. Please allow at least six weeks for change of address. Include your old address, as well as new—enclosing if possible an address label from a recent issue.
EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care; however publisher assumes no responsibility for return or safety of art work, photographs, or manuscripts.
ELECTRONICS WORLD (August, 1970, Vol. 84, No. 2). Published monthly at One Park Avenue, New York, New York 10016, by Ziff-Davis Publishing Company—also the publishers of Airline Management and Marketing Including American Aviation, Boating, Business & Commercial Aviation, Car and Driver, Cycle, Flying, Modern Bride, Popular Electronics, Popular Photography, Skiing, Skiing Area News, Skiing Trade News, Stereo Review, and Travel Weekly. One year subscription rate for U.S., U.S. Possessions, and Canada, $7.00; all other countries, $8.00. Second Class postage paid at New York, N.Y. and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash.

Radio & Television news

By FOREST H. BELT /Contributing Editor

Color for 1971 is Fancier

Most manufacturers have already shown distributors—and some key dealers—what they'll sell during the 1971 season. As usual, color TV got the spotlight. A multitude of gadgetry adorns various models, but the gadgets are aimed mostly at further simplifying operation for the customer. The extra emphasis on innovations is attributed to the present sag in color sales.

Some models have electronic (varactor) tuning. The top of the *Sylvania* line has an 11-button electronic tuner. Any button can be set for any v.h.f. or u.h.f. station. This meets the impending FCC requirement that v.h.f. and u.h.f. tune comparably. But it isn't enough where there may be more than 11 channels (such as on a modern cable system).

A customer still must call a technician whenever a new station goes on the air or when the set is moved to another town. The FCC ruling hasn't stipulated customer-tunable channel selection, but that's coming.

Philco-Ford has a diode-controlled u.h.f. tuner with six push-buttons for its high-end sets. *Zenith* has a 14-position electronic tuner. The customer touches a pushbar to change channels. A technician sets up any programmed sequence of u.h.f. or v.h.f. stations.

The automatic tint control (a.t.c.) is coming into its own in 1971 models. It maintains flesh tones even when broadcasts distort them. Few sets use the phase-shifting system pioneered last year by *Magnavox*. However, *Admiral*, *Philco-Ford*, *RCA*, and *Zenith* all try in some way to make the faces look right.

(Technical details on the entire line of 1971 color-TV sets from all manufacturers will appear, with a chart of important features, in a forthcoming issue. Watch for it.—Editors)

One-Year Labor Warranty

Certain high-end *RCA* color receivers now carry a full-year labor warranty. Customers who buy models beginning with the letters EP, FP, GP, or HP, or the limited-run Model G-2000, get first-year service paid for by *RCA*. To get warranty service, the purchaser contacts the dealer he bought the set from or his independent service agency, or *RCA* headquarters in Indianapolis. Setups are not covered; neither are installation, antenna work, and "nuisance" calls to adjust operating controls.

The one-year labor warranty isn't new. *Hitachi* has had it for some time. *Motorola* inboards service labor for one year on some of its Quasar and Quasar II models. It's not always a happy idea.

The chief objection service-industry spokesmen have is that independent technicians aren't paid enough for repairs under these warranties. Independent servicers contend, and rightly, that they should be paid their regular prices, not some "formula" fee worked out by the national service department or the sales division of the manufacturer.

Video Recorders and Players

New ones keep popping up and their developers keep saying they are for home use. But they are expensive. *Motorola/CBS* have the electronic video recording (EVR) system, in color. *RCA* has its home video playback system which it calls SelectaVision, but that's not yet available. None of these is for home recording—only for playback of recorded programs marketed by the manufacturer. Some companies offer video tape recorders (VTR) but cost makes them impractical for the home video recordist.

A version promised for this year is Cartrivision—developed by *Cartridge Television, Inc.*, a division of *Avco Corp.* It will be put on the market by *Admiral.* The system is color compatible and records right off the air. Tape cartridges come in ¼-, ½-, 1-, and 2-hour sizes, either blank or with prerecorded programs by *Avco*.

There's also a new electron-beam video recording system reported in Japan. It's description makes it sound like a cross between the EVR film system and the *RCA* vinyl-film system. We don't have details as yet.

A Few More IC's for TV

Consumer electronics companies are still plugging integrated circuits into their designs when they can. *Zenith* has more IC's than ever in its 1971 line.

RCA pioneers a lot in this respect. At the IEEE Spring Conference in June, the company showed a TV i.f. section on one monolithic chip and a chroma section on two chips.

The i.f. chip includes video i.f. amps, video detector, sound i.f. detector and amp, a.g.c. stages and a zener regulator for the stages in the IC. One chroma chip has a chroma amp, bandpass amp, color oscillator, a.c.c. stages, color-killer stages, and d.c.-operated chroma gain control, plus a zener regulator. The other chroma chip has demodulators, difference amps, d.c.-operated tint (phase) control, and zener regulator. All three IC's use 16-lead packaging.

Hi-Fi Shows Go Suburban

The Institute of High Fidelity discontinued its New York Hi-Fi Show. No particular reason was given, although one guess is that the Consumer Electronics Show became a better value for exhibitors. Now the IHF has decided to hold two new-type shows later this year, just to see how they work. They will be held in suburban towns near major population centers.

The first, which will serve the New York City area, is to be held in Westbury, Long Island, New York. The dates are September 15-22, and the location is the Island Inn Motel. A second Show will be held October 30 through November 1 at the Marriott Motor Inn in Newton, Massachusetts, a suburb of Boston. If these shows attract enough serious buyers of hi-fi gear, the Institute of High Fidelity will plan several others for 1971.

Electronic Tuning for Auto Radios

Philco-Ford is planning varactor-tuned AM-FM radios for auto use. Scheduling is loose, but the special sets should be ready for the 1972 model year. Of course, the first cars to have them will be *Fords*. One advantage is size, but another is remote tuning from the back seat. Reduction of mechanical gadgetry will be a bonus for technicians who service car radios. The radios, as envisioned now, will be modular in construction and will have ceramic i.f. tuning and several integrated circuits.

Subscription TV Garners More Problems

For nearly 20 years, pay television has been the subject of heated and bitter discussion. Legislation has been proposed and defeated, court cases have swung through the judicial orbit, and symposiums have met and disbanded—all without any significant resolution of the key question: Does the American public get the opportunity of receiving special programs, at a fee, if they want to?

A recent FCC decision (this column, December 1969, page 23) made it possible for pay-TV planners to go ahead and file applications for approval of systems. Then a court case brought by part of the motion-picture industry held plans up awhile, but the ultimate decision went in favor of subscription television (STV).

Representative John Dingell of Michigan, a Democrat, then introduced a bill in the House of Representatives to kill pay-TV entirely. In committee, the bill was violently opposed by pay-TV proponents. The outcome was an amended version which purports to allow subscription TV under certain carefully stipulated circumstances. But the circumstances seem almost a hoax.

Pay-TV under the bill could exist in less than 30 of the top-50 television markets, and in fewer than 50 markets in the whole country. When you add the many other restrictions, the compromise bill appears no more than what the original bill was: a ban on subscription TV. Some of the views stated in the committee report classify the amendment as "hypocrisy."

The bill may live or die on the House floor. If it goes through, pay-TV is in trouble again. And there is little relief in sight.

Flashes in the Big Picture

National Commission on Product Safety reports that Government programs to promote product safety are "widespread public deception"; only hope is that industries that produce items with safety hazards will do their duty by customers voluntarily. . . . Dean Burch, chairman of the Federal Communications Commission, displeases broadcasters with his liberal attitudes toward cable-TV and pay-TV; both have gained much ground in recent FCC decisions. . . . Courses in music education to go into EVR format for schools. . . . *Motorola, Arnet,* and *Canadian G-E* have all quit making color picture tubes. . . . Mexican broadcast station XTRA, not governed by FCC rules, has transmitted stereo programs on AM; takes two receivers —one tuned slightly above station frequency and one tuned slightly below. . . . *Zenith* has all-solid-state color set, using Dura-Modules and integrated circuits. ▲

For the Record

RCA's "ServiceAmerica"

WM. A. STOCKLIN, EDITOR

IN announcing the formation of its new *ServiceAmerica* division, *RCA* has caused quite a furor in the radio-TV service industry. According to present plans, *ServiceAmerica* will concentrate on servicing and maintaining all brands of radio, television, and home-entertainment products. It will operate separately from the present *RCA Service Co.*, which limits its service to *RCA* and *Whirlpool* appliances exclusively. Independent technicians plan to fight this move with every resource at their disposal. Many large and powerful local and state service-technician associations are reported to be contacting their elected representatives at the state and federal levels. Association attorneys have been consulted in the hope that *RCA* can be stopped in the courts. One of these local associations predicts that such a step by *RCA* could wipe out the entire independent TV service industry.

From this reaction, it would seem that the independent service fraternity has lost all confidence in its own abilities. They must believe their service proficiency could never match that of *RCA*, or feel that they could not compete on a national scale insofar as pricing is concerned. At least, that is how it appears.

If this were true, then we'd say more power to *RCA* for providing the consumer with better service at lower cost. It's time the independent fraternity realizes that their industry is no more immune to legitimate competition than set manufacturers are. We feel sure, however, that this apparent lack of confidence is unfounded and that the independent service system will certainly survive. It will be able to provide service of equal, if not better, quality and due to the higher overhead of large organizations, the independent service technician should be able to underprice *RCA* without hurting himself. In the long run, we feel the added competition will benefit the service industry as a whole, possibly even raising its level of competence and improving its business methods, and should result in a closer relationship among the independents.

But can *RCA's ServiceAmerica* survive? Apparently they're not too sure either. Why have two separate service organizations so closely related? It doesn't seem sound business practice. However, it does give them the option of moving in either of two directions. Should *ServiceAmerica* prove unsuccessful for any of various reasons, it can then be merged with *RCA Service Co.* and confine its operations solely to *RCA* equipment. On the other hand, if it does succeed, the two could still be merged into one, with both servicing all brands. They have nothing to lose.

Other manufacturers have tried this before. Most manufacturers have given thought to captive servicing and have either failed in the attempt or given it up. *Western Union* had what seemed to be a great idea—a nationwide service organization anyone could get by calling a *Western Union* operator. But this failed due to *WU's* lack of knowledge of the servicing field.

RCA is in a better position to succeed, of course, but there are problems:

1. Getting qualified technicians is just one of them. Incidentally, *RCA* service technicians will be unionized so that their salaries and fringe benefits in most cases will be above those of the independent.

2. Parts distributors are concerned, naturally, but *RCA* pledges to purchase all parts, including vacuum tubes, through normal local distributor channels. We feel sure, though, that *RCA* parts will be used wherever possible.

3. Although competitive manufacturers appreciate having their equipment serviced by competent technicians, they have mixed feelings about *RCA's* technicians being in a position to make recommendations to the customer. The company insists, however, that its technicians will make no product recommendations.

Obviously, the independent technician should consider *ServiceAmerica* a competitor and act accordingly. Parts substitutions will probably become commonplace, but uppermost in the mind of every technician should be a determination to provide the best possible service, and if *RCA* tubes and replacement parts give better performance, then they should be used.

One thing that the independent service technician should not forget is that servicing isn't the sort of profession that can be mass-produced or completely automated. It is a personalized business; the relationship a technician develops with his customer is most important and much more easily established by a small shop. Bigness, in this sense, is actually a detriment.

One thing in favor of the independent is that *RCA* has never undercut prices and, therefore, the fees, in most cases, will set a level for the independent service technician to shoot at. Another important factor is that other set manufacturers, parts distributors, and especially competitive tube and transistor makers, will value the independent more highly and be more appreciative of the business sent his way by the independent.

Now is the time, though, for all independent service technicians to work together to form or join local associations in every major area and to pool their efforts in a nationwide organization. Such a combined effort can only result in improved service and in a much more professional service industry. ▲

ELECTRONICS COMES ALIVE AS YOU LEARN BY DOING WITH CUSTOM TRAINING EQUIPMENT

Nothing is as effective as learning by doing. That's why NRI puts so much emphasis on equipment, and why NRI invites comparison with equipment offered by any other school, at any price. NRI pioneered and perfected the use of special training kits to aid learning at home. You get your hands on actual parts like resistors, capacitors, tubes, condensers, wire, transistors and diodes. You build, experiment, explore, discover. You start right out building your own professional vacuum tube voltmeter with which you learn to measure voltage and current. You learn how to mount and solder parts, how to read schematic diagrams. Then, you progress to other experimental equipment until you ultimately build a TV set, an actual transmitter or a functioning computer unit (depending on the course you select). It's the practical, easy way to learn at home—the priceless "third dimension" in NRI's exclusive Electronic TV-Radio training method.

SIMPLIFIED, WELL-ILLUSTRATED "BITE-SIZE" LESSON TEXTS PROGRAM YOUR TRAINING

Lesson texts are a necessary part of training, but only a part. NRI's "bite-size" texts are as simplified, direct and well-illustrated as half a century of teaching experience can make them. The amount of material in each text, the length and design, is precisely right for home-study. NRI texts are programmed with NRI training kits to make things you read come alive. As you learn, you'll experience all the excitement of original discovery. Texts and equipment vary with the course. Choose from major training programs in TV-Radio Servicing, Industrial Electronics and Complete Communications. Or select one of seven special courses to meet specific needs. Check the courses of most interest to you on the postage-free card and mail it today for your free catalog.

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

custom training kits "bite-size" texts

HI-FI PRODUCT REPORT

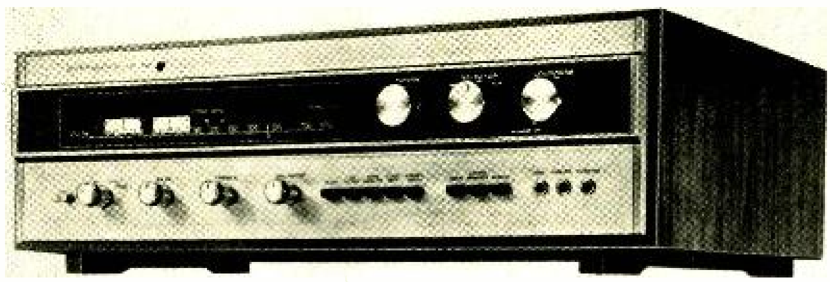
EW LAB TESTED

by Hirsch-Houck Labs

Sherwood SEL-200 Stereo-FM Receiver
KLH Model 33 Speaker System

Sherwood SEL-200 Stereo-FM Receiver

For copy of manufacturer's brochure, circle No. 1 on Reader Service Card.



THE *Sherwood* SEL-200 is one of the most sensitive and powerful stereo-FM receivers available, and heads the comprehensive *Sherwood* line of high-fidelity components. It is a true heavyweight of receivers, weighing about 30 pounds and measuring 19⅛" x 6¼" x 14" in its walnut cabinet. Behind its attractive gold and black panel is an FM tuner of advanced design, and a dual 60-watt amplifier with very low distortion.

The front-panel controls of the SEL-200 are functionally grouped. Across the upper part of the panel are the dial and the three basic operating controls—tuning, input selector, and loudness/power switch. Across the lower part of the panel are the secondary controls (with smaller knobs) such as the tone controls, balance control, and mode selector (stereo, either channel, or mono). Other functions are handled by push-button switches. One group of five operates the FM-muting circuit, high-cut filter, tape monitoring, loudness compensation, and a Stereo Only function that allows only stereo-FM broadcasts to be heard. A second group of three push-buttons controls the main and remote stereo speaker systems, and a single mono speaker that carries the sum of the two channels. Any combination of speakers may be used simultaneously, as long as the amplifier does not see less than a 4-ohm load impedance.

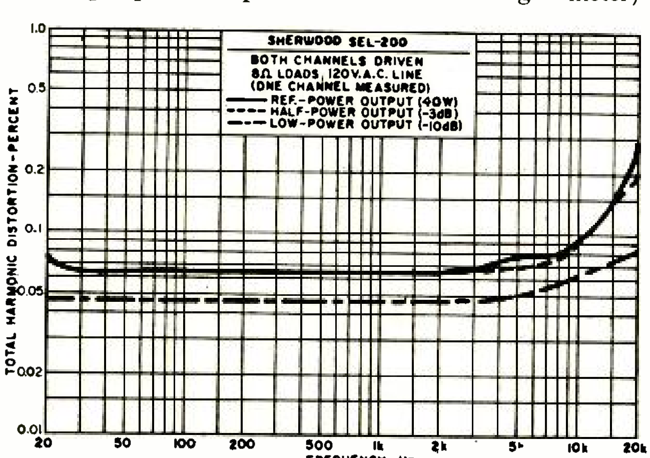
In the rear of the unit, in addition to the usual array of inputs and outputs, are the tape output and monitoring input connectors. The latter are paralleled with two stereo phone jacks on the panel, so that a tape recorder can be patched into the receiver whose rear is not accessible. Alternatively, it is possible to dub from one recorder to another using the facilities of the SEL-200. The FM-muting threshold adjustment is in the rear, as is a three-position switch for adjusting phono sensitivity for cartridges of different outputs.

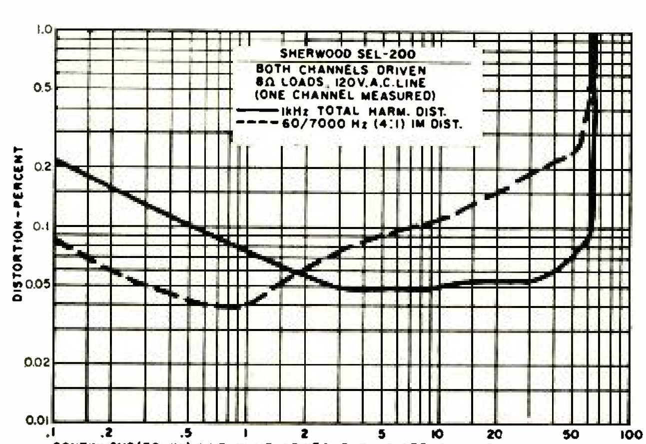
The dial of the SEL-200, although not truly linear, is calibrated at 200-kHz intervals, and very accurately at that. It is possible to preset it to any FM channel without any uncertainty as to tuning accuracy. It and the two tuning meters (a zero-center and a relative signal-strength meter) are illuminated only when FM is used. Two lights identify the Aux and Phono inputs when they are used. In FM, there are red and yellow lights on the dial face that signify stereo or mono reception. The intensity of dial and meter illumination can be varied, or shut off entirely, with a small knob on the panel.

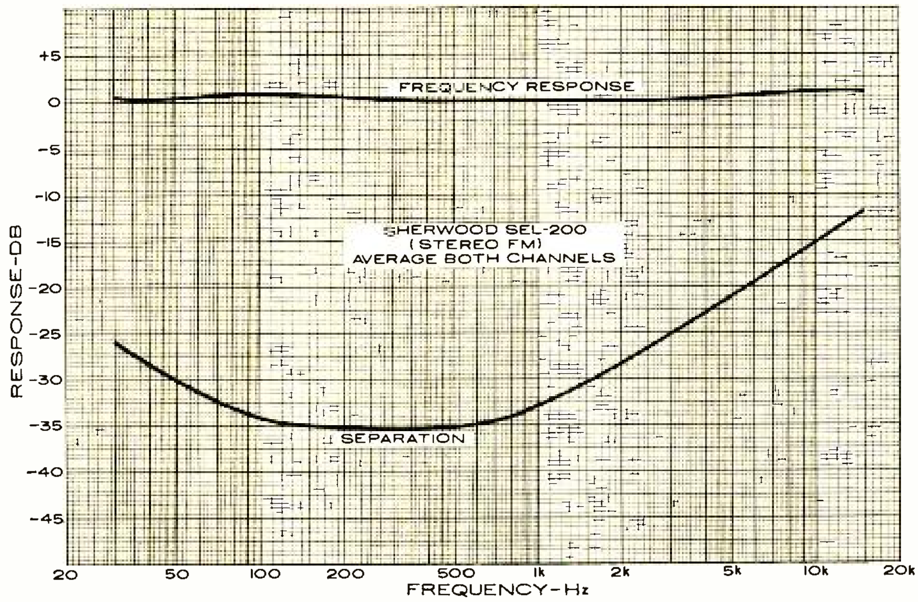
The FM tuner section has a FET front end and an i.f. amplifier with hermetically sealed IC's instead of the plastic-encapsulated types used in some consumer products. This should add to long-term reliability, since absorption of moisture by plastic devices is one cause of semiconductor failure. The i.f. selectivity is obtained with a hermetically sealed, 9-pole *LC* filter using toroid inductors. This is claimed to have superior characteristics to crystal filters, used in some other fine tuners, and shares their advantage in not requiring periodic alignment.

The interstation-muting circuit of the SEL-200 has been designed to operate without the thumps and noise bursts that are typical of most muting circuits. In our use tests, we were impressed by its smooth operation, making this particular muting circuit one of the very few such circuits that we have found that does its job properly.

The amplifiers of the SEL-200 carry several power ratings, from 275 watts (IHF ±1 dB, 4 ohms) to 2 × 60 watts (continuous, 8 ohms). The latter is based on only one channel being driven. With both channels driven, the amplifier is rated at 40 watts per channel at less than 0.3% distortion from 20 to 20,000 Hz. In our tests, distortion at full power and half power were virtually the same, typically 0.065% and not over 0.1% from 20 to 11,000 Hz. The distortion rose slightly to 0.3% at 20 kHz. At one-tenth







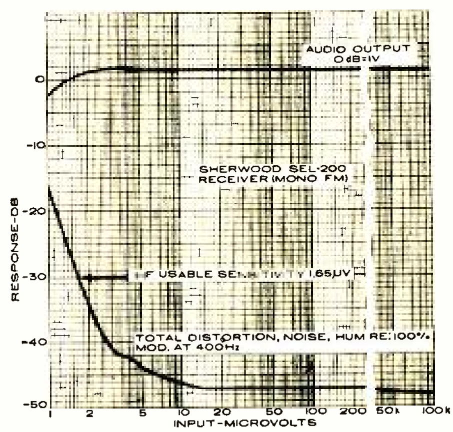
power, it was slightly under 0.05% from 20 to 5000 Hz, increasing to 0.085% at 20 kHz.

The 1000-Hz harmonic distortion was under 0.1% from 0.5 watt up to about 60 watts, with both channels driven. An apparent rise to 0.23% at 0.1 watt was due to noise rather than distortion (the test was made with the receiver's gain at maximum). The IM distortion was under 0.1% up to about 8 watts, rising smoothly to 0.23% at 50 watts and clipping at about 60 watts.

Since it appeared that the 40-watt-per-channel rating was rather conservative, we repeated the distortion-*versus*-frequency measurement at 60 watts. Even at 50% above rated power, the distortion was typically about 0.5% over most of the frequency range, and below 0.75% from 27 to 15,000 Hz. At 20 Hz the distortion was still only 1.6% (most receivers and amplifiers have enough trouble delivering their rated output at 20 Hz, let alone a 150% overload).

We could not measure the full-power distortion at 20 kHz because the receiver's protective circuits cut off the amplifiers. They are very effective, although disconcerting in their action. The receiver simply goes "dead," and the only way to restore service is to shut off power for about 10 seconds and turn it on again. We would like to see a warning light to show that the circuits have operated, since it is easy to assume that something has blown out when no sounds can be produced.

The amplifier of the SEL-200 has very high gain, requiring only 68 millivolts in the Aux inputs for 10-watts output. The three phono sensitivities for 10-watts output are 0.72, 1.5, and 3.0 millivolts. Corresponding overload levels are 17.5, 35, and 73 millivolts. Most cartridges should be used with one of the less sensitive settings to prevent overload on strong peaks. Hum and noise were 77 dB below 10 watts on Aux



and 64.5 dB below 10 watts on Phono inputs, both of which are quite inaudible.

The loudness compensation has very listenable properties, boosting only the low frequencies at low settings, but not to an undesirable extent. The high filter, which has a 12 dB/octave slope above 5 kHz, worked very effectively. RIAA equalization was accurate within +0.5, −1.5 dB from 30 to 15,000 Hz. Most of the tone-control action took place with knob settings between ⅓ and ⅔ of the way from center to end limits. There was an unusually large amount of control at low frequencies, amounting to +22.5 dB and −18 dB at 50 Hz.

The FM tuner of the SEL-200 had a measured IHF Usable Sensitivity of 1.65 microvolts, and its distortion was less than 0.5%, which is the residual of our signal generator. The FM frequency response was unusually flat, within ±0.5 dB from 30 to 15,000 Hz. Stereo-FM separation was better than 25 dB from 30 to 3000 Hz, and about 35 dB at mid-frequencies. It measured 12 dB at 15 kHz (a perfectly satisfactory figure) but we could see that the presence of 38-kHz signal in the outputs was limiting our ability to measure true separation at the upper frequencies. By filtering out some of the 38-kHz component, we improved the 15-kHz separation figure to about 16 dB, but this is not far from the measurements of our signal generator and we have no doubt that the separation of the receiver was better than 16 dB.

In use tests, the receiver was a pleasure to operate. It was obviously sensitive, very easy to tune with its smooth flywheel tuning and accurately calibrated dial, and we enjoyed the freedom from annoying noises when tuning across signals with the muting on. It sounded superb, and is one of the few receivers with enough clean audio power to do justice to any speaker system.

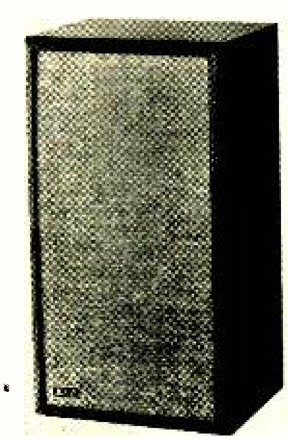
The *Sherwood* SEL-200 sells for $599, including a metal cabinet (walnut cabinet optional). It is not inexpensive, but neither is any receiver, or combination of separate components, with any pretentions to this sort of performance. ▲

KLH Model 33 Speaker System

For copy of manufacturer's brochure, circle No. 2 on Reader Service Card.

AFTER years of making only fully sealed acoustic-suspension speaker systems, *KLH* has introduced its Model 33 which is described as having "controlled acoustic compliance." This is a bookshelf system with a cylindrical duct that we first thought was operating as a reflex port. However, the port opening is smaller in size than a reflex port would be. Actually, the port is designed to increase the stiffness of the air in the enclosure at low frequencies. This is to reduce distortion and control the excursion of the cone. The port opening does not reinforce the output response at low frequencies as would a conventionally designed reflex-type port. The Model 33 measures 23⅜" × 12¾" × 10⁵⁄₁₆" and weighs about 30 pounds.

The Model 33 is a two-way system, with a newly designed 10-in woofer. The cone is molded of a special asphalt and paper mixture, giving it desirable rigidity with built-in damping to smooth out its response near its upper frequency limits. Strips of damping material are deposited on the cone to further damp undesired resonance modes. In the de-



sign of the speaker system, *KLH* has aimed for a flat response and low distortion in the 40- to 120-Hz region, which includes most musical bass material, at the expense of the output in the lowest bass octave.

At 1500 Hz there is a crossover to a 1¾-in cone tweeter, with a center dome for improved high-frequency dispersion. A three-position switch provides a slight adjustment of high-frequency level—about 1 dB above or 3 dB below normal. There is no "shelf" or other discontinuity in the response curve at the crossover frequency, in any of the three positions of the switch.

We are presently employing a modified frequency response measurement technique to reduce the effects of room resonances on the test results. Below 300 Hz, the speaker's response is measured with a single close-up microphone, for comparison with a calibrated reference speaker located in the same position. Adding the difference between the two curves to the known response of the reference speaker, we obtain a low-frequency response curve virtually unaffected by room resonances. Above 300 Hz, the outputs of 8 microphones are averaged to smooth out reflections. A slight peak of about 3 dB at 350 Hz seems to be one of the few remaining identifiable room effects. At the high frequencies, principally above 10 kHz, we also correct for the response of our calibrated microphone.

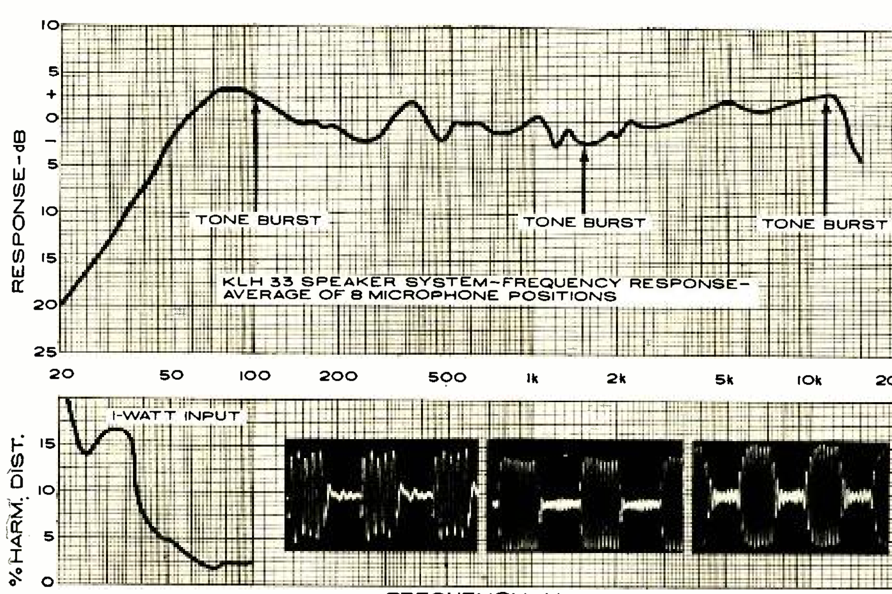
The over-all response of the speaker was very flat and smooth, within ±2.5 dB from 50 to 14,000 Hz (except for a maximum point of 3.5 dB at 80 Hz). Measurements at 45 degrees off the speaker's axis indicated excellent dispersion, with less than 5-dB loss from the axial response below 10 kHz. Tone-burst response was uniformly excellent throughout.

The distortion of the speaker, at a 1-watt drive level, was under 5% down to 50 Hz, but increased rapidly at lower frequencies, to 15% at 37 Hz. This appears to be consistent with its design, since it was not intended to deliver room-rattling output from organ pedal notes.

In listening tests, there was certainly no lack of clean bass output from the speaker. Over-all it was superbly balanced and smooth sounding. Impressed by its quality, we made an A-B comparison against a highly regarded, top-priced acoustic-suspension system and, in general, could hear no significant difference between them. However, in the very low bass, the Model 33 came off second-best in the comparison. Frequencies below 50 Hz are quite rare in music so that this should not be a significant factor for most listeners. It is more than balanced by the exceptional smoothness and ease of the total sound from the loudspeaker system.

The Model 33 is a rather low-efficiency speaker. The manufacturer suggests using an amplifier of at least 10 watts per channel (continuous) output. We consider that figure too low, since it could produce distortion from amplifier overload on occasion. For serious listening, we would recommend at least 30 watts per channel, as does *KLH* in its accompanying instructions. In fact, we especially enjoyed listening to the Model 33 driven from a very-high-quality 60-watt amplifier, which resulted in a caliber of sound not usually expected from moderate-priced loudspeaker systems.

The *KLH* Model 33 sells for $99.95. As we have pointed out, its quality is in most respects indistinguishable from that of speakers selling for several times its price. Some very fine sounding speaker systems have become available in this price bracket during recent months, and the Model 33 definitely is another that should be heard before making a final choice. ▲



When you're young your ears are sharp and your pocket book is flat

And you can hear every dB of difference between what you can afford and what you'd like to.

Sony understands.

So we brought out an inexpensive amplifier and tuner that look and sound *almost* as good as the expensive ones.

The FM stereo/FM-AM tuner has switchable AFC, solid-state i.f. filters, FET's and everything you need to bring in all stations richly, clearly, enjoyably.

The amp has 44 watts of IHF power, a front-panel Aux input, high filter, tape monitor, speaker switching and a sexy, sliding balance control.

And, they sell for one hundred twenty dollars each—complete with walnut cabinet.

We call the tuner the ST-5600, and the amp the TA-1010. You'll call them nicer names. Enjoy these at your hi-fi dealer. Sony Corporation of America, 47-47 Van Dam Street, Long Island City, N.Y. 11101.

THE SONY® STEREO TWINS, $120 EACH

LETTERS

FOUR-CHANNEL STEREO

To the Editors:

I enjoyed your four-channel stereo article by Robert Berkovitz in the Feb. issue—a very penetrating survey of the situation at this time.

Perhaps I could contribute a historical note: The first surround-stereo recordings to my knowledge were made in 1961 of the Northwestern Concert Band. These experiments were inspired by the ELECTRONICS WORLD article of May, 1961 by John Hogan, which suggested the three-speakers-in-front, one-in-the-rear format. Those Northwestern experiments, however, clearly revealed the two-front, two-rear format as being superior. Our experiments have continued up to the present time, but our first public announcement was to the Audio Engineering Society in 1968.

No doubt there were others experimenting in this medium. I know the late Lloyd Ryan of *General Electric* made some 4-channel recordings with Enoch Light, although I do not know if they were the "surround" type. Also *Nortronics* marketed some 4-channel tapes in the early 1960's.

JIM CUNNINGHAM
8 Track Recording Co.
Chicago, Ill.

* * *

IMPORTED HI-FI EQUIPMENT

To the Editors:

During transit to the USA from my last duty station in Bahrain (Arabian Gulf) my *Pioneer* receiver was slightly damaged. Not having a circuit diagram and wishing to effect repairs myself, I wrote to *Pioneer Electronics USA* (Farmingdale, Long Island) and requested advice on sources of supply. By return I received the full circuit of my set "with compliments."

If volume of advertising is anything to go by, *Pioneer* commands only a fraction of the market when compared with the firm who manufactured another component of my hi-fi system. Faced with damage also to this component, I wrote to the firm not once, but twice, and have yet to receive a reply.

Perhaps the answer is that if you spend enough on glossy brochures, one becomes convinced that one does not have to indulge in the luxury of good customer relations; it certainly appears so.

Anyway, my congratulations to *Pioneer*; I would certainly recommend them to my best friend.

MAJOR W. L. WOOD, R Signals
British Army Staff, British Embassy
Washington, D. C.

This letter was written in response to an item "Back to the Factory Repairs" which appeared in a recent "Radio & Television News" column by Forest Belt, in which he complained about the difficulty in getting parts and service data from manufacturers of imported home-entertainment equipment. According to this and other similar letters we have received, those companies making hi-fi equipment seem to do a better job in this regard than many of the TV and radio manufacturers.—Editors

* * *

AIR CONTROLLER'S RADAR

To the Editors:

Here's a comment on the article "Air Controller's Radar Sees Through Weather" (p. 32, April issue). The article seems to imply that the elimination of clutter on the radar scope is something very new. Not so!

Twenty years ago, while serving as a radar technician in the Army, I worked on the AN/TPS-1D search radar that eliminated ground clutter while still showing the aircraft. For example, a plane flying below the top of a mountain would show up, but not the mountain. This was accomplished by what was then called the MTI (Moving Target Indicator) circuit.

KEN GREENBERG
Chicago, Ill.

To the Editors:

The "clutter eliminator" described is old stuff. *Bendix* and other companies have used the weather-outline generator for several years.

The article makes an erroneous and misleading statement in connection with Fig. 3 when it states "the location of the tornado was clearly displayed to the controller." Examination of Fig. 3 shows no such display of any tornado; nor is it possible to display a tornado itself by such means. The conventional precipitation "hook" which may or may not indicate the possible presence of a tornado has been known for years, but even it was not evidenced in Fig. 3 which merely showed two twin centers of precipitation side by side.

T. M. Morse
Winston Salem, N. C.

* * *

BRITISH RADAR

To the Editors:

In connection with my work, I see a copy of your periodical each month and I was particularly interested in the article in your March issue entitled "1937—A New Device to Detect Aircraft."

What fascinated me most was the statement that the May night in 1937 was a turning point in military history. Whose history? Certainly not British history, because by May, 1937 the Bawdsey Radar Station became operational, manned by trained personnel, having equipment which could keep watch on quite a large area. In March, 1936 radar apparatus at Bawdsey could detect and locate aircraft at 1500 feet some 75 miles away.

But I suppose that, because of your article, countless young Americans will get the impression that the U.S.A. was responsible for the British invention!

J. S. Ewins
London, England

We don't believe the author meant to minimize the British contribution to the development of radar, including the invention of the multicavity magnetron which made microwave radar possible. —Editors

* * *

RADIO-STATION ENGINEER

To the Editors:

Ken Knecht's article in the May, 1970 issue ("The Chief Engineer of a Small Radio Station") profiles this vocation well. He properly emphasizes the diverse duties, with sufficient detail to convey a "feel" for the technical responsibilities of the job.

A real need exists for technicians at small stations which dominate the broadcast field. (Nearly ⅞th of the nation's radio stations are 1000 watts or less.) Once the acme of technical excellence, today's small station often operates with erratic equipment amid wiring jungles left by itinerant First Phones not interested in broadcasting.

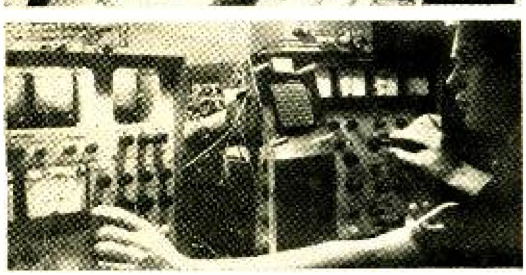
For the conscientious individual who enjoys varied duties and dislikes routine, the small radio station offers rewards far beyond the industry's lagging pay scale. One thing for sure: no one ever became bored at a small radio station!

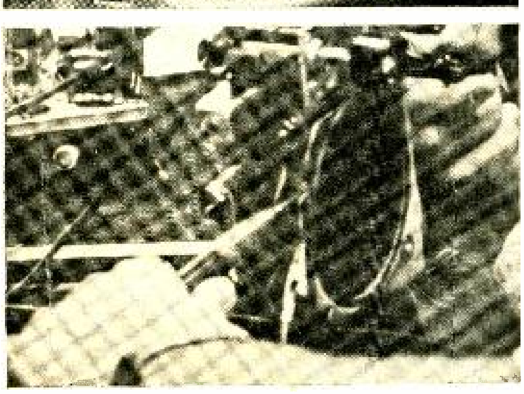
Ronald Pesha
Chief Engineer, *KFKA*
Greeley, Colo.

A number of other readers have written to us along these same lines with respect to the Chief Engineer's job.—Editors. ▲

If you're a natural "Mr. Fix-it"...

why not see your knack by sending for this on your future in





If you've been using your mechanical ability only on weekend projects while you spend the rest of the week in a dull, low-paying job—you just don't know how much your ability could be worth!

Consider this: according to the National Science Foundation, four million trained technicians will be needed within the next five years; yet projections show that *less than one million will* be available. Already, big and small companies are competing desperately for technicians...spending hundreds of millions of dollars in newspaper advertising to woo them with excellent salaries and mouth-watering fringe benefits!

Today there's almost no field that doesn't depend on electronic equipment and the technicians who can make it work...from life-saving medical electronics to computer technology to the exotic new field of *astrionics*—the application of electronics to space flight!

How can you learn to become a technician? Our free booklet will explain how United Technical Institute can actually train you to be ready for your first position in just a matter of months—thanks to our practical learn-by-doing approach.

Whether you attend classes or take our home-study course, you'll find yourself thinking and acting like a professional technician from the very first day...facing the same challenges you would face on the job...simple at first, then more complex in a series of natural, easy-to-digest steps. All along the way, you'll be guided by expert UTI instructors. Even if you found ordinary schooling dull, you'll find UTI training fascinating!

There couldn't be a better time for you to put your technical ability to work on the most important project of all...earning you more money at work you really enjoy doing! Send for UTI's free booklet today by mailing the coupon.

NEWS HIGHLIGHTS

Drunkproof Cars?

General Motors, hoping to reduce highway fatalities, is currently experimenting with a physiological tester that *may* keep inebriates off the road. Game-like device is based on its ability to weed out those whose judgment, coordinated responses, vision, and short-term memory have been impaired by amount of alcohol or drugs consumed. Tester to be built into instrument panel of car will display a random number of as many as five digits from 1-9 when ignition key is turned on. (A new five-digit number will appear with each turn of ignition key.) After a few seconds (as yet to be determined) the numbers turn off and a push-button telephone-type keyboard, located directly below display, will light. It is at this time that driver's sobriety is tested because he has only a limited time period in which to punch numbers that appeared on display into keyboard. If successful, car will automatically start, and if driver fails, he will have two more chances. After three successive failures, car will become inoperable for an extended period of time (one-half to one hour), after which he has three more tries. Tester, in research stage at *GM's AC Electronics Div.*, Milwaukee, Wis., still has many questions to answer, such as how to modify tester for physically handicapped, how to prevent sober person from starting car for inebriated driver, etc. Unit, which can also be used as an additional anti-theft (or anti-child) device, is expected to cost as much as a car radio. Once perfected, *GM* would like to see device legislated as a required safety accessory.

More on EVR

Robert E. Brockway, president of *CBS Electronic Video Recording Division,* predicts EVR will develop into multi-million-dollar business for advertising, public relations, sponsored education, industrial training, and sales promotion and service. Potentially, EVR has something to offer for everyone—from housewife to professional man. In addition, performing talent, artists, and writers will find EVR a new source of revenue and royalties. Taking advantage of the mass market that EVR will make available to movie industry, the board of directors of *20th Century-Fox*, under the leadership of Darryl F. Zanuck, chairman and chief executive officer of the firm, has authorized transfer of selected *Fox* feature films to *CBS* EVR cartridge system. Mr. Brockway has credited Dr. Peter C. Goldmark, president and director of research for *CBS Labs,* as the creative genius behind EVR—which has been labeled by *Time* magazine as one of the ten outstanding electronic achievements of the 1960's.

Lasers—In Retrospect

In spite of great promises laser technology held out for mankind at its inception ten years ago, Dr. Theodore H. Maiman, its inventor, feels that, realistically, the laser is at most only a "magnificent tool with a presently limited market." Citing their use in surveying, eye surgery, IC production, holography, etc. . . . Dr. Maiman feels that lasers find their biggest markets with the military and science since they are not as cost-conscious as industrial users. Although great improvements have been made performance- and cost-wise, most industrial lasers are still too expensive and are used only when conventional techniques are inadequate. As to the future, Dr. Maiman envisions lasers being used as a short-range, high-data-rate communications link and with computer optical memory systems that will store trillions of bits of information. (Our October Special Issue section will carry an article that provides further details on optical memories.)

PO Modernization—Via Japan

With the Administration placing strong emphasis on Post Office modernization, Postmaster General Winton M. Blount purchases high-speed automatic letter-handling machine first seen at Tokyo Central Post Office last year. Machine, developed by *Tokyo Shibaura Electric Co., Ltd. (Toshiba),* is said to be able to cull and stack mail automatically, by thickness and size, at a rate of up to 23,000 pieces an hour and detect and face-cancel stamps on each standard-format piece of mail selected and sorted by culling machine. Price of unit is said to be about $200,000. In addition, thinking along modernization lines, *Toshiba* also has available a machine that, in addition to facing the postmarking mail, automatically distinguishes and sorts Special Delivery mail from ordinary mail by recognizing color and shape of postage stamps and a device that automatically reads handwritten Zip Codes and sorts mail according to geographical destination at a speed of 5 pieces per second.

Radio Shack-Allied Radio Merge

Lewis Kornfeld, vice-president of *Radio Shack,* named president of combined *Radio Shack* and *Allied Radio* division by Charles D. Tandy, chairman of the parent *Tandy Corp.* New combine, estimated at $180 million, includes nearly 700 *Radio Shack* company-owned and franchised stores and 41 *Allied Radio* stores. *Allied* catalogue order booths will be located in each *Radio Shack* store and, in turn, *Radio Shack* products will be made available through *Allied Radio* stores.

Radiation Survey

On May 15, industry, in cooperation with Government health authorities, launched survey of nation's microwave ovens to evaluate their radiation emission characteristics. Surveys were initiated by Public Health Service when State and Federal health authorities found radiation emitted from some ovens exceeded voluntary industry standard of 10 mW/cm^2 (soon to be 1 mW for ovens prior to sale and 5 mW after sale). Each manufacturer is required to provide trained personnel and instruments for conducting surveys of their own ovens. As a check against survey results, the Environmental Health Service's Bureau of Radiological Health is conducting an independent oven study that should be concluded about September 1. Oven owners may learn locations of survey contact points by calling local distributors. Part 1 of a two-part article on Microwave Ovens appears on page 25 of this issue.

Measuring Car Pollutants

To help enforce government's exhaust emission standards for cars produced during and since 1968 (not emit hydrocarbons exceeding 275 parts per million by volume or more than 1.5 percent carbon monoxide by volume when tested), *Sylvania Electric Products Inc.* has developed a portable, low-cost electronic exhaust analyzer. Analyzer, employing a metal probe at the end of a long, flexible cable, draws sample of idling engine's exhaust into gas handling unit for cooling and removal of water, soot, and other particles. Filtered sample then flows into analytical cell where an infrared light beam is passed through sample. Since each gas absorbs a specific amount of infrared signal, the presence and level of gases in exhaust can be determined by comparing infrared signal remaining in cell, as measured by detectors, against the original beam output. Detector output is converted to voltage signals which operate direct-reading carbon monoxide and hydrocarbon meters on top of unit. Analyzer, which is 24" x 18" x 13", uses solid-state electronics and can be supplied with recording equipment to provide printed readouts. Unit is also capable of being altered to measure oxides of nitrogen and carbon dioxide.

Sight Extenders

"Don't fire until you see the whites of their eyes"—not such an easy task when searching for the enemy from a helicopter on after-dark military missions. *Mosaic Fabrication Div., Bendix Aerospace-Electronics Co.,* has developed a fiber-optic transmission device, called a flexible imagescope, which is an important part of the INFANT (Iroquois Night Fighter and Night Tracker) night-vision system. System allows helicopter crews to detect targets at night, even in absence of moonlight and starlight. Target area is panned by xenon searchlights (infrared light) that, although invisible to human eye, provide sufficient illuminaton for night-vision system. Imagescope, fitted with lens system at both ends, is made up of thousands of precision-aligned small clad-optical-glass fibers that break up image into as many parts which are individually transmitted and then reassembled at viewing end. Device can be bent, twisted, or snaked into any hard-to-reach area and is available in lengths up to 15 feet. Flexible imagescopes are also used for inspection of interiors of jet engines, nuclear reactors, and the human body.

What's New Around?

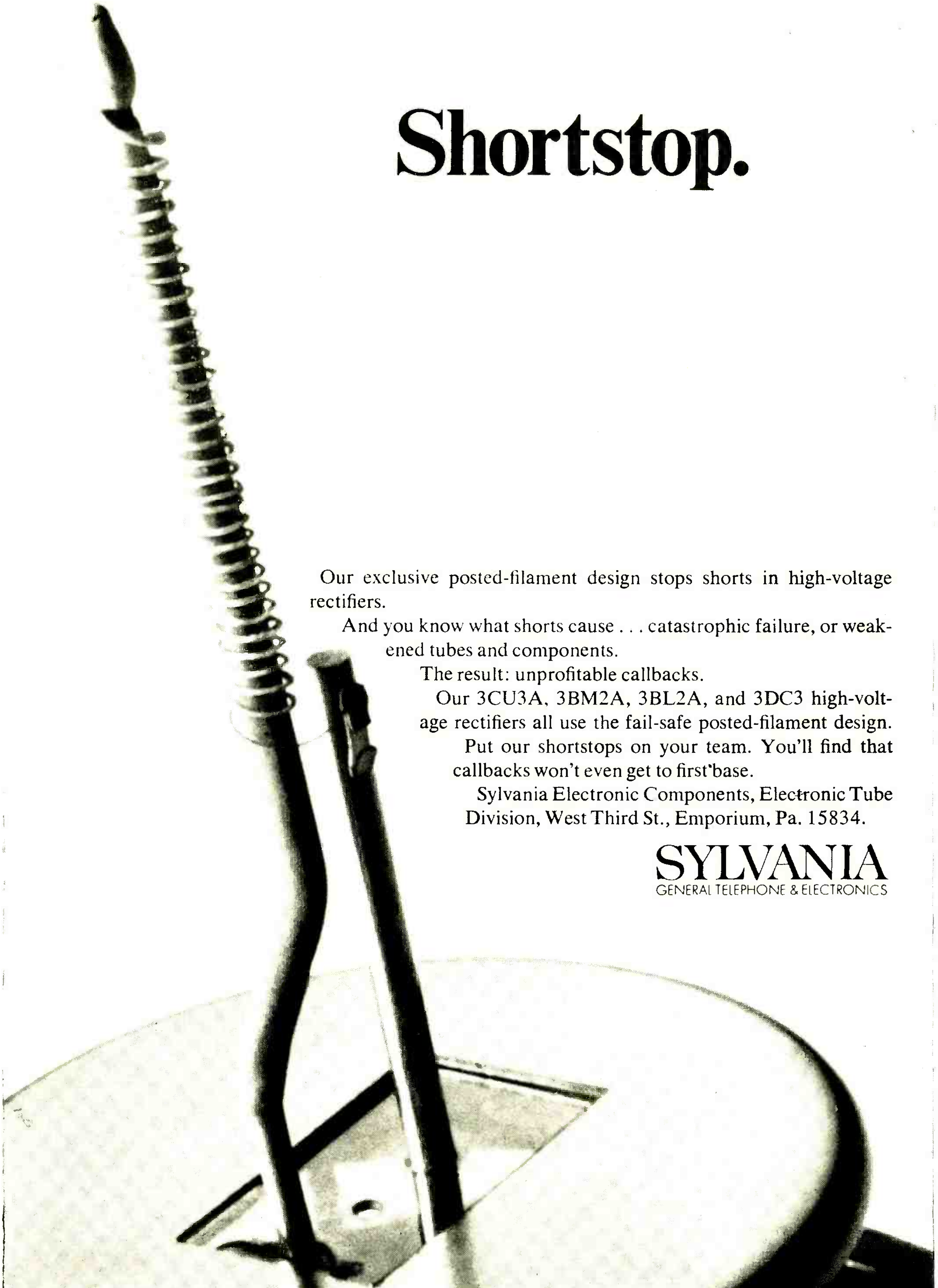
RCA, taking advantage of today's money-conscious market, is offering closed-circuit TV users the industry's first single-tube, black-and-white TV camera that can be converted to full color operation. Obviates purchase of an additional color-TV camera when need arises. High-resolution monochrome camera (PK-430) converts to color by adding special color-encoding optical system and small electronic color processor (10 inches of space). Basic camera includes 10:1 zoom and type 8507 vidicon tube which provides horizontal resolution of 600 lines for detailed pictures. Camera priced at $5995 and conversion equipment at $4755 in comparison to color-TV cameras that range in price from $10,000 to more than $80,000. . . . Good news for radio and TV viewers bothered by interference caused by static discharge from conventional fluorescent and mercury lamps. *Toshiba* and the Central Technical Laboratory of the *Japan Broadcasting Corp. (NHK)* have jointly perfected what is said to be "first noise-free mercury lamp in the world." Its static strength is 20-30 times less and noise frequency 100 times less than mercury lamps now in use. Pricing and production plans have not been announced as yet.

Electronics Honor Roll

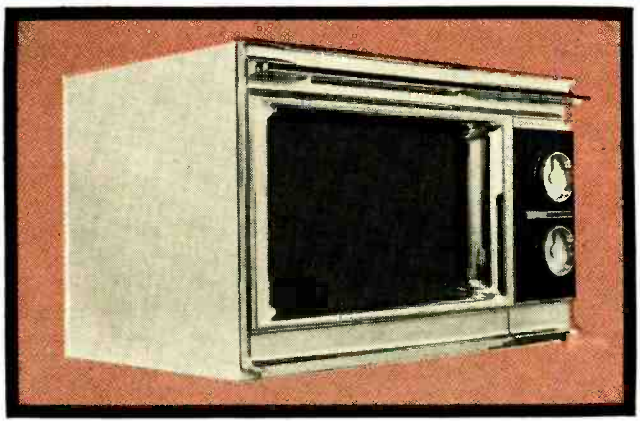
Paul G. Hansel, vice-president of *Electronic Communications, Inc.,* and general manager of the company's Aerospace Electronics Group, received industry's most coveted honor, the "Pioneer Award," from the Aerospace and Electronic System Group of IEEE. Award recognizes Mr. Hansel's achievement in field of doppler v.h.f. omnirange (doppler VOR) navigation, accomplished over 25 years ago (June, 1945) and now widely used on U.S. and European airways. . . . Audio Engineering Society bestows Fellowship on James J. Noble, vice-president of engineering, *Altec Lansing,* "for his contributions as designer and director engineering for a broad line of audio equipment." Mr. Noble has been with *Altec* since May, 1941 and is a member of IEEE and Society of Motion Picture and Television Engineers. . . . "Tiger of the Year" award presented to Wilfred L. Larson, president and general manager of *Switchcraft,* at the electronic industry Young Tigers' "Annual Growl" held in conjunction with 1970 NEW Show. Award, which is electronic industry's equivalent of an Oscar, is presented annually to the recipient for his outstanding accomplishments in his job and for service to the industry. The Young Tigers is an organization of executives with five to twenty years' service in the electronics industry.

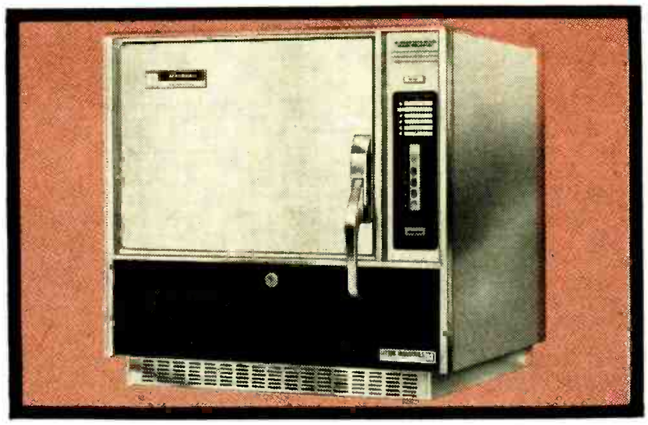
Victory—Japanese Style

According to Electronic Industries Association's (EIA) Marketing Services Department, Japanese consumer electronics equipment is dominating South Vietnam market. Figures received from Japan Ministry of Finance indicate 1969 Japanese consumer electronics exports to South Vietnam totaled $52.6 million with additional $7.9 million in consumer-related components, far surpassing U.S. consumer electronics exports. For example, 312,897 tape recorders ($22.8 million) compared to 120 units from U.S. and 94,798 TV receivers to our 151 were shipped to South Vietnam by Japan in 1969. ▲


Shortstop.
Our exclusive posted-filament design stops shorts in high-voltage rectifiers.
And you know what shorts cause . . . catastrophic failure, or weakened tubes and components.
The result: unprofitable callbacks.
Our 3CU3A, 3BM2A, 3BL2A, and 3DC3 high-voltage rectifiers all use the fail-safe posted-filament design.
Put our shortstops on your team. You'll find that callbacks won't even get to first base.
Sylvania Electronic Components, Electronic Tube Division, West Third St., Emporium, Pa. 15834.
SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

MICROWAVE OVENS
– Revolution in Cooking





Typical microwave ovens for home and vending-machine use are the Amana Radarange® (left) and Litton Heat-n-Eat (right). The home unit has adjustable minute and second timers while timing in vending-machine unit is by means of 6 push buttons.

Part 1.—Operating Principles and Design

By DAN R. McCONNELL / Product Planning Manager, Microwave Ovens, Amana Refrigeration, Inc.

The real capabilities as well as the shortcomings of the electronic oven. A technically sophisticated design is required to make the oven perform as claimed and, at the same time, be a safe and reliable product.

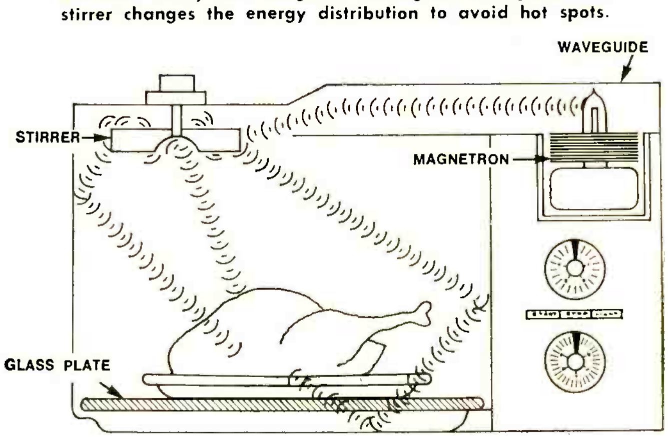
MICROWAVE oven, electronic range, and a host of names devised to capture the essence of the device, all refer to a cooking appliance called revolutionary by some, the latest consumer gimmick by others. Revolution or gimmickry? In this article we will discuss the capabilities of the microwave oven and its limitations. This will show the design required to make the product perform as claimed in the advertising and be, above all, safe and reliable.

The microwave oven *does* cook as fast as has been advertised. A beef roast can be cooked "well done" in five minutes per pound, a lobster tail completely cooked from the frozen state in five and one-half minutes, a package of frozen corn in five minutes, a hamburger in one minute, and a baked potato in four minutes. The microwave oven can provide nutritional advantages as yet little explored, and can brown food under certain conditions, although it doesn't cook everything well.

This device, now being manufactured in increasing quantities in the United States, Europe, and Japan, has been commercially available for a number of years. The complex technology required to design microwave ovens was, until recently, possessed by few companies. Many years were required to turn a laboratory wonder into a practical, reliable product, and many more to reduce the costs to acceptable consumer levels.

The microwave oven is one of the original "spin-off" products from microwave technology, utilizing magnetron design concepts, resonant cavities, waveguide technology, and power-supply design from laboratories engaged in developing componentry for radar. The fundamental patent, titled succinctly "Treating Foodstuffs," was filed in 1945 by *Raytheon Company's* nearly legendary Dr. P.L. Spencer. From 1945 to 1954 alone, Dr. Spencer's laboratories in the company's Microwave & Power Tube Division were granted more than 117 patents covering such fundamental aspects

Fig. 1. An S-band magnetron radiates microwave energy into oven cavity via a length of rectangular waveguide. The stirrer changes the energy distribution to avoid hot spots.



MICROWAVE-OVEN INDUSTRY NOW AND IN THE FUTURE

MICROWAVE cooking is still in its infancy in the United States. Although no exact figures are available, it is estimated that approximately 50,000 microwave ranges were produced in the U.S. in 1969. Fairly conservative projections predict a rise to 250,000 units by 1975. More optimistic forecasters foresee twice that rate in five years.

Most of the production in 1969 has been in portable, counter-top domestic ranges. In the period 1954-1968 the majority of production was in commercial or vending units, for restaurants and institutional use. In that time period as well, most production was concentrated in this country, although an increasing array of models were appearing in England, Holland, Sweden, and Japan.

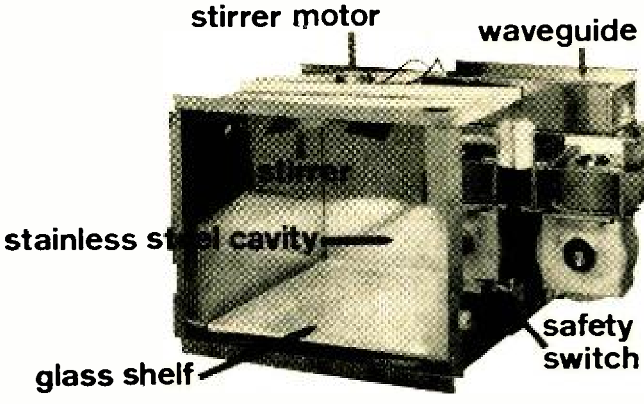
In 1967-1968, a remarkable thing happened in Japan that will have a powerful effect on the American and European markets for domestic microwave ovens. In the years from 1966-1968, production of microwave ovens in Japan "took off," going from 15,000 in 1966, to 50,000 in 1967, and 100,000 in 1968. Some 200,000-250,000 units are predicted for 1969 sales *in Japan*, with the Japanese industry built up to a capacity of 30,000 units per month by January of this year.

As microwave cooking is accepted in the U.S. and the U.S. market begins to expand, who will be the beneficiaries of that expansion, U.S. or Japanese producers? Although the microwave oven was invented in the U.S. and first marketed here, it achieved mass acceptance much earlier in Japan. The reasons for this are not economic. Even though the Japanese ovens are somewhat less expensive, they represent a greater percentage of income to the Japanese consumer.

Why Japan, then? First, the standard American gas or electric range is not in common use in Japan. Gas service is not readily available; electric service to a home is limited. Many Japanese homes literally have made a single jump from hibachi to microwave oven. Second, the oven is ideal for the Japanese diet. Vegetables, fish, fruits, and meat in stews and sautés are done superbly. The Japanese housewife does not see browning limitations as a disadvantage. Other reasons are similar to those that imply a similar growth here; working wives and active homemakers welcome a release from long hours of meal preparations; they welcome the added flexibility in meal planning, the spontaneity that fits with present and future emphasis on recreational activity.

Whether American technical innovations will overcome Japanese cost advantages will determine who acquires the major share of future sales in the U.S. The many real advantages inherent in the device—the ever more active life style of our young people, the simple work- and time-saving features—speak strongly for increasing acceptance and growth of microwave cooking. To another generation of housewives a microwave oven may be as much a necessity as the refrigerator-freezer and conventional range are today.

Fig. 2. Interior construction of oven with magnetron removed.



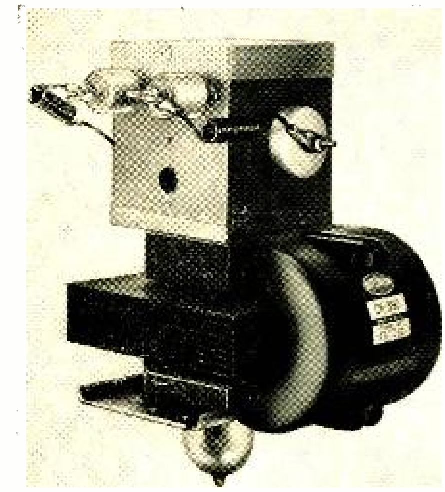


Fig. 3. An early permanent-magnet magnetron for ovens.

of microwave-oven technology as c.w. magnetrons and power supplies for microwave heating, microwave cavities, mode stirrers, and door-seal designs. Later, patents by *Tappan*, *General Electric*, and *Litton* further advanced the art.

In 1947 *Raytheon* introduced a commerical range, followed by other models in 1951 and 1954. In 1955 *Tappan* entered the market with a home range under license to *Raytheon*. *Litton*, also beginning under license to *Raytheon*, became a major force in the commercial and vending markets by the mid-60's. *General Electric*, independently pursuing microwave-oven research in the late 40's, was on the market with a range in 1956.

The high initial cost of microwave ovens, the marginal reliability, and the production and consumer distribution limitations of firms like *Raytheon* and *Litton* inhibited the long-awaited growth of the home-range market. In 1967, the marriage of *Raytheon* technology with *Amana Refrigeration, Inc.* consumer know-how led to the introduction of the *Amana* Radarange® microwave oven. This was the first microwave oven to feature compact size, operate from standard 115-volt, 15-amp house lines, and be offered for less than $500 at retail.

Recently, *Amana* has been joined in the consumer marketplace by several manufacturers of compact portables, such as *Litton Industries* (under *Montgomery Ward*, *Tappan*, and *Admiral* labels), by *Roper Corporation* (under *Sears Roebuck* label), by *Toshiba* of Japan, and by *Hayakawa* of Japan (under *Sharp* label). In addition, free-standing combination and double-oven ranges are manufactured by *General Electric*, *Tappan*, and *Roper* (*Sears Roebuck* label). The characteristics of these and other ranges are presented in the comparison chart (Table 1).

In discussing the microwave oven, the first question is usually, "How does it cook?" A basic understanding can be obtained by describing the design and operation of the device, then discussing the interaction of microwaves in the oven with different substances, including food.

Microwaves & Magnetrons

Microwaves are frequently defined as that portion of the electromagnetic frequency spectrum where the wavelengths are about the size of ordinary objects. Below the frequency of microwaves are the upper television bands (u.h.f.). Above the microwave range is the infrared portion of the spectrum. From a lower limit of 500 MHz (wavelength = 60 cm) through 10,000 MHz (wavelength = 3 cm) the frequencies are primarily occupied by radar and microwave communications equipment. Two exceptions are 915 MHz and 2450 MHz, which are allocated for the use of Industrial, Scientific, and Medical purposes (ISM). In these two frequency allocations are concentrated all microwave-oven designs for the cooking of food, as well as industrial systems for food processing, textile and wood drying, and many other devices.

The microwave range is so useful because the wavelengths are just the convenient sizes to be focused into beams, transmitted through space, and propagated in coaxial cables and waveguides with great accuracy and little loss. Enormous amounts of information can be carried, transmitted, and received over great distances. Recall the S-band Apollo communications systems (2300 MHz), tracking radars, and satellite communications systems (4000-8000 MHz), and all the other military, space, and commercial radars and communications systems.

Microwave frequencies in the neighborhood of the 915-MHz and 2450-MHz bands have two interesting and important properties that enhance the microwave-cooking phenomenon. One property is that the dimensions of a practical multimode cavity for these bands are ideal for the size of cooked food. Another property is that these frequencies both penetrate (and heat) all the way through foods, and not just on the skin surface, while strongly interacting with the molecular structure of the food substance, resulting in a rapid rate of heating. At lower frequencies the rate of heating is slower. At higher frequencies, heating is concentrated more on the surface of the food.

MFGR.	BRAND	TYPE*	CAVITY SIZE (in)	FREQ. (MHz)	COOKING POWER (r.f. watts)	LINE VOLTAGES, CURRENTS
Amana	Amana	portable	9⅛" h. x 14⅝" w. x 13⅜" d.	2450	650	115 V, 14.5 A
General Electric	GE	combin.	11" h. x 15" w.*** x 15" d.	915	600	230 V**
Hayakawa	Sharp	portable	8¼" h. x 13¾" w. x 14½" d.	2450	600	115 V, 14.0 A
International Crystal	International Crystal	portable	8" h. x 11¾" w. x 11" d.	2450	650	115 V, 14.0 A
Litton	Signature (Mont. Ward)	portable	8¾" h. x 15" w. x 12" d.	2450	575	115 V, 14.0 A
Roper	Kenmore (Sears)	portable	7½" h. x 17½" w. x 13¼" d.	2450	650	115 V, 14.5 A
Tappan	Tappan	double oven	11" h. x 16½" w. x 12" d.	2450	1200/750	230 V**
Toshiba	Toshiba	portable	8" h. x 13" w. x 10" d.	2450	600	115 V, 14.0 A
—	Westinghouse	portable	9⅛" h. x 14⅝" w. x 13⅜" d.	2450	650	115 V, 14.5 A

*No actual price information is shown because of local fluctuations. In general, most U.S. portables are offered for $450-$550, the smaller and lower power Japanese imports for $400-$450, and the large combination and double-oven ranges for $800-$1000. **Current varies because of multiple-element features. ***Microwave cooking volume confined to 15-inch diameter turntable.

Table 1. Some currently available microwave ovens, along with their specifications.

The microwave oven can be described as a resonant cavity (usually rectangular) into which microwave energy is fed from a waveguide. The microwave energy is generated by a vacuum tube familiar to radar people since the beginnings of the art—the magnetron. Although other cavities can be used (a spherical cooking cavity has been shown by *Husquavarnh* in Sweden) and other types of generators are feasible (klystrons, solid-state devices), the magnetron-waveguide-rectangular-cavity system comprises almost all the microwave-oven production in the world today.

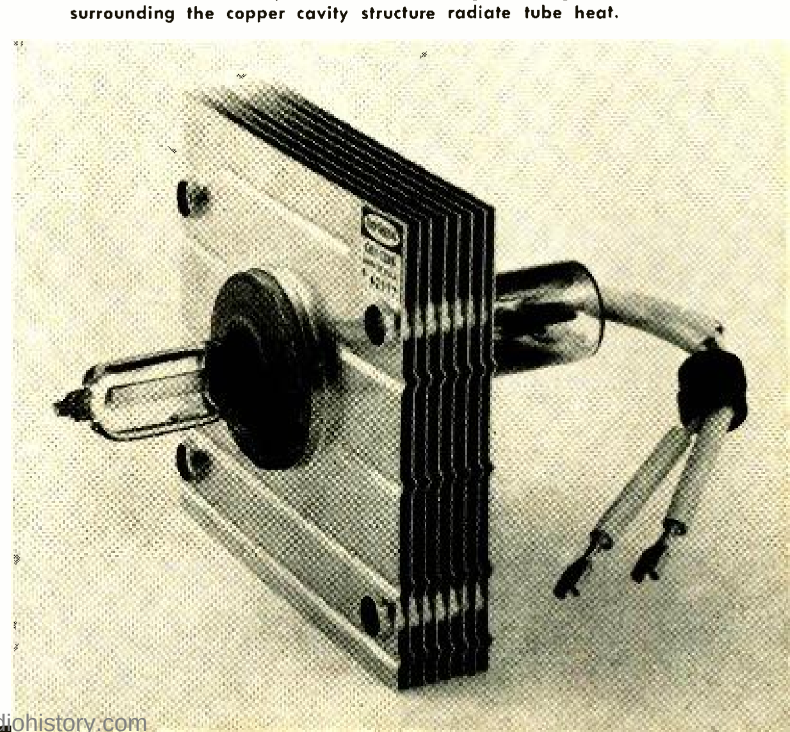
The drawing of Fig. 1 and photo of Fig. 2 show a typical scheme wherein power from a 2450-MHz magnetron is fed into an S-band waveguide. In this case the waveguide is RG 104/U, a standard rectangular guide, measuring 4.46 by 2.31 inches. The waveguide feeds directly into the cavity which is resonant in a number of modes of oscillation. Food placed in the cavity will absorb energy and convert the absorbed energy into heat. Design features that vary from one model and manufacturer to another include (1) the type of magnetron and power supply, (2) the method of "feeding" energy to the oven, (3) the "mode stirrer" or equivalent method, and (4) a door seal designed to allow easy entry to the cooking cavity while suppressing leakage of microwave energy to the outside world.

Magnetron-tube design has been covered in numerous texts. Magnetrons for microwave ovens, however, have been treated infrequently. These so-called "cooker tubes" have evolved over the years, having become by this time a highly specialized, long-life variety. Typically generating from 500 watts to 1500 watts of microwave power, these tubes are water- or air-cooled, may be focused by permanent magnet or electromagnet, generally couple energy out through an antenna and dome, and may incorporate filtering to suppress "back-end" radiation.

The magnetron tube in Fig. 3 is an early *Raytheon* type, the QK390. One of the first tubes used in a commercial microwave oven, the QK390 required a permanent magnet for focusing, was water-cooled, required 180-second warm-up, and typically generated 1200 watts at 50% efficiency. A later *Raytheon* type, the QK1381 (Fig 4), is focused by an electromagnet coil, is air-cooled, requires no warmup, and typically generates 750 watts at 60% efficiency. Another common type, the *Litton* 5001, has permanent magnets, and an air-cooling structure. It requires a brief warmup and typically generates 750 watts, or 1000 watts at 55% efficiency. Many types similar to the latter two designs are produced all over the world under license to these firms.

The magnetron cross-section in Fig. 5 shows a common twelve-cavity design. Each cavity is resonant at the fundamental frequency of oscillation. As the cathode is heated in a hard vacuum, electrons are "boiled off," accelerated

Fig. 4. A more recent coil-focused, no-warmup magnetron. Coils fit over the glass envelope at right. The enclosed probe at left radiates the output r.f. into the waveguide. Large fins surrounding the copper cavity structure radiate tube heat.



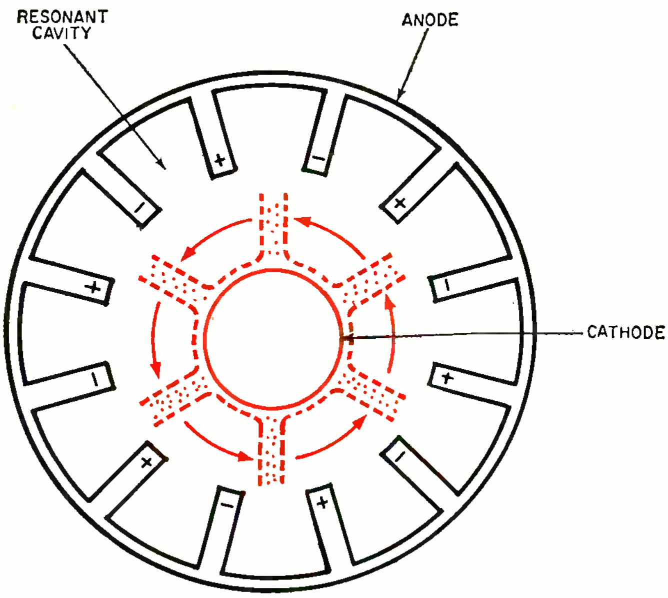


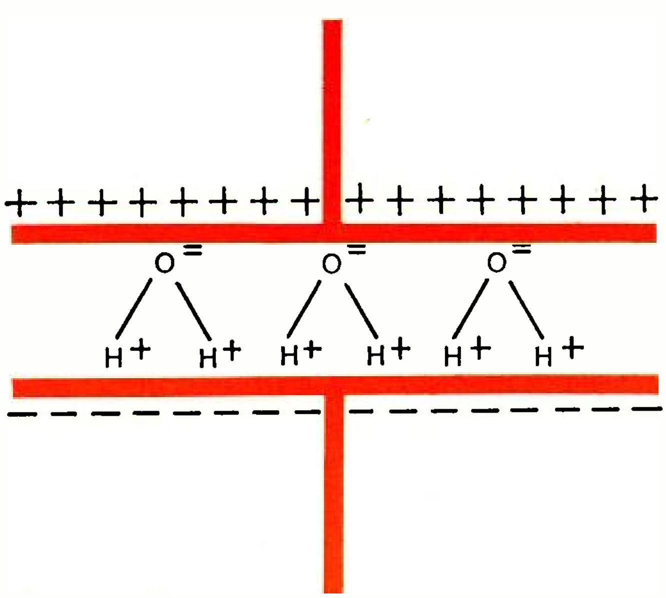
Fig. 5. Magnetron cross-section showing 12 resonant cavities and rotating "spokes" of focused clouds of electrons moving from central cathode to anode under influence of high voltage.

toward the anode by a high voltage (typically 4000 volts), and rotated in a helical path by the magnetic focusing field. As electrons boil off they rotate in clouds, tangential to the cavities, stimulating the build-up of microwave energy in these cavities.

As the rotating electrons interact with the fields in the cavities they get more strongly focused until "spokes" of electrons are formed, much like the spokes of a rotating wheel. When the spokes of electrons, or space charge, rotate synchronously with the microwave fields of the cavities, the maximum energy is coupled from the electrons to the oscillations in the cavities. Alternate cavities are connected by straps so that all cavities resonate in unison. When the entire structure is "humming" in unison, energy flows up the antenna, is fed into the waveguide, finally being fed into the cooking cavity.

One magnetron problem that has caused some grief in the past is related to the fact that the resonant cooking cavity is unable to absorb much energy. Thus, if an oven is operated empty, or with large metal pans inside, much of the microwave energy is reflected back to the magnetron where it is dissipated as heat. Excess heating may, in some cases, be enough to destroy the magnetron. In other cases, the overheating simply shortens the operating life of the tube. Although advances in tube and oven designs have reduced the likelihood of catastrophic failures, the latter problem is the reason for the warnings in most instruction books against metal cookware and against empty-oven operation.

Fig. 6. Water molecules under influence of electric field.



Some magnetrons are designed with internal chokes or external filters on the cathode or "back" end of the magnetron. These devices suppress the unwanted leakage of microwaves from the back end of the tube.

When designing a power supply for a magnetron, one observes that electrically a magnetron is similar to a diode. Small changes in magnetron high voltage cause large changes in current; therefore, some means must be employed to limit the current. If the current were not limited or regulated, the magnetron would burn up in a short time.

One scheme for limiting the current is to use an electromagnetically focused magnetron, in which the anode current is the same as that of the magnet coil. As the anode current increases, so does the magnetic field. The magnetic field, in turn, limits the current.

A second scheme that is often used is to regulate the voltage to the tube using a ferromagnetic resonant circuit. By regulating the voltage on the tube the current is also limited or regulated.

Coupling to Oven Cavity

There are many means that can be used to feed or couple microwave energy into an oven cavity. A few examples of coupling devices include voltage probes, current loops, slots, and direct waveguide feeds.

No single method of coupling energy to the cavity is best for all oven designs. The particular mechanism must be chosen on the basis of the coupling efficiency, evenness of cooking pattern, and magnetron performance over a wide range of cooking loads.

Oven match, v.s.w.r., and phase have a tremendous effect on tube life and performance. If the phase conditions produced by the load forces the magnetron to operate in an unstable region called the "sink," moding will be introduced causing the tube to fail. On the other hand, if the phase position of the load is opposite to the sink, efficiency of the magnetron is greatly reduced, thereby resulting in wasted energy.

The coupling mechanism should be designed so that the magnetron delivers the same amount of power to the oven cavity over a large range of loads. If this can be accomplished, the oven will operate at its maximum efficiency with all food loads. If the oven power doesn't vary with food loads, the selection of cooking time would become very simple. For example, if one baked potato takes 4 minutes to cook, 2 potatoes will take 8 minutes, and 3 will take 12 minutes. If the power does vary, 1 potato may take 6 minutes, 2 may take 9 minutes, and 3 may take 12 minutes.

The most difficult design problem with any microwave oven is the attainment of an even cooking pattern. Most cooking cavities, being considerably longer than one wavelength, will sustain several modes of oscillation. The intensity of fields along the walls will be very low, while standing waves in the cavity produce hot spots (peaks) and cold spots (nulls). There are two common methods evening out the hot and cold spots. One moves the peaks and nulls through the food, and the other moves the food through the peaks and nulls. The first method utilizes a "mode stirrer" or simply "stirrer." The second method uses a turntable for the food.

The stirrer looks much like a multiple-bladed fan, driven by a motor, and located adjacent to the oven feed point. Each position of the stirrer blade creates a different food condition resulting in a distinct pattern of fields in the cavity. As the stirrer rotates through all positions, the patterns are "stirred," moving the hot spots and cold spots around.

The result is a much-improved cooking pattern. A more restrictive, but satisfactory method is to place the food on a turntable and rotate, through the hot and cold spots.

Door designs capable of suppressing microwave leakage will be discussed later (Part 2) in relation to the general subject of microwave oven safety. Parts of that section will deal with the proper design of closure systems, of viewing screens, and of door interlocks.

How Does it Cook?

Now let us consider the nature of the interaction between microwave fields and a food substance. Three types of interaction are possible: *reflection, transmission, or absorption.* Some substances reflect microwave energy as a mirror reflects visible light. These substances are electrically conductive materials, such as the common metals. The most reflective common metals are copper, silver, and aluminum. Steels vary in reflectivity to a point where some varieties are rather "lossy;" *i.e.*, absorptive. In general, however, all metals cause high reflections, and this is the basis for the prohibition on use of metal pots and pans.

Objects that transmit microwaves without absorbing energy are termed "transparent." In much the same way that window glass is transparent to light, many materials are transparent to microwaves. Many plastics, ceramics, and papers are essentially transparent, with some exceptions. The transparency to microwaves makes paper plates, glass, and ceramics ideal materials for utilization as microwave cookware.

The third type of interaction, absorption, is of fundamental interest since absorption is the basis for cooking. Substances absorb microwaves to a varying degree according to some rather complex mechanisms.

The complexity of the interaction has led to certain oversimplified explanations, such as "it cooks from the inside out," "it cooks by internal friction," or better yet "by molecular friction." These common expressions do capture some of the reality of the process. The food does not cook from "outside in" as in the convection/conduction (heating the air) process or infrared process of a conventional gas or electric range. Since most foods are poor conductors of heat, conventional methods require long time periods to avoid overcooking the outside while undercooking the inside. Microwaves penetrate the food, setting up an interaction between food and waves throughout, cooking through the entire depth of the food simultaneously.

The interaction itself, the "molecular friction," is really a *dielectric-heating phenomenon.* Many materials, chiefly nonconductors of electricity, absorb microwaves. The amount of absorption is determined by two characteristics of the material, namely the dielectric constant and the dielectric loss tangent or dissipation factor.

The first of these characteristics is a measure of the polarization of the molecule when in the presence of an electric field. Polarization refers to a separation of electrical charge, or dipole moment of the molecule. A water molecule, for instance, has a dipole moment even in the absence of an electric field. The hydrogen end of the molecule is positively charged. The oxygen end is negatively charged. The separation of electrical charge by a distance creates the "dipole moment." The dipole moment of the molecule is related to the strength of the alignment of the molecule in the electric field. The water molecule in Fig. 6 aligns itself so that the positive charges are closer to the negative plate of the capacitor, and the negative charges are closer to the positive plate. In the microwave oven the molecules align themselves with the time-varying electric field in the cavity at a 2450-MHz rate.

The second characteristic, the dielectric loss or dissipation factor, relates to the "so-called" friction created by the furious activity of molecules aligning themselves with a field that is changing its polarity at a rapid rate. Some

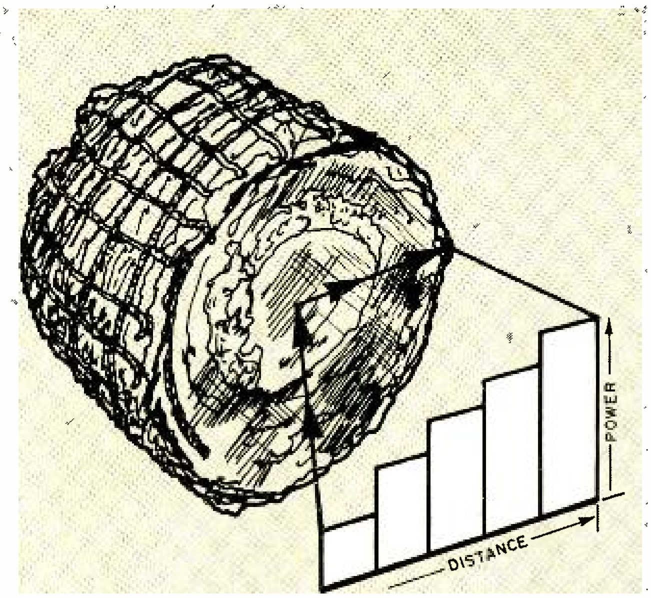


Fig. 7. More power is absorbed near the outside of food, such as a beef roast, than is absorbed near the center.

molecules have a significant delay or relaxation time such that they don't respond fast enough to the changes in the polarity of the field. The forces generated in this non-ideal orientation are the basis for dielectric loss.

The differences between materials in the values of dielectric constant and loss tangent are why some substances heat rapidly and some, seemingly, not at all. It is also the reason for selective heating, which allows the water content to dominate the heating rates of most things.

High-loss materials absorb so much energy that a selectivity is introduced, *i.e.*, when high-loss materials are present with low-loss materials, almost all of the energy is absorbed by the lossier substance.

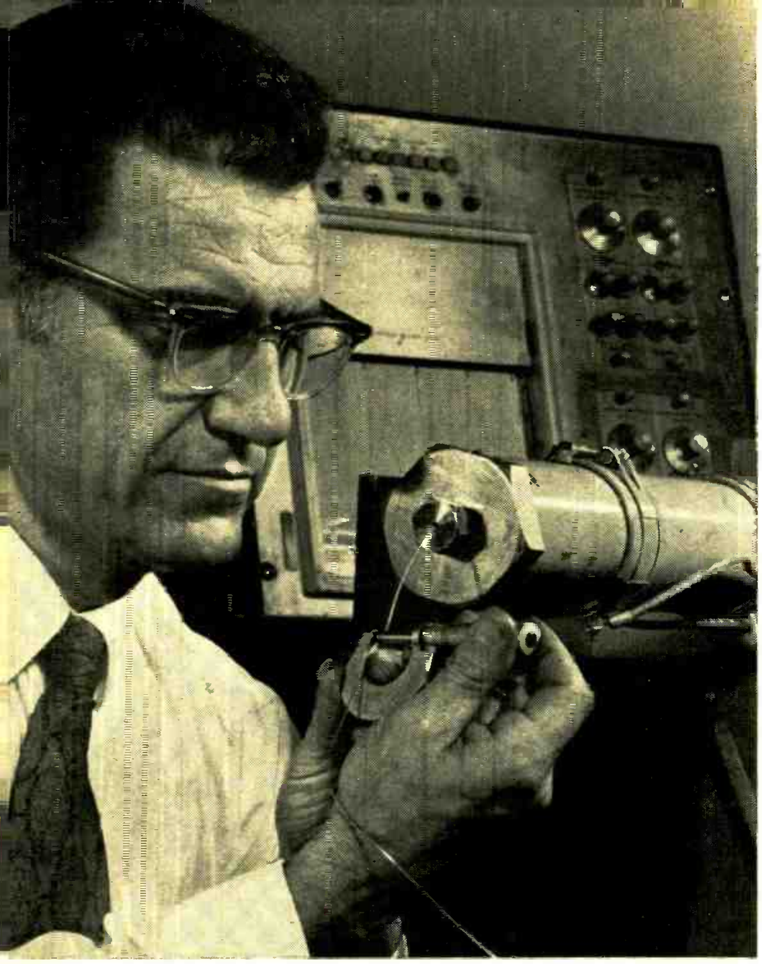
The unique properties of water (high dielectric constant and high losses) explain the powerful interaction between almost all foods and microwaves, and the reason why dry, but moderately lossy papers and glasses absorb little energy. When used as containers, they are heated only indirectly by the food itself.

Depth-of-Penetration Effect

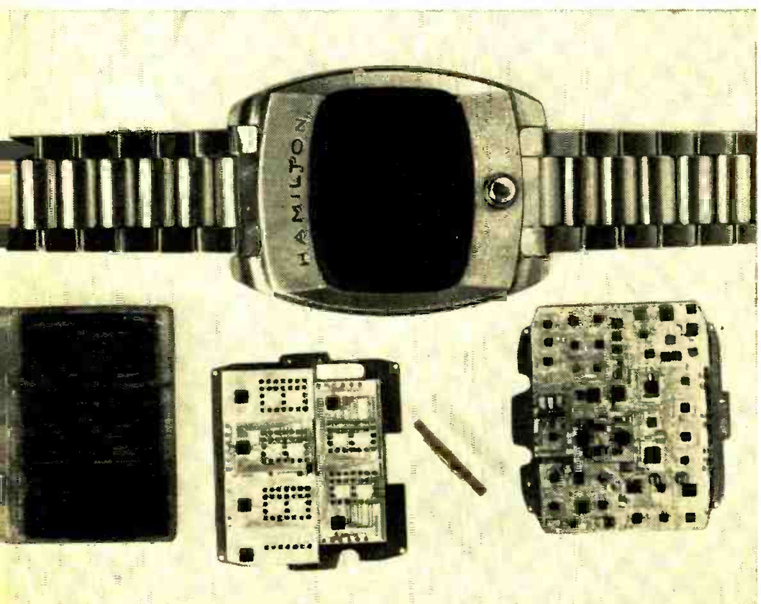
Another characteristic of the microwave-heating process is the depth-of-penetration effect. As energy is absorbed by the material, the intensity of the fields diminishes from the surface to the interior (Fig. 7). Depending on the type of substance, its size, and the frequency of the microwave energy, there can be a significant difference in temperature levels, hence in the rate of cooking, between the outside surface and the center.

The depth at which the power has dropped to half-value in cold water is approximately 4.0 cm at 1000 MHz and 0.5 cm at 3000 MHz. For cold (not frozen) beef the values are approximately 10.0 cm for 1000 MHz and 2 cm for 3000 MHz. A four-inch thick (10.2-cm) beef roast cooked at 2450 MHz will cook with four times the power at the surface than at the center. The effect is that the roast becomes more done on the outside than on the inside—it browns. Contrary to common impression, beef will brown in a microwave oven if it's thick enough. At 915 MHz the same roast will not brown as effectively, since the depth of penetration in beef is almost five times as great. Even at 2450 MHz, however, a two-inch (5-cm) steak can support very little difference in heating rate. Thin pieces of beef can be browned on the outside but only by browning the inside too. For cuts less than two (*Continued on page 75*)

Recent Developments in Electronics



Wire Made by Hydrostatic Extrusion. (Top left) Aluminum wire has been made experimentally by a new process in which it is squeezed out like toothpaste. Fluid under high pressure does the squeezing. The new process, known as "continuous hydrostatic extrusion," has a number of important advantages over conventional wire drawing. The latter process, which has been in use for nearly 4000 years, makes wire by pulling it through smaller and smaller dies. Advantages of the new method include lower equipment costs, cheaper maintenance, greatly reduced space and power requirements, less wire breakage, reduced labor, and greater wire strength. A prototype production machine is presently being designed and built by Western Electric for installation in Atlanta, Ga. Due for completion by the end of the year, this machine will produce aluminum wire at speeds up to 4000 feet per minute in sizes as small as 24 gauge. Only one pass through machine will be required regardless of wire size.

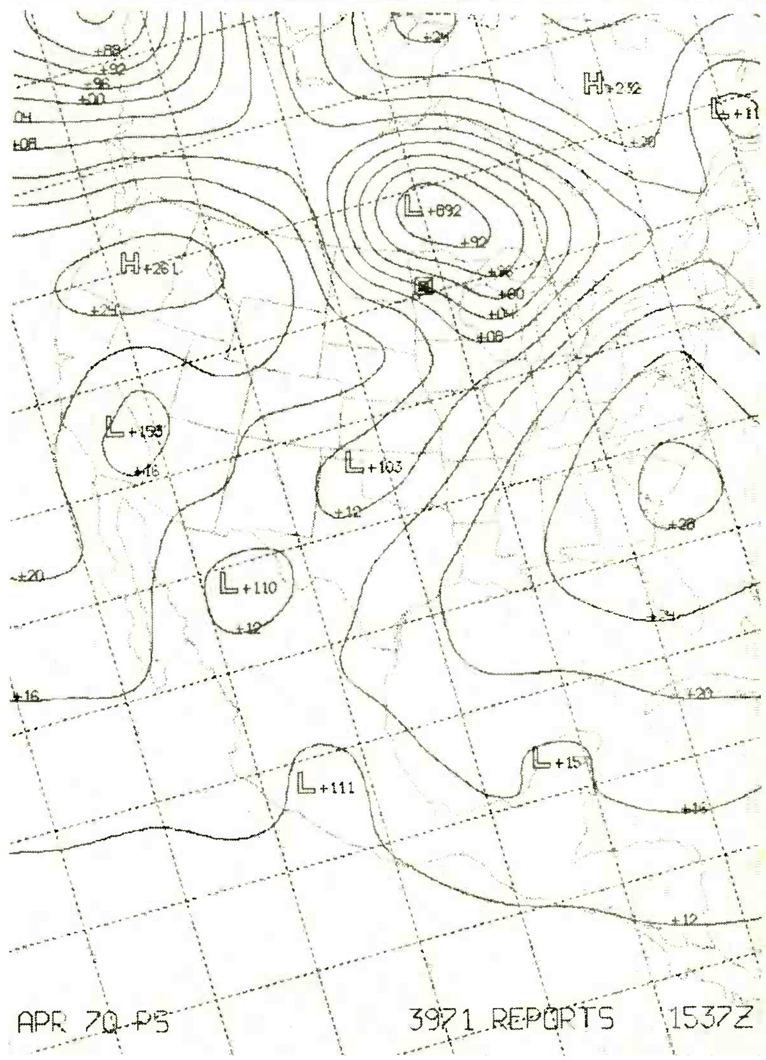


Electronic Digital Wristwatch. (Center) A solid-state wrist computer which is programmed to tell time, has no hands and no moving parts, indicates the time only when asked to do so, and is highly accurate and durable has been demonstrated recently to the press. Developed jointly by Hamilton Watch Co., who will distribute it, and Electro/Data Inc., who will produce it, the new timepiece uses computer-logic circuitry and light-emitting diodes for the display. The case is the size of a conventional man's wristwatch and it contains the components shown below in the photo. At the extreme left is a $4\frac{1}{2}$-volt rechargeable silver-zinc battery that runs the watch at up to 6 months before requiring recharge. Next is the display side of the computer module with its 44 complementary-symmetry MOS IC's and its 6 light-emitting diode matrices for displaying hours, minutes, and seconds. The tiny rod-like device is a quartz crystal that oscillates at 32,768 HZ and times the counters and dividers. At the right is the reverse side of the computer module. To conserve battery power, the time is displayed only when called for by simply pressing a push-button below the watch face. Before you rush out to buy one, however, note that only a thousand of the units are scheduled for production during next year and at a price tag on the order of $1500 each.

Hospital Emergency Radio Network. (Below left) A 12-hospital emergency radio communications network, dedicated recently, will provide faster and more efficient medical and hospital treatment for residents of 11 counties in southeastern Kentucky. The system, developed and installed by Motorola, provides a comprehensive two-way radio network for daily operation as well as total communications coordination during an emergency or disaster. The network enables individual hospitals to maintain radio contact with doctors, nurses, and other key personnel and with ambulances, rescue squads, State police, local police, and sheriffs. The system covers an area of some 4500 square miles; it was planned by the Southeastern Kentucky Regional Health Demonstration Corp., and was financed by the hospitals and a grant from the Appalachian Regional Commission. Cost of the entire system was just under $300,000. This includes remote-control console (shown in photo) and a base station for each hospital, mobile two-way radios for ambulances and other emergency vehicles, and portable two-way radios and pocket paging receivers for hospital people.

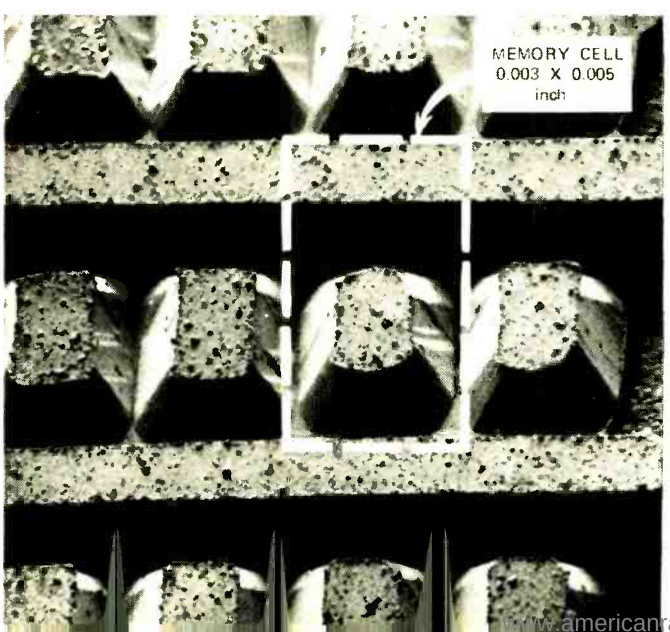
Microwave Mapping Radiometer. (Top right) Slung under the wing of this Navy aircraft is a new high-resolution, wide-angle microwave mapping radiometer operating in the K_a band (around 35 GHz). The solid-state miniaturized system is used for terrain mapping. Mapping information is displayed on a TV monitor in the aircraft. Signals are simultaneously recorded on magnetic tape for translation into photographs. The system automatically adjusts to altitude and speed. Excellent resolution is provided by an antenna beamwidth of 20 ft/1000 ft altitude. Development work was by Naval Weapons Center, Corona, Calif.

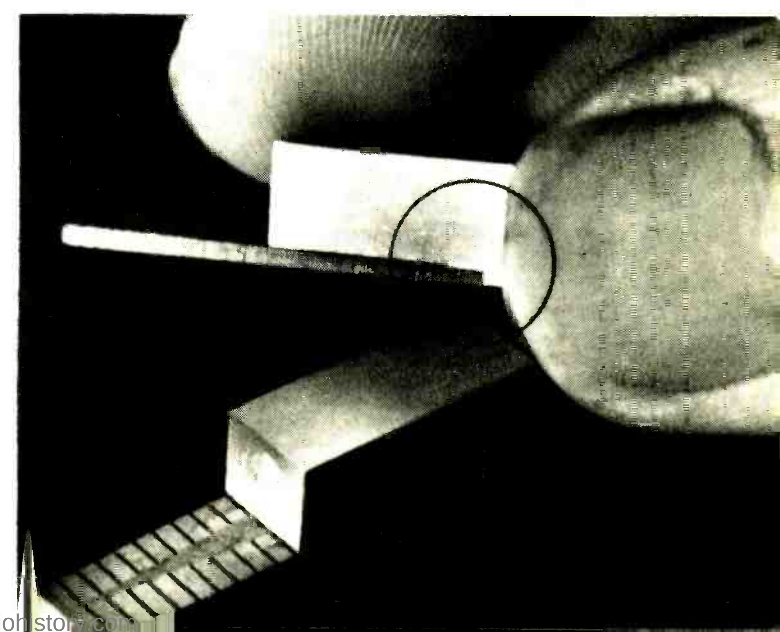
Computer-Drawn Weather Map. (Center) This weather map of North America was produced by a new electrostatic printer/plotter which transforms digital information directly into graphics at 800,000 plot points per second—faster than most computer outputs. The plotter, made by Varian Associates, has 1400 styli across a 14-in wide chart grid and does almost instantaneously what previously used drum-type preprinted paper printers took as long as 15 minutes to do. The unit is now being used by the Navy to produce detailed meteorological and oceanographic maps of the entire northern hemisphere or magnified sections of it. The plotter prints its own ocean shorelines, geographic boundaries, grid lines, and alphanumeric annotations.



Charge-Transfer Computer Memory. (Below left) A new type of semiconductor memory that promises access speeds measured in billionths, rather than millionths, of a second is being experimented with at Bell Labs. Each memory cell, outlined in the scanning electron microscope photomicrograph shown, consists of a metal semiconductor (Schottky) diode with a large guard ring connected in series with a diffused "p-n" junction diode. Cells, which can be individually accessed in a memory array, are arranged in an X, Y structure using a metal beam lead for the X direction and a silicon bar for the Y direction. Experimental arrays based on the principle have been made by using photolithography, silicon etching, and air-isolation.

Miniature Laser Array for Computer Memory. (Below right) Circled in the photo is a miniature array of 20 gallium arsenide junction lasers—each measuring 8-mils long and 0.5-mil wide. Such laser arrays have potential in magnetic-optical computer mass storage. High-power laser pulses can write information by altering the magnetic properties of a spot of thin magnetic film by means of localized heating. Continuous operation at lower power is then used to read out the information by providing light output whose changes on polarization correspond to stored bits of information. The arrays, being worked on at IBM Research are operated at − 196° since recording medium, thin film of europium oxide, needs such temperatures to respond.





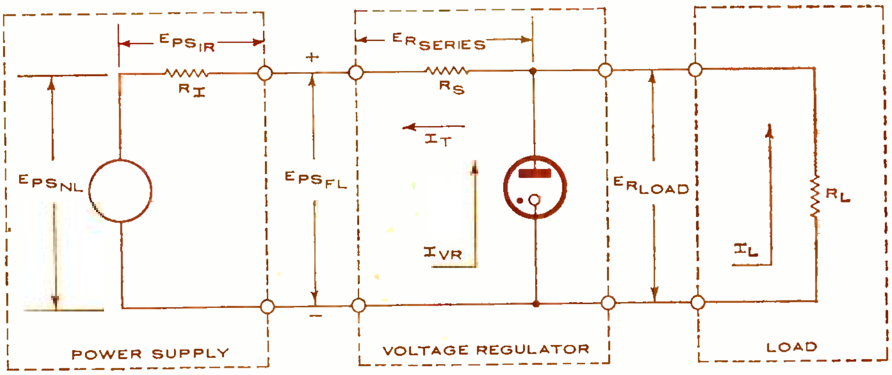
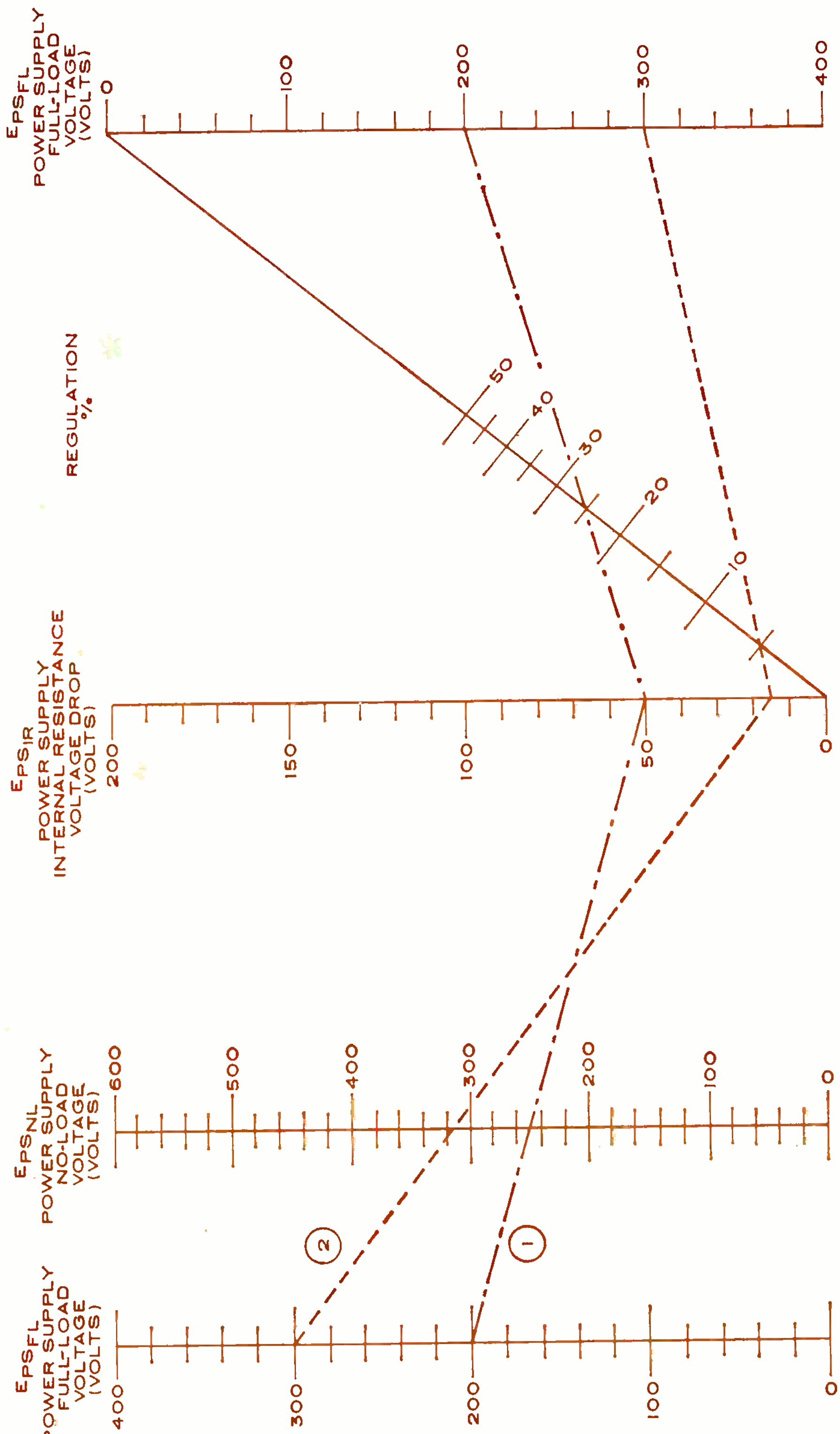


Fig. 1. Simple VR-tube circuit showing various parameters graphed in nomograms.

Voltage Regulator Design Nomograms

By CHESTER W. YOUNG

This pair of nomograms simplifies regulator design when standard voltage-regulator tubes are employed.



THE design of voltage regulators for electronic equipment is fairly straightforward but since several items must be considered each time, the accompanying two nomograms can help out in the preliminary design trade-off calculations.

Regulation of VR-Tube Supply

Fig. 1 shows a simple VR-tube voltage-regulator circuit. The first nomogram, Fig. 2, covers the characteristics of the power supply that provides the source of power for the regulator. The regulation of the power source can be expressed by the equation:

$$\%\ \text{regulation} = \frac{E_{PS_{NL}} - E_{PS_{FL}}}{E_{PS_{FL}}} \times 100$$

where $E_{PS_{NL}}$ is the output voltage of power supply with no load, and $E_{PS_{FL}}$ is the output voltage of power supply with full load.

$$\text{Also, } E_{PS_{NL}} - E_{PS_{FL}} = E_{PS_{IR}}$$

where $E_{PS_{IR}}$ is the voltage drop across the internal resistance of the power supply.

◀ Fig. 2. Design nomogram showing percent regulation for various supply voltages.

The first three scales on the left of the first nomogram solve this second equation.

The third scale is linked together with the two scales on the right in a "Z"-nomogram to solve the first equation, with the percent regulation given on the diagonal scale of the "Z."

Example Using First Nomogram

1. If we have a power supply that has an output voltage of 250 volts with no load which drops to 200 volts when the load is connected, we have a 50-volt drop across the internal resistance. The 200-volt point on the left scale is joined by a straight line (1) to the 250-volt point on the second scale from the left. This line is extended to the 50-volt point on the next scale to the right. This point is joined to the 200-volt point on the scale on the extreme right by a straight line and the intersection of the % regulation scale is at 25%.

2. A second example of a better regulated supply (2) is one that has a 315-volt no-load voltage and a 300-volt full-load voltage. This gives us a 15-volt drop. When this 15-volt drop is divided by the 300-volt full-load voltage, we have a 5% regulated supply, as indicated on the nomogram.

(The usefulness of the nomogram can be extended to low-voltage power supplies simply by dropping the final zero from all the voltage scales.—Editor)

VR-Tube Series Limiting Resistor

The second nomogram (Fig. 3) aids in the determination of the resistance and wattage of the VR-tube series resistor. The nomogram has within it a 3-scale vertical alignment chart and two 3-scale "Z"-nomograms. The first three scales on the left solve the equation

$$E_{R_{SERIES}} = E_{PS_{FL}} - E_{R_{LOAD}}$$

where $E_{R_{SERIES}}$ is the voltage across the series dropping resistor, $E_{PS_{FL}}$ is the voltage output of the power supply under full load, and $E_{R_{LOAD}}$ is the voltage to be maintained across the load resistor by VR tube.

The six standard VR tubes—0A2, 0A3, 0B2, 0B3, 0C3, and 0D3—are marked on the left scale at their regulated voltage points.

The first "Z"-chart solves the equation

$$R_{SERIES} = \frac{E_{R_{SERIES}}}{I}$$

where R_{SERIES} is the required resistance of the series dropping resistor, $E_{R_{SERIES}}$ is the voltage across the series dropping resistor, and I is the total current to be drawn under regulating conditions.

The second "Z"-chart solves the equation

$$P_{R_{SERIES}} = I^2 R_{SERIES}$$

where $P_{R_{SERIES}}$ is the power dissipation of series dropping resistor, I is the total current through resistor, and R_{SERIES} is the resistance of resistor.

Second Example

Let us continue with the second example of the first nomogram. If we are designing a regulator to use an 0A2, we pick the 150-volt point on the left-hand scale of Fig. 3 and join it by a straight line to the 300-volt point on the adjacent Full-Load Voltage scale and continue to the third scale to find 150-volt drop across the series limiting or dropping resistor that is required in the circuit.

Since we are using a 30-mA VR tube, we continue on with a second straight line from the 150-volt point through the 30-mA point on the adjacent diagonal scale to the 5000-ohm point on the R_{SERIES} scale. Drawing a third straight line from this point through the second diagonal scale at the 30-mA (0A2) point to the $P_{R_{SERIES}}$ scale, we find a 4.5-watt dissipation. Hence, either a 5- or 10-watt resistor should be selected depending on the safety factor desired for the particular application. ▲

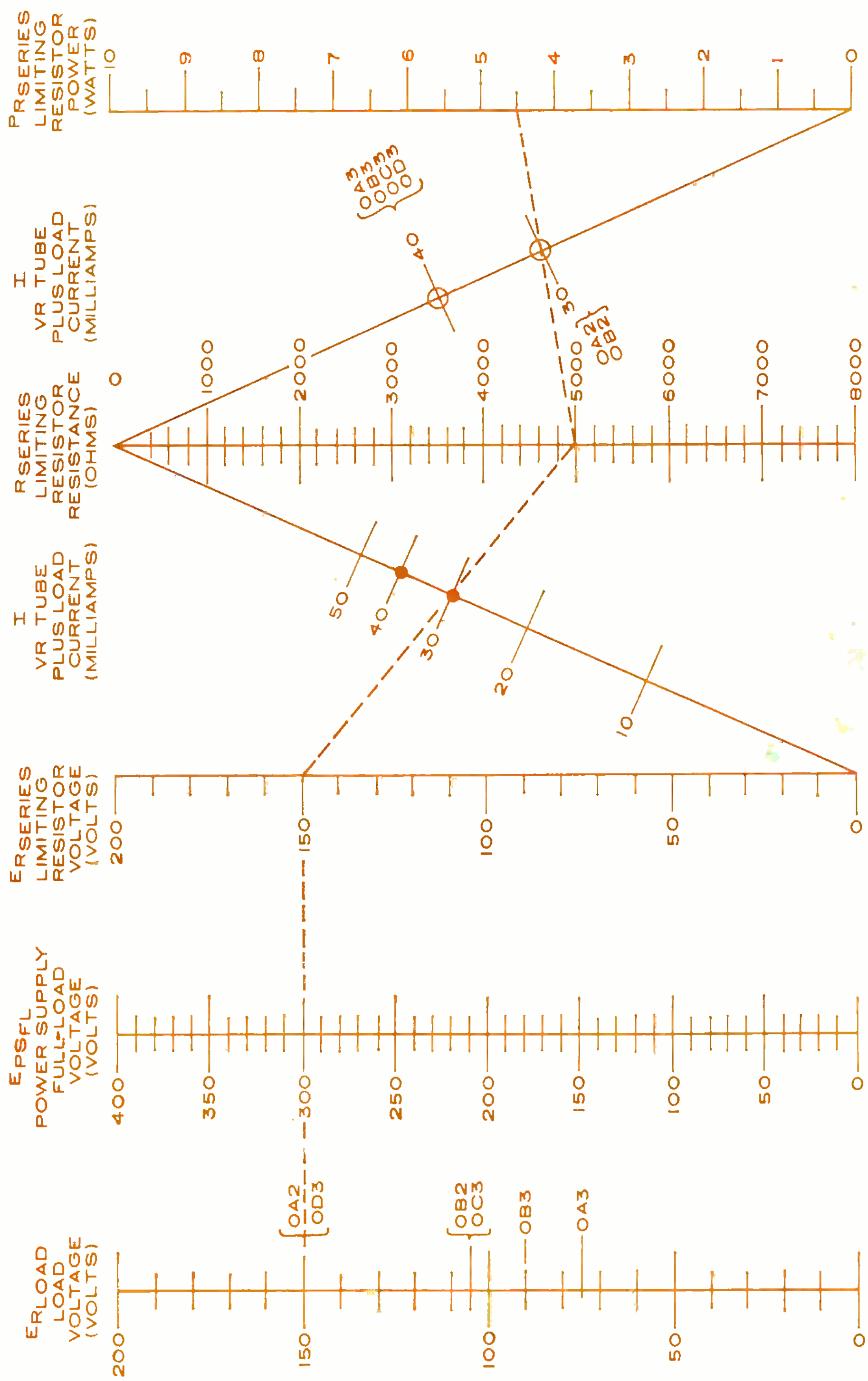


Fig. 3. Design nomogram showing resistance and power for series limiting resistor.

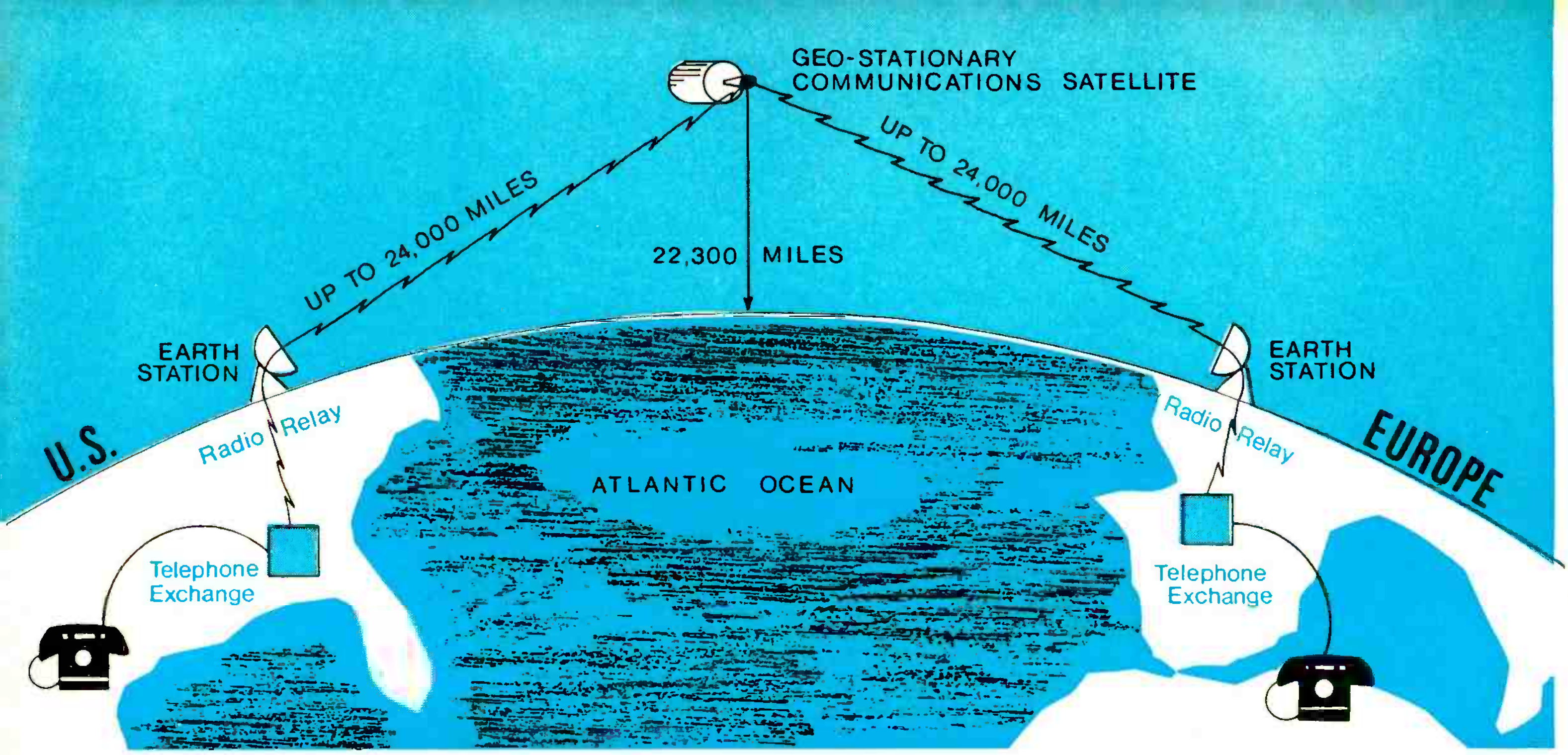


Fig. 1. An overseas telephone call may have to travel as much as 50,000 miles just to cross some 3500 miles of ocean.

TRANSMISSION DELAYS and ECHOES in SATELLITE COMMUNICATIONS

By RICHARD G. GOULD / Chief, Advanced Technology Division
International Telecommunications Directorate, Office of Telecommunications Management

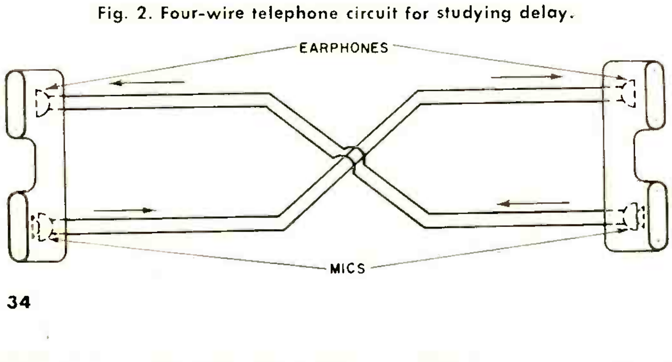
Transmission delays caused by long path lengths have not produced the problems predicted because of effective echo suppression. Here's how this technique is being used to provide good service on overseas phone calls via satellites.

"Shall we have the Thompsons over for dinner?"
(after a delay) "Sure, dear."
"If you feel that way about it, I won't invite them!"

WHAT kind of telephone conversation was that? Was it noise, distortion, or low volume that made the wife misunderstand what her husband meant? It was none of those things; it was *transmission delay*. Before communications satellites like Early Bird were launched and put into commercial service, telephone-company engineers and scientists were telling that story about the Thompsons and warning that people wouldn't like satellite circuits.

Now, with almost five years of experience with those satellites under our belt, we know that people have accepted satellite circuits. Hundreds of overseas callers use them every day. But that transmission delay is still there and most experts agree that a circuit with delay is not quite as good as one without any. Where does the delay come from? Just how bad is it? And why does the delay produce an echo that causes more problems than the delay itself?

Fig. 2. Four-wire telephone circuit for studying delay.



Transmission Delay

Radio waves travel with the speed of light. How can there be a noticeable delay?

The communications satellites now used by Intelsat, the international organization of 70 countries, are geo-stationary; that is, they take exactly 24 hours to orbit the earth. Therefore, the communications satellites that relay the radio signals appear to stand still over the same spot on the earth all the time. Hence, the large antennas at the earth stations don't have to follow a satellite that sweeps across the sky: once the antenna is pointed at the satellite, it will "see" that satellite all day long—and all year long.

The problem is that the satellites have to be 22,300 statute miles from the earth to give them a 24-hour orbital period (Fig. 1). At the speed of light, 186,000 miles per second, it takes a radio wave 0.12 second to reach the satellite. It takes the same time for the signal to come back down to the distant earth station in some other country. This makes a total of 0.24 second for a one-way trip.

If you were talking to someone over a satellite circuit and asked him a question, it would take that long before he heard you. If he answered right away, it would take twice that long, or 0.48 second before you heard his answer. Actually, people don't answer immediately in a typical conversation, nor does one start saying something immediately after the other person finishes. There is usually some reaction time for thinking.

But whatever reaction time is normal in a conversation, the delay is added to it every time one speaker stops and the other starts.

Sometimes, of course, both people will be speaking at once: either to interrupt, or to say things like, "sure" or "that's right." This double-talking will cause serious problems on circuits with delay and echo suppressors, but those will be discussed later.

How annoying or confusing is an added delay of about ½ second? Many tests have been run; the consensus is that most people don't detect that amount of delay during normal conversation, and of those who can, only a small percentage are bothered by it. However, those tests were made with "pure" delay.

If a telephone circuit were set up so there were one pair of wires from the microphone in one instrument to the earpiece in the other, and another pair of wires for the other direction of speech (Fig. 2), pure delay would be there if the wires were very long. Another way that delay gets in is if the wires are "loaded" by means of inductors inserted along their length. Loading is done to equalize the loss at all frequencies. However, the inductors also slow down the signals so they travel slower than the speed of light. On some cables, for example, the speed of transmission is only 7% that of light. If two pairs of wires are used, the circuit is called "four-wire."

Almost all telephones in the world are two-wire, though; that is, both halves of the conversation go over the same two wires. Most telephone calls, calls from one part of town to another, and calls up to 1500 miles, are on two-wire circuits. The reason is economy; four wires cost almost twice as much as two, and switching in the telephone exchange is more expensive when you have to switch four wires. However, four wires are often needed when the call is long-distance. Not only do amplifiers have to be put into the circuit to boost the volume, but the directions of transmission have to be split if the circuit goes over the microwave radio-relay systems that the telephone company uses. This split in the direction of conversation is accomplished with a hybrid coil.

A hybrid is made up of two transformers connected in a bridge circuit with a balancing network (Fig. 3). If the bridge is perfectly balanced and the network has exactly the same impedance as on the 2-wire side, speech coming in from the two-wire side is sent to the transmit branch where it travels to the distant end—being amplified along the way when necessary. The speech coming in on the receive branch is sent to the two-wire side. When it is not balanced, most of the incoming speech goes to the two-wire side as intended, but some sneaks across the hybrid and enters the transmit branch. The transmit branch thinks that it is speech from the two-wire side and sends it to the far end. But that speech just came from the far end. It is echo as far as the distant talker is concerned.

How Bad is Echo?

Echo is with us all the time. Our speech is constantly bouncing off the walls around us and being returned to our ears. When the returned speech is loud and delayed, it becomes annoying. Concert halls have to fight echo if the music is to be heard clearly without the destructive cancellations that echo can cause.

We constantly use our own speech as a control signal for the feedback mechanism in the brain that regulates the speed and volume of every word we say. Our own speech reaches the ear both through the air and through the bones of the head. For those with normal hearing, the 6-in air path provides most of the control. If anything happens to disturb that path, the speech will be affected. With ear plugs, for example, most people will talk louder.

If delay is added to the path between the mouth and the ear, the whole speaking process breaks down. A simple way of doing this is to use a tape recorder with widely separated record and playback heads. The speaker listens to a delayed recording of his own voice using earphones. The brain waits to hear what was just said before signaling the vocal cords to make the next sound. After hearing that one, it waits again until that sound is heard. The process snowballs and most people are literally speechless within three or four words.

This effect is used to tell if someone is lying about being deaf or hard of hearing in one or both ears for an insurance

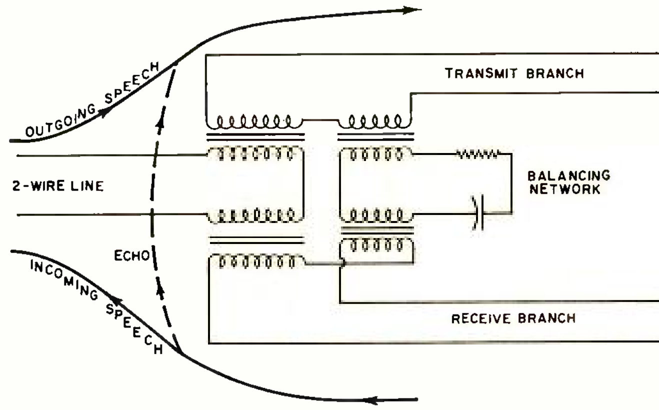


Fig. 3. Hybrid coils are used to split off into separate transmit and receive branches signals on a 2-wire line.

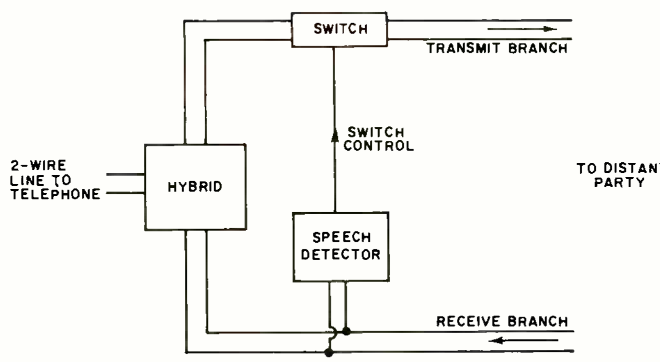


Fig. 4. The simplest form of echo suppressor shown here gives distant speaker control over near transmit branch.

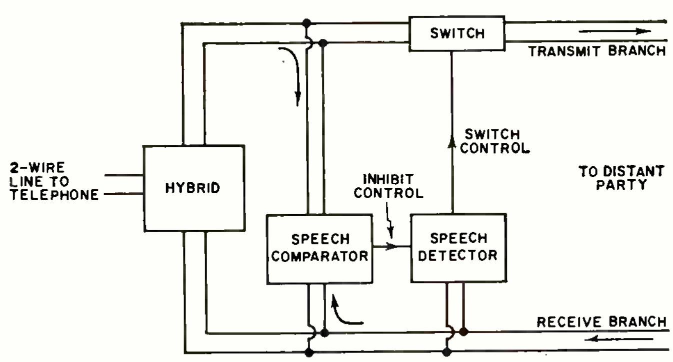


Fig. 5. This suppressor gives near speaker some control.

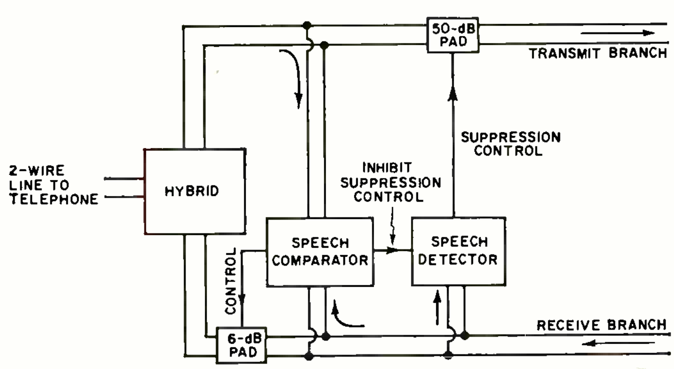


Fig. 6. A current echo suppressor permits double-talking.

claim. His own delayed speech is fed back to the supposedly bad ear. If his speech is affected, then the ear is okay.

Organists have learned to live with delayed echoes. Typically, the pipes of a church organ are far from the keyboard. Not only that, but some pipes are farther away than others. That means that there will be a delay between the time the organist presses a key and the time he hears the note. He must learn to ignore the differing delays and play at the tempo he wants in spite of what he hears. Of course, he can't block out all awareness of his own music: he needs some feedback to make its quality, timbre, and expression exactly what he wants. Others, though, need some kind of echo suppression if they are to be able to use—and enjoy—long-distance telephone circuits.

Echo Suppression

There are three approaches to echo suppression. One is to prevent the echoes from being generated in the first place. The way to do that is make the impedance of all two-wire circuits that could ever be connected to a hybrid, the same as the balancing network. That's a hopeless job: there are over 100 million such lines in the United States. Some of them are short, some long, some on one kind of cable, and some on another. The impedance of the circuit to a store across the street from the telephone exchange is very different from the circuit that goes ten miles out into the country. Engineers joke about the worst possible case: a circuit to a farm house that uses the barbed-wire fence—and the farmer left a gate open!

To take care of this wide variation in impedance, a "compromise" network is used: a 900-ohm resistor in series with a 2-μF capacitor. This results in an average echo loss of about 15 dB throughout the country. Not only is 15 dB not good enough, but, just like all averages, there are circuits with lower losses, and circuits with higher losses. To provide high-quality circuits, about 50-dB echo loss is required. That means only one hundred thousandths of the speech power can be returned as echo.

A second way, the one used now, is to suppress echoes after they're created. A third method that has been proposed in recent years, is to cancel the echoes. First, let's see how a suppressor works.

The simplest kind of suppressor is one that looks for speech on the receive branch and opens the transmit branch whenever it detects an incoming signal (Fig. 4). That's fine for suppressing echoes, but it wouldn't permit double-talking or break-in. The distant speaker would have absolute control over the near transmit branch. Thus, the near party could never break in until the distant speaker had finished.

The next refinement would be to permit the near speaker to have some control over his own transmit branch (Fig. 5). In this kind of suppressor, a comparator would measure signals on the receive and the transmit branch. If there were signal only on the receive branch, the switch would open the transmit line. If there were signal only on the transmit, or on both branches, the circuit would keep the transmit branch open.

The problem here is that both the desired speech and the echo would get through at times of double-talking. Talking on a circuit like this is very confusing at times of interruption, which is a difficult part of conversation in the first place.

The suppressors now used permit double-talking and suppress much of the echo (Fig. 6). In these units, a 50-dB loss pad can be inserted in the transmit branch, and a 6-dB pad can be inserted in the receive branch. When there is incoming signal only on the receive branch, the 50-dB pad is inserted in the transmit branch. This suppresses the echo by the required amount. When there is speech only on the transmit branch, no pads are put in. Thus, the outgoing speech reaches the distant end with no added loss. When there is speech on both the transmit and receive branches, only the 6-dB pad is inserted. With this connection, the desired incoming speech is unfortunately knocked down by 6 dB but the interrupting speech going out on the transmit branch is not cut at all. Any echo is also cut by the 6-dB pad, plus whatever loss there is in the hybrid. Suppressors such as these are a compromise between perfect echo suppression and perfect double-talking capability.

Experience has generally been good with suppressors of this type. They are in daily use on all satellite circuits. But, in several controlled tests, many people did comment on their calls in such a way that engineers could tell they were talking about break-in difficulties with these

(*Continued on page* 65)

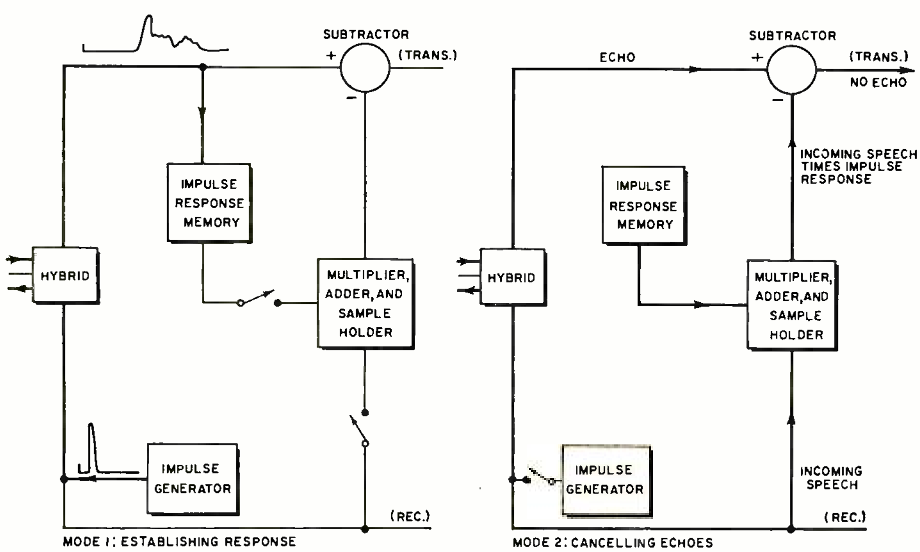
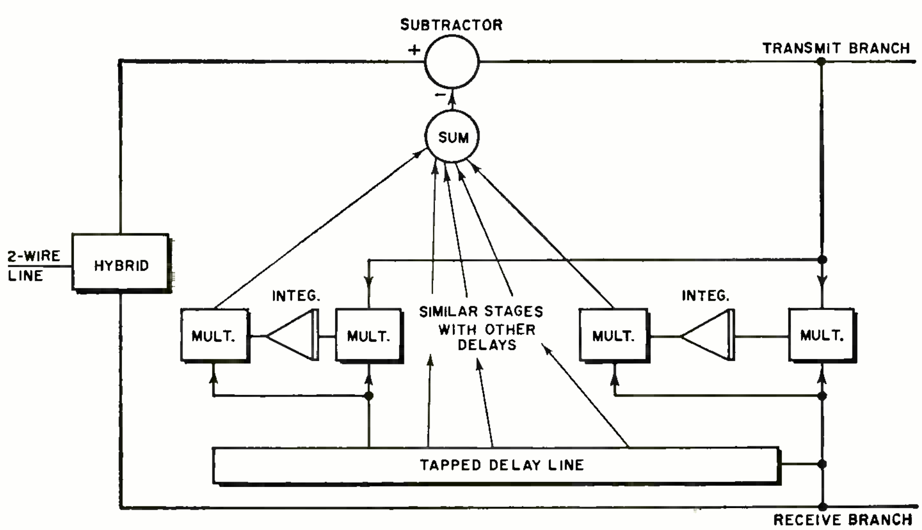


Fig. 7. Echo canceller of the impulse-response type is illustrated. For clarity, each line represents a pair of wires.

Fig. 8. This echo canceller is of the transversal-filter type. Again, for the sake of clarity, each line is a pair of wires.



NEW TEST SIGNAL for Color TV

By WALTER H. BUCHSBAUM / Contributing Editor

Field testing is underway on new vertical interval reference signal which permits stations to check their transmitted color on field-by-field basis.

DESPITE the various automatic color and tint control circuits used in the latest TV models, colors still seem to vary. Even if the receiver is adjusted perfectly during a color movie, the commercial may often have improper hue. Local-station programs invariably have different colors than network presentations and it seems that, no matter how the color controls are set, the critical viewer has to reset them frequently.

Aware of this situation, the Broadcast Television Systems Committee of the Electronic Industries Association (EIA) has plans which can, ultimately, bring us truly uniform color signals. The committee has arranged to field test the use of new vertical interval reference (VIR) signals, which permit color signal monitoring on a field-by-field basis. Local stations could then make necessary corrections to assure that, at least at the transmitter, the color signals are uniform. As of this writing, local on-the-air-tests are scheduled to take place in June in the metropolitan New York area and network tests should be completed in July. The results of these tests will determine the future recommendations of the committee. In addition to the VIR feature, the committee may also recommend changes in existing specifications for some of the critical parameters of the color signal, all aimed at giving better color reception.

The VIR Signals

VIR signals, as their name implies, occur during the vertical interval, just before the visible picture starts. (See "Television's Built-In Test Signals" by Ivan Mertes in the March 1970 issue.)

As anyone can verify by juggling the brightness and vertical hold controls, the top and bottom lines of the picture are normally blanked out. The proposed VIR signals will occur during line 20 and will appear on an oscilloscope as shown in Fig. 1.

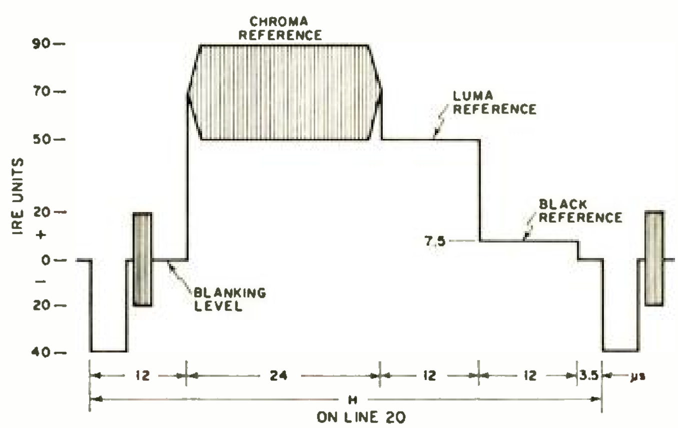
While a number of variations of this arrangement will be tried, the basic scheme provides for three essential elements; the *chroma reference*, the *luma reference*, and the *black reference*. The chroma reference is the same color reference signal as is transmitted as the color sync burst, but occurring for half of the picture line period. The level labeled "luma reference" serves as indication of brightness or luminance level, in terms of the final color picture, and occupies one quarter of the line period. The final quarter is occupied by the black-reference level which, as is apparent from Fig. 1, is slightly higher than the blanking or "blacker-than-black" level on which the color sync burst is superimposed.

All of these signals and levels are part of the existing FCC color-TV standards, but their availability during line 20 of every frame allows TV station engineers to monitor the color subcarrier signals as well as the luminance and black levels. It is relatively simple to get the picture of line 20 on an oscilloscope and then the levels can be clearly observed. In the case of network-oriented programs, the local station can correct for level and phase changes which occurred along the way.

While the VIR signals are intended primarily for use at TV stations or network monitoring points, receiver circuits can be developed to utilize the VIR signals too. A simple counter, starting at the vertical-retrace period, can select the 20th line and its level can then be used to set automatic color control circuits. This means that the receiver can be effectively adjusted automatically on a frame-by-frame basis. Then, even if there is a difference between transmissions originating from color film, studio, or outdoor events, the receiver will automatically compensate for them. Hopefully, however, the VIR signals will permit station engineers to produce uniform transmissions at all times, allowing receiver circuits to become somewhat simpler, rather than much more complex.

In any event, extensive tests, lengthy discussions, reviews, and re-reviews will be required before the VIR signal can become part of the color-TV standards. Even after the FCC accepts and authorizes VIR signals, it will take a few months to build the circuits generating these signals. In the meantime, the critical viewer will just have to adjust the color controls as different programs are switched in. ▲

Fig. 1. Composition of new test signal appearing on line 20.



PUTTING REED SWITCHES to WORK

By DON BLACKLOCK

These magnetically operated devices have been widely used as proximity switches. Here are some additional applications in the field of logic.

This new reed switch, from Cutler-Hammer, when operated at 250 V a.c., is able to make or close a circuit with an inductive inrush current of 10 amperes (2500 VA) and break or open a circuit at a current of 2 amperes or 500 volt-amperes.

IN a relatively short time, reed switches have assumed an increasingly important role in electronic and electromechanical equipment. Reed switches are appearing with increasing regularity in such diverse applications as telephone switching, data processing, home appliances, and logic circuits for industrial controls.

The reed switch is a device which can be operated in environments of explosive or corrosive gases or liquids, with no danger from arcing or deterioration of contacts from corrosion. The switching device may be activated in a variety of ways, mechanical as well as electrical.

Because the reed switch lacks the "space-age" glamour of integrated circuits, little data concerning this device has been available outside of specialized design publications and manufacturers' spec sheets. To be able to apply this device, a good understanding of the basic principles is essential; so let us take one apart, see what makes it operate, and what it can accomplish.

Construction and Operating Principle

As we look at Fig. 1A we see that the reed switch is a very simple device. The heart of the switch is the two thin metal leaves or reeds. These reeds are cantilever-supported so their free ends have a small overlap and are separated by a small gap.

The reeds are enclosed in a glass capsule which supports and holds the reeds in alignment, while protecting them from contamination. With the reeds enclosed, the next logical step is to fill the capsule with a dry inert gas. This provides further protection against contamination.

Although the reed capsule appears simple, it is a precision unit with very close dimensional and alignment tolerances maintained during manufacture. The reeds are of a magnetic metal with diffused gold or rhodium, thereby reducing contact resistance. Switches are available in a number of sizes ranging from a ¾-inch × 0.1-inch diameter capsule to a 2-inch × 0.2-inch diameter capsule.

Next, how does it operate sealed in a glass capsule? This is done with magnetic force. Should we place a source of magnetic force, such as a permanent magnet, close to the reed capsule we have the condition shown in Fig. 1B.

The metal of the reeds provides a flux path, concentrating lines of force along the reeds' length. The reeds assume the magnetic polarity as shown, causing attraction between the reed ends. When the flux density is raised high enough, the attraction overcomes the rigidity of the reeds, and they come together, making electrical contact. With reeds in contact, the gap is zero, and a lower flux density can maintain the contact. This produces a pull-in drop-out differential, which will be used later in biasing applications.

Electrical Ratings

Contact ratings vary widely among manufacturers and no attempt will be made to list all such ratings. Table 1 lists typical ratings for reed switches; exact ratings should be obtained from the manufacturer of the device. Generally, ratings will be determined by the size and plating of the reeds for the reed is an electrical conductor and current capacity is a function of contact area.

A word of caution is called for regarding current capacity. The ratings listed are for resistive loads. When switching reactive loads the switch must be drastically derated, or preferably the load properly suppressed. When required to switch unsuppressed reactive loads, reed switches will be rapidly and irreversibly destroyed by welding the contacts.

The load switched has a definite affect on operational life of the switch. Table 1 shows an increase of 100 times in operations between rated load and dry-circuit (zero-current) conditions.

The initial contact resistance of a reed switch is very low, somewhere in the neighborhood of 100 milliohms or less, the exact value depending upon reed plating material and contact area. The resistance will also vary slightly with the magnetic drive used to operate the switch. This is due to contact pressure; higher drive results in higher contact force and lower resistance.

The maximum contact resistance which can be tolerated in a particular application will impose a limit upon the mechanical life of the switch for the resistance rises towards the end of useful life. The resistance will, typically, approach 2 ohms.

Mechanical Characteristics

Several factors determine the operational life of the switch. Life is seldom limited by mechanical failure of the reeds but more often by excessive contact resistance, or contact sticking due to pitting or welding.

For mechanical switching, reed switches can be classed as medium-speed devices. Typical values are under 3 milliseconds for make (operate) and 1 or less millisecond for break (release).

The cyclic speed of reed switches is related directly to the size or mass of the reeds. The small or miniature switches have a higher limit due to smaller reeds. Typical limits would be 2000 cycles per second for the miniature switches with 400-500 cycles for the larger size standard devices. This is a high cyclic rate for a mechanical switch but the limit should be kept in mind when using a reed switch as an r/min transducer.

Like most mechanical switches, reed devices are subject to contact bounce. This must be considered in applications where the device inputs signals to high-speed transistor logic circuits, for the bounce may be seen as multiple closures. In this type of application some form of suppression must be used. This can be a simple *RC* network, but preferably, a Schmitt trigger or a one-shot multivibrator (MV) should be used as a signal conditioner, to deliver a clean signal. Where the switch closure is to trigger an MV, the triggering action should take place upon the break or trailing edge. The make or leading edge of the switch closure should be used to arm the MV circuit.

When using a reed switch as an r/min transducer for driving an electronic counter, care must be taken that the bounce does not add extraneous input pulses, giving a false counter reading. Most good-quality counters have built-in input signal conditioning circuits, and careful adjustment of the trigger threshold sensitivity control will eliminate any triggering problem.

Careful study of the characteristics listed in Table 1 will provide an understanding of the electrical and mechanical capabilities and limitations of reed devices. By following the manufacturer's ratings and specifications, the reed switch will prove to be a highly reliable device.

In order to custom-design a reed relay or proximity switch, some measurement of the basic device's sensitivity is needed. How much magnetomotive force is required to operate the switch? For electrical operation using a solenoid rather than a permanent magnet this is most conveniently expressed as ampere-turns.

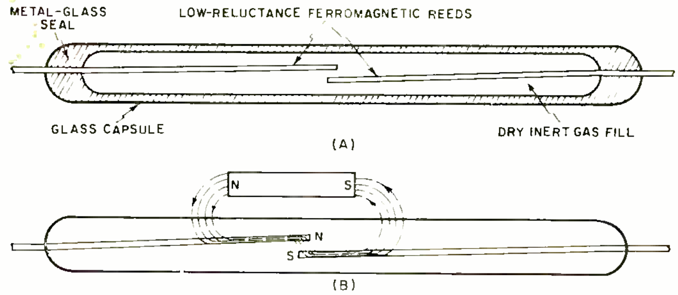


Fig. 1. (A) Basic construction of the simple reed switch. (B) Flux pathway from external magnet through the reeds.

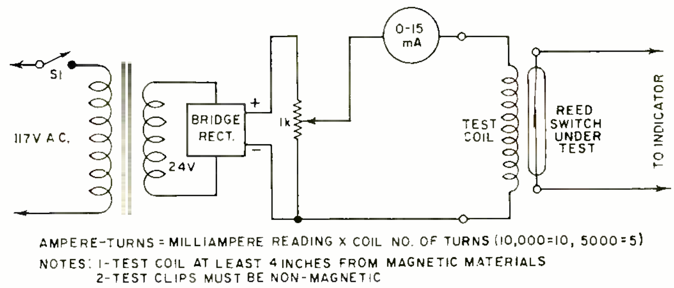


Fig. 2. Test circuit for pull-in and drop-out sensitivity.

Table 1. A number of specifications for typical standard and miniature reed switches using rhodium-plated contacts.

SPECIFICATIONS	STANDARD	MINIATURE
Maximum Voltage	150 V d.c. 250 V a.c.	50 V d.c. 150 V a.c.
Maximum Current (Switch) (Carry)	1.5 A 6 A	0.375 A 2.5 A
Maximum Power	25 W 40 VA	6 W 10 VA
Max. Initial Resistance	50 mΩ	100 mΩ
Max. End-of-Life Res.	2 Ω	2 Ω
Peak Breakdown Volt.	500 V	300 V
Operate Speed	2.5 ms (inc. bounce)	1 ms (inc. bounce)
Release Speed	1.0 ms (inc. bounce)	0.1 ms (inc. bounce)
Closure Rate (Max.)	400 cycles/s	2000 cycles/s
Insulation Resistance	5000 MΩ	1000 MΩ
Temperature Range	−55°C to +150°C	−55°C to +150°C
Contact Capacitance	1.5 pF	0.5 pF
Vibration	10 G at 10-55 cycles/s	10 G at 10-55 cycles/s
Shock	15 G min.	15 G min.
Life with Rated Load	5×10^6 operations	5×10^6 operations
Life with Dry Circuit	500×10^6 operations	500×10^6 operations

Many of the low-cost reed switches listed in parts catalogues are intended primarily for use as proximity switches. As a result, the manufacturer supplies little electric drive data, usually only *x* number of turns of *y* gauge wire and some value of operating voltage. For some applications this may be sufficient, but for custom-design of a relay, more exact data is needed. Fig. 2 shows a test circuit that provides the measurements from which an ampere-turn rating can be determined for a reed switch. From this rating a variety of coils can be selected to meet required operating voltages or currents for sensitive relays.

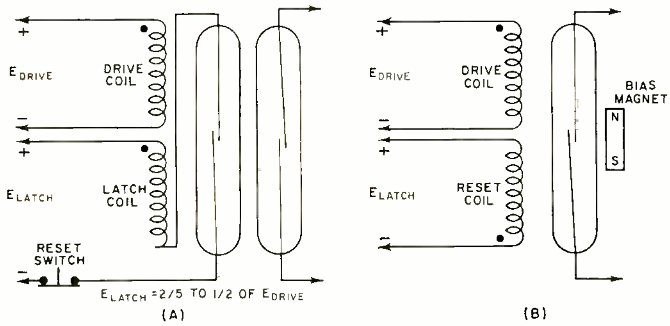
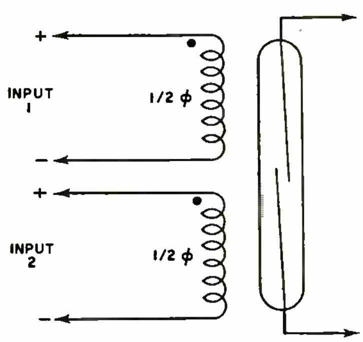
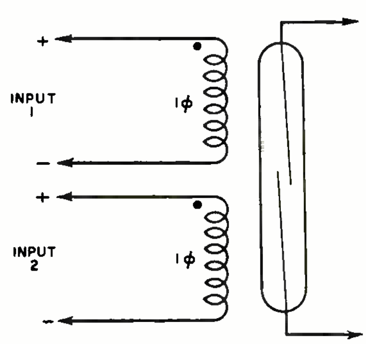


Fig. 3. (A) Electrical and (B) magnetic latch. The dots indicate similar magnetic polarity; a reversal of such polarity is obtained by either reversing the electrical polarity of the applied voltage or reversing the winding direction of the coil. In (A) the circuit is latched or held closed by application of smaller, magnetically in-phase latching signal; circuit is reset by opening reset switch. In (B) circuit is latched by aiding PM; reset is by magnetically bucking reset-coil field.



RELAY TRUTH TABLE		
INPUT 1	INPUT 2	OUTPUT
OFF	OFF	NO
ON	OFF	NO
OFF	ON	NO
ON	ON	YES

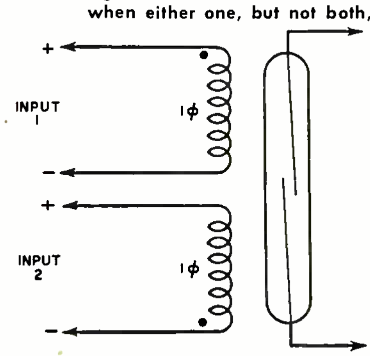
Fig. 4. The reed relay as an "and" circuit or gate. An output is produced only when both inputs are applied.



RELAY TRUTH TABLE		
INPUT 1	INPUT 2	OUTPUT
OFF	OFF	NO
ON	OFF	YES
OFF	ON	YES
ON	ON	YES

Fig. 5. The reed as an "or" circuit. Note an output is produced when either one or both inputs are applied

Fig. 6. The exclusive-"or" circuit produces an output only when either one, but not both, of the inputs is applied.



RELAY TRUTH TABLE		
INPUT 1	INPUT 2	OUTPUT
OFF	OFF	NO
ON	OFF	YES
OFF	ON	YES
ON	ON	NO

Test Circuit Measures Sensitivity

The only part of the test circuit that may present a problem is the standard test coil, which can be home-made. The coil must be wound on a bobbin with a hollow center to allow insertion of the reed switch. Plastic drinking straws make good core materials. Use the regular size for miniature switches and the thicker size for standard switches.

Cut the straw just long enough to enclose the switch capsule. Cement 1-inch-diameter plastic washers on each end. Now, the next job is winding the bobbin with 10,000 turns of fine magnet wire. The exact gauge is not critical. No. 32 or smaller wire may be used. For that matter, 10,000 turns are not mandatory, but 5000 should be the minimum number of turns, otherwise current drain can get out of hand. The number of turns should be in even thousands for ease of calculation.

The reed switch is inserted in the test coil and connected to an ohmmeter, or other indicator. Starting with the 1000-ohm pot set to minimum, close S1 and advance the pot until the reed switch closes. Using this as a starting point, reduce the pot setting while operating S1 until the reed switch will consistently close when S1 is closed. Read the milliamp meter and multiply this reading by the number of turns in the test coil. The product that is obtained is the ampere-turn rating for pull-in.

With S1 closed, carefully decrease the pot setting until the reed switch just starts to open. Read the meter and again multiply by the coil turns; this product is the drop-out sensitivity. The pull-in and drop-out differential can be expected to be approximately 50%. All tests should be repeated several times to obtain an average value.

Where possible, several switch capsules should be tested to determine the production tolerance. This procedure will establish the ampere-turn sensitivity for switches with unknown characteristics or will serve to verify manufacturers' listed data.

With the wide variety of permanent magnets available in all sizes, shapes, alloys, and values of magnetomotive force there is no simple way to use a reed switch ampere-turn rating to predict operation when the switch is driven by a permanent magnet.

The only practical way is to construct a test fixture which will duplicate operating conditions. It is then possible to measure the desired characteristics. For limited applications, use the cut-and-try method to determine magnet placement and movement. This is not a very scientific method but it does the work.

The Reed Relay

The reed relay consists of a reed switch along with its operating coil. The basic relay is a single-pole, single-throw, normally open or form-"A" relay. This is the configuration used in the sensitivity test setup described above. This basic form may be expanded by adding reed capsules to produce multipole form-"A" relays.

Multipole form-"A" relays require a different coil configuration as the coil must surround a number of reed capsules. The coil bobbin must be of oval cross-section with the long axis of the oval long enough to contain the required number of reed capsules. Due to problems encountered with flux distribution and coil dimensions, 4 to 5 poles are the normal limit for this configuration, although more are possible in some cases.

The next basic relay is the single-pole, single-throw, normally closed or form-"B". This is a form-"A" relay with a permanent magnet (PM) added to bias the reed to the closed position. The device is caused to open by supplying the required drive to the coil to cancel the bias of the PM. The sensitivity of this type of relay may vary greatly from the ampere-turn rating of the reed capsule. The strength and positioning of the bias magnet must be considered. A strong magnet placed close to the reed capsule may increase ampere-turn sensitivity several times, as this bias field must be canceled, or at least weakened to the drop-out point by the drive applied to the coil. Another factor must be considered in reference to the coil drive. When too large a coil drive is applied, the bias field will not only be canceled but sufficient flux may be built up across the reeds to cause them to close again.

Applications may arise where insufficient drive is available to operate a reed relay and it is not practical to add a relay driver to supply the needed drive. It is possible to use a PM to supply positive, additive bias, thus effectively increasing relay sensitivity. The amount of improvement will depend on the pull-in drop-out differential of the basic relay. The smaller this differential, the greater the increase in sensitivity that may be realized. The drop-out is the limiting factor, for the bias magnet can only supply a flux slightly below this value, otherwise the relay will "latch" and no longer open. The placement of the bias magnet is critical and best determined by experiment.

The reed relay may be latched in either of two ways, electrical or using PM bias. Electrical latching is accomplished as with any relay, using one set of contacts to complete the latch circuit.

A more flexible method is by using PM bias. The bias magnet is positioned so as to provide a flux somewhat above the drop-out value of the reed capsule, but still below the pull-in value. The reeds close when power is applied to the coil and, due to the bias, will remain closed upon removal of power. The relay is cleared or unlatched by application of opposite-polarity drive to the coil. Applications requiring an isolated clear can be met by using a dual-winding coil, one winding being used as the drive coil and the other being used as the clear winding (Fig. 3). Coil polarity must be observed, with drive positive and clear negative, both with respect to the PM bias.

Reed capsules are available which have a second contact and are able to perform single-pole, double-throw or form-"C" switching.

Logic Applications

In the field of industrial control, reed devices are finding increasing use. They are capable of performing the logic functions of *and*, *or*, and exclusive-*or* operations. It is possible to construct flip-flop circuits and expand these into binary, binary-coded decimal, and decimal counters, ring counters, bidirectional counters, and shift registers just as with solid-state logic elements. For industrial applications, this use of relay logic has the advantages of not requiring rigid environmental control, precise voltage and frequency regulation. Also the relay circuits are able to withstand high vibration and shock levels. Operating speed is, of course, far slower than with solid-state circuits.

Logic functions are obtained by using drive coils with two or more isolated windings. The coils are wound on plastic bobbins with oval cross sections to accommodate two or more reed capsules along with any bias magnets that may be required.

The *and* circuit or gate is merely a basic reed relay with two drive coils and one or more reed capsules (Fig. 4). When designing reed relays with multiple coil windings, the amount of magnetic flux required to operate the reed switch must be considered. This force is normally referred to as one flux unit (ø). A percentage of this one flux unit may be supplied by each coil of the multiple winding. If ½ flux unit is supplied by coil #1 and ½ from coil #2, the reed switch will actuate and a two-input *and* circuit is formed. The basic *and* circuit

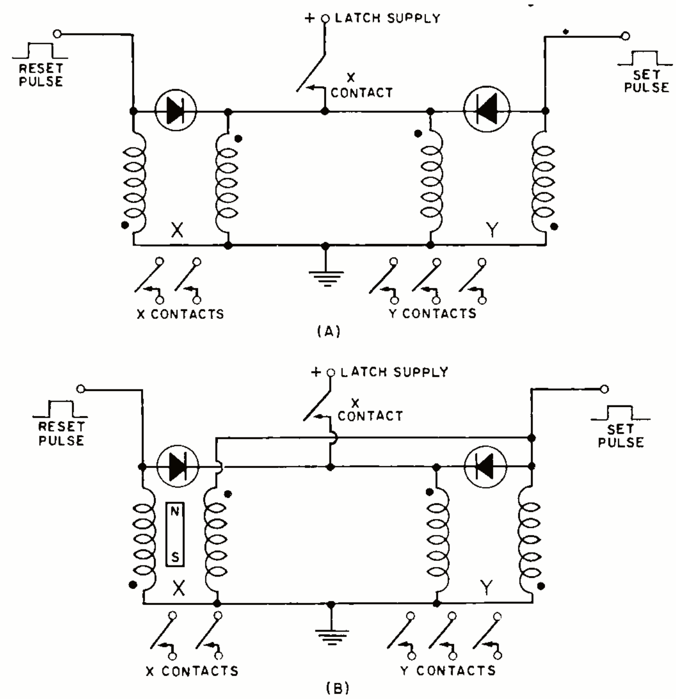


Fig. 7. Reed-relay flip-flops with (A) electrical and (B) magnetic memories. Number of contacts used is optional.

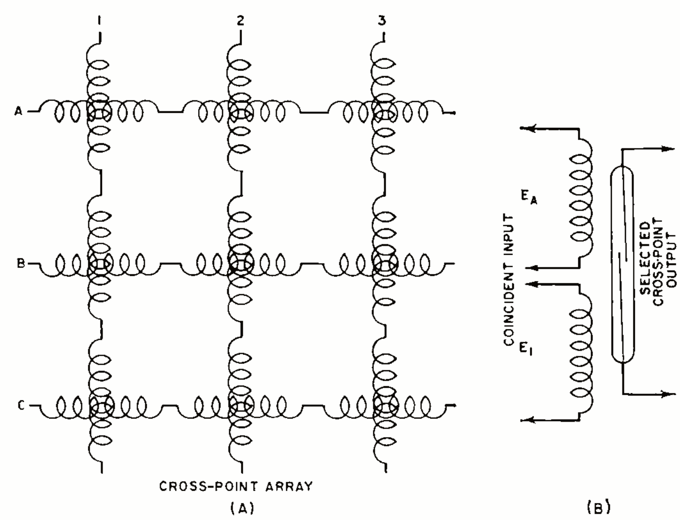


Fig. 8. Cross-point matrix switching with reed relays.

could be expanded to a 3-, 4-, or 5-input *and* gate, but each input requires a separate winding. Proper phasing of the coils must be observed for their fields must be connected in parallel-aiding.

The next logic element is the *or* circuit or gate. The basic 2-input circuit (Fig. 5) is the same as the *and* gate with one exception. Instead of ½ flux unit being supplied to each of the two coils, each coil receives one full flux unit and, as a result, each can effect a relay closure.

With a slight change the circuit becomes an exclusive-*or* circuit, as shown in Fig. 6. This change is in the polarity of the drive coils. The coils are so connected that their fields cancel when both are energized.

Reed relays can also perform the logic function of an inverter. This is accomplished with a form-"B" relay.

The next logic function to be discussed is that of the two-input set-reset (RS) flip-flop. This circuit requires two double-wound relays connected as shown in Fig. 7.

The flip-flop may use either electrical or magnetic memory; operation of each is identical. However, with magnetic memory the X contacts remain closed when power is removed. Operation is as follows:

The double-wound coils have been labeled "X" and "Y"

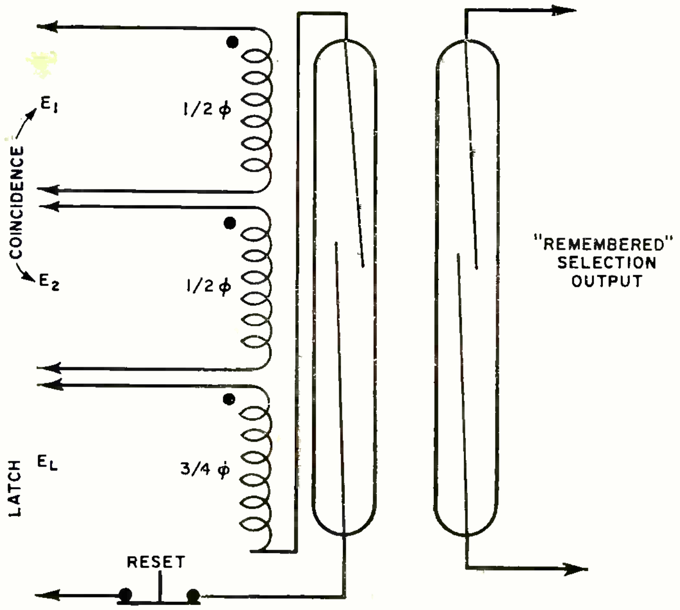


Fig. 9. Circuit diagram of matrix element with a memory.

and are diode-coupled in position so as to produce zero flux when both windings are energized. In the circuit with electrical memory (Fig. 7A) one winding of each double-wound coil is connected to an X reed switch for latching. With magnetic memory (Fig. 7B) only one winding of the Y coil is connected to an X reed switch for latching.

The presence of a set pulse energizes both windings of Y, but only one winding of X, causing X reed switches to operate. The removal of the set pulse de-energizes one Y winding, the other remains energized through the X latch, thus allowing all Y reed switches to operate. The FF is now in one of the two stable conditions and will remain so until application of the reset pulse. In the electrical-memory FF, presence of the reset pulse energizes both X windings causing X reed switches to release. In the magnetic-memory FF, the reset pulse energizes the release winding of X causing X reed switches to release. In both cases one Y winding remains energized through the X diode and the Y reed switches remain operated until termination of the reset pulse. Removal of the reset pulse causes Y reed switches to release and the circuit is prepared to re-cycle.

The final application of the reed relays to be discussed is cross-point matrix switching. The single-mode (no memory) matrix element is an *and* circuit in a cross-point array (refer to Fig. 8).

Each potential selection point (A1, A2, A3, etc.) comprises a double-wound relay. Selection is accomplished when both coils are energized by a matrix coincidence, *i.e.*, A1.

With loss of this input coincidence, the output switch closure will be lost as this configuration has no memory. Fig. 9 shows a matrix element with electric memory. Magnetic memory can also be used (This form has been developed for telephone switching.)

Application Considerations

The uses of a reed switch/magnet combination are limited only by the imagination of the user. This combination can be used, for example, as limit switch, float switch, sensor in intrusion alarm system, r/min sensor, etc. Almost any operation involving movement can be monitored or sensed by the reed switch/magnet combination. Either the switch or the magnet may be moved. The movement may be used to interpose a magnetic shield (soft-iron vane) between the switch and magnet. Fig. 10 shows some of the possibilities.

The reed switch or relay is a versatile device which can provide a highly reliable and sensitive switching component. The applications are almost unlimited, but like all things, the unit is not a universal problem solver. If the following items are evaluated, they will help in determining if a reed switch or relay should be used.

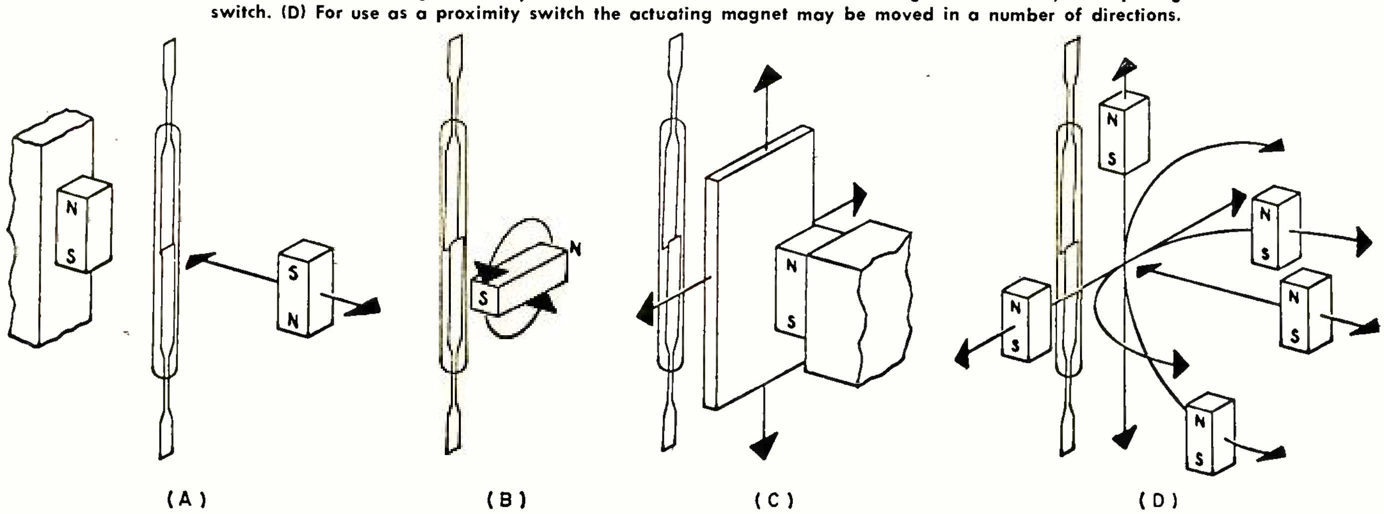
1. Contact rating
2. Contact arc suppression
3. Coil e.m.f. suppression (deleterious effects of back-e.m.f. on the other circuit components)
4. Effect of back-e.m.f. suppression on actuation speed
5. Magnetic shielding (ambient flux fields, flux leakage, etc.)
6. Environment (temperature, humidity, shock, vibration)
7. Polarities of coils and magnets
8. Magnet aging compensation
9. Should transistors be chosen due to higher-speed switching requirements?
10. Should power relays be chosen due to higher-power requirements?

The larger electronic parts suppliers list a good selection of reed switches and relays in their catalogues. Some coils are also listed. Manufacturers include *Cutler-Hammer*, *GE*, *Hamlin*, *Alco*, and *James*.

For those interested in experimenting with reed devices, a design kit containing reed capsules, test coils, and magnets is available from *New Product Engineering, Inc.*, 812 Manchester Avenue, Wabash, Indiana 46992 at about $10.

For those who desire individual components, your electronics supplier may have the *GC Electronics* "Calectro" line which includes reed switch kits with coil and magnet. ▲

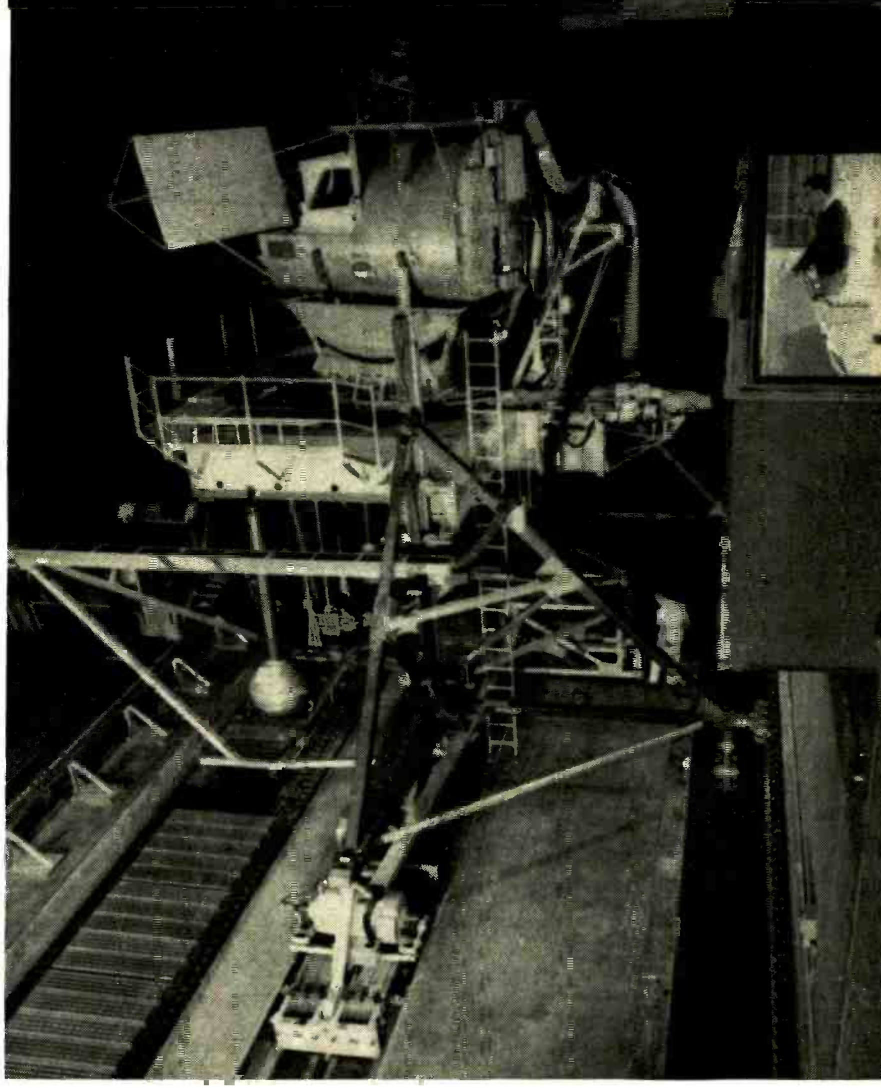
Fig. 10. Some possible magnet arrangements for reed switches. (A) Fixed magnet at left closes switch normally. When its field is overcome by the moving magnet, switch opens. (B) Rotation of magnet is used to actuate switch. (C) Shielding is done by soft-iron vane that is moved between magnet and switch, thus opening switch. (D) For use as a proximity switch the actuating magnet may be moved in a number of directions.



FLIGHT SIMULATOR for SUPER JETS

By FRED W. HOLDER

This 6-story high machine uses color TV and computers to simulate flight characteristics of almost any aircraft.



The motion-generator structure of NASA's FSAA with cockpit located on top provides the six degrees of motion necessary to simulate the actual flight of an aircraft.

AIRCRAFT like *Boeing's* giant 747 jet liner mark the beginning of a new era in aviation—the age of the super jet. Even faster and larger jet transports lie just over the horizon. To obtain design data on the handling characteristics of these big "birds," the National Aeronautics and Space Administration (NASA) has invested $2.6 million in a new Flight Simulator for Advanced Aircraft (FSAA). This new machine stands six stories high and is capable of simulating the flight characteristics of almost any aircraft.

Why use a simulator? According to NASA's Ames Research Center, where FSAA is located, it is far cheaper and safer to operate a simulator than a prototype aircraft.

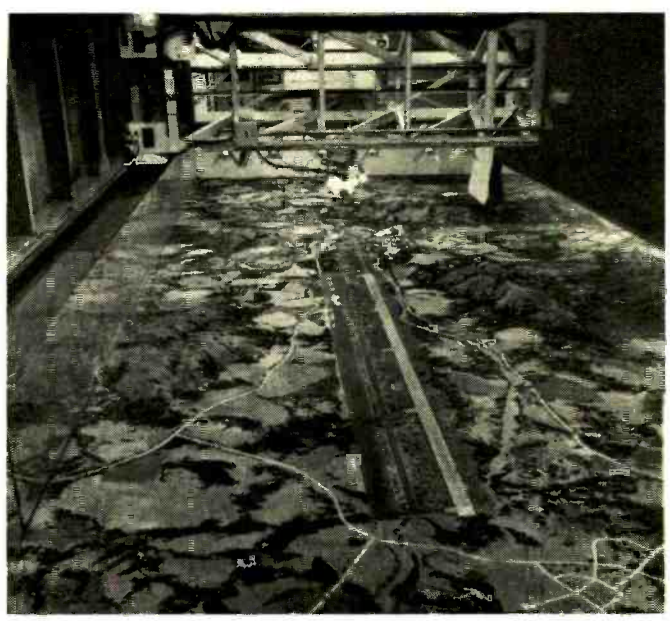
Sophisticated simulators like FSAA give pilots an experience virtually identical to actual flight. They can simulate critical flight and control situations such as engines-out and low-visibility landings in complete safety on the ground. Moreover the FSAA can simulate engine cut-off during take-off, which can't be done with an actual aircraft.

Aircraft simulators like FSAA are not new; they have been used for research and pilot training since World War II. The existing simulators, however, couldn't provide the large cockpit movements necessary to realistically simulate the super jets. Charged with designing the FSAA, Ames Research Center engineers John Dusterberry, Maurice White, and Shizuo Doiguchi had to incorporate motion capabilities large enough to simulate the movements of a cockpit located up to 150 feet forward of the plane's center of rotation. Implementation of their design is a simulation capability significantly beyond that of any other aircraft research simulator.

The FSAA consists of a very large motion generator which transmits all of the six possible rotational and linear motions to a three-man cockpit. The cockpit is fitted with the equipment and instrumentation necessary to duplicate the flight deck of a typical transport aircraft. Realism is provided in the form of out-of-the-window view, engine and mechanical noises, vibration, periodic bumps of tar strips on runways, the initial big bumps of touchdown, climb-out attitude of take-off, restricted visibility, and turbulent air conditions.

The full-color, out-of-the-window (*Continued on page* 73)

The color-TV camera "flies" over model countryside and airstrip. What camera sees is projected onto screen in front of the research pilot, making him feel as though he is actually flying. Camera lands and takes off from model runway.



Is Omnidirectionality Desirable in a Loudspeaker?

By DON DAVIS / Director, Commercial Sound Products
Altec Lansing (Div. of LTV Ling Altec, Inc.)

Author's view is that for faithful reproduction of original sound, directional speakers covering listening area with direct rather than reverberant sound provide best results.

Editor's Note: The several proponents of omnidirectional speaker systems have recently made a strong case in favor of their products—speakers that rely on wall reflections to spread the sound and create greater ambience so that the listener appears to be surrounded by sound. These proponents feel that since most sound that is heard "live" is mainly reflected rather than direct sound, it would be more realistic to use a speaker system that produces mainly reflected sound in the listening room. Not so widely heard from are those on the other side who, like our author, feel that the ambiance and sound reflections have already been recorded on the disc or tape. He feels it is the job of the speaker system to reproduce these exactly as recorded by means of speakers whose output is mainly direct rather than reflected sound. Here are his views on this important topic.

AS early as 1930 Wolff and Malter stated in their paper "Directional Radiation of Sound" (*Journal of the Acoustical Society*) that "it is well known that the radiation from a point source is uniform in all directions." From this fact—the omnidirectionality of a point source—has developed the misunderstanding that such omnidirectionality would always be desirable in a real source. In truth, what is desired is a reproducer with a fixed distribution that does not vary with frequency. While the omnidirectional "ideal" point source would have such a fixed distribution pattern, it would not be the ideal source for the reasons to be discussed in this article.

Basic Assumptions

If we wish to accurately reproduce the sound field that appears at the diaphragm of a recording microphone, in essence we wish to reproduce at some delayed time in a different location, the same sound field at the listener's ears. The sound that impinges on the diaphragm of the recording microphone consists of a certain amplitude, tonal balance, and, in the case of indoor concert halls and studios, a ratio of direct-to-reverberant sound. That is, some of the sound arrives at the diaphragm of the recording microphone directly from the musicians and some arrives after first reflecting off one or more surfaces in the recording space.

If we assume that our recording and playback chain adds or subtracts nothing from our recorded signal, then our goal is to cause a sound field with the same amplitude, tonal balance, and ratio of direct-to-reverberant sound to impinge on our listener's eardrums. With precision earphones such reproduction yields startlingly realistic *directional re*-creation effects.

In a properly made classical recording the desired ratio of direct-to-reverberant sound has been carefully established by knowledgeable A&R (artists and repertoire) men and/or producers. This ratio is accurately reproduced only in the direct sound field of the loudspeaker and is lost in the confusion of the reverberant sound field of the listening room if the listener moves into it or establishes an artificial one within his own listening area.

A distinction should be made between those recordings cut entirely with the desire to furnish the listener with an accurate reproduction of the original environment in a famous concert hall and those equally legitimate artists and artisans who want to change the original conditions into what they regard as an enhanced condition for the ultimate listener.

In the first place, the recording engineer places his microphones at positions in the concert hall that allow a blend between the direct and reverberant sound in the hall distinctive to that orchestra and that hall. Such recordings are treasured jewels sought out and enjoyed by a small but discriminating group of serious music listeners.

In the second case, the recording room can be eliminated entirely by fastening vibration pickups to the musical instruments and feeding their outputs directly to the recorders. Not only are the performing artists' value judgments recorded but, as the processing continues, the value judgments of the producer, mixing engineer, and other artisans as well; thus, the burgeoning market for artificial reverberation, echo channels, variable-speed tape recorders, and multi-channel dub-downs. Still further intercession can be and is made by the listener through his choice of equipment, its location in the room, his tone controls, and the additional "coloring" devices he chooses to employ.

What About Directional Microphones?

If the microphone used in the recording is placed in the concert hall's reverberant field (which incidentally is where most of the audience is), the sound arrives from many directions; we have a diffuse sound field. In such circumstances, a directional microphone is of no use and, in fact, can be detrimental since directional microphones cannot be made as smooth in amplitude response as a comparable quality omnidirectional unit.

In the direct sound field of the orchestra, typically under 30 feet in most concert halls, a directional microphone *can* find information that is directional in nature. Thus some use can be made of a cardioid microphone; for example, in discriminating between a violin on its frontal axis and a trumpet on its rear axis. But it should be realized that audience noise still arrives as a reverberant sound (hence omnidirectionally) and the only discrimination left to the microphone user is that of relative proximity of the microphone to relative noises. When "close-miking" techniques are used there is, of course, a bare minimum of "room effect." Any "room effect" desired by the listener must either be supplied by sitting in the reverberant field of the listening room and taking whatever it happens to have—good or bad—or else he adds his own "coloring" *via* the devices mentioned earlier.

As knowledge and control of loudspeaker directivity is coupled to loudspeaker-room equalization, we will witness increasing interest on the part of recording engineers in preserving the original recording site's reverberant field characteristics relative to the orchestra's direct sound at a desirable listening position in the hall.

Direct-to-Reverberant Sound

If you were to listen in an anechoic chamber or outdoors away from reflecting surfaces to a well-made recording taken in a concert hall, you would hear only the complex composite signal from the original concert hall. Your ears and brain, having no other distracting aural references, would "feel" as if they were in the concert hall. The goal, then, if true reproduction (fidelity) is desired, would be to deliver to a listener's ears in a small listening room the same complex composite signal as recorded with as high a signal-to-noise ratio as possible—the "noise" being the reverberant field in the small listening room. In essence, this means that every effort should be made to achieve a large ratio of direct-to-reverberant sound from the loudspeakers that are used.

Critical-Distance Calculations

Let's assume that through detailed sound-system equalization such as with *Altec's* Acousta-Voicing (see "Equalizing the Sound System to Match the Room" in our January, 1970 issue), we have controlled the amplitude and the tonal balance at the listener's ears. Our question then becomes "What about the ratio of direct-to-reverberant sound present in the listening room at the listener's position?"

To explore this question, let's examine in order: (1) an omnidirectional sound source, (2) a hemispherical source, and (3) a source having a conical angle of distribution that is 90° × 90°.

First, we need to determine how much sound-pressure level (SPL) at, say, 4 ft such a source would develop if it were 100% efficient in its conversion of electrical power to acoustic power. This is done in order to see what effect reducing the distribution angle has on the distribution of the *power* radiated. The formula used is:

$$20 \log_{10} \frac{\sqrt{\dfrac{1 \ watt}{142.24 r^2 (1 - \cos\frac{\theta}{2})10^{-7}}}}{0.0002 \ dyne/cm^2} = \text{dB SPL at 4 ft}$$

where:

142.24 = a constant derived from the density of air times the velocity of sound in air times 2π,

r = distance from sound source,

θ = the angle subtended by the spherical surface area.

Using the formula for the three (*Continued on page* 56)

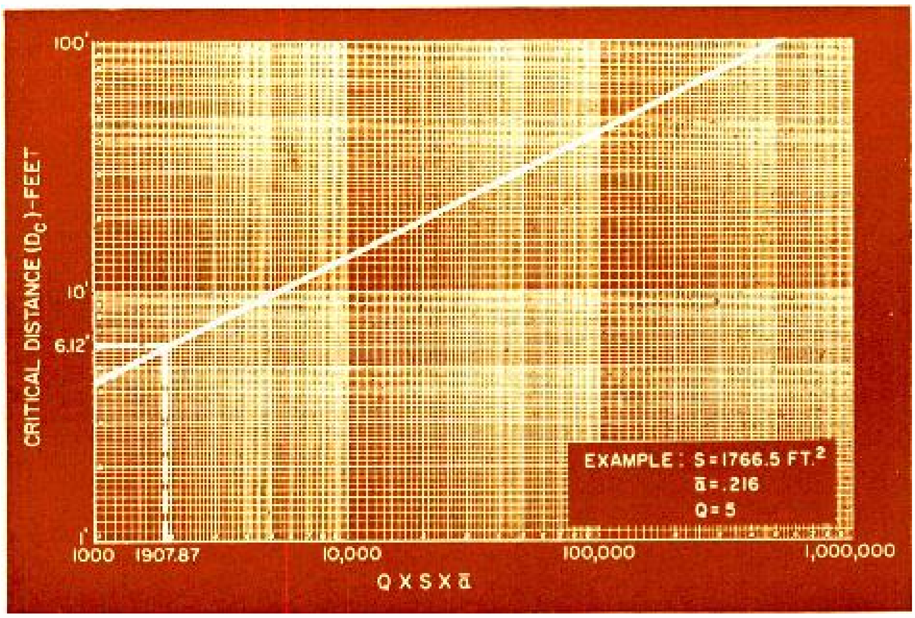


Fig. 1. Graph permits determination of critical distance at which direct and reflected sounds are equal when the following factors are known: the directivity factor (Q), total surface area of room in ft^2 (S), average absorption coefficient ($\bar{a}$).

FET's as Audio Switches

By G. NEAL/Navigational Aids Section
National Research Council of Canada

By applying voltage to the gate and keeping drain-to-source voltage at zero, the resistance of an FET may be controlled.

THE FET is presently employed principally as a low-noise, high-input-impedance r.f. amplifier or mixer, but another useful application tends to be overlooked. The *Siliconix* Application Note, "UNIFETS as Voltage-Controlled Resistors," describes how the R_{DS} (drain-to-source resistance) of an FET may be controlled by the V_{GS} (voltage applied between gate and source) when V_{DS} (drain-to-source voltage) is kept at zero, R_{DS} may vary from a few ohms in the "on" state to many megohms in the "off" state.

A circuit such as the one shown in Fig. 2 may be devised in which an audio signal is applied at V_{in} and an audio voltage obtained at V_{out} if V_{GS} is kept within certain limits, depending on the type of FET employed.

Such a circuit is very useful, for instance, if a number of audio signals must be fed to a common point (*e.g.*, modulator input) one at a time, without any interaction between them (see Fig. 1).

It is found that for $V_{GS} = 0$, V_{out} will start to flatten on one peak when V_{in} exceeds a particular level.

Table 1 provides some pertinent information on a number of low-cost FET's, both *p*- and *n*-channel units, which were connected as shown in Fig. 2.

Temperature tests conducted at ±25°C indicated little change in the cut-off voltages or maximum input signal to still produce a sine-wave output. It can be seen that the voltage supplied to the gate to cut off the signal may be either positive or negative with respect to ground, depending on the type of FET considered (*n*- or *p*-channel). It is then possible to have either a positive or negative voltage source in a system and choose the (*Continued on page* 59)

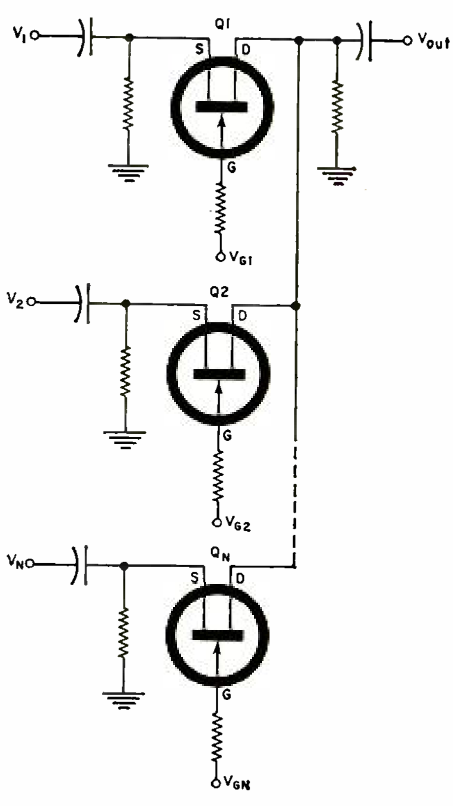


FIG. 1

Fig. 1. How a number of audio signals can be fed to a common point (modulator input) at one time, without any signal interaction.

Fig. 2. How the audio signal applied at the input and the audio voltage obtained at the output can be kept within certain limits.

Fig. 3. Circuit for use with a negative power supply in which a voltage of less than −0.7 V at V_{B2} can provide a signal at V_{out}.

Fig. 4. A circuit designed to be used with a positive voltage system. Refer to text.

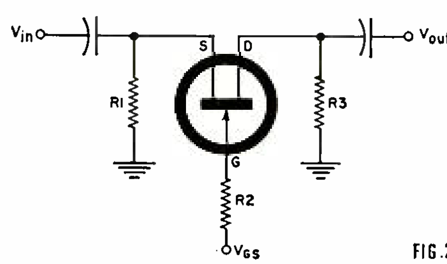


FIG. 2

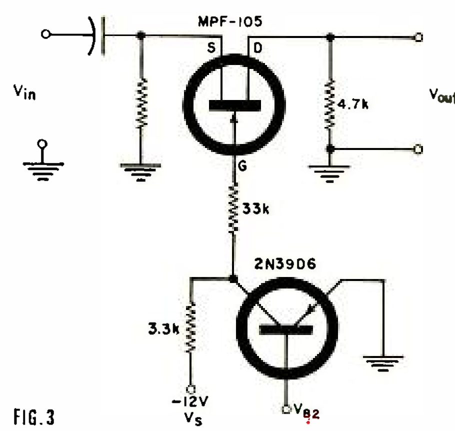


FIG. 3

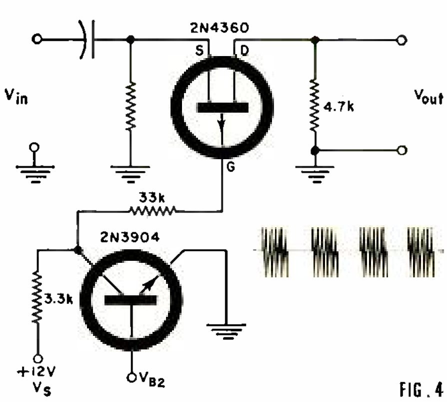


FIG. 4

DIGITAL INSTRUMENTS

Part 2. Counting and Decoding Circuits

By DONALD L. STEINBACH / Research Engineer Sr., Lockheed Missiles & Space Co.

Counters and decoders are fundamental elements in almost all digital instruments. Developing appropriate counter and decoder combinations is one of designer's most important considerations.

COUNTERS and decoders are essential parts of measuring instruments that display electrical parameters in direct-reading digital form. Counters totalize the number of events that occur at their input, and the instantaneous state of the counter is directly related to the number of events that have occurred. Decoders monitor the states of the counters and derive related outputs, suitable for driving a numerical readout device driver, for each different state. It follows, then, that if the unknown parameter can be converted to a series of sequential events whose quantity is proportional to the magnitude of the parameter, the counter and decoder combination will indeed allow the unknown parameter to be expressed in direct-reading digital form.

The choice of a particular counter and decoder combination is strictly up to the designer/user. Factors which will influence the decision are: type of display to be used, compatibility with other equipment and components within the system, combined counter and decoder wiring complexity and package count, over-all performance goals, and cost. The instruments that will be described later in this series will use modulo (divide by) 4, modulo 6, and modulo 10 counters, and the readout devices discussed last month. State tables accompany every circuit included in this article to assist in analyzing (or troubleshooting) the decoders and counters.

Logic Symbols

The diagrams of the counters and decoders are in logic-symbol form, designed around RTL (resistor-transistor logic) IC's. These and other IC's will be discussed in detail in next month's article. The reader who is unfamiliar with logic terminology and digital IC's should review the three references listed at the end of this article—as they will provide ample background information.

The inverter, positive-logic *nor* gate, and JK flip-flop (FF) logic symbols and behavior are shown in Fig. 1. The inverter simply supplies an output level that is opposite that applied to its input. The *nor* gate output is 1 *only* when *all* of its inputs are 0. The JK FF has two outputs, Q and Q′ (Q′ represents $\bar{Q}$, read "not Q" in this article), that are always at opposite levels with respect to each other. The levels at S (set) and C (clear) prior to the arrival of a clock pulse (CP) at input T (trigger) specify what the state of the FF will be after the CP (a CP is a 1-to-0 transition at T). Input C_D (direct clear) overrides all other inputs, clearing the FF (driving Q to 0).

All of the logic diagrams in this article are developed around the JK FF, *nor* gate, and inverter. Circuit complexity and/or IC package count may often be reduced by replacing certain *nor* gate and inverter combinations with *or* gates, *and* gates, or *nand* gates. The inverter may, of course, be replaced with a *nor* gate having one of its two inputs connected to logical 0. The mechanics of these substitutions is illustrated in Fig. 2.

Counters

Counters are, by design, dividers. Thus, the output of one counter may be connected to the input of a second counter to increase the total number of events (CP's) that the counting system is capable of counting and displaying. A single counter can be designed to count to any arbitrary number, but large-modulo counters are usually made up of cascaded lower-modulo counters in the interests of preserving the designer's sanity.

There are many different logic configurations that will provide a counter with a given capacity. The choice of a configuration is usually based on counting code, speed, complexity, and ease of decoding. A complete discussion of all variations would easily fill a small book; only binary counters and ring counters will be considered here.

Binary Counters

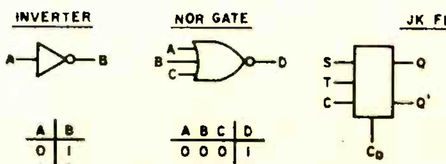
The counters in Figs. 3, 4, and 5 are called binary counters because their states advance in natural binary form (the 01 state is interpreted as $0 \times 2^1 + 1 \times 2^0 = 1$, etc.). The binary-coded-decimal (BCD) data outputs interface directly with most other logic system components such as packaged decoders, digital printers, etc. The outputs of a binary counter can be processed to drive a binary-coded display directly, rather than decoded for use with a more conventional indicator. This approach should not be overlooked, particularly where the additional cost of a decoder and numeric readout is deemed excessive.

The modulo 4 binary counter (Fig. 3) is really two cascaded modulo 2 counters. The S and C inputs are both connected to a logical 0 level, so that the FF's change state with each CP—FF1 changes state with each input CP and FF2 changes state each time FF1 switches from the 1-state to the 0-state.

The modulo 6 binary counter (Fig. 4) utilizes the gating capability of some of the JK FF S and C inputs. Note that clock pulses (1-to-0 transitions at T) are applied to FF2 and FF3 when FF1 changes state from 1-to-0 at CP2, CP4, and CP6. The connection from Q′ of FF2 to C of FF3 prevents FF3 from leaving the 0 state until after FF2 changes state at CP2. At CP4, FF3 changes to the 1-state and the connection from Q of FF3 to C of FF2 prevents FF2 from leaving the 0 state at CP6. Thus, the counter state is 000 (the same as its initial state) after CP6, and the counting cycle starts over. This example demonstrates the usefulness of the JK FF in counting circuits.

The modulo 10 (decade) binary counter of Fig. 5 is widely used in digital counting systems. With suitable gating, four FF's capable of counting to 16, are made to return to their initial states at every tenth input CP. The additional gate is required because C4 (input C of FF4) is controlled by two other signals, Q′ of FF2 and Q′ of FF3. Note that a second *nor* gate could replace the inverter.

Ring counters usually require more FF's than other types of counters because the maximum possible count is 2N for the ring counter rather than 2^N as for the binary counter (N is the number of FF's in the counter). The ring counter is easily decoded, as we shall see later, and the cost of the additional FF's is sometimes offset by a corresponding reduction in the cost of the decoder. When the modulo 6 ring counter in Fig. 6 is compared with the modulo 10 ring counter in Fig. 7, it is obvious that they (and all other ring counters) have the same basic configuration. This type of ring counter is intended for counting even numbers and the input load factor of the counter increases as more FF's are added. A modulo 4 ring counter is not shown here since it offers no



A	B
0	1
1	0

A	B	C	D
0	0	0	1
1	0	0	0
0	1	0	0
1	1	0	0
0	0	1	0
1	0	1	0
0	1	1	0
1	1	1	0

S	C	Q^{n+1}	
0	0	Q'^n	(TOGGLES)
1	0	1	(SET)
0	1	0	(CLEAR)
1	1	Q^n	(NO CHANGE)

Fig. 1. Logic symbols and truth tables of basic logic elements.

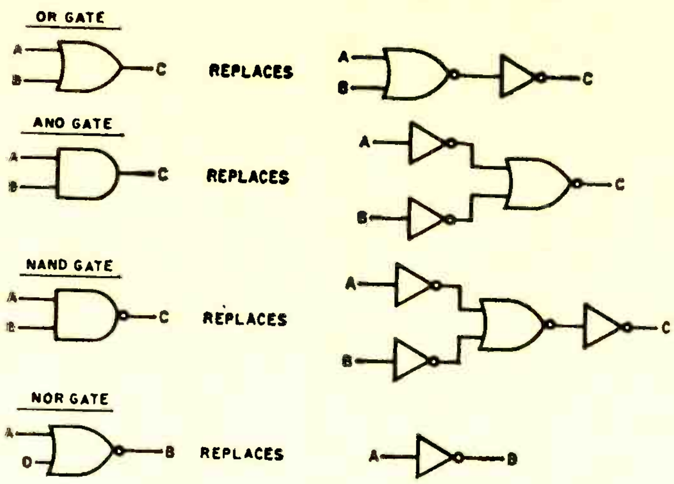
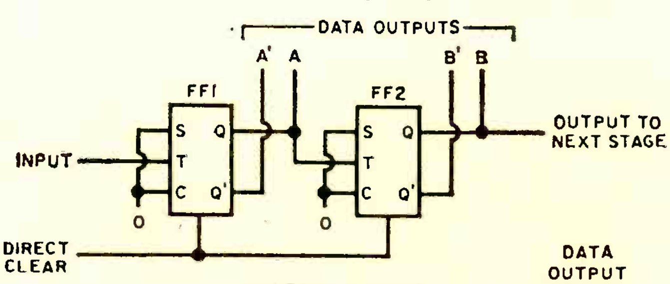
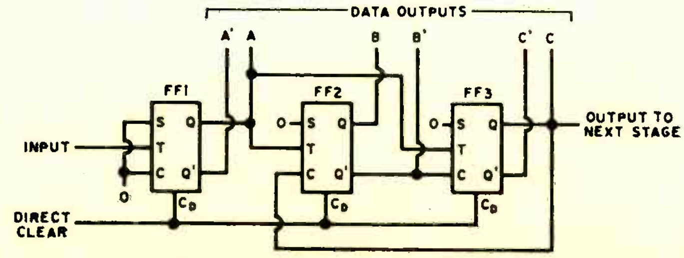


Fig. 2. The "nor" gates and inverter combination on the right may be replaced with the logic elements shown on the left.

Fig. 3. Modulo 4 binary counter logic diagram and state table.

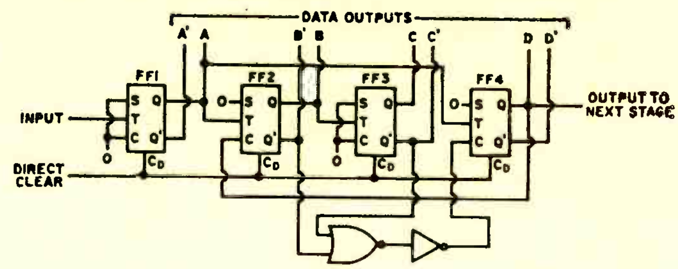


AFTER	INTERNAL LEVELS						DATA OUTPUT LEVELS	
	S1	C1	Q1	S2	C2	Q2	A	B
CLEAR	0	0	0	0	0	0	0	0
CP 1	0	0	1	0	0	0	1	0
CP 2	0	0	0	0	0	1	0	1
CP 3	0	0	1	0	0	1	1	1
CP 4			0			0		



AFTER	INTERNAL LEVELS									DATA OUTPUT LEVELS		
	S1	C1	Q1	S2	C2	Q2	S3	C3	Q3	A	B	C
CLEAR	0	0	0	0	0	0	0	1	0	0	0	0
CP 1	0	0	1	0	0	0	0	1	0	1	0	0
CP 2	0	0	0	0	0	1	0	0	0	0	1	0
CP 3	0	0	1	0	0	1	0	0	0	1	1	0
CP 4	0	0	0	0	1	0	0	1	1	0	0	1
CP 5	0	0	1	0	1	0	0	1	1	1	0	1
CP 6			0			0			0			

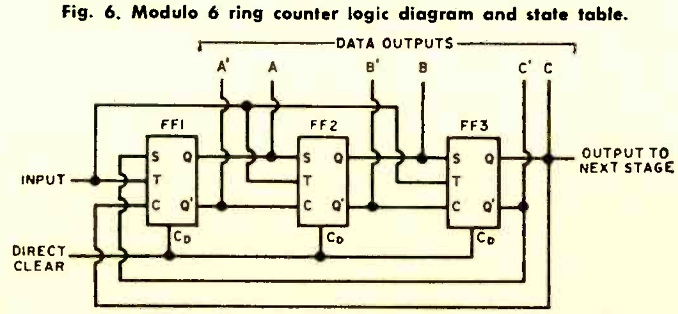
Fig. 4. Modulo 6 binary counter logic diagram and state table.



AFTER	INTERNAL LEVELS												DATA OUTPUT LEVELS			
	S1	C1	Q1	S2	C2	Q2	S3	C3	Q3	S4	C4	Q4	A	B	C	D
CLEAR	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CP 1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0
CP 2	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0
CP 3	0	0	1	0	0	1	0	0	0	0	1	0	1	1	0	0
CP 4	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0
CP 5	0	0	1	0	0	0	0	0	1	0	1	0	1	0	1	0
CP 6	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0
CP 7	0	0	1	0	0	1	0	0	1	0	0	0	1	1	1	0
CP 8	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1
CP 9	0	0	1	0	1	0	0	0	0	0	1	1	1	0	0	1
CP 10			0			0			0			0				

Fig. 5. Modulo 10 binary counter logic diagram and state table.

Fig. 6. Modulo 6 ring counter logic diagram and state table.



AFTER	INTERNAL LEVELS									DATA OUTPUT LEVELS		
	S1	C1	Q1	S2	C2	Q2	S3	C3	Q3	A	B	C
CLEAR	1	0	0	0	1	0	0	1	0	0	0	0
CP 1	1	0	1	1	0	0	0	1	0	1	0	0
CP 2	1	0	1	1	0	1	1	0	0	1	1	0
CP 3	0	1	1	1	0	1	1	0	1	1	1	1
CP 4	0	1	0	0	1	1	1	0	1	0	1	1
CP 5	0	1	0	0	1	0	0	1	1	0	0	1
CP 6			0			0			0			

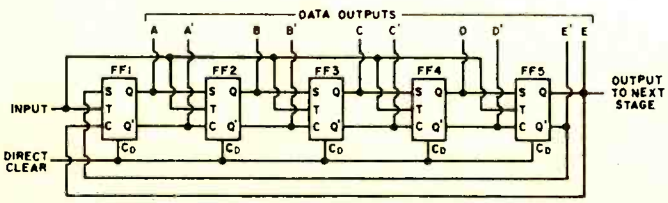
decoding advantages over the modulo 4 binary counter.

Decoders

The decoders described in this article derive outputs for use with 10-numeral or 7-segment visual readout display drivers from the data outputs of the counters. Decoders have an almost endless variety of configurations, and the ones illustrated here are those preferred by the author. The output drive of a counter is not always greater than the input load presented by a decoder; interface buffering is then required. A storage register is often placed between a counter and a decoder so that the previous count remains displayed while the counter contents are updated.

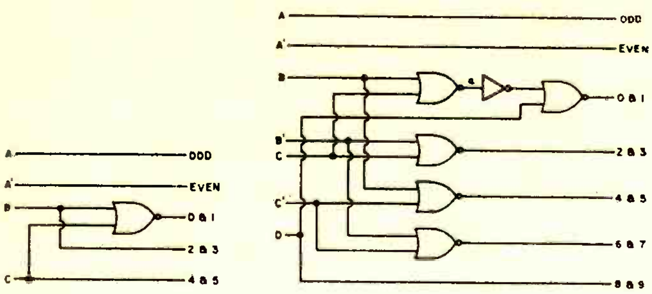
Biquinary Decoders

Decoders of the biquinary family are the simplest decoders for decoding the binary-coded-decimal (BCD) data outputs of binary counters. Examination of the "Outputs" column of the state table for the decoder in Fig. 8B reveals that each numeric output line is energized for two consecutive



AFTER	INTERNAL LEVELS S1	C1	Q1	S2	C2	Q2	S3	C3	Q3	S4	C4	Q4	S5	C5	Q5	DATA OUTPUT LEVELS A	B	C	D	E
CLEAR	1	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0
CP 1	1	0	1	1	0	0	0	1	0	0	1	0	0	1	0	1	0	0	0	0
CP 2	1	0	1	1	0	1	1	0	0	0	1	0	0	1	0	1	1	0	0	0
CP 3	1	0	1	1	0	1	1	0	1	1	0	0	0	1	0	1	1	1	0	0
CP 4	1	0	1	1	0	1	1	0	1	1	0	1	1	0	0	1	1	1	1	0
CP 5	0	1	1	1	0	1	1	0	1	1	0	1	1	0	1	1	1	1	1	1
CP 6	0	1	0	0	1	1	1	0	1	1	0	1	1	0	1	0	1	1	1	1
CP 7	0	1	0	0	1	0	0	1	1	1	0	1	1	0	1	0	0	1	1	1
CP 8	0	1	0	0	1	0	0	1	0	0	1	1	1	0	1	0	0	0	1	1
CP 9	0	1	0	0	1	0	0	1	0	0	1	0	0	1	1	0	0	0	0	1
CP 10			0			0			0			0			0					

Fig. 7. Modulo 10 ring counter logic diagram and state table.



(A)

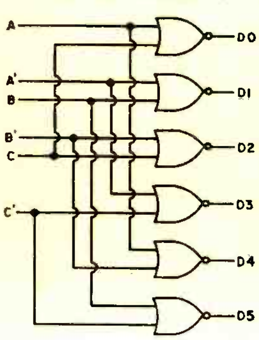
COUNT	INPUTS A	A'	B	C	OUTPUTS ODD	EVEN	0 & 1	2 & 3	4 & 5
CLEAR	0	1	0	0	0	1	1	0	0
1	1	0	0	0	1	0	1	0	0
2	0	1	1	0	0	1	0	1	0
3	1	0	1	0	1	0	0	1	0
4	0	1	0	1	0	1	0	0	1
5	1	0	0	1	1	0	0	0	1

(B)

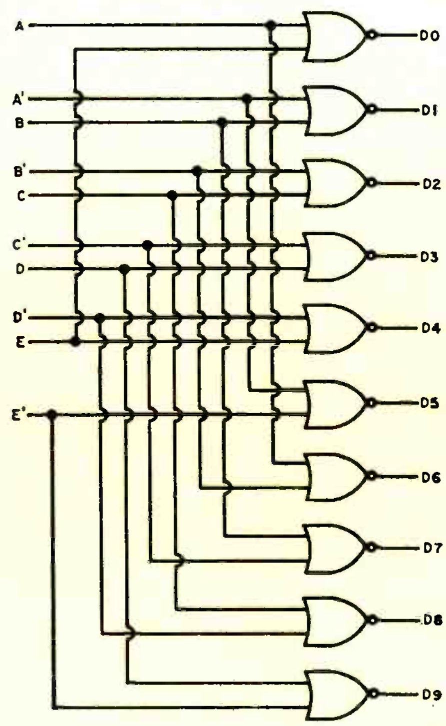
COUNT	INPUTS A	A'	B	B'	C	C'	D	a	OUTPUTS ODD	EVEN	0 & 1	2 & 3	4 & 5	6 & 7	8 & 9
CLEAR	0	1	0	1	0	1	0	1	0	1	1	0	0	0	0
1	1	0	0	1	0	1	0	1	1	0	1	0	0	0	0
2	0	1	1	0	0	1	0	0	0	1	0	1	0	0	0
3	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0
4	0	1	0	1	1	0	0	0	0	1	0	0	1	0	0
5	1	0	0	1	1	0	0	0	1	0	0	0	1	0	0
6	0	1	1	0	1	0	0	0	0	1	0	0	0	1	0
7	1	0	1	0	1	0	0	0	1	0	0	0	0	1	0
8	0	1	0	1	0	1	1	1	0	1	0	0	0	0	1
9	1	0	0	1	0	1	1	1	1	0	0	0	0	0	1

Fig. 8. Logic diagrams and state tables of biquinary decoders for both the (A) modulo 6 binary counter and (B) modulo 10 binary counter circuits shown in Figs. 4 and 5, respectively.

Fig. 9. Logic diagram and state table of decimal decoder for the modulo 6 ring counter circuit shown in Fig. 6.



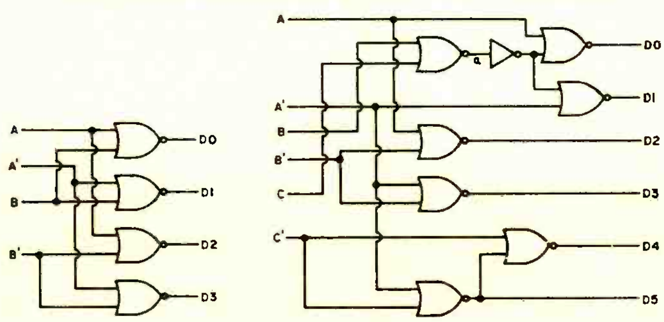
COUNT	INPUTS A	A'	B	B'	C	C'	OUTPUTS D0	D1	D2	D3	D4	D5
CLEAR	0	1	0	1	0	1	1	0	0	0	0	0
1	1	0	0	1	0	1	0	1	0	0	0	0
2	1	0	1	0	0	1	0	0	1	0	0	0
3	1	0	1	0	1	0	0	0	0	1	0	0
4	0	1	1	0	1	0	0	0	0	0	1	0
5	0	1	0	1	1	0	0	0	0	0	0	1



COUNT	INPUTS A	A'	B	B'	C	C'	D	D'	E	E'	OUTPUTS D0	D1	D2	D3	D4	D5	D6	D7	D8	D9
CLEAR	0	1	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0
1	1	0	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0
2	1	0	1	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0
3	1	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0
4	1	0	1	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0
5	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
6	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0
7	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0
8	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0
9	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1

Fig. 10. Logic diagram and state table of decimal decoder for the modulo 10 ring counter circuit shown in Fig. 7.

Fig. 11. Logic diagrams and state tables of BCD-to-decimal decoders for (A) modulo 4 binary counter and (B) modulo 6 binary counter circuits shown in Figs. 3 and 4, respectively.



(A)

COUNT	INPUTS A	A'	B	B'	OUTPUTS D0	D1	D2	D3
CLEAR	0	1	0	1	1	0	0	0
1	1	0	0	1	0	1	0	0
2	0	1	1	0	0	0	1	0
3	1	0	1	0	0	0	0	1

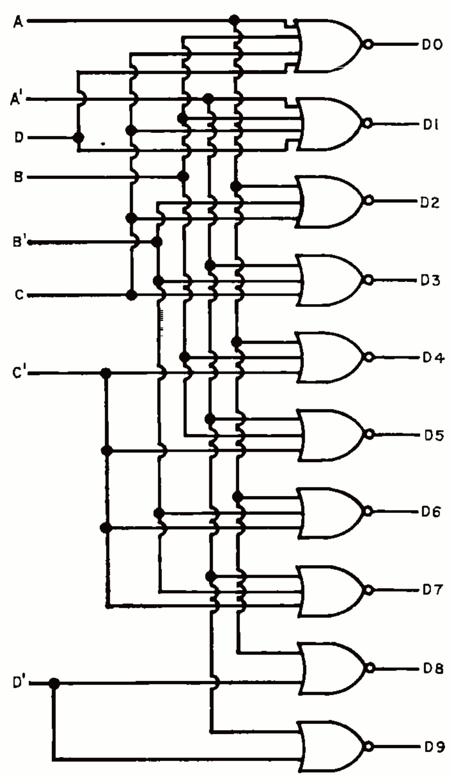
(B)

COUNT	INPUTS A	A'	B	B'	C	C'	a	OUTPUTS D0	D1	D2	D3	D4	D5
CLEAR	0	1	0	1	0	1	1	1	0	0	0	0	0
1	1	0	0	1	0	1	1	0	1	0	0	0	0
2	0	1	1	0	0	1	0	0	0	1	0	0	0
3	1	0	1	0	0	1	0	0	0	0	1	0	0
4	0	1	0	1	1	0	0	0	0	0	0	1	0
5	1	0	0	1	1	0	0	0	0	0	0	0	1

counter states (*i.e.*, 0 and 1, 2 and 3, etc.), and that the odd and even control outputs are energized only during the odd and even counts, respectively. Thus, simultaneous 1-levels on the "even" output line and the "2 & 3" output line represent a count of 2, simultaneous 1-levels on the "odd" output line and the "2 & 3" output line represent a count of 3, and so on. Obviously, the remainder of the decoding is accomplished somewhere else—namely in the indicator or its associated driver circuitry.

Special biquinary numerical indicator tubes have one anode for all odd-numbered cathodes and a second anode for all even-numbered cathodes. These tubes are expensive, however, and an alternate approach is usually chosen.

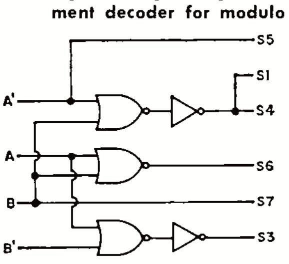
The biquinary decoder offers real economy when used to drive individual lamps. One terminal of all odd-numbered lamps is connected to an "odd-bus," one terminal of all even-numbered lamps is connected to an "even bus," and the remaining terminals of sequential lamps (0 and 1, 2 and



COUNT	INPUTS A	A'	B	B'	C	C'	D	D'	OUTPUTS D0	D1	D2	D3	D4	D5	D6	D7	D8	D9
CLEAR	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0
1	1	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0
2	0	1	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0
3	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0
4	0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0
5	1	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0
6	0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0
7	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0
8	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0
9	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1

Fig. 12. Logic diagram and state table of BCD-to-decimal decoder for the modulo 10 binary counter shown in Fig. 5.

Fig. 13. Logic diagram and state table of BCD-to-seven segment decoder for modulo 4 binary counter shown in Fig. 3.



* SEGMENT S2 IS ALWAYS ILLUMINATED

COUNT	INPUTS A	A'	B	B'	OUTPUTS S1	S2	S3	S4	S5	S6	S7
CLEAR	0	1	0	1	1	1	1	1	1	1	0
1	1	0	0	1	0	1	1	0	0	0	0
2	0	1	1	0	1	1	0	1	1	0	1
3	1	0	1	0	1	1	1	1	0	0	1

3, etc.) are connected together and driven from the appropriate numeric output line from the decoder.

BCD-to-biquinary decoders for modulo 6 and modulo 10 binary counters are shown in Figs. 8A and 8B, respectively. The data outputs of a modulo 4 binary counter are already in biquinary form; additional decoding is not required.

Decimal Decoders

Unlike the biquinary decoders, decimal decoders have one unique output for each counter state to be identified, or for each digit to be displayed. The decimal decoder accomplishes the complete decoding function within itself and does not require any external selecting logic; they can be used with individual lamps or with numerical indicator tubes.

Decimal decoders for ring counters are straightforward; all states can be decoded using two-input *nor* gates. Decimal decoders for modulo 6 and modulo 10 ring counters are illustrated in Figs. 9 and 10, respectively.

BCD-to-decimal decoders (Figs. 11A, 11B, and 12) are more complex, in general, than either the biquinary or ring-counter decoders. Many different configurations are possible, but the designer will normally attempt to both minimize package count (this does not necessarily imply reduction of the number of logic elements) and the loading on the counter data outputs. It should be obvious that these decoders can be constructed from identical gates (one gate for every decoder output) each having as many inputs as there are flip-flops in the counter. However, this approach maximizes rather than minimizes the loading on the counter data outputs.

Seven-Segment Decoders

None of the decoders described thus far is suited for use in a system using the popular seven-segment readout devices. The design of these decoders is complicated by the fact that various combinations of decoder output lines must be energized for each counter state. This usually requires the generation of "new" logic functions within the decoder. Here, again, many configurations are possible and the diagrams shown in Figs. 13, 14, and 15 represent only one such approach.

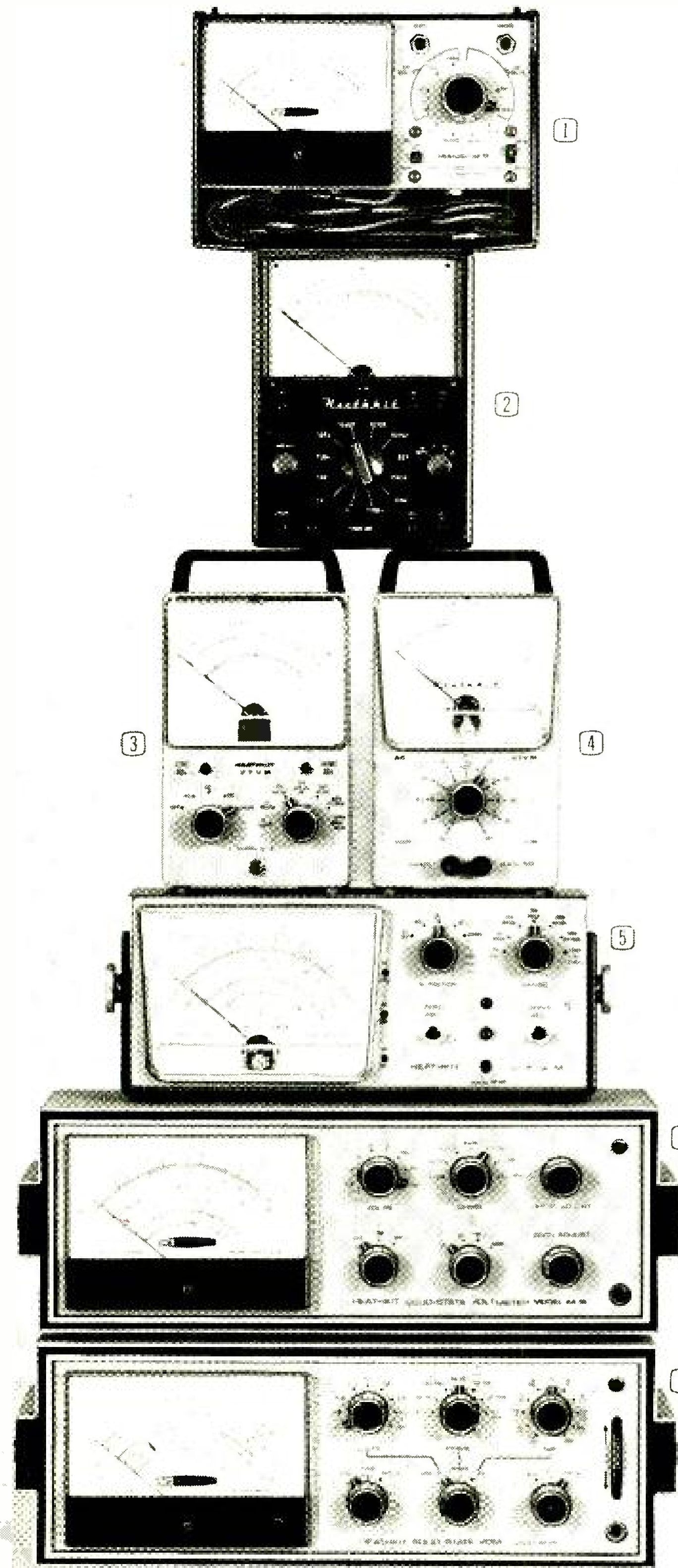
The segment designations and numerals formed are as described in Part 1 of this series. Some of the commercial seven-segment decoders do not form the "tails" on numerals 6 and 9, eliminating the possibility of a numeral 8 with one defective segment (the upper left one or the lower right one) being displayed as a 6 or a 9. Obviously, if the center segment fails, an 8 will appear as a 0.

Application

The circuits described in this article will normally be assembled from off-the-shelf integrated-circuit logic elements The reader is again cautioned that the IC load and drive requirements must be satisfied at the counter/decoder interface, and within the decoders. The latter will not be a problem unless logic families are intermixed.

Complete IC decade counters with BCD data outputs are available, as are decimal decoders and decimal decoder-drivers, and a limited selection of seven-segment decoders and decoder drivers. Their cost compares favorably with that of similar systems assembled from individual IC's and the speed of the counters is often somewhat higher. The advantage of these devices in large-scale production operations is obvious—the total number of external package connections is reduced, reducing production costs and improving reliability. The experimenter may, however, prefer to use individual IC's so that an entire relatively expensive counter or decoder package will not have to be replaced in the event of the failure of a single element or interconnection within the package.

Next month's article will discuss some of the integrated circuits that can be used to implement (and in some cases replace) these counter and decoder (*Continued on page 72*)



Stack These Up Against The Others

your best buys in meters come from Heath

For over 20 years, Heath has been the first choice in meters for tens of thousands of service technicians, schools and home labs. There's a reason for this continued popularity — Heath meters are designed to have that balance of versatility, needed features and low cost that make them your best buy. For the price of just a couple of meters from others, you can buy every meter Heath makes. We believe that you should still be able to get a stack of meters without spending a pile of money. When you need a meter, look to Heath. For performance, versatility and top dollar value, the others just don't stack up.

1 **$21.95* Buys A Portable Solid-State Volt-Ohm-Meter.** Four ranges on AC & DC volts measure 1-1000 volts full scale. Four resistance ranges measure 0.1 ohm to 1000 megohms. Features convenient battery operation . . . zero & ohms adj. controls . . . DC polarity reversing switch . . . spare jack for HV & RF probes . . . rugged polypropylene carrying case. IM-17, 4 lbs.

2 **$31.95* Buys A Portable Volt-Ohm Milliammeter.** Measures AC & DC volts 1.5-5000 full scale. DC current from 150 uA to 15A. Resistance midscale from 15-150,000 ohms. Large 4½" 50 uA movement meter for extra accuracy. MM-1, 5 lbs.

3 **$29.95* Buys An Accurate VTVM.** 7 AC & DC ranges measure RMS volts from 1.5-15000 full scale . . . AC P-P from 4.0-4000 . . . 7 resistance ranges from 0.1 ohms to 1000 megohms. 25 Hz — 1 MHz response. Single probe makes all measurements. IM-18, 5 lbs. Assembled IMW-18, 5 lbs. . . . $49.95*

4 **$41.95* Buys A Laboratory AC VTVM.** Especially useful for low-level AC & audio work. Ten RMS ranges from 0.01—300 V full scale . . . measures dB from 52 to +58. ±1 dB response from 10 Hz—500 kHz. 10 megs. input impedance. IM-38, 4 lbs. Assembled IMW-38, 5 lbs. . . $49.95*

5 **$39.95* Buys A Big Service Bench VTVM.** Has the same high performance as the IM-18 above, plus added features to make it more useful for service work . . . separate 1.5 & 5 VAC scales . . . calibration controls that are adjustable from the front panel . . . versatile gimbal mounting . . . large 7" meter. IM-28, 7 lbs. Assembled IMW-28, 7 lbs. . . . $59.95*

6 **$46.95* Buys A Big Solid-State Volt-Ohm Meter.** Battery-powered portability plus built-in AC supply. 8 AC & DC ranges 0.5-1500 full scale . . . 7 resistance ranges (10 ohm center scale) x1-x1 meg. High input impedance & 6" meter for greater accuracy. IM-16, 10 lbs. Assembled IMW-16, 11 lbs. . . . $69.95*

7 **$85.00* Buys A Deluxe Solid-State Volt-Ohm Milliammeter.** 9 AC & DC ranges from 150 mV-1500 V full scale . . . 7 resistance ranges measure from 1 ohm to 1000 megohms . . . 11 current ranges from 15 uA-1.5 A full scale. 100 kHz response . . . high input impedance . . . large 6" meter with zero center. IM-25, 10 lbs. Assembled IMW-25, 10 lbs. . . . $120.00*

HEATHKIT
a Schlumberger company

NEW
FREE 1970 CATALOG!
Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, guitar amplifiers, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

HEATH COMPANY, Dept. 15-8
Benton Harbor, Michigan 49022

☐ Enclosed is $__________, plus shipping.

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

Name__________

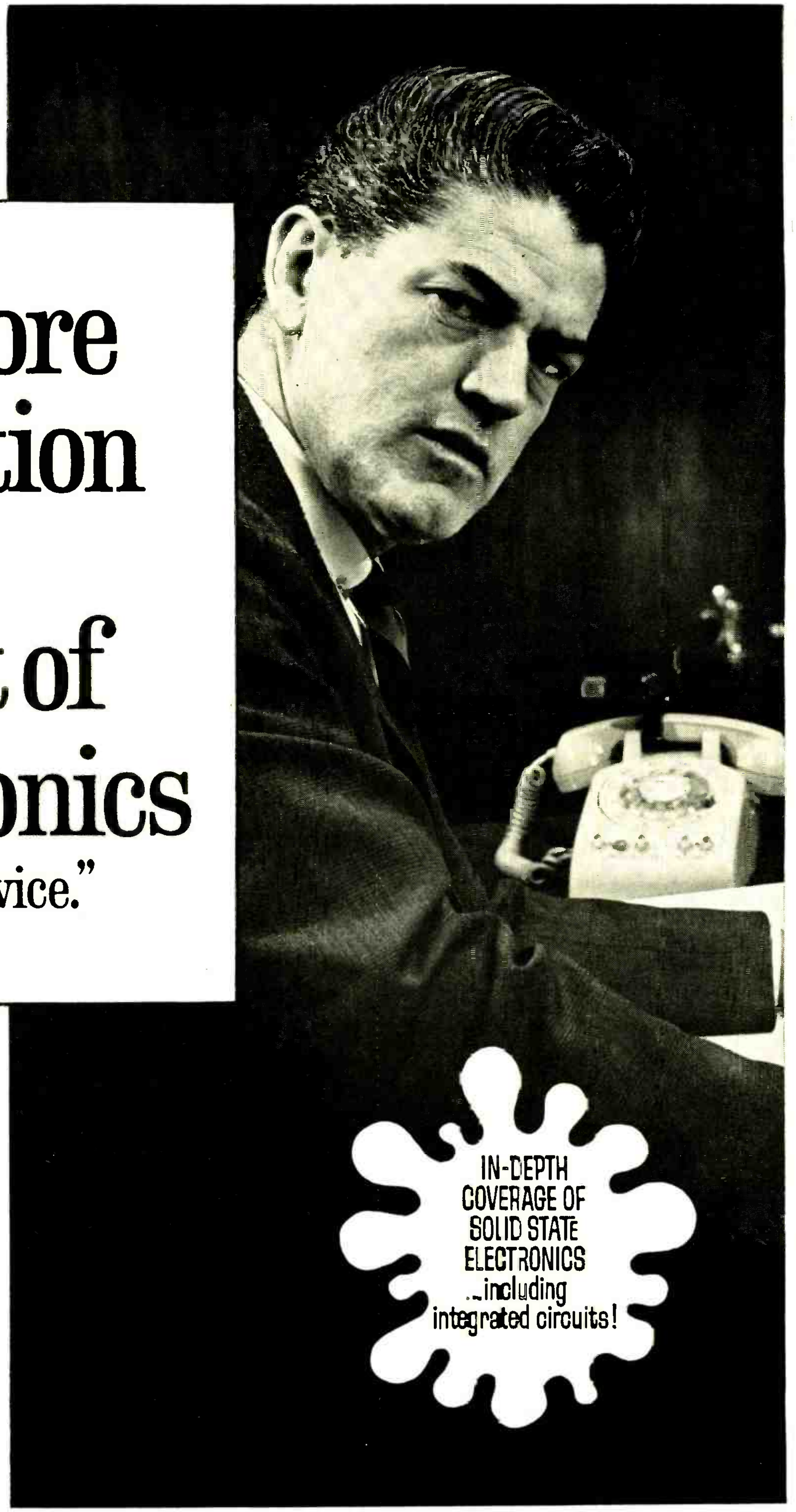
Address__________

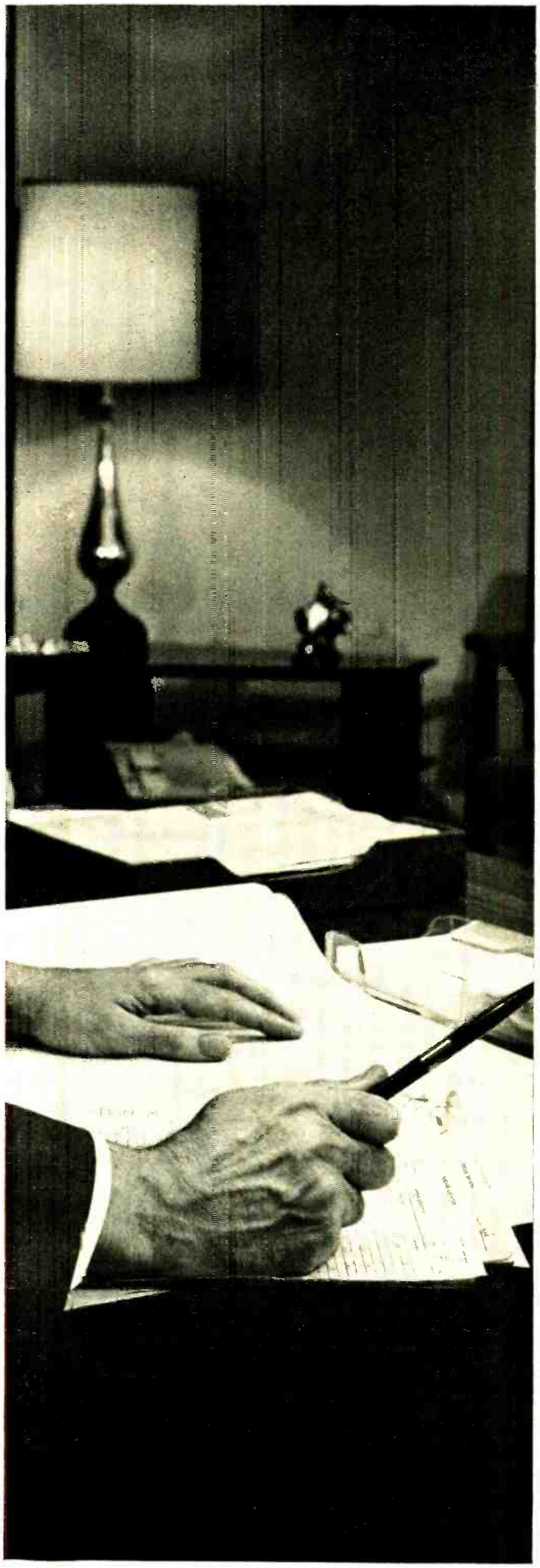
City__________ State__________ Zip__________

*Mail order prices; F.O.B. factory. Prices & specifications subject to change without notice. TE-221R

CIRCLE NO. 137 ON READER SERVICE CARD

"Get more education or get out of electronics ...that's my advice."





Omnidirectional Speakers

(Continued from page 45)

sound sources mentioned previously, we find:

	dB SPL at 4 ft	D_I	D_F or Q
Omnidirectional source	107.40	0.00	1.00
Hemispherical source	110.41	3.01	2.00
90° × 90° source	115.74	8.34	6.82

The *directivity index* (D_I) is the difference in dB SPL between the controlled radiator minus the total SPL at 4 ft from the omnidirectional radiator when both are fed the same electrical input power. The *directivity factor*, D_F or Q, is the power ratio represented by the directivity index.

Typical Listening Room

With these basic parameters of distribution in mind we now need to examine a typical listening room. The author's apartment living room, for example, has a total surface area (floor, ceiling, walls) of 1766.5 ft². By multiplying each surface area of differing material by the average absorption coefficient of that material and then summing all surface areas times their absorption coefficients and dividing by the total surface area, the average absorption coefficient for the room was obtained:

$$\frac{s_1a_1 + s_2a_2 + s_3a_3 \ldots . s_na_n}{S} = \bar{a}$$

where s = individual surface area, a = individual surface area's absorption coefficient, S = total surface area, and $\bar{a}$ = average absorption coefficient for the room.

The author's living room has an average absorption coefficient of $\bar{a} = 0.216$. Having this room information allows the calculation of the critical distance D_C, from a given sound source in a given room.

$$D_C = 0.14\sqrt{QS\bar{a}}$$

Fig. 1 allows the calculation of D_C whenever Q,S, and $\bar{a}$ are known. *The critical distance is that distance from the sound source at which sound energy from the sound source equals the reverberant (reflected) sound energy*. By definition then, D_C is the distance at which the ratio of direct-to-reverberant sound in a given space is 1 to 1.

The over-all SPL tends to remain constant beyond D_C while the direct sound continues to follow the inverse square law (decreases by 6 dB for every doubling of the distance). Hence, at $2D_C$ the ratio of direct-to-reverberant sound is −6 dB and at $4D_C$ it is −12 dB. Once the ratio has exceeded −12 dB the sound is no longer considered intelligible for good speech communication and such ratios are avoided in large sound-reinforcement systems. In small rooms where the time delays cause less interference, only the sound of the originating hall or studio is masked by the reverberant field of the small rooms.

Let's apply this information to three loudspeakers in the author's living room:

	D_C	$4D_C$
Omnidirectional dispersion	2.7 feet	10.8 feet
Hemispherical dispersion	3.87	15.48
90° × 90° dispersion	7.14	28.56

It can be seen that accurate reproduction of the ratio of direct-to-reverberant sound of the original signal is limited to listeners within 2.7 feet in the case of the omnidirectional loudspeaker, 3.87 feet with the hemispherical, and up to 7.14 feet with the 90° × 90° loudspeaker.

It is evident then that if all listeners in a 20-foot living room are to be in a position to hear accurate reproduction of the original signal, a directional loudspeaker should be used. If we sit back in the reverberant field of the loudspeaker in the listening room, we can change the ratio of direct-to-reverberant sound that we hear but it will have no relation to the signal originally recorded. This is because the ratio of direct-to-reverberant sound at the diaphragm of the recording microphone is far different in the larger hall than it would be in a small listening room. If you intend to faithfully reproduce the ratio of direct-to-reverberant sound that characterizes a famous hall or studio, you must sit in the predominantly direct sound field of the speaker in the listening room.

The current interest in four-channel reproduction leads directly to the problems we have been discussing. If the placement of the loudspeakers matches that of the microphones used, if the listener is sitting in all the loudspeaker's direct sound fields, and if each of the four channels is carefully equalized to ensure the same signal at the listener's ears as appeared at the microphone, the effect should be startling. However, there is danger that all four paths become additional reverberance sources in relation to the listener.

While it can be and is an interesting experiment as well as an artistic experience to artificially alter the ratio of direct-to-reverberant sound in the listening room, it shouldn't be thought of as a faithful reproduction of the original. For accurate reproduction (high fidelity) what really is desired is a loudspeaker with very stable and sufficiently narrow distribution characteristics that cover the listening area with predominantly direct sound and little else. ▲

Editor's Note: A somewhat different point of view will be expressed on this topic by George Augspurger, Technical Director of James B. Lansing Sound, in next month's issue.

Future of AMATEUR RADIO

Changing attitudes toward ham radio may affect significantly the future of electronics in the U.S.

By **John Frye**

MAC and Barney were goofing off. After delivering a color set to a country home, they had been driving along a deserted gravel road bordering the Wabash River when Mac suddenly pulled the truck off onto a grassy bank shaded by sycamore trees.

"Come on," he said to his redheaded assistant, "let's take a breather. Matilda can mind the store for a few minutes."

They strolled down to the edge of the placid stream, where Mac promptly sprawled on the cool grass and Barney followed suit. For a little while neither spoke as they watched a buzzard sailplaning against the blue sky overhead and listened to the almost inaudible murmuring of the river. Finally Barney broke the silence.

"Mac, remember a couple of months back when I exercised extremely bad timing and was off with the flu three days while one of the final amplifier tubes in my ham transceiver was kaput?"

"Yeah."

"Well, I could still use the receiver portion; so I spent a lot of time just listening across the bands—something I rarely do when the rig is operating. The experience was quite an eye-opener—or ear-opener, if you prefer."

"In what way?"

"In the way of who was doing the operating and what they were talking about. Most operators were apparently on the shady side of fifty and the conversation was definitely senior-citizenish. One group actually called itself the 'Old Duffers Net.' Another group pontificated daily on what's wrong with the country—the chief fault apparently being the country's failure to remain as it was a half-century earlier. Favorite subjects for discussion seemed to be physical ailments, DX, retirement plans, and boasts about important jobs held by grown children or the cute antics of grandchildren."

"You must have felt a little odd listening to those conversations."

"No more so than when I finally slid down to the Novice c.w. bands and found a few teenagers laboriously spelling out comments on drag racing, states they had worked, surfboarding, and chick-chasing."

"What kind of conversations did you expect to find?"

"The kind so common when I got into ham radio: chats about new transmitters being built, results obtained from new antennas, lots of talk about 'fists,' and spirited arguments about tank-circuit Q, whether or not you could trust v.s.w.r. readings, and the best way to tune a mobile whip antenna. I decided perhaps I had been listening too much in the daytime when you would normally expect to find the kids and the retired people on the air; so I did some more listening until nearly midnight. Same difference: the old timers were still talking politics and senior-grade DX; the youngsters were still talking junior-grade DX and cars. What I failed to find was a group of fellows in their twenties and thirties, young enough to be enthusiastic about their hobby but old enough and experienced enough to be doing something interesting and productive with it.

"This bothered me, and I combed through the magazines and fired off a letter to the ARRL, the one really important organization of American amateurs, to see if I were imagining a change in the typical ham."

"Were you?"

"No. The American amateur growth rate has been slowing down for the past few years. On June 1, 1950, there were 86,662 U.S. hams. This figure shot up to 160,000 by 1957 and reached a peak of 258,881 in 1965. Then, in 1966, our total actually slid down to 257,836; but we struggled back up to 260,052 by June of last year. This set of figures is all the more significant when viewed against the backdrop of the population explosion taking place in this same period.

"This slowdown has resulted in an increase in the age of the average radio amateur, but when you try to pin down just how much of an increase, you encounter frustration. The word 'average,' as you probably know, is merely a number indicating a central tendency of a group of samples or scores. At least three different kinds of averages are in common statistical use: the *mean*, the *median*, and the *mode*. The arithmetic mean is what you usually have in mind when thinking of an average. It is obtained by adding together all the scores and dividing by the number of scores.

"For example, suppose we have five hams aged respectively 16, 24, 35, 60, and 60. Our 'scores' in this instance are the respective ages; so we add them all together and divide by five and get a mean age of 39. To find the median, you arrange the scores in order and count in to the middle from either end. In an odd number of scores, the median will be the middle score; in an even number, it will be the arithmetic mean of the two most central scores. In our example, the median is 35 years. The mode is simply the most numerous score. That would be 60 years in our example. Only when all the scores are symmetrically distributed—falling away equally on either side of the most numerous center—do the mean, median, and mode coincide. The point I'm making is that you must know what 'average' a tabulator is talking about, and some of the writers I've read are a little careless in making this distinction.

"Anyway, according to a survey made by the Stanford Research Institute four years ago, the median age of the U.S. amateur rose from 34 in 1950 to 41.5 in 1966. Offsetting this, however, is the result of two surveys made in 1949 and again in 1969 by the ARRL to determine the age distribution of new amateur licenses. In the earlier year, the majority of licenses were obtained by a broad spectrum of ages between 17 and 32, with the greatest number being obtained at the age of 28. In 1969 the much narrower span 14 to 18 accounted for the great majority of new licenses, with the peak falling at 16. In 1969 more than five times as many 16-year-olds obtained new licenses as did the 28-year-olds.

"All this confirmed my own suspicions: ham population is clustered in the teens and the past-middle-age groups. Young adults are not represented in the ham population in accordance with their number in the population as a whole."

"Knowing you, I'll bet you've got some theories as to why."

"Yep," Barney said, propping himself up on his elbows, "I've got several theories, some from other people and some of my own. The decreasing growth of hams is partly due to the $4 fee for a license instituted a few years back. Formerly many hams kept their tickets even though they didn't use them, since there was no charge involved. Instituting the fee caused these people to drop their unused calls. In a few instances the license charge may have prevented prospective hams from getting a license; but I doubt this was true in many cases, since the fee is a small item compared to the cost of setting up an adequate ham station in these days of 'store-bought' rigs.

"Probably a more potent reason for the slow-down in our growth is the plain fact amateur radio no longer has the oh-gee-whiz quality for this blasé generation it had for my own. I was thrilled to pieces over the prospect of being able to send my voice through the air, but in these days kids can buy a couple of 100-milliwatt CB transceivers for twenty-five dollars that will let them talk back and forth for several blocks without a license of any sort. To their way of thinking, ham radio is just more of the same."

"I'm sure you're right," Mac said, nibbling on a sprig of pepper grass. "But there are other reasons I can think of. More high school graduates now go straight into college or into military service, and in either case they do not have the time necessary to devote to an absorbing hobby. Also, since the in-thing to do these days is to blame everything on TV, we may as well admit TV watching has inclined many youngsters toward being spectators rather than doers —especially when doing requires the hard study and the effort necessary for acquiring a ham license."

"That would be easy to fix if simply increasing the number of hams were the only consideration," Barney pointed out. "All we'd have to do would be to discard the present code requirements and make the written exam so easy anyone could pass it. Some manufacturers only interested in selling amateur equipment would like that. So would many individuals too lazy to study for a license. But this would not really extend the 'privilege' of being a ham intact to more individuals. Instead it would render it cheap and worthless."

"I sense you feel amateur radio is more than a fascinating hobby."

"You sense right," Barney grunted as he sent a stone skipping over the surface of the river. "I'm thoroughly convinced interest in ham radio has had a great deal to do with this country's leadership in the field of electronics. While amateur radio provides emergency communications in times of disaster and furnishes trained operators for the military, these contributions are secondary to its major function: sparking the interest of youth in this all-important field. As a friend of mine comments, 'You can whistle CQ on the campus of any great engineering university, in any major electronic research lab, or in a NASA control center and get an answer from another ham—or probably several answers.' Wherever important action is in the field of electronics you'll find hams or ex-hams."

"I see what you're driving at. You think an interest in ham radio motivates a youngster strongly at a most important time in his life and that this interest-motivation stays with him."

"That's right, and I think this sort of motivation is the best there is for productivity in a highly technical field requiring dedication and continuous study. As our society becomes more affluent, money becomes less effective as a motive for hard work. In fact, it's not very effective now. Increasing a worker's pay often encourages absenteeism because the worker feels he can afford to lay off and do something more interesting."

"Glad to hear you testify," Mac commented, getting up and brushing his trousers. "I was going to give you a raise, but now I'll not risk it."

"Don't forget I'm a highly motivated ham!" Barney said quickly. "Seriously, I see no great cause for concern in the slow-down in ham growth in view of all the social, economic, and cultural factors contributing to it. Ham radio, like mathematics or playing the piano, is not for everyone.

"But somehow, in some way, we should manage to inform more youngsters about what ham radio has to offer in the way of challenge to intelligence and skill, in the way of world-wide comradeship, and in the way of diversity of amateur activities: DXing, experimenting, traffic handling, teletypewriter operation, communicating *via* television or satellite, etc. We should let the youngsters see clearly the great gulf that separates the CB operator from the radio amateur. Let us do that, and all ages will again be heard regularly on the ham bands, and America will not lack for enthusiastic and dedicated workers to keep us in the forefront of electronic progress—hey, wait for me!" he called as he heard Mac start the truck. ▲

CAPACITOR SALES SOAR

THE capacitor industry made huge gains in 1969, racking up an 11.1% increase over 1968, according to data compiled by EIA's Marketing Services Department. U.S. factory sales of capacitors amounted to $489.7 million in 1969 as against $440.9 million for 1968.

Total unit sales reached 3.1 billion during 1969, an increase of 7.9% over unit sales of 2.9 billion in 1968.

Tantalum electrolytics paced the year's gains with an increase of 22.1% in dollar volume and 61.2% in unit sales. Significant gains were also registered for paper and film dielectric types, aluminum electrolytics, and mica dielectrics.

Ceramic dielectric fixed types and variable capacitors were down in dollar sales during 1969. ▲

FET's as Audio Switches

(*Continued from page* 46)

appropriate type of FET to provide the signal switching.

By experiment it was found that $R2$ must be 33k for maximum V_{out} for a given V_{in} (Fig. 2). The cut-off voltage varies inversely with $R1$.

Fig. 3 is a circuit for use with a negative-supply system in which a voltage of $\leqq -0.7$ V at V_{B2} will provide a signal at V_{out}. There is a very sharp transition from no output to maximum V_{out} as -0.7 is reached at V_{B2}. If this switching point voltage needs to be reduced (made more negative) a zener diode may be put in series with the base.

Fig. 4 is a circuit to be used with a positive-voltage system. The input signal appears at the output whenever V_{B2} is $\geqq 0.7$ V.

An alternative method of control is to make $V_{B2} = 0$ and vary V_S. The output signal will then be cut off when $V_S \geqq +2.7$ V. As with the negative-voltage system, zener diodes may be used in series with the base of the 2N3904 to increase the voltage required to pass the input signal.

Some measured values taken with several different zeners in series with the base of the 2N3904 are given in Table 2.

Incidentally, the input impedance of this circuit (Fig. 2) is approximately 16 megohms when $R1$ and $R3$ are removed. This means that if $R1$ is not used, the impedance seen looking into the switch from the source will be the input impedance of the circuit driven from it (when this is $<<16$ megohms).

The circuits of Figs. 3 and 4 may also be used to produce blocks of r.f. (up to several MHz) pulsed at an audio rate as indicated by the waveforms included in Fig. 4. The r.f. must be fed to the V_{in} terminals with the audio applied at V_{B2}. ▲

Type	Maximum V_{in} for sine-wave V_{out} at $V_G=0$ (peak-to-peak V)	V_{out} for Maximum V_{in}	V_G to reduce V_{out} to zero for maximum V_{in}
"n"-Channel			
2N5457	2.5V	2.2V	−3.1V
2N5459	7.9V	7.0V	−9.1V
2N3819	4.9V	4.5V	−6.0V
3N126	3.7V	3.2V	−5.5V
"p"-Channel			
2N2386	4.3V	3.6V	+6.0V
2N4360	4.1V	3.6V	+5.9V

Table 1. Specifications of low-cost "p-" and "n-" channel FET's. Values used to compile this table: R1—2.2k, R2—33k, R3—4.7k.

Table 2. Measured values with several different zeners in series with the base of 2N3904 transistor shown in circuit of Fig. 4.

Zener diode type	Minimum d.c. input to produce max. V_{out}	Maximum d.c. input to cut off V_{out}
None	0.75V	0.70V
1N702	1.87V	1.80V
1N703	2.38V	2.30V
1N705	4.30V	3.90V

Universal REGULATED POWER SUPPLY

By ROY A. WALTON

A professional-quality, versatile power supply that can be inexpensively constructed from easily obtainable spare parts.

THE power supply is the most common, and frequently the most expensive, component in electronic gear. For these reasons, a single power supply that can be adjusted over a wide range to meet the needs of many different electronic devices would be more economical than putting a separate power supply in each unit.

Here is a highly versatile power supply that can be constructed at moderate cost. It has a.c. outputs for 12.6 volts and 6.3 volts as well as switched outputs that furnish 400 volts d.c. (unregulated), 200 to 300 volts d.c. (continuously variable) electronically regulated at better than 1% for loads up to 60 milliamps, 375 or 150 volts d.c. from voltage-regulator tubes, and 150 to 0.1 volt d.c. for loads from 100 milliamps to 1 milliamp. Its moderate cost is due to the fact that most of the expensive components can be found on a discarded TV chassis. (Your local TV service technician will probably sell you an old chassis that still has a power transformer, filter chokes, and capacitors on it for a few dollars.)

This power supply (Fig. 1) is actually four separate units tied together by switch *S2A* and *S2B*. The rectifier-filter circuit is made up of parts with suffix numbers 1 through 3. Your attention is directed to the parts list which gives a range of values for these components that will work well. The voltage-regulator tube circuit has parts suffixed 10-12, the electronic voltage-regulator parts are numbered 20-27, and the voltage divider network 30-37.

One or more of these four units can be constructed and used in conjunction with other apparatus as long as the unit is supplied with proper voltages and the output ratings are not exceeded.

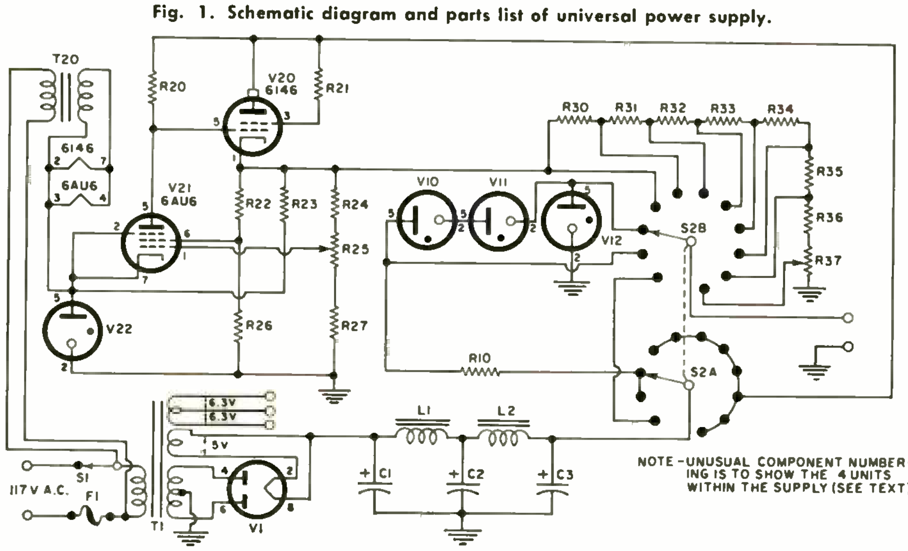
Operation

Full-wave rectifier *V1* rectifies the secondary voltage of *T1*, while *C1*, *C2*, *C3*, *L1*, and *L2* serve to smooth the rectifier ripple voltage. An estimate of the expected no-load output voltage for this type circuit can be obtained by multiplying the transformer secondary voltage by 0.707. Switch *S2A* routes this filtered voltage to either the voltage-regulator tube circuit or the electronic voltage regulator.

When the voltage is routed to the VR tube circuit, it is passed through *R10*, a limiting resistor which is of a value that will just permit minimum tube current to flow and allow maximum permissible tube current to flow when there is no load. (If in building this unit the output voltage of the rectifier-filter is not 440 volts, *R10* may be calculated by using the formula: $R = (E_S - E_R)/I$, where *R* is the resistance in ohms, E_S the source voltage, E_R the sum of the related voltage drops of the tubes, and *I* the maximum rated current in amps (*e.g.*, $R = 450 - (150 + 150 + 75) / 0.03 = 2500$ ohms).

The action of the electronic voltage regulator is as follows. *V22* furnishes 105 volts reference for the control tube, *V21*. When the load on the output terminals increases, the output voltage decreases and this condition causes the control grid of *V21* to become less positive which, in turn, causes *V21* to draw less current through *R20*. As less current flows through *R20* the grid voltage of the series regulator, *V20*, becomes more positive and the voltage drop across this tube decreases, thereby compensating for the reduction in output voltage.

Fig. 1. Schematic diagram and parts list of universal power supply.



R10—2000 ohm res.
R20—2.2 megohm res.
R21—470 ohm res.
R22—100,000 ohm res.
R23—7500 ohm, 5 W wirewound res.
R24—47,000 ohm res.
R25—100,000 ohm pot
R26—150,000 ohm res.
R27—68,000 ohm res.
R30—1500 ohm, 25 W wirewound res.
R31—1000 ohm, 10 W wirewound res.
R32—2000 ohm, 5 W wirewound res.
R33, R34—10,000 ohm, 5 W wirewound res.
R35—20,000 ohm, 2 W res.
R36—68,000 ohm, 1 W res.
R37—50,000 ohm pot
C1—8 μF, 1000 V elec. capacitor (or 160-8 μF, 450 w. V d. c. min.)
C2—8 μF, 1000 V elec. capacitor (or 80-8 μF, 450 w. V d.c. min.)
C3—10 μF, 600 V elec. capacitor (or 40-10 μF, 450 w. V d.c. min.)
L1, L2—8 H choke (or 4-12 H)
F1—5 A fuse
S1—S.p.s.t., 2A, 110V switch
S2—11-pos., 2 deck rotary switch
T1—Power trans. 117 V: pri.: 610 V c.t.; 5 V, 12.6 V c.t. sec. (see text)
T20—Fil. trans. 117 V: 6.3 V
V1—5R4WGY (or 5AS4A, 5AV4, 5DB4, 5R4G 5V4G, 5V3, 5T4, 5Y3, 5Z3, 5931)
V10, V11—OA2 (or VR-150, 6073, 6626)
V12—OC2
V20—6146 (or 5933, 807, 6L6GB)
V21—6AU6 (or 6AU6A, 6BA6, 6136, 7543)
V22—OB2 (or 6074, 6627)

Potentiometer $R25$ is used to vary the output voltage from 200 to 300 volts.

The tube heaters are run with their a.c. voltage at d.c. reference-voltage potential so as to not exceed the heater-to-cathode voltage ratings of the tubes. $T20$ should either be a separate filament transformer or a winding on $T1$ that is isolated from all other windings. It is not advisable to use the same 6.3 volts for $V20$ and $V21$ as used for the 6.3-volt a.c. output, as the heaters, and consequently the voltage across them, are floating at 105-volt d.c. In the prototype, the heater voltage for these tubes is obtained from $T20$, a separate filament transformer. If transformer $T1$ is chosen with an extra 6.3-volt secondary, $T20$ will not be needed.

Voltage Divider

Output from the electronic voltage regulator is fed directly into the voltage-divider network. This network is designed so that by selecting the proper tap with $S2B$ and adjusting $R25$, voltages ranging from 150 volts to 0.1 volt may be obtained for loads from 100 milliamps to 1 milliamp. Output from the divider is not considered a regulated voltage. Potentiometer $R37$ in this network serves to adjust very low voltage at low loads.

The values given in the parts list are those used in the prototype with a range of acceptable substitutes shown in parentheses. A tube manual should be consulted for the proper tube pin numbers when using other than the tubes listed as they vary from those given on the schematic.

Parts placement is non-critical; however, wire and switches should be "heavy" enough to handle the power requirements. ▲

"All I did was turn on my RC transmitter and it opened every garage door within five miles."

MOSFET Utility Preamp for Test Equipment

By J. F. STERNER
RCA Electronic Components

Simple 20-dB preamp to extend range of scope, a.c. voltmeter or v.t.v.m. Can also be used as microphone preamplifier.

An easy-to-build preamplifier that extends the sensitivity of oscilloscopes, a.c. voltmeters, and the 1.5-volt a.c. range of vacuum-tube voltmeters has been developed. In addition, the preamplifier may be employed with either high- or low-impedance microphones.

The preamplifier, shown in Fig. 1, uses an *RCA* 3N128 or 40467 MOS transistor with two diodes placed in the gate circuit for protection against accidental overload. The maximum recommended input level to the preamp is 0.5 volt peak-to-peak; larger signals cause conduction in the protective diodes and result in signal distortion. However, the preamp is not needed with the above instruments when input signals greater than 0.5 volt are available.

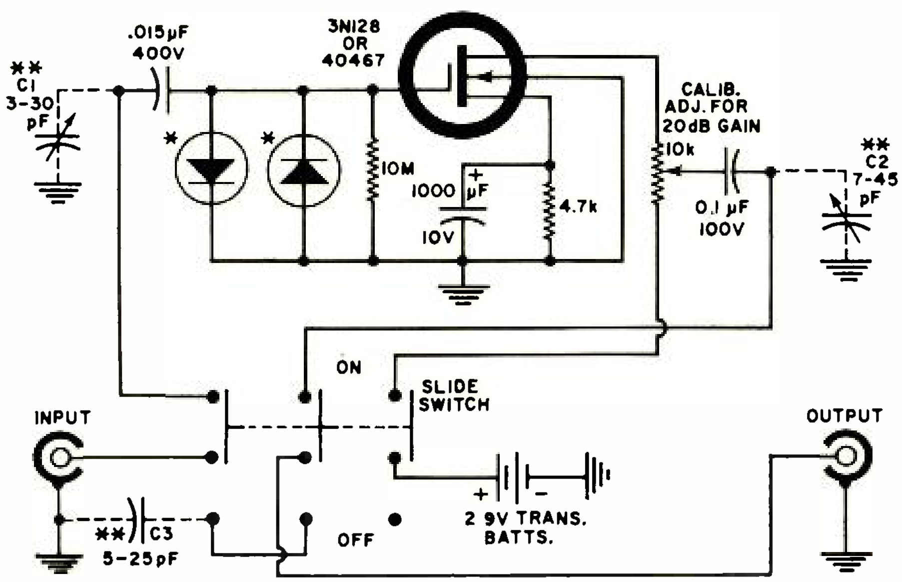
Power for the preamp is supplied by two 9-volt transistor-radio batteries, connected in series. The small current drain of the circuit (less than 0.5 milliampere) results in long battery life.

In addition, preamp gain is relatively stable with changes in battery voltage; for a drop from 18 to 12 volts, the unit exhibits less than a 10-percent drop in gain. The total gain of the preamp is greater than 20 dB, and can be adjusted to exactly 20 dB (10×) by means of a potentiometer in the drain circuit of the MOS transistor.

The a.c. input impedance of the circuit is greater than 1 megohm at 1000 Hz; frequency response is within 1 dB from less than 30 Hz to more than 100 kHz. Trimmer capacitors may be added, as shown in Fig. 1, to retain the wide-band performance of oscilloscopes equipped with probe and cable assemblies.

When the "On/Off" switch of the preamp is in the "Off" position, the input is connected directly to the output.

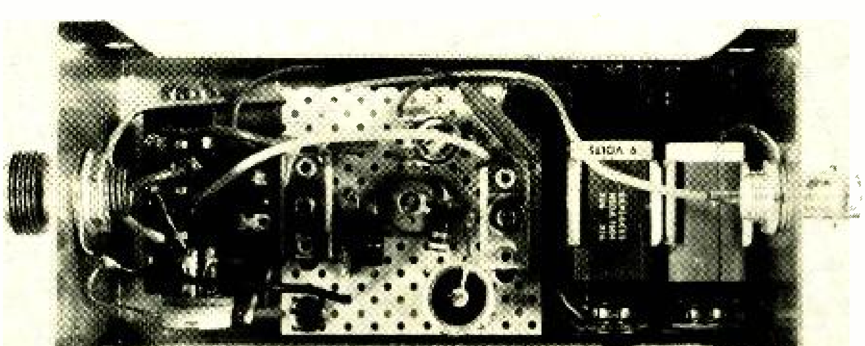
The preamplifier circuit is built on a 2 × 2-inch piece of perforated circuit board, as shown in the photo. All component leads are pulled through the holes and connected and soldered at the rear. Two ⅜-inch-long threaded spacers are used to mount the board to the chassis. The completed circuit is mounted in a 5 × 2¼ × 2¼-inch closed chassis box.



* IN914 OR ANY HIGH-FREQ., HIGH-BACK-RESIS. SILICON DIODES FOR GATE PROTECTION
** OPTIONAL ADJUSTMENTS FOR BEST SQUARE-WAVE RESPONSE

Fig. 1. Circuit of high-gain preamp shows the use of a MOSFET.

Inside view of preamp with cover removed. Circuit is on 2" x 2" perforated board. Power is from pair of transistor batteries.



Test and Calibration

Calibration of the preamplifier depends on its application. In general, an audio generator is used to provide an input signal to the preamplifier which, in turn, is connected to the measuring apparatus with which it is to be used. In using the preamp to increase the sensitivity of a scope, proceed as follows. First, the preamp is switched to the "Off" position, the oscilloscope vertical-gain control is set for maximum sensitivity, and the generator output is set for a 2-inch trace at 1000 Hz. The scope's vertical range is then set for one-tenth of maximum sensitivity to produce a trace of 0.2 inch. At this point, the preamp is turned "On" and the preamp "Calibrate" control is adjusted until a 2-inch deflection is again produced on the scope; this procedure adjusts the circuit for exactly 20-dB gain.

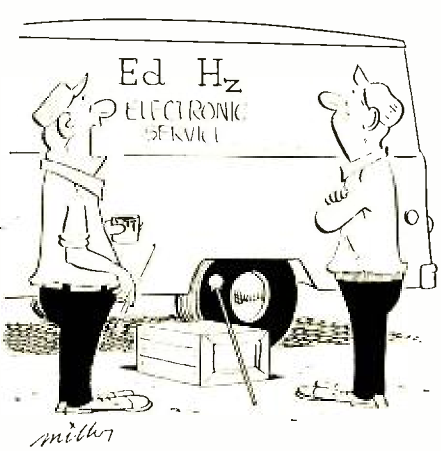
The same basic procedure is followed if the preamp is to be used with an a.c. voltmeter. In this case, it is desirable to use a reference point of 0.8 of full scale on the most sensitive range with the preamp turned off. The meter scale is then switched to a 10-times-less-sensitive range, and the preamplifier is turned on and adjusted to produce the original meter reading.

If the preamp is to be used with a v.t.v.m., it should be used only to extend the 1.5-volt a.c. scale to 0.15-volt a.c. after calibration to a particular instrument. The signal from the audio generator is first set for 0.15 volt with the preamplifier turned off, and then the preamplifier is turned on and adjusted for a reading of 1.5 volts or a gain of 20 dB. Because the a.c. input resistance of a v.t.v.m. changes with range switch position, this calibration will not be correct for scales other than the 1.5-volt a.c. range.

High-quality scopes have shielded probes and cables that are capacitance-compensated to retain high input impedance at high frequencies. When the preamp is used with such scopes, the capacitance of the connecting shielded lead is sufficient to require correction if the original performance is to be retained. This compensation can be provided in the preamp circuit as follows:

First, a 12-inch-long RG-62U coaxial cable is used to connect the preamp to the scope's vertical input. Because this cable represents added capacitance of about 15 picofarads to the scope, the cable compensating capacitor must be removed from the scope and placed in the preamp; this capacitor is shown as C3 at the "On/Off" switch in Fig. 1. At this point, the preamplifier is calibrated for 20-dB gain, as described previously. With the preamp switch in the "Off" position, C3 is then adjusted as recommended in the oscilloscope instruction book. The preamp is then switched on, and the signal from the audio generator is reduced until the scope trace amplitude and waveform are equivalent to those in the off position. Capacitors C1 and C2 can then be adjusted alternately to obtain the same waveform obtained previously in the off position.

If the preamp is to be used only for low-frequency amplification (1000 Hz or less), capacitors C1, C2, and C3 may be omitted. ▲



"OK, but E,D,H,Z doesn't make much sense to me, Mr. Hertz."

Electronics World SUBSCRIBER SERVICE

Please include an address label when writing about your subscription to help us serve you promptly. Write to: Electronics World, P.O. Box 1093, Flushing, N.Y. 11352

CHANGE OF ADDRESS: Please let us know you are moving at least four to six weeks in advance. Affix magazine address label in space to the right and print new address below. If you have a question about your subscription, attach address label to your letter.

AFFIX LABEL

name address city state zip-code please print

If you have no label handy, print OLD address here.

TO SUBSCRIBE: Check boxes below.

☐ New ☐ Renewal
☐ 5 years $26
☐ 3 years $18
☐ 1 year $7

SPECIFY:

☐ Payment enclosed—You get 1 extra issue per year as a BONUS!
☐ Bill me later.

Add'l postage: $1 per year outside U.S., its possessions & Canada.

name ______ please print ______ 0335

address ______

city ______

state ______ zip-code ______

BOOKS

"RADIOLOGICAL HEALTH HANDBOOK" compiled and edited by Bureau of Radiological Health and the Training Institute, Environmental Control Administration. Revised 1970 Edition. 447 pages. Price $4.00. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. (PHS Publication No. 2016.)

This is a basic reference work for radiological health personnel and students and reflects radiological health responsibilities under the new Radiation Control for Health and Safety Act. Changes resulting from progress in radiation-protection technology as well as those reflected by the Act are incorporated in this up-dated handbook.

This 1970 edition contains a new chart of the nuclides, a universal decay table instead of individual isotope listings, microwave and laser glossaries, film-speed charts, depth-dose tables, and "rules of thumb" information.

Those working with lasers, x-ray equipment, or those who design color-TV receivers and equipment that radiate to some degree will find this a valuable reference source of vital information.

* * *

"RADAR HANDBOOK" edited by Merrill I. Skolnik. Published by *McGraw-Hill Book Company,* New York. 1536 pages. Price $39.50.

This comprehensive treatment of the major aspects of radar brings together the knowledge of 51 experts, each writing about his specialty. Prepared for those who are involved in the design, development, or procurement of radar systems as well as researchers in radar technology, this massive volume covers both military and civilian applications of radar, including marine radar, satellite surveillance radar, radar astronomy, and spaceborne radar. In addition, the Handbook includes information on lasers, beacons, passive detection, and electromagnetic capability as related to radar.

Since the authors have assumed that those using this reference work are familiar with radar circuitry, no attempt has been made to provide mathematical derivations or detailed exposition. Extensive bibliographies accompanying each chapter permit the user to delve deeper if he desires.

With 1140 illustrations, a comprehensive index, and the broad coverage provided, this volume should become *the* source for up-to-date and authoritative information on any aspect of radar components and performance.

* * *

"RCA RECEIVING TUBE MANUAL" compiled and published by *RCA Electronic Components,* Harrison, N.J. 07029. 672 pages. Price $2.00. (Technical Series RC-27)

This newly revised and updated edition of the manual provides information on the entire line of home-entertainment type receiving tubes, picture tubes for black-and-white and color TV, and voltage-regulator and voltage-reference tubes made by *RCA.*

The circuits sections, which is always a popular feature of these manuals, covers 36 practical tube applications and includes detailed descriptions explaining the function and operation of individual stages and the complete circuits to help those building equipment from the schematics.

There is, as usual, an applications guide for receiving tubes, data and curves covering all active receiving types, data on discontinued and replacement types, tabular charts of data on picture tubes, voltage regulators, and voltage reference tubes as well as basing diagrams and other useful information.

* * *

"BASIC ELECTRIC CIRCUITS" by Donald P. Leach. Published by *John Wiley & Sons, Inc.,* New York, N.Y. 657 pages. Price $9.95.

This volume is addressed to technical school students and electrical/electronics technicians who wish to up-grade their skills. In twenty chapters the author covers electrical fundamentals, network theorems, d.c. meters, general network equations, magnetics, inductance, capacitance, series and series-parallel a.c. circuits, resonance, and three-phase circuits. A working knowledge of arithmetic and algebra is the only prerequisite for using this text.

The author has provided five appendices which include most of the tables and charts used in conjunction with the text. Answers to review questions and selected problems are also included either for self-checking or for classroom exams.

* * *

"HOW TO USE TEST INSTRUMENTS IN ELECTRONICS SERVICING" by Fred Shunaman. Published by *Tab Books,* Blue Ridge Summit, Pa. 17214. 251 pages. Price $7.95 hardbound, $4.95 paperbound.

This handy manual outlines basic techniques for using standard test equipment in servicing various types of electronic circuitry, including radios, TV sets, audio equipment, and CB gear.

Included are discussions of scopes, multimeters, signal generators, sweep and color generators, audio servicing instruments, the capacitor checker, probes, tube/transistor and special-purpose checkers, and signal-tracing instruments. A concluding chapter deals with instrument maintenance.

The text is well illustrated with photos of equipment, partial schematics, scope traces, line drawings, and pictorials but it suffers from poor proofreading as well as a number of technical inconsistencies.

* * *

"CB RADIO OPERATOR'S GUIDE" by Robert M. Brown. Published by *Tab Books,* Blue Ridge Summit, Pa. 17214. 220 pages. Price $6.95 hard cover, $3.95 soft cover.

This is an introductory text for new and would-be CBers. In ten informally written chapters the author covers an introduction to CB, getting a license, selecting equipment, the hand-held transceiver, CB antennas, coax cable and connectors, the installation, how to optimize a station, troubleshooting equipment, and CB and public service (providing emergency assistance).

A comprehensive appendix reprints FCC rules, Canadian rules, a listing of class-D channels and frequencies, and details on Part 15 channel regulations.

This volume is lavishly illustrated not only by line drawings, charts, tables, and graphs but by hundreds of photographs showing various types of equipment and how it is used in different situations.

Anyone considering the purchase of CB equipment should read this thorough-going analysis of equipment and procedures before laying out his hard-earned cash for a rig.

* * *

"WORKSHOP IN SOLID STATE" by Harold E. Ennes. Published by *Howard W. Sams & Co., Inc.,* Indianapolis, Ind. 46206. 371 pages. Price $9.95.

Although this volume was designed as a training adjunct for broadcast engineers making the transition from tube circuitry to transistorized equipment, the text can be used by technicians in other electronic equipment servicing fields.

Since the students are assumed to have fairly extensive vacuum-tube know-how, the exposition is at an advanced level with basics covered in review fashion rather than in depth. There are experiments to be performed, questions to be answered, and formulas to solve but none of these need hinder those with a good practical working knowledge of electronic circuitry. ▲

Satellite Communications

(*Continued from page* 36)

suppressors. Few people made any comments about delay or echo.

The third way to get rid of echo is with an echo canceller. These devices are still in the laboratory stage, but some units have been described and demonstrated at scientific meetings.

One is the *impulse-response* variety (Fig. 7). In this canceller, an impulse—a sharp, narrow, high-amplitude spike—is generated at the receive branch at the beginning of a telephone call. The impulse hits the hybrid and travels down the two-wire line. If the line is not matched to the compromise network, some of the impulse will eventually appear at the transmit branch. From its changed shape, we know everything about the impedance of the two-wire line over which the original impulse traveled. This impulse response is then stored in a digital memory. Then, all during the conversation, speech coming in at the receive branch is multiplied by this impulse response and subtracted from the signal appearing on the transmit branch. This process will cancel all the echo, but will have no effect on speech originating on the two-wire side.

The problems with this canceller that have yet to be solved include the following: the two-wire line connected at the beginning of the call may not be the one used for the entire conversation. For example, many business calls are answered at a local switchboard and then connected to the desired extension; the impulse response from the switchboard may not be the same as from the extension. For another thing, the impulse response describes linear networks. If there are non-linear elements, such as a compandor, in the connection, they will distort the measurement. Lastly, the characteristics of the line can change during the conversation.

Another canceller now being developed is based on *automatic-transversal filters* (Fig. 8). This device looks for correlation—that is, similarities—between the signals at the receive branch and transmit branch. It then generates a waveform designed to cancel any signal at the transmit branch that correlates with an earlier signal on the receive branch. Only echoes will show that kind of correlation.

The problem with this type of canceller is that it takes a long time to "settle." That is, it may take from half a second to five seconds to adjust itself, depending on how loud the echo is. During that time, any talking by the party at the near end will confuse the canceller.

When they work the bugs out of these cancellers, maybe the Thompsons will get invited to dinner. ▲

1 LEADER IN ELECTRONICS TRAINING

When you think of electronics, you immediately think of RCA...a name that stands for dependability, integrity and pioneering scientific advances. For over a half century, RCA Institutes, Inc., a service of Radio Corporation of America, has been a leader in technical training.

2 RCA AUTOTEXT TEACHES ELECTRONICS FASTER, EASIER, ALMOST AUTOMATICALLY

Beginner or refresher, AUTOTEXT, RCA Institutes' own method of programmed Home Training will help you learn electronics more quickly and with less effort, even if you've had trouble with conventional learning methods in the past.

3 THOUSANDS OF WELL PAID JOBS ARE NOW OPEN TO MEN SKILLED IN ELECTRONICS

RCA Institutes is doing something positive to help men with an interest in electronics to qualify for rewarding jobs in this fascinating field. Every year, literally thousands of high paying jobs in electronics go unfilled just because not enough men take the opportunity to train themselves for these openings.

4 WIDE CHOICE OF CAREER PROGRAMS

Start today on the electronics career of your choice. On the attached card is a list of "Career Programs", each of which starts with the amazing AUTOTEXT method of programmed instruction. Look the list over, pick the one best suited to you and check it off on the card.

5 SPECIALIZED ADVANCED TRAINING

For those already working in electronics or with previous training, RCA Institutes offers advanced courses. You can start on a higher level without wasting time on work you already know.

6 PERSONAL SUPERVISION THROUGHOUT

All during your program of home study, your training is supervised by RCA Institutes experts who become personally involved in your efforts and help you over any "rough spots" that may develop.

7 VARIETY OF KITS YOURS TO KEEP

To give practical application to your studies, a variety of valuable RCA Institutes engineered kits are included in your program. Each kit is complete in itself. You never have to take apart one piece to build another. At no extra cost, they're yours to keep and use on the job.

8 FROM RCA INSTITUTES TRANSISTORIZED TV KIT, VALUABLE OSCILLOSCOPE

Those enrolled in RCA's television course or program receive complete transistorized TV Kit. All students receive a valuable oscilloscope—both at no extra cost and only from RCA Institutes.

9 CONVENIENT PAYMENT PLANS

RCA Institutes offers a unique tuition plan that lets you progress at your own pace. You only pay for lessons as you order them. You don't sign a contract obligating you to continue the course. There's no large down-payment to lose if you decide not to continue. However, if you desire, RCA Institutes also offers a convenient monthly payment plan.

10 RCA INSTITUTES GRADUATES GET TOP RECOGNITION

Thousands of graduates of RCA Institutes are now working for leaders in the electronics field; many others have their own profitable businesses. This record is proof of the high quality of RCA Institutes' training.

CLASSROOM TRAINING ALSO AVAILABLE

If you prefer, you can attend classes at RCA Institutes Resident School, one of the largest of its kind in New York City. Coeducational classroom and laboratory training, day and evening sessions, start four times a year. Simply check "Classroom Training" on the attached card for full information.

JOB PLACEMENT SERVICE, TOO!

Companies like IBM, Bell Telephone Labs, GE, RCA, Xerox, Honeywell, Grumman, Westinghouse, and major Radio and TV Networks have regularly employed graduates through RCA Institutes' own placement service.

SEND ATTACHED POSTAGE PAID CARD TODAY! FREE DESCRIPTIVE BOOK YOURS WITHOUT OBLIGATION! NO SALESMAN WILL CALL!

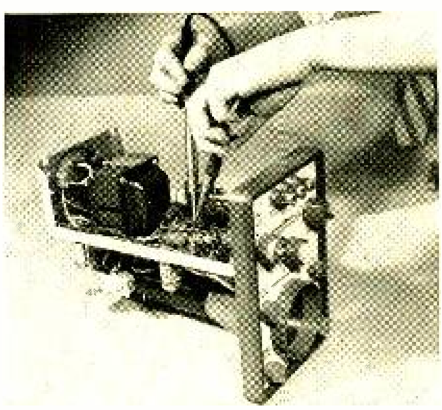
All RCA Institutes courses and programs are approved for veterans under the New G.I. Bill.

RCA INSTITUTES, DEPT. 240-008-0
320 West 31st Street,
New York, N.Y. 10001

Accredited Member National Home Study Council

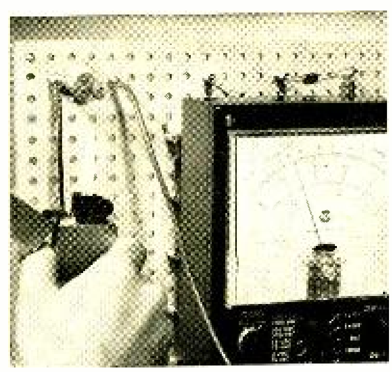
RCA

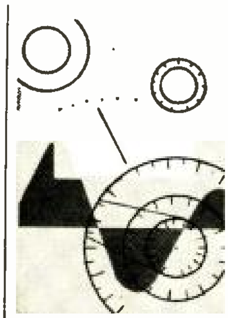
Construction of Multimeter.



Construction of Oscilloscope.

Temperature experiment with transistors.





TEST EQUIPMENT

Product Report

Triplett Model 801 Solid-State V.O.M.

For copy of manufacturer's brochure, circle No. 3 on Reader Service Card.

NEW solid-state v.o.m.'s are coming from the test-equipment manufacturers almost faster than we can count them. One of the latest we have seen is the new *Triplett* Model 801. The manufacturer refers to this unit as a laboratory instrument and it should find much use not only in laboratories but for advanced electronic servicing as well.

A unique feature of the new meter is the use of two ohmmeter circuits. One of these, referred to as "conventional ohms," uses a 1½-volt power source. The other, referred to as "low-power ohms," uses a 35-millivolt power source. The former circuit applies 57 mW of power to the device under test on the lowest ohms range and correspondingly less power at the higher ranges. The low-power ohms circuit, on the other hand, applies only 35 μW of power to the device under test on the corresponding range, and lower power at the higher resistance ranges. This means that we can measure front and back resistance of transistors, diodes, and IC's without the ohmmeter voltage source biasing the semiconductors either into or out of conduction.

The 8-in meter, with its mirrored scale, is extremely easy to read. There is a single scale for all resistance measurements and a dual linear scale for all a.c. and d.c. measurements. A dB scale is also provided. The meter movement is a 25-μA taut-band unit.

Six transistors, including an FET for high-impedance input, along with four semiconductor diodes are used in the instrument. Four batteries are employed to make the unit completely portable. One of these is a standard 1.5-volt "D" cell used as the conventional ohmmeter battery. The other three are 4.2-volt mercury or alkaline batteries used for zero reference and to supply power to the transistor meter amplifiers.

The solid-state v.o.m. has 10 d.c. voltage ranges at 11 megs input resistance at 2% accuracy, 12 a.c. voltage ranges at 10 megs input resistance at 3 or 5% accuracy, 12 dB ranges, 12 a.c. and d.c. current ranges at 3 or 4% accuracy, 7 conventional ohms ranges, and 8 low-power ohms ranges.

Price of the new Model 801 is $200, including shielded probe. ▲

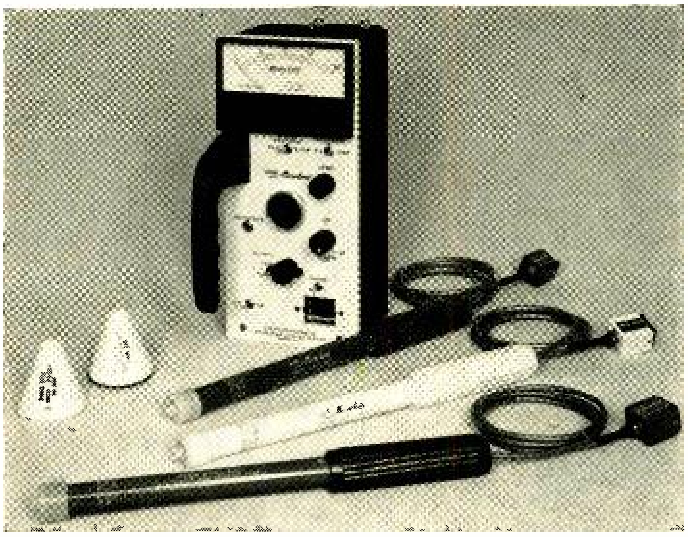
Narda Model 8100 Electromagnetic Radiation Meter

For copy of manufacturer's brochure, circle No. 4 on Reader Service Card.

THIS month we are running Part 1 of a two-part article on microwave ovens. In order to make sure that these ovens do not leak excessive electromagnetic radiation, we must have some sort of detector and radiation meter to check such leakage. The *Narda* Model 8100 is just such an instrument. It was developed as an outgrowth of a cooperative effort on the part of company engineers, *Underwriters' Laboratories*, the National Center for Radiological Health, and various microwave oven makers.

The instrument is able to accurately measure radiation close to the oven door. It measures the total field radiated rather than just one field of a particular polar orientation. The Model 8100 is a direct-reading instrument with a wide range of power-density levels. It is also portable, light in weight, and uses a probe-type scanner with the readout device separated from the antenna.

The detector is calibrated at 915 and 2450 MHz, the two frequencies most commonly used for microwave cooking. Accuracy is ±1 dB at both frequencies. Radiation densities are indicated on a compact metering unit which weighs only 3½ lbs. The meter is powered by



a 15-volt rechargeable nickel-cadmium battery, or it can be operated from a 115- or 230-volt a.c. power line.

Three different probes, each having a dynamic range of 23 dB, can be used with the meter. The hand-held probes are interchangeable and provide full-scale power density indications from 200 μW/cm^2 to 200 mW/cm^2. Accurate readings can be made as low as 10 μW/cm^2. (The newly proposed standard maximum level of radiation for ovens is 5 mW/cm^2.) The probes, containing antenna and detector, are so designed that they do not distort the field being measured. As a matter of fact, the higher frequency probe can be as close as 2-in from a radiating source without affecting the field. This permits close-up measurements to be made of radiation coming from cracks and joints at varying distances from the radiating source. Normally, a 2-in long foamed polyethylene spacer is placed on the probe tip to maintain an accurate distance spacing for the measurements.

The unit is equipped with an audible alarm which sounds if the power density is greater than the preset level. The alarm also sounds if the test instrument becomes inoperative for any reason.

Price of the Model 8100, complete with shielded and padded carrying case, battery, recharging line cord, and one probe and spacer is $725. The one probe provides two power ranges (0.2 and 2 mW/cm^2 full-scale, or 2 and 20 mW/cm^2 full-scale, or 20 and 200 mW/cm^2.) Three probes are required to cover the entire range of power-density measurements. Price of the instrument with all three probes is $960. ▲

Sencore BE156 Bias Supply

For copy of manufacturer's brochure, circle No. 5 on Reader Service Card.

WHEN the technician prepares to sweep-align a color-TV receiver, he needs a d.c. bias supply to deliver voltages to the front-end and i.f. strip of the receiver. Many sweep generators include a source of d.c. bias voltage to be used for this purpose. However, TV set manufacturers are continuing to specify additional voltages for alignment work. Hence, a source of one or two bias voltages may not be sufficient to do the job. *Sencore's* previous model of this unit, the BE113, for example, provided only two negative-output 20-volt supplies.

This new BE156 supply provides three separate, adjustable 0 to 25-volt supplies and these can be switched to either positive or negative polarity. The negative bias voltages are needed for tube-type receivers, while positive bias voltages are required for solid-state sets. The circuit consists of a half-wave rectifier using a solid-state diode working into an *RC* filter network.

In addition to the three bias supplies, an output voltage of 0 to 75 volts negative is provided for those solid-state color sets using 67.5 volts to bias the chroma amplifiers during alignment.

This seven-in-one bias supply is versatile enough so that it can be used with any sweep and marker generator. The three 25-volt supplies are well-filtered at 1/10 of one percent ripple and have little or no interaction between them. The output test leads can even be shorted together regardless of switch or control settings without damage to the unit.

Price of the new *Sencore* Model BE156 is $24.95. ▲

(Continued from page 50)

circuits. In addition, a selection of the integrated circuits to be covered in later articles will be introduced. A typical digital integrated circuit product line from one manufacturer will be examined to demonstrate the affect of performance, packaging, and operating temperature on cost.

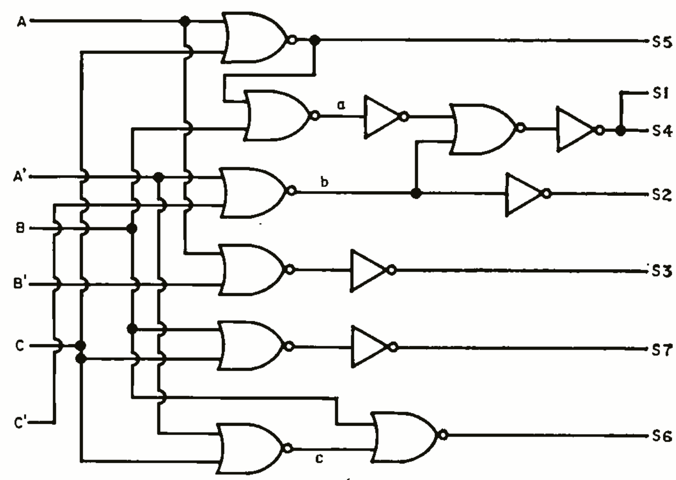
(Continued Next Month)

REFERENCES

Lancaster, Donald E.: "Using New Low-Cost Integrated Circuits," ELECTRONICS WORLD, March, 1966.

Lancaster, Donald E.: "IC Decimal Counting Techniques," ELECTRONICS WORLD, September, 1968.

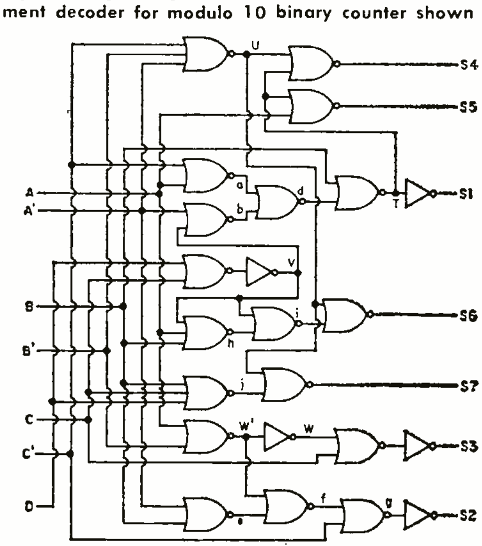
Steinbach, Donald L.: "IC Frequency Dividers & Counters," ELECTRONICS WORLD, December, 1968 & January, 1969.



COUNT	INPUTS A	A'	B	B'	C	C'	a	b	c	OUTPUTS S1	S2	S3	S4	S5	S6	S7
CLEAR	0	1	0	1	0	1	0	0	0	1	1	1	1	1	1	0
1	1	0	0	1	0	1	1	0	1	0	1	1	0	0	0	0
2	0	1	1	0	0	1	0	0	0	1	1	0	1	1	0	1
3	1	0	1	0	0	1	0	0	1	1	1	1	1	0	0	1
4	0	1	0	1	1	0	1	0	0	0	1	1	0	0	1	1
5	1	0	0	1	1	0	1	1	0	1	0	1	1	0	1	1

Fig. 14. Logic diagram and state table of BCD-to-seven segment decoder for modulo 6 binary counter shown in Fig. 4.

Fig. 15. Logic diagram and state table of BCD-to-seven segment decoder for modulo 10 binary counter shown in Fig. 5.



COUNT	INPUTS A	A'	B	B'	C	C'	D	a	b	d	e	f	g	h	i	j	T	U	V	W	W'	OUTPUTS S1	S2	S3	S4	S5	S6	S7
CLEAR	0	1	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	0	0	1	0	1	1	1	1	1	1	0
1	1	0	0	1	0	1	0	0	1	0	1	0	0	0	1	1	1	0	0	1	0	0	1	1	0	0	0	0
2	0	1	1	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	1	1	0	1
3	1	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	1	1	1	1	0	0	1
4	0	1	0	1	1	0	0	1	0	0	0	1	0	0	0	0	1	0	1	1	0	0	1	1	0	0	1	1
5	1	0	0	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	1	1	0	1	0	1	1	0	1	1
6	0	1	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	1	1	1	1	1
7	1	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	1	1	0	1	1	1	0	0	0	0
8	0	1	0	1	0	1	1	0	0	1	0	1	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1
9	1	0	0	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	1	1	1	0	1	1

Flight Simulator

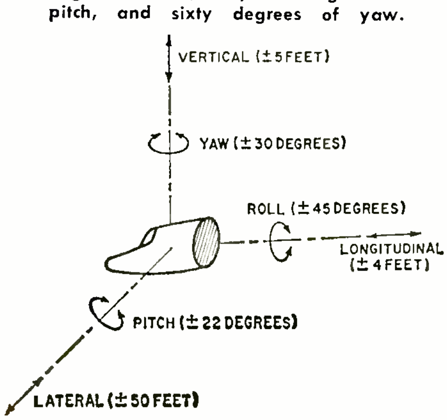
(*Continued from page 43*)

view is simulated by a closed-circuit, color-television system. A small color-TV camera "flies" over a model countryside containing an airport. The changing landscape "seen" by the camera is projected in color onto a screen in front of the pilot's window. This view adds to the realism, giving the pilot the "feel" that he is maneuvering over the landscape and landing or taking off from the airport.

How does it work? The pilot is assigned a general flight task. In flying the task, he introduces control actions that change the attitude and flight-path of the simulated aircraft. The control signals from the pilot are converted into simulator movements in the various axes of motion by a digital-analog computer combination. All actions simulated conform to the aircraft design characteristics contained in the computer program. The computer controls the motion generator, which positions the cockpit, and the sound generation equipment to simulate the most realistic flight conditions possible. By changing the computer program, the flight characteristics of almost any aircraft can be simulated by FSAA.

NASA indicated that the design data for advanced jet transports they expect to obtain from FSAA will answer some very important questions about these giant aircraft: how should the work of running the aircraft be divided among the crew? how much inherent stability must an aircraft have to be flown by human pilots? what kind of control systems are best? and what are the requirements for hydraulic and electrical systems for these aircraft? The answers to these questions will be obtained by research pilots as they "fly" the FSAA to develop pilot-handling data. This data will provide the basic guidelines for the design of new aircraft or for the evaluation of those already built. ▲

FSAA motion generator provides realistic cockpit movements within its limits of 100 feet of lateral motion, ten feet of vertical motion, eight feet of forward and back (longitudinal) motion, ninety degrees of roll, forty-four degrees of pitch, and sixty degrees of yaw.



ABOUT YOUR SUBSCRIPTION

Your subscription to ELECTRONICS WORLD is maintained on one of the world's most modern, efficient computer systems, and if you're like 99% of our subscribers, you'll never have any reason to complain about your subscription service.

We have found that when complaints do arise, the majority of them occur because people have written their names or addresses differently at different times. For example, if your subscription were listed under "William Jones, Cedar Lane, Middletown, Arizona," and you were to renew it as "Bill Jones, Cedar Lane, Middletown, Arizona," our computer would think that two separate subscriptions were involved, and it would start sending you two copies of ELECTRONICS WORLD each month. Other examples of combinations of names that would confuse the computer would include: John Henry Smith and Henry Smith; and Mrs. Joseph Jones and Mary Jones. Minor differences in addresses can also lead to difficulties. For example, to the computer, 100 Second St. is not the same as 100 2nd St.

So, please, when you write us about your subscription, be sure to enclose the mailing label from the cover of the magazine—or else copy your name and address exactly as they appear on the mailing label. This will greatly reduce any chance of error, and we will be able to service your request much more quickly.

C.E.T. Test, Section #7

Color Television

By DICK GLASS*

What is your electronics servicing I.Q.? You must get 75% on entire exam to pass.

This is the seventh in a series of 12 test sections to be published monthly. While these test exam sections are not part of the actual NEA C.E.T. examinations presently being administered, they are similar in nature. Should you find you are able to correctly answer 75% or better, you might be a candidate to become a registered CET. You can take the exam in your area but you must show 4 years of experience to qualify.

(Answers will appear next month.)
Answers to last month's quiz appear on page 84.

1. Which of the following problems normally would not cause a loss of color?
(a) an open delay line
(b) misadjusted fine tuning
(c) defect in color killer circuit
(d) defect in burst circuit

2. Improper purity can be caused by:
(a) a misadjusted yoke
(b) misadjusted ion trap
(c) misadjusted pincushion control
(d) misadjusted pincushion magnets

3. The color killer stage in most receivers must be turned "off" by:
(a) the color burst signal
(b) the color oscillator saw-tooth
(d) a keying pulse from the horizontal section
(c) the demodulator feedback signal

4. The color difference signals are most useful to proper operation of the receiver:
(a) at the picture tube
(b) at the phase detector
(c) at the burst amplifier
(d) at the inputs to demodulator

5. An uneven color level "venetian blind" effect, on certain programs, giving horizontal bands approximately 1½" apart vertically on a 23" receiver, indicates:
(a) poor a.g.c. filtering
(b) poor video tape reproduction at station
(c) poor phase detector alignment
(d) poor bandpass alignment

6. Which statement is incorrect?
(a) the automatic frequency control of tuner-oscillators is used to prevent customer fine-tuning errors
(b) a.f.c. circuits supply a d.c. correction voltage to the tuner oscillator
(c) a.f.c. circuits often use a varactor device in the tuner
(d) use the sound i.f. signal as a comparator source voltage

7. For color a.f.p.c. alignment it is necessary to use a:
(a) v.t.v.m.
(b) sweep generator
(c) bias supply
(d) AM generator

8. The Hue or Tint control is not usually found in which circuit?
(a) color oscillator
(b) burst amplifier
(c) color phase detector
(d) demodulator output

9. Which of the following operations would usually change the convergence of the color picture tube the least?
(a) resetting the high voltage
(b) resetting vertical linearity control
(c) resetting purity magnets
(d) resetting yoke position

10. Which of the following color picture-tube types is not in common use?
(a) single-gun type
(b) dual-trace type
(c) three-gun type
(d) in-line three-gun type

*Executive V.P., NEA, 1309 W. Market St., Indianapolis, Ind. 46222 assisted by Lew Edwards, chairman of Test Make-up Subcomm.

Microwave Ovens

(*Continued from page 29*)

inches, there is no difference in cooking rate between the outside and inside surfaces.

Many foods cooked in a microwave oven are distinctly different in nutritional retention, appearance, and flavor compared to ordinary cooking. Several university studies have commented on the superior retention of all vitamins with microwave cooking. One reason is the avoidance of the use of water in cooking vegetables, potatoes, and fruits. Since many of the nutrients are dissolved in cooking water and lost with conventional cooking, microwave cooking simply avoids this problem by not cooking with water. In addition, the lower surface temperature of the foods and the shorter cooking times reduce the evaporation and breakdown of many food nutrients. The same factors that promote the retention of nutrients act to preserve delicate color and flavor compounds. Vegetables and fruits retain brighter colors and fresher flavors than with any conventional method of cooking. To the author's taste, vegetables cooked by microwave are unsurpassed even by the French "flash-cooking" methods.

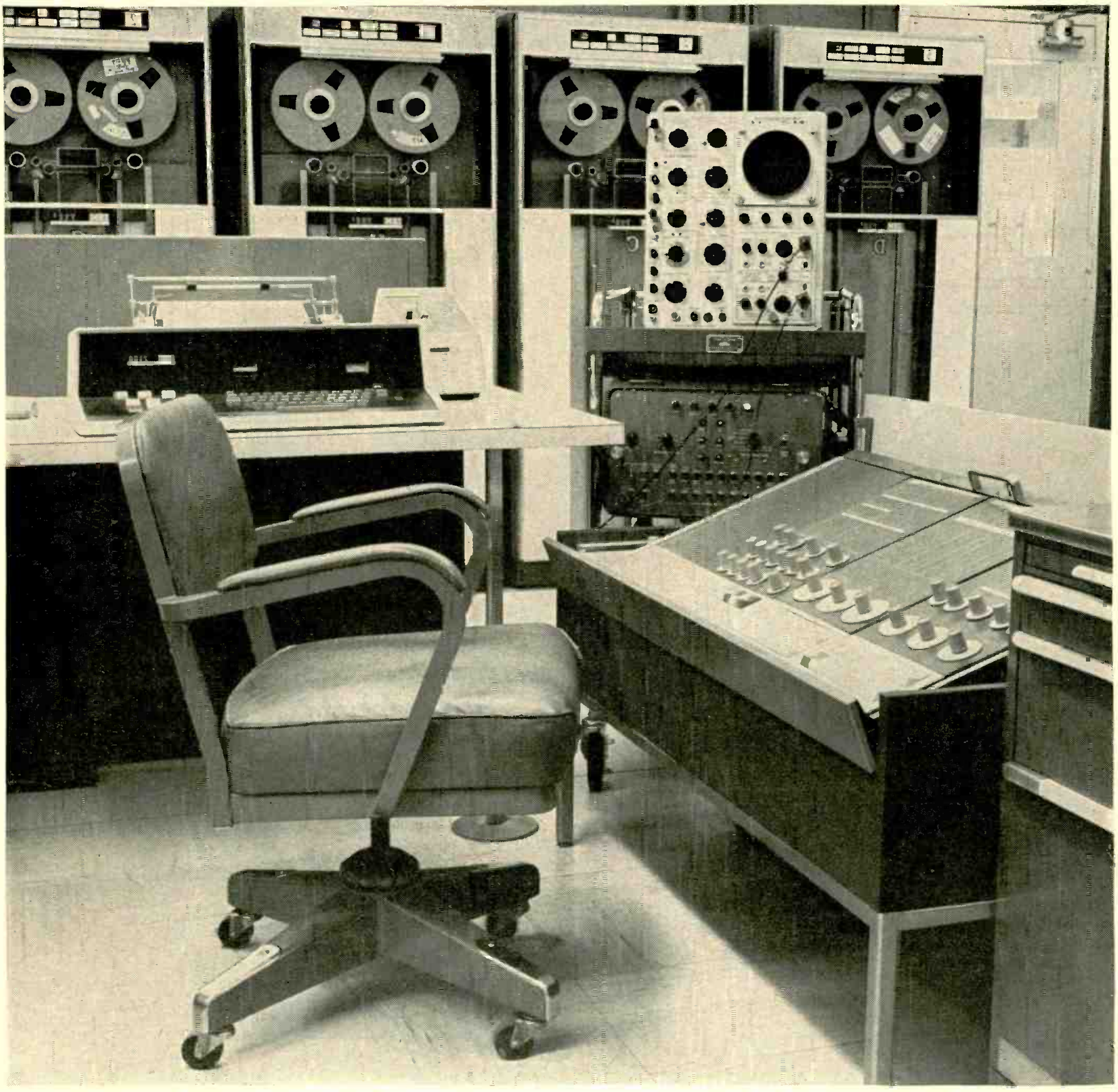
Similar nutritional, color, and flavor advantages apply to fish, poultry, and casseroles. Many meat products acquire a typical texture and appearance. Bacon is done exceptionally well at 2450 MHz; crisping bacon is difficult with a 915-MHz range. Beef roasts, hams, turkeys, roasting chickens, and the like are cooked with a very favorable browned exterior. Because of the depth-of-penetration limitations, however, there is no way to achieve a seared-surface, medium-rare steak in a microwave oven. Brushing the surface with some kitchen products helps the appearance, but to achieve a "standard American steak," browning by conventional means is recommended. A quick surface searing in a broiler, followed by microwave finish cooking, seals in flavor, producing a superior steak. This last browning method is very common in restaurants today.

Some units incorporate a browning element, some recommend browning meats outside the range. The design choice is straightforward. An integral browning element overcomes the appearance problem with steaks in the microwave oven. Integrating this feature makes the range complete; no other appliance is necessary. The disadvantages include the loss of the cool-cooking, easy-cleaning features of the microwave oven, and more seriously, the elimination of some good design approaches to low-leakage door design. The high temperatures associated with a conventional browning element prevents the use of dissipative vinyl gaskets and vinyl spacers and fillers for choke designs.

Another major feature of the microwave oven is the ability to rapidly thaw frozen foods. This feature foretells a rapid growth in the availability of frozen convenience foods, gourmet meals, and high-quality frozen meals, packaged especially for microwave ovens. This combination will enhance both product areas and further increase the utility of microwave cooking.

Frozen roasts and steaks can be thawed quickly, being made ready to cook in 6 to 10 minutes per pound. If one portion of the food thaws before the rest, the thawed portions (containing water) then absorb energy faster than the frozen portion (containing ice). The proper technique requires a few minutes of standing to equalize temperatures, repeating the cycle until thawing is complete. The range instruction manual recommends the proper cycle times, depending upon the weight and type of food to be thawed.

Next month, in Part 2 of this article, we will cover the important aspects of microwave radiation and safety features to be found in these ovens. (*Concluded Next Month*)



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

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

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

How You Can Succeed In Electronics
...Select Your Future From Six Career Programs

The "right" course for your career

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

1. Electronics Technology

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

NEW!

2. Broadcast (Radio & TV) Engineering

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

3. First Class FCC License

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

4. Electronic Communications

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

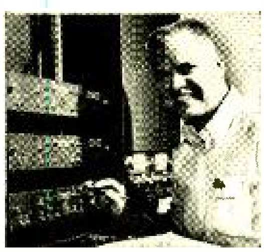
5. Industrial Electronics & Automation

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

NEW!

6. Electronics Engineering

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



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

An FCC License...or your money back!

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

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

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

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

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

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

CIE lessons are always up-to-date

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

Full accreditation...your assurance of competence and integrity

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

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

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

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

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

I am especially interested in:

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

Name ______________________ Age ______
(PLEASE PRINT)

Address ______________________

City ____________ State ________ Zip ______

☐ Check here for G.I. Bill information — EW-80

CIRCLE NO. 146 ON READER SERVICE CARD

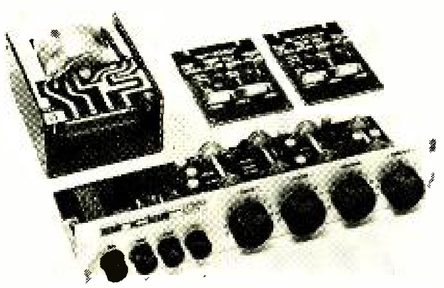
NEW PRODUCTS & LITERATURE

For additional information on items identified by a code number, simply fill in coupon on Reader Service Card. In those cases where code numbers are not given, may we suggest you write direct to the manufacturer on business letterhead.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • COMMUNICATIONS

AUDIO MODULES

The Project 60 group of audio modules, made in England by Sinclair, has recently been expanded to include a stereo preamplifier/control



unit, a choice of two audio amplifier modules, and three power-supply modules. An optional filter module is also available.

The modules in the group are designed to be used together or separately in special applications in the home or industry. They enable the builder to alter his hi-fi setup at will. All of the modules incorporate silicon epitaxial transistors, allowing these cool-running circuits to be installed within existing consoles, in walls, or in turntable bases.

The Stereo 60 preamp/control center has a brushed aluminum front panel with black knobs and controls.

Technical specifications on the complete line of modules in the Project 60 group are available on request. Audionics

Circle No. 6 on Reader Service Card

TV/FM ANTENNA LINE

A new series of TV/FM outdoor antennas has been introduced as the "Permacolor" line. The antennas feature a solidly riveted, permanent connection between the elements and the feedlines, eliminating reception problems caused by poor electrical connections.

The new line includes a full range of u.h.f./v.h.f./FM combinations as well as v.h.f./FM models, for virtually every reception area from metropolitan to deep fringe. The combination models also feature an improved u.h.f. corner reflector which augments v.h.f. reception, plus a wide-band bowtie u.h.f. dipole. Snap-off elements are provided on most models for adjusting the antenna to local FM and u.h.f. reception requirements.

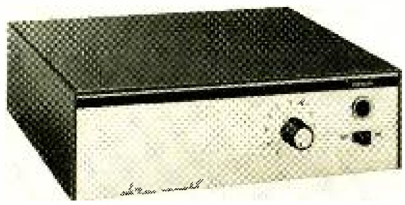
Information on the various models in the line will be supplied on request. RCA Parts and Accessories

Circle No. 7 on Reader Service Card

VOICE-CONTROL MONITOR

A new voice-control monitor which automatically reduces the volume output of p.a. systems when someone gets too close to the microphone or telephone or speaks too loudly is now available as the "Vox Limiter" Model VCM-1.

The compact, solid-state instrument uses integrated circuits and may be spliced into any p.a. line between the microphone or telephone and the



amplifier. By setting the sound level to the softest voice likely to use the system, the volume is automatically reduced to this predetermined level of audibility, irrespective of the loudness of other voices.

The unit measures 2⅞" x 9" x 9" and weighs 3 pounds. Bell P/A

Circle No. 8 on Reader Service Card

BREADBOARD SYSTEM

According to the company, the patch points mounted on logic diagrams and identified with IC pin numbers make "Comp-U-Kit" unique among IC breadboards. Each IC mounts on its own PC module screened with that IC's logic diagram. Dual patch points allow daisy-chaining.

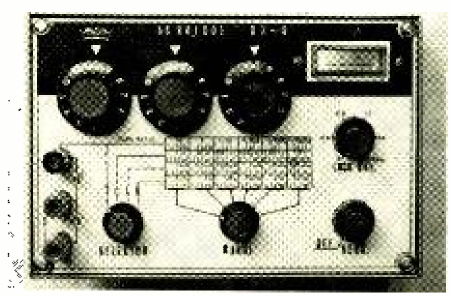
Patching and debugging times are reduced as much as 50% by the matching pin-and-patch numbers and the logic diagrams. A novel rail system provides both mechanical support and low-impedance power feed. The system allows any size breadboard from four IC's up to hundreds of IC's. Scientific Measurements

Circle No. 9 on Reader Service Card

A.C. BRIDGE

A miniature, transistorized, universal a. c. bridge which measures resistance, inductance, capacitance, and winding ratio of transformers is now on the market. It measures 5" x 7⅛" x 3" and weighs just 2¼ pounds.

Operation of the direct-reading, six-decade bridge is simple, making it suitable for produc-



tion testing as well as for laboratory applications. The portable unit is powered by an inexpensive 9-volt battery although six 1½-volt penlight cells may be used as well.

Measurement ranges and accuracies are: resistance 0.1 ohm to 11.1 megohms, 1% to 5% depending on resistance value; inductance 1 μH to 111 H, 2% to 5% depending on inductance value; capacitance 10 pF to 1110 μF, 1% to 5% depending on capacitance value. Internal frequency is 1 kHz. C. H. Mitchell.

Circle No. 10 on Reader Service Card

CASSETTE TAPE DECK

The Model 200 tape deck is designed to connect to existing stereo and component systems to provide record and playback capabilities, using the Phillips-type cassette as the tape format.

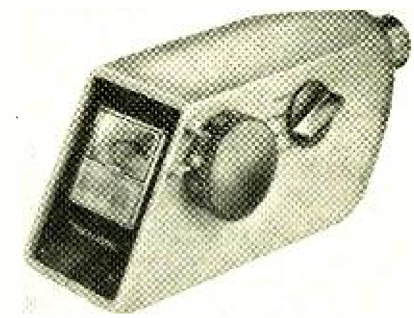
Among the innovations incorporated in the deck are the "B-Type" Dolby system for noise reduction, user selection of proper bias, and record and playback equalization for three classes of tape. Also included is a single large vu meter used in conjunction with a special circuit that automatically monitors both stereo channels and computes and reads the higher level at any given instant. According to the company, this simplifies the recording procedure and insures that the original balancing set-up of one channel versus another will be accurate.

The unit measures 14¾" x 10⅝" x 3¾" and weighs 14 pounds. Additional details are available on request. Advent

Circle No. 11 on Reader Service Card

MUSIC/SOUND-LEVEL METER

A moderately priced sound-level meter designed for all-around general use is now being marketed. The test range is from 60 to 116 dB



or from quiet-room level to ear-damaging noise level.

Each instrument is individually calibrated to ± 2 dB at a 74-dB level. Frequency response is 40-40,000 Hz ±2 dB and the meter can provide a high-fidelity output voltage at 1 volt minimum from a miniature phone jack. Meter ballistics are ASA standard fast; or slow for average readings. The all-silicon solid-state circuit uses a 2U6 standard transistor battery. The case is shaped to minimize sound reflections and measures 7¼" x 2¾" x 2½" Radio Shack

Circle No. 12 on Reader Service Card

PORTABLE INVERTER

The Model 12T-RME-1 portable inverter operates from 12 volts d. c. and delivers 110 volt, 60-Hz a. c. at 125 watts maximum. The output is frequency stable and automatically controlled so that the unit can be used to operate small tape recorders, record players, and most popular 11" to 13" portable TV sets in cars, boats, mobile homes, etc.

In addition, the inverter can be used to operate test equipment, power tools, soldering irons, and certain household appliances. ATR Electronics

Circle No. 13 on Reader Service Card

AUTO/MARINE TACHOMETER

An all-electronic auto/marine tachometer in kit form is now available as the Model KG-340. It measures engine speed from zero to 8000 r/min on any 4, 6, or 8 cylinder engine with a 12-volt electrical system.

The unit may be mounted in any position and the rotatable head bezel adjusted for best visibility of the 3¼" lighted dial. An all-metal case and ruggedly constructed meter make the unit highly resistant to shock and vibration. The circuit compensates for normal variations in temperature and battery voltage, providing readings with an accuracy of ±2% of full scale.

The kit comes complete with all cables and mounting hardware as well as step-by-step instructions for assembling and installing the unit. Allied Radio

Circle No. 14 on Reader Service Card

ENTERTAINMENT SYSTEM

The Model 8000 home-entertainment system is capable of handling 100 watts through its four air-suspension speakers which match the control unit. The system features an 8-track cartridge player, AM/stereo-FM receiver, and a built-in preamp which can be used in conjunction with a magnetic-cartridge record player if desired.

The control unit cabinet has a drop-front door for hide-away styling, separate bass and treble controls for each speaker, a channel selector with indicator light, phono or tape input jack, and a tuning meter that is employed for accurate stereo reception.

Frequency response is 20-20,000 Hz and distortion is less than 1% at normal levels. Westbury Div.

Circle No. 15 on Reader Service Card

STEREO HEADSETS

The 100 Series of stereo headsets has been redesigned to provide smoother frequency response, more rugged voice-coil structure, better transient response, and more low-frequency output. The phones provide a greater bandwidth than previously.

The redesigned dynamic headsets carry an "A" designation and three models are in the series: 100A (17 ohms), 103A (300 ohms), and 106A (600 ohms).

Frequency response is from 20-16,000 Hz. Distortion is less than 1% over the audio band, according to the company. David Clark

Circle No. 16 on Reader Service Card

CB SCANNER

A 23-channel CB scanner which permits visual identification of all channels in use is now available as the "Scanalyzer 23" Model 779.

The unit allows continuous and simultaneous visual monitoring of all 23 channels and permits

the instant determination of the channels in use. It can also be used to determine the signal strengths of all 23 channels by means of its adjustable sensitivity control.

The unit is all solid-state and uses 38 semiconductors in a unique circuit configuration on which patents are pending. A data sheet that provides complete specs on this unit is available on request. Commander Electronics

Circle No. 17 on Reader Service Card

R.F. WATTMETER

The new portable "Thruline" coaxial wattmeter is an insertion-type instrument for measuring forward and reflected c.w. power in 7/8" EIA as well as in r.f. cable transmission lines. It measures r.f. power flow under any load condition with an accuracy of ±5%.

The wattmeter consists of a triple-scale case-mounted meter, a section of precision-machined reference transmission line, and a reversible plug-in element for power and frequency-range selection.

This component approach permits connection choices to N, C, SC, UHF, BNC, TNC, LC, HTV, LT, General Radio Type 874, and 7/8" EIA flanged systems with full-scale power ranges

from 1 watt to 10,000 watts in discrete frequency bands from 0.45 MHz to 2.3 GHz.

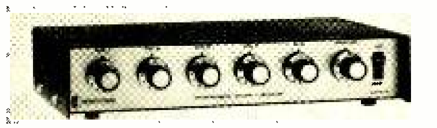
Complete details on this meter and additional available options will be forwarded upon request. Bird Electronic

Circle No. 18 on Reader Service Card

MIKE-MIXER/PREAMP

Switchable inputs that accept both high- and low-impedance microphones plugged directly into the mixer are special features of the new UMX-4 microphone mixer/preamplifier.

A flick of a switch changes the input from a



low to a high impedance, with no transformer or other accessories necessary. As many as four microphones, each with individual controls, can be used with the solid-state unit. An auxiliary input is provided for use with tape recorders, AM-FM tuners, telephone paging adapter, subscriber music service, and similar applications.

The self-contained unit, which can be operated from the a. c. line or from external batteries, can be used by news media for taping or video recording and remote broadcasting. University Sound

Circle No. 19 on Reader Service Card

HANDS-FREE INTERCOM

A new intercom that permits both hands-free and private answering has been introduced as the Series 3000. The standard desk master station is shaped much like an upright telephone but contains speaker, microphone, and dialing mechanism

In operation, the master station functions as a normal desk unit but when lifted the station serves as a handset for confidential conversions. Placed horizontally, face down on the desk, the station is automatically switched to complete privacy and all incoming calls are announced by a momentary tone. A numbered keyboard permits touch dialing of any station in the system.

The master station measures 9½" high x 3¼" wide x 5" deep. It comes with an 8-foot flexible cord with six-pin plug and can be operated on 105-125/210-230 volts, 50 or 60 Hz.

A brochure describing the Series 3000 intercom system is available on request. DuKane

Circle No. 20 on Reader Service Card

V.H.F. MARINE ANTENNAS

A new line of v.h.f. marine ship-to-shore communications antennas has just been introduced. The line includes four new shipboard antennas and three shore-station antennas. All shipboard antennas are constructed of marine fiber glass and chrome-plated brass fittings. The line covers the frequencies from 156 through 163 MHz.

A four-page, four-color brochure describing this line will be forwarded on request. Hy-Gain

Circle No. 21 on Reader Service Card

DIGITAL PANEL METER

A new digital panel meter which features a bright display with 1-inch characters for good visibility from wide angles has been developed as the Model 3350. All digits in the display are in the same plane and are composed of seven segments, each of which is illuminated by a high-intensity neon bulb. The display also has independent windows for identification of four parameters or units (°F, °C, pH, V, PSI, etc.).

Applications include pH meters, spectrophotometers, hospital patient-monitoring systems, temperature indicators, and industrial process instrumentation. An optional analog output is available for strip-chart recorders.

The basic model is a 3½-digit meter with four voltage ranges from 1.999 mV to 199.9 V; accuracy is ±0.1% of reading ±0.05% f.s. Many options, including wide-range zero offset, preamplifiers for 1-V or 10-V resolution, buffered BCD outputs, etc. are available.

For a complete story of meter capabilities, send your letterhead request to Russ Walton, Electro-Numerics Corp., 2961 Corvin Drive, Santa Clara, Calif. 95051.

FREQUENCY METER

UniComp's Model 101 frequency meter measures and indicates the frequency of an input signal. The frequency is indicated on a needle-type meter movement.

The use of hybrid digital/analog techniques provides high accuracy counts, according to the company. A built-in circuit allows self-calibration or the unit can be calibrated against an external source. Accuracy is better than 3%.

Signal input waveforms may be repetitive pulses or sine waves ranging from 5 Hz to 1 MHz—a multiplexer switch of 1X, 10X, 100X, 1000X, and 10,000X allows greater range. The meter will also indicate the average frequency of random events.

A letterhead request addressed to Wayne M. Aamoth in the marketing department of the company at 18219 Parthenia St., Northridge, Calif. 91324 will bring full details.

NOISE ELIMINATOR

A noise blanker for use with CB and Business Band radios has been developed for use on mobile or base stations to eliminate virtually all external impulse noise such as ignition system, power line,

and general electrostatic and radio hash. The unit is also said to increase side-channel rejection, thereby eliminating splatter and bleed-over from adjacent channels.

The unit is installed between the antenna and the radio and is externally wired to each. The eliminator is completely self-contained, features 29 solid-state components, and measures 2" x 6" x 5" and comes complete with owner's manual and mounting accessories for use with any CB or Business Band radio. Omega-t

Circle No. 22 on Reader Service Card

TURNTABLE PACKAGE

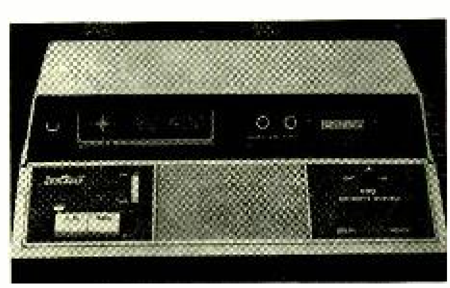
The Model 610/X turntable package has been designed for the serious enthusiast with a limited budget. The new model includes a synchronous motor for precise rotational speed, a viscous-damped cue and pause control, dual-range anti-skate control for both elliptical and conical styli, swing-away record arm for unobstructed single play, and a machine-cast heavy platter.

Included in the turntable package is a Decormatic base which incorporates an illuminated power switch that permits the complete receiver system to be shut off automatically by the turntable upon completion of the last record. A Shure M-93E cartridge and deluxe dust cover complete the package. BSR McDonald

Circle No. 23 on Reader Service Card

BURGLAR/FIRE ALARM

A single-wire burglar/fire alarm system which provides a digital readout of the exact location of



the intrusion or fire is now being offered as the ESP 400.

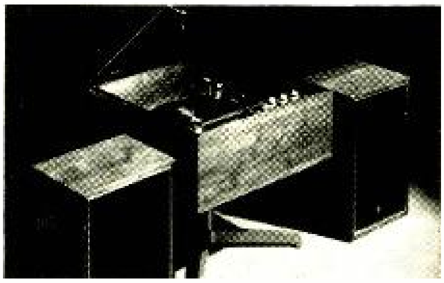
The trigger for the readout consists of sensors averaging only 0.75 inch x 0.12 inch which can be attached to jewelry boxes, paintings, other valuables, or doors and windows and connected to the main unit by a single flat 28 or 32 gauge wire. A backup device in the control panel operates the system if an intruder has cut a wire or tampers with the system. Fire protection is given by special sensors which instantly detect flame smoke and heat surge.

Complete details on the ESP 400 will be supplied on request. U.S. Fire & Security

Circle No. 24 on Reader Service Card

HOME MUSIC CENTER

A three-component, decorator-designed home music center is on the market as the C-6000A. The center consists of a central control unit housing a stereo-FM/AM tuner, an automatic turn-



table, plus a solid-state amplifier that can supply 36 watts (IHF) of audio power. All operating controls for the system are housed in the walnut-finished control cabinet.

Sound output is through a pair of compact walnut-finished matching infinite baffle enclosures, each housing an 8" woofer and horn-type tweeter. The speakers may be bookshelf or wall mounted. Pioneer

Circle No. 25 on Reader Service Card

BALL-HEAD MICROPHONES

Two new ball-head ultra-cardioid dynamic microphones that feature a 25-dB front-to-back rejection ratio and a built-in "on-off" switch are available as the Models 850s and 850.

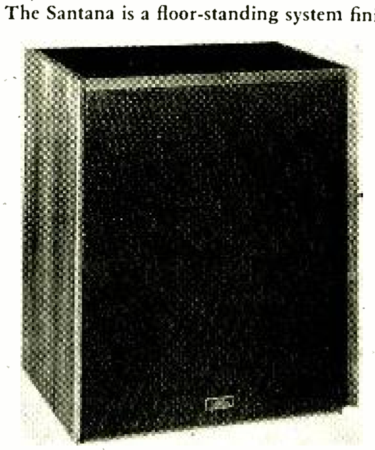
The Model 850s is a rugged multi-impedance microphone designed for either indoor or outdoor use. It is finished in glare-proof, brushed satin chrome and scratch-resistant black chrome trim. It is fixed-stand mounted. The "on-off" switch is built into the swivel mount for performer control and convenience. The Model 850 features an "easy-on" swivel adapter in place of the "on-off" switch assembly. It can be changed from stand mount to hand held in seconds. Frequency response of both models is 40-15,000 Hz. Astatic

Circle No. 26 on Reader Service Card

CONTEMPORARY SPEAKERS

Two new speaker systems of contemporary design have been put on the market as the "Santana" (Model 879) and the "Capri" (Model 887A).

The Santana is a floor-standing system finished



on all four sides and with a black composition slate top. It uses a Biflex 15" speaker plus a high-frequency tweeter. Impedance is 8 ohms and the system can be used with amplifiers having continuous power ratings up to 40 watts. Frequency range is 35-18,000 Hz with a crossover at 2500 Hz. The system is 24½" high x 20½" wide x 17" deep.

The Capri is a bookshelf-size system that covers the frequency range 50-18,000 Hz and will handle 40 watts. The enclosure is an infinite baffle design with an 8" high-compliance low-frequency speaker and a 3" direct-radiator cone-type tweeter. Crossover frequency is 2500 Hz. The cabinet is of hand-rubbed oiled walnut with a modern grille. It measures 19" wide x 10" high x 9" deep. Altec Lansing

Circle No. 27 on Reader Service Card

IC THRESHOLD DETECTOR

A new monolithic threshold detector with input sensitivity typically 1 nanoampere is available as the PA494. It is intended for applications requiring the logic function of a Schmitt trigger but offers superior voltage and temperature stability, according to its maker.

Operating voltage of the PA494 is 2.3 to 9 volts. The output current drive capability is 250 mA maximum. This wide range of voltage and current capability makes the unit compatible with many types of linear and digital circuits.

The trigger threshold is 0.6 of the supply voltage and has 10% hysteresis. Threshold stability is less than 1% variation over the entire voltage and temperature operating range. Operating temperature is −40 to +100 degrees C. Other features include an overshoot (free wheeling) diode and absence of interaction between input and output.

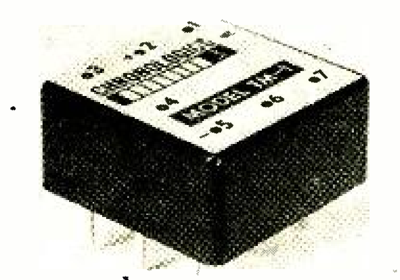
The unit is suitable for applications including Schmitt triggers, level detectors, time delays, low-voltage relay drivers, contact-bounce eliminators, square-wave generators, lighting (photoelectric controls), humidity controls, touch switches, and r. f. sensors, among others.

An 8-page data sheet with complete specifications is available on request. General Electric

Circle No. 28 on Reader Service Card

TIMING MODULES

Chronologics Inc., 24 Martin Street, Webster, N. Y. 14580 has introduced the TM Series of timing modules which provide timing ranges



from milliseconds to hours. Timing is fixed or adjustable with delay or interval modes of operation.

Outputs are pulse, continuous, or complementary and the completely encapsulated assemblies are ready for mounting. Repeat accuracy is ±1% at constant temperature. The series features "on-off" voltage level control.

An 8-page data sheet containing full details on the TM Series will be forwarded upon letterhead request.

MODULAR MOBILE RADIOS

Motorola's Communications Division has introduced a modular two-way mobile radio line which is completely solid-state and features a high-band model with up to 110 watts r.f. power output.

Called "Micor" mobile FM radios, the new units use custom monolithic IC's which drastically reduce the number of components. Each radio consists of seven military-grade glass-epoxy circuit boards which plug into a central interconnect board. Intercabling wires have been virtually eliminated.

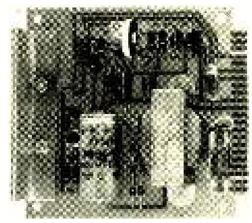
Since the unit is solid-state, no power supply is required. The radio runs directly off the vehicle battery assuring cooler, more reliable operation. Ten watts of audio power output insure that messages will be heard from inside or outside the vehicle even in high noise environments.

For complete details on this new "Micor" line, send your letterhead request to Jerry Ewing at the company, 1301 E. Algonquin Road, Schaumburg, Ill. 60172.

POWER SUPPLY FOR IC's

Armour Electronics Corp., 51 Jackson Street, Worcester, Mass. 01608 has developed a low-cost plug-in power supply which is designed to power approximately 120 IC's and will deliver 5 volts d.c. at 1.2 amps.

Line and load regulation, ripple, and stability are all consistent with typical IC manufacturer



specifications. The Model PC5 supply is short-circuit protected electronically and automatically recovers when the current overload is removed. It can be supplied with an overvoltage option if desired. As many as four of the supplies can be connected in parallel and still meet all stated specs.

To obtain complete performance specs and mechanical options, send your letterhead request to Charles Armour, president of the firm, at the above address.

AM/STEREO-FM RECEIVER

The Model 120 AM/stereo-FM receiver delivers 50 watts per channel music power, has an illuminated linear tuning scale for pinpoint station selection, and features two vu meters to show signal strength and FM station centering.

Rotary knobs choose volume, balance, treble, bass, dual-speaker systems, and input selection. There are five position-action slim-line tab switches to perform the secondary control functions: tape monitor, mono/stereo, low filter, high filter, and loudness. In addition, the receiver has a stereo headphone jack, FM-stereo indicator light, multiple connection jack, and standard phone jacks to connect tape inputs and outputs as well as phono jacks for magnetic cartridge and other auxiliary sources.

Amplifier power bandwidth (IHF) is 20-30,000 Hz at 8 ohms. Music power output is 120 watts at 4 ohms and 100 watts at 8 ohms.

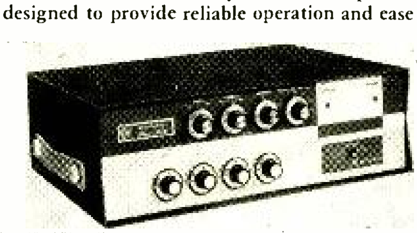
The 5½" x 17½" x 13⅜" cabinet is of hand-rubbed oiled walnut faced with brushed aluminum and jet black acrylic. Roberts

Circle No. 29 on Reader Service Card

P.A. AMPLIFIERS

Two new lines of professional-quality public-address amplifiers, the Flex-Pak series NT and the Custom-Flex series NXT, have been announced. Both lines are solid-state and each has models with power ratings of 30, 60, and 120 watts. Included also in the NXT series is a mixer-preamplifier, Model NXTM.

The all-silicon circuitry of these amplifiers is designed to provide reliable operation and ease of



maintenance. The standard microphone input capability of the amplifiers is three high-impedance inputs for the NT line and five high-impedance inputs for the NXT models. Two inputs of either the NT or NXT models may be converted for use with a magnetic phono cartridge.

Various accessories to provide additional flexibility are available for both lines. Complete specifications on the units themselves and the optional components are available on request. Bogen

Circle No. 30 on Reader Service Card

ANSWERING MACHINE

The Phone-Mate 100 is an automatic telephone-answering instrument which will automatically deliver a pre-recorded message to each caller. It also records incoming messages when plugged into an ordinary cassette or reel-to-reel recorder.

A monitor feature permits the user to hear who is calling without picking up the phone. This screening ability is designed for busy business people plagued by unwanted calls. The user can override the unit and talk to the caller as usual if he chooses.

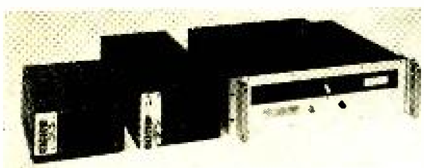
The instrument plugs into an ordinary 4-prong telephone extension jack which is supplied with the unit. It works with any telephone instrument or system. Tron-Tech

Circle No. 31 on Reader Service Card

MODULAR POWER SUPPLIES

A new line of high-efficiency, low-ripple modular power supplies is now available from Lambda Electronics Corp., Melville, N. Y. 11746.

Designated the LV Series, the new line is offered at current ratings to 170 amperes and fixed



voltage ranges to 15 volts d.c. An advanced SCR circuit provides greater than 50% efficiency and the electronic ripple reducer results in an unusually low output ripple of less than 10 mV r.m.s. maximum.

The series is offered in three package sizes from 3 to 15 volts and up to 170 amperes. Packages E and EE are sub-rack modular power components measuring $4\frac{15}{16}$" x $7\frac{1}{2}$" x $11\frac{3}{4}$" and $4\frac{15}{16}$" x $7\frac{1}{2}$" x $16\frac{1}{2}$" respectively. Package G is a full-rack unit measuring $5\frac{1}{4}$" x 19" x $16\frac{1}{2}$".

To obtain full specs on this new line write to the Sales Manager of the company at 515 Broad Hollow Road in Melville on your business letterhead.

CAR CASSETTE PLAYER

An automatic reversing car cassette player has just been introduced as the Model 3700. The player offers continuous music—mono or stereo—in both directions without the driver having to touch the player or flip the cassette over once it is in place.

Instant slot loading automatically turns the player on when the cassette is clicked into place while an eject-stop button pops the cassette out of the player at the touch of a finger.

The player is easy to tune. Separate controls for volume, balance, and tone give precise adjustment for perfect stereo reception. A fast-wind control permits high-speed forward and manual reverse operation for repeating or locating a favorite selection. Optional speakers for use with the player are available. Bell & Howell

Circle No. 32 on Reader Service Card

pH/VOLTMETER

A new servo-digital pH/voltmeter designed for classroom applications is now available as the EU-302A. The new meter reads pH from 0-14 with ±0.07 pH accuracy and 0.02 pH resolution. Voltage readings are from 0 to ±1.4 volts with ±0.007-volt accuracy and 0.002-volt resolution. Controls for temperature compensation from 0

to 100° C, standardization, and pH calibration assure exact pH and voltage measurements, according to the manufacturer.

The all solid-state circuitry incorporates a high-impedance FET potentiometric input to eliminate loading errors while high stability and noise immunity are obtained from the isolated chopper and solid-state a.c. phase-lock amplifier.

The EU-302A accepts standard electrodes for general-purpose pH measurement or specific ion electrodes. Heath

Circle No. 33 on Reader Service Card

MANUFACTURERS' LITERATURE

AUDIO/VISUAL PRODUCTS

A six-page foldout, listing products in the Sharpe line for audio/visual applications in schools, is now available for distribution.

Pictured and described are headphones, headset microphones, cordless headsets, audio stations, and sound centers. The catalogue also lists the various impedances and frequencies that apply to the equipment and available options. Scintrex

Circle No. 34 on Reader Service Card

AUDIO CONNECTORS

A single-page product bulletin (No. 198) describing three new additions to the "Q-G" (quick-ground) series of audio connectors has been issued.

The bulletin explains the engineering features of the new male and female right-angle cord plugs, together with a new panel-mounting female receptacle. The new connectors are available in 3, 4, or 5 contact configurations. Switchcraft

Circle No. 35 on Reader Service Card

IC's AND DIODES

A 20-page short-form catalogue which lists many new types of TTL and linear integrated circuits, diodes, MOS devices, chips, wafers, and MIL-Spec devices is ready for distribution.

The various sections picture and describe TTL IC's, linear IC's, DTL IC's, epoxy and glass rectifiers, thyristor diodes, silicon and germanium diodes, modules and special products, silicon transistors, MOS arrays, semiconductor chips and wafers, and MIL and Hi-Rel semiconductors. A listing of stocking distributors is also included. ITT Semiconductors

Circle No. 36 on Reader Service Card

REPLACEMENT TRANSISTORS

A cross-reference to the company's universal replacement transistors and rectifiers has been issued in convenient pocket-size form. The guide folds to a handy 3" x $5\frac{1}{2}$" for ready reference by distributors, dealers, and technicians.

The most popular transistors and rectifier types used in professional servicing work and technical experiments are listed in numerical order and then cross-referenced to the company's line of replacements. International Rectifier

Circle No. 37 on Reader Service Card

SPECIFYING LC FILTERS

A 10-page illustrated monograph (TD 2-70) on how to specify LC filters is being offered without charge to engineers.

Based on the company's computer-aided filter design experience, the publication discusses a number of important specifications, including frequency response, impedance, passband ripple, shape factor, operating temperature range, packaging, and environment. A two-page glossary is provided for those not completely familiar with filter terminology. Cambridge Thermionic

Circle No. 38 on Reader Service Card

INTRUSION ALARM DATA

A four-page product brochure containing applications, features, and specifications on the firm's line of ultrasonic intrusion alarm equipment is now available for distribution.

The brochure also contains data on protection accessories which may be used as optional security devices on the ultrasonic sensors, security-system cameras, and other products for standard or custom installations. Bourns Security

Circle No. 39 on Reader Service Card

INDICATOR LIGHTS

The new 20-page Catalogue L-161K features an extensive line of miniature and large indicator lights. It includes illustrations and details complete specifications needed to pick the right indicator for the job.

Catalogue sections include some 13 varieties of miniature and large indicator lights in both open and panel types. Another section lists the different lens cap assemblies available for use with the lights. Dialight

Circle No. 40 on Reader Service Card

CHEMICALS IN SERVICING

Two fully illustrated booklets which explain how to use chemicals to make servicing of electronic equipment easier and more efficient are now available for the asking.

The first booklet explains how to use "Tun-O-Foam" tuner lubricant/cleaner to restore corroded tube sockets, unfreeze coils, lubricate controls, keep indoor antennas working smoothly, and as a heat sink for power transistors. The second booklet tells how servicing can be speeded by using "Tun-O-Wash" aerosol cleaner/degreaser to restore erratic spindles, idler wheels, motors, rubber drive wheels, gears, tight seal controls, relays, switches, picture-tube anodes, and PC boards encrusted with flux. Chemtronics

Circle No. 41 on Reader Service Card

PANEL-METER CATALOGUE

A comprehensive 20-page catalogue (D-70) featuring standard and special panel meters that are designed for such applications as electronic instrumentation, communications equipment, industrial process control, military ground-support equipment, laboratory and educational uses is now off the press.

Three-hole punched for ring-binder use, the catalogue provides detailed electrical and mechanical specifications as well as dimensional and mounting drawings. A handy listing of sales and service modification centers plus the firm's sales representative organizations is also provided. Triplett

Circle No. 42 on Reader Service Card

ELECTRONIC COMPONENT LINE

Solitron Devices, 256 Oak Tree Road, Tappan, N.Y. 10983 has issued a 208-page catalogue covering its line of electronic components.

The $8\frac{1}{2}$" x 11" catalogue is divided into three sections: solitrodes, zeners, rectifiers, high-voltage and special rectifier assemblies, standard power hybrid circuits, and outline drawings; small-signal, Hi-Rel power, r.f. power, custom power hybrid circuits, industrial and germanium transistors, materials, thermometers, FET's, linear IC's and MOS IC's, and outline drawings; microwave components of various types.

The products are illustrated throughout the catalogue and an index of part numbers and JEDEC types is provided.

APPLICATIONS REPORT

Two new application reports which evaluate dual-gate MOSFET's in color-TV receivers have been issued by Texas Instruments.

One 8-page report (CA-136), "MOSFET's in Color Television High-Frequency Section," shows with the help of performance characteristics how these FET's are as effective as vacuum tubes in eliminating crossmodulation in tuners.

The second report (CA-133), entitled "Dual-Gate MOSFET's in TV IF Amplifiers," discusses considerations involved in designing an i.f. amplifier using these components. Details on calculations for a bridged-T trap, series-tuned traps, and a sound take-off are included.

Your letterhead request for either or both of these reports should be addressed to the company, Inquiry Answering Service, P.O. Box 5012, M/S 308, Dallas, Texas 75222.

CONDENSED IC CATALOGUE

The Integrated Circuits Division of General Instrument Corp., 600 W. John Street, Hicksville, N.Y. 11802 has issued a 20-page condensed catalogue covering integrated circuits used as voltage regulators, clock drivers, ladder switches, amplifiers, hybrid switches, power amplifiers, etc.

Circuit diagrams, tables of characteristics, and other descriptive material are provided for each device. Details on the company's custom circuit design capabilities are also included.

ELECTRONIC TEST ACCESSORIES

Pomona Electronics Co., Inc., 1500 East Ninth St., Pomona, California 91766 has issued a 56-page general catalogue of test accessories which lists 420 items—50 of which are new this year.

Included is complete engineering information on black boxes, patchcords and receptacle jacks, isolation plugs, two-pin connector test adapters, molded test accessories and patch cords, cable assemblies, test leads, connecting leads, test socket adapters—all designed to meet rigid industrial and military specs. The listings are completely illustrated.

INSTRUMENT RENTALS

The "1970 Instrument Databook and Rental Catalog" is now available to bona fide users and specifiers of electronic instrumentation who request it on their business letterheads.

Designed for specifying and purchasing, the databook logically sorts instruments and compares pertinent specifications. Other sections cross-reference manufacturer's model numbers and list local phone numbers for various geographic areas. The publication simplifies alternate source selection to spec-to-spec comparison of equipment from major manufacturers.

A special section is devoted to rental rates and other leasing information. The products include analyzers, counters, digital voltmeters and DPM's, impedance and phase measurement, microwave instruments and RFI/EMI, scopes, pulse and function generators, power supplies, signal sources, sweep generators, and voltmeters.

Letterhead requests should be addressed to R. P. McGrath, Sales Manager, Leasametric, 822 Airport Boulevard, Burlingame, Calif. 94020.

INDUSTRIAL CONNECTORS

A comprehensive line of electrical/electronic connectors, plugs, and sockets is described in a new 32-page catalogue which the Amphenol Industrial Division has just published.

The four-color publication contains photographs, line drawings, electrical characteristics, and mechanical specifications for all interconnection products in the company newly expanded industrial line.

Included are standard and miniature industrial/commercial tube/relay sockets and bases, crystal sockets, standard and miniature power connectors, PC board connectors, rack-and-panel connectors, test jacks and plugs, UL outlet type plugs and sockets, microphone and audio connectors, and accessories and assembly tools.

To obtain a free copy of "Industrial Interconnections" (II-1), address your letterhead request to the company at 1830 South 54th Ave., Chicago, Ill. 60650.

FEEDTHROUGH CAPACITORS

A single-page bulletin covering a new line of high-power, high-frequency non-radiating feedthrough capacitors is now available from Polyflon Corporation, 32 River Street, New Rochelle, N. Y. 10801.

The bulletin provides information on the operating characteristics of the capacitors, design features, and suggested applications. Pictures show various sizes and how the capacitors appear when assembled in parallel to increase attenuation while maintaining low inductance.

CONSUMER ELECTRONICS DATA

The Consumer Products Division of the Electronic Industries Association has announced the 1970 Golden Anniversary Edition of its "Consumer Electronics Annual."

The new edition outlines the industry's first fifty years and contains a year-by-year statistical review of products through 1969 including TV sets, radios, phonographs, and magnetic tape equipment. The publication also contains a listing of the industry's contributions to the national economy, a chronology of important industry events, a glossary of terms used in the industry, and a list of the names and addresses of major allied trade associations.

Copies are available at 50 cents each, postpaid, from the association at 2001 Eye Street, N.W., Washington, D.C. 20006. Payment must accompany your order.

SEMICONDUCTOR LINE

Texas Instruments has just released a 60-page condensed catalogue covering its complete line of integrated circuits, discrete semiconductors, and components.

Each unit is described, pertinent characteristics listed, and package views provided. Seven pages are devoted to case outlines of discrete devices. For military device selection, a list cross-references military spec requirements with appropriate transistors, diodes, and resistors.

A product index permits users to quickly find specific production information they may have need for.

Letterhead requests to the company's Inquiry Answering Service, P.O. Box 5012, M/S 308, Dallas, Texas 75222 should specify "1970 Condensed Catalog."

TUBE/SEMICONDUCTOR MANUAL

Sylvania Electronic Components has announced publication of the 14th edition of its technical manual containing essential mechanical and electrical ratings for receiving tubes, TV picture tubes, and solid-state devices.

The replacement guide features equivalent types for approximately 28,000 transistors, diodes, rectifiers, IC's, and color oscillator crystals. The manual has been increased to 624 pages in order to permit listing of comprehensive information on electronic devices used in color and black-and-white TV sets, AM and FM radios, hi-fi equipment, and general industrial gear. Expanded technical data is provided for domestic and popular imported types of receiving and picture tubes.

The manual, priced at $1.90 per copy, is available from local Sylvania distributors. ▲

PHOTO CREDITS

Page	Credit
12	Sherwood Electronic Labs
13	KLH Research & Development
25 (left), 26	Amana Refrigeration, Inc.
25 (right)	Litton Industries
27	Raytheon
38	Cutler-Hammer
43	NASA Ames Research Center
62	RCA Electronic Components
70	Triplett Electrical Instruments
71 (top)	The Narda Microwave Corp.
71 (bottom)	Sencore

Answers to C.E.T. Test, Section #6

Published in Last Month's Issue:

1. **(d)** It is inefficient, time-wise, to plot an i.f. response curve using an AM generator and v.t.v.m. But such a method will provide a graphic reproduction of the system responses. (Of course it is quicker to use a sweep generator and scope.)
2. **(d)** a, b, or c are all indications of poor alignment (although they may be caused by circuit troubles other than alignment). Out of sync color normally would be caused by problems in the color circuitry.
3. **(c)** The sound carrier is aligned to be placed in the "sound hole" or "slot" near the base of the total peak video i.f. sweep response curve. Any large sound-carrier levels tend to cause a 920-kHz beat between the color and sound carriers.
4. **(d)** Adjacent sound. When aligning the i.f.'s, this 47.25-MHz frequency must be aligned to a minimum level to trap out the adjacent-channel sound signal.
5. **(c)** A marker generator or other type of single-frequency producer, or remover, identifies selected frequencies on the i.f. response curve by producing a slight spike, or other disruption of the curve, at the marker's known frequency.
6. **(a)** 3.08-4.08 MHz is the desired flat frequency response.
7. **(b)** The a.g.c. substitution box must be lower in impedance than the set's own a.g.c. system in order to be the controlling r.f./i.f. bias voltages and eliminate any control by the set a.g.c.
8. **(a)** This is the normal test point area for connecting the scope in alignment. Size of the load resistor for the detector in tube sets might be in the 10k-ohm range or less and have 1-10 volts developed across it to drive the video amplifier stage.
9. **(a)** This is normal procedure, aligning the sound section in modern TV receivers using the station signal and the technician's ear.
10. **(b)** The mixer output circuit and the i.f. link contain some i.f. alignment adjustments and must be included in i.f. alignment, rather than connecting the sweep generator directly to the first i.f. grid, base, or input.

ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 85¢ per word (including name and address). Minimum order $8.50. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.

READER RATE: For individuals with a personal item to buy or sell. 50¢ per word (including name and address). No minimum! Payment must accompany copy.

GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd month preceding cover date (for example, March issue closes January 1st). **Send order and remittance to: Hal Cymes, ELECTRONICS WORLD, One Park Avenue, New York, New York 10016.**

FOR SALE

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 4040 North Nashville Avenue, Chicago, Ill. 60634.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna, Nahant, Mass. 01908.

METERS Surplus, new, used, panel or portable. Send for list. Hanchett, Box 5577, Riverside, Calif. 92507.

CONVERT any television to sensitive big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco-A22, Box 10563, Houston, Texas 77018.

INVESTIGATORS, LATEST ELECTRONIC AIDS. FREE LITERATURE. CLIFTON, 11500-J NW 7th AVE., MIAMI, FLORIDA 33168.

TREASURE HUNTERS! Prospectors! Relco's new instruments detect buried gold, silver, coins. Kits, assembled models, Transistorized. Weighs 3 pounds. $19.95 up. Free catalog. Relco-A22, Box 10839, Houston Texas 77018.

EUROPEAN wholesale new products catalog, $1.00 refundable. Deecow, 10639 Riverside, North Hollywood, Calif. 91602.

MUSIC LOVERS, CONTINUOUS, UNINTERRUPTED BACKGROUND MUSIC FROM YOUR FM RADIO, USING NEW INEXPENSIVE ADAPTER. FREE LITERATURE, ELECTRONICS, 11500-Z NW 7th AVE., MIAMI, FLORIDA 33168.

SENCORE, B & K TEST EQUIPMENT UNBELIEVABLE PRICES. FREE CATALOG AND PRICE SHEET. FORDHAM RADIO, 265 EAST 149TH STREET, BRONX, N.Y. 10451.

SEMICONDUCTORS and Parts. Catalogue free over 100 pages. J. & J. Electronics, Box 1437, Winnipeg, Manitoba, Canada. U.S. Trade directed.

MC790P—$2.00, MC724P, MC 789P $1.05. Write for catalog. Hal Devices, Box 365Z, Urbana, Illinois 61801.

CONSTRUCTION PLANS: LASER . . . $2.00. Listening Devices—two F. M. Mike Transmitters . . . $1.00. Tail Transmitter . . . $1.00. Sound Telescope . . . $2.00. Infinity Transmitter . . . $2.00. Equipment and kits available. Howard, 20174 Ward, Detroit, Michigan 48235.

ELECTRONIC ignition, various types. Free literature. Anderson Engineering, Epsom, N.H. 03239.

BURGLAR ALARM SYSTEMS and accessories. Controls, bells, sirens, hardware, etc. **OMNI GUARD** radar intruder detection system, kit form or assembled. Write for free catalog. Microtech Associates, Inc., Box 10147, St. Petersburg, Florida 33733.

ELECTRONIC PARTS, semiconductors, kits. Free Flyer. Large catalogue $1.00 deposit. Bigelow Electronics, Bluffton, Ohio 45817.

ELECTRONIC COMPONENTS—Distributor prices. Free catalogue. Box 2581, El Cajon, California 92021.

STROBES, color organs, the incredible Strobit. NEW! Heavy-Duty CD ignition. ELECTRIC CANDLES for flameless candle-light. REMOTE (WIRELESS) SWITCH for anti-prowler system. TOUCH SWITCH for space-age lamps, lights. ASSEMBLED and KITS. Send 25¢, specify interest. Teletronics, Box 1266 B, South Lake Tahoe, Calif. 95705.

LINEAR AMPLIFIERS: "Hawk"—25 watts output—$99.95; "Raider"—100 watts—$139.95; "Maverick-250"—250 watts—$244.95. AM/SSB. "Scorpion" 50 watt 12 volt mobile—$99.95; "Bandit 11" 100 watt mobile—$169.95. 20-35 megacycles. (Illegal Class D 11 meters.) Dealer inquiries invited. D & A Manufacturing Co., 1217 Avenue C, Scottsbluff, Nebraska 69361.

TV TUNER REPAIRS—Complete Course Details, 12 Repair Tricks, many plans, two lessons, all for $1.00. Refundable. Frank Bocek, Box 832, Redding, Calif. 96001.

SLOW FLASHING TURNLIGHTS ARE DANGEROUS. WINKER-KIT DOUBLES FLASHING RATE. $3.00 FOR ALL CARS. GUARANTEED. ACE, 11500 N.W. 7TH AVENUE, MIAMI, FLORIDA 33168.

6-TRANSISTOR alternator voltage regulator. Fits most cars. Free literature. Yuenger Engineering Co., 13381 Wheeler Pl., Santa Ana, Calif. 92705.

TECHNICIANS and **ENGINEERS**—Teach yourself computer logic and advance professionally. Comp-U-Kit Logic Lab with modern 7400 TTL integrated circuits, a quality patch system, and our outstanding logic book is only $39.00 postpaid. Free literature. Scientific Measurements, C120, 9701 Kenton, Skokie, Illinois 60076.

LOGIC-MODULES—Electronic Kits, Pulsers, Comparators, Booklets, and Comp-U-Kit Logic Lab. Free literature. Scientific Measurements, C121, 9701 Kenton, Skokie, Illinois 60076.

ELECTRONICS ENGINEERING AND INSTRUCTION

LEARN ELECTRONIC ORGAN SERVICING at home. All Makes including transistors. Experimental kit—troubleshooting. Accredited NHSC. Free Booklet. **NILES BRYANT SCHOOL,** 3631 Stockton. Dept. A, Sacramento, Calif. 95820.

DEGREE in Electronics Engineering earned mostly by correspondence. Free brochure. Dept. G-9, Grantham School of Engineering, 1505 N. Western Ave., Hollywood. California 90027.

FCC First Class License in six weeks—approved for Veterans Training. Schools in Dallas, Atlanta, Chicago, New Orleans, Minneapolis and Houston. Write Elkins Institute, 2603C Inwood Road, Dallas, Texas 75235.

R.E.I.'s famous (5) week course for the First Class Radio Telephone License is the shortest, most effective course in the nation. Over 98% of R.E.I. graduates pass F.C.C. exams for 1st class license. Total tuition $395.00. Job placement free. Write for brochure Radio Engineering Incorporated Schools, 1336 Main Street, Sarasota, Florida 33577—or 3123 Gillham Road, Kansas City, Missouri 64109—or 809 Caroline Street, Fredericksburg, Virginia 22401—or 625 E. Colorado Street, Glendale, California 91205.

ELECTRONICS! Associate degree—29 months. Technicians, field engineers, specialists in communications, missiles, computers, radar, automation. Start September, February. Valparaiso Technical Institute, Dept. N, Valparaiso, Indiana 46383.

MEMORIZE, STUDY: "1970 TESTS-ANSWERS" FOR FCC FIRST AND SECOND CLASS LICENSE. Plus "Self-Study Ability Test." Proven. $5.00. Command, Box 26348-W, San Francisco 94126.

LEARN DIGITAL LOGIC and integrated circuits. Free brochure. Performance Enterprises, Inc., Box 1058, Pompano Beach, Fla. 33061.

PLANS AND KITS

ROCKET Plans Proven, catalog 10¢. Rockets, P.O. Box 7274, Long Beach, California 90807.

TRANSISTORIZED DC POWER SUPPLY — Build your own, 5-40 volts, 1-5 amps, excellent regulation. Plans $2.00. **NERONE ELECTRONICS,** Dept. 101, Box 238, New Baltimore, Michigan 48047.

"TALKING" PLANTS? Almost! New, transistorized plant response detector gives dramatic audio pitch as living plant reacts to physical harm or rough conditioning electronically. Accepts tape machines for recording of phenomena or monitoring by stereo/mono sound systems. A fascinating discovery tool for engineers, hobbyists, inventors, educators! Illustrated plans with professional references and parts list—only $4.95; with p.c. board for error-free construction—now only $9.98, check or M.O. Electro-Physics Laboratory, Dept. EW8, P.O. Box 3284, San Bernardino, Calif. 92404.

POWER your bicycle electrically using storage battery. Complete illustrated plans $3.00. A.E.E., P.O. Box 292, Minneapolis, Minnesota 55440.

CLASSIFIED ADVERTISING ORDER FORM

Please refer to heading on first page of this section for complete data concerning terms, frequency discounts, closing dates, etc.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35

_____ Words { @ .50 Reader Rate / @ .85 Commercial Rate } = $_____

Insert _____ time(s) Total Enclosed $_____

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP

SIGNATURE _____

WORD COUNT: Include name and address. Name of city (Des Moines) or of state (New York) counts as one word each. Zip Code numbers not counted. (Publisher reserves right to omit Zip Code if space does not permit.) Count each abbreviation, initial, single figure or group of figures or letters as a word. Symbols such as 35mm, COD, PO, AC, etc., count as one word. Hyphenated words count as two words. EW-8-70

1970—WINTER $1.35
ELECTRONIC EXPERIMENTER'S HANDBOOK
148 pages of the most fascinating and challenging construction projects for the electronics hobbyists. All with complete schematics, illustrations, parts list, and easy-to-follow instructions that guarantee you perfect finished products.

1970—SPRING $1.50
ELECTRONIC EXPERIMENTER'S HANDBOOK
Another big package containing the most challenging, fun-to-build electronics projects ever! Be sure to order this one today!

1970 $1.35
STEREO/HI-FI DIRECTORY
Giant 180 page buyer's guide listing more than 1,600 individual Stereo/Hi-Fi components by 176 manufacturers. Nine individual sections complete with specs, photos, prices—the works!

6 Vital Components

For Knowledge... For Profit... For Sheer Electronics Enjoyment!

1970 $1.35
TAPE RECORDER ANNUAL
Over 130 pages covering every aspect of tape recording. Complete buyer's guide to the brands and models on the market. Expert tips on equipment — making better tapes — editing — copying — everything you want and need to know about tape recording.

1970 $1.35
COMMUNICATIONS HANDBOOK
148 fact packed pages for the CB, SWL or HAM. Equipment buyer's guide — photos — tables — charts — getting a license — everything to make this the world's most complete guide to communications.

1970 $1.35
ELECTRONICS INSTALLATION & SERVICING HANDBOOK
For the serviceman who is also a businessman — the hobbyist who is also a perfectionist! Covers all 8 areas of consumer electronics servicing — all the tricks of the trade—in one complete, up-to-date guide. This is the industry's "how-to" book for installing and servicing consumer electronics equipment.

ZIFF-DAVIS SERVICE DIVISION • Dept.W
595 Broadway, New York, N.Y. 10012
Please send me the annuals I've checked below:

- ☐ 1970 Electronic Experimenter's Handbook-Winter
- ☐ 1970 Electronic Experimenter's Handbook-Spring
- ☐ 1970 Stereo/Hi-Fi Directory
- ☐ 1970 Tape Recorder Annual
- ☐ 1970 Communications Handbook
- ☐ 1970 Elect. Installation & Servicing Handbook

I am enclosing $________. My remittance includes an additional 25¢ per copy for shipping and handling (Outside U.S.A. all magazines are $2.00 per copy, postpaid.) EW 8-70

print name ____________

address ____________

city ____________

state ________ zip ________

PAYMENT MUST BE ENCLOSED WITH ORDER

TUBES

TUBES——Lowest prices. Foreign-American. Obsolete, receiving, special purpose, transmitting tubes. Send for tube, parts catalog. United Radio Company, 56-E Ferry St., Newark, N.J. 07105.

TUBES, SEMICONDUCTORS, ELECTRONIC EQUIPMENT & COMPONENTS. Quality merchandise only! Serving engineers, Purchasing Agents, TV/HiFi Servicemen and Hams for 20 years. Write for Catalog or call 212-WA 5-7000. **BARRY ELECTRONICS,** 512 Broadway, New York, N.Y. 10012.

RECEIVING & INDUSTRIAL TUBES, TRANSISTORS, All Brands—Biggest Discounts. Technicians, Hobbyists, Experimenters—Request **FREE** Giant Catalog and **SAVE! ZALYTRON,** 469 Jericho Turnpike, Mineola, N.Y. 11501.

TUBES—33¢ each. Year guarantee. Tuner Cleaner $1.00. Free catalog. Cornell, 4213-W University, San Diego, Calif. 92105.

WANTED

QUICKSILVER, Platinum, Silver, Gold. Ores Analyzed. Free Circular. Mercury Terminal, Norwood, Mass. 02062.

QUICK CASH . . . for Electronic Tubes, Semiconductors, Equipment (Receivers, Transmitters, Scopes, Vacuum Variables, etc.) Send lists now! Write: **BARRY ELECTRONICS,** 512 Broadway, New York, N.Y. 10012 (212-WA 5-7000).

COMPUTERS ASN-7, four CP-221 Latitude Longitude, four CP-289 Navigational used on KC-135 and F101. H. J. Burke Co., Inc., 234 Garibaldi Avenue, Lodi, N.J. 07644.

DO-IT-YOURSELF

PROFESSIONAL ELECTRONICS PROJECTS— $1.00 up. Catalog 25¢. **PARKS,** Box 25665A, Seattle, Wash. 98125.

PSYCHEDELIC LIGHTING MANUAL! Make light-machines, strobes, organs, kaleidoscopes, etc. Send $2.00. Lightrays Company, 713-A Pine, Philadelphia, Pa. 19106.

TAPE AND RECORDERS

BEFORE renting stereo Tapes, try us. Postpaid both ways — no deposit — immediate delivery. Quality — Dependability—Service—Satisfaction—prevail here. If you've been dissatisfied in the past, your initial order will prove this is no idle boast. Free Catalog. Gold Coast Tape Library, Box 2262, Palm Village Station, Hialeah, Fla. 33012.

RENT 4-track open reel tapes—all major labels—8,000 different—free brochure. Stereo-Parti, 55 St. James Drive, Santa Rosa, Calif. 95401.

STEREO TAPES, save 20, 30% and more, postpaid anywhere U.S.A. We discount batteries, recorders, tape/cassettes, 80-page catalog 25¢. **SAXITONE TAPES,** 1776 Columbia Road, N.W., Washington, D.C. 20009.

OLD Radio Programs on tape. 6 hours for $8.00. Catalog 50¢. Don Maris, 1926 Cherokee, Norman, Okla. 73069.

CASSETTES, Pre-recorded Spoken Word—over 100 titles—educational, including language. Cassette and 8-track Blanks plus many accessories. Send 10¢ in stamps or coin for latest literature. Cassettes Unlimited, P.O. Box 13119W, Pittsburgh, Pennsylvania 15243.

PERSONAL Development Cassette Tape—Rush $2.99 to F. J. Kielian, 130 Drake Avenue, South San Francisco, California 94080.

STEREO TAPE TRANSPORT—7" reel—2 speeds—pause control—made for famous manufacturer —50 to 15,000 Hz—with rec/play and erase heads, without case. Send m.o. or check for $19.50 to Stereo Center, 218 Columbia St., Utica, N.Y. 13502. $2.50 for prepaid shipping and insurance.

RECORDS

OLDIES—45 RPM—original hits. Over 4000 available. Catalog 25¢. C & S Record Sales, Box 197, Wampsville, N.Y. 13163.

GREGORY ELECTRONICS

We Offer A Whopping 15% Discount*

on these special items in quantities of 10 or more

MOTOROLA

30-50 MHz Mobile Units

Motorola T41GGV 30-50 MHz, 6/12v. 30 watt, vibrator power supply fully narrow band, complete with accessories	$108.
Same as above, T41G series	$ 88.
T51G Series vibrator power supply TX narrow band	$ 98.
RX wide band Fully narrow band (TX & RX)	$118.
T51GGV vibrator power supply TX, narrow banded RX wide band	$118.
Fully narrow band (TX & RX)	$138.
Above prices include accessories (Less accessories, deduct $20.)	
Motorola T44AAV—450-470 MHz 6/12 volt, 15 to 18 watt, complete accessories	$ 48.
With private line minus reeds	$ 78.
Motorola U44BBT 450-470 MHz 12 volt, 15 watt transistor power supply with private line (dual squelch) complete with accessories	$198.
Less PL	$168.

GENERAL ELECTRIC

PROGRESS LINE
2-WAY MOBILE EQUIPMENT
30-50 MHz MOBILE UNITS

14" case, complete accessories, fully narrow banded	
MA/E13-6/12 volt, 30 watts, vibrator power supply	$148.
MA/E16-6/12 volt, 60 watts, vibrator power supply	$178.
450-470 MHz—14" case complete accessories MA/E42, 6/12 volt, 15 watt, vibrator power supply	$118.
MT42-12 volt, 15 watt, transistor power supply complete with accessories	$148.

*THIS IS A NET DISCOUNT

Motorola and RCA EQUIPMENT AT NEW LOW PRICES
Reconditioned & Used FM 2-Way Radio Equipment
We Buy Late Model Equipment for Cash
SEND FOR NEW 1970 CATALOG

GREGORY ELECTRONICS

GREGORY ELECTRONICS CORPORATION
249 RT. 46, Saddle Brook, N.J. 07662
Phone: (201) 489-9000

CIRCLE NO. 115 ON READER SERVICE CARD

WHOLESALE TO ALL
Breadboard Kits—"RF" Kits—"PC" Kits—Perf. Phenolic Board—Copper Clad Board—Cowl Type Electronic Cabinets—Heat Sinks—Solid State Hobby Kits—Solderless Connectors—Hardware Kits—Transistor Sockets and many more items. Send for free catalog from: H. M. C. Sales, P.O. Box 276—Santa Susana, California 93063

SPECIAL interest records available, produced by the editors of the world's leading special interest magazines. Send for free catalog. Record Catalog EW, Ziff-Davis Publishing Company, One Park Avenue, New York, N.Y. 10016.

POPULAR organ albums factory direct. Concert Recording, Lynwood, Calif. 90262.

HIGH FIDELITY

LOW, LOW quotes: all components and recorders. Hi-Fi, Roslyn, Penn. 19001.

CELEBRATION SALE!

WE CAN NOW SHIP TO YOU DIRECT FROM OUR U.S. WAREHOUSE. NO CUSTOMS DUTIES—STRAIGHT TO YOUR DOORSTEP IN THE MAIL — AND WE ARE CELEBRATING!

7 YEARS OF SELLING ONLY NEW BRANDED 1st GRADE SURPLUS SEMICONDUCTORS.

EVERY DEVICE COMES WITH A DATA SHEET!

U.S. INTEGRATED CIRCUIT MANUFACTURERS' END OF PRODUCTION INVENTORY.

RTL

900*	Buffer	$ .89
902*	R-S Flip Flop	1.25
903*	3 input nand/nor gate	.89
904*	Half adder	1.25
907*	4 input nand/nor gate	.89
914	Dual 2 input nand/nor gate	.89
915*	Dual 3 input nand/nor gate	.89
923	J-K Flip Flop	.99
925*	Dual 2 input gate expander	.89
927*	Quad inverter	.89
993	Dual 2 input gate and dual 2 input expander (914 + 925)	.99
995	Dual buffer and dual 3 input gate (2 x 900 + 915)	.99

Most available in flat pack or metal TO-5.

DTL

930*	Dual 4 input nand/nor gate	.99
932*	Dual 4 input buffer	.89
933*	Dual 4 input extender	.89
944	Dual 4 input nand/nor power gate	1.25
946*	Quad 2 input nand/nor gate	1.15
949	Higher speed higher drive level 946	1.35
951*	Monostable multivibrator	2.55
961	Higher speed higher drive level 930	1.35
962	Triple 3 input nand/nor gate	.99
963	Higher speed higher drive level 962	1.35

**Available in Military Spec. at twice the above price.*

Most available in flat pack or dual in line.

***EXTRA SPECIAL!* Dual in line case only.**

662	Dual nand/nor gate. I of 6 input and I of 4 input	.75
663	Sextuple inverter	.75
664	Quad 2 input nand/nor gate	.85
666	Triple 3 input nand/nor gate	.85

ORDERS OF $10 OR MORE DEDUCT 10%.

Terms: Check or money order to address below. Include fixed shipping charge 30¢. Minimum order $3.00. Minimum COD $5.00 and 25% down. Shipment from N. Dakota.

J. & J. ELECTRONICS
P.O. Box 1437, Winnipeg, Man., Canada
(204) 943-6916

CIRCLE NO. 134 ON READER SERVICE CARD

FREE! Send for money saving stereo catalog E8W and lowest quotations on your individual component, tape recorder or system requirements. Electronic Values, Inc., 200 West 20th Street, N.Y., N.Y. 10011.

DIAMOND NEEDLES AND STEREO CARTRIDGES at low, low prices for Shure, Pickering, Stanton, Empire, Grado and ADC. Send for free catalog and price sheet. We will be happy to quote on any cartridge—Magnetic, Ceramic or Crystal. All merchandise brand new and shipped **PREPAID. LYLE CARTRIDGES,** Dept. E, 265 East 149 Street, Bronx, New York 10451.

HI-FI Components, Tape Recorders at guaranteed "We Will Not Be Undersold" prices. 15-day money-back guarantee. Two-year warranty. No Catalog. Quotations Free. Hi-Fidelity Center, 239 (L) East 149th Street, New York 10451.

HI-FI components, tape recorders, sleep learning equipment, tapes. Unusual Values. Free catalog. Dressner, 1523 R Jericho Turnpike, New Hyde Park, N.Y. 11040.

HI-FI EQUIPMENT—GET Our **"ROCK BOTTOM"** prices on **NAME BRAND** amplifiers—tuners—tape-recorders — speakers **FRANCHISED — 60 YEARS IN BUSINESS.** Write for this month's specials—**NOW!** Rabson's 57th St., Inc., Dept. 569, 119 W. 57th St., New York, New York 10019.

AMAZING DISCOUNTS on famous brand high fidelity stereo components. No small wonder that we have set new sales records each year since 1959. Write: Arkay Electronics, 1028-02 Commonwealth, Boston, Mass. 02215.

SAVE over 33⅓ on a pair of one of the world's best speaker systems shipped direct to you from factory. Try them in your home for thirty days. Write KGLL Inc., Water St., Lewiston, Maine 04240.

PROFESSIONAL STEREO TONE ARM—Similar to Shure M232 or Rek-o-kut S320. Plug in shell, finger lift, adjustable counterweight, no springs, arm rest, heavy connecting cables with pin plugs, beautifully balanced. One year warranty. Made by famous turntable-arm manufacturer in Switzerland. Send check or M.O. for $9.50 plus $1.50 for shipping and insurance. Stereo Center, 218 Columbia Street, Utica, New York 13480.

GOVERNMENT SURPLUS

JEEPS Typically From $53.90 . . . Trucks From $78.40 . . . Boats, Typewriters, Airplanes, Multimeters, Oscilloscopes, Transceivers, Electronics Equipment. Wide Variety, Condition, 100,000 Bid Bargains Direct From Government Nationwide. Complete Sales Directory and Surplus Catalog $1.00 (Deductible First $10.00 Order). Surplus Service, Box 820-K, Holland, Michigan 49423.

MANUALS for surplus electronics. List 20¢. Books, 4905 Roanne Drive, Washington, D.C. 20021.

BOOKS

NEW!! ELECTRICAL ENGINEERS HANDBOOK, Arthur Liebers—$7.95. Conductors, Wiring, Circuits, Generators, Transformers, AC DC Motors, DC Generators. Hundreds of Designs, Drawings, Symbols. KEY PUBLISHING CO., 830 Broadway, New York, New York 10003.

PERSONALS

MAKE FRIENDS WORLDWIDE through international correspondence. Illustrated brochure free. Hermes, Berlin 11, Germany.

HOUSTON Remailings, Forwarding, Confidential $3.00 Monthly. Box 12263, Houston, Texas 77017.

SECRET Loans by Mail. Borrow $100 to $1500 for any good reason in absolute privacy. No interviews, no endorsers, no co-signers. Fast service. Write: Dial Finance Co., Dept. H-594, 410 Kilpatrick Bldg., Omaha, Nebraska 68102.

HYPNOTISM

FREE Hypnotism, Self-Hypnosis, Sleep Learning. Catalog! Drawer H400, Ruidoso, N.M. 88345.

PHOTOGRAPHY—FILM EQUIPMENT, SERVICES

SCIENCE Bargains—Request Free Giant Catalog "CJ"—148 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts, War Surplus bargains. Edmund Scientific Co., 300 Edscorp Bldg., Barrington, New Jersey 08007.

IMPOSSIBLE? SUPER-VALUES IN SURPLUS ELECTRONICS & OPTICS

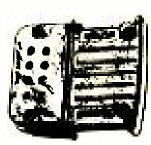
68 Page Catalog - 25 cents.... Free with order

Plug-In

DTL INTEGRATED CIRCUITS---80% DISCOUNT

This is the SP600 series of integrated circuits made by Sprague and Signetics. Compatible with other manufacturers integrated circuits. Each order will include circuits for decade counters, bi-directional counters, decoding circuits, shift registers, memories and many other circuits, in addition to data sheets. These I.C.'s represent one of the latest and most economical logic families for equipment design. Available are the SP616A J-K flip-flop, SP629A R-S flip-flop, SP631A quad 2 input gate expander, SP659A dual 4 input buffer driver, SP670A triple 3-input nand/nor gate, and SP680A quad 2 input nand/nor gate. Removed from new equipment.

PRICES ********************** POSTAGE PAID
SP616A, SP631A, SP670A, SP680A................$0.50 ea
SP620A, SP629A, SP659A,..........................$0.75 ea
Minimum order $5.00 worth of logic. A20% Discount on orders of 100 or more units.



NOISE CANCELLING MICROPHONE

Carbon microphones used in high altitude Air Force G suits. Impedance, 40 ohms at 85 milliamperes D.C. Uniform response 200 to 4,500 Hz. Construction is brass nivar and bakelite. Rugged blast-proof, sealed, altitude compensated. New with application sheet. Minimum order 5 units.

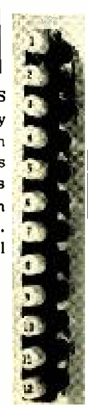
5NCM........5 for $2.00 postpaid

EXPERMINTERS TTL LOGIC KIT

This kit contains sixteen J-K flip-flop, eight dual four input nand/nor gates, eight quad two input nand/nor gates, eight triple three input nand/nor gates and three of our instant ultra-large logic cards with mating connectors. Full information on the integrated circuits, including circuits for counters, decoders, memories, shift registrs etc are included. The I.C.'s are made by T.I. Sprague or Signetics (no choice) and are new packaged in the flat-pak configuration. I.C.'s are or equivalent to 54/7400 series logic.

LOGIC EXPERIMENTATION KIT LEK $29.50 P.Pd.

LOTS OF OTHER BARGAINS IN I.C.s' and ASSOCIATED ELECTRONICS GET OUR PICTURED CATALOG NOW.

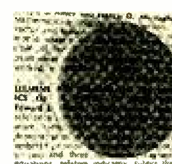


SYLVANIA 6ESB LOGIC INDICATOR LAMPS

These hard to get lamps will draw only 35 milliamperes, and operate directly from the output of 5 volt logic gates. Eliminates the complexity of separate driver transistors and extra supplies. Available complete with sockets and caps, in banks of 12 lamps. O.E.M. Price $8.99. Less than 1/3 original price.

12SLIL $2.75 postpaid

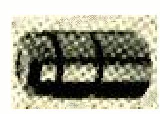
Telephone 617-532-2323

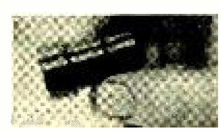


COHERENT FIBER OPTIC FACEPLATE

High resolution faceplate 1 1/16 " dia. X 3/8" thick. Original use in the Starlite Scope, Gov't Cost $180.00. Use for demonstration, science fair projects etc. May have slight edge chips.

FOF ..... $5.00 P.Pd.





WIDE ANGLE 8MM PROJECTION LENS

This lens is a coated 4-element design, mounted in a black anodized aluminum barrel. The 19 mm focal length lens gives a third wider screen picture than with a standard 1" F.L. lens you may now be using. Technical data: F/1.6, F.L. 19 mm, length 2", diameter 3/4".

19WAPL $2.50 P.Pd.

SUPER 8 MM PROJECTOR LENS F.L. 32 MM

This lens was made by EK as a super 8 mm movie projector lens. It was manufactured for use on EK's finest projectors. This is one of the very highest quality projector lenses available on the surplus market and is well worth at least twice the low price offered here. Data f/1.6 FL 32mm.

1.6FL32MM $4.00 P.Pd.

BF

B. & F. ENTERPRISES

P. O. BOX 44 :: HATHORNE, MASSACHUSETTS 01937

CIRCLE NO. 150 ON READER SERVICE CARD

EMPLOYMENT INFORMATION

FOREIGN and USA job opportunities available now. Construction, all trades. Earnings to $3,000.00 monthly. Paid overtime, travel, bonuses. Write: Universal Employment, Woodbridge, Conn. 06525.

EXCITING OVERSEAS JOBS. Directory $1.00. Research Associates, Box 942-E, Belmont, California 94002.

INVENTIONS WANTED

PATENT Searches including maximum speed, full airmail report and closest patent copies, $6.00. Quality searches expertly administered. Complete secrecy guaranteed. Free Invention Protection forms and "Patent Information." Write Dept. 23, Washington Patent Office Search Bureau, 711 14th Street, N.W., Washington, D.C. 20005.

INVENTORS! Sell your invention for cash or royalties! Our client manufacturers eagerly seek new items. Patented. Unpatented. Financial assistance if needed. 25 years proven performance. For free information, write Dept. 25, Gilbert Adams, Invention Broker, 80 Wall St., New York, N.Y. 10005.

EDUCATIONAL OPPORTUNITIES

LEARN WHILE ASLEEP, Hypnotize! Strange catalog free. Autosuggestion, Box 24-ZD, Olympia, Washington 98501.

MAGAZINES

BACK DATE MAGAZINES! Send needs. Midtown, Box 917-EW, Maywood, N.J. 07607.

BUSINESS OPPORTUNITIES

FREE CATALOGS. Repair air conditioning, refrigeration. Tools, supplies, full instructions. Doolin, 2016 Canton, Dallas, Texas 75201.

I MADE $40,000.00 YEAR by mailorder! Helped others make money! Start with $10.00—Free proof. Torrey, Box 318-N, Ypsilanti, Mich. 48197.

JAPANESE Electronics New Products Monthly! Specimen copy $1, deductible. **Dee,** 10639-W Riverside, North Hollywood, Calif. 91602.

FREE BOOK "999 Successful Little-Known Businesses." Work home! Plymouth 445-H, Brooklyn, New York 11218.

MAKE BIG MONEY raising chinchillas, rabbits, guinea pigs for us. Catalog—25¢. Keeney Brothers, New Freedom, Pa. 17349.

BECOME CITIZEN BAND DEALER, Write RJS Communications, Brockton, Massachusetts 02403.

MUSICAL INSTRUMENTS

30% DISCOUNT any name brand musical instrument. Free catalog. Freeport Music, 127-L Sunrise Hway, Freeport, N.Y. 11520.

RUBBER STAMPS

RUBBER ADDRESS STAMPS $2.00. SIGNATURE $3.50. FREE CATALOG. JACKSON'S, BOX 443-G, FRANKLIN PARK, ILL. 60131.

MISCELLANEOUS

WINEMAKERS: Free illustrated catalog of yeasts, equipment. Semplex, Box 122-76, Minneapolis, Minn. 55412.

JAPAN'S PUBLICATIONS GUIDE Business, pleasure, education. $5.00. INTERCONTINENTAL, CPO 1717, Tokyo 100-91.

STOP BURGLARS THE EASY WAY!! Affix authentic "Protected by Electronic Sentry Alarm" Decals to auto windows, doors and windows of home, retail stores; vending machines, etc. Whether you have an alarm or not —thieves stay away! Only $1.00 each set of two. J. Ross, 80-34 Kent St., Jamaica, N.Y. 11432. Dept. EW.

BRAND NEW! GENERAL ELECTRIC PA-237 2-WATT AUDIO AMPLIFIER

•Lowest Prices •Brand New!

2 watts continuous 9 to 27 volt supply, 8 mV sensitivity, includes 11 circuits, for phono, tape recorders, dictating, TV, FM, movie.

$3.95

709C OP AMPLIFIER

☐ Guaranteed! With Spec.

TYPICAL USES: •AC AMPLIFIER •RIAA PHONO PREAMP •INTEGRATOR •MULTIPLIER

1.49

BRAND NEW! RTL-TTL 'ICS'

ALL GUARANTEED! With Spec Sheets!

99¢ Each, 3 for $2.75

	Description	
☐ SG43SD	Dual 4 Input Nand/Nor Gate	TTL
☐ W215F	JK Flip Flop	DTL
☐ W266F	Quad 2 Input Gate	DTL
☐ 320T	JK Flip Flop (fastest logic)	ECL
☐ 900FF	Buffer	RTL
☐ 908TU	Full Adder	RTL
☐ 909TU	Buffer	RTL
☐ 912TU	Half Adder	RTL
☐ 913TU	Shift Register	RTL
☐ 914TF	Dual 2 Input Gate	RTL
☐ 923TF	JK Flip Flop	RTL
☐ 960TU	Dual Buffer	RTL
☐ 7470FX	JK Flip Flop (35mhz)	TTL
☐ 7302FX	Dual JK Flip Flop	DTL
☐ 84 00UF	Quad 2 Input Gates	TTL

EPOXY SILICON TRANSISTORS

5 for $1

Type	Sale
☐ 2N2222	5 for $1
☐ 2N2368	5 for $1
☐ 2N3396	5 for $1
☐ 2N3565	5 for $1
☐ 2N3568	5 for $1
☐ 2N3638	5 for $1
☐ 2N3641-3	5 for $1
☐ 2N3645	5 for $1
☐ 2N3793	5 for $1
☐ 2N4248	5 for $1
☐ 2N4288-9	5 for $1

SOLID STATE 1970 WINNERS

- ☐ Fairchild 741 OP. Amplifier* $2.98
  *frequency compensated 709
- ☐ Westinghouse Voltage Regulator 0 to 40 VDC Positive $1.19
- ☐ Shockley Diodes, 4 layers .... 3 for $1.19
- ☐ Neon & Nixie Driver 2N4410 .... 4 for $1.00
- ☐ SCR/Triac Trigger Diodes .... 4 for $1.19

TEXAS! NATIONAL! FAIRCHILD COUNTING "IC's"

Guaranteed! W/Spec Sheets Any 3 — 10% Discount!

- ☐ 958 Decade Counter $4.95
- ☐ 959 Quad Latch 3.95
- ☐ SN7493 4 Bit Counter 4.95
- ☐ SN7490 Decade Counter 5.50
- ☐ SN7475 Quad Latch 4.50
- ☐ SN7441 BCD Decoder 8.50
- ☐ 9301 1-to-10 Decoder 4.95
- ☐ 9306 BCD Up/Down Counter (24-Pin DIP) 9.95
- ☐ 9300 4 Bit Univ. Shift Register 2.49
- ☐ 9304 Dual Full Adder 4.95

"MEMORIES" for 1970?

- ☐ Fairchild 1128 8 bit $2.49
- ☐ Fairchild 9033 16 bit $3.98
- ☐ Philco PL5R100 Dual 50 bit $12.50
- ☐ 4000 Bit Core Planes $8.50

☐ Westinghouse WC334 one watt audio amp, TO-5 case Guaranteed! **1.49**

Terms: add postage. **Rated:** net 30, cod's 25%
Phone Orders: Wakefield, Mass. (617) 245-3829
Retail: 211 Albion, St., Wakefield, Mass.

POLY PAKS P.O. BOX 942W LYNNFIELD, MASS 01940

10¢ FOR OUR "SUMMER" BARGAIN CATALOG ON: ☐ Semiconductors ☐ Poly Paks ☐ Parts

CIRCLE NO. 123 ON READER SERVICE CARD

LIBERTY PAYS MORE!

WILL BUY FOR CASH

ALL TYPES:

- ★ ELECTRON TUBES
- ★ SEMICONDUCTORS
- ★ TEST EQUIPMENT
- ★ Military Electronic Equipment

WIRE—WRITE—PHONE COLLECT!
We pay freight on all purchases—

LIBERTY OFFERS MORE!

PRESTEL FIELD STRENGTH METER

(Model 6T4G)

Only **$120.00** F.O.B. New York

- ★ Never Anything Like It!
- ★ 1-Man Can Do A Better Job than 3 in the Same Time!
- ★ A Gold-Mine for Antenna Installers!

Calibrated from 40 to 230, and 470 to 860 in 4 Bands Megahertz, from 10 to 50.000 Microvolts. Nothing makes it easier to properly and speedily find the correct place to install TV, FM and Communication Antennas. You can measure and hear the signals with this 4½ volt battery economically powered unit.

LIBERTY ELECTRONICS, Inc.

548 Broadway, New York, New York 10012
Phone (212) 925-6000

CIRCLE NO. 130 ON READER SERVICE CARD

DIGITAL COUNTERS, CALIBRATION CERTIFIED:

10 Hz to 220 MHz:
Hewlett-Packard 524D (8 DCU's) & 525A & B 950.00
Hewl-Pack 524C (8 big numbers) & 525A & B 995.00
Solid-State 7 Nixie CMC 730CU & plugins... 1050.00
10 Hz to 510 MHz:
Substitute 525C for B in any above, add..... 150.00
10 Hz to 100 MHz:
Beckman 7370 (8 DCU's) & 7570 & 7571 495.00
10 Hz to 1000 MHz:
Beckman 7370 (8 DCU's) & 7570 71/72/73.. 995.00
10 Hz to 12.400 MHz:
Add H.P. 540B Transfer Osc. to any above.. 375.00
12,000 MHz WITH NO CALCULATIONS:
Beckman 7370 (8 DCU's) and #7580...... 1295.00
10 Hz to 120 KHz:
Hewl-Pack #522B (5 DCU's), Universal..... 199.50
DC to over 2 mhz. Universal:
H.P. #5233L solid-state, 6 nixies **750.00**

$2538.00 ACQ.-COST FREQUENCY METER FOR $75.00!

AN/URM-79 (FR-4/U in Transit Case): 100 khz to 20 mhz, 7 bands, each 50,000 dial div. .001% accur., .0001% stabil. Measures & Emits. Built-in AC sply, scope for zero-beating and serial-matched calib. book includes instruct. Exc. cond., money-back grty OK. Shpg wt 146 lbs.

$975.00 #65B SIGNAL GENERATOR FOR $295.00!

Meas. Corp. generators from the test line of a multi-million-dollar Radio Mnfr. We bought strictly as-is but at the right price so can sell strictly as-is but at the right price. Instruction Book with each! **#65B is the FAA's favorite** because the CW can also be AM up to 100%. 75 khz to 30 mhz, manual or motor-driven tuning. Calib. Vo **0.1 uv to 2.2 VOLTS** across your 50 ohm load.

SIGNAL GENERATOR SIMILAR H.P.'s 608D:

Marconi TF-801D/1: 10 to 470 mhz, CW & AM up to 90%. Crystal-calibrated each 2 and 5 mhz and movable cursor (hairline indicator) to reset the dial at each zero beat, gives freq. accuracy 0.01%. Standard 50 ohm Zo from Type N plug. Vo calib. accurately 0.1 uv to 1 v. Leakage & FM too low to measure. Capacity-coupled contactless turret bandswitching eliminates down time. Very handsome design, carefully engineered $1650.00 instrument. Like new appearance, completely overhauled, with calib. sticker and certificate traceable to N.B.S With Book **595.00**

CALIBRATED & GRTD OSCILLOSCOPES:

Tek 502 Dual Beam, 0.2 mv/cm, 1-100 khz .. 475.00
Tek 504: 5 mv/cm sensitivity, 0-450 khz ... 450.00
Tek 531 with **53C** dual-trace plugin 545.00
Tek 541A with 24 mhz dual-trace plugin 850.00
Tek 543B 33 mhz scope & **CA** 2-trace 999.50
Same but in rack-mtg cabinet 899.50
H.P. 175A with 0-40 mhz 2-trace vertical and calib. variable-delay sweeper 999.50
H.P. 130B: 1 mv/cm sensit., 0-300 khz 350.00

IF YOU DON'T SEE IT HERE, ASK FOR IT!

We have **AUDIO** Engrg Test Equipment including Spectrum Analyzers, cheap! Spectrum Analyzers to 44 ghz, cheap! RFI Equipment! Lots of GOOD material!

But don't ask for a general catalog . . . we believe that is nonsense in surplus . . . we get new things in almost every day! **WE ALSO BUY!** So tell us what you have, condition, and your asking price!

R. E. GOODHEART CO. INC.
Box 1220-A, Beverly Hills, Calif. 90213
Phone: Area 213 272-5707

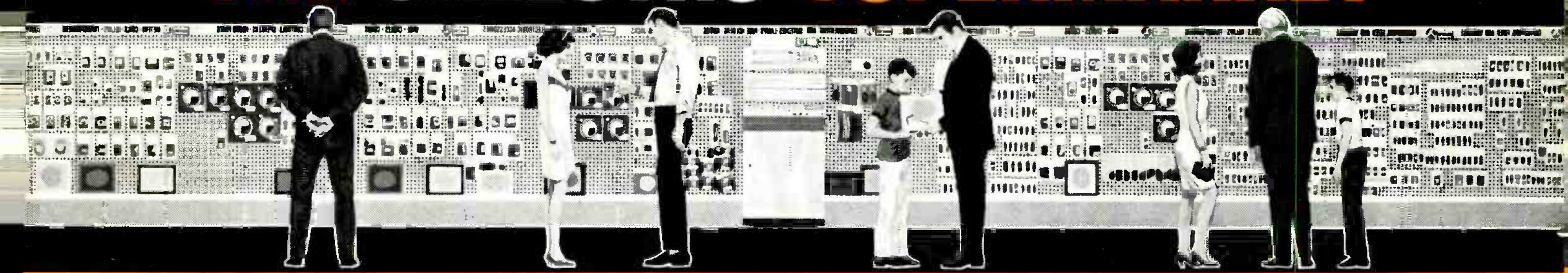
Printed in U.S.A.

ELECTRONICS WORLD

August 1970

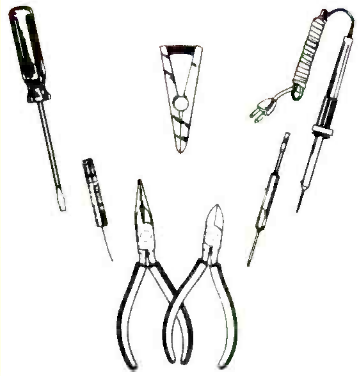
ADVERTISERS INDEX

THE CALECTRO SUPERMARKET



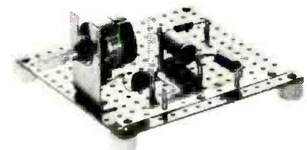
EVERYTHING IN ELECTRONICS!

VARIABLE BALANCE STEREO HEAD PHONE
Unique "Sound Level" control on each earpiece permits adjustment. Frequency range: 20 to 20,000 + cps. 6½' cord with stereo plug. Impedance 4 to 16 ohms.
Cat. No. Q4-132 $17.95 Net

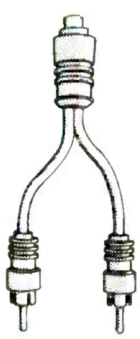


HOBBYIST'S SOLDERING AND TOOL KIT
Diagonals, long nose pliers, soldering iron and solder, solder aid tool, heat-sink, and screwdriver. An ideal gift item.
Cat. No. H3-378 $7.95 Net.

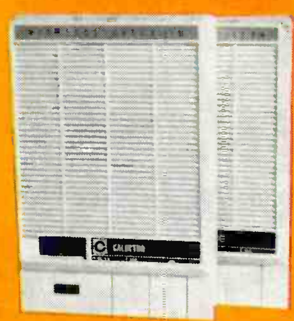
TAPE RECORDER MICROPHONE
Outstanding performance on music and speech for the price. Low impedance matches late model solid state recorders. Removable desk stand; 4½' cord with dual plugs that fit most models. Freq. Response: 100-8k Hz. Output: — 77 dB. Impedance: 200 ohms
Cat. No. Q4-146 $4.95 Net



EXPERIMENTER'S CIRCUIT BOARD KIT
Contains a 3¾" x 4" perforated board, 15 terminals (No. J4-636) and 4 mounting feet w/screws. Build small circuits, hobby and science projects, etc.
Cat. No. J4-660 $.98 Net



AUDIO ADAPTORS
"Y" Audio Adaptor has a phono pin jack on one end and dual phono pin plugs on the other.
Cat. No. Q4-288 $.99 Net



TWO STATION WIRELESS INTERCOM
Just plug into any electrical outlet. Completely portable. Expand system anytime with additional units. Two unit system complete in display pack.
Cat. No. N4-110 $34.95 Net

MINIATURE LAMPS
Type PR2 • 2.5 volt • 0.50 amp •
Cat. No. E2-430 • Pkg. of 2 $.29 Net
Type PR3 • 3.6 volt • 0.50 amp •
Cat. No. E2-431 • Pkg. of 2 $.29 Net

STANDARD 1000 VOLT CAPACITOR
High quality, compact and reliable.

RESISTORS
Attractively packaged 2 per pack, showing values, color codes and formulas.

THE "GC CALECTRO HOBBYIST HANDBOOK"
The "GC Calectro Hobbyist Handbook" is available at your nearest Calectro Electronic Supermarket. One is located near you. WRITE TODAY and we'll rush you the name and address of your nearest Calectro Supermarket.

GC ELECTRONICS **CALECTRO** G-C ELECTRONICS A DIVISION OF HYDROMETALS, INC.

400 SO. WYMAN ST, ROCKFORD, ILLINOIS 61101
CIRCLE NO. 138 ON READER SERVICE CARD