IS A SINGLE WOOFER BEST FOR STEREO?

Popular Electronics

FIFTY CENTS / MAY 1971

New Uses For Electro-luminescence

Build: HI-AMPERAGE FLASHER PROJECT

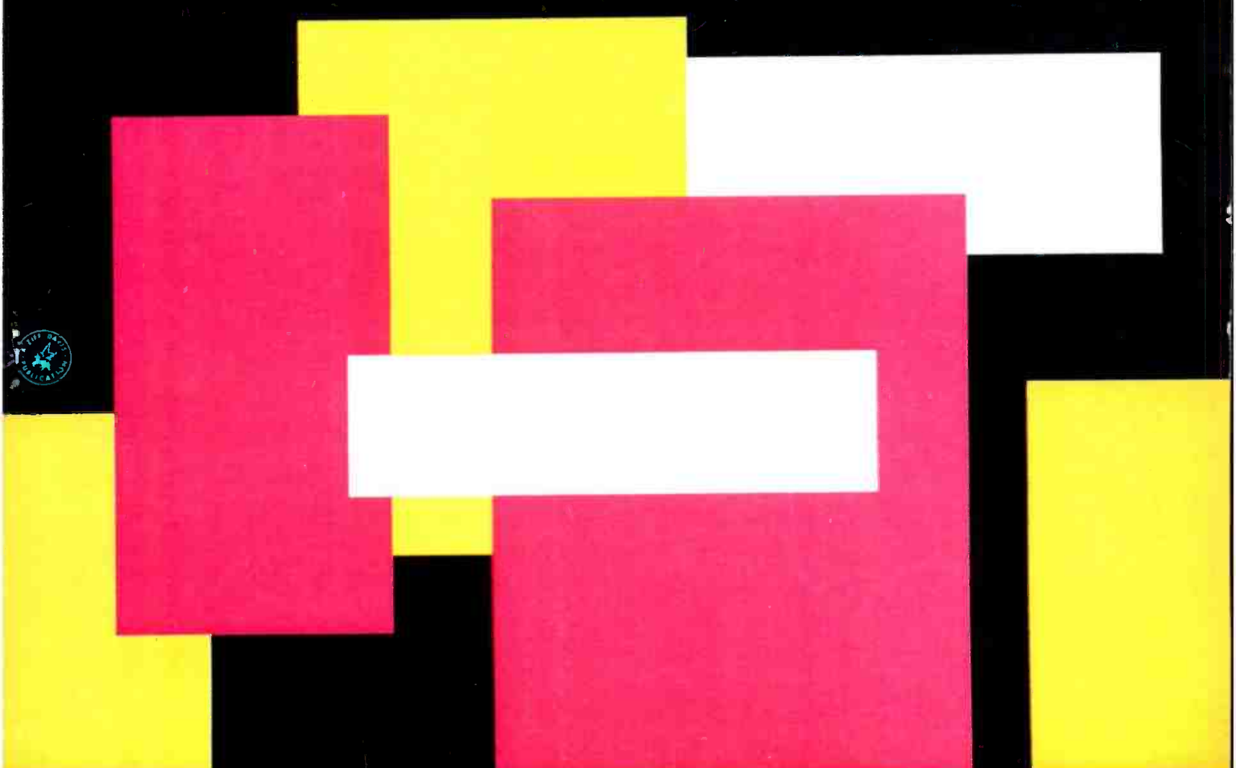
ALL ELECTRONIC PUZZLE

NEW IC AUDIO FILTER

MIMIMUM COMPONENT STEREO AMP

Plus: MORE CHEMICALS FOR ELECTRONICS

Tests: MICROWAVE OVEN, AR-6, TEN-TEC RECEIVER



EXPERIENCE IS STILL YOUR BEST TEACHER

NRI designed-for-learning training equipment gives you priceless confidence because your hands are trained as well as your head.

Learning Electronics at home the NRI way is fast and fascinating. Read opposite page.

Read opposite page.

OLDEST AND LARGEST SCHOOL OF ITS KIND

Accredited by the Accrediting Commission of the National Home Study Council

You get more for your money from NRI

—more value, more solid experience so essential to careers in Electronics. NRI's pioneering "discovery" method is the result of more than half a century of simplifying, organizing, dramatizing subject matter. In each of NRI's major courses you learn by doing. You demonstrate theory you read in "bite-size" texts programmed with NRI designed-for-learning professional lab equipment. Electronics comes alive in a unique, fascinating way. You'll take pleasure in evidence you can feel and touch of increasing skills in Electronics, as you introduce defects into circuits you build, perform experiments, discover the "why" of circuitry and equipment operation.

Almost without realizing it, the NRI discovery method gives you the professional's most valuable tool—practical experience. You learn maintenance, installation, construction and trouble-shooting of Electronic circuits of any description. Whether your chosen field is Industrial Electronics, Communications or TV-Radio Servicing, NRI prepares you quickly to be employable in this booming field or to earn extra money in your spare time or have your own full-time business. And you start out with training equivalent to months—even years—of on-the-job training.

NRI Has Trained More Men for Electronics Than Any Other School

— By actual count, the number of individuals who have enrolled for Electronics with NRI could easily populate a city the size of New Orleans or Indianapolis. Over three-quarters of a million have enrolled with NRI since 1914. How well NRI training has proved its value is evident from the thousands of letters we receive from graduates. Letters like those excerpted below. Take the first step to a rewarding new career today. Mail the postage-free card. No obligation. No salesman will call. NATIONAL RADIO INSTITUTE, Electronics Division, Washington, D.C. 20016.

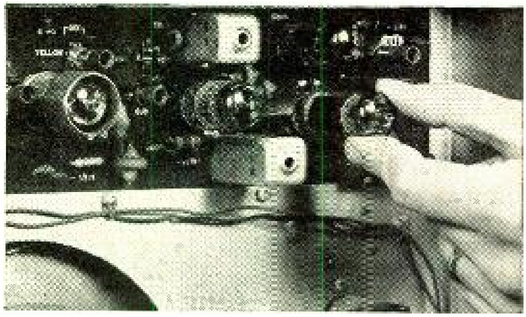
L. V. Lynch, Louisville, Ky., was a factory worker with American Tobacco Co., now he's an Electronics Technician with the same firm. "I don't see how the NRI way of teaching could be improved."

G. L. Roberts, Champaign, Ill., is Senior Technician at the U. of Illinois Coordinated Science Laboratory. In two years he received five pay raises. Says Roberts, "I attribute my present position to NRI training."

Don House, Lubbock, Tex., went into his own Servicing business six months after completing NRI training. This former clothes salesman just bought a new house and reports. "I look forward to making twice as much money as I would have in my former work."

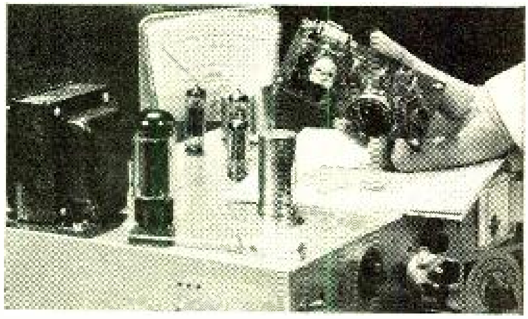
Ronald L. Ritter of Eatontown, N.J., received a promotion before finishing the NRI Communication course, scoring one of the highest grades in Army proficiency tests. He works with the U.S. Army Electronics Lab, Ft. Monmouth, N.J. "Through NRI, I know I can handle a job of responsibility."

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



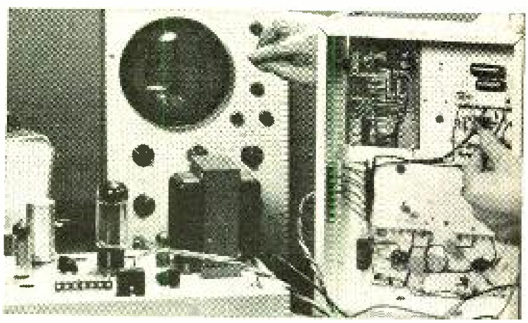
COLOR TV CIRCUITRY COMES ALIVE

as you build, stage-by-stage, the only custom Color-TV engineered for training. You grasp a professional understanding of all color circuits through logical demonstrations never before presented. The TV-Radio Servicing course includes your choice of black and white or color training equipment.



COMMUNICATIONS EXPERIENCE

comparable to many months on the job is yours as you build and use a VTVM with solid-state power supply, perform experiments on transmission line and antenna systems and build and work with an operating, phone-cw, 30-watt transmitter suitable for use on the 80-meter amateur band. Again, no other home-study school offers this equipment. You pass your FCC exams—or get your money back.



COMPETENT TECHNICAL ABILITY

can be instantly demonstrated by you on completing the NRI course in Industrial Electronics. As you learn, you actually build and use your own motor control circuits, telemetering devices and even digital computer circuits which you program to solve simple problems. All major NRI courses include use of transistors, solid-state devices, printed circuits.

VOLUME 34 NUMBER 5

MAY 1971

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

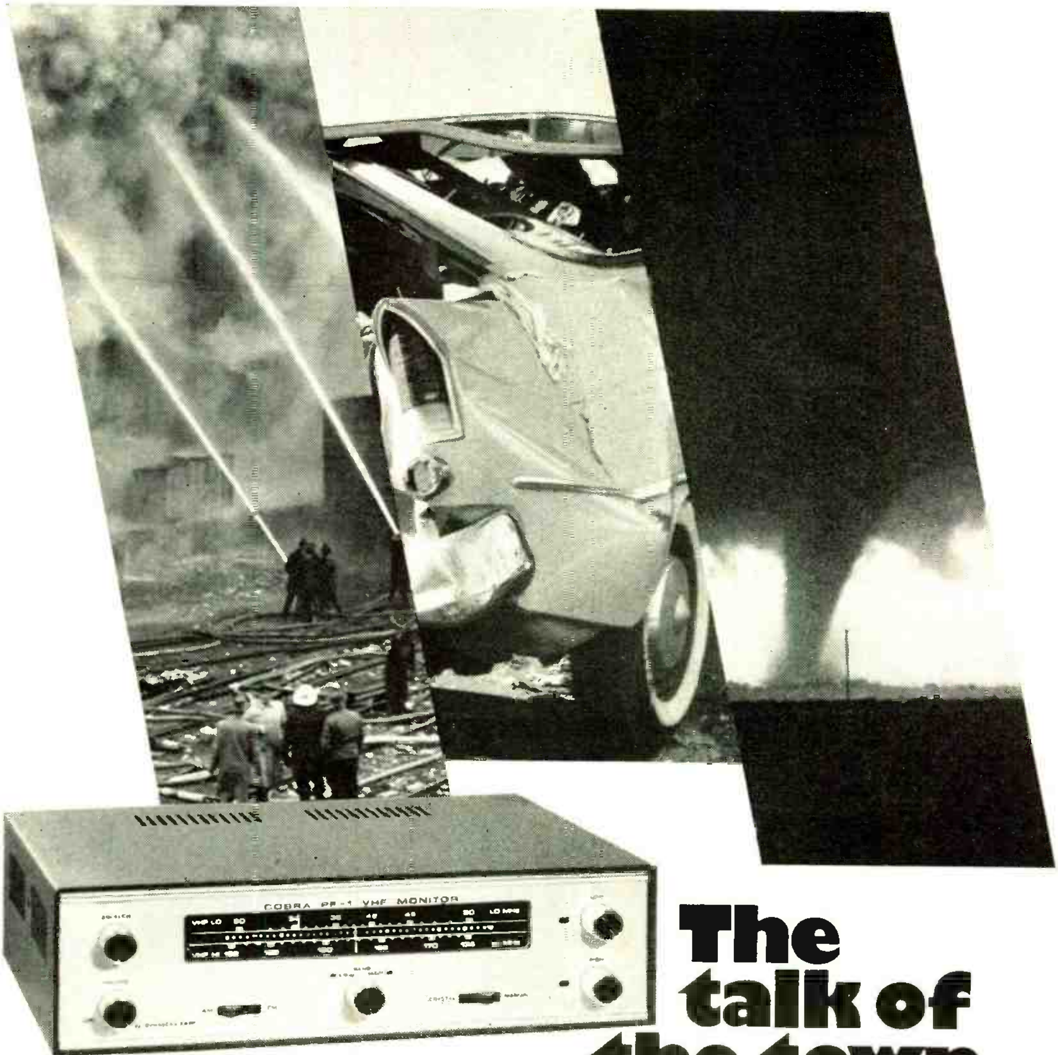
FEATURE ARTICLES

DEPARTMENTS

POPULAR ELECTRONICS is Indexed in the Reader's Guide to Periodical Literature

This month's cover designed by Edward I. Buxbaum

POPULAR ELECTRONICS, *May 1971. Volume 34. Number 5. Published monthly at One Park Ave., New York, N.Y. 10016. One year subscription rate for U.S., U.S. Possessions and Canada, $6.00; all other countries, $7.00. 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. Subscription service and Forms 3579: P.O. Box 1096, Flushing, N.Y. 11352. Editorial offices for manuscript contributions, reader inquiries, etc.: One Park Ave., New York, N.Y. 10016.*



The talk of the town

New Cobra PF-1 AM/FM Police/Fire Monitor

Now you can hear about all the exciting events in your town *as they happen.* Traffic jams, robberies, dangerous criminals at large. Exact details of the latest fire. Hazardous storm warnings . . . before it's too late.

It's amazing! The new Cobra PF-1 monitors government VHF channels and lots more. Does it better than any other radio of its kind. All at a price you can afford.

Unlike other monitors, you receive both AM and FM high and low bands without an extra set of crystals. And in addition to manual tuning, you get crystal control option for a high and low pre-selected frequency—a feature usually available only in the most expensive radios.

So why settle for less? Exclusive noise limiting circuits reduce ignition interference and insure quiet operation. And the ultimate in new solid state circuit design gives you top reach and selectivity.

You even get a modern decorator-styled exterior suitable for any decor or auto interior.

Ask your dealer about the exciting new Cobra PF-1. Or write us for complete details. And you'll know all the talk of the town!

Cobra PF-1 $119.95

All solid state with IC, 2 tunable VHF bands (30MHz to 50MHz & 152MHz to 174MHz), independent tuning knobs for each band, dial scale calibration, crystal control option for high and low band preselected frequency (your choice of crystals, $5 each), reverse polarity protection for DC operation, exclusive dual noise limiting circuits, antenna and mounting bracket for mobile use included. 117 volt AC or 12 volt DC. Unique circuit permits application of AC and DC simultaneously. If AC fails, DC power source takes over.

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

CIRCLE NO. 7 ON READER SERVICE PAGE

Popular Electronics

LAWRENCE SPORN
Publisher

OLIVER P. FERRELL
Editor

LESLIE SOLOMON
Technical Editor

JOHN R. RIGGS
Managing Editor

EDWARD I. BUXBAUM
Art Director

ALEXANDER W. BURAWA
Associate Editor

ANDRE DUZANT
Technical Illustrator

PATTI MORGAN
Assistant Editor

JUDITH L. HOGAN
Editorial Assistant

J. GORDON HOLT
L. E. GARNER, JR.
DAVID L. HEISERMAN
Contributing Editors

STANLEY NEUFELD
Associate Publisher

RICHARD J. HALPERN
Advertising Manager

ROBERT UR
Marketing Manager

MARGARET DANIELLO
Advertising Service Manager

FURMAN H. HEBB
Group Vice President
Electronics and Photographic

ZIFF-DAVIS PUBLISHING COMPANY
Editorial and Executive Offices
One Park Avenue, New York, New York 10016
212 679-7200

Midwestern Office
The Pattis Group, 4761 West Touhy Ave.,
Lincolnwood, Illinois 60646, 312 679-1100
GERALD E. WOLFE, DICK POWELL

Western Office
9025 Wilshire Boulevard, Beverly Hills, California 90211
213 CRestview 4-0265; BRadshaw 2-1161
Western Advertising Manager, BUD DEAN

Japan: James Yagi
Oji Palace Aoyama; 6-25, Minami Aoyama
6-Chome, Minato-Ku, Tokyo 407-1930/6821

Circulation Office
P.O. Box 1096, Flushing, N.Y. 11352

William Ziff, President
W. Bradford Briggs, Executive Vice President
Hershel B. Sarbin, Senior Vice President and Secretary
Stanley R. Greenfield, Senior Vice President
Philip Sine, Financial Vice President and Treasurer
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

Ziff-Davis also publishes Airline Management and Marketing Including American Aviation, Boating, Business & Commercial Aviation, Car and Driver, Cycle, Electronics World, Flying, Modern Bride, Popular Photography, Skiing, Skiing Area News, Skiing Trade News, Stereo Review, and Travel Weekly.

Forms 3579 and all subscriptions correspondence should be addressed to POPULAR ELECTRONICS, Circulation Department, P.O. Box 1096, 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.

Member Audit Bureau of Circulations

DIRECT & CURRENT

Ninth in a Monthly Series by Oliver P. Ferrell, Editor

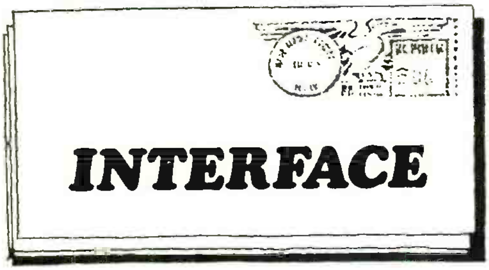
BEGRUDGING—BUT TRUE

There's an undercurrent swirling around hobby and experimental electronics that has long-range repercussions. Maybe it's because of the cutback in defense spending; maybe it's because the electronics manufacturers now realize that consumer spending may bail them out; or maybe it's the result of a lot of things; but the handwriting is on the wall—several aerospace components manufacturers are eying hobby electronics. After nearly a decade of gradually turning away from the hobbyist, manufacturers are starting up the other side of the full circle, wondering whether or not they might have missed something a lot bigger than a onesy-towsy marketplace.

While it is difficult for anyone to pinpoint the cause of this change in philosophy, there are signs that manufacturers are thinking in terms of romancing the hobbyist. Some unique and difficult-to-obtain components are soon to be offered to experimenters at vastly reduced prices and several manufacturers are ready to set up distribution facilities especially for technicians, experimenters, and hobbyists. The latter idea—which is only a little further along than the "talking stage"—may open the flood gates.

Simultaneously, the sale of electronic kits is starting to climb and, while some of the very high ticketed items may not be moving as fast as their manufacturers would like, there has been a subtle increase in volume and numbers of purchasers. Even the sale of partial kits—such as those mentioned in POPULAR ELECTRONICS construction articles—is booming and magazine readers are clamoring for more projects, more experimental information, and more ideas on what can be done with parts now available.

The picture on the horizon is exciting, welcome, and certainly long overdue. From some quarters, the change in attitude toward the electronics hobbyist is being offered begrudgingly; but for what it's worth, it is the feeling here at POPULAR ELECTRONICS that the next 12 months may see a healthy revolution in hobby electronics.



PRAISE AND PINK NOISE

I finished building the "Pink Noise Generator" (December 1970, p 61) just in time for final exams. I used the generator during study sessions—and guess what—I got all A's.

J. STALER
Los Angeles, CA

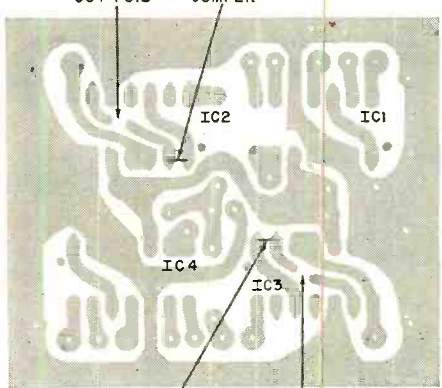
50-HZ CLOCK

I have found that, with one simple modification, the Digi-Vista Clock (December 1970 and January 1971) can be used on a 50-Hz power line. In the case of the six-digit clock, locate *IC2* on the scaler board and cut the foil pattern between pins 2 and 9 as shown here.

Then solder a jumper between pins 1 and 2 of *IC2*. This changes the counter from a divide-by-six to a divide-by-five. For the four-digit clock, make the modification to both IC2 and IC3.

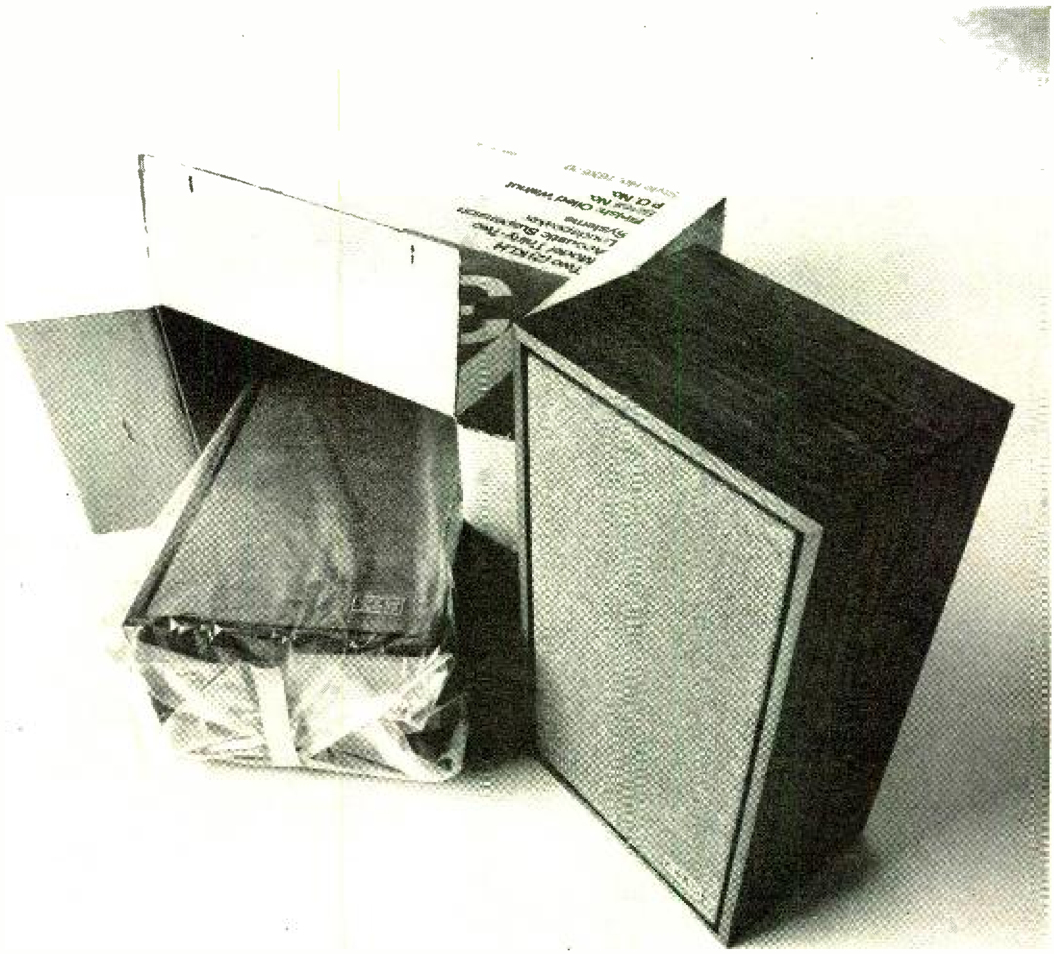
If you are traveling between 50-Hz and 60-Hz areas, use a suitable switch to connect pin 2 of the modified IC(s) to pin 1 for 50 Hz and pin 9 for 60 Hz.

A. C. VAYHINGER
Telecommunications Advisor
USOM/PSD
APO San Francisco, CA 96346



LIGHT BULBS GALORE

Your readers may be interested in a service we have to offer if they are ever in need of specialized light bulbs. We carry in stock over 15,000 different light bulbs from one watt



The new KLH Thirty-Two is the best speaker you can buy for the money.

Bravado has never been our bag. But after carefully comparing the new model Thirty-Two with our competitor's best-selling loudspeaker, we're going to break our rule.

Our product is superior.

You see, the Thirty-Two sounds like a very close relative of our now famous Model Six.

With good reason.

It's designed like a Six. It's built like a Six. And it shares many of the Six's finest listening qualities. Bass response that curls your toes. A mid-range that seduces you with its smoothness. And an overall sound quality that finally puts an end to listening fatigue.

But the Thirty-Two not only sounds like an expensive speaker, it looks like one, too. It is unquestionably the best looking loudspeaker in its price range.

The price?

Almost as amazing as the sound. Just $47.50 ($95 the pair).†

Make sure you hear—and see—the new KLH Thirty-Two soon. And compare it with the best-known speaker in its price range. We are sure you will agree that there's never been anything like it for the money.

Anybody's money.

For more information on the Model Thirty-Two, write to KLH Research and Development Corporation, 30 Cross St., Cambridge, Mass. 02139. Or visit your KLH dealer.

KLH*

KLH RESEARCH AND DEVELOPMENT CORPORATION

*A trademark of KLH Research and Development Corporation

†suggested retail price. Slightly higher in the west.

CIRCLE NO. 16 ON READER SERVICE PAGE

to 10,000 watts and one volt to 300 volts in innumerable sizes, shapes, and colors. We are supplied by over 40 manufacturers, both foreign and domestic, with photo, microscope, computer, neon, xenon, black light, germicidal, hobby, miniature, mercury, etc. We believe we have the largest variety of light bulbs and matching sockets in the United States.

JOHN TISON
Jetronics Ltd.
2691 Patricia Avenue
Los Angeles, CA 90064

OUT OF TUNE

In "Non-Destructive Transistor Tester" (March, p 47) the following table was omitted.

GAIN CONVERSION TABLE

Meter Indication	Current	H_{FE} I_{C1}	I_{C2}
2	10 μA	0.5	0.1
3	15	0.75	0.15
4	30	1.5	0.3
5	50	2.5	0.5
6	100	5	1.0
7	140	7	1.4
8	200	10	2
9	300	15	3
10	400	20	4
12	600	30	6
14	900	45	9
16	1.2 mA	60	12
18	1.6	80	16
20	2.0	100	20
22	2.36	118	23
24	2.75	137	27
26	3.26	163	32
28	3.48	174	35
30	4.05	200	40
32	4.55	228	45
34	5.1	255	51
36	5.75	277	57
38	6.17	308	62
40	6.63	332	66
42	7.30	365	73
44	7.85	382	78
46	8.43	420	84
48	9.26	463	93
50	9.85	494	99

"Build a Wheatstone Bridge and Substitution Box" (February, p 62). To avoid continuous drain on the battery, connect switch *S25* directly in series with the battery rather than between *S26* and *R27/R25*.

"Build the Psych-Tone" (February, p 25). In the Parts List on page 26, zener diode *D8* is listed as a 1N746. In the schematic on page 30, it is 1N747. The correct component is 1N746, though the 1N747 would work perfectly well. There is only a slight difference in voltage values.

(*Continued on page* 99)

a remarkable listening experience for stereo headphone owners!

The phenomenal realism of binaural sound recording is demonstrated by Stereo Review's

AMAZING NEW BINAURAL DEMONSTRATION RECORD

Created specifically for playback through stereo headphones, this unique record presents the listener with sound of unsurpassed realism. It recreates at each of the listener's ears the precise sound that each ear would have heard—independently—at the original scene.

Binaural recording re-creates the directions, distances, and even the elevations of sounds better than any other recording method. The super-realism of binaural recording is accomplished by recording the acoustical input for each ear separately, and then playing it back through stereo headphones. Thus the sound intended for the left ear cannot mix together with the sound for the right ear, and vice versa. This technique eliminates all acoustical problems in playback, such as the effects of "dead" rooms, over-reverberant rooms, variations in stereo perspective caused by changes in sitting position, and variations in frequency response due to changes in speaker positioning.

Binaural recording offers the listener the identical acoustical perspective and instrument spread of the original. The sound reaching *each ear* is exactly the same as would have been heard at the live scene. The Stereo Review Binaural Demonstration Record is the only record of its kind; there is nothing else like it. It provides a unique listening experience that you will want to share with your friends.

"MAX"—GENIE OF BINAURAL RECORDING. More than a year of intense effort was devoted to the preparation of this recording. "Max," a specially constructed dummy head, was modeled by a professional sculptor, then cast in silicone rubber. Super-precision capacitor microphones were installed in Max's ears so that each microphone would pick up exactly what each human ear would hear. The two separate sound channels were then fed into an ultra-low-noise electronics system and then recorded on an advanced-design tape recorder operating at 30 inches per second.

In making location recordings for the demonstration side of the record, a recording technician taped miniature capacitor microphones into his ears, so his head would serve its normal acoustical role as an absorber and reflector of sound. The result is a demonstration of phenomenal recorded sound.

STARTLING REALITY. The Binaural Demonstration Record offers 45 minutes of sound and music of startling reality. Side 1 introduces you to binaural recording via a narrated demonstration in nine sequences, taking you through a variety of situations that show off the remarkable depth and natural perspective of binaural recording.

You'll marvel at the eerie accuracy with which direction and elevation are re-created as you embark on a street tour in binaural sound—Sounds Of The City...Trains, Planes & Ships... a Basketball Game, a Street Parade, a Steel Fabrication Plant, The Bird House at the Zoo—all demonstrating the incredible realism of binaural sound reproduction.

MUSIC IN BINAURAL. With "Max" acting as your extension ears, the musical performances presented on the Binaural Demonstration Record transport you to the concert hall for a demonstration of a wide variety of music. Selections total 23 minutes, and include examples of jazz, rock, organ, and chamber music.

A highlight of the record is the first recording of *Space Virgin*, a new jazz work by noted composer Ronnie Roullier. Insiders have already called it one of the most exciting jazz recordings ever made. The organ recordings, with Frederick Swann at the keyboard of the majestic Riverside Church organ, have been hailed for reproducing the whole range of organ sonorities totally without distortion, and are among the most memorable listening experiences of a lifetime.

The Stereo Review Binaural Demonstration Record is the ultimate in sound reproduction. It has been made without compromise for the owner of stereo headphones. If you own stereo headphones, this record is a *must*.

Note: Although headphones are necessary to appreciate the near-total realism of binaural recording, the record can also be played and enjoyed on conventional stereo systems.

Order your Stereo Review Binaural Demonstration Record today. ONLY $5.98.

RECORDS, Ziff-Davis Service Division, 595 Broadway, N.Y., N.Y. 10012

Please send ________ Binaural Demonstration Records at $5.98 each, postpaid. My check (or money order) for $________ is enclosed. (Outside U.S.A. please send $8.00 per record ordered.) N.Y. State residents please add local sales tax.

PE-5-71

Print Name ________________

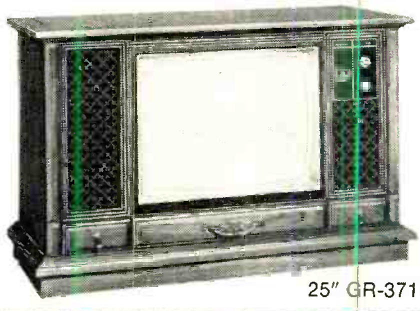
Address ________________

City ________________

State ________________ Zip ________

PAYMENT MUST BE ENCLOSED WITH ORDER

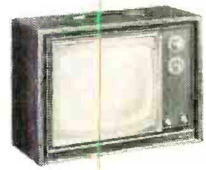
23" GR-370



25" GR-371MX

20" GR-270

18" GR-269



14" GR-169

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

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

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

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

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

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

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

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

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

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

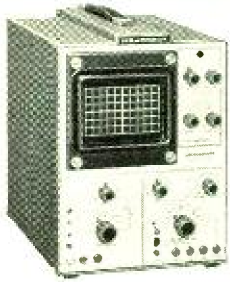
18" GR-269 . . . the Heathkit "compact" color TV. Has the same highly sophisticated modular solid-state circuitry as the GR-371MX, but modified to accept the popular 180 sq. in. color picture tube. Features AFT, "Instant On", 3-stage IF, MOSFET VHF tuner, switch-controlled degaussing . . . all standard.

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

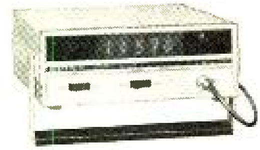
14" GR-169 delivers console performance with portable convenience. Here's the GR-371MX modular circuitry modified slightly to accept a 14" diagonal picture tube. Features MOSFET VHF tuner, 3-stage IF, switch-controlled degaussing, complete up-front secondary controls, built-in VHF & UHF antennas. Handsome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

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

TO-101 Legato Theater Organ

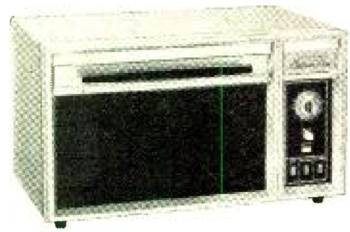


IO-102 5" Scope



IB-101 Frequency Counter

GD-29 Microwave Oven



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

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

Kit TO-101, 299 lbs. **$1495***

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

Kit GD-29, 97 lbs. **$399.95***

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

Kit IO-102, 29 lbs. **$119.95***

Assembled IOW-102, 29 lbs. **$179.95***

Assembled PKW-101, 1 megohm probe, 1 lb. .... **$ 19.95***

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

Kit IB-101, 7 lbs. **$199.95***

See these and 300 other Heathkit suggestions at one of the following Heathkit Electronic Centers:

CALIFORNIA: Anaheim, 92805, 330 E. Ball Road; **El Cerrito, 94530**, 6000 Potrero Avenue; **La Mesa, 92401**, 8363 Center Drive; **Los Angeles, 90007**, 2309 S. Flower St.; **Redwood City, 94063**, 2001 Middlefield Rd.; **Woodland Hills, 91364**, 22504 Ventura Blvd.; **COLORADO: Denver, 80212**, 5940 W. 38th Ave.; **GEORGIA: Atlanta, 30305**, 5285 Roswell Road; **ILLINOIS: Chicago, 60645**, 3462-66 W. Devon Ave.; **Downers Grove, 60515**, 224 Ogden Ave.; **MARYLAND: Rockville, 20852**, 5542 Nicholson Lane; **MASSACHUSETTS: Wellesley, 02181**, 165 Worcester St.; **MICHIGAN: Detroit 48219**, 18645 W. Eight Mile Rd.; **MINNESOTA: Hopkins, 55343**, 101 Shady Oak Rd.; **MISSOURI: St. Louis, 63123**, 9296 Gravois Ave.; **NEW JERSEY: Fair Lawn, 07410**, 35-07 Broadway (Rte. 4); **NEW YORK: Jericho, L.I., 11753**, 15 Jericho Turnpike; **New York, 10036**, 35 W. 45th Street; **OHIO: Cleveland, 44129**, 5444 Pearl Rd.; **Woodlawn, 45215**, 10133 Springfield Pike; **PENNSYLVANIA: Philadelphia, 19149**, 6318 Roosevelt Blvd.; **Pittsburgh, 15235**, 3482 William Penn Hwy.; **TEXAS: Dallas, 75201**, 2715 Ross Avenue; **Houston, 77027**, 3705 Westheimer; **WASHINGTON: Seattle, 98121**, 2221 Third Ave.; **WISCONSIN: Milwaukee, 53216**, 5215 W. Fond du Lac

Retail Heathkit Electronic Center prices slightly higher to cover shipping, local stock, consultation and demonstration facilities. Local service also available whether you purchase locally or by factory mail order.

HEATHKIT

HEATH COMPANY, Dept. 10-5
Benton Harbor, Michigan 49022 *a Schlumberger company*

☐ Enclosed is $________, plus shipping

Please send model (s)________

☐ Please send FREE Heathkit Catalog.

Name ________

Address ________

City ________ State ________ Zip ________

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

CL-410R

CIRCLE NO. 13 ON READER SERVICE PAGE

NEW LITERATURE

Blonder-Tongue Laboratories, Inc., recently published a pamphlet titled "An Introduction to MATV." The text of the pamphlet presents the basic facts necessary to understand master antenna television systems. The approach used is not on the engineering level. Rather, the pamphlet is written to provide the reader with an overview of the subject. Included is a Glossary of Terms in which are defined the word and symbol jargon common to the MATV field.

Circle No. 75 on Reader Service Page 15 or 95

A four-page brochure which describes in detail a new line of seven loudspeakers for use in hi-fi system installations is available from *CTC Corp*. The five system choices described include the compact "Futura I" which features a 4½" full-range acoustical air-suspension speaker with a 10-oz ferrite magnet and a power rating of 10 watts rms. At the top of the line is a three-way 12" sound system which employs a matched network composed of a 12" woofer, 4½" midrange speaker, and a 3" tweeter. Suggested internal enclosure dimensions for each speaker system are provided.

Circle No. 76 on Reader Service Page 15 or 95

Test Equipment Catalog No. 57-T which can be obtained from *Triplett Corp*. features information on the company's complete line of multimeters. The listing covers digital VOM's. the newest laboratory-accuracy FET VOM, accessories, sales and service data, and a unique VOM Selection Chart. The comprehensive catalog is well illustrated and gives the technical details of each VOM listed.

Circle No. 77 on Reader Service Page 15 or 95

Catalog No. 711 available from *BF Enterprises* lists an interesting and fascinating potpourri of items for the optics, photography, nautical, and electronics buffs. Of particular interest to the hobbyist in electronics are the listings for Instant Logic matrix plug-in circuit boards, a digital project kit, and reduced-price integrated circuits. Cameras and lens assemblies, electrotheodolites and rotary tables, and time pieces and sextants are among the many items that fill out the catalog listings.

Circle No. 78 on Reader Service Page 15 or 95

Popular Electronics READER SERVICE PAGE

free information service:

Here's an easy and convenient way for you to get additional information about products advertised or mentioned editorially (if it has a "Reader Service Number") in this issue. Just follow the directions below...and the material will be sent to you promptly and free of charge.

1. On coupon below, circle the number(s) that corresponds to the key number(s) at the bottom or next to the advertisement or editorial mention that is of interest to you. (Key numbers for advertised products also appear in the Advertisers' Index.) Print or type your name and address on the lines indicated.

2. Cut out the coupon and mail it to: POPULAR ELECTRONICS, P.O. Box 8391, Philadelphia, PA 19101.

note: If you want to write to the editors of POPULAR ELECTRONICS about an article on any subject that does not have a key number, write to POPULAR ELECTRONICS, One Park Avenue, New York, N.Y. 10016. Inquiries concerning circulation and subscriptions should be sent to POPULAR ELECTRONICS, P.O. Box 1096, Flushing, N.Y. 11352.

5/71—3
Void after June 30, 1971

Popular Electronics P.O. BOX 8391
PHILADELPHIA, PA. 19101

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	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

NAME *(Print clearly)*____________________

ADDRESS____________________

CITY__________ STATE______ ZIP CODE______

Electronics LIBRARY

THE RADIO AMATEUR'S HANDBOOK (48th Edition)

by The Headquarters Staff, ARRL

The American Radio Relay League is justifiably proud of its annual Handbook. This is the 1971 edition—the 48th in a series that started in 1926. This reviewer recommends the Handbook (but see below) to any serious student of electronics—regardless of his interest in amateur radio. It is a storehouse of information—concise, orderly, well-written, and encompassing. It is trite to say, but no hobbyist should be without a recent edition.

It's not an easy task to make something like the ARRL Handbook look brand new each year. Sections devoted to theory often undergo only the slightest changes, and major emphasis is placed on the construction projects—transmitters, receiving equipment, antennas, etc. After carefully scanning the 1971 Edition, we cannot help but wonder why the ARRL doesn't re-issue the Handbook just every other year. The changes and additions made between the 47th and 48th editions are very modest and there is little motivation or enticement for the owner of the 47th to invest in the 48th. If you skipped the 47th and have a 45th or 46th edition, this is a good time to up-date, but if your 47th edition is in good condition—keep it.

Published by The American Radio Relay League, Inc., Newington, CT 06111. 688 pages. Soft cover, $4.50. Hard cover, $7.50.

Recent Arrivals

ESTIMATING THEORY WITH APPLICATIONS TO COMMUNICATIONS AND CONTROL

by Sage and Melsa

Another volume in the "Series in Systems Science," this book was written by engineers for engineers to provide a comprehensive coverage of estimation theory, including decision theory. Questions of true mathematical rigor have been largely ignored.

Published by McGraw-Hill Book Co., 330 West 42 St., New York, NY 10036. Hard cover. 529 pages. $16.50.

(Continued on page 99)

Additional information on products described in this section is available from the manufacturers. Each new product is identified by a corresponding number on the Reader Service Page. To obtain additional information on any of them, circle the number on the Reader Service Page, fill in your name and address, and mail it in accordance with the instructions.

AVANTI TWO-METER FM ANTENNA—A variant of the popular Astro-Plane CB antenna has been made available by *Avanti Research and Development* for use in the 2-meter ham band. Of particular importance to base stations--such as FM repeaters—the new model ARD-257 produces an omni-directional pattern with more than 4 dB gain (measured over a quarter-wave ground plane). Bandwidth of the Model ARD-257 encompasses all of the 2-meter ham band and the power handling capability is 1000 watts at a nominal input impedance of 50 ohms. Vertically polarized, the measured VSWR is 1.5:1, or less and the overall length is approximately 65 inches. The antenna is constructed of aircraft quality aluminum and fiberglass.

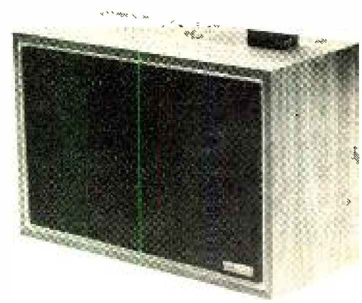
Circle No. 79 on Reader Service Page 15 or 95

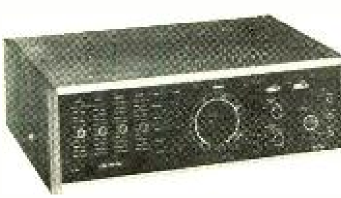
LAFAYETTE SSB TRANSCEIVER—The Telsat SSB-25 available from *Lafayette Radio Electronics* is fully compatible with all other AM, DSB and SSB CB units and delivers full 23 channel crystal controlled operation with 69 modes on both receive and transmit. Dual-conversion superheterodyne receiver's sensitivity is 0.5 μV on AM and 0.15 μV on sideband. A ±2-kHz fine tuning clarifier simplifies sideband tuning and there is a front-panel r-f gain control. Also variable squelch; and a built-in burglar alarm control circuit.

Circle No. 80 on Reader Service Page 15 or 95

JANSZEN ELECTROSTATIC SPEAKER SYSTEM—Bookshelf speaker Model Z-700A (*Electronic Industries, Inc.*) has a ferrite magnet bass driver with a free air-cone resonance of 19 Hz and total system resonance of 38 Hz. Low-frequency response is virtually flat (±3 dB down to 31 Hz) and is down 6 dB at 20 Hz. Complete system comprises low-frequency drive and two electrostatic elements with claimed flat response from 31 to 20,000 Hz, down 6 dB at 20 Hz and 30,000 Hz.

Circle No. 81 on Reader Service Page 15 or 95





OLSON STEREO FM/AM RECEIVER—Several interesting and probably beneficial details are included in the Model RA-290 receiver from *Olson Electronics*: a circular tuning dial with well-defined marks for FM logging; two tuning meters; slide controls for volume, balance, bass and treble; rocker switches for high and low filters, loudness, FM muting and tape monitoring; and front-

(*Continued on page* 22)

10 Reasons why RCA Home Training is

your best investment for a rewarding career in electronics:

Performing transistor experiments on programmed breadboard — using oscilloscope

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 half a century, RCA Institutes, Inc., a subsidiary of RCA, 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 **WELL PAID JOBS ARE 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. There are challenging new fields that need electronics technicians... new careers such as computers, automation, television, space electronics where the work is interesting and earnings are greater.

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 **HANDS-ON TRAINING**

To give practical application to your studies, a variety of valuable RCA Institutes engineered kits are included in your program. You get over 250 projects and experiments and as many as 22 kits in some programs. Each kit is complete in itself. You never have to take apart one piece to build another. They're yours to keep and use on the job.

8 **FCC LICENSE TRAINING— MONEY BACK AGREEMENT**

Take RCA's Communications Career program—or enter with advanced standing and prepare immediately for your 1st, 2nd, or 3rd class FCC Radio Telephone License examinations. RCA Institutes money-back agreement assures you of your money back if you fail to pass the FCC examination taken within 6 months after completing the course.

9 **CONVENIENT PAYMENT PLANS**

You get a selection of low-cost tuition plans. And, we are an eligible institution under the Federally Insured Student Loan Program.

10 **RCA INSTITUTES IS FULLY ACCREDITED**

RCA Institutes is an accredited member of the National Home Study Council. Licensed by N. Y. State—courses of study and instructional facilities are approved by the State Education Department.

VETERANS: TRAIN UNDER NEW GI BILL

SEND ATTACHED POSTAGE PAID CARD TODAY! FREE DESCRIPTIVE BOOK YOURS WITHOUT OBLIGATION!

If reply card is detached, send this coupon today.

RCA INSTITUTES, INC.
DEP'T. 694-005-1
320 W. 31 ST.
NEW YORK, N.Y. 10001

Please send me FREE illustrated career catalog. I understand that I am under no obligation.

Name ______________________

Address ______________________

City ______________________

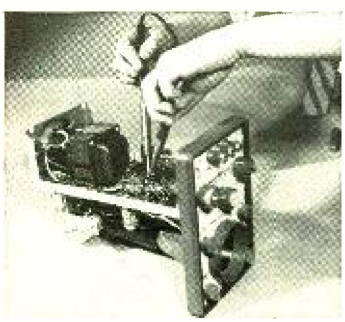
State ______________ ZIP ________

Age ________

Veterans: Check here ☐

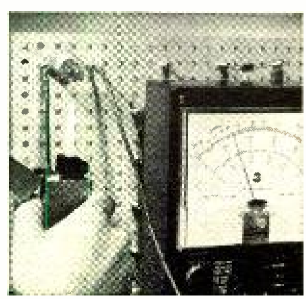
RCA

Construction of Multimeter.



Construction of Oscilloscope.

Temperature experiment with transistors.



panel jacks for headphone and tape input and output. Add to this an all solid-state circuit (FET input) with 175 watts output—and a Garrard turntable can be mounted on the top.

Circle No. 82 on Reader Service Page 15 or 95

SPIRATONE STROBOSCOPE FLASH—Those wild action photos that you see in the magazines can be made easily with a Model SS100 Stroboscope from *Spiratone, Inc.* Flashes of 1/15,000 of a second up to 30 times a second produce a three-second exposure with about 100 separate images. You can use it with almost any still camera and it has its own power cord, synch plug, and flash-rate adjustment. Use it for fun or for making time and motion studies, in quality control work, for teaching, and in sports. With a flashtube, it's $29.95.

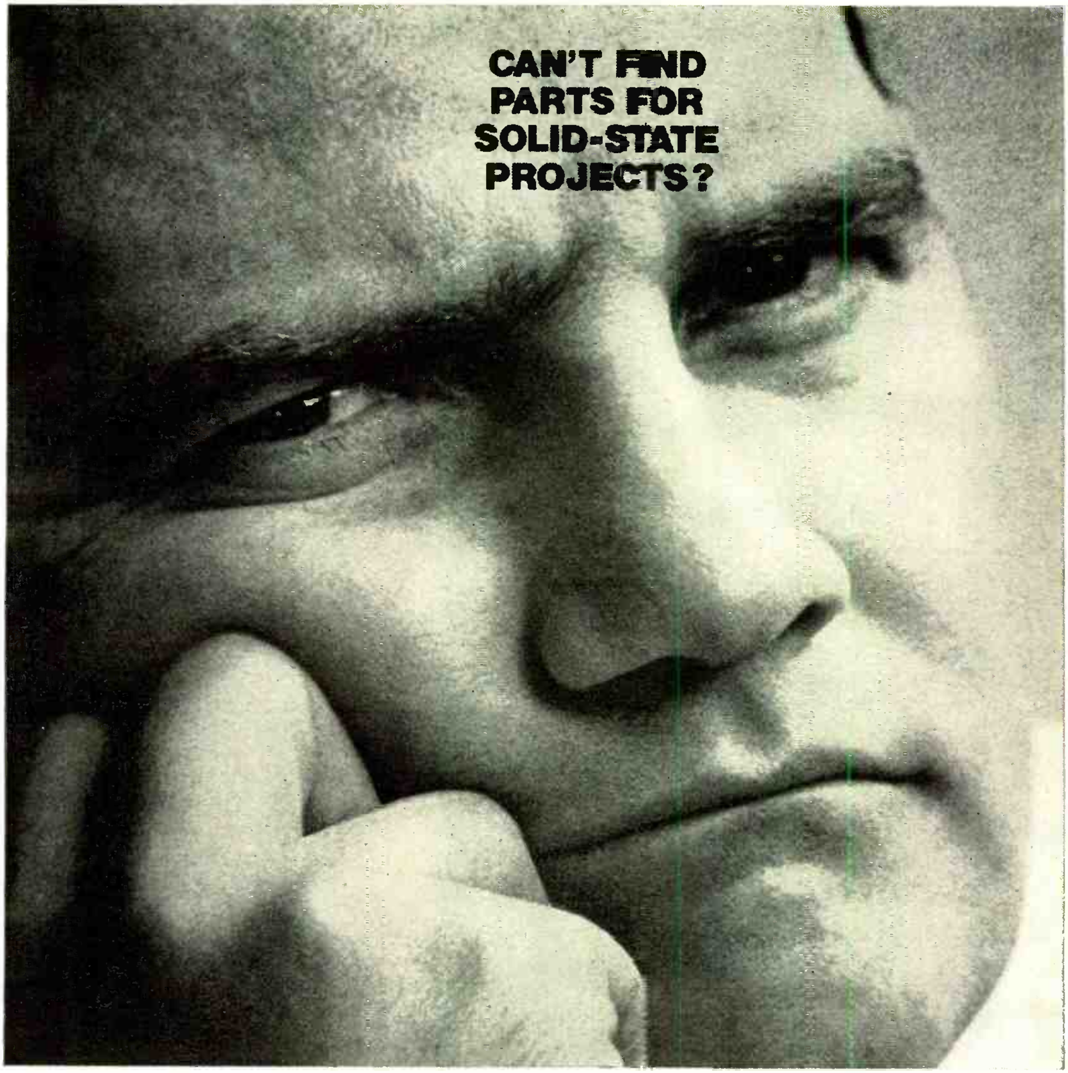
Circle No. 83 on Reader Service Page 15 or 95

KRIS SEQUENTIAL SCANNING RECEIVER—The "Tri-Bander" introduced by *Kris Inc.* takes a lot of the chore out of channel monitoring by sequentially scanning a preset 16 channels—8 in the high band, 4 in low band and 4 UHF frequencies. The user can reprogram the unit to monitor any combination of frequencies without changing boards or modules. Rate of scan can be adjusted from ½ second per channel to 150 channels per second. The channel number is displayed on a digital readout. It can also be programmed to skip frequencies or monitor any single frequency.

Circle No. 84 on Reader Service Page 15 or 95

AKAI ¼" VIDEO TAPE RECORDER—There are a number of possibilities for use of the Model VT-100 *Akai America, Ltd.* video tape recorder—as a training aid, for audio-visual promotional purposes, and quite possibly as a home entertainment component. It is the only video tape recorder which uses ¼" tape, which makes it lightweight and compact and lower in operating costs than other VTR systems. With a tape recording speed of 11¼ ips, 20 minutes of recording time are provided on one reel. The complete system (at $1295) includes camera, video tape recorder-player, battery charging adapter, and built-in video monitor.

Circle No. 85 on Reader Service Page 15 or 95



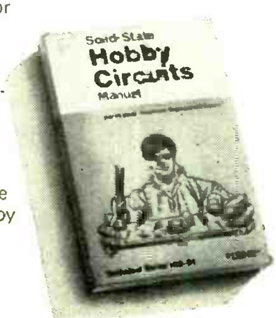
RCA Integrated Circuit Project Kits eliminate that problem for hobbyists, educators, technicians, hams.

Stop running all over town trying to hunt up a part for your solid-state projects! Get RCA IC Project Kits — complete with active and passive components, predrilled printed-circuit boards, and easy-to-follow instructions.

As a matter of fact, RCA IC Project Kits are a convenient and inexpensive source for all kinds of circuits: from intruder- and fire-alarms to a 9-V regulated power supply, from amplifiers to marine-band converters.

See your Distributor or Dealer listed on the following two pages for the IC Project Kit of your choice. And while you're there, purchase the 368-page RCA Solid-State Hobby Circuits Manual, HM-91 — it details over 60 interesting circuits, and includes a section on theory and operation of solid-state circuits.

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



RCA

CIRCLE NO. 21 ON READER SERVICE PAGE

YOU CAN FIND PROJECT KITS AT

ALASKA

Anchorage
Team Electronics
404 E. Fireweed Lane

ARIZONA

Phoenix
Sterling Electronics, Inc.
1930 North 22nd Avenue
Yuma
Yuma Electronics
320 8th Street

ARKANSAS

Texarkana
Lavender Electronics, Inc.
522 East 4th Street

CALIFORNIA

Inglewood
Olson Electronics
4642 West Century Blvd
Long Beach
Olson Electronics
714 Pine Avenue
Los Angeles
Olson Electronics
3620 West Pico Blvd
Lynwood
Olson Electronics
10906 Atlantic Avenue
North Hollywood
Olson Electronics
5356 Lankershim Blvd
Pomona
Olson Electronics
680 West Holt Avenue
San Diego
Olson Electronics
2519 El Cajon Blvd
San Francisco
Olson Electronics
169 Eleventh Street
Santa Ana
Olson Electronics
1329 South Main Street
Santa Clara
Olson Electronics
2125 El Camino Real
Torrance
Olson Electronics
20914 S. Hawthorne Blvd.

COLORADO

Arvada
Team Electronics
Arvada Plaza Shopping Center
9232 West 58th Avenue
Boulder
Burstein-Applebee Company
Basemar Shopping Center
Denver
Burstein-Applebee Company
800 Lincoln Street
Ft. Collins
Team Electronics
107 S. College
Pueblo
Pueblo Radio TV Supply Company
301 East Northern Avenue

CONNECTICUT

New Haven
Hatry Electronics
610 Boulevard
New London
Jabbour Electronic Supplies, Inc.
227 Jefferson Avenue
Norwalk
Arrow Electronics, Inc.
18 Isaac Street

FLORIDA

Coral Gables
Olson Electronics
5855 Ponce de Leon
Miami
Olson Electronics
1644 N.E. Second Avenue

GEORGIA

Albany
Specialty Distributing Company
428 Roosevelt Avenue
Athens
Specialty Distributing Company
230 Epps Bridge Road
Atlanta
Heathkit Electronic Center
5285 Roswell Avenue
Olson Electronics
485 Peachtree St., N.E.
RCA Distributing Corporation
1500 Marietta Boulevard, Northwest
Augusta
Specialty Distributing Company
1541 15th Street
Specialty Distributing Company
1251 Gordon Park Rd.
Brunswick
Specialty Distributing Company
2812 Carrie Street
Columbus
Specialty Distributing Company
1112 Brookhaven Boulevard
Decatur
Olson Electronics
2571 North Decatur Road
Macon
Specialty Distributing Company
539 Arch Street
Marietta
Specialty Distributing Company
105 White Avenue
Savannah
Specialty Distributing Company
612 East Broad Street
Valdosta
Specialty Distributing Company
916 Marion Street

ILLINOIS

Carpentersville
Team Electronics
Meadowdale Drive, Space 1A
Chicago
Howard Electronic Sales, Inc.
4573 S. Archer Avenue
North Central Electronic Supply Company
3412 West Bryn Mawr
Olson Electronics
4101 N. Milwaukee Avenue
Olson Electronics
123 N. Western Avenue
Olson Electronics
2641 W. 95th Street
Downers Grove
Heathkit Electronic Center
224 Ogden Avenue
Evanston
Tri-State Electronics
707 W. Howard Street
Melrose Park
Olson Electronics
1354 Winston Park
Morton Grove
Olson Electronics
6231 Dempster Street
Rock Island
Team Electronics
1714 5th Avenue

INDIANA

Anderson
Seybert's Electronic Supply
14 & Main Streets
Bloomington
H. A. Williams & Son
204 South Rogers Street
Columbus
H. A. Williams Co.
1003 Washington St
Evansville
Ohio Valley Sound, Inc.
20 E. Sycamore St
Fort Wayne
Ft. Wayne Electronics Supply, Incorporated
3606 E. Maumee Ave
Indianapolis
Graham Electonics-Glendale Incorporated
6101 N. Keystone Ave
Graham Electronics Supply, Inc.
133 S. Pennsylvania St.
Jeffersonville
Moakler Electronics
500 E. Chestnut St
Lafayette
Lafayette Radio Supply, Inc.
408 E. North St
Muncie
Muncie Electronic Supply, Inc.
222 North Madison St.
Richmond
H. A. Williams Co.
1114 South F Street
Terre Haute
Midwest Supply Electronics, Inc.
2015 Garfield Ave
Vincennes
Ohio Valley Sound, Inc.
902 Main St

IOWA

Cedar Rapids
Team Electronics
216 8th Street, S.E.
Team Electronics
4444 First Avenue
N.E. Lindale Plaza
Des Moines
Team Electronics
3660 Merle Hay Road
Team Electronics
1718 6th Avenue
Dubuque
Team Electronics
20 South Main Street
Fort Dodge
Team Electronics
2307 5th Avenue, South
Mason City
Team Electronics
30 First Avenue, S.W.
Sioux City
Team Electronics
2015 4th Street
Waterloo
Team Electronics
2750 University Avenue

KANSAS

Garden City
Team Electronics
215 W. Kansas Avenue
Hutchinson
Team Electronics
14 South Main Street
Overland Park
Burstein-Applebee Company
Metcalf Shopping Center
Wichita
Amateur Radio Equipment Company, Incorporated
1203 East Douglas Street
Team Electronics
784 North West Street
Team Electronics
812 S. Woodlawn

KENTUCKY

Louisville
P. I. Burk's Company, Inc.
842 South Seventh St
Peerless Electronics Equipment Company
1815 So. 7th St.
Owensboro
Ohio Valley Sound Inc.
600 West 3rd St

LOUISIANA

Baton Rouge
Sterling Electronics, Inc.
5201 Government Street
Gretna
Sterling Electronics, Inc.
1504 Stumpf Blvd
Houma
Sterling Electronics, Inc
252 Magnolia Street
Lafayette
Sterling Electronics, Inc
1416 S. College
Metairie
Olson Electronics
1833 Airline Highway
Sterling Electronics, Inc.
5029 Veterans Highway
New Orleans
Sterling Electronics, Inc.
537 S. Claiborne Avenue
Shreveport
Koelemay Sales Company, Inc.
2530 Linwood Avenue

MAINE

Portland
Commercial Distributors
8 Somerset Street

MARYLAND

Aberdeen
Harco Electronics, Inc.
Carsins Run—Rt. 22
Hagerstown
Allegheny Electronics, Inc.
1301 Potomac Avenue
Salisbury
Standard Elec. Supply Co., Inc.
701 Snow Hill Road

MASSACHUSETTS

Boston
De Mambro Radio Supply Co.
1095 Commonwealth Avenue
A. W. Mayer Co., Inc.
895 Boylston Street
Sager Electrical Supply Company
172 High Street
Brockton
Ware Radio Supply Corp.
913 Centre Street
Lynn
Land Electronics Supply Co., Inc.
9R Franklin Street
Melrose
Melrose Sales Company
166 Tremont Street
New Bedford
C. E. Beckman Company
11-35 Commercial Street

MICHIGAN

Adrian
Wedemeyer Electronic Supply Co.
2982 Treat Road
Allen Park
Olson Electronics
15847 Southfield Road
Ann Arbor
Wedemeyer Electronic Supply Co.
2280 Industrial Highway
Benton Harbor
Colfax Co.
1485 M-139 Bldg. #2
Clawson
Radio Supply & Engineering Co., Inc
1203 W. 14 Mile Road
Detroit
Heathkit Electronic Center
18645 West 8 Mile Road
Olson Electronics
15620 Grand River Avenue
Olson Electronics
14243 Gratiot Avenue
Radio Specialties Co., Inc.
12775 Lyndon
Rissi Electronic Supply Co.
14405 Wyoming Avenue
Ferndale
Midway Electronics Supply
993 West 8 Mile Road
Flint
Shand Electronics, Inc.
2401 South Dort Highway
Grand Rapids
Bursma Radio Supply Co.
1030 Scribner Avenue, N.W.
Jackson
Wedemeyer Electronic Supply Company
1617 E. Michigan Avenue
Lansing
Wedemeyer Electronic Supply Company
800 Merrill Avenue
Menominee
Team Electronics
M & M Plaza, P.O. Box 212
Muskegon
Electronic Distributors, Inc.
1960 Peck Street
Roseville
Radio Specialties Co., Inc.
27882 Gratiot Avenue
Saginaw
Norley Brothers, Inc.
4375 Holland Road
Westland
Olson Electronics
200 North Wayne Road
Wyandotte
Radio Specialties Co., Inc.
2953 Fort Street

MINNESOTA

Bloomington
Team Electronics
2515 W. 79th Street
Duluth
Team Electronics
2954 Miller Trunk Highway
Hibbing
Team Electronics
112 E. Howard Street
Mankato
Team Electronics
Madison East
Minneapolis
Team Electronics
337 E. Hennepin Avenue
Team Electronics
2640 Hennepin Avenue
Team Electronics
6413 Lyndale Avenue, South
Team Electronics
720 29th Avenue, S.E.
Moorhead
Team Electronics
115 8th Street, South
Rochester
Team Electronics
102 4th Street, S.E.
St. Cloud
Team Electronics
117 5th Avenue, South
St. Paul
Team Electronics
455 Rice Street
Team Electronics
1534 White Bear Avenue
West St. Paul
Team Electronics
1733 S. Roberts Street
Willmar
Team Electronics
920 E. Litchfield

MISSOURI

Kansas City
Burstein-Applebee Company
3199 Mercier Street

RCA SOLID-STATE
THESE LOCATIONS

Lee's Summit
Burstein-Applebee Company
244 N Oldham Parkway
Springfield
Burstein-Applebee Company
1904 S Glenstone Blvd.
Team Electronics
1430 E Sunshine
St. Joseph
St Joseph Radio & Supply Co.
720 South 9th Street
St Louis
Olson Electronics
1517 Olive Street

MONTANA

Billings
Team Electronics
2501 Grand Avenue
Bozeman
Team Electronics
1008 N 7th Street
Great Falls
Team Electronics
613 Central Avenue
Missoula
Team Electronics
1805 South Avenue, West

NEBRASKA

Lincoln
Team Electronics
2055 O Street
Omaha
Team Electronics
6109 Ames Avenue
Team Electronics
3901 Leavenworth Street
Team Electronics
12100 West Center Road
Bel Air Plaza

NEVADA

Las Vegas
Olson Electronics
Wonder World
3651 Maryland Pkwy & Twain

NEW HAMPSHIRE

Concord
Evans Radio, Inc , Box 893

NEW JERSEY

Pennsauken
RESCO Electronics
Airport Central Highway
Airport Industrial Park
Springfield
Route Electronics, Inc
Echo Plaza U S Route 22
Totowa
Arrow Electronics Inc
225 Route 46

NEW MEXICO

Albuquerque
Sterling Electronics, Inc
1712 Lomas Boulevard, N E.

NEW YORK

Albany
RTA Distributors, Inc
991 Broadway
Batavia
Radio Equipment Corporation
5 Center Street
Bayside
Arrow Electronics, Inc
206-19 45th Road
Buffalo
Olson Electronics
711 Main Street
Olson Electronics
3259 Sheridan Drive
Radio Electric Products, Inc
1398-1400 Main Street
Radio Equipment Corporation
3240 Sheridan Drive
Radio Equipment Corporation
196 Vulcan Street
Radio Equipment Corporation
1532 Walden Avenue
Farmingdale
Arrow Electronics, Inc
900 Broad Hollow Rd (Rt 110)
Lackawanna
Crosstown Electronics, Inc
Abbott and Ridge Road
Middletown
Artec Distributors
17-21 Cottage Street
Mineola
Arrow Electronics, Inc.
525 Jericho Turnpike
Nanuet
Arrow Electronics, Inc
195 West Route 59
New York
Arrow Electronics, Inc.
78-91 Reade Street
Dale Electronics Corporation
244 West 14th Street

Packard Electronics Corp.
33 Union Square West
Olean
Radio Equipment Corporation
1615 State Street
Rochester
Masline Electronics, Inc.
511 Clinton Avenue, South
Schenectady
Grimmer's Electronic Parts Supply
41 N Brandywine Avenue
Syracuse
Salina Electronics, Inc.
2100 Park Street
Troy
Trojan Electronic Supply Co., Inc.
15 Middleburg Street
Yorkville
Valley Electronic Laboratories, Inc.
Truck Route 5A

NORTH CAROLINA

Asheville
Freck Radio & Supply Co., Inc.
38-40 Biltmore Avenue

NORTH DAKOTA

Bismark
Team Electronics
2304 East Broadway
Grand Forks
Team Electronics
1503 11th Avenue, North
Minot
Team Electronics
209 11th Avenue S W

OHIO

Akron
Fox Radio Parts Co
300 Akron Square Shopping Center
1615 S Arlington St
Olson Electronics
260 South Forge Street
Olson Electronics
69 W State Street
Canton
The Electronic Center, Inc
1300 N Cherry Avenue
Cincinnati
Olson Electronics
815 Main Street
Cleveland
Fox Audio Center
3736 Rocky River Drive
Olson Electronics
21850 Center Ridge Road
Olson Electronics
2020 Euclid Avenue
Olson Electronics
6813 Pearl Road
Columbus
Hughes-Peters, Inc
481 East 11th Avenue
Olson Electronics
2280 Morse Road
Olson Electronics
16 West Long Street
Elyria
EL A-Co
235 Lodi Street
Lima
Hutch and Son
Roberts at Lenore
Mansfield
Fox Radio Parts Co
1225 Park Avenue, W
Servex Electronic Distributing, Inc
755 Springmill Road
Marion
Servex Electronic Distributing Inc
224 N Prospect St
Mayfield Heights
Olson Electronics
6153 Mayfield Road
Perrysburg
Main Line Distributors, Inc.
Willis Day Industrial Park
Sandusky
Servex Electronic Distributing Inc
534 Columbus Avenue
Tiffin
Hutch and Son
278 N Washington
Toledo
Hillebrand Electronic Supply
4665 W Bancroft
Willoughby
Olson Electronics
36212 Euclid Avenue
Willo Plaza Shopping Center

OKLAHOMA

Muskogee
Sooner Radio & Television Supply, Incorporated
110 Callahan Street

Oklahoma City
Radio Supply, Inc
724 North Hudson Avenue
Sterling Home Electronics
5611 South Western Avenue
Sterling Home Electronics
4327 N W 23rd Street
Tulsa
Radio, Inc
1000 South Main Street
S & S Radio Supply Company
537 South Kenosha

OREGON

Eugene
United Radio Supply
974 W 6th Avenue
Pendleton
Round-Up Electronics
2927 Riverside Avenue

PENNSYLVANIA

Pittsburgh
Olson Electronics
5918 Penn Mall
Olson Electronics
3405 Saw Mill Run Blvd

SOUTH CAROLINA

Charleston
Wholesale Radio Supply Co.
515 East Bay Street

SOUTH DAKOTA

Rapid City
Team Electronics
1101 Omaha Street
Sioux Falls
Team Electronics
613 West 41st Street
Warren Supply Company
196 E 6th Street
Watertown
Team Electronics
223 9th Avenue, S E

TENNESSEE

Bristol
Lafayette Radio Electronics
'Associate Store'
1375 Volunteer Parkway
Chattanooga
Curle Radio Supply Company
439 Broad Street
Radio and Appliance Distributors Inc
2515 Cannon Avenue
Kingsport
Radio Electric Supply Co.
961 East Sullivan Street

TEXAS

Austin
Modern-Electrotex
914 W 12th Street
Sterling Electronics Inc
1712 Lavaca
Wholesale Electronic Supply
703 W 7th
Beaumont
Sterling Electronics Inc
3810 College
Bryan
Sterling Electronics, Inc.
903 South Main Street
Corpus Christi
Modern-Electrotex
4019 Brett
Sterling Electronics, Inc.
805 S Staples Street
Dallas
Adleta Electronics Co
1914 Cedar Springs
Olson Electronics
6215 Hillcrest Avenue
Southwest Radio Supply Company
1820 North Harwood Street
Sterling Electronics, Inc.
4428 Lemmon
Sterling Electronics, Inc
3510 Marvin D Love Freeway
Sterling Electronics Inc
2875 Merrell Road
Sterling Electronics of Dallas
11420 North Central Expressway
Sterling Electronics of Dallas
2608 Ross Avenue
El Paso
Midland Specialty Company
2235 Wyoming Avenue
Fort Worth
Adleta Electronics Co.
100 S Freeway at Vickery
Sterling Home Electronics
2939 West 7th Street
Garland
Newark-Dallas Electronic Corporation
707 Easy Street

Greenville
Lavender Electronics Inc of Greenville
2311 Washington
Houston
Electrotex
2300 Richmond Avenue
Sterling Electronics, Inc
4201 Southwest Freeway
Sterling Home Electronics
3118 Smith
Sterling Home Electronics
8404 Winkler Drive
Irving
Sterling Electronics, Inc
D B A Crabtree Wholesale Electronics
254 West Carpenter Freeway
La Marque
Electrotex
216 Byrd Street
Lufkin
Electrotex
430 Atkinson Drive
Odessa
Midland Specialty Company
2101 Andrews Highway
Paris
Lavender Electronics, Inc of Paris
250 South Main Street
San Antonio
Modern-Electrotex
910 W Laurel
Sterling Electronics, Inc
1407 S W Military Drive
Sterling Electronics, Inc
4600 San Pedro Avenue
Sherman
Lavender Electronics Inc of Sherman
308 East Houston Street
Tyler
Lavender Electronics Inc
503 East Oakwood Street
Victoria
Modern-Electrotex
1007 North William
Waco
The Hargis Company, Inc
1205 Washington Avenue

UTAH

Salt Lake City
Team Electronics
6237 South Highland Drive

VIRGINIA

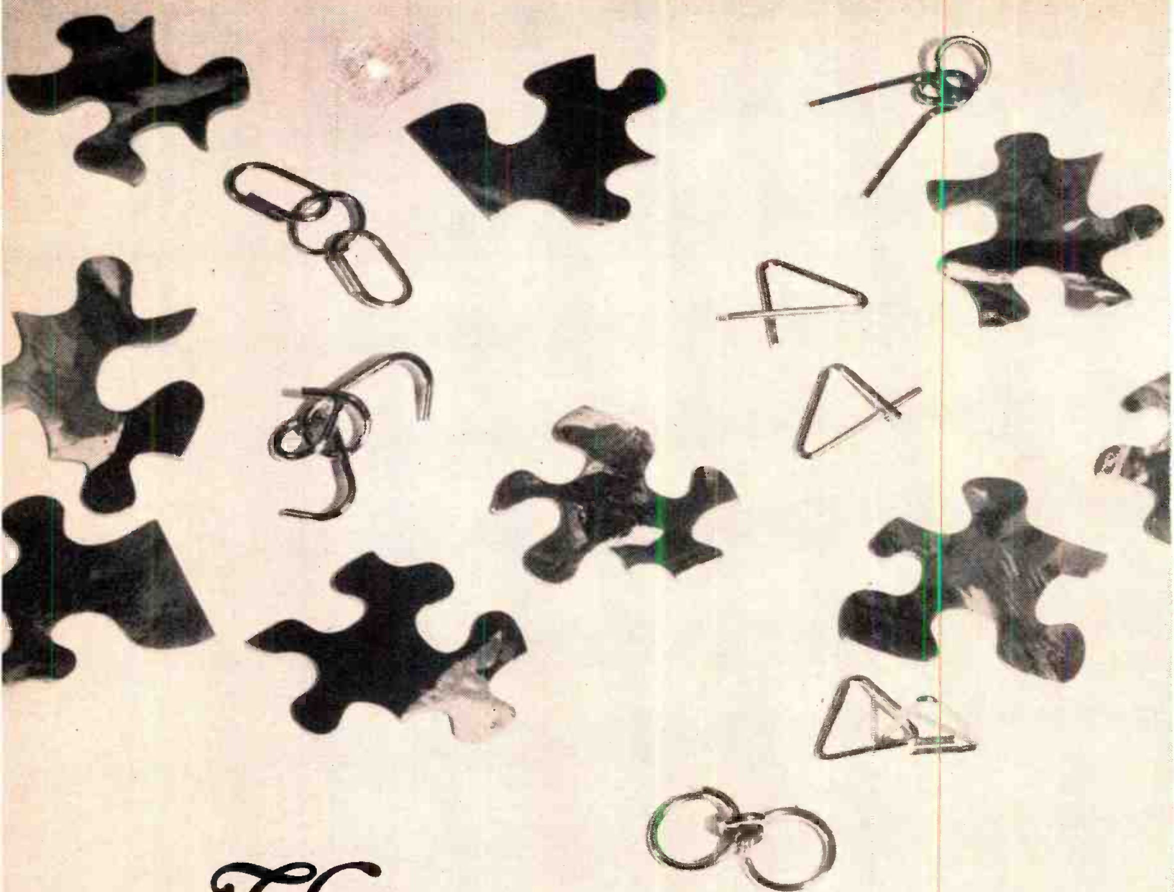
Arlington
Arlington Electronic Wholesalers Inc
3636 Lee Highway
Charlottesville
Graves Electronics Inc
1700 Allied Street
Harrisonburg
Electrical Wholesalers Inc
611 N Main Street

WASHINGTON

Everett
Pringle Electronic Supply, Inc
2101 Colby Avenue
Wenatchee
Mid-State Electronics
611½ North Wenatchee Avenue

WISCONSIN

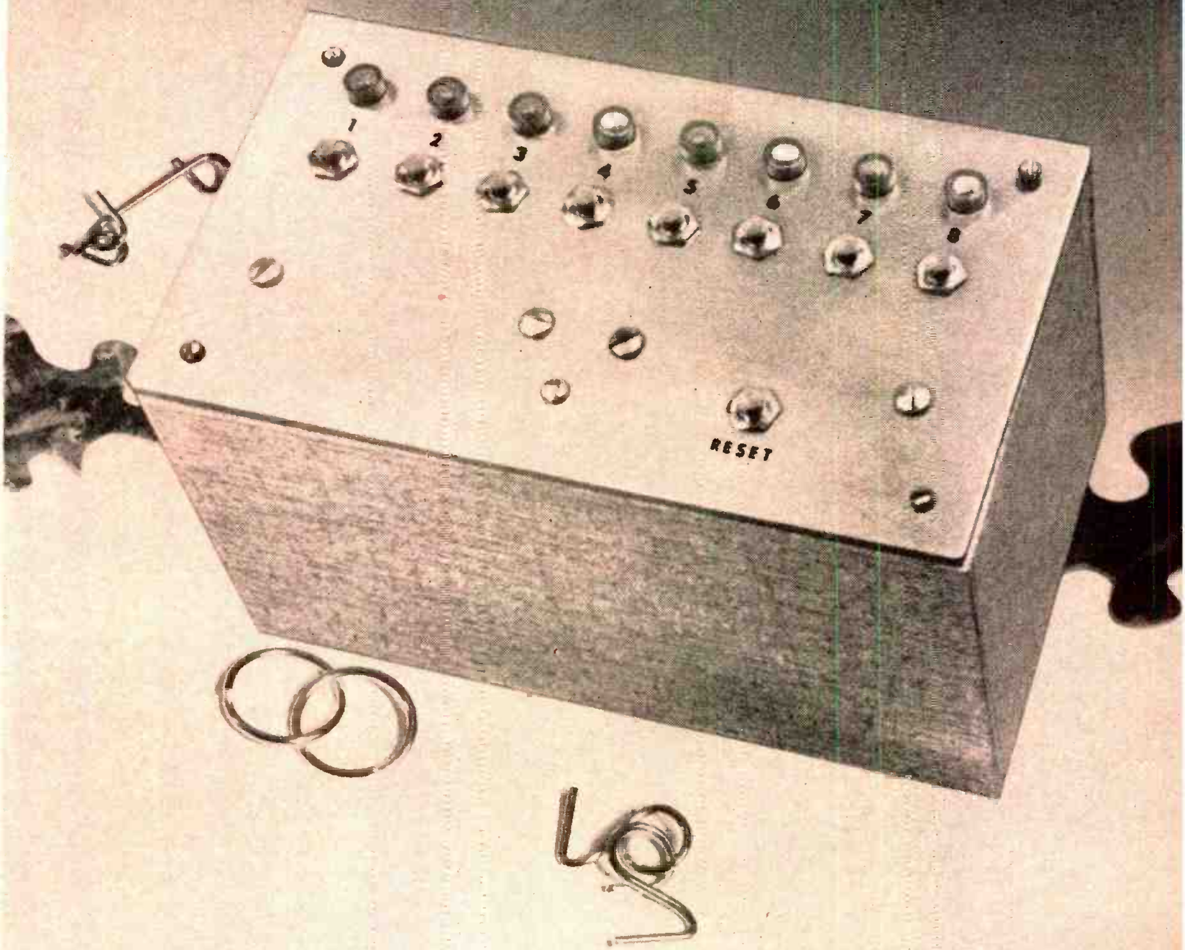
Appleton
Team Electronics
1828 West Wisconsin Avenue
Eau Claire
Team Electronics
2321 E Clairemont Parkway
Green Bay
Team Electronics
821 Military Road
La Crosse
Team Electronics
1505 Losey Blvd South
Madison
Team Electronics
3365 East Washington Avenue
Milwaukee
Olson Electronics
5830 West Fond du Lac Avenue
Olson Electronics
423 West Michigan Street
Team Electronics
7512 W Appleton Avenue
Manitowoc
Team Electronics
1801 Marshall Street
Racine
Team Electronics
3701 Durand Avenue
Elmwood Plaza Shopping Center
Schofield
Team Electronics
725 Grand Avenue



The PRINCEPS PUZZLE

Assemble the first all-electronic puzzle

BY JAMES W. CUCCIA



PUZZLES—whether they are word games, jigsaws, entwined nails, or interlocked pieces of wood—are the joy (or bane) of many people's existences. Whatever the overall reaction, however, nearly everyone is fascinated by a real "toughie"—providing he is assured the solution is possible and the whole thing is not a hoax.

Presented here is an ancient puzzling principle in a new guise—the electronic "Princeps Puzzle." The solution to Princeps Puzzle is based on clear-cut rules of logic (as used in everyday computers) and, assuming you get your unit properly assembled and wired, it is definitely possible—though not quickly obtained through some trick of black magic.

There are eight lights and eight pushbuttons on the puzzle. There

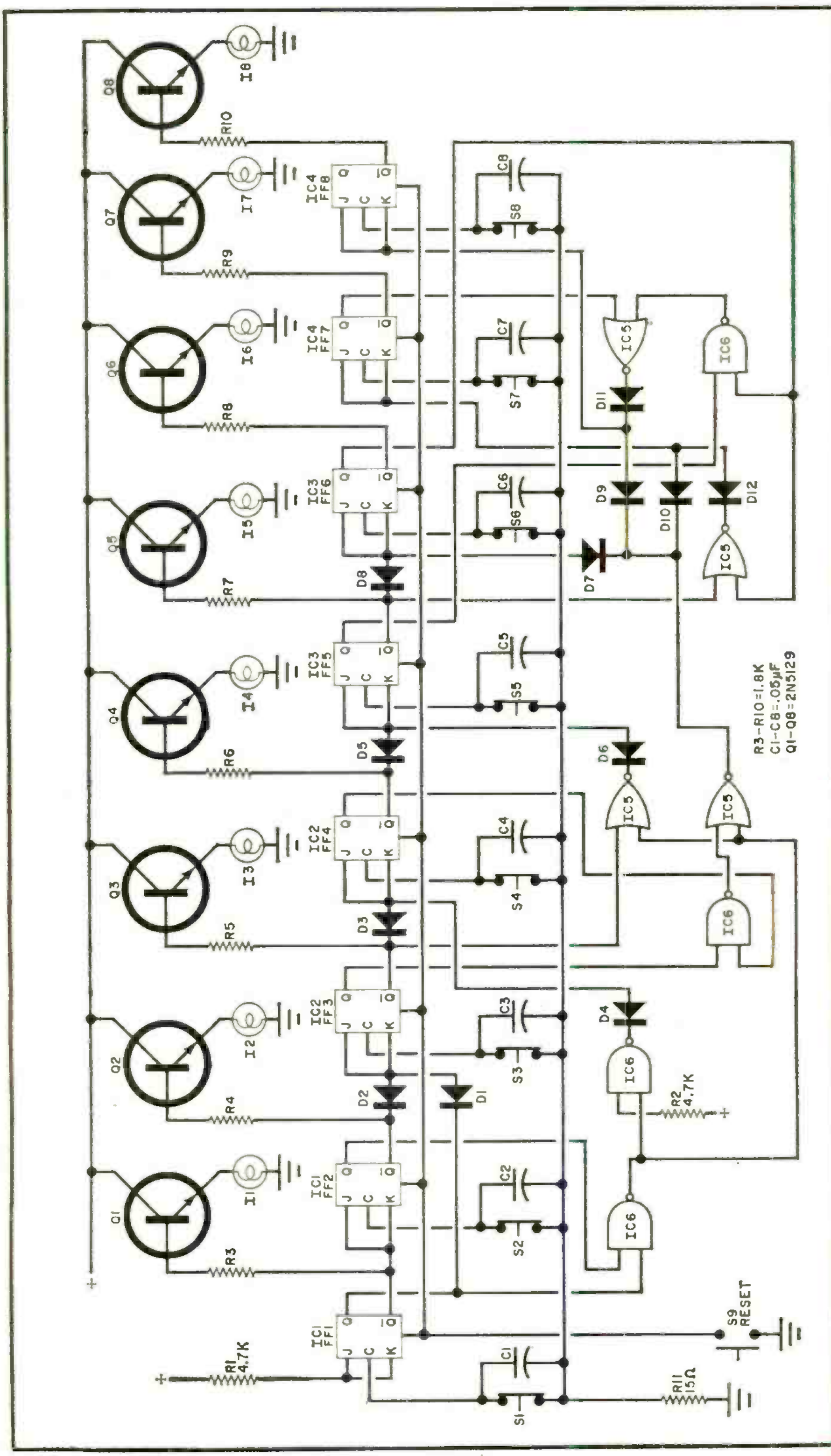
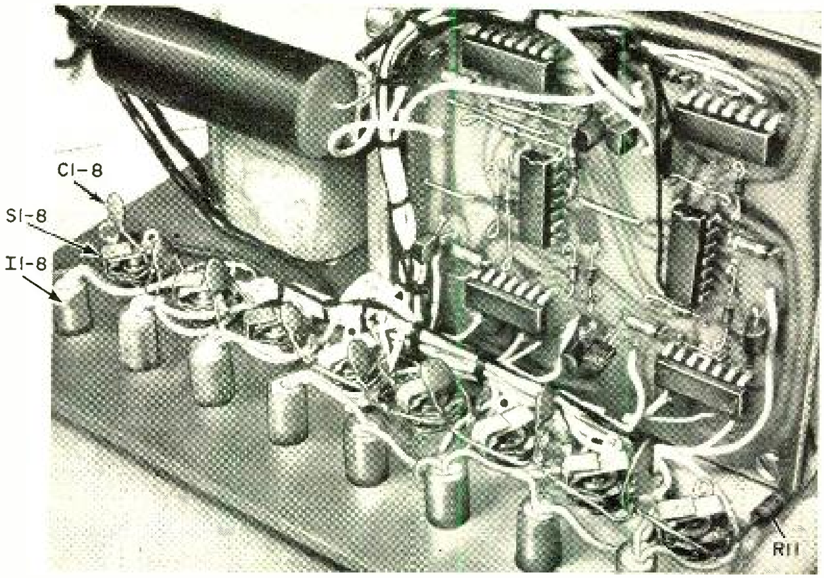


Fig. 1. Note that there is no actual trigger pulse applied to the flip-flops. Merely opening the associated pushbutton is enough to toggle the stage. The capacitor on the switch removes contact bounce.



Construction is left to the builder. Here, the lamps, switches and capacitors are grouped in lines on the front panel. The PC board is mounted on a pair of brackets.

is also a reset button which, when pressed, turns on all the lights at any time. The point of the puzzle then is to get them all turned off again by pressing the appropriate numbered buttons. You can figure out the solution to the Princeps Puzzle from the logic diagram shown in Fig. 1; and we'll give you a hint—it takes 170 pushes of one button or another in the proper sequence to get all the lights off. Once you get the system down pat, you'll be able to turn off all the lights in a minute or two—after watching your friends push and puzzle and puzzle and push for hours.

The detailed procedure for all 170 steps is too long to print here—besides we don't want to spoil your fun—but we'll send you a copy if you send 20¢ to cover handling and mailing to Editorial Dept., POPULAR ELECTRONICS, One Park Ave., New York, NY 10016.

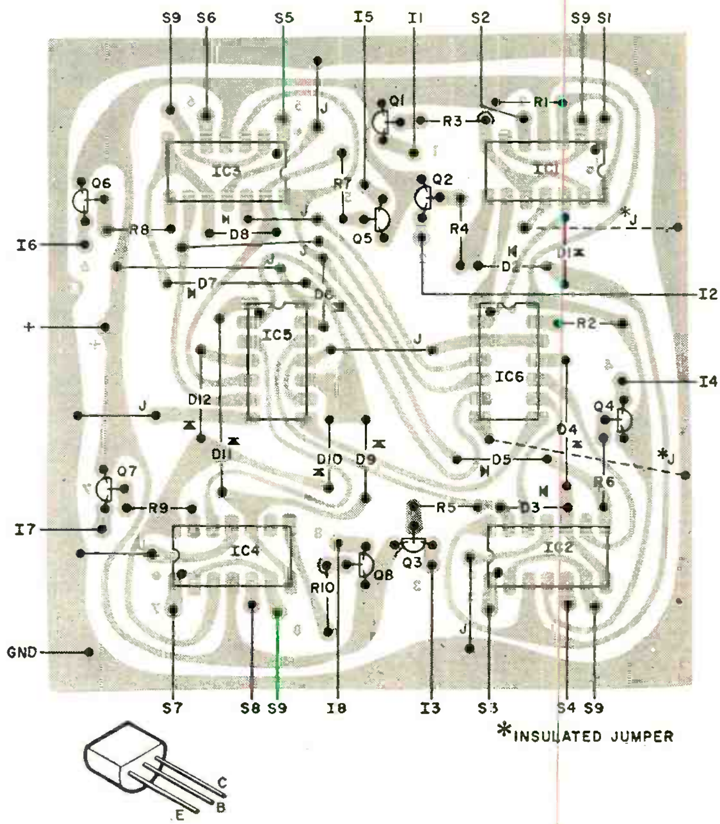
PARTS LIST

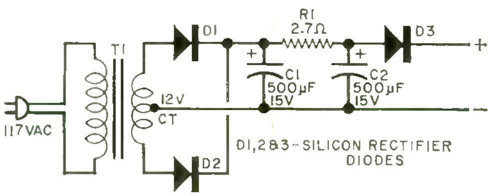
C1-C8—0.05-μF disc capacitor
D1-D13—Small-signal silicon diode
I1-I8—6.3-volt, 50-mA pilot light
IC1-IC4—Dual JK flip-flop (Motorola MC-7473P)
IC5—Quad 2-input NOR gate (Motorola MC-7402)
IC6—Quad 2-input NAND gate (Motorola MC7400)
Q1-Q8—2N5129 transistor
R1,R2—4700-ohm, ¼-watt resistor
R3-R10—1800-ohm, ¼-watt resistor
R11—15-ohm, ½-watt resistor
S1-S9—Spst pushbutton switch (Switchcraft 103 or similar)
Misc.—Suitable chassis, plastic lens for lamp (8), line cord, grommet, mounting hardware, etc.
Note: The following are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, TX 78216: etched and drilled PC board at $2.90, postpaid; complete kit of parts including board, chassis, and power supply at $29.95, plus postage and insurance for 3 lb.

Construction. The electronic portion of Princeps Puzzle is assembled on a printed circuit board as shown in Fig. 2. Be sure to get the proper orientation on the IC's and the correct polarities on the diodes. Use a low-wattage soldering iron and fine solder to avoid damaging the semiconductors with heat. The eight lights and their associated pushbuttons and capacitors are mounted on the front panel along with the reset button and *R11*. Once these are installed, the circuit board can be attached to the front panel as shown in the photographs.

The wiring between the switches, lamps, and board is not critical but it should be color coded to avoid confusion. A line-operated power supply, delivering approximately 5 volts is shown in Fig. 3. This supply may be assembled within the chassis using terminal strips to hold the components.

Fig. 2. Actual size foil pattern (left) and component installation (below) for the puzzle. Note that two insulated jumpers are shown and can go on foil side of the board.





PARTS LIST

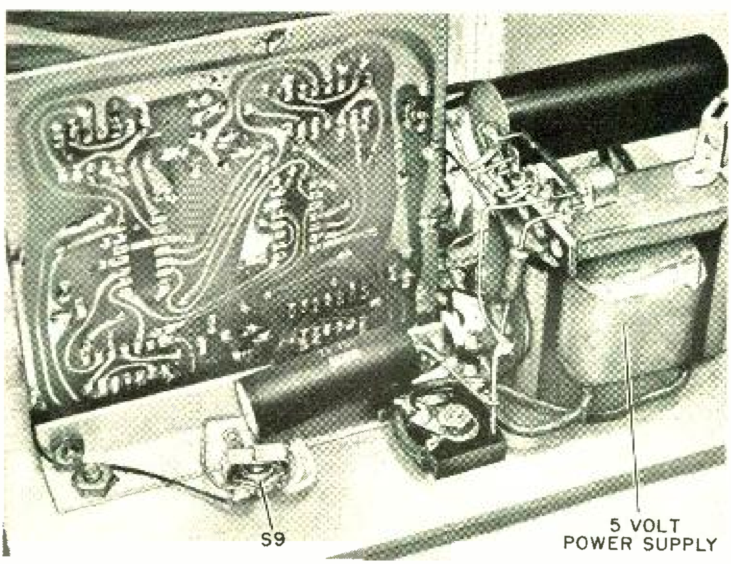
C1,C2—500-µF, 20-volt electrolytic capacitor
D1-D3—50-PIV, 1A silicon diode
R1—2.7-ohm, 1-watt resistor
T1—Transformer: secondary 12 VCT, 1A

Fig. 3. Typical power supply for use with the puzzle. Any other type of five-volt supply may be substituted.

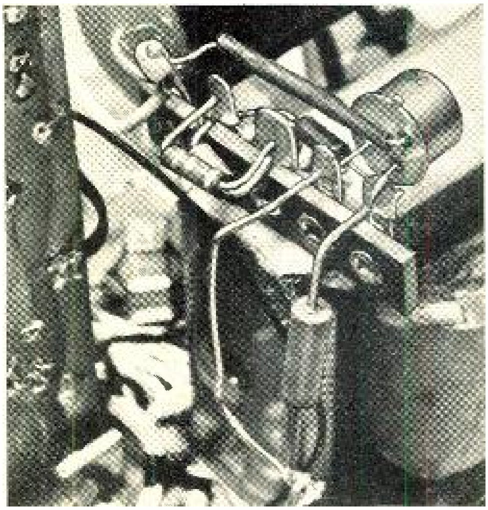
Theory of Circuit Design. The circuit uses four dual JK master-slave flip-flops, a quad two-input NAND gate, and a quad two-input positive NOR gate. The lamps are driven by emitter followers which are connected to the $\overline{Q}$ output of the flip-flops. In Fig. 1, the flip-flops are numbered to correspond to the lamps that they control.

The JK inputs to *FF1* are held at a high level at all times so that any pulse on the C input changes the Q output and turns *I1* on or off. The $\overline{Q}$ output of *FF1* also controls the JK inputs to *FF2*. Thus *FF2* can be changed by a pulse on C only if the $\overline{Q}$ output of *FF1* is high—meaning *I1* is on. The Q output of *FF1* is coupled to *FF3* through diode *D1* and to one input of the NAND gate which is one of the controls for *FF4* through *FF8*. Thus *FF3* through *FF8* are operative when *I1* is off and the other control levels are correct. The $\overline{Q}$ output of *FF2* is coupled to *FF3* through *D2* so that *FF3* can function only when *I1* is off and *I2* is on. The Q output of *FF2* is coupled to *FF4* through *FF8* through a NAND gate so that they can operate only when *FF2* is off and other conditions are met.

The $\overline{Q}$ output of *FF3* is coupled through *D3* to *FF4* so that the latter can only operate when *I3* is lit. The $\overline{Q}$ output of *FF3* is also coupled to a NOR gate and its Q output to a NAND gate. These gates control *FF5* through *FF8* so that they cannot operate unless *I3* is off. The $\overline{Q}$ output of *FF4* is coupled to *FF5* through *D5* so that *FF5* can operate only when *I4* is on. The Q output of *FF4* is connected to one input of a NAND gate coupled



The author elected to use a five-volt regulated dc supply in his prototype. The bridge rectifier, pass transistor, and filters can be seen above.



This view shows the value in using a terminal strip to mount off-board electronic components, in this case the regulated power supply. Such an approach can be used in any type of supply, or in any other project that requires outboard component mounting.

to *FF6*, *FF7*, and *FF8* so that they can operate only when *I4* is off and other conditions are met.

The $\bar{Q}$ output of *FF5* is connected through *D8* to *FF6* so that *FF6* can operate only when *I5* is on. The $\bar{Q}$ output of *FF5* is also connected to a NOR gate while its Q output is connected to a NAND gate to control *FF7* and *FF8* so that they can operate only when *I5* is off and other conditions are met. The Q output of *FF6* is used only as a lamp drive but its Q output is connected to a NOR gate to control *FF7* and to a NAND gate to control *FF8* so that *FF7* can operate only when *I6* is on and *FF8* can operate only when *I6* is off.

The $\bar{Q}$ output of *FF7* is used only to drive *I7* and its Q output is connected to a NOR gate to control *FF8*. Thus *FF8* can operate only if *I7* is on. The $\bar{Q}$ output of *FF8* is used as a lamp drive only.

The clock input to each flip-flop requires that the input be held low, increased momentarily, and then returned to low. This condition is met by the normally closed pushbutton switches *S1* through *S8*. A capacitor across each switch integrates the pulse and eliminates contact bounce.

The overall logic circuit then controls the lamps so that *I1* can be turned on or off at any time and to change the condition of any other lamp, the lamp immediately preceding the one to be changed must be on and all other lamps preceding that one must be off. This is the format that must be followed in solving the puzzle.

There are two modifications that can be tried. To make it easier, only the first six lamps and their associated circuits can be used—eliminating *I7* and *I8* and associated circuits. To make things more difficult, interchange the pushbuttons so that they don't line up with the lights—but be sure you know what's what or you may wind up on the puzzled side yourself. —30—

THE CASE FOR THE SINGLE WOOFER

BY DAVID B. WEEMS

PROS AND CONS ON AN OLD SUBJECT: THE THIRD SPEAKER IN A STEREO SYSTEM

THE IDEA of using a single woofer to reproduce the bass information present in the signals on both stereo channels is about as old as consumer stereo itself. Even today, there are audio authorities who maintain that, in some respects, one woofer can be better than two. To support their cases, they cite such advantages as extended bass response; better midrange and high-frequency performance; reduced turntable rumble; and more flexibility in speaker arrangement.

Going back in history (stereo history, that is), you will find that the Electro-Voice "Esquire-Stereon," Stephens "Stereodot," and Jensen "Galaxy" employed a mixed-signal speaker of one kind or another. All of these systems were essentially three-speaker setups in which the middle speaker carried the combined stereo signal, though it was not necessarily limited to operation in the bass range. Two small "satellite" speakers filled out these systems, providing left- and right-channel sound sources.

The Galaxy was a bit unusual. In it, the center speaker *was* used mainly for bass and low midrange reproduction, rolling off in response above 1000 Hz. Its crossover point from satellites to woofer was about 350 Hz.

None of these three-speaker systems seemed to inspire any great loyalty from stereo buffs of the time; but there was one other system that might have succeeded where the others failed. It was the Weathers "Triphonic," which also had three speakers, but the third speaker did not have to be located in the middle. It contained a 10-in. woofer which had a falling response above 100 Hz, with a crossover point from satellites to woofer at 80 Hz—low enough to make the woofer's sound non-directional.

Sometimes called the "camouflage" system, the Triphonic's satellite speakers were disguised as books, while the woofer box was small enough to be hidden under a piece of furniture. The system was probably the first attempt to exploit the unique advantages of single-woofer stereo.

Regardless of its originality, the Triphonic system was a commercial failure, which probably tainted the single-woofer concept for manufacturers and stereo buffs alike. Commercial success or failure is an unreliable guide to what is good or bad, but one possible factor attributing to the failure of the Triphonic was the need for interchangeability between amplifiers and speakers. The period of transition from monophonic to stereophonic sound was also a time for change in amplifier design as transistors began to supplant vacuum tubes. Early transistorized amplifiers were often fussy about what was connected to their outputs. (Even today, certain precautions must be observed before connecting a mixed bass circuit to some amplifiers.) Most audio buffs took the easier method of using two separate speaker systems—including two woofers.

Some equipment buyers, following the reasoning that if one is good, two are better, automatically associated the idea of a single woofer with inferior quality. Department store salesmen, looking for a quick sale, were often responsible for perpetrating this misconception. Most of them use the ploy of emphasizing the number of speakers inside their system consoles as important advantages without reference to overall system quality.

Nor did the Weathers system offer much in the way of a status symbol for the prospective buyers. Apparently, the only buyers interested in the Triphonic were impressed by the novelty of "invisible" speakers.

The return of interest in mixed bass is evident in the Infinity "Servo-Static I." Unlike the Weathers system, it is neither small in size nor moderately priced. This raises the question: Do the Infinity speakers demonstrate that a novel concept, once shot down by the $100 competition, can make it in the $1000 bracket? Of course, with their motional feedback and high overall quality, they have more going for them than just mixed bass. But whatever the reason, the fact that some audio fans are plunking down $2000 for a common bass system suggests that single-woofer stereo is worth a careful second look.

The owner of two large speakers would gain little by adding a third woofer to rob power from the two already in use. But if going to a mixed bass permits the use of a significantly larger woofer, then one advantage seems certain—improved bass response.

Of course, some experts feel that extension of the bass range is insufficient reason for the switch to the single woofer, claiming that separate woofers are less likely to excite room resonances than one large woofer. Others contend that smaller woofers have the advantage of better transient response and bass detail over the bigger woofers. There are differences in sound character between a large woofer and a small one; but only a careful listening test will help you to determine which, if either, you prefer.

The second advantage is less obvious but just as important for some rooms. Stereo speaker systems, even small compacts, are often placed on the floor which enhances bass response but makes the high frequencies sound both unnatural and poorly dispersed. Here, the use of a separate woofer permits the placement of satellite speakers for optimum high-frequency sound dispersion and stereo effect. It also provides an opportunity for imaginative furniture arrangement.

With a properly chosen crossover frequency, the direction of the sound from the woofer will not be noticeable. The woofer box can be tucked away under a piece of furniture, put in a closet, or even moved into an adjoining room. If the woofer is removed too far, discriminating listeners might detect a phase shift between the fundamental bass tones from the woofer and harmonics of those tones produced by the stereo satellite speakers. But the stereo effect itself will not be compromised. The listener will still hear some bass instruments on the left, others on the right, since the location of each instrument is recognized by its overtones which are produced by the upper range speakers.

The use of a common woofer for both channels also insures the physical separation of the low-frequency speaker from the treble speakers. Putting a tweeter in an enclosure designed for good bass response, even if the tweeter is acoustically isolated, makes no engineering sense at all. The dangers of sound reproduction distortion and damage to small speakers which are not sealed off from the woofer are well known. What is sometimes overlooked is the effect of the enclosure shape and size on high-frequency sound dispersion.

A large rectangular cross section enclosure has sharp corners at the front edge which produce diffraction effects, particularly when the midrange speaker or tweeter is installed in the front middle of the enclosure. These effects may cause peaks or dips, up to as much as ±5 dB in the response curve[1].

Enclosure diffraction, which produces interaction between the diffracted waves and the normal waves, was demonstrated by Dr. Harry F. Olson of RCA Laboratories some 20 years ago[2]. But another shortcoming of the large enclosure when used for the middle and high frequencies, though not as well recognized, may be just as important to consider. The wider the front of the enclosure, the poorer is the dispersion of midrange and high-frequency sound.

It is an irony that speakers can be made to sound expansive and "big," due to good dispersion, by making them smaller. When the midrange and tweeter speakers are removed from the woofer's enclosure, the designer is free to make use of enclosures that fit the requirements of optimum upper frequency response and dispersion. An obvious example of one possible approach is the line source, or narrow midrange column, as described in "Totem Poles For Stereo" (POPULAR ELECTRONICS, January 1966).

Reducing turntable rumble through the use of a single woofer has often been suggested. The theory is based on the fact that rumble vibrations in a turntable tend to be in the vertical plane, to which the ideal stereo pickup will respond by producing equal and out-of-phase voltages in each channel. These signals, if carried through the stereo system and reproduced by the speakers without phase shift differences, will cancel the rumble frequency. A stereo system with a woofer in each channel, when operated in proper balance, should theoretically cancel the rumble; but various factors, such as the listener's position with respect to each woofer, may prevent perfect cancellation.

When a single woofer is used for both channels, the unpredictable factor of room acoustics is canceled. Then rumble cancella-

The mixed-signal woofer in the "Totem Poles For Stereo" project (January 1966) was located in the squat box shown in the center of the photo. The "totem poles" on each side contained the satellite speakers.

The best way to get electronics into your head

No book ever written can give you the "feel" of electronics.

This is why every NTS course in Electronics includes the most modern, professional training equipment in kit form.

Putting equipment together, kit by kit, can teach you more about electronics than a whole library of bone-dry theory.

Each kit contains illustrated instructions.

You look at the pictures, then you apply what you see as you assemble or service your equipment.

What could be simpler? Or more fun? You'll enjoy every profitable minute.

Here's just some of the equipment you get to build and what you will learn.

Color TV
295 sq. in. picture.

NTS COLOR AND B&W TV SERVICING

You receive a big screen color TV with many unique features, including self-servicing equipment so you can make all normal test operations. You also get an AM-SW radio, solid-state radio, field-effect transistor, Volt-Ohmmeter and electronic tube tester. You learn about electronic principles, trouble-shooting, hi-fi, multiplex systems, stereo and color TV servicing.

Solid-state B&W TV 74 sq. in. picture (cabinet included)

The B&W TV receiver features the latest in *solid-state circuitry*, making your TV training the most modern, most advanced available.

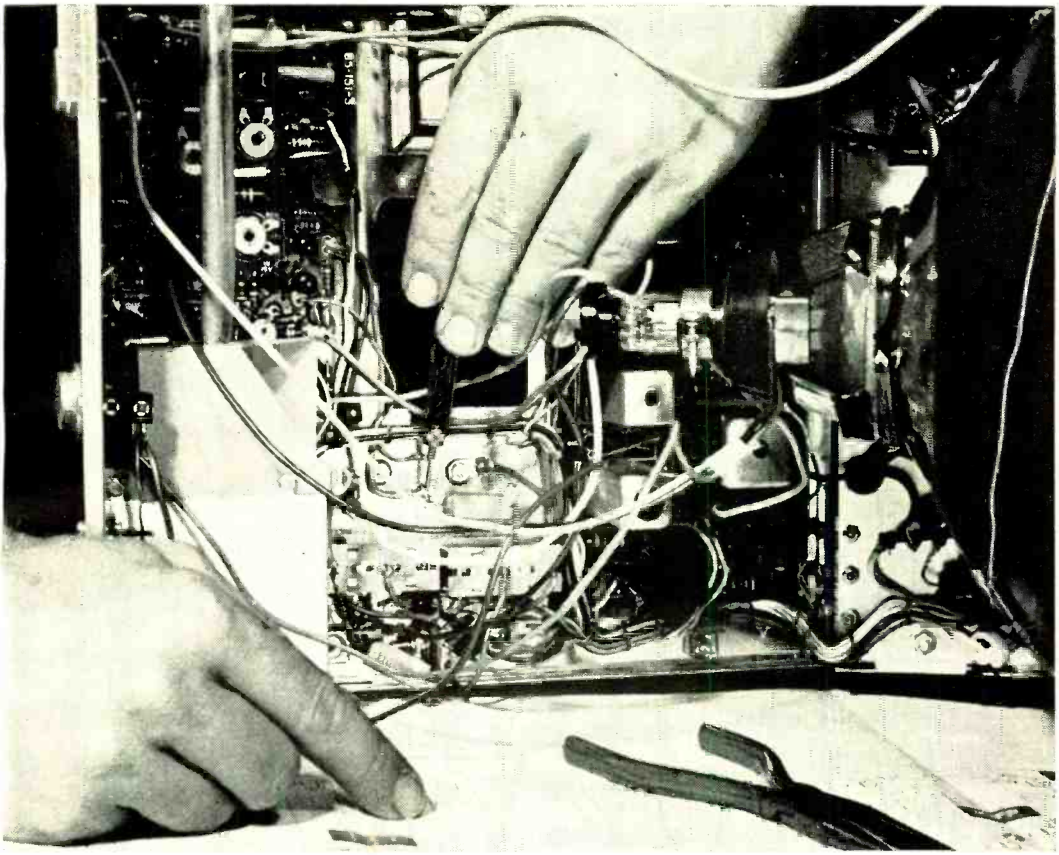
NTS COMPUTER ELECTRONICS

One of the 10 important kits included is this remarkable Compu-Trainer® — an NTS exclusive. It's a fully operational computer logic trainer — loaded with integrated circuits. It introduces you quickly to the how, what, when, and why of computers. This unit is capable of 50,000 operations per second.

Exclusive Compu-Trainer®

NTS ELECTRONICS COMMUNICATIONS

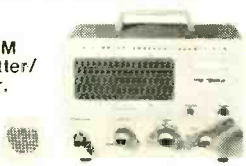
Two exciting courses in the big-paying fields of transmitting and receiving equipment. Either one qualifies you for your FCC First Class Radio-



is to have the actual equipment in your hands.

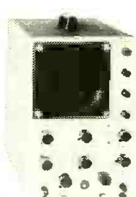
Telephone License. *NTS assures you will pass this FCC exam within 6 months after successfully completing your course — or your tuition is refunded.* You receive 14 kits to build an amateur phone 6 meter VHF tranceiver plus NTS' exclusive 6 transistor solid-state radio and a fully transistorized volt-ohmmeter.

5 watt AM transmitter/ receiver.



NTS AUTOMATION/ INDUSTRIAL ELECTRONICS

Let NTS put you into the age of electronic controls. Systems automation is rapidly becoming the emphasis of modern industry. NTS training includes equipment like a 5" wide band oscilloscope. You also get the new, exclusive NTS Electro-Lab — a complete workshop that lets you build five industrial controls to regulate motor speed, temperatures, pressure, liquid level, smoke, and much more.



5" Oscilloscope

Mail card today for free, full-color catalog that details what each training program offers. (Or if card is missing, send coupon.) No obligation. No salesman will call.

Remember, the best way to get electronics into your head is to have the actual equipment in your hands. The sooner you mail the card, the sooner you'll get your hands on the finest, most advanced electronics home training ever offered.

CLASSROOM TRAINING AT LOS ANGELES You can take classroom training at Los Angeles in sunny California. NTS occupies a city block with over a million dollars in facilities devoted exclusively to technical training. Check box in coupon.

APPROVED FOR VETERANS

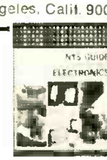
Accredited Member: National Association of Trade and Technical Schools; National Home Study Council.

NATIONAL TECHNICAL SCHOOLS

WORLD-WIDE TRAINING SINCE 1905

4000 S. Figueroa St., Los Angeles, Calif. 90037

If card is missing check coupon and mail for free color catalog and sample lesson. Now.



Please rush Free Color Catalog and Sample Lesson, plus information on course checked below. No obligation. No salesman will call.

National Technical Schools
4000 S. Figueroa St., Los Angeles, Calif. 90037

- ☐ Master Course in Color TV Servicing
- ☐ Color TV Servicing
- ☐ Master Course in TV & Radio Servicing
- ☐ Practical TV & Radio Servicing
- ☐ Master Course in Electronic Comm.
- ☐ FCC License Course
- ☐ Master Course in Electronics Tech.
- ☐ Industrial and Automation Electronics
- ☐ Computer Electronics
- ☐ Basic Electronics

Dept. 205-051

Name ____ Age ____

Address ____

City ____ State ____ Zip ____

☐ Check if interested in Veteran Training under new G.I. Bill
☐ Check if interested only in Classroom Training at Los Angeles

tion depends solely upon proper operation of the stereo cartridge and the amplifying system, components which are more subject to control than are speakers or the acoustical environment.

The claimed advantages of the single woofer do not rule out the question: What does it do to the stereo image? Does a single woofer improve the bass response at the expense of overall sound quality? There is no simple answer to this question. Several factors are involved—most critically, the choice of system crossover frequency.

If the crossover point is too high, the listener will detect the direction of the bass frequencies, and the stereo illusion will be impaired. There is a critical frequency, at least for a given listening environment, below which the direction of the sound is unimportant. To determine this frequency, we can rely on theory.

There is a scientific principle which states that two signal sources cannot be distinguished directionally if they are separated by less than one wavelength. So, assuming an average speaker separation of 8 ft, the critical frequency would be 140 Hz.

Another theoretical consideration concerns the size of the listening room itself. One authority on audio, Norman Crowhurst, states that if a room is large enough to hold a train of waves at crossover, the listener will be able to locate the direction of the bass sounds.[3] According to his theory, a room 20 ft long could hold several wavelengths at 350 Hz (a typical crossover point) and the stereo effect will suffer.

But following theory alone is like relying on an insurance policy without reading the fine print. There may be aspects of the problem not covered by theory. For example, no filter network cuts off sharply enough to eliminate all frequencies above the crossover point. Typically, the attenuation slope is 6, 12, or 18 dB/octave. Because sharp cut-off filters cause phase shift, many authorities prefer the 6- or, at most, 12-dB filter. If the 6-dB/octave filter is chosen, it will be necessary to lower the frequency of the crossover in order to preserve the desired degree of separation at the higher frequencies.

J. Gordon Holt, the author of the monthly "Stereo Scene" in this magazine, says the passband of the bass speaker should lie below 150 Hz. He further specifies that the signal to the woofer be down at least 15 dB at 200 Hz, if possible, to avoid directional cues. To satisfy these requirements, a 12-dB network should cross over at 80 Hz or lower, and a 6-dB network should cross over at 60 Hz or lower. Minor variations from these points will hardly be noticeable.

In hooking up a mixed-signal woofer, there are problems that go beyond the purely physical. As mentioned earlier, a major reason for

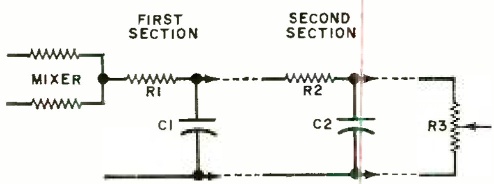
RC LOW-PASS FILTER

In the diagram (right), a single section filter consisting of R1 and C1 will produce only a 6 dB/octave slope in the response curve. By following the first section with a like section (R2 and C2), the rolloff slope is theoretically increased to 12 dB/octave. But R2 should be ten times the value of R1 to assure that the two stages operate more independently. Typically, a 50,000- or 100,000-ohm potentiometer, to control the level of the bass, is used to terminate the filter.

The following Time Constant Chart can be used to simplify the adjustment of RC values for various crossover frequencies:

F (Hz)	T (μSec)
60	2700
70	2300
80	2000
90	1800
100	1600
125	1300
150	1100

Since time constant T in microseconds is equal to resistance R in ohms times capacitance C in microfarads, the value of C for various crossover points can be calculated by plugging the appropriate figures into the formula: C = T/R.



The typical tolerance of paper capacitors is ±20 percent. Hence, some variation in performance is to be expected. Also, when two or more sections are used in the filter, there is a chance of interaction between the sections, and the crossover point might occur at a frequency lower than that calculated.

The results obtained from the formula should be treated as only approximate values for the capacitors. The response of the network can be tailored to fit various situations by substituting various values of C to raise or lower the crossover point.

the neglect of the single woofer concept is the necessity for choosing a circuit that is compatible with the amplifier you intend to use. Six methods of using a mixed-signal woofer with an existing stereo system are shown in the schematic diagrams in Fig. 1. One or more of these methods should work with just about any amplifier.

Circuit A would be the most versatile but for the fact that it requires a special woofer with dual voice coils which could be connected directly in parallel with the existing speaker systems. In circuits A, B, and C, it may be desirable to insert a capacitor in series with the left- and right-channel speakers. A properly chosen capacitor will offer sufficient reactance at low frequencies to prevent any possibility of a low-impedance load below the crossover frequency point. For example, if the crossover frequency is 150 Hz, University Sound engineers specify a series capacitor of 150 μF for each speaker and inductances of 8 mH in series with the woofer's voice coils. (You can obtain the capacitors and inductors from University Sound, 9500 West Reno, Oklahoma City, OK 73101.)

A single woofer may be simply wired into the output of one of the channels of an amplifier (circuit B). While there is the possibility that the bass instruments on the other channel would be lost with a one-channel woofer, it is not likely for disc recordings which employ blended bass.

Another approach to incorporating the woofer into your system is to use a 1:1 mixing transformer (such as the Electro-Voice XT-1) as shown in circuit C. This setup is useful for tube-type amplifiers but can be used with solid-state systems *only* if a large-value capacitor—say, 500 μF—is inserted in the right channel line, and then only if the amplifier is known to be stable with a capacitive load.

If you own a solid-state amplifier, study the instruction manual and/or the schematic diagram to determine if the output connections for the left and right channel common points can be safely tied together before resorting to circuits D-F. A 500-μF capacitor between the common terminals can be used with those amplifiers which are overparticular about direct hookups. Many amplifiers use a common ground line; and for these no problem exists.

Two low-cost methods of obtaining a sum signal from both stereo channels for driving a single woofer are shown in circuits D and E. The former is a typical method of deriving a

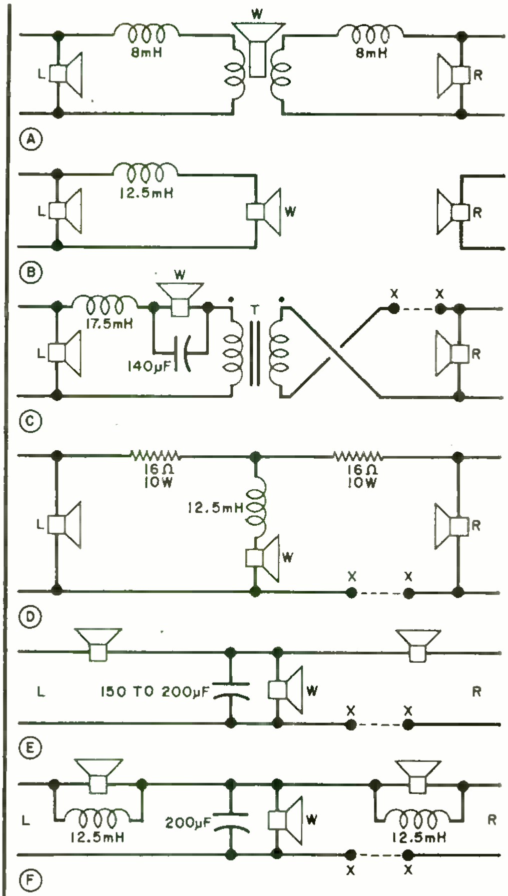
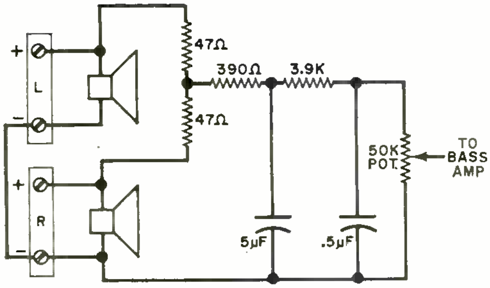


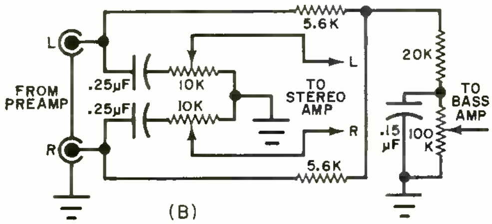
Fig. 1. Do not use circuits C-F with solid-state amplifiers unless a 500-μF capacitor is inserted between X's, and then only if the amplifier is known to be stable operating into capacitive load.

third-channel sum signal in some amplifiers. Here, a series inductor has been added to the woofer line as a low-pass filter. The use of the isolation resistors has some disadvantages, such as a loss of 6 dB in woofer output and reduced damping effect on the woofer itself.

Circuit E is a simple European setup mentioned by Baxandall[4] (who does not strongly recommend it). He cites the possibility of interaction of the three speakers because of the series arrangement between stereo speakers and woofer which could produce dips and peaks in the frequency response curve. Electro-Voice engineers offer a refinement of the circuit by adding a couple of inductors as shown in circuit F. The chokes offer a low-impedance path for the low frequencies, providing a bass rolloff in the left and right speakers. In this circuit, the full-range speak-



(A)



(B)

Fig. 2. Mixed signal for bass amplifier is derived from output terminals of stereo amplifier (top diagram) or from preamplifier output (directly above).

ers appear in series with the woofer only near the crossover frequency.

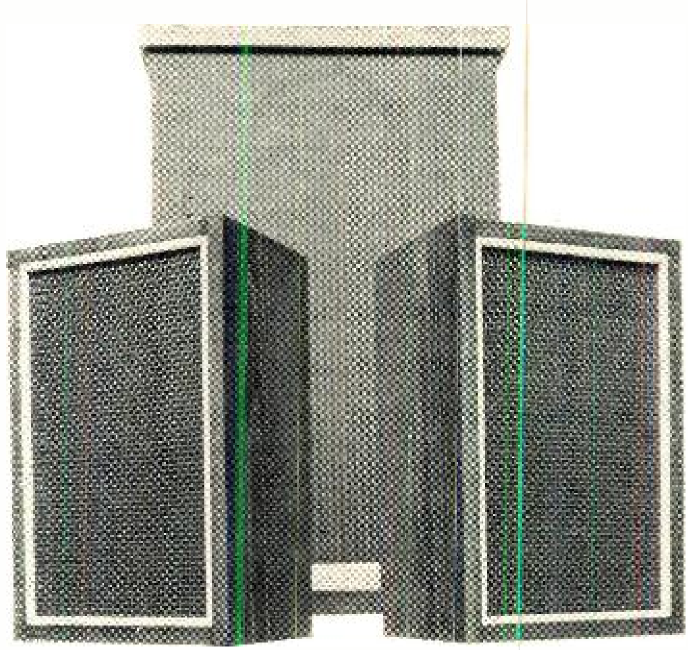
The Fig. 1 circuits have one significant advantage. They do not require an extra amplifier to drive the woofer. But they also have common disadvantages. For one, the inductors and capacitors that make up the crossover networks operating at the proper low frequencies must have large values. The values stated in the diagrams are for 100 Hz or higher. Another type of filter should be used for operation at lower, and perhaps more desirable, crossover points.

J. Gordon Holt has a definite opinion on the best way to operate a common-bass system. He states, "I'm convinced that the only way to do this properly is via a separate amplifier. It would provide full woofer damping and complete control of woofer level without loss of side-speaker separation."

Holt offers two methods of crossing over from a stereo amplifier to a bass amplifier, both of which are shown in Fig. 2. Circuit A in Fig. 2 is a passive filter network with crossover at 80 Hz and a 12 dB/octave slope. The frequency of the crossover can be raised to 100 Hz by changing the capacitor values to 4 µF and 0.4 µF, respectively. Passive filters work well but have inherent insertion losses which, in some cases, will most likely necessitate an extra stage of amplification.

Ideally, the crossover should be located between the preamplifier and main amplifier as

(*Continued on page* 97)



In typical single-woofer system shown here, woofer is located in large box in background; satellite speakers are in small foreground boxes.

EL PANEL DRIVER

CHANGING VOLTAGE AND FREQUENCY ON ELECTROLUMINESCENT PANELS CHANGES BRIGHTNESS AND COLOR / BY NORMAN P. HUFFNAGLE

Although it is widely hailed as one of the great breakthroughs in modern lighting design, electroluminescence (EL) remains something of an enigma to the scientist as well as the layman. The first demonstration (performed by Lossev) showing that a single crystal of zinc sulfide would emit light when under the influence of an electric field occurred back in 1923. Later, in 1936, G. Destriau reported that electroluminescence had been obtained from a thin layer of fine particles placed between two electrodes—either with or without a dielectric suspension medium. The light was so faint that, at first, some researchers doubted its existence, but verification was forthcoming and practical uses began to evolve.

Electroluminescent lamps are now used in the form of panels as night lights and to illuminate instrument panels in aircraft and space vehicles. In the future they will probably be used on automobile dashboards and other instrument panels where a nonglaring, yet highly visible cold light in various colors is required.

Despite its acceptance and use, however, there remains some doubt as to just how electroluminescence actually works. Like its cousin the light-emitting diode (LED), the EL lamp is a solid-state device and, as such, is

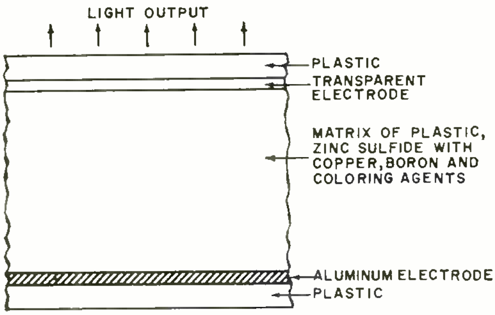


Fig. 1. This enlarged view of a thin electroluminescent panel shows how "sandwich" is created.

immune to catastrophic failures due to vibration, environmental extremes, etc. Also, since it is solid-state, it can be used in conjunction with solid-state power supplies providing a homogeneous overall system.

However, unlike the LED, which uses low-voltage dc power, the EL device requires a high-voltage ac supply. Electroluminescent panels now available operate in excess of 10,000 hours at 60 Hz and 117 volts, delivering 1 to 1.5 footlamberts of light. If the operating voltage and frequency for such panels are changed, they can produce up to 100 footlamberts.

All of this results from a phenomenon whereby light is emitted from a thin layer of crystalline phosphor (usually zinc sulfide) situated in a "capacitor sandwich" as shown in Fig. 1. This particular phosphor emits a green light when stimulated and also makes an excellent host crystal for a number of color-changing additives. You have probably seen zinc sulfide (ZnS) a number of times since it is the basic phosphor used to coat the screens of oscilloscope CRT's. (In this case, the phosphor is excited by high-speed electrons from the CRT gun.)

As shown in Fig. 1, the phosphor compound is sandwiched between a thin aluminum foil and a transparent, although conductive, electrode. The aluminum also provides some reflection, increasing the light output, while the transparent electrode permits the light to escape. The entire EL panel is then sealed within a moisture-proof plastic which also provides electrical isolation. The overall assembly is approximately 1/32" thick with a 1- to 5-mil separation between the two electrodes.

Electron Impacts. Although a background in solid-state physics is necessary to a full understanding of the presently known mechanisms whereby an EL panel emits light, a not too rigorous, yet acceptable explanation is that, under the application of an intense electric field, electrons are removed from the surface of the phosphor particles, accelerated by the applied field, and caused to collide with other phosphor particles. These impacts cause energy to be given up in the form of light. In the case of zinc sulfide, this light falls in the green portion of the optical spectrum.

The electrical field strength necessary to perform this phenomenon is between 200 and 800 volts dc applied between the two parallel electrodes spaced 1 mil apart. For the panels that are available commercially (such as night lights), the conventional power line peak voltage of about 300 volts is sufficient to cause light emission.

Although the first EL phosphors used the green emission of ZnS:Cu (zinc sulfide with a copper additive), it was soon found that adding other elements created a range of different colors. One other fact turned up: many EL phosphors exhibit an unusual emission property called "frequency color shift." For example, one of the most efficient and easily made phosphors, ZnS:Cu:Cl has a broad green emission band when excited at a frequency of 100 Hz and 100 volts rms per mil. As the frequency is raised, however, the emission band broadens and moves toward the

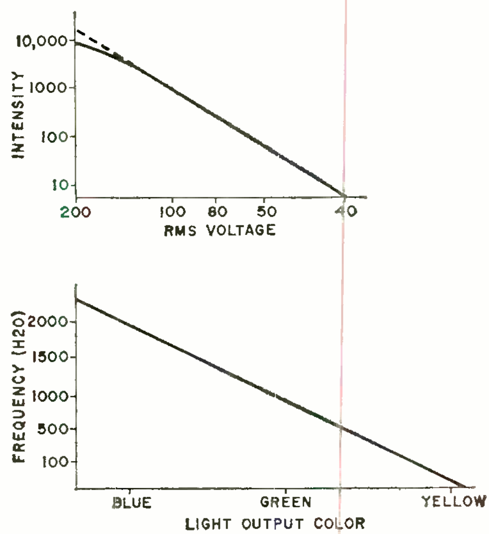
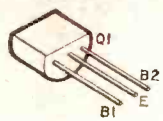
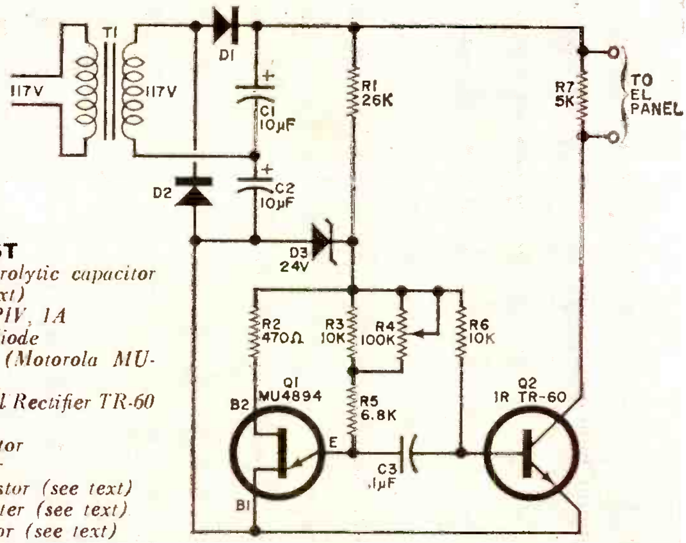


Fig. 2. There is a relationship between intensity and voltage, and between color and frequency as shown here. These curves are illustrative only.





PARTS LIST

C1,C2—10-μF, 150-volt electrolytic capacitor
C3—0.1-μF capacitor (see text)
D1,D2—Rectifier diode, 600PIV, 1A
D3—24-volt, 400-mW zener diode
Q1—Unijunction transistor (Motorola MU-4894 or similar)
Q2—Transistor (International Rectifier TR-60 or similar)
R1—26,000-ohm, 5-watt resistor
R2—470-ohm, ½-watt resistor
R3—10,000-ohm, ½-watt resistor (see text)
R4—100,000-ohm potentiometer (see text)
R5—6800-ohm, ½-watt resistor (see text)
R6—10,000-ohm, ½-watt resistor
R7—5000-ohm, 25-watt resistor
T1—117:117-volt isolation transformer
Misc.—Suitable chassis, EL connector strip, mounting hardware, etc.

Fig. 3. When using this variable-frequency panel driver, remember that about 320 volts ac is present across R7 so take extreme care.

shorter wavelengths, and at 20 kHz, the peak wavelength is in the deep blue region.

This spectrum shift is primarily a frequency characteristic and is essentially independent of the applied electric field. The curves in Fig. 2 show the effects of such changes on an arbitrary panel. Values are illustrative and not absolute.

With an ac supply, the light output from an EL panel occurs in two bursts per cycle—one near each peak of the sine-wave excursion. The quantity of light emitted is a function of the applied frequency and the voltage. For a fixed frequency, increasing the voltage increases the brightness. For a fixed voltage, increasing the frequency increases the light output and, over a small range, changes the color.

Building an EL Power Supply. To see more clearly how electroluminescence works, it is helpful to build a small variable frequency power supply. This can be done in one of two ways. A schematic for the first supply is shown in Fig. 3. In this circuit, *D1, D2, C1,* and *C2* form a voltage doubler having a dc output of about 320 volts. (Ripple is not im-

(This article continues on page 48. On next two pages are some uses for EL panels.)

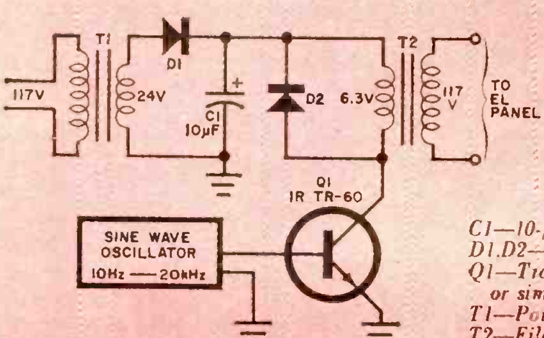
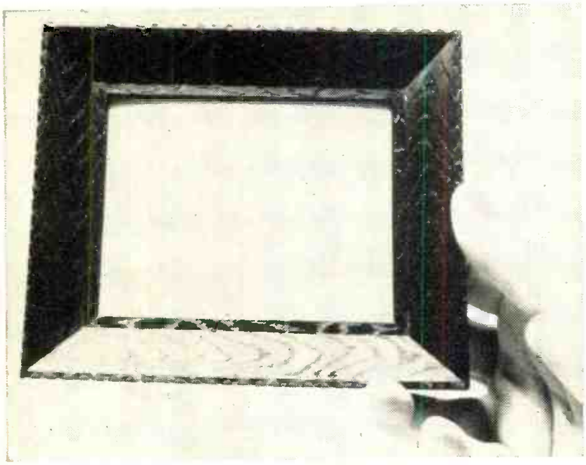


Fig. 4. This panel driver uses an external audio generator to drive the switching transistor. The ac output here is also high, so take care when making panel connections.

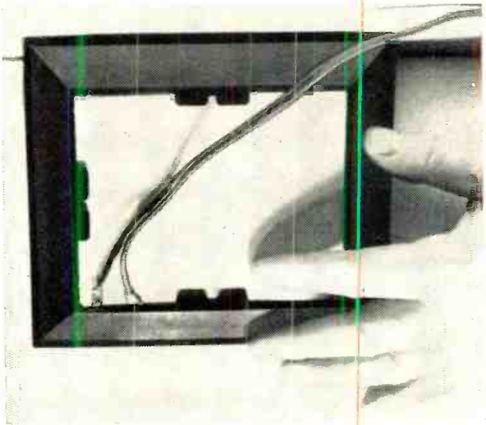
PARTS LIST

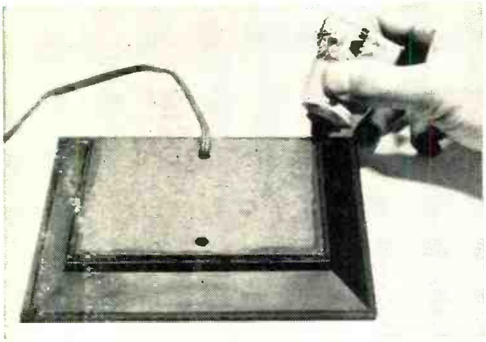
C1—10-μF, 100-volt electrolytic capacitor
D1,D2—silicon rectifier, 600 PIV, 1A
Q1—Transistor (International Rectifier TR-60 or similar)
T1—Power transformer, secondary 24V, 1A
T2—Filament transformer, secondary 6.3V, 600 mA
Misc.—Suitable chassis, EL connector strip, mounting hardware, audio generator.

USES FOR EL PANELS



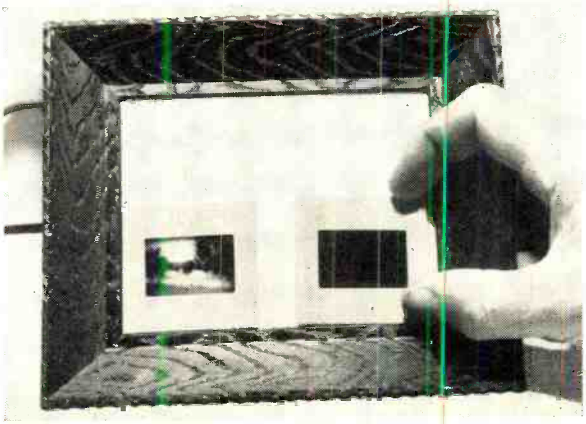
Plastic or wood (not metal) picture frame (above), fitted with electroluminescent panel becomes convenient light-box viewer for slides and photo negatives. Before fitting EL panel into frame (right), solder a-c line cord to metal tabs on the panel.

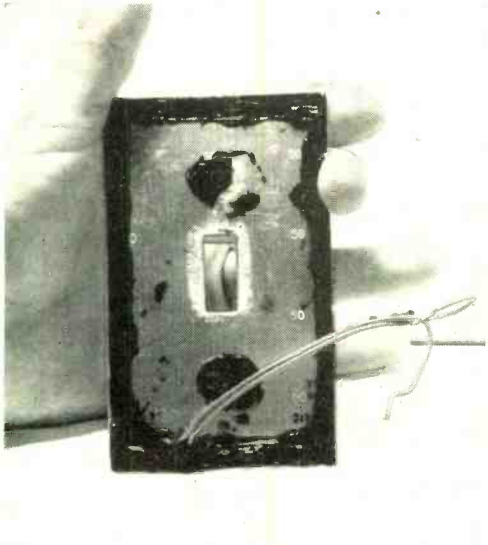


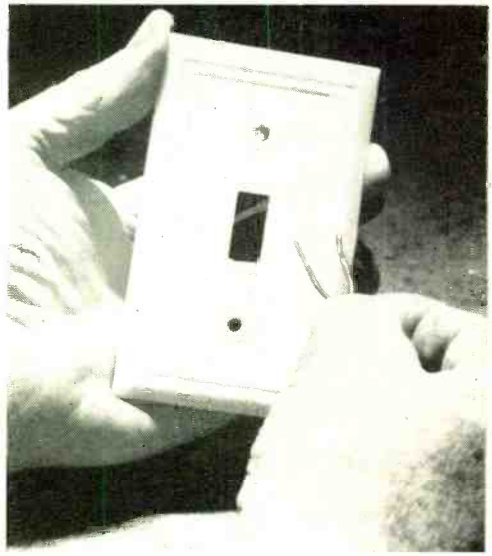


Next, fit piece of Masonite or hardboard over rear of frame, cementing into place with silicone rubber compound (left). Also, fill line cord exit hole with cement to provide strong strain relief.

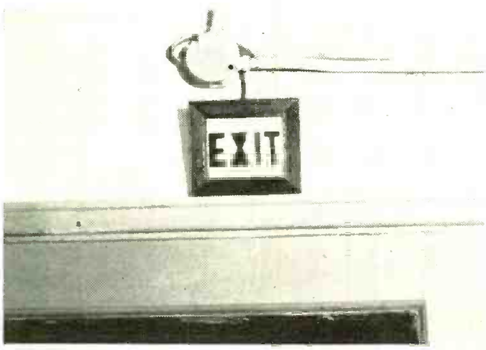
Evenly distributed soft light from EL panel reduces eye strain when viewing slides and negatives as shown at right.





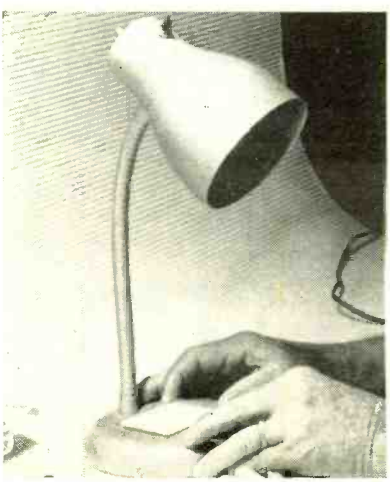


Locate light switches quickly in a darkened room with a back-lighted switch plate. Cement EL panel to the rear of a translucent switch plate (above) and use a sharp knife to make clearance holes through the panel for mounting screws. Make sure that the power to the switch is shut down; then connect the wire leads from the EL panel to the power line terminals on the switch (not the switched) terminals). Properly mounted behind the switch plate, the EL panel is invisible as shown upper right.

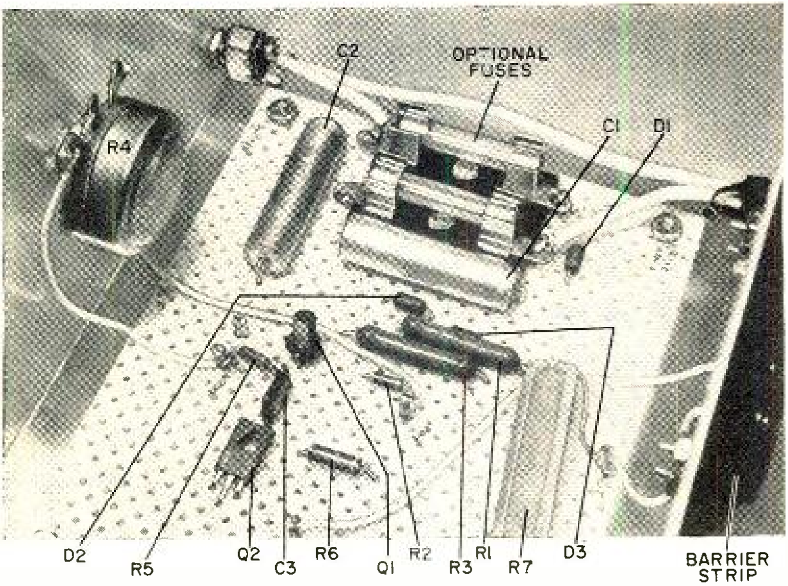


Opaque black or translucent colored tape turns the viewer described on the opposite page into custom-made exit signs. Leads from the sign connect directly to a-c power line for constant-on operation.

Framed EL panel mounted inside hi-fi console provides illumination for you to see what you're doing. For this application, use a white or a yellow electroluminescent panel which has brighter output.



Panel mounted on base of desk lamp at left serves same function as panel mounted behind switch plate. Leads from EL panel pass through holes previously drilled through base and connect to line cord with wire nuts. Cement panel to lamp base after making absolutely certain that the panel and the wires are electrically insulated from the base of the lamp.



The circuit may be built up on perf board as layout is not critical. Connection to the EL panel is through barrier strip on rear of chassis. The line isolation transformer is mounted at one end of the chassis and must be used for safety.

portant in this case.) Resistor *R1* and zener diode *D3* form a 24-volt supply for the oscillator circuit containing unijunction transistor *Q1*. Transistor *Q2* is a driving amplifier. The period of oscillation is a function of the interstage coupling components of the two transistors, with potentiometer *R4* adjusted to vary the frequency. For the values shown, the frequency is adjustable from about 200 to 800 Hz. By operating *Q2* in the switching mode, dissipation and losses are cut to a minimum.

The output pulse across *R7* is a square wave having an amplitude of about 320 volts with a variable duty cycle and repetition rate. If it is desired to modify the frequency, reducing the value of *C3* or the *R3*, *R4*, *R5* network increases the frequency and vice versa. The maximum frequency is reached when *Q2* cannot turn off. Tests on the circuits show that using a value of 10,000 ohms for *R6* and a series combination of a 3900-ohm fixed resistor and a 5-megohm potentiometer for *R3*, *R4*, and *R5*, permits operation from about 20 Hz to nearly 2 kHz.

The UJT used in this circuit may be of almost any type as long as it can take the 24-volt supply. Any npn transistor can be used for the driver as long as it has a collector-emitter breakdown rating over 320 volts.

The circuit of another supply is shown in Fig. 4. Here, an external sine wave generator is used as the driving source, with a voltage step-up produced by filament transformer *T2*. In this, as in the first circuit, remember that a high ac voltage is present on the EL test points so handle them with care. The EL panel output and connectors should be well insulated.

The supply may be constructed in any way desired. Construction of a prototype is shown in the photos.

Some EL panels are fitted with slender electrical connections. Do not bend them back and forth too many times or you will break them off at panel.

Operation. Connect the EL panel to the driver being careful not to cause accidental shorting between the high-voltage leads. With the driver turned on, note that varying the frequency changes the brightness of the panel and, in some cases, the color. —30—

BY DANIEL MEYER

BUILD THE

Five Forty POWER AMPLIFIER

18 WATTS PER CHANNEL USING LATEST INTEGRATED CIRCUIT

ALTHOUGH integrated circuits are used almost universally now in digital circuits, only recently have they begun to make serious inroads in linear circuits—especially in the area of high-performance audio devices. Most IC audio power amplifiers are restricted in power output and performance, thus limiting their use in quality music systems.

It is now possible to build an 18-watt (rms) per channel power amplifier using a new integrated circuit (the 540) coupled to a pair of output transistors. The total harmonic distortion of the amplifier is 0.1% at low levels, 0.6% at 10 watts and slightly over 1% before clipping. With an input impedance of approximately 10,000 ohms and requiring about 400 mV driving power, a pair of these amplifiers can be used in a stereo system to deliver 15 watts per channel, with a power supply of modest size. With a larger supply, up to 20 watts (IHF) is available per channel.

Tests show that the distortion level is consistent from 20 Hz to 20 kHz and actually decreases somewhat at higher frequencies—quite the opposite of conventional power amplifiers. Frequency response is within 1 dB from 5 Hz to 100 kHz. Square-wave tests show no trace of ringing or instability. This is quite good for an amplifier costing $11 per channel—comparing favorably with many units of much higher price.

Theory of Circuit Design. The schematic diagram of the 540 Amplifier is shown in Fig. 1. A block diagram showing principles of operation is shown in Fig. 2. The first stage in the IC is a differential amplifier having its own constant current source. Next is a pair of common-base amplifiers that presents a low

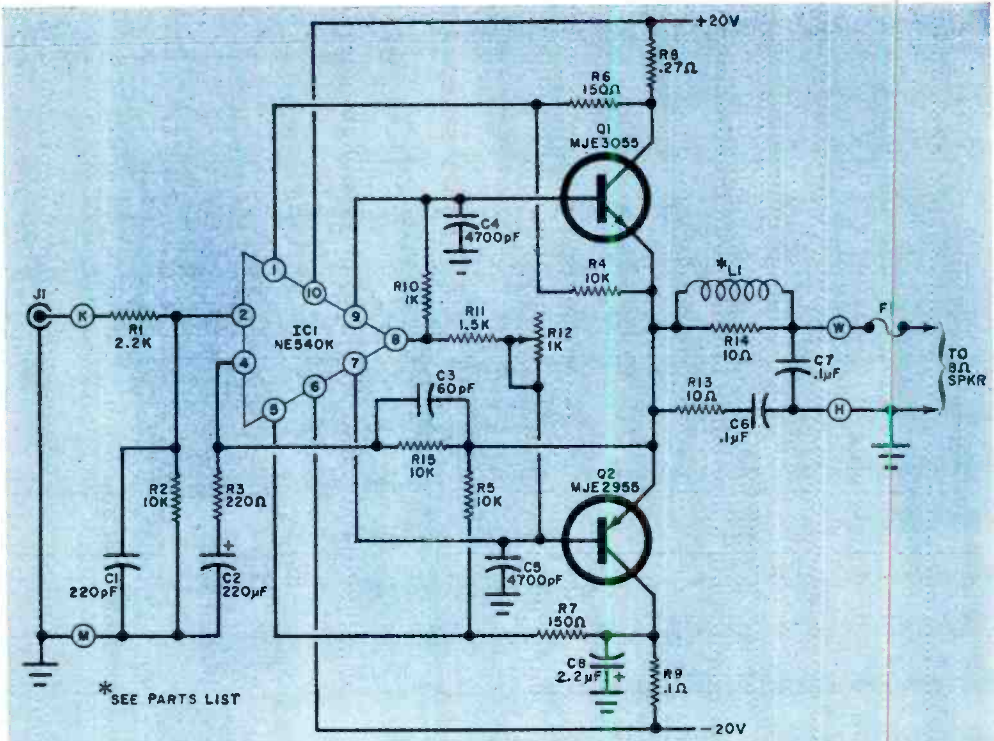


Fig. 1. Having an input impedance of about 10,000 ohms, a single IC is capable of driving two power transistors to full output, requiring about 400 mV input.

PARTS LIST

C1—220-pF, 5% polystyrene capacitor
C2—220-μF, 6-volt electrolytic capacitor
C3—60-pF, 5% polystyrene capacitor
C4,C5—4700-pF, polystyrene capacitor
C6,C7—0.1-μF, Mylar (or other film) capacitor
C8—2.2-μF, 50-volt electrolytic capacitor
F1—1-ampere fuse (optional, see text)
IC1—Integrated circuit (Signetics NE540K)
J1—Phono connector
L1—Single layer #24 or #26 insulated wire wound on R14
Q1—Transistor (Motorola MJE-3055)
Q2—Transistor (Motorola MJE-2955)
R1—2200-ohm, ½-watt, 10% resistor
R2,R4,R5,R15—10,000-ohm, ½-watt, 10% resistor
R3—220-ohm, ½-watt, 10% resistor
R6,R7—150-ohm, ½-watt, 10% resistor
R8—0.27-ohm, 5-watt, 10% resistor
R9—0.1-ohm, 5-watt, 10% resistor
R10—1000-ohm, ½-watt, 10% resistor
R11—1500-ohm, ½-watt, 10% resistor
R12—1000-ohm trimmer potentiometer (IRC X-201 or similar)
R13,R14—10-ohm, 1-watt, 10% resistor
Misc.—Suitable chassis, terminal board for speaker connections, mica washers, silicone grease, heat sink for IC1, etc.
Note—The following are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, TX 78216: etched and drilled PC board #186b at $2.30 postpaid; complete kit of parts for one channel amplifier (including PC board) #186c at $10.50 plus postage and insurance for 6 oz; two amplifier kits and power supply #CA-186 at $37.50 plus postage and insurance for 6 lb.

impedance to reduce any Miller effect that would impair high-frequency response. This stage is supplied with power through a zener diode and current source. In this way, power supply variations do not affect performance of the input stage.

The outputs of the common-base amplifiers drive a double differential amplifier which also has its own constant current source.

The next stage is composed of the actual output drivers of the IC, one operating on the positive half cycle, the other on the negative half. The output circuit has a built-in protection arrangement to limit the current

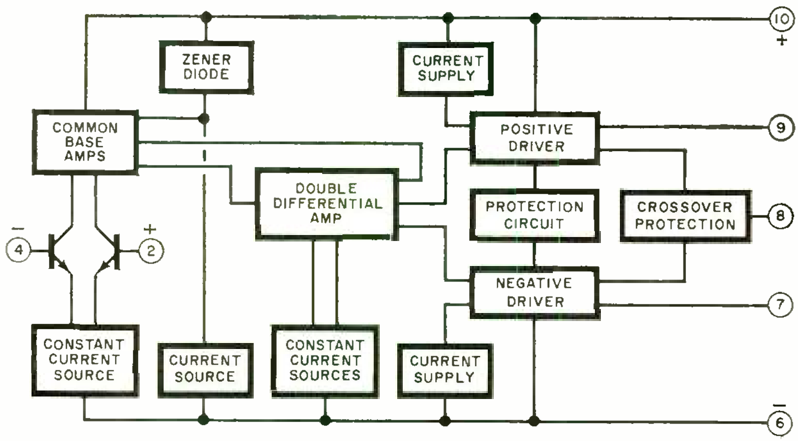


Fig. 2. There are 31 transistors and 26 resistors in 540K IC, making up the circuit shown here. Note how unique protection circuit provides maximum safety.

when the load resistance is too low. A transistor is used to bias the output so that crossover distortion does not occur.

The protection circuit used here keeps the output transistors from being damaged by any type of load. Ordinarily current protection prevents damage if the load is resistive or slightly reactive, but it could not prevent destruction of the output transistors if the amplifier is driven hard with a highly reactive load. If you want to see how this happens (and can spare a pair of output transistors), take any transistor amplifier with ordinary overload protection and drive it to full output with a 100-Hz square wave. Do not use any load resistor on the output terminals. Now begin adding 10-μF capacitors across the load At some point, perhaps with the first capacitor, the output transistors will heat up and probably be destroyed as the silicon chip goes into secondary breakdown. In the 540 amplifier, this cannot happen if the protection resistors are the correct value. Any voltage-current combination that is outside the safe operating area of the transistors clamps the drive current to the output stages.

The amplifier can be destroyed by overloading at frequencies above the audio range (over 30 kHz) for extended periods of time, but this is not a normal operating procedure. If there is any possibility of such an occurance, a filter system should be used in the preamplifier. For good transient response, an audio amplifier should have a bandwidth that goes beyond 100 kHz, but it must not be driven at high levels at these high frequencies

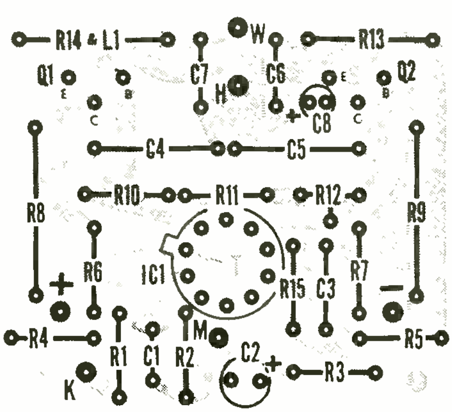


Fig. 3. Actual size foil pattern (right) and component installation (above) for the 540 amplifier.

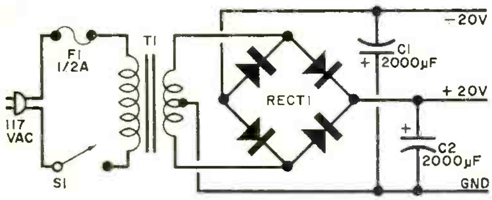


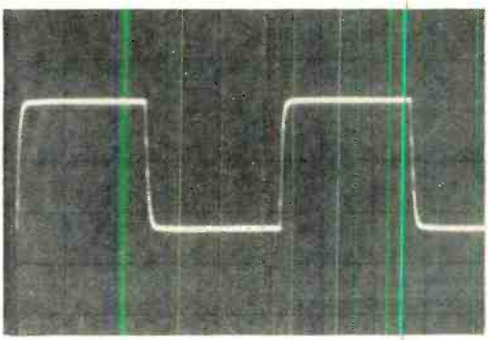
Fig. 4. This simple dual-output power supply is designed to handle a 540 stereo system.

PARTS LIST

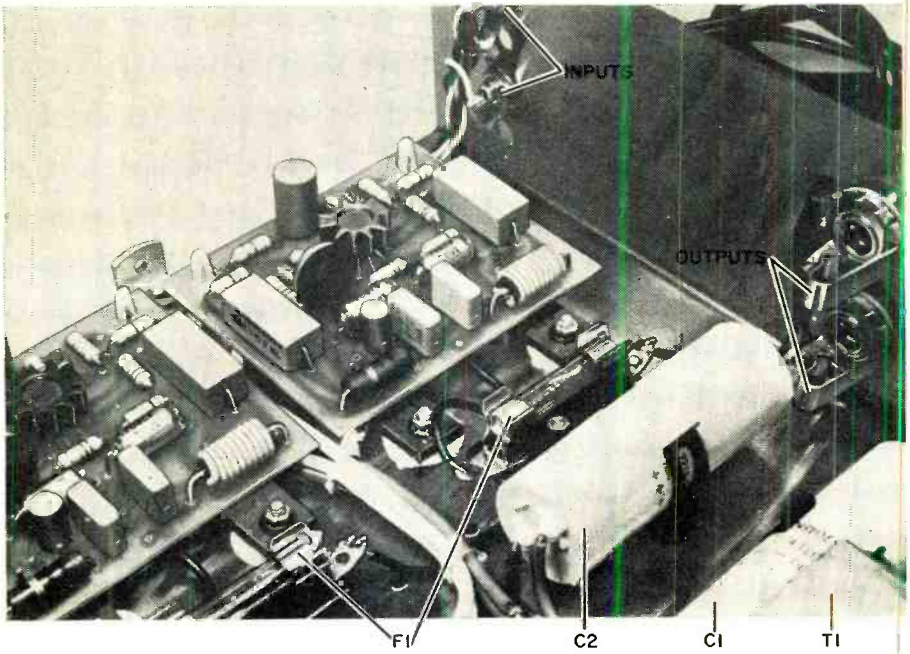
C1,C2—2000-µF, 35-volt electrolytic capacitor
F1—0.5A slow-blow fuse and holder
RECT1—Use four 1A silicon rectifiers
S1—Spst slide or toggle switch
T1—Power transformer: secondary, 32V, 1.5A
Misc.—Mounting hardware, terminal strips, line cord, feedthrough.
Note—See Parts List with Fig. 1 for availability of parts.

or common-mode conduction will quickly overheat and destroy the output transistors.

Construction. A single-channel power amplifier can be built on a printed circuit board as shown in Fig. 3. Note the position of the tab on the integrated circuit and the polarities of the electrolytic capacitors. Use a low-power soldering iron and fine solder to make all connections. The two power transistors (*Q1* and *Q2*) are mounted with their metal sides against the mounting surface. The board can be mounted using nylon clips and screws through the transistors. Use a mica washer covered on both sides with heat sink compound to avoid electrical contact between the transistors and the metal chassis.



The output waveform of a 10-kHz square-wave input shows no sign of ringing or other instabilities.



The two channels are supported on plastic standoffs while the power supply components are mounted on the base of the chassis. A neat cable harness adds to the professional look of this chassis.

HIRSCH-HOUCK LABORATORIES

Project Evaluation

This amplifier is an interesting demonstration of how simple such a device can be with the aid of current integrated circuit technology. It is a rather lowpower unit by current standards, but could hardly be improved upon for its price.

With both channels driven, a realistic full-power rating would be about 10 watts per channel. However, at 10 watts, the distortion curve is quite flat across the entire audio frequency range—just below 1.0%. Similarly flat curves are obtained at reduced power: at half power the distortion is about 0.3% and at 1/10 power, just under 0.1%. All figures apply from 20 Hz to 20 kHz.

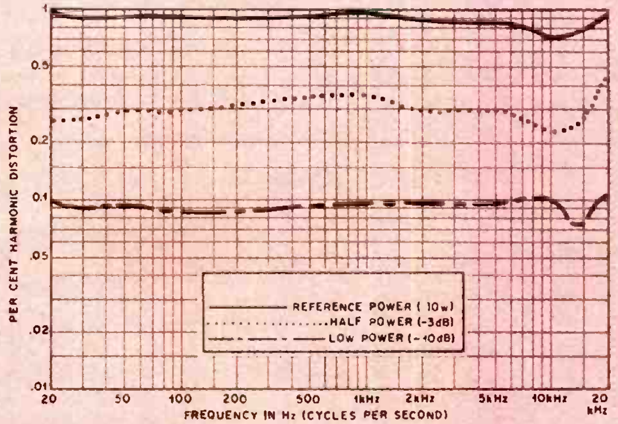
The 1000-Hz harmonic distortion, under 0.1% at low power rises smoothly to 0.15% at 2 watts, and more steeply to 1.75% at 15 watts. At higher powers it increases sharply. The IM curve has a similar shape, from 0.3% at 0.1 watt to 0.85% at 3 watts, and 4.2% at 10 watt.

At the clipping point, the power output was 21.2 watts into 8 ohms and 12.1 watts into 16 ohms. The amplifier is not intended for use with a 4-ohm load.

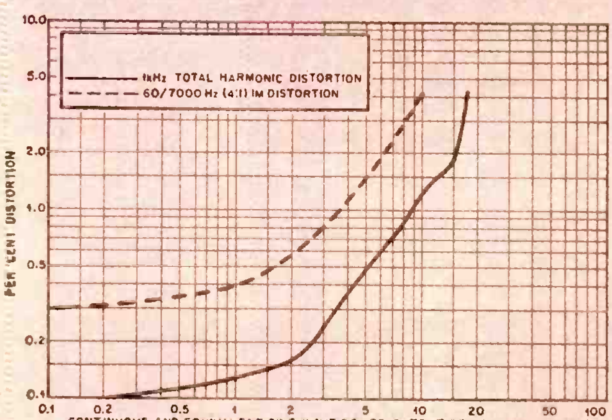
The frequency response was excellent; down 0.2 dB at 10 Hz and 50 kHz, down 0.7 dB at 5 Hz, and down 3 dB at 170 kHz. Square-wave rise time was 2 microseconds. Noise level was a very low –87 dB referred to 10 watts.

The preceding measurements were made with the bias controls set as received. Adjusting them did not produce any significant change in distortion. However, we did not observe the "glitch" in the waveform (referred to in the article) while adjusting the controls.

Subject to the above limitations, the 540 amplifier appears to be a very satisfactory low-power unit with low enough distortion for any installation where an amplifier of this power rating is likely to be used.



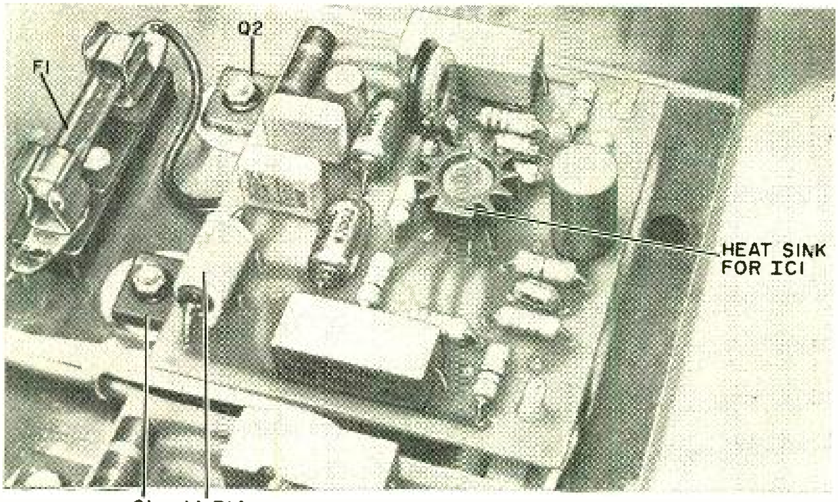
Very low percentages of harmonic distortion are present at all output power levels and across entire frequency range of the amplifier.



Total harmonic distortion and intermodulation distortion increase sharply at higher power outputs. Both channels driven with 8-ohm loads. One channel was measured.

Do you work in electronics? Find out how CREI can give you the specialized technical knowledge you need for better pay, more security.

Mail postpaid card for FREE book and complete information.



Note that Q1 and Q2 (of each channel) have their leads connected to the board, but are thermally (not electrically) affixed to the chassis to provide heat-sinking.

Construction of the prototype of the 540 Amplifier is shown in the photographs. Any type of chassis arrangement can be used. The only control is the on-off switch on the power supply shown in Fig. 4. These components can be mounted on the chassis and suitable terminal strips. Although a dual 20-volt supply is specified for an 18-watt (per channel) output, a lower supply voltage may be used with a corresponding decrease in output power. The amplifier will work, at greatly reduced specifications, with a supply as low as five volts on each side.

Once the components have been assembled, connect a pair of color coded insulated leads to terminals K and M on the board. Twist the wires together and connect them to the appropriate input jacks. Connect terminal K to the "hot" terminal of the jack and M to the ground lug. Connect terminal H of the board to the point on the power supply where the center tap on the secondary of *T1* is connected. Connect terminal W to the speaker output point and terminal H and the ground side of the speaker output to the power supply ground. On a high-gain, wide-bandwidth amplifier of this type, it is very important that these input and output connections be properly made.

The output fuse (*F1* in Fig. 1) is optional since the amplifier has a protection circuit, but it is advisable to protect the speaker in case of a high dc input or in the event an output transistor should fail.

The four power supply rectifier diodes are mounted on a suitable terminal strip on the chassis base.

Testing. To set the bias control, apply a 10-kHz signal to drive the amplifier to an output of 1 watt or less and connect the output to an oscilloscope. With *R12* set for minimum resistance, there will be a small "glitch" or disturbance in the viewed waveform at the zero crossing. Adjust *R12* until the glitch straightens out. Do not advance *R12* beyond this point—to do so may cause excessive idle current in the output transistors. While the scope is connected, raise the sweep speed and check for any signs of high-frequency oscillation which, if present, may be cured by adding low-value capacitors to ground from the suspect points. Also check for heating of the output transistors. —30—

By Roger Melen and Harry Garland

BUILD THE FIL-OSCILLATOR

IT'S A TWOSOME: SHARP AUDIO FILTER & VERSATILE WAVEFORM GENERATOR

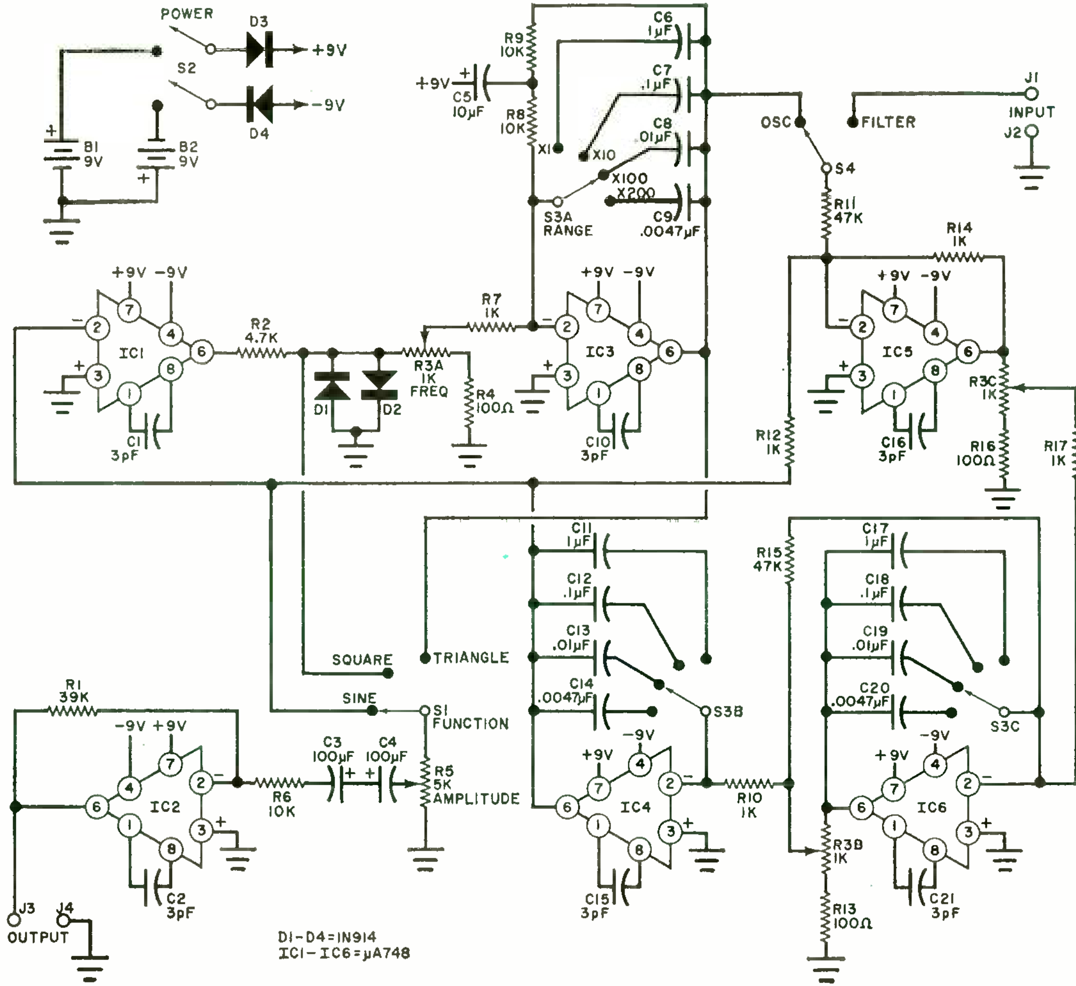
ACTING just as if it were born under the zodiacal sign of Gemini (the twins), the Fil-Oscillator is an unusual laboratory instrument having two distinct personalities: it is both a high-Q audio filter and a low-distortion sine, square or triangle wave generator. (Detailed specifications are given in the Table.)

The heart of the Fil-Oscillator circuit (see schematic) is a sharp active filter (using three op amps) which can be tuned over the audio spectrum. Since all non-sinusoidal waveforms can be broken down into their constituent sine wave elements, it doesn't matter what shape is applied to the input of the filter. A sine wave of the frequency to which the filter is tuned appears at the output. Because of this sharp filtering action, the filter can be used in a wide number of audio frequency applications, including measurement of the overtones (harmonics) of a musical instrument, charting the frequency spectrum of a complex waveform, measurement of the harmonic distortion of an amplifier or speaker system, or boosting the selectivity of a ham or SWL receiver.

As an oscillator, the device serves as a function generator of laboratory quality, developing low-distortion sine, square, or triangle waves which are very useful in various test procedures. The Fil-Oscillator's active filter is used to derive the sine waves producing a purer waveform than is possible in conventional waveshaping circuits.

Six inexpensive IC op amps are used in the Fil-Oscillator, and its total cost is about $35.

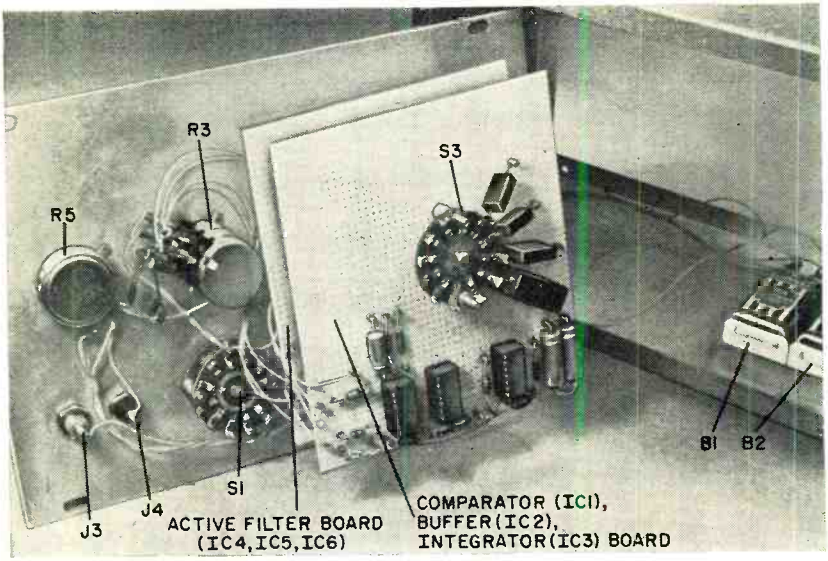
Theory of Circuit Design. The Fil-Oscillator is in four functional sections: an active



PARTS LIST

B1,B2—9-volt battery
C1,C2,C10,C15,C16,C21—3-pF capacitor
C3,C4—100-μF, 6-volt electrolytic capacitor
C5—10-μF, 12-volt electrolytic capacitor
C6,C11,C17—1-μF Mylar capacitor
C7,C12,C18—0.1-μF Mylar capacitor
C8,C13,C19—0.01-μF Mylar capacitor
C9,C14,C20—0.0047-μF Mylar capacitor
D1-D4—1N914 diode
IC1-IC6—Op amp integrated circuit (Fairchild μA748)
J1-J4—Five-way binding post
R1—39,000-ohm, ¼-watt resistor
R2—4700-ohm, ¼-watt resistor
R3—1000-ohm, 3-gang potentiometer
R4,R13,R16—100-ohm, ¼-watt resistor
R5—5000-ohm potentiometer
R6,R8,R9—10,000-ohm, ¼-watt resistor
R7,R10,R12,R14,R17—1000-ohm, ¼-watt resistor
R11,R15—47,000-ohm, ¼-watt resistor
S1—3-position, 1-pole rotary switch
S2—Dpst slide or toggle switch
S3—4-position, 3-pole rotary switch
S4—Spdt slide or toggle switch
Misc.—Suitable chassis (see text), perf board and clips, battery clips and connectors, knobs (4), handle and feet (optional).
Note—The set of six integrated circuits can be obtained from Schweber Electronics, Order Dept., Westbury, NY 11590 for $8.80, including postage and handling. Ask for μA748 dual in-line commercial grade IC's.

Besides serving as a function generator having sine, square, or triangle wave output, the circuit also includes a unique tunable active filter suitable for any type of waveform analysis.

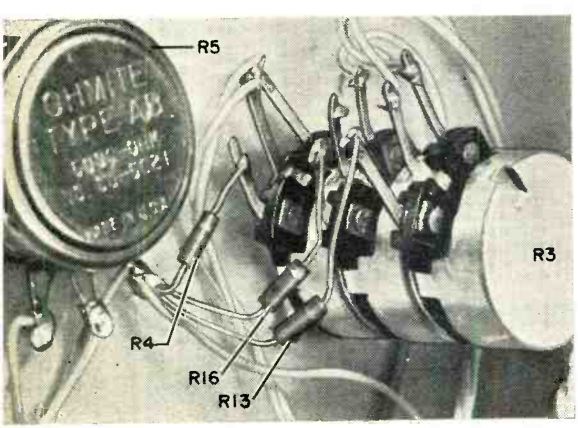


This photo shows how the prototype was constructed but this arrangement is not absolutely necessary. Circuit can be built on a PC or perf board and wired to front panel.

filter consisting of *IC4*, *IC5*, and *IC6*; an integrator (*IC3*) which produces triangle waveforms; a comparator (*IC1*) to generate square waves; and a buffer output amplifier (*IC2*).

The frequency range of the active filter is selected by three-section switch *S3*, while three-section potentiometer *R3* controls the frequency within the selected range. When mode switch *S4* is in the FILTER position, an arbitrary input signal may be applied to the active filter input. When *S4* is in the OSCILLATOR position, the active filter extracts the fundamental sine wave component from the triangle wave output of *IC3*. The sine wave output of the active filter is applied to comparator *IC1*. When the sine wave voltage at the input to the comparator is positive, the comparator output swings negative, and vice versa. The amplitude of the square wave output is limited by diodes *D1* and *D2* before the signal is applied to *IC3*. Since the integral of a square wave is a triangle, the output of *IC3* is triangular.

The input to the buffer amplifier (*IC2*) is selected by *S1*. Potentiometer *R5* serves as the amplitude control. The output of the generator is taken directly from the low-impedance output of *IC2*.



Three-section frequency potentiometer is built up from add-on controls similar to IRC-CTS type 45. The resistors are connected directly as shown.

Construction. The prototype was built in a 9″ × 6″ × 5″ aluminum cabinet, though any type of housing may be used. The components were assembled on two pieces of perf board mounted on switch *S3*. This switch is a conventional 11-position, 5-gang rotary switch which can be disassembled and the second and fourth gangs removed. These two portions of the switch were then replaced by two 4¾″ square pieces of perf board.

The comparator (*IC1*), buffer amplifier (*IC2*), and integrator (*IC3*) and their associated components were mounted on the board that replaced the fourth gang of the switch; the active filter (*IC4*, *IC5*, and *IC6*) and their components were mounted on the board replacing the second gang. Dual in-line sockets were used for each of the IC's with perf

HIRSCH-HOUCK LABORATORIES
Project Evaluation

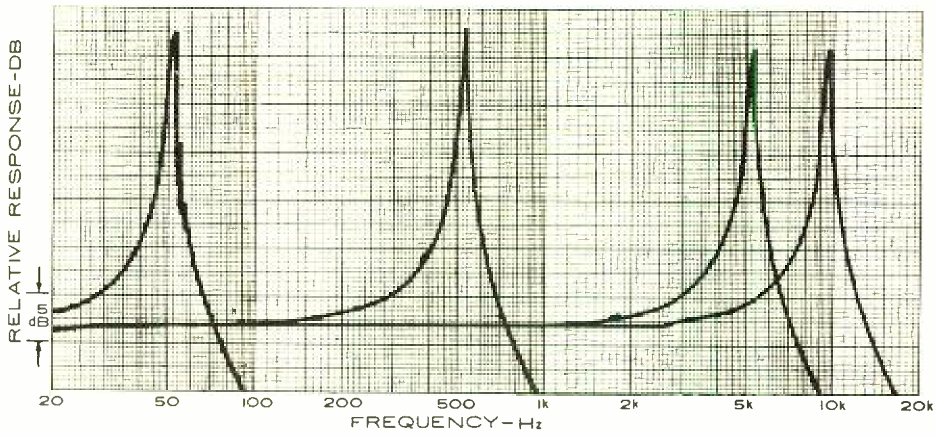
This is a very useful instrument for an audio engineering laboratory and, in a simplified form (with just the filter), it would be a valuable addition to any amateur radio shack.

In the filter mode over the audio range, the pass-band gain of the filter varied less than 2.0 dB. Rejection of frequencies higher than that to which the filter was tuned was a little better than claimed with the third harmonic being attenuated by 49 dB at a fundamental of 1000 Hz. Rejection at lower frequencies was not as good as claimed by the author. At one-third of the filter frequency, the response was down 29.5 dB versus 35.5 dB given by the author. The noise output of the filter was 0.9 mV and appeared to be essentially independent of the level control setting. This would indicate that the noise is being generated after the level control in the output stage. An input of 0.38 volt is required for the filter to deliver 1.0 volt output at 1000 Hz. The maximum output before clipping in IC2 is 4.4 volts rms (high-impedance load).

To check the effectiveness of the filter in reducing distortion from a test oscillator, the output of a Radford low-distortion oscillator was fed through the Fil-Oscillator. At 1000 Hz, the input signal was 0.14% distortion, but after passing through the Fil-Oscillator, the distortion was 0.014%.

In the oscillator mode, the output amplitude varied from 1 to 2 dB over the full range and harmonic content was low at all frequencies—typically slightly under 0.05% up to 1000 Hz and about 0.07% in the 10-kHz to 20-kHz region. Distortion was essentially all third harmonic. The square wave does not have an ideal shape and has a noticeable tilt. The rise time was about 5 microseconds. At audio frequencies, the triangular wave appeared good, but at very high frequencies there was distortion visible.

The filter mode may be used to add audio selectivity to any communications receiver utilizing a narrow bandwidth. It is possible to copy CW signals through considerable QRM and QRN.



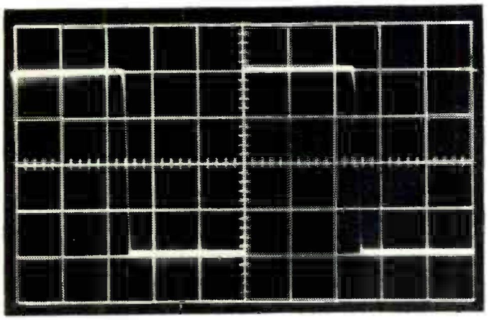
board clips to hold the passive components.

The various controls should be mounted on the front panel and the batteries on the bottom of the chassis.

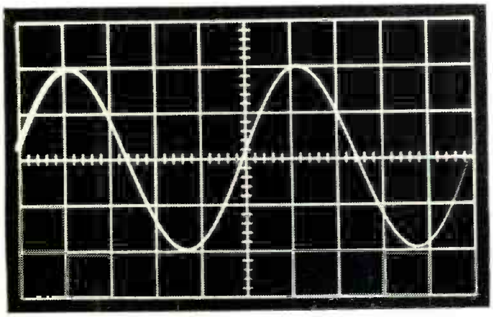
Label the controls on the front panel with transfer type covered with a clear plastic spray. Add a handle and rubber feet to improve the utility and appearance.

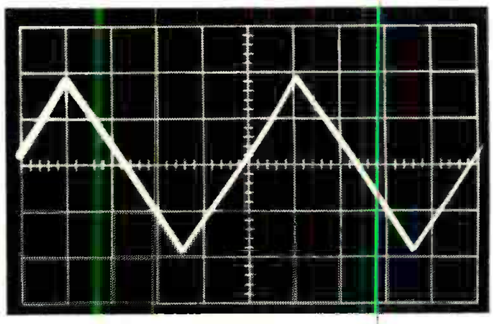
Calibration. Potentiometer *R3* can be calibrated by comparing the output of the Fil-Oscillator with that of a known audio frequency on an oscilloscope. A conventional audio generator and a frequency counter can be used to set the exact horizontal amplifier frequency if you want a more exact calibration. As each frequency is found, mark the position of *R3*. Once one range has been calibrated, and if high-quality Mylar capacitors have been used, the other ranges should fall in step with the markings.

Operation. The frequency range is selected by switch *S3* (RANGE) with the actual



Of the three functions provided by the generator, the square wave (left) and the sine wave (below left) are the most useful in test applications. The triangle wave (below) is a special type of waveform used in vibration studies, servo applications, medical research, etc. Note that the 3 waveforms are clean and show no signs of distortion. The thickening of the trace on the left side is a malfunction of the oscilloscope used.





frequency determined by the setting of *R3*. Switch *S1* is used to select either a sine, square or triangle wave output, while *R5* determines the output amplitude.

When the Fil-Oscillator is set to the same fundamental frequency as that contained in the input and with *S4* on FILTER, the output displayed on an oscilloscope indicates the level of the fundamental waveform. For example, assume you want to measure the second harmonic distortion of an audio amplifier. Apply a sine wave of known frequency to the input of the amplifier and connect the output to the Fil-Oscillator. Set the Fil-Oscillator to the second harmonic of the applied frequency and the output displayed on a scope will indicate the magnitude of the second harmonic in the amplifier output. This same procedure can be applied to higher harmonics or to a speaker system or musical instrument if a good microphone and preamplifier (if needed) are used to drive the Fil-Oscillator.

Anyone who has listened to the CW ham bands appreciates the importance of having a highly selective receiver. One disadvantage of using Q multipliers and similar circuits is that the selectivity control is very "touchy." Since the Fil-Oscillator has a constant, rather than a variable, Q, it is much easier to use. Simply connect the audio output of the receiver to the Fil-Oscillator input and set the filter frequency to obtain some pleasing tone. Only CW signals of that frequency (using the receiver BFO, of course), will pass through the filter—the others being rejected. This may show up drift in the receiver as well as the BFO. The output of the Fil-Oscillator can be connected to any external audio amplifier or to a headset. —30—

FIL-OSCILLATOR SPECIFICATIONS

Filter	
Q	45 (nominal)
Frequency range	15 Hz to 32 kHz
Rejection at 3X resonant frequency (1-volt rms input)	200:1
Rejection at ⅓X resonant frequency (1-volt rms input)	60:1
Noise output	less than 0.5 mV rms
Oscillator	
Output waveforms	sine, square, triangle
Frequency range	15 Hz to 32 kHz
Output amplitude	0 to 4 volts peak-to-peak
Output impedance	100 ohms
Output protection	short-circuit proof

Getting to know coolers, lubricants and special agents

Chemicals for Electronics

LAST MONTH on these pages we expressed some surprise that so few electronics experimenters make use of the many chemical aids available to them from jobbers and distributors. This is particularly true if the experimenter has encountered the so-called "tough dog." Technically, the TD is an intermittent—a circuit defect that can drive hobbyists wild with frustration.

Intermittents pop up when your equipment works well for 10 or 15 minutes, then loses power, generates distortion, becomes erratic, or quits altogether. The problem is that as you try to track down the trouble, it moves off in another direction. Fortunately, most TD's are related to heat and can be tamed by using a simple chemical tool—an aerosol can of component cooler.

PART 2 OF A 2-PART STORY BY LON CANTOR

SPECIAL CHEMICALS

HEAT ELIMINATING GEL

One of the "strangest" chemicals that the hobbyist/experimenter may want to try is Cool-It-Gel sold by Dynatek Industries, Box 24268, Cleveland, OH 44124. This jelly-like substance is a pale blue viscous mix that is brushed, dipped or fashioned like putty to make a heat sink! If, for example, some of the Cool-It-Gel is "puttied" around transistor leads ready for soldering, the Gel will protect the transistor by dissipating the heat. The Gel itself gradually disappears and will not run, drip, prove to be toxic, create fumes, etc. The manufacturer recommends Cool-It-Gel for electricians and welders working in tight quarters or with delicate components. A trial pint is $2.95, postpaid.

Thermal Intermittents. There are two basic types of thermal intermittents: (1) components that work properly only when they are hot, and (2) components that work properly only when they are cool. Some resistors, for example, start off in fine shape when they are cool, but rapidly change in value when heated up. If you check circuit voltages when the equipment is hot, you may obtain all sorts of "wrong" voltage readings. When the equipment is turned off and the resistors are checked with an ohmmeter, all the readings are good—since in most instances the resistor has cooled down enough to look normal.

In some instances, solid-state devices will have internal metallic contacts that tend to open when the ambient temperature rises. On the other hand, some components have hairline cracks or contacts that do just the opposite: open up when the component is cool. The latter sort of intermittent (enclosing the crack or contact after the equipment has been turned on) is probably one of the most frustrating problems.

No matter what the cause of the failure, all thermal intermittents can be tracked down with a good freezing spray. However, beforehand, take the following steps:

A. Based on the symptoms and your understanding of how the equipment works, use flow logic to isolate the trouble to one or two stages.

B. If the equipment is vacuum-tube operated, replace all the tubes in the suspected stages. Don't test the tubes because intermittents are seldom detectable on a tube tester.

C. Apply power to the equipment and heat it up as rapidly as possible. Some technicians cover equipment with a cardboard box to speed heating in the absence of ventilation. Let the equipment operate until the trouble either appears or disappears and at this point you have a chance of proceeding with your troubleshooting.

Use a chilling spray with an extension tube to spray each resistor, capacitor, and semiconductor *individually*. Keep the spray away from vacuum tubes—a cold spray can easily crack the glass envelope. When you note a dramatic difference in circuit performance, you'll know you have spotted the culprit. Spraying the faulty component with the cooler should turn the trouble on or off like flipping a switch. Replace the faulty component and "cook" the equipment for at least an hour. Respray the new component to make sure that you have really located the trouble.

Other Component Cooler Uses. Aside from locating thermal intermittents, component coolers are excellent for finding hairline cracks on printed circuit boards. Cracks are a real nuisance, since you can't see them with the naked eye unless you know precisely where to look. A good component cooler will help you spot the trouble fast. Simply spray the cooler (without the extension tube) over the suspected circuit board. The areas covered by printed conductors will frost up, turning white. The areas without the etched conductors won't change color. Any crack in a conductor will look like a thin, dark line and should stand out prominently.

Aerosol freezing sprays make an excellent soldering aid. They can be used to protect delicate components such as transistors, diodes, and integrated circuits which might be damaged by the heat of soldering. Spray the component, chilling it thoroughly and you won't have to worry about using a heat sink. Many experimenters also use component coolers to prevent cold soldered joints. Once the solder is flowing freely and the connection has been made, they give the new joint a quick blast of the chilling cooler. This blast quickly absorbs the heat from the solder and eliminates the possibility that something might move before the solder has set. Also, the cooler washes away excess rosin and residue, leaving a clean, bright, soldered joint. Certainly this method is far preferable to the practice in many laboratories of cooling the solder joint with a little spit at the end of your finger.

A freezing spray can also be used to rescue a power transformer. Experimenters sometimes fire up circuits only to see the power transformer start to smoke. When this happens, pull the plug fast and reach for your aerosol cooler. If you chill the transformer fast enough, you will keep the wax, varnish and shellac from running and causing internal shorts in the transformer windings.

Choosing a Component Cooler. With all the component coolers on the market, how do you choose the right one? The best coolers are made with blends of Freon. As mentioned in the first part of the story, Freon is Dupont's trademark for trichlorotrifluoroethane. This product is used both as an aerosol propellant and as a cleaning agent. Special blends of Freon are excellent as coolers working on much the same principle as a refrigerator—a liquid changed to a gas absorbing a tremendous amount of heat. A good component cooler can drop the temperature of a small component to minus 50 degrees Fahrenheit in a matter of seconds.

Some manufacturers of component coolers for the sake of economy will add vinyl chloride to their product. Vinyl chloride is cheaper, but does not cool as well as Freon and, what's worse, tends to run (cooling unwanted components). It also has the undesirable

SPECIAL CHEMICALS

QUICK BONDING LIQUID

Zipbond Contact Cement distributed by Tescom Corp., Instrument Division, 2633 S.E. 4th St., Minneapolis, MN 55414 is one of the most unusual chemicals available to the advanced hobbyist and experimenter. It may be used to bond a wide range of materials — metals, plastics, glass, rubber and hard woods. There is no mixing or heat treating—simply apply a drop of liquid for each square inch of surface to be bonded. Apply light pressure for about a minute and a bond of very high shear strength is made. Zipbond is expensive ($15.95/oz), requires careful use, and should be refrigerated when being stored.

after-effect of leaving a residue. You can usually detect the presence of vinyl chloride in a circuit cooler with your nose—it smells sharply of chlorine.

Oddly enough, packaging makes a difference in component coolers. Freon products are packed under high pressure and must be in a seamless can. Aerosol cans with seams simply can't hold this amount of pressure and for safety, the law requires the use of seamless cans for all high pressure applications. Coolers packed in seamed cans or using vinyl chloride do cost less, but in most cases, this is considered to be a false economy. For one thing, inadequate cooling can cause you to skip right over a defective component and the better products can chill more components per ounce of cooling fluid.

Lubricants. The experimenter with a home workshop has an incredible variety of lubricants available to him from electronics parts distributors and hardware stores. The most common lubricants are of the type known as all-purpose, penetrating and lubricating oils. Made from petroleum bases, these lubricants are excellent for freeing rusted parts, as well as reducing friction in motor bearings, couplings, etc. Most of these lubricants tend to retard rust and many are available not only in drop cans, but as aerosols.

Some of the more unusual lubricants that should be investigated by the experimenter include white grease, dry graphite and silicones. White grease is excellent for small motors, gears and bearings and is available in small squeeze tubes. Graphite has been used in a powder form for locks and is now available in aerosol cans. Silicone lubricants are very slippery, wear well, and usually seal out moisture. These lubricants are also available in aerosol cans and function very well over a wide range of operating temperatures.

A Teflon dry lubricant is now available in an aerosol can and is used where very high operating temperatures are encountered. Cryogenically processed Teflon is also used, although it is not commonly available to most experimenters.

Insulating and Protective Coatings. No electronics experimental laboratory workbench is complete without a bottle of brush-on insulating coating (or varnish) and an aerosol can of acrylic protective spray.

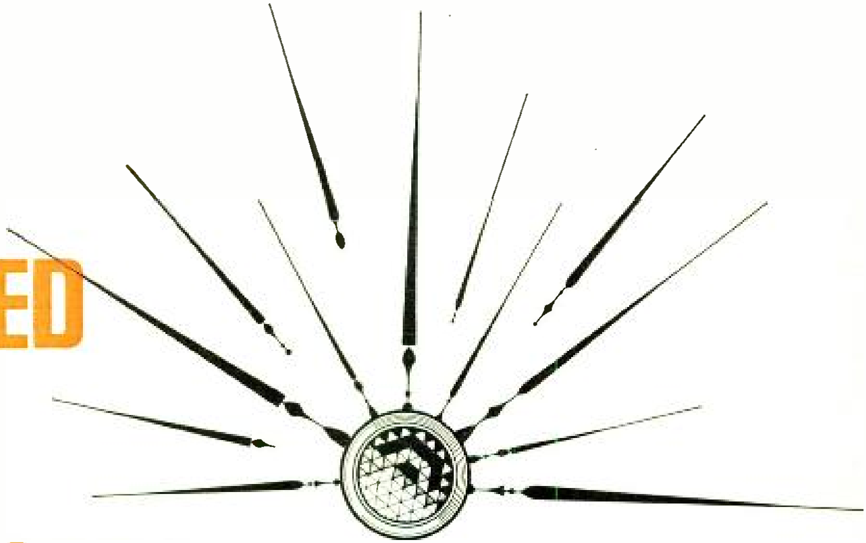
Brush-on insulating coatings are particularly useful around high-voltage circuits where they can be used to stop arcing and corona. These coatings can also be used for "potting" components, holding high voltage leads in place, insulating PC boards, and making temporary repairs to exposed wiring.

Acrylic insulating and protective sprays may also be used to coat low voltage exposed wiring, waterproof spark plug cabling in ignition systems, inhibit rust and corrosion on exposed surfaces, act as a protective coating for outdoor antennas (especially in areas where there is salt spray or industrial smog), and/or retard fungus and mildew. Although most of the crystal-clear acrylic sprays are available in aerosol cans, you can also buy a viscous acrylic liquid in a bottle and apply it with a brush. In many instances, the latter method is to be preferred—especially when working in tight corners. —30—

Loss of gain and erratic operation resulted from manufacturing defect in by-pass capacitor. Tipoff was gradual loss of signal after receiver had been in operation for an hour. Cooling down suspect components with freezing spray quickly pin-pointed defective capacitor.

BY RONALD L. IVES

RUGGED AUTO EMERGENCY FLASHER



NEITHER RAIN, NOR DUST, NOR BUMPS WILL STAY ITS ACTION

ALTERNATELY flashing blue lights used on emergency vehicles (and increasingly on campers, trailers, etc.) are either mechanically or electronically driven and they operate fine as long as the going is smooth and they are not subjected to extremes of temperature and humidity. But the vehicles that use such lights are just those that are required to travel occasionally where adverse environmental conditions are encountered.

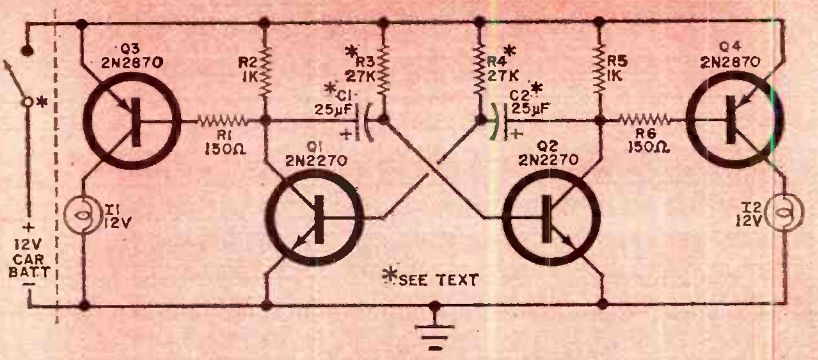
Little can be done to improve the reliability of mechanical flashers due to their sensitivity to vibration but electronic units can be made to be quite dependable. This is achieved through good circuit design, careful selection of components, and rigorous assembly techniques.

The improved electronic flasher whose circuit is shown overleaf was designed to eliminate thermal problems—primarily by separating the timing function (*Q1* and *Q2* multivibrator circuit) from the lamp switching function (*Q3* and *Q4*).

Silicon transistors are used for *Q1* and *Q2* in the symmetrical multivibrator circuit. Transistors *Q3* and *Q4*, the lamp drivers, are germanium power types, biased well into cutoff to prevent continuous conduction at high temperatures. Further protection against thermal damage is obtained by mounting *Q3* and *Q4* on the project case and using small slip-on heat radiators on *Q1* and *Q2*.

No "revolutionary new" design principles are employed in the improved flasher. Simple reliability and ruggedness under difficult conditions were the only really important requirements looked for in the design stages. Fortunately, it was found that the simple no-nonsense multivibrator/power switching system more than adequately filled the bill if certain common-sense assembly techniques were applied.

When selecting components for the improved auto flasher, get the best. For example, use only metal-cased transistors for *Q1*-*Q4*. Substituting plastic-encapsulated "equivalent" transistors will likely cause erratic operation under changing humidity environments. Also, use silicone paste when mounting *Q3* and *Q4* to the project case and when slipping onto *Q1* and *Q2* Thermalloy No. 2330C-5 heat radiators.



Transistors Q1 and Q2 in multivibrator circuit are silicon types, while Q3 and Q4 lamp drivers are germanium power types. The flash rate of the system is determined by the RC time constants of the R3/C1 and R4/C2 combinations

PARTS LIST

C1,C2—25-μF, 25-volt electrolytic capacitor (Sprague Atom Type TVA 1205—see text)
I1,I2—12-volt lamp (see text)
Q1,Q2—2N2270 silicon transistor
Q3,Q4—2N2870 germanium power transistor
R1,R6—150-ohm, 1-watt resistor
R2,R5—1000-ohm, 2-watt resistor
R3,R4—27,000-ohm, 1-watt resistor (see text)
Misc.—7" x 5" x 3" aluminum utility box; epoxy-glass circuit board with push-in solder terminals; 4-lug barrier block Cinch-Jones No. 4-142-Y); Teflon tubing; heat radiators for Q1 and Q2 (Thermalloy No. 2230C-5); mica insulators for Q3 and Q4; machine hardware with stainless steel lockwashers; flat black paint; potting compound (optional—see text); hookup wire; spacers; brass strip; solder; etc.

The flash rate of the system is determined by the time constant of the *C1/R3* and *C2/R4* combinations. The flash rate is determined by the formula: $F = 1/(1.4RC)$, where R is *R3* or *R4* and C is *C1* or *C2*; R is in megohms, C is in microfarads, and F is in hertz. For the values given, the flash rate will be about once every second. Slower and faster flash rates can be obtained by increasing or decreasing the values of *R3* and *R4*, or by decreasing or increasing the values of *C1* and *C2*. The flash rate, however, should not exceed five times/second. Remember, if you change either R or C in one side of the circuit, the same change must also be made in the other side to obtain symmetry.

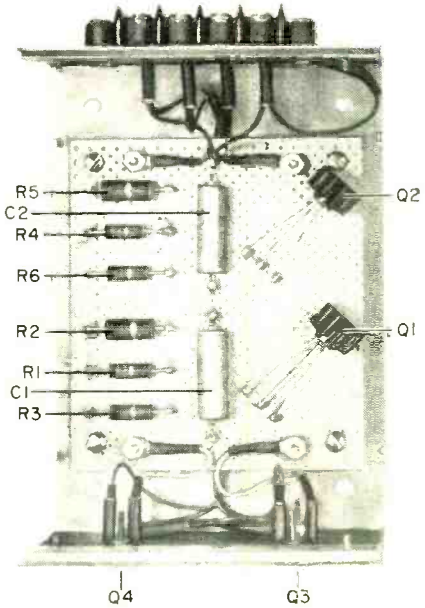
The capacitors used in the prototype for *C1* and *C2* are Sprague Atom Type TVA 1205. These capacitors demonstrate somewhat more resistance to temperature extremes than the manufacturer guarantees. Their effective temperature range is from about −50° F to about 200° F. Low temperatures do not harm the capacitors; when the capacitors warm up again, they operate within specifications. However, temperatures exceeding 200° F will usually cause these capacitors to exhibit permanent high leakage, requiring their immediate replacement.

Another item you should take care in selecting is the circuit board. Phenolic boards just do not stand up to vibration stresses and environmental conditions as well as do epoxy-glass boards. The epoxy-glass board you select should be of the heavy-duty variety with solder connectors to match.

Now, you can begin assembling the flasher system. Use an aluminum case to house the components after painting all outer surfaces of the case a flat black to improve heat radiation. Mount *Q3* and *Q4* to one wall of the case with mica insulators and appropriate hardware. The best lockwashers to use here and wherever mounting is to take place are stainless steel. They bite better, assuring a more vibration-resistant anchor.

On the opposite end of the case, mount the barrier block. Make the clearance holes for the solder terminals to the barrier block a bit oversize to permit plastic sleeving to be slipped over the lugs after hookup wires are soldered to the lugs.

Referring to diagram above, wire components on the circuit board, making all interconnections with hookup wire from the bottom side of the board. To insure good vibration resistance, pinch shut the push-in terminals after the component leads are inserted and



Use perforated G-10 epoxy-glass board and heavy-duty push-in connectors to assure rugged assembly. Heat radiators on Q1 and Q2 bolt down to board.

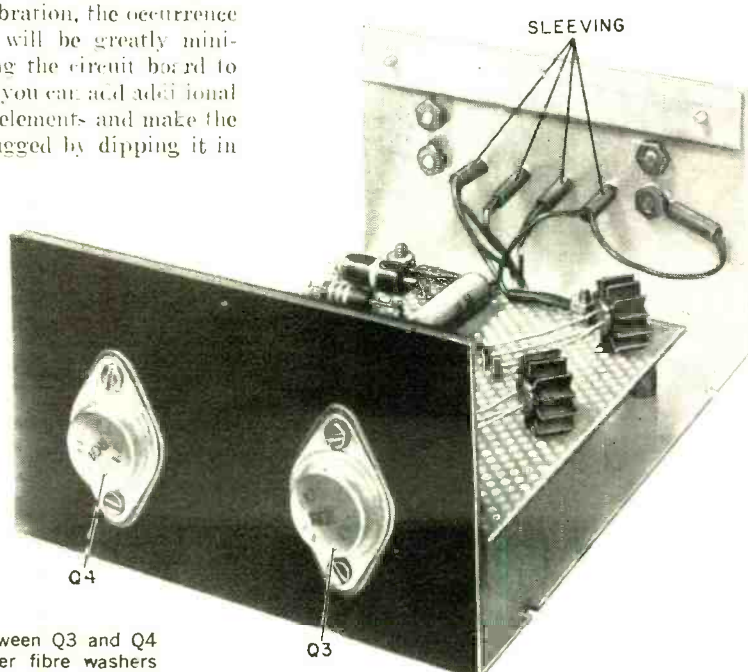
before soldering. Likewise, firmly wrap around the terminals all wire leads on the underside of the board before soldering. With these steps taken, even if the solder eventually crystallizes under vibration, the occurrence of connection failure will be greatly minimized. Before mounting the circuit board to the floor of the chassis, you can add additional protection against the elements and make the assembly even more rugged by dipping it in or coating it with a semi-solid plastic or silicone-rubber compound to seal it. However, if you take this step, make certain that the compound used does not require heat curing and is an electrical insulator.

Once the circuit board is mounted in place, connect and solder the wires coming from it to the appropriate points on the terminal block and switching transistors.

The aluminum case is not designed to withstand heavy vibration. To overcome this deficiency, it is a good idea to back up the upper lip of the chassis channel with strips of hard brass or bronze bar stock that has been drilled and tapped to accept the cover screws. Two lengths of 5/8″ × 3/32″ stock will do nicely. An alternative approach would be to fasten the case together with pop rivets at 2″ intervals and place electrician's *rubber* tape between the metal surfaces to be joined to provide an almost air-, water-, and dust-tight assembly.

The lights to be operated by the improved auto flasher are standard blue truck clearance lights (DoRay No. 1130) designed to use GE No. 67 IJ lamps which draw about 0.6 ampere at 12 volts. If you wish, you can substitute GE No. 1156 lamps which are about three times as bright and draw about 1.7 amperes. Even brighter lamps can be used—

(*Continued on page* 98)



To provide insulation between Q3 and Q4 and chassis, use shoulder fibre washers or transistor sockets and mica insulators.

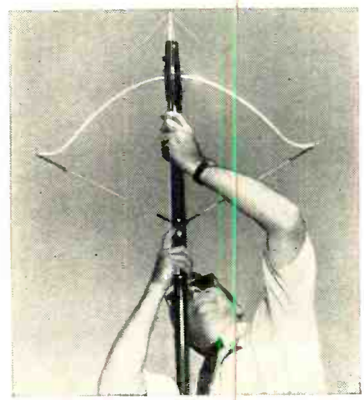
COMMUNICATIONS

AERONAUTICAL RADIO

New SSB Regulations—Don't be surprised if all commercial in-route airline traffic goes single sideband (SSB) sooner than expected. In early February the FCC removed its restrictions on the use of single sideband by aircraft radio stations operating below 30 MHz. Aeronautical radio is one of the last holdouts in the use of straight double-sideband AM radio transmissions for voice communications on shortwave frequencies. Plans for use of SSB call for a switchover in the mid-1970's, but the outlook now is for SSB with suppressed carrier to go into use almost immediately.

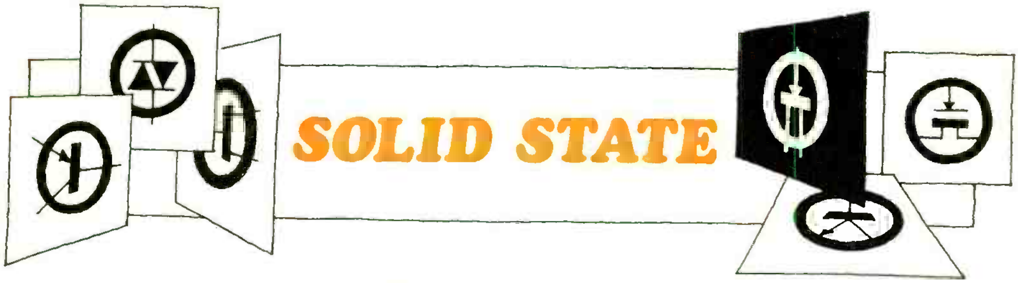
MILITARY ELECTRONICS

I Shot an Arrow in the Air—*In Scottsdale, Arizona, Motorola's Government Electronics Division has designed a new radar target scoring system in which a medieval crossbow plays an important part. The engineers at Motorola wanted firsthand, accurate information on radar performance similar to that used to detect mortar barrages. A special arrow fired by the crossbow acts as a decoy giving a strong radar return so that the flight trajectory can be pinpointed and the path compared with the radar return and predicted backward to the firing point.*



CITIZENS RADIO (CB)

EIA Files for Class E Service—After one false start, the prestigious Electronic Industries Association (Citizens Radio Section) has petitioned the Federal Communications Commission (RM-1747) for an amendment to the Part 95 and Part 15 Rules. These Rules pertain to the allocation and assignment of frequencies for Class D Citizens Radio Service. In substance, the EIA proposes a new Class E Citizens Radio Service utilizing narrow band FM voice with 25-kHz spacing on 80 channels between 220.0 MHz and 222.0 MHz. This would be in the band currently allocated to the Amateur Radio Service. The EIA petition proposes a power output of 25 watts and possible antenna heights up to 60 feet. In addition, the EIA petition recommends the assignment of certain channels for specific CB uses including: mobile to same licensee, emergency, travel assistance, mobile to different licensees, business communications only, marine communications only, manufacturing plant communications only, local traffic control, etc. The EIA petition now joins a somewhat similar petition filed in late 1970 allocating another section of the 220-225 MHz ham band for use by CB'ers.



SOLID STATE

One Hundred Eightieth in a Monthly Series by Lou Garner

FIRST ANNOUNCED in June of 1948 by representatives of the Bell Telephone Laboratories, the invention of the transistor opened a whole new era in the field of electronics. Over the intervening years, scientists and engineers have combined their increasing theoretical knowledge of semiconductor behavior with an expanding base of accumulated practical experience to refine and improve manufacturing techniques, developing new types of devices and a variety of specialized designs to fit virtually every circuit design requirement.

The original unit's descendants, then, have evolved gradually, generation by generation, from a barely understood, costly, noisy, and sometimes undependable, difficult-to-use component into a dazzling array of inexpensive and reliable devices capable of handling signal frequencies into the gigahertz range at power levels from micro- to kilowatts. Offshoots from the main family tree, in turn, have developed impressive families of their own—switching devices such as SCR's and Triacs, signal processing diodes, light emitters and sensors, and, of course, multiple device integrated circuits.

But not all branches of the transistor family tree have been successful. A number of generic devices, promising at the time, have withered and, except for a few old timers, are all but forgotten. We wonder, for example, how many of our readers have ever heard of such devices as the *analog* transistor, the *spacistor*, the high-gain *composite* transistor, the *transtrictor*, or the *double-based diode*.

Although it was the founder of the modern solid-state family, the first *point-contact* transistor itself had a relatively brief life span. It never achieved high production levels, nor was it ever used in mass-produced consumer products, for it was supplanted within a few short years by the less expensive, more reliable and quieter junction transistor—a type that has had a long and successful history since its introduction in 1951 and, even today, is still available from many sources.

Hand assembled in a small brass tube, the original point-contact transistor, illustrated in Fig. 1, consisted of a minute block of n-type germanium upon which rested two closely adjacent fine wire "cat's whisker" contacts. One of the contact electrodes was arbitrarily dubbed the *emitter*, for it was used to "emit" or eject current carriers into the semiconductor cube; the other the *collector*, for it served to receive or "collect" the current carriers; while the small block of germanium itself was naturally called the *base*. The original electrode identification has been preserved to the present day, even though the base has long since ceased to be a solid cube of germanium.

A special type of point-contact transistor, the *coaxial* transistor was produced in limited quantities for experimental high-frequency applications. It consisted of a small disk of semiconductor material secured in a tubular cartridge, with the pointed wires serving as its emitter and collector electrodes mounted coaxially to the cartridge's body and arranged to make pressure contacts on opposite sides of the disk. In addition to the good high-frequency characteristics of conventional point-contact transistors, the device offered a moderate degree of shielding between its input and output terminals, when used in the grounded-base configuration.

Developed in an effort to combine the superior high-frequency performance of point-

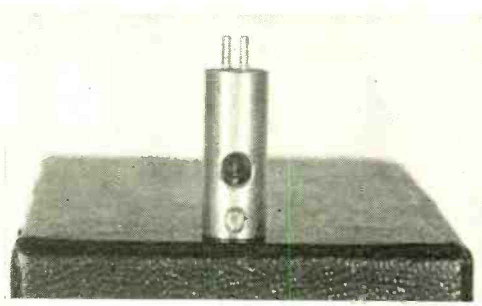


Fig. 1. Original point-contact transistor was assembled in a brass tube and consisted of two fine-wire "cat's whiskers" and tiny cube of germanium.

How to become a "Non-Degree Engineer"

In today's electronics boom the demand for men with technical education is far greater than the supply of graduate engineers. Thousands of real engineering jobs are being filled by men without engineering degrees—provided they are thoroughly trained in basic electronic theory and modern application. The pay is good, the future is bright . . . and the training can now be acquired at home—on your own time.

THE ELECTRONICS BOOM has created a new breed of professional man—the non-degree engineer. Depending on the branch of electronics he's in, he may "ride herd" over a flock of computers, run a powerful TV transmitter, supervise a service or maintenance department, or work side by side with distinguished scientists on a new discovery.

But you do need to know more than soldering connections, testing circuits and replacing components. You need to really know the fundamentals of electronics.

How can you pick up this necessary knowledge? Many of today's non-degree engineers learned their electronics at home. In fact, some authorities feel that a home study course is the *best* way. *Popular Electronics* said:

"By its very nature, home study develops your ability to analyze and extract information as well as to strengthen your sense of responsibility and initiative."

Cleveland Method Makes It Easy

If you do decide to advance your career through home study, it's best to pick a school that *specializes* in the home study method. Electronics is complicated enough without trying to learn it from texts and lessons that were designed for the classroom instead of the home.

Cleveland Institute of Electronics concentrates on home study exclusively. Over the last 30 years it has developed tech-

niques that make learning at home easy, even if you once had trouble studying. Your instructor gives the lessons and questions you send in his undivided personal attention—it's like being the only only student in his "class." He not only grades your work, he analyzes it. And he mails back his corrections and comments the same day he gets your lessons, so you read his notations while everything is still fresh in your mind.

Students who have taken other courses often comment on how much more they learn from CIE. Says Mark E. Newland of Santa Maria, Calif.:

"Of 11 different correspondence courses I've taken, CIE's was the best prepared, most interesting, and easiest to understand. I passed my 1st Class FCC exam after completing my course, and have increased my earnings by $120 a month."

Always Up-to-Date

Because of rapid developments in electronics, CIE courses are constantly being revised. This year's courses include up-to-the-minute lessons in Microminiaturization, Laser Theory and Application, Suppressed Carrier Modulation, Single Sideband Techniques, Logical Troubleshooting, Boolean Algebra, Pulse Theory, Timebase Generators...and many more.

CIE Assures You an FCC License

The Cleveland method of training is so successful that better than *9 out of 10 CIE graduates who take the FCC exam pass it.* This is despite the fact that, among non-CIE men, 2 out of every 3 who take the exam fail! That's why CIE can promise in writing to refund your tuition in full if you complete one of its FCC courses and fail to pass the licensing exam.

This Book Can Help You

Thousands who are advancing their electronics careers started by reading our famous book, "How To Succeed in Electronics." It tells of many non-degree engineering jobs and other electronics careers open to men with the proper training. And it tells which courses of study best prepare you for the work you want.

If you would like to cash in on the electronics boom, let us send you this 44-page book free.

Just fill out and mail the attached postpaid card. Or, if the card is missing, mail the coupon at right.

NEW COLLEGE-LEVEL CAREER COURSE FOR MEN WITH PRIOR EXPERIENCE IN ELECTRONICS

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

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

Please send me without cost or obligation:
Your 44-page book "How To Succeed In Electronics" describing the job opportunities in Electronics today, and how your courses can prepare me for them.
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
- ☐ Electronics Engineering

Name____________________ (PLEASE PRINT)
City____________________
Address____________________
State____________________
Zip__________ Age__________

☐ **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 card or in this coupon for G. I. bill information.

PE-16

If coupon has been removed, write to Cleveland Institute of Electronics 1776 E. 17th St., Cleveland, Ohio 44114

CIRCLE NO. 6 ON READER SERVICE PAGE

contact types with the reliability, low noise and ease-of-manufacture of junction devices, the *surface-barrier* transistor (SBT) and its improved version, the surface-barrier diffused type (SBDT), enjoyed a moderate success for a while, although it is considered obsolete today. It consisted of a wafer of doped semiconductor material which had been etched thin on opposite sides by an electrolytic process, with its emitter and collector electrodes applied as plated metallic dots by reversing the etching process. The SBDT was similar, except that dopant impurities were diffused into the base region from the plated metallic dots.

In one sense the forerunner of today's increasingly popular monolithic Darlington devices, the *composite* transistor, shown in Fig. 2, was actually a pre-wired multi-stage Darlington amplifier assembled from selected individual transistors and potted in a single case with its terminals identified as conventional transistor electrodes. Relatively expensive, it offered extremely high gain combined with a moderately high power handling capability and found its chief applications in special purpose audio amplifiers.

Analogous in concept, performance characteristics, and general layout to a vacuum tube, (hence its name) the *analog* transistor had high input and output impedances. As in a vacuum tube, a central emitter region served as the "cathode," and this, in turn, was surrounded by an area of intrinsic semiconductor material in which were formed "grid" electrodes doped with an opposite polarity to that of the emitter. This structure was surrounded by yet another layer of semiconductor material doped similar to the emitter and serving as the unit's "plate." As far as we can determine, however, the analog transistor was never manufactured as a production device.

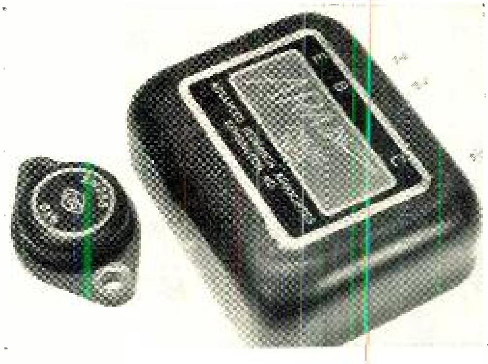


Fig. 2. The large package was forerunner of the now-popular TO-5 Darlington device. Compare its size with conventional TO-3 power transistor at left.

Despite its intriguing name, the *spacistor* was not developed for use in earth-circling satellites or on the moon. Rather, its name was derived from the use of an internal space-charge region as a control element. A four-terminal device, the spacistor consisted of a pn junction, forming its base and collector electrodes, a pressure contact injector and an alloyed contact modulator. In operation, the unit's base-collector current was controlled by modulating the strongly biased electric field set up within the device's junction region. Featuring high input and output impedances as well as an excellent high-frequency response, the device was difficult to manufacture in production quantities economically and, as a result, was never developed beyond the experimental stage.

Essentially two junction transistors in a single housing, with the emitter of one connected to the base of the second, the *tandem* transistor was manufactured in limited quantities for a while. In operation, the device was equivalent to a common-collector

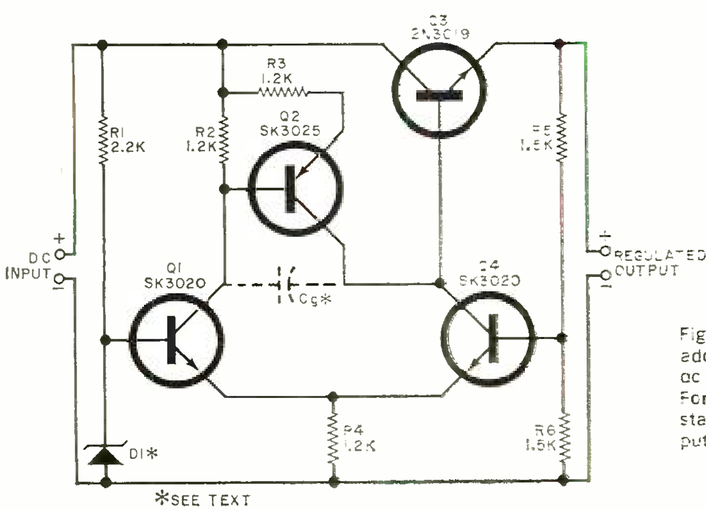


Fig. 3. This voltage regulator can be added to almost any unregulated dc supply to improve performance. For example, it can supply a constant 12 volts at 100 mA with inputs ranging from 18 to 30 volts.

stage direct-coupled to a common-emitter amplifier, and offered a useful variable gain characteristic coupled with relatively high input and output impedances.

Produced in experimental quantities, the *thyraton transistor* was so named because its "all or nothing" conduction characteristics were similar to those of a thyratron tube. It was a unique unit with a junction emitter and point-contact collector and was suitable for application similar to those in which SCR's, Triacs and related solid-state switching devices are used today.

Interestingly enough, not all of yesterday's exotic devices have disappeared from the technical scene, nor are they even obsolete by today's standards. In fact, a number of old timers—in modern dress, of course—are not only still around, but often are considered to be among the latest devices. Their names, however, have been changed to protect the innocent and confuse the curious.

For example, the fabulous—when first introduced—*double-based diode* is now called, perhaps more appropriately, the unijunction transistor. Similarly, the "obsolete" *fieldistor, transtrictor* and *unipolar transistor*, all similar devices, are still available, but you'll have to ask for them by their modern name—field effect transistors (or, as many prefer, FET's)!!

How about that?

Reader's Circuit. Adapted from a British design, the voltage regulator circuit illustrated in Fig. 3 was submitted by reader Gene McRichard (Kensington, Md.), who suggests it might be used in digital and control power supplies, preamps, test instruments, or in any similar equipment application requiring a low-ripple, well-regulated, moderate-current dc source. It can be added to any conventional dc power supply furnishing a moderately well-filtered output at reasonable voltage levels. With the components specified, the circuit can supply, typically, 12 volts at loads of up to 100 mA with inputs of from 18 to 30 volts.

Referring to the schematic diagram, *Q3* acts as the series-regulating device and is controlled by a modified differential amplifier, *Q1*, *Q2*, and *Q4*. In operation, the amplifier serves to compare the reference voltage supplied by zener diode *D1* with the circuit's load voltage, as abstracted by voltage-divider *R5-R6*, adjusting *Q3*'s base bias automatically to maintain a constant output voltage. Variable collector load *Q2* acts to superimpose an inverse ripple signal on the control bias and thus to improve filter action.

With neither layout nor lead dress critical, the voltage regulator may be assembled either on perf board or a suitable etched circuit, as preferred. It can be used as an outboard addition to an existing power supply or incorporated as part of a complete design. Aside from observing good wiring practice, only two precautions are needed. First, of course, an adequate heat sink should be provided for *Q3*. Second, the completed unit should be checked for parasitic oscillation; if present, neutralizing capacitor *Cg* (shown dotted, Fig. 3) should be added to the circuit. The capacitance value will depend on distributed wiring capacities and other factors but, in general, will be on the order of 0.001 μF.

Calculator in Your Pocket. When IC's were first introduced, we thought it was marvelous that as many as five or six transistors and a couple of resistors could be jammed onto one tiny silicon chip. As the years went by, more and more semiconductors and their associated components began to appear in new IC's. Now the Mostek Corp., in conjunction with the Nippon Calculating Machine Co., has come up with a whole calculator on a chip. The chip is approximately the size of three grains of rice and contains over 2100 transistors, 360 logic gates, and 160 flip-flops, all mounted in a dual 20-lead package measuring 0.6" by 2". This IC replaces the entire conventional internal circuitry of a calculator and is connected directly to the power supply, readouts, and keyboard. Because of the very low power consumption, a hand-held calculator such as that shown in the photo is now going into production in Japan (along with other models).

Believe it or not, this is a complete 12-digit calculator that can add, subtract, divide, multiply.

These calculators are capable of adding, subtracting, multiplying, and dividing numbers up to 12 digits in length and they have floating point entry, four-place selection for the decimal point, and leading-zero blanking for the digital display. One unit has LED 7-segment readout powered by a small rechargeable battery, while the other has a

(*Continued on page* 89)

THE PRODUCT GALLERY

Ninth in a Monthly Series by "The Reviewer"

INASMUCH as this month's Product Gallery will cover quite a bit of ground, your columnist will forego his usual opening remarks, but will correct a typographical error that appeared in this column on page 82 of the March issue. This typo was in my review of the Winegard "Sensar" TV antenna and said that the broadband amplifier had a gain of 40 dB—a pretty good trick for such a small package. The correct figure was obviously 10 dB—which is still significant and perfectly adequate for signal-capturing ability of the unusual Sensar antenna design.

TEN-TEC MODEL RX-10 AMATEUR RADIO RECEIVER

There is a refreshing new face in the amateur radio equipment marketplace. Refreshing because of the nature of the products manufactured—nothing too glamorous, no power houses, and just about the best dollar value around. Ten-Tec says they're interested in getting more hams on the air and are concentrating on developing good low cost gear primarily for the Novice ham licensee. The RX-10 receiver falls in this category and is the first wholly new receiver circuit design to be manufactured in the past few years. Because it is aimed at the Novice, the RX-10 is basically designed for CW reception. The receiver can be used for SSB and AM reception, although its ability in this area leaves something to be desired.

Synchrodyne Detector. The unusual circuit of the RX-10 is roughed out in the accompanying block diagram. The receiver is all solid-state and has full coverage of the 80/75-, 40-, 20-, and 15-meter amateur radio bands. For the convenience of the novice or beginner, a code practice oscillator has been included.

The principle of operation is that of heterodyning the incoming radio frequency in the mixer so that a CW signal will produce an audio beat note at the output of the detector. If the input signal is 3725 kHz and the VFO signal is 3726 kHz, the audio output from the linear detector will be 1000 Hz. The action is similar to that obtained using a BFO in conjunction with the i-f strip in a conventional receiver.

The audio output from the synchrodyne detector is passed through a low-pass, 2-kHz filter and fed into a four-stage high-gain audio amplifier. The low-pass filter between the detector and the amplifier limits the audio frequency pass-band and thus effectively determines the selectivity as shown in the accompanying graph. However, there is an audio image problem and in the example above, an input signal at 3727 kHz will also produce a 1000-Hz beat note. Tuning is quite sharp and fairly strong signals are required to achieve optimum tuning.

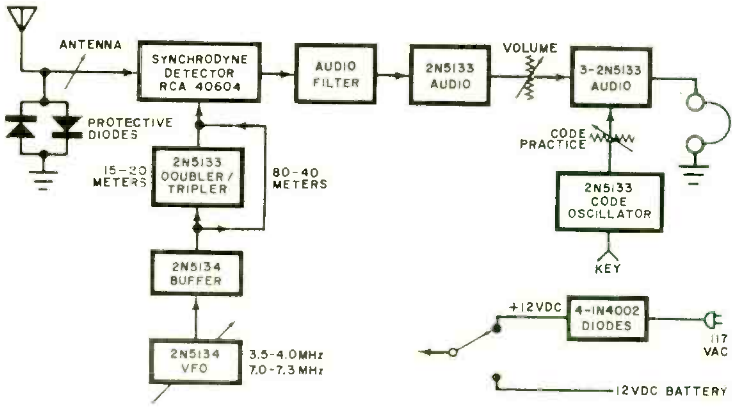
The RX-10 receiver can be used for SSB reception in the usual manner by tuning the receiver to zero beat with the suppressed carrier. Again—as mentioned above—there will be no discrimination of the unwanted sideband which may or may not constitute a problem. Otherwise, SSB reception is notably good. You can receive AM signals by zero beating or synchronizing the receiver VFO with the incoming carrier—roughly a form of exalted-carrier reception. Technical information on the synchrodyne circuit appeared in *Electronic Engineering,* March, 1947, page 75, under the byline of Mr. D. G. Tucker.

Circuit Simplicity. In designing the RX-10 receiver, every effort appears to have been made to produce an efficient circuit with a minimum number of components. Probably the most important circuit surrounds the VPO which operates between 3.5-4.0 MHz to tune the 75/80-meter bands. On the three higher frequency bands, the VFO tunes 7.0-7.3 MHz and harmonics are used to cover the 20- and 15-meter bands.

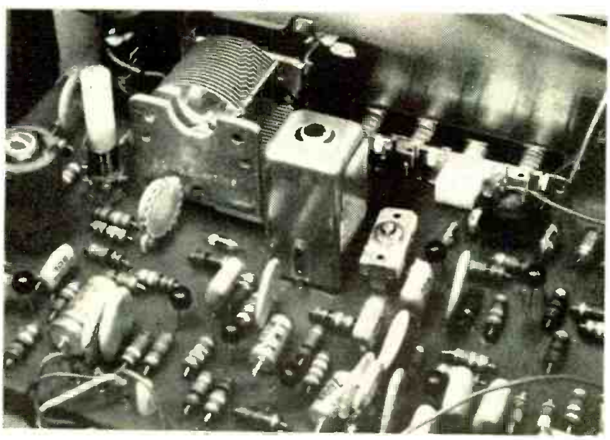
The input r-f L/C circuit tunes 80 meters down to 40 meters. When the capacitor is tuned just counterclockwise of the 7-MHz marker, a mechanical switch adds a high-Q toroid-wound inductor which is used to resonate the synchrodyne detector in the 20- and 15-meter bands. When listening on these

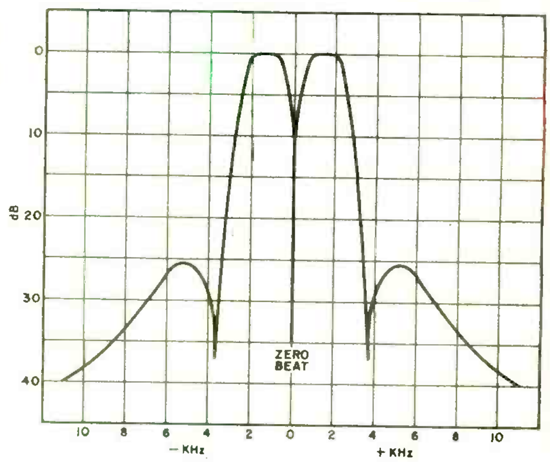
TEN-TEC AMATEUR RADIO RECEIVER (Model RX-10)

Ten-Tec's radio amateur band receiver is all solid-state and is the only receiver on the market built around the synchrodyne (direct conversion) circuit. Receiver covers the 4 major bands and has pushbutton band change.

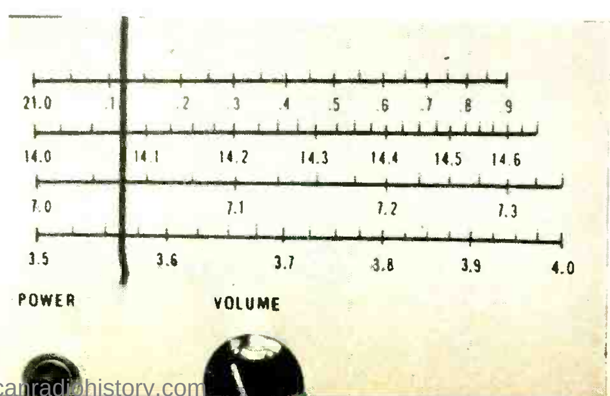


Block diagram of the Ten-Tec RX-10 is at the left. Below is the very strange selectivity curve. Note that receiver converts incoming r-f signals to audio without further r-f amplification. Selectivity is ideal for CW and SSB reception in the ham bands.





Low-cost receiver is built on one large printed circuit board. Top-quality components and workmanship predominate. The tuning dial (right) was not intended to be accurate, but does spread the 4 ham bands out over most of the logging scale.



bands, it is imperative that the ANTENNA control be set to the proper range in accordance with the pushbutton band selector. Confusion may result if the operator accidentally leaves the ANTENNA control near the 40-meter marker while otherwise tuning the 80-meter band. This eccentricity is due to the harmonics of the VFO operating on 80 meters. This is also of particular concern with the 15- and 20-meter bands where the ANTENNA marks are quite close together and where the harmonics of the 7-MHz VFO produce 20-meter signals when the pushbutton band selector is set for 15 meters and the ANTENNA control tuned to 20 meters.

Test Figures. The RX-10 receiver has sufficient frequency stability to hold an SSB signal in tune after a 30-minute warm-up. VFO variation with line voltage change is greater on 75/80 meters than on any of the other bands and amounts to plus or minus 400 Hz with ±10% line voltage variation. On 40 meters the same 10% line voltage variation results in only a ±35-Hz frequency shift. Operating power would normally be obtained from a 117-volt ac source, but the receiver may be operated from 12 volts dc if desired.

Sensitivity measurements on the RX-10 receiver indicated that for a 10-dB (S+N)/N figure the input on 80 meters had to be 2.2 μV. On 40 meters the sensitivity was 1.8 μV, on 20 meters the sensitivity was 2.2 μV, and on 15 meters the sensitivity was 2.0 μV.

All in all, the RX-10 receiver is a fairly unusual product and whether or not it will be accepted by budding Novice licensees remains to be seen. In favor of immediate acceptance of the RX-10 is the very important factor of cost since a receiver with the bandspreading and selectivity built around the usual principles of a superheterodyne receiver would sell for twice as much money (or about 1.5 times as much in a kit). The built-in code practice oscillator is a little bonus for the Novice who wants to get "on the air" practice mixed with honing of his own fist. The size and portability of the RX-10 are also in its favor and we shouldn't be surprised to see Ten-Tec soon announce a matching transmitter.

ACOUSTIC RESEARCH, INC. AR-6 FULL RANGE SPEAKER SYSTEM

If you haven't heard it before, permit me to let you in on a secret—the generic term "bookshelf speaker system" is a misnomer. That term is nothing more than a polite generalization for a rectangular shaped box with grille cloth on one side. To compound the indignity, a number of bookshelf speakers are far too big to fit on bookshelves and even if many of them could, the excessive weight would soon displace or buckle the shelves themselves. Acoustic Research has certainly been aware of this problem (the "lightweight" AR-2x weighed 33 lbs) and some months ago announced its new model AR-6—a toddling 20 pounder.

The AR-6 is an "under $85" two-way full-range speaker system measuring 19½" wide by 12" high by 7" deep. The system comprises a brand new 8" woofer and one of the better AR dome-type tweeters with a crossover at 1500 Hz. The speaker box is walnut finished with a light neutral beige grille cloth. A version of the AR-6 in unfinished pine is available for $72.

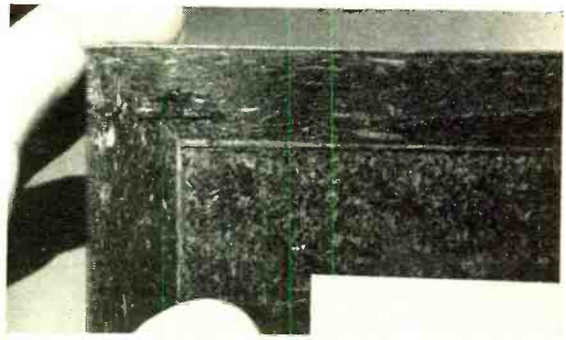
After some initial tests with the AR-6, a phone conversation with the manufacturer confirmed our impression that the 8" woofer is capable of doing the job performed by the 10" woofer in the AR-2x and the AR-5. Reportedly, production models of the AR-6 are now leaving the plant with a measured resonance of 56 Hz—plenty respectable for a system in this small a box. Julian Hirsch has reported in STEREO REVIEW that the magnet structure of the AR-6 woofer has been redesigned and now consists of several small magnets around the pole piece instead of the customary single magnet. This apparently provides the voice coil with an extra long linear excursion. Acoustic Research also reports that they consider the tweeter in the AR-6 pretty darn good and rate it at just about the second best tweeter they manufacture and roughly comparable to the tweeter in the original AR-3.

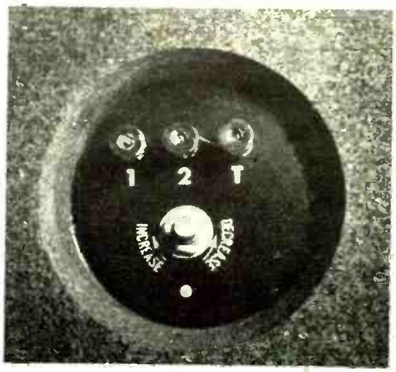
Laboratory Tests. A frequency response curve—from information supplied to us by the Hirsch-Houck Laboratories—indicates that the AR-6 is within plus or minus 4 dB from 45 Hz to 12.5 kHz. Low frequency harmonic distortion was measured as being under 2% at a 1-watt drive level at 50 Hz. At a 10-watt drive level, distortion had increased to just about 4%. This low distortion figure is compatible with what audiophiles have come to expect from the AR family of speakers.

Also like most speakers in the AR family, the AR-6 has a very slight "lift" in the audio range between 250 and 1500 Hz. Out beyond 2000 Hz, there is a gentle roll-off in the frequency response which can also be "lifted" by cranking up the tweeter level control. The AR-6 is a somewhat power-hungry speaker system and for optimum performance should never be used with an amplifier rated under 20-25 watts rms per channel. The nominal impedance of the AR-6 is 8 ohms.

Listening Tests. Unlike speaker systems produced by various other manufactur-

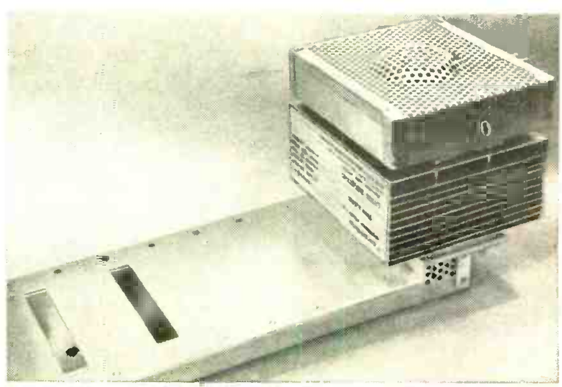
ACOUSTIC RESEARCH SPEAKER SYSTEM (Model AR-6)





This is a true bookshelf speaker system measuring 19½" x 12" x 7"—though it is shown here on a fireplace mantel. The AR-6 uses a new 10" diameter woofer with a remarkably clean, low bass note response. Heavy-duty construction and careful mitering of corners is shown in above view. As usual with AR speakers, there are thumb nut terminals at rear with a connecting link that ties woofer to tweeter. Woofer may be operated separately by removing link. Control varies tweeter output level. Although it is small, the AR-6 has a big speaker sound and should be used with an amplifier that has more than 20 watts output. Nominal input impedance is 8 ohms.

HEATHKIT MICROWAVE OVEN (Model GD-29)



Unique microwave oven kit looks as shown in above photo when assembled. Control panel at right of oven has 4 pilot lights: power on, microwave generator on, door open, and hi-temp warning. Master on/off pushbutton and timer complete panel. The unit at right is the magnetron generator working at 2450 MHz with a power output of around 650 watts. Generator is air-cooled by fan built in rear wall of oven. There are no tuning adjustments on generator.

ers, every AR sounds pretty much like every other AR. This is even true of the AR-6 which is the "low end" of the Acoustic Research line. What nuances that exist between the AR-6 and the top price AR-3a are reasonably subtle, although the same cannot be said for the AR-6 versus the AR-4. In the case of the 3a, added dollars give the listener better power handling capabilities, more flexibility of midrange and tweeter level controls, and somewhat deeper bass. To my ears, the AR-4 has a "suspect" sound and really doesn't belong in the AR family. To the inexperienced ear, this reviewer finds it difficult to distinguish the AR-6 from the AR-2ax, or even to some extent, the AR-5. Possibly after sustained "A-B" tests, the differences would become obvious, but the AR-6 has the instinctive ability to reproduce very clean deep rolling bass notes with an absence of over-hang. This is a quality common to all of the good AR speakers. In our tests, the AR-6 needed the tweeter level control turned practically full up to balance the upper midrange and highs with a dynamic bass response. This may have been a personal preference, or even a necessity to compensate for the listening room. In any case, the AR-6 has what it takes and when used with the right amplifier should satisfy all but the most discriminating listener.

HEATHKIT MICROWAVE OVEN (Model GD-29)

It's difficult to wax poetic over the latest Heathkit—a microwave oven. Some builders will certainly call it a fun thing to construct and have around the house, but the oven lacks the challenge of involved "electronics" and the overall construction is so foolproof as to be ridiculous. About nine-tenths of the time expended assembling the GD-29 is spent on sheet metal and hardware. The electronics portion is either part of the safety interlock/timer circuit or powering the magnetron microwave generator. The latter is self-contained and requires only mounting and power connections. The safety interlock/timer contains rather uncomplicated and unglamorous electrical wiring. If you haven't guessed it by now, you'll spend most of the time fussing and fuming with sheet metal screws. The assembly task is not difficult—nor especially time consuming—although you can expect to rack up about 15 hours before reaching the point in the manual called "Initial Tests."

A WOMAN'S REPORT ON THE MICROWAVE OVEN

After curbing your fear that nefarious microwaves are running around loose and that you can't open the oven door without frying your hand, you will find this strange gadget starting to grow on you. Of course, you've got to throw that old textbook about cooking out the window and learn a new method. Once you've mastered the basics, the rest comes easy. Think of cooking in terms of weight and water content and divide your old gas oven roasting time in half or thirds and you're on your way to becoming the envy of your neighborhood.

Microwave cooking does all the things claimed—speeds up cooking leftovers, defrosts frozen meat and vegetables, and is a snap to keep clean, but the one thing that may be most fascinating is that microwave cooking is innovative. The Heathkit looseleaf cookbook is only a starter—don't hesitate to try a new dish or concoction because it's not in the book, just use your feminine logic and go to it. And, let your teenagers use it—it's clean, fast, and they'll find it a lot of fun. Lastly, don't go running off when roasting or baking because microwaves are fast and the basting must be performed every three to five minutes which is really not time enough to read a paragraph or so in your favorite magazine.

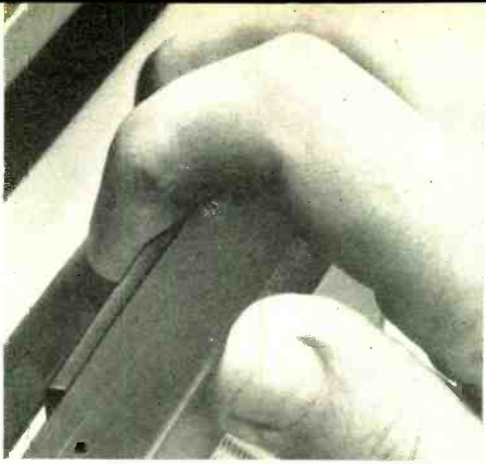
There's been too much publicity about microwave cooking for this reviewer to waste your time in a re-hash (no pun). I'll let the better half tell you what she thinks (see above). There were no problems encountered in assembling the GD-29 and the only area that might cause some concern is the door seal and capacitive seal plate. Just read the assembling instructions and you're in business. As a matter of fact, the only problem that was encountered was in mounting the stirrer shield which is a plastic dish hanging from the top surface of the oven to cover the stirrer blades. The shield was slightly distorted and had to be shifted around to provide adequate clearance of the stirrer blades.

Builders should note that the oven itself is relatively large. It measures 25½" wide, 15¾" deep, and 15" high. This absorbs considerable kitchen counter space and most

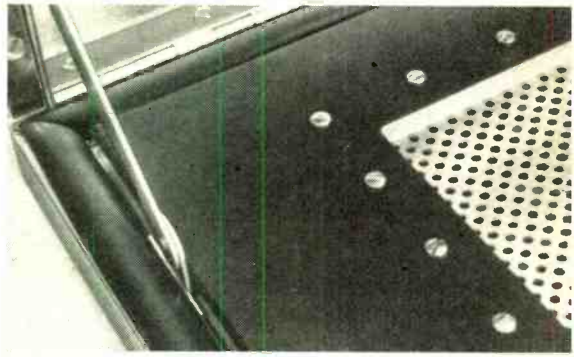
(*Continued on page 96*)

FOR MORE INFORMATION

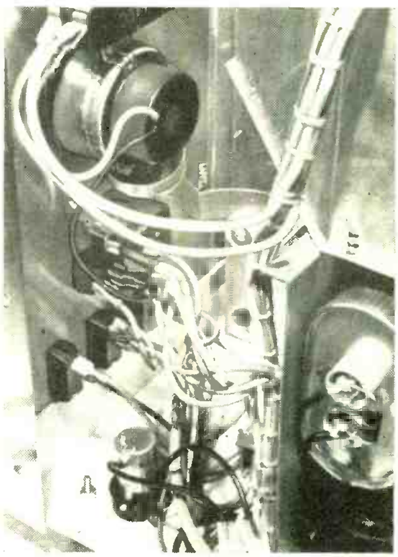
Ten-Tec RX-10 Receiver—Circle No. 86 on Reader Service Page 15 or 95.
Acoustic Research AR-6 Speaker—Circle No. 87 on Reader Service Page 15 or 95.
Heathkit GD-29 Microwave Oven—Circle No. 88 on Reader Service Page 15 or 95.



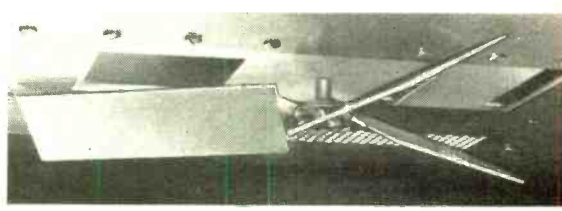
Oven door handle has built-in pressure bar switch that activates SCR to release safety interlock. Door can be opened only when the oven is powered. When door is open, magnetron cannot be turned on.



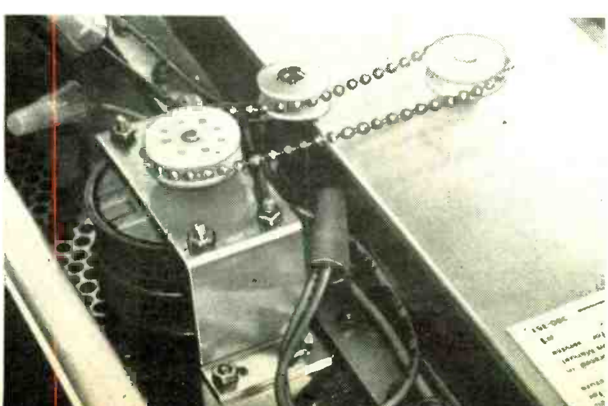
Door seal and Teflon-coated capacitive seal plate are components requiring great care during assembly process. User must keep door seal clean and free of food particles to prevent r-f leakage.



Front (right) and rear (left) views of panel controls and pilot lights. Note nonlinear timer scale and the master on-off pushbutton switch below the thumb.



Slowly revolving fan "spills" microwaves around inside of oven for even heating. When oven is complete, fan is enclosed in a plastic shield. Motor to drive fan is seen at left. Microwaves enter oven chamber from ports above blades of the fan.



OPPORTUNITY AWARENESS

Thoughtful Reflections On Your Future

Thirteenth in a Monthly Series by David L. Heiserman

Military Electronics Training

I have been assigned to the Air Training Command at Keesler Air Force Base in Mississippi to study Heavy Communications Electronics. Will my military electronics training be useful in establishing a career when I return to civilian life?

● Have no fear that your training will be only "military" in scope. What you learn about basic electronics theory and the use of various types of field and lab-type test equipment will be an invaluable building block for a career. Military technical schools—and those at Keesler are a prime example—offer the trainee the unique opportunity of combining equal parts of theory and practical elements in the basics and valuable practical experience on some of the most sophisticated gear you are likely to encounter in or out of the service.

Training in the Keesler tech schools is generally divided into two parts. The first and most important phase is devoted to the study of electronic theory. The second phase puts the theory into practice and introduces you to examples of the actual equipment on which you will be expected to work later. It is in the second phase where specialization takes place.

The training you receive at Keesler will be similar to what you could expect from most civilian-run technician-level resident schools. Your practical experience on actual communications equipment obtained in "sets" (phase two) and out in the field will actually be the start of your career. Many Keesler graduates have gone onward and upward in civilian careers in communications.

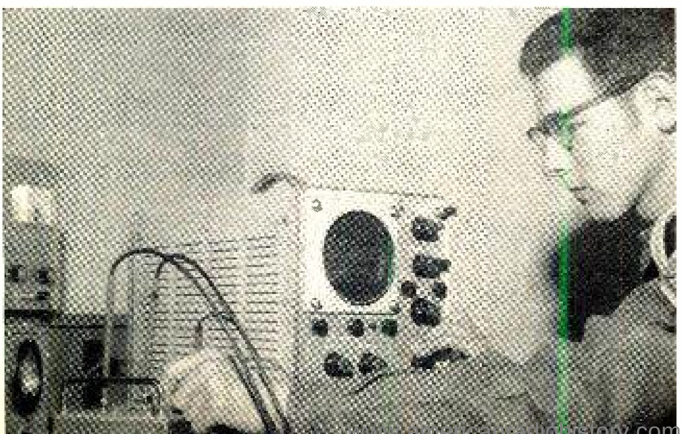
IEEE Membership

Ever since I graduated from school and got my first job, I have heard people talk about the IEEE. Can you tell me something about the requirements for membership and the benefits of same?

● The IEEE (Institute of Electrical and Electronics Engineers) is a large, active, highly regarded professional society for electrical and electronics engineers. With about 150,000 members, the IEEE also has the distinction of being the world's largest engineering society. As far as many engineers and employers are concerned, the IEEE is THE society for profesionally competent people working in electronics.

The IEEE was founded in 1884 by a group

(*Continued on page* 94)



Throughout every phase of his training at Keesler AFB tech schools, the student is always exposed to actual test gear. In photo at left, Airman J. A. Neurath, Plainville, CT, uses an oscilloscope in blocking oscillator laboratory project.

Self-pacing students learn theory and do Lab work (upper left) as part of electronics principles course in Keesler's Computer Systems Department before entering computer maintenance training.

Instructor Sergeant Stephen R. DiStasio of Sacramento, CA, assists Airman Gerald W. Ralston of Grand Fork, ND, in running receiver sensitivity alignment of AN/GRC-169 Collins microwave transceiver (above) in Radio Relay Maintenance course.

Sergeant Elvin B. Jordan of Troy, AL, maintenance instructor, demonstrates to Airman James L. Kaehler of Dayton, OH. proper procedure for replacing circuit boards in SAC Command & Control System.

(U. S. Air Force Photos)

Troubleshooting techniques on data intercept console of air-to-ground communications system are developed by students in supplemental course for experienced maintenance personnel. While learning operations of console, students are able to detect malfunctions purposely injected and requiring maintenance to correct.

STEREO SCENE

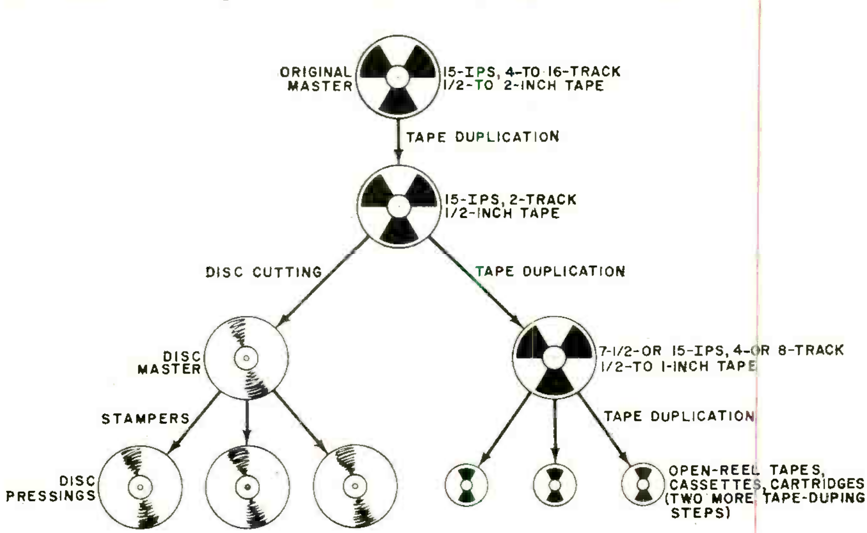
Ninth in a Monthly Series by J. Gordon Holt

WHERE THE MUSIC SOUNDS BEST

THE SLOGAN, "Music sounds best on tape," has been used by one of the largest producers of prerecorded music tapes for the home market. It's a slogan that has been around for years and is a great advertising phrase. The logic behind the words seems unassailable since everyone who hasn't had his head in an ostrich hole knows that all discs originate as tape masters. It would seem reassuringly self-evident, then, that prerecorded tapes, being tapes, should be superior to discs.

If you think that the above is unquestionable, let's follow a piece of canned music from the recording session to your living room. Typically, a music recording results from sound picked up by from 6 to 20 different microphones—some being mixed at the recording session—with the whole "schmeer" Dolbyized and recorded on from 4 to 16 parallel tracks on low-noise tape that may be $\frac{1}{2}$ to 2" wide and running at 15 ips. This must then be "mixed down" to produce the usual two-channel stereo signal and subsequently recorded onto another tape, usually at 15 ips on $\frac{1}{2}$" low-noise tape. Some recording studios may add one or two additional copying steps for various reasons of their own, but the two-channel mixdown is the final tape-copying step in disc manufacture. It is not however the last step in the manufacture of prerecorded tapes.

The discing master has two tracks recorded in one direction only. Since prerecorded tapes have four (or eight) in both directions, these tapes must be made from a special multi-track duping master or "mother" tape, which is made by copying from the two-track discing masters onto $\frac{1}{2}$-inch low-noise tape, usually at $7\frac{1}{2}$ or $3\frac{3}{4}$ ips (to facilitate high-speed duplication). This adds one more tape-duping step beyond the discing stage. The final step—copying of the cassettes, cartridges or open-reel tapes—adds another tape-duping step. And each step degrades the signal quality.



Though the processes of preparing discs and tapes (as shown here) appear to involve the same number of steps, the tape duplicating process, changes in spacing, etc. add extra noise.

The master tape for making discs is still Dolbyized, but the noise-reducing deprocessing is done as the music is going to the disc cutterhead. The disc sound is probably as good as the state of the art permits. Accumulated tape hiss, print-through, scrape flutter, and so on have been minimized by Dolby noise reduction. The manufacturing steps after cutting the master disc are all mechanical and there are very few things that can go wrong that cannot be seen with the naked eye. Because all of its signal-carrying grooves are on its exposed surfaces, a brief visual inspection is all that is needed to ascertain that a disc pressing is okay.

On the other hand, there is no known method of simultaneously transferring the magnetic patterns from one recorded tape to another. The magnetized tape coding is sandwiched between layers of plastic backing material and in order to transfer the coding to another tape, it is necessary to wind through its entire length.

Dollars By The Minute. In almost any business, time is money. Running a half-hour tape all the way through at a normal playing speed would be inordinately expensive. In order for prerecorded music tapes to compete with discs on a unit-cost basis, the tapes are duplicated by re-recording at a very high rate of speed. Typically, the duplicating speed is 8 to 16 times the normal playing speed of the finished tape. The master tape is usually a continuous loop—to obviate the need for rewinding—and to make tapes price-competitive with discs, the master playback machine feeds an array of "slave" tape duplicators. Usually up to 10 copies are made from each "swipe" of the master tape.

With discs, things that are not readily visible are usually picked up in spot checks of listening quality and since audible-only (as opposed to visual) problems usually affect a whole series of pressings from a single stamper, it is easy to weed out and discard the dud discs. On the other hand, there is no way of visually inspecting tapes and they must be spot checked by a listening test which might pick up poorly adjusted slave recorders, but would rarely pinpoint random sporadic tape problems. Such tape problems have their counterparts in the bubbles and pits that might show up during visual inspections of every disc coming off the manufacturing line. The occasional disc with a bubble can be caught and rejected, but the tape with an occasional dropout or

POPULAR ELECTRONICS SUBSCRIBER SERVICE

Please include an address label when writing about your subscription to help us serve you promptly.
Write to: P.O. Box 1096, Flushing, N.Y. 11352

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

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

name ______ please print ______
address ______
city ______
state ______ zip-code ______

TO SUBSCRIBE: Check these boxes: —☐ New –☐ Renewal
☐ 5 years $21 ☐ 3 years $15 ☐ 1 year $6

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

0504

name ______ please print ______
address ______
city ______ state ______ zip ______

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

STEREO SCENE

(Continued from page 87)

short bursts of flutter (due to tape feed irregularities) or crackles (due to static discharges) passes with inspection simply because it's not worth the duplicator's time to search for momentary defects. To the buyer who pays $7.95 for the finished tape, one such flaw can be an annoyance worth the effort of returning the tape to the dealer.

Just because it's possible to detect practically every defective disc, there's no guarantee that every disc producer will exercise that much quality control. Some manufacturers and producers do, though, as witness the superbly noiseless surfaces of most Deutsche-Grammophon discs.

This is where discs carry off all the honors.

A Progression of Threes. All other things being equal, tape hiss increases by 3 dB above its original level every time the tape is copied. It also rises by 3 dB every time the tape speed or the recorded track width is halved, and there are a number of these little 3-dB increases between the discing master tape and the commercially prerecorded tape.

The discing process adds no significant noise to the signal. Disc "hiss" is actually tape hiss from the discing master, and it is typically extremely low in level.

Going from the original 15 ips of the disc cutting master to 7½ ips (for an open-reel prerecorded tape) adds 3 dB of hiss. Going from the original two tracks to four on the same width tape adds another 3 dB, and reducing the tape width (and hence the track width) by half to produce 4 tracks on ¼" tape adds another 3 dB, giving a total of 9 dB to make all these changes. The changes also involve two duplicating steps which add up to 6 dB more and the four-track open reel tape could have 15 dB more hiss than a good disc—at twice the consumer price!

For cassettes, you could add another 3 dB for again halving the track width and a whopping 6 dB for dropping from 7½ ips to 1⅞ ips, for a total of 24 dB.

Tape producers have not been unaware of this hiss bugaboo. Some time ago, Ampex Stereo Tapes introduced a final duping process called EX+ which allows them to tape at recording levels just a hair shy of the overload point. This obviates the need for making tape copies with a 6 dB safety "headroom" and allows Ampex to get about 5 dB more clean signal on the tape and thus override 5 dB of hiss. When cassette-recorder manufacturers incorporated Dolby B circuits in their machines, it took little persuasion to convince tape producers of the wisdom of pre-Dolbying the better cassettes. Open-reel prerecorded tapes are not being pre-Dolbyed (as yet) and most open-reel tapes and Dolbyed cassettes now have about the same subjective hiss levels. Both are still notably "hissier" than many current disc recordings.

Tipping the Scales. Discs are subject in playback to two potential problems unknown to tape: surface noise and tracking distortion. Of course, a brand new disc played with a top-rated phono cartridge and associated electronics will manifest little, if any, of either problem and will sound clearly better than the best open-reel prerecorded tape—no matter how good the tape playback equipment may be. The human element muddies the waters and the average stereophile may unknowingly tip the scales to favor the tape sound.

The constant background hiss from tape tends to be more easily ignored than the random and sometimes startling clicks and pops from a disc. Let's face it, most people do not take care of their discs and the moderate amount of distortion that makes a prerecorded tape sound slightly muddy is a lot less offensive to the ear than the shattering, tearing distortion heard from a mis-tracked disc feeding a typically distorting amplifier. This is when music does sound better on tape; when the reproducing system is wide-range enough to have pretensions to fidelity, but not low enough distortion.

In terms of potential fidelity we can agree that, "Music sounds best on tape," if that person is talking about the original master tape or its final mix-down. But the prerecorded tapes that you buy at your corner hi-fi store or record mart are not comparable to master tapes. In terms of what you can buy, music has the potential for sounding better on discs with prerecorded tapes running a poor second. Whether or not you extract optimum sound quality from your discs is up to you, and that's another story. —30—

SOLID STATE

(Continued from page 77)

liquid crystal 7-segment readout and operates from a conventional transistor radio battery—good for about 20 hours. However, it might be quite a while before they replace the pencil and paper system, since present cost is about $395. It is hoped that the cost will come down soon.

This pocket-size calculator has rechargeable battery, 8 readouts, and multiply, divide, add, and subtract functions with automatic decimal point.

Another battery-powered, pocket-size calculator is being offered by Sharp Electronics. This little gem is only 4" × 6½" × 3" and weighs 1½ lb. Its 8 readouts and 10-position keyboard enable it to add, subtract, multiply, and divide with the answer instantly displayed. It also includes an automatic decimal point, a negative sign, and and overflow indicator. The internal batteries are good for three hours of operation before re-charging or it can be powered from the commercial line. Price is $345. Four LSI packages form the electronics portion, with each LSI unit containing 1875 elements (transistors, resistors, capacitors, and diodes). This MOS device was created by North American Rockwell for the Apollo moon shots.

Manufacturer's Circuits. Amperex's TAA560 is an exceptionally versatile device. Assembled in a standard type TO-72 case, the unit is a silicon monolithic integrated circuit intended for low-voltage timing and control equipment applications. Featuring eight transistors, two diodes, and six resistors, its internal circuitry, illustrated in Fig. 4, comprises a modified Darlington input forming part of a Schmitt trigger which, in turn, controls a three-stage, direct-coupled amplifier equipped with Zener limiters.

Two of the TAA560's many potential applications are illustrated in Fig. 5—a temperature sensitive alarm (A) and a touch-operated switch (B). These circuits were abstracted from Amperex's four-page Specifications/Applications bulletin for the TAA560. Among the other practical circuits described in the bulletin are a sinewave/squarewave generator, a latching lamp driver, and a camera shutter time control. All five circuits feature a single TAA560 as their active device and require a minimum of additional components.

In the temperature sensitive alarm circuit, Fig. 5(A), *IC1* provides the multiple functions of level detector, oscillator, and speaker driver. In operation, a drop in *IC1*'s dc input voltage at pin 2 initiates oscillation, developing an audible alarm signal. This voltage drop, in turn, will result when there is a change in the thermistor's (*R2*) temperature past a predetermined level as established by the setting of sensitivity control *R1*, for the control and the thermistor, together, form a simple voltage-divider.

Suitable for use either in control applications or for magical illusions, the touch operated switch Fig. 5(B), will switch "Off" or "On," latching in either mode, whenever a moderately high resistance (such as the body) is bridged across the appropriate terminals. As in the previous circuits, *IC1* is a TAA560 and the resistors are half-watt units. The indicator lamp may be any low-voltage type requiring no more than 75 mA. If desired, however, the lamp may be replaced with a sensitive relay, with its contacts used to control more powerful loads, such as a solenoid, small motor, buzzer, or high-wattage lamp.

Neither parts arrangement nor wiring dress is critical in either of the circuits. Amperex recommends, however, that either a

Fig. 4. The TAA560 circuit (right) shows it to be a sophisticated high input impedance Schmitt trigger controlling a dc coupled power amplifier.

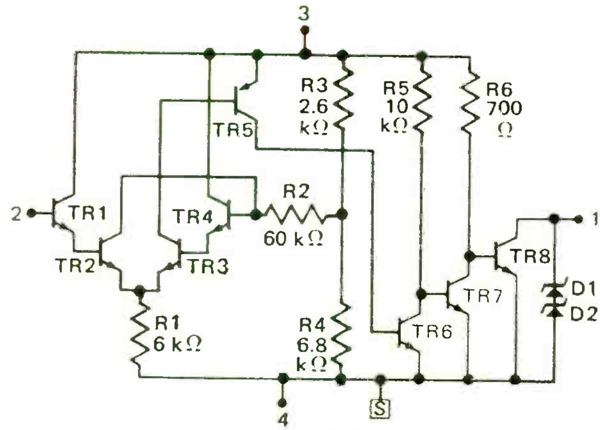
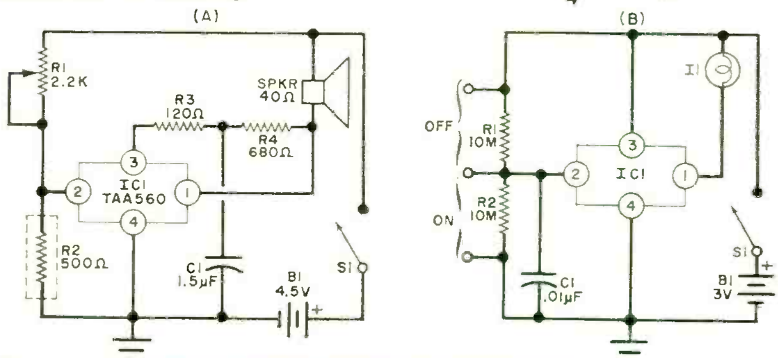


Fig. 5. Two uses for the TAA560 are: (A) a temperature-sensitive alarm, and (B) a touch-operated switch. In both circuits, an absolute minimum of external components is necessary.



battery or regulated dc power supply be used for optimum performance.

HELP!!! Reader Lewis H. Cline, W8EXS (603 Fremont St., Middleville, MI 49333) has a problem and is seeking assistance. An active ham, W8EXS has been plagued with electrical noise interference on the 40- and 80-meter bands. He feels that the noise is caused by nearby electromechanical industrial equipment, for it may continue for hours, only to stop suddenly. Further, he is sure he can filter out the noise at the offending equipment once he locates the source.

Briefly, W8EXS would appreciate advice on assembling a transistorized, broadband, highly directional, moderately sensitive receiver which he can use as a "Spook-Hunter." If any of our readers can suggest a suitable circuit and layout, please write directly to W8EXS with the necessary information, forwarding a copy to yours truly for reference. If we learn of a suitable design, we would be pleased to consider it for a future "Reader's Circuit."

Device News. Fairchild Semiconductor (313 Fairchild Drive, Mountain View, CA 94040) has announced a new dual one-of-four decoder/multiplexer that can be used in such digital applications as logic control, demultiplexing and latch selection. Identified as the MSI 9321, the new device is a medium-scale IC featuring two independent decoders, each designed to accept two binary weighted inputs and provide four mutually exclusive active low outputs. Available in both 16-pin dual-in-line and 16-lead beryllium oxide flatpacks, the MSI 9321 has a typical propagation delay of only 15 ns (from enable to output) and can handle a fanout of 10 TTL loads.

A new ultra-low-voltage complementary MOS digital circuit has been added to RCA Solid State Division's (Route 202, Somerville, NJ 08876) popular COS/MOS line. Designated the TA5987, the new developmental device consists of a dual complementary pair plus inverter having nanowatt standby power dissipation and microwatt operational power dissipation. Functionally identical to

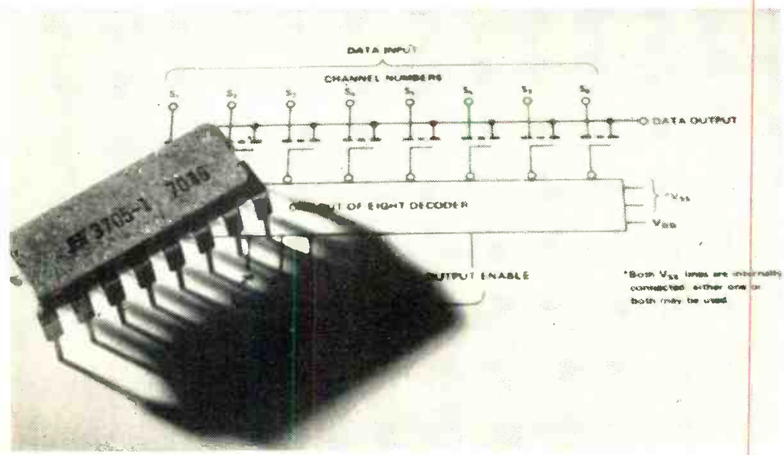


Fig. 6. Siliconix multiplex switch can pass any of eight input signals on command. Designed for OEM circuits, it would make an 8-trace scope front end.

the standard 12-volt CD4007, the TA5987 is specified to operate from 1.5-volt supply voltages, and is ideally suited for use in ultra-low power crystal oscillator circuits. Provided in 14-lead flat-packs or dual-in-line ceramic packages, it also can be used in such configurations as NAND/NOR gates, triple inverters, dual transmission gates, and so on.

Siliconix, Inc. (2201 Laurelwood Road, Santa Clara, CA 95054) has announced a new monolithic 8-channel multiplex switch, the SI3705DK. Utilizing p-channel enhancement-mode technology, the new IC includes a one-out-of-eight decoder on the chip and provides TTL compatible logic input lines. Other features include enable control, a high ON/OFF ratio, zero offset voltage and a low 10 nA leakage current. Illustrated in Fig. 6, the new device is packaged in a 16-pin ceramic DIP, and is intended for A/D converters, multiplexing in analog or digital data transmission systems and similar applications.

Books, Booklets & Brochures. The General Electric Company (Syracuse, NY 13201) has issued three new publications which, we feel, belong in every experimenter's technical library. All three should be available through local GE semiconductor distributors.

Carrying a nominal 25-cent price tag, GE's *Entertainment Semiconductor Almanac*, publication No. ETRM-4311F, is a 52-page reference booklet listing some 20,000 different domestic and foreign semiconductor devices cross-referenced to GE Universal Replacement type numbers. In addition, the booklet includes valuable servicing tips and detailed electrical and physical specifications for both the Universal Replacement and Experimenter/Hobbyist Component lines.

Printed on thin, strong paper similar to that used in bibles, GE's *Electronics Experimenters Circuit Manual*, publication No. ETRM-3960A, might well be considered a "bible" for the hobbyist. Priced at $2.00/copy, the book has over 250 pages of useful data. After a short introduction, a 40-plus page section covers such topics as basic theory, component operation, the care and handling of components, safety precautions, radio interference, and troubleshooting. The balance of the book is devoted to a description of practical construction projects ranging from a 1-watt audio amplifier to a one-kilowatt flasher with photoelectric control. The projects are grouped into five major sections—audio projects; automotive and marine projects; games and hobbies; home, farm, and camp projects; and, finally, workshop projects.

That's just about the whole story for this month. —*Lou*

OPPORTUNITY AWARENESS

(*Continued from page 84*)

of 25 men (including Thomas Edison and Alexander Graham Bell) interested in electricity. Their stated purpose was "The advancement of the theory and practice of Electrical Engineering and the Allied Arts and Sciences and for the maintenance of high technical and ethical standards among its members." And it appears that the IEEE has stuck to these original objectives.

Benefits of Membership. Primary benefits include professional recognition, close association with others with common interests, educational programs, and the opportunity to see and read both comprehensive and specialized journals.

As far as professional recognition is concerned, membership in the IEEE is on about the same level as an engineering degree or a professional engineer's certificate. When applying for a job in electronics, for example, including your IEEE standing on the application can go a long way toward getting you a better job and higher pay. The reason for this is that the IEEE has always managed to restrict its membership to professionally competent men and women.

Although the IEEE is a giant organization, its 200 regional groups hold meetings and seminars on a small, person-to-person scale thus permitting close association between members in the same locale and with the same special interests. Members are also offered a wide variety of educational opportunities. As a member of IEEE, for example, you could now enroll in a 12-week home study in introductory computer programming. This course and others like it are approved by the New York State Education Dept., and cost is only $45.

Publications of the IEEE are many and varied. Every member receives free the official monthly magazine "IEEE Spectrum." Student members can receive either "Spectrum" or the "IEEE Student Journal." On a more technical level is the "IEEE Proceedings," to which members may subscribe for $7 per year. Then there are 33 "Transactions" and "Group Journals"—all of a highly specialized nature (with no advertising).

Requirements for Membership. There are five grades of IEEE members: Student, Associate, Member, Senior Member, and Fellow. The grade achieved by a member depends largely on his education, experience, and record of professional achievement.

Student membership is open to "registered

Popular Electronics

READER SERVICE PAGE

free information service:

Here's an easy and convenient way for you to get additional information about products advertised or mentioned editorially (if it has a "Reader Service Number") in this issue. Just follow the directions below...and the material will be sent to you promptly and free of charge.

1. On coupon below, circle the number(s) that corresponds to the key number(s) at the bottom or next to the advertisement or editorial mention that is of interest to you. (Key numbers for advertised products also appear in the Advertisers' Index.) Print or type your name and address on the lines indicated.

2. Cut out the coupon and mail it to: POPULAR ELECTRONICS, P.O. Box 8391, Philadelphia, PA 19101.

note: If you want to write to the editors of POPULAR ELECTRONICS about an article on any subject that does not have a key number, write to POPULAR ELECTRONICS, One Park Avenue, New York, N.Y. 10016. Inquiries concerning circulation and subscriptions should be sent to POPULAR ELECTRONICS, P.O. Box 1096, Flushing, N.Y. 11352.

5/71—4
Void after June 30, 1971

Popular Electronics P.O. BOX 8391 PHILADELPHIA, PA. 19101

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	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

NAME *(Print clearly)*____________________

ADDRESS____________________

CITY__________ STATE______ ZIP CODE______ students in electrical engineering or related courses." Most student members belong to an organized branch at their school. You can get a list of schools that have active student branches by writing the IEEE for the booklet "Your Challenge in Electrical Engineering" (see address below). Student memberships are $8 per year.

Associate memberships are open to "those with engineering interests who are capable of rendering service to IEEE and the profession." This involves proving that you are actively involved in some kind of electrical engineering or related work. You also must have the endorsement of at least one person who knows you professionally—preferably an IEEE member. The annual dues are $25.

For a Member grade in IEEE, you must be able to "show evidence of your professional level of experience and competence" as an engineer, scientist, teacher, or executive in the electrical or electronics technology. Requirements include endorsements by at least three IEEE members of Member grade or higher. Annual dues are $25.

For Senior Member grade, the dues are the same, but you must be able to "show evidence of having attained distinction over a period of at least five years." This includes activities such as publishing some original papers or books, holding patents, directing some kind of successful project or making "creating contributions well above the routine ones." Senior Members must have the endorsement of at least three IEEE members holding grades of Senior Member or Fellow. This is the highest grade that can be attained by application.

The grade of Fellow in IEEE is "conferred only upon a person of outstanding and extraordinary qualifications and experience." This is an honorary professional grade that is roughly equivalent to getting an honorary doctor's degree from MIT. Fellows have a free lifetime membership.

Most members start out at the Student or Associate grade and work their way up to Senior Member over a period of years. It is important to note that the IEEE recognizes the possibility of a person's being a professionally competent engineer without having a college degree. A degree helps but if you have the ability, record of professional accomplishment and ethical standards required, membership is entirely possible.

For more details about membership and activities, write to:

IEEE
345 East 47th St.
New York, NY 10017

PRODUCT GALLERY

(*Continued from page 82*)

users will probably find it convenient to put the oven on a wheeled patio cart. Also, the 117-volt ac power requirement is close to 15 amps. The power must also come from a three-way ac outlet and preferably from a 20-25 amp service line.

Safety. Heathkit went right down to the mat with the Federal Communications Commission over the question of microwave leakage and safety. The fact that the oven was "cleared" by the FCC is an indication that the Commission was convinced a kit builder could assemble the GD-29 oven without creating r-f pollution. It is not surprising that the FCC and the Department of Health, Education and Welfare are concerned over r-f pollution. There are estimates from the HEW that one-third of all pre-assembled microwave ovens are leaking r-f—mostly because of inadequate cleaning around the door seals.

When properly constructed, the GD-29 microwave oven has leakage less than the new HEW standards that go into effect October 6, 1971. The new regulations will specify that microwave ovens must have less than 1-mW radiation when brand new and less than 5-mW radiation when in use. —30—

SINGLE WOOFER

(Continued from page 42)

shown in circuit B. The component values specified provide for a 6 dB/octave slope with a crossover at 60 Hz. The woofer cut-off point can be raised to 80 Hz by substituting a 0.1-μF capacitor in place of the 0.15-μF capacitor.

The crossover networks in Fig. 2 can be tailored to fit a particular installation simply by changing the values of the capacitors, working with the time constant chart and information in the box on page 40.

Another possible method of connecting a bass amplifier to a stereo amplifier is through an electronic crossover. Such crossovers were popular in pre-stereo times when the idea behind their use was to reduce intermodulation distortion with the aid of two or three amplifiers to cover the entire audio spectrum. Some of those crossovers probably added as much distortion as the multiple amplifiers prevented, but they should be adequate for a low-pass filter if designed for a crossover frequency of 100 Hz or lower.

Single woofer stereo systems can be like the girl with the curl—very, very good or just plain horrid. Their design requires careful attention to the choice of the crossover frequency and the mixing circuit. If these two challenges are met and overcome, the concept opens all kinds of interesting possibilities for stereo systems that can be both practical and superb in performance.

Of course, the special problems of the single woofer can be avoided by going the well-traveled path of the easy-to-hook-up traditinal two-speaker system stereo setup. But the easiest way to enjoy stereo would be to buy a department store portable "stereo" setup and forget the nuts and bolts. Well, if that's your answer to the problem, to each his own. —30—

References

1. *Radiotron Designer's Handbook*, F. Langford-Smith RCA 1953, p 850.
2. "Direct Radiator Loudspeaker Enclosures," H. F. Olson, *Audio Engineering*, November 1951.
3. *Stereophonic Sound*, N. H. Crowhurst, John F. Rider, 1961, p 92.
4. "L-C/H-Q Mark I" Part 2, P. J. Baxandall, *The Audio Amateur*, Summer 1970, p 14.

EMERGENCY FLASHER

(*Continued from page 69*)

for up to 5 amperes of current drain—if you wish in this circuit. But you had better check the traffic laws in your locality before installing the brighter lamps. In general, clearance and identification lights exceeding 25 watts tend to be distracting to oncoming drivers.

The more rugged a switch that is used the better will be the reliability of the flasher system. For this reason, it is suggested that you invest in a "mil. spec." or heavy-duty industrial switch. If you go the route of selecting an automobile switch, the reliability of the system will be compromised. The auto switches are designed to withstand the relatively minor vibrational stresses of paved-surface roadways—just barely.

Finally, if a pilot lamp is desired to tell you when the system is being operated, you can connect a 33-ohm, 2-watt resistor in series with a #44 lamp and connect the assembly between the negative and positive buses on the barrier block.

Preventive maintenance with the flasher consists of routine checks before and after each use, a routine check every 2000 miles, and blowing out the dust each time the mud is dumped out of the air filter and the oil is replaced. The capacitors, which reputedly have a service life of two years, gradually lose capacitance and increase their leakage with age. The result is an increase in flashing rate which signals the need for replacement. Actual service life of modern electrolytic capacitors considerably exceeds ten years in some cases.

This flasher should be more than rugged enough for most needs—unless you continually travel over rock-strewn, rutted terrain that would tax even a mountain goat. The prototype flasher has withstood the rigors of summer off-road driving in the Mojave Desert; in the sand dunes along the Gulf of California; and many miles of winter off-road driving in the mountains of Arizona and New Mexico.

Designed originally for use in search and rescue vehicles, the improved flasher is equally at home in campers, jeeps and rovers, boats, etc.—anywhere where the going gets rough and vibration and the elements can spell the end of conventional flasher systems. —30—

LIBRARY

(*Continued from page* 16)

PRINCIPLES OF COMMUNICATION SYSTEMS

by Taub and Schilling

The outgrowth of courses conducted at the graduate and advanced undergraduate levels, this book can serve as a one-semester course in the advanced study of communication systems. Introductory chapters cover the mathematical background required for the remainder of the text.

Published by McGraw-Hill Book Co., 330 West 42 St., New York, NY 10036. Hard cover. 514 pages. $15.95.

ELECTRONIC DESIGNER'S HANDBOOK, Second Edition

by T. K. Hemingway

More than 70 of the diagrams that appeared in the first edition have been modified and updated to reflect the state of the art in addition to the changes and new material added to the text.

Published by TAB Books, Blue Ridge Summit, PA 17214. Hard cover. 294 pages. $9.95.

ABC'S OF INFRARED

by Burton Bernard

This basic introduction to the theory and applications of infrared technology begins with a history of infrared techniques. Covered in detail are the theories behind emission, absorption, reflection, and transmission of infrared energy.

Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Soft cover. 144 pages. $3.50.

ADVANCED ELECTRONIC INSTRUMENTS AND THEIR USE

by Sol D. Prensky

Described in detail are sophisticated general-purpose laboratory test instruments currently in use in industry and research. Representative instruments are discussed to familiarize the reader with their capabilities and limitations.

Published by Hayden Book Co., 116 West 14 St., New York, NY 10011. 208 pages. $9.50 hard cover; $6.95 soft cover.

ELECTRONIC DESIGN DATA BOOK

by Rudolph F. Graf

This book simplifies the task of the engineer, technician, amateur, or students who finds it imperative to locate essential data in the shortest possible time. Timely, practical information, is presented in ready-to-use nomograms, tables, charts, and formulas.

Published by Van Nostrand Reinhold Co., 450 West 33 st., New York, NY 10001. Hard Cover. 312 pages. $17.95

LABORATORY MANUAL FOR ELECTRONIC SHOP PRACTICES

by Avtgis & Megow

This Wentworth Institute book introduces the reader to the various tools and fabrication and assembly techniques for making professional-quality project prototypes. The stress is on development of efficiency, quality workmanship, and creativity in a practical shop environment.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Soft cover, 139 pages. $7.95.

OUT OF TUNE

(*Continued from page* 10)

On "The QRP Thing" (February, p 39) circuit boards and complete kits of parts are available from Red Johnson Electronics, 440 Pepper St., Palo Alto, CA 94306. Write for prices and ordering information.

"Chemicals for Electronics" (April, p 25). In the table on page 28, Chemtronics Contact Kleen should be listed under "Cleaning Relay Contacts" and Chemtronics Super Trol Aid should be under "Cleaning Noisy Potentiometers."

ELECTRONICS MARKET PLACE

NON-DISPLAY CLASSIFIED: COMMERCIAL RATE: For firms or individuals offering commercial products or services, $1.25 per word (including name and address). Minimum order $12.50. 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. 80¢ per word (including name and address). No Minimum! Payment must accompany copy.

DISPLAY CLASSIFIED: 1" by 1 column (2⅝" wide), $110.00. 2" by 1 column, $215.00. 3" by 1 column, $320.00. Advertiser to supply cuts.

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, **POPULAR ELECTRONICS,** One Park Avenue, New York, New York 10016.

FOR SALE

FREE! Bargain catalog. Fiber optics, LED's, transistors, diodes, rectifiers, SCR's, triacs, parts. Poly Paks, Box 942, Lynnfield, Mass. 01940.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna, Nahant, Mass. 01908.

ROCKETS: Ideal for miniature transmitter tests. New illustrated catalog. 25¢. Single and multistage kits, cones, engines, launchers, trackers, rocket aerial cameras, technical information. Fast service. Estes Industries, Dept. 18-E, Penrose, Colorado 81240.

LOWEST Prices Electronic Parts. Confidential Catalog Free. **KNAPP,** 3174 8th Ave. S.W., Largo, Fla. 33540.

WE SELL CONSTRUCTION PLANS. TELEPHONE: Answering Machine, Speakerphone. Carphone. Phonevision, Legal Connector, Auto Dialer, Central Dial System. **TELEVISION:** $35.00 Color Converter, Tape Recorder, 3DTV. $25.00 Camera. **HOBBYIST:** Electron Microscope, 96 Hour Tape Music System, Ultrasonic Dishwasher, Radar-Oven, Electronic Tranquilizer. Plans $4.95 each. **COURSES:** Telephone Engineering $39.50, Detective Electronics $22.50, Anti-Detective Electronics $27.50. **NEW SUPER HOBBY CATALOG AIRMAILED $1.00.** Don Britton Enterprises, 6200 Wilshire Blvd., Los Angeles, Calif. 90048.

WEBBER LAB's. Police & Fire Converters. Catalog 25¢. 72 Cottage Street, Lynn, Mass. 01905.

INVESTIGATORS, LATEST ELECTRONICS AIDS. FREE LITERATURE. CLIFTON, 11500-L NW 7th AVE., MIAMI, FLORIDA 33168.

ELECTRONIC PARTS, semiconductors, kits. FREE FLYER. Large catalog $1.00 deposit. BIGELOW ELECTRONICS, Bluffton, Ohio 45817.

RADIO—T.V. Tubes—36¢ each. Send for free catalog. Cornell, 4213 University, San Diego, Calif. 92105.

CLEARANCE SALE rectifiers, transistors, 1000's other items. Catalog 15¢. General Sales Company, 254 Main, Clute, Texas 77531.

MECHANICAL, ELECTRONIC devices catalog 10¢. Greatest Values—Lowest Prices. Fertik's, 5249 "D", Philadelphia, Pa. 19120.

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.

SENCORE, B&K TEST EQUIPMENT UNBELIEVABLE PRICES. FREE CATALOG AND PRICE SHEET. FORDHAM RADIO, 265 EAST 149TH STREET, BRONX, N.Y. 10451.

ELECTRONIC COMPONENTS—Distributor prices, Free catalog. Box 2581, El Cajon, California 92021.

FREE Kit Catalog: Shortproof Powersupply $39.50. Ultrasonic Alarm $37.25. SWTPC, Box B32040, San Antonio, Tex. 78216.

AMATEUR SCIENTISTS. Electronics Hobbyists, Experimenters. Students . . . Construction Plans—all complete, including drawings, schematics, parts lists with prices and sources . . . Radar—Build your own ultrasonic doppler radar. Detect motion of people, automobiles, even falling rain drops. Transistorized, uses 9 volt transistor battery—$4.50 . . . Long-Range "Sound Telescope"—This amazing device can enable you to hear conversations, birds and animals, other sounds hundreds of feet away. Very directional. Transistorized. Uses 9V battery—$3.50 . . . Robot Man—Moves hands and arms—$3.50 . . . Or send 25¢ coin (no stamps) for complete catalog. Other items include Psychedelic strobes, light shows, lasers . . . 46 different projects. Technical Writers Group, Box 5994, State College Station, Raleigh, N.C. 27607.

DIAGRAMS—Radios $1.50, Television $3.00. Give make and model. Diagram Service, Box 1151PE, Manchester, Conn. 06042.

ELECTRONIC Ignition. Various Types. Information 10¢. Anderson Engineering. Epsom, N.H. 03239.

NEW! PHONE PATCH with automatic switch. Now you can record those important conversations automatically. **ONLY** $19.95. Chelco Electronics, 11835 Wilshire Blvd., Los Angeles, Calif. 90025.

BACKGROUND MUSIC, continuous commercial-free. Solid-state **MUSICON SCA ADAPTER** plugs into any FM Tuner, Receiver. Line powered. 5 year guarantee! Only $39. postpaid. K-Lab, Box 572Z, South Norwalk, Conn. 06856.

NEW SEMICONDUCTOR LIGHT EMITTING DIODES—bright red lights replace light bulbs. Typical life 100 years. Operate at 1.65 volts, 50 milliamps. Order 2 for $2.98 **NOW.** Data sheet and instructions included. Monsanto Company, Hobby Section, 10131 Bubb Road, Cupertino, California 95014.

CONVERT any television to sensitive, big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco-A33, Box 10563, Houston, Texas 77018.

FREE catalog, parts, circuit boards for **POPULAR ELECTRONICS** projects. **PAIA ELECTRONICS,** Box C14359, Oklahoma City, OK 73114.

MATRIX ARRAY COMPONENT UNITS; needed in experimenter laboratory and repair shop, catalog 10¢. **CUHINCO,** 2404 Stratton Drive, Rockville, Maryland 20854.

CITIZENS Band-Shortwave Listener-Ham equipment from Amrad Supply, Inc. Free Flyer, 1025 Harrison St., Oakland, Calif. 94607.

PSYCHEDELIC Strobe Kit: Complete with 110w/sec. tube, reflector, chassis and cabinet $17.50 plus postage and insurance. 2 lbs. (Extra tubes $3.50) SWTPC, Box E32040, San Antonio, Texas 78216.

CONSTRUCTION PLANS: Laser . . . $2.00. 2-FM microphone transmitters . . . $1.00. FM telephone transmitter . . . $2.00. Sound telescope . . . $2.00. Space monitor-missile tracker . . . $2.00. Equipment and kits available. Howard, 20174 Ward, Detroit, Michigan 48235.

REPAIR that set! Individual instructions, sketches, $5. Money-back guarantee. Charles Brown, 321 Price, Philadelphia, Penn. 19144.

FREE Kit Catalog: Color Organs $11.00, Psychedelic Strobes $17.50, Professional quality—lowest prices. SWTPC, Box F32040, San Antonio, Texas 78216.

ANTIGRAVITY, experiment and theory; Rushed—$2.00. U.S. Inquiries. Intertech-7A6, Box 5373, Station-F, Ottawa, Canada.

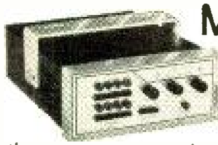
EXCITING LISTENING! Police—Fire—Emergency calls on your broadcast radio, $19.95 up. Also crystals, receivers, scanners, dualband. Salch Company, Woodsboro 48, Texas 78393.

HOBBYISTS—Electronic components at huge savings. Transistors 6/25¢, resistors 5¢, capacitors 10¢. Thousands of items. Catalogue free. SASCO Electronics, 1009 King Street, Alexandria, Va. 22314.

WOULD YOU SPEND 25¢
to save $25.00 or more? Citizens Band, AM and SSB 2-way Radios, USA and Export Models.
Send 25¢ for catalog to:
BAGGY'S RADIO
P. O. Box 778, 6391 Westminster Avenue
Westminster, CA 92683
Dealer Inquiries Invited

LEARN the facts of electronics and your privacy. Send for the Tron-X Manual, P.O. Box 38155, Hollywood, CA 90038. $5.95.

duo-band • auto search
Monitor Receiver



pei 8-channel scanning monitor HL-44 locks on active channel, then resumes search when channel goes quiet. Program scanning speed, any number of high or low band channels by plugging in crystals. NO WIRING CHANGES. Use it on your desk or in your car.

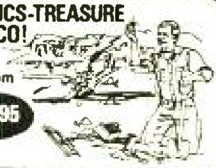
Write for free literature.

pei PETERSEN ELECTRONICS, INC.
1000 South Main— Council Bluffs, Iowa 51501

WOULD YOU SPEND 25¢ to save $25.00 or more? Citizens Band, AM and SSB 2-way radios, USA and export models. Send 25¢ for catalog to: BAGGY'S RADIO, 6391 Westminster Avenue, Westminster, CA 92683. Dealer Inquiries Invited.

SEMICONDUCTORS: Buy from single source. Serving experimenters, hobbyists. No minimums. SN 7400N, $1.90; MC724P, $1.10, Etc, RLabs, Box 253, Burlington, Ma. 01803.

FIND COINS-GOLD-RELICS-TREASURE
metal locators by JETCO!



- Lightweight
- Easy to Use
- Comes Complete
- Made in USA
- 5 yr. Guarantee
- Immediate Delivery!
- Write for FREE Catalog.

priced from $39.95

Jetco ELECTRONIC INDUSTRIES, INC.
P. O. BOX 132, PE HUNTSVILLE, TEXAS 77340
PHONE ORDER TO: 713/295-5422

BRAINWAVE Feedback Electroencephalophone. Send 10¢, J. & J. Enterprises, 8102E, Bainbridge, Wash. 98110.

IC's, Accessories. Free price list. Tri-Tek, P.O. Box 14206, Phoenix, Arizona 85031.

HOOSIER ELECTRONICS Authorized dealers for Regency Scanners and CB, also Midland, HyGain, Drake, Ten-Tec, Galaxy, Hallicrafters. All equipment new and fully guaranteed. Write today for our low quote. Hoosier Electronics, R.R. 25, Box 403, Terre Haute, Indiana 47802.

LOWEST PRICES, PRINTED CIRCUIT BOARDS. METAL & PLASTIC RODS-SHEETS-TUBES. POST PAID. FREE LIST. FOWLER, 1605 QUILL STREET, INDIANAPOLIS, IND. 46203.

SEMICONDUCTOR BONANZA! CATALOG: 10¢. NEBULA, BOX 1115, LAFAYETTE, INDIANA 47902.

ORGAN OWNERS! Do your own thing! Save time and money. Tune your organ conveniently, accurately, inexpensively. Loss of tone quality and variation of pitch are easily and quickly corrected. Learn about our professonal, economical tuning instrument. Write to Musicon Electronics Co., Dept. PE, Box 59, Fort Washington, Pa. 19034.

ELECTRICAL MULTIMETERS, New, high quality, very reasonable. Request details. Newera, 4480 Broadview, Cleveland, Ohio 44109.

NEW solid state design SCA adaptor for background music from your FM set. Easy installation. High reliability. $39.95. Complete with instructions and station list. Altoz Electronics Inc., Box 7474, Hollins, Va. 24019.

INTEGRATED CIRCUITS, 741C Operational Amplifiers, $1.75. A. Miller, 1039 Sheffield Place, Thousand Oaks, California 91360.

ANTI-SEIZE stick for solder tips. Quick, clean, lasting. $1.00. Tilco, Box 40404, San Francisco 94140.

QUALITY components at low cost. Catalogue 10¢. Send name to Gust & Company, Box 24081, Edina, Minnesota 55424.

JAPAN HONG KONG DIRECTORY. World products information. $1.00 today. Ippano Kaisha Ltd., Hillyard, Washington 99207.

F.C.C. TYPE EXAMS . . . Guaranteed to prepare you for F.C.C. 3rd, 2nd and 1st phone exams. 3rd class $7.00, 2nd class $12.00, 1st class $16.00, complete package $25.00. Research Company, Box 22141, Tampa, Florida 33622.

APTITUDE TESTS . . . Designed to determine your ability to be successful in the field of electronics. $5.00. Research Company, Box 22141, Tampa, Florida 33622.

TV TUNER REPAIRS—Complete Course Details, 12 Repair Tricks, Many Plans, Two Lessons, all for $1. Refundable. Frank Bocek, Box 833, Redding, Calif. 96001.

FLASHLAMP, $2.98, Lasers, Photoflash, Beacons, Psychedelic Strobes, Plans, ZD706, Box 3261, San Jose, California 95116.

FREE Electronics Catalog. Tremendous bargains. Edu-Kits, Department C-697 D, Hewlett, New York 11557.

SPACE-AGE TV CAMERA KITS & PLANS

BE A PIONEER IN HOME TELECASTING! Build your own TV CAMERA. Model XT-1A, Series D, $116.95 ppd. Solid-State. Step-by-step construction manual. High quality. Connects to any TV without modification. Ideal for home, experimenters, education, industry, etc.

PHONE or WRITE for CATALOG.

Many other kits, parts and plans available including starter kits, focus/defl. coils, vidicon tubes, const. plans, etc.

1301 N. BROADWAY **ATV Research** DAKOTA CITY, NEBR. 68731

BURGLARY—Fire Protection. Free catalog. Installation Manual loaned Free to interested parties. Safeway, 92-A Brighton 11th Street, Brooklyn, New York 11235.

EUROPE'S top quality electronic parts, ridiculous prices. Catalog 35¢. Electrovalue-America, Box 27A, Swarthmore, Pa. 19081.

67KC SCA adapter. Solid state, wired, tested. Operates on 9 to 30 volts. Use between FM tuner and audio amplifier. $15.50. Postpaid USA with instructions, station list. Mark and Alan, P.O. Box 172, Chesterland, Ohio 44026.

INVESTIGATORS—Detectives—Industrial security officers. Latest subminiature electronic equipment. Catalog 50¢. Jack, Box 19422, Sacramento, Calif. 95819.

PRINTED CIRCUITS Quick. Free Estimates. Industrial Photo B-18, Oakhurst, N. J. 07755.

PLANS AND KITS

FREE Kit Catalog: Digital Microlab $29.95. Also Segmented and Nixie Readouts, Timebases, Scalers, Electronic Digital Clocks (all featured in **Popular Electronics**) SWTPC, Box C32040, San Antonio, Tex. 78216.

PSYCHEDELIC LIGHTING MANUAL! Make strobes, kaleidoscopes, organs, etc. Send $2.95. Lightrays, 1315-D Weaver, Philadelphia, Pa. 19150.

FREE kit Catalog: Amazing new Universal Digital Instruments with plugins as featured in **Popular Electronics.** Unbeatable prices. SWTPC. Box D32040, San Antonio, Tex. 78216.

COLOR CONVERTER FOR BLACK AND WHITE TELEVISION

New electronic patented system. A do-it-yourself kit for hobbyists and experimenters. Plans and instructions available. Write for free brochure.

BELE ELECTRONICS CORP.
111 Northeast Second Avenue, Miami, Florida 33132

FREE Kit Catalog. Why does every major College, University, Technical School, Research & Development Center buy from us? Because we have the highest quality and lowest prices. Free catalog. SWTPC, Box H32040. San Antonio, Tex. 78216.

PRINTED Circuit kits and supplies to make any P.C. Board in this magazine. Send $5.00 ppd. for Experimenters Kit, catalog and instructions. Techniques, Inc., Englewood, New Jersey 07631.

TELEVISION Training Kits, Parts, Plans. $2.99. Free Flyer. Aline, 434 West 4th Street, West Islip, New York 11795.

SCR (electronic switch) Hobbyist Kit. SCR's, many plans, circuit theory. $4.95. Catalog free. John Huntley, 909 Wisconsin, San Francisco, CA. 94107.

HIGH FIDELITY

TAPE RECORDERS, Hi-Fi, components, Sleep Learning Equipment, tapes. Unusual Values. Free Catalog. Dressner, 1523R, Jericho Turnpike, New Hyde Park, N.Y. 11040.

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. **LYLE CARTRIDGES**, Dept. P, 365 Dahill Road, Brooklyn, N.Y. 11218.

LOW, Low quotes: all components and recorders, HiFi, Roslyn, Penna. 19001.

FREE Kit Catalog. Amplifiers: Lil Tiger $11.10, Universal Tiger $30.00, Preamp $44.50 (Featured in Popular Electronics) SCA Adaptors $14.55. SWTPC, Box A32040, San Antonio, Tex. 78216.

UNIVERSAL POWER AMPLIFIERS, from 50 Watts to 1,000's of Watts RMS—for musical instruments and stereo, catalog ADC 2005. Sound effects catalog #SE-100S, musical instruments and stereo pre-amp, 8-channel PA Pre-Amp, FM vibrato, Leslie effect. Marshal sound and more. Both full color catalogs $1.00 Amplifier Design Corp., P. O. 4, Rossford, Ohio 43460.

WANTED

CASH PAID! Unused tubes, electronic equipment. Barry, 512 Broadway, NYC 10012.

QUICKSILVER, Platinum, Silver, Gold, Ores Analyzed. Free Circular. Mercury Terminal. Norwood, Mass. 02062.

ALL kinds Electronic Gear and parts wanted for handicapped people. Everything accepted. Send to Handicapped Workers, Olivewood Crafts, 43, Chefetz Chaim St., Petah-Tiqwa, ISRAEL.

TUBES

TUBES "Oldies", latest. Lists free. Steinmetz, 7519 Maplewood, Hammond, Indiana 46324.

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.

RADIO & T.V. Tubes—36¢ each. Send for free catalog. Cornell, 4213 University, San Diego, Calif. 92105.

TUBE Headquarters of World! Send 10c for Catalog (tubes, electronic equipment) Barry, 512 Broadway, N.Y.C. 10012.

TUBES—Lowest prices. Foreign-American. Obsolete, receiving, special purpose, transmitting tubes. Send for tube, parts catalog. United Radio Company, 56-P Ferry St., Newark, N.J. 07105.

TAPE AND RECORDERS

OLD radio programs on tape. 6 hours for $8.00. Catalog 50¢. Don Maris. 1926 Cherokee, Norman, Okla. 73069.

STEREO TAPE RENTAL for particular people. Free catalog. Gold Coast Tape Library, Box 2262, Palm Village Station, Hialeah, Fla. 33012.

RENT 4-Track open reel tapes—all major labels—3,000 different—free brochure. Stereo-Parti, 55 St. James Drive, Santa Rosa, Ca. 95401.

BARGAIN MUSIC, Tape, Equipment Catalog, 25¢. Saxitone, 1776 Columbia Road, Washington, D.C. 20009.

EXCITING Apollo 11 moon landing tapes. Guaranteed $4.00. Specify speed. Box 2373, Van Nuys, California 91401.

REPAIRS AND SERVICES

TV Tuners rebuilt and aligned per manufacturers specification. Only $9.50. Any make UHF or VHF Ninety day written guarantee. Ship complete with tubes or write for free mailing kit and dealer brochure. JW Electronics, Box 51C, Bloomington, Indiana 47401.

CITIZEN'S Band radios repaired. Chicago Land Area. 312-455-1491.

INSTRUCTION

LEARN ELECTRONIC ORGAN SERVICING at home all makes including transistor. Experimental kit—trouble-shooting. Accredited NHSC, Free Booklet. **NILES BRYANT SCHOOL**, 3631 Stockton, Dept. A, Sacramento, Calif. 95820.

LEARN WHILE ASLEEP, Hypnotize! Strange catalog free. Autosuggestion, Box 24-ZD. Olympia, Washington 98501.

DEGREE in Electronics Engineering earned mostly by correspondence. Free brochure. Dept. G-9, Grantham School of Engineering, 1505 N. Western Ave., Hollywood, California 90027.

WANT AN F.C.C. 1st CLASS LICENSE? WANT TO BECOME A DISC-JOCKEY? REI has a school near you VA approved. Call toll free: 1-800-237-2251 or write REI, 1336 Main St., Sarasota, Florida 33577, Florida Residents call: 813-955-6922

HIGHLY effective home study courses in Electronics Engineering Technology and Electronics Engineering Mathematics. Earn your Degree. Write for Free Descriptive Literature. Cook's Institute of Electronics Engineering, (Dept. 15), P.O. Box 10634, Jackson, Miss. 39209. (Established 1945).

FREE brochure self-improvement books. Eldon McBrayer, 412 Arthur Street, Huntsville, Ala. 35805.

MEMORIZE, STUDY: "1971 TESTS-ANSWERS" FOR FCC FIRST AND SECOND CLASS LICENSE—plus—"Self-Study Ability Test." Proven! $9.95. Satisfaction guaranteed. Command, Box 26348-P, San Francisco 94126.

FCC LICENSE through tape recorded lessons. Radio License Training, 1060D Duncan, Manhattan Beach, Calif. 90266.

INVENTIONS WANTED

INVENTIONS wanted. Patented; unpatented. Global Marketing Service, 2420-P 77th, Oakland, Calif. 94605.

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. 9, Washington Patent Office Search Bureau, 711 14th Street, N.W., Washington, D.C. 20005.

INVENTORS! Don't sell your invention, patented or unpatented, until you receive our offer. Eagle Development Company, Dept. 9, 79 Wall Street, N.Y., N.Y. 10005.

FREE "Directory of 500 Corporations Seeking New Products." For information regarding development, sale, licensing of your patented/unpatented invention. Write: Raymond Lee Organization, 230-GR Park Avenue, New York City 10017.

PATENT SEARCHES, including copies of related United States Patents. Inventors, attorneys, manufacturers use our "World-Wide" Airmail service Free: "Invention Record" form and "Information Every Inventor Needs", Hayward Company, 1029HR Vermont, Washington, D.C. 20005.

INVENTORS: Protect your ideas! Free "Recommended Procedure". Washington Inventors Service, 422T Washington Building, Washington, D.C. 20005.

FREE PAMPHLET: "Tips on Safeguarding Your Invention." Write: United States Inventors Service Company, 501-H Thirteenth Street N.W., Washington, D.C. 20004.

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-J. Holland, Michigan 49423.

GOVERNMENT Surplus. How and Where to Buy in Your Area. Send $1.00. Surplus Information, Headquarters Bldg.-PE, Washington, DC 20036.

MANUALS for surplus electronic equipment. List 25¢. Books, 4905 Roanne Drive, Washington, DC 20021.

ARMY surplus electronics catalog, 10¢. Russell Electronics, 9410 Walhampton, Louisville, Kentucky 40222.

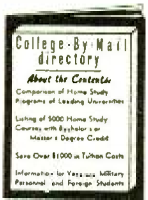
GOVERNMENT SURPLUS. Complete Sales Directory and Buying Guide $1.00. Surplus Publications, Box 26062-F, Los Angeles, Calif. 90026.

BOOKS

FREE catalog aviation/electronic/space books. Aero Publishers, 329PE Aviation Road, Fallbrook, California 92028.

FREE book prophet Elijah coming before Christ. Wonderful bible evidence. Megiddo Mission, Dept. 64. 481 Thurston Rd., Rochester, N.Y. 14619.

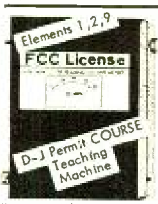
SELF-HELP BOOK CLUB SELF-HELP BOOK CLUB SELF-HELP BOOK CLUB
No membership rules. No minimum purchase. No contract to sign.



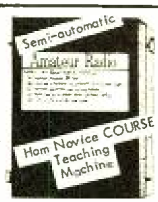
"..college education by mail. Save time, tuition. High school, too." Send $2

"....you quickly master trig, the key to technical advancement." Send $2

"...be a Disc Jockey. Success secrets and tips. FCC rules. facts." Send $2



"..you will pass the FCC 'Disc Jockey' exam on your first try." Send $5



"....includes all theory in Ham Novice exam. The #1 Hobby." Send $5

"..very valuable course for all Citizens Band (CB) radio licensees." Send $5

Enclosed is $__.00 plus 50¢ postage. To: SELF-HELP BOOK CLUB, Dept 50
My name, address, ZIP are attached. MILPITAS, CALIF. 95035
Please send me (list titles wanted):

AUTHORS' SERVICES

AUTHORS! Learn how to have your book published promoted, distributed. FREE booklet "ZD," Vantage, 516 West 34 St New York 10001.

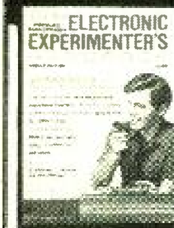
MAGAZINES

JAPAN PUBLICATIONS GUIDE Business, pleasure, education. $5.00. INTERCONTINENTAL, CPO 1717, Tokyo 100-91.

OVER 2,000,000 backdate magazines! Specify needs. Midtown, Box 917-PE. Maywood. New Jersey 07607.

INTERNATIONAL Magic Magazine monthly. Tricks, dealers, news. Three month trial $1.00. Genii, Box 36068-Z, Los Angeles, Calif. 90036.

ELECTRONIC EXPERIMENTER'S HANDBOOK



148 pages of the most fascinating and challenging construction projects for the electronic hobbyists. All with complete schematics, illustrations, parts list, and easy-to-follow instructions

1971 Winter edition ....$1.50..#33
1971 Spring Edition ....$1.50..#26
1970 Winter edition ....$1.35..#97
1970 Spring edition ....$1.50..#14
1968 Spring edition ....$1.25..#84

Order by number from
Ziff-Davis Service Div., 595 Broadway • N.Y., N.Y. 10012
Enclose an additional 35¢ per copy for postage and handling.
(Outside U.S.A. all magazines are $2.50 per copy, postpaid.)
PAYMENT MUST BE ENCLOSED WITH ORDER

BUSINESS OPPORTUNITIES

I MADE $40,000.00 Year by Mailorder! Helped others make money! Start with $10.00—Free Proof. Torrey, Box 318-N, Ypsilanti, Michigan 48197.

FREE BOOK "999 Successful Little Known Businesses" Work home, Plymouth 445-Y, Brooklyn, N.Y. 11216.

$200.00 DAILY In Your Mailbox! Your opportunity to do what mail-order experts do. Free details. Associates, Box 136-J, Holland, Michigan 49423.

MAKE BIG MONEY raising chinchillas, rabbits, guinea pigs for us. Catalog—25¢. Keeney Brothers, New Freedom, Pa. 17349.

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 { @ 80¢ (Reader Rate) / @ $1.25 (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.
PE571

HOW to make $1,000,000 in only ten years! Start with $10! Details Free! International Service, (PE), Box 11796, Atlanta, Georgia. 30305.

FREE CATALOGS. Repair air conditioning, refrigeration. Tools, supplies, full instructions. Doolin, 2016 Canton, Dallas, Texas 75201.

MAILORDER! Make big money working home. Free report reveals millionaire's trade secrets! Executive (1K5), 333 North Michigan, Chicago 60601.

PIANO TUNING learned quickly at home. Tremendous field! Musical knowledge unnecessary. GI Approved. Information Free. Empire School, Box 327, Miami, Florida 33145.

I MADE $2,000.00 Monthly by Mailorder—Evenings only. You can too! Free Proof! Kingman, Box 7227ZB, Erie, Penn. 16510.

SELL HERTEL BIBLES—Part Time. Finest reference Bible available. Demonstrator and supplies furnished. Excellent commissions. Write International Book, Dept. PE, Box 118, Wichita, Kansas 67201.

EARN $100.00 weekly. Postage, envelopes, etc. furnished. Details $1.00. Serviceg, P.O. Box 1573, Worcester, Mass. 01601.

MAILORDER MONEYMAKING KIT. Start home. Capital unnecessary. Free details, Pictures. Prudential, Box 327-PE2, Boston 02199.

CHINCHILLA income guaranteed. Terms: 25¢, bulletin $1.00, Rainbow, Port Richey, Fla. 33568.

HYPNOTISM

"MALE-FEMALE HYPNOTISM" EXPOSED, EXPLAINED! "SECRET METHOD"—THEY NEVER KNOW! $2, RUSHED. GUARANTEED! ISABELLA HALL, SILVER SPRINGS, FLORIDA 32688.

SLEEP Learning. Hypnotic method. 92% effective. Details free. ASR Foundation, Box 7021PE HC Station, Lexington, Ky. 40502.

HYPNOTIZE ELECTRONICALLY . . . or money-back! Television repairman's accidental discovery. Uses television set. $2. Elton's, Box 12167-PE, St. Petersburg, Florida 33733.

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.

RECORDS

POPULAR organ albums factory direct. Concert Recording, Lynwood, Calif. 90262.

SPECIAL interest records available, produced by the editors of the world's leading special interest magazines. Send for free catalog. Record Catalog-PE, Ziff-Davis Publishing Company, One Park Avenue, New York, N.Y. 10016.

RECORDS, Tapes, Below Wholesale. Top names. Johnny Cash, Ray Charles, etc. 50 45's $4.95. Albums, Tapes, 6 for $9.95 plus 15 Free 45's with purchase. Sample 45 and Album $2.00. Telstar Records, 1709 Vanstone, Loves Park, Ill. 61111.

TREASURE FINDERS

FREE TREASURE GUIDE! Fact-filled collectors edition; send 50¢ for postage. Also request free literature on ultrasensitive, professional Fisher Detectors. **FISHER RESEARCH,** Dept. PE-5, Palo Alto, California 94303.

GOLD, Silver, Relics! Located with powerful Detectron Metal Detectors. Free Informaton. Terms, Detectron, Dept. PE5, Box 243, San Gabriel, California 91778.

TREASURE FINDER locates buried gold, silver, coins, treasures. 5 powerful models. $19.95 up. Free catalog. Relco-A33, Box 10839, Houston, Texas 77018.

FREE: Jetco Electronics Free 24 page Treasure Finder catalog. Find metals, minerals, gold, silver, coins and relics, Jetco, Box 132 PE, Huntsville, Texas 77340.

PROFESSIONAL SPORTS FILMS

25¢ SAVES $1.00 on Big Time Sports Film Catalog! Super 8/8. **SPORTLITE,** Elect Dept, Box 24-500, Speedway, Indiana 46224.

RUBBER STAMPS

RUBBER ADDRESS STAMPS $2.00. SIGNATURE $3.50. FREE CATALOG. JACKSON'S, BOX 443-G, FRANKLIN PARK, ILLINOIS 60131.

YOUR Call Included! (Pocket.) $3.00. Brown's, 321 Price, Philadelphia, PA 19144.

MUSICAL INSTRUMENTS

30% DISCOUNT name brand musical instruments. Free catalog. Freeport Music, 127-N Sunrise Highway, Freeport, N.Y. 11520.

WHOLESALE! Professional Amplifiers, PA Systems, Guitars. Free Catalog. Carvin, Escondido, Calif. 92028.

GUITAR PLAYER MAGAZINE, Sample copy 25¢, 348 No. Santa Cruz, Dept. 26, Los Gatos, Calif. 95030.

GUITARIST'S DISCOUNT CATALOG, $1.00 including 10 free picks. Musicians Supply, Box 1368, Dept. R-1, Los Gatos, Calif. 95030.

GUITAR TUNING RECORD, 10 Ways demonstrated. Send $1.50. Guitar Player Magazine, 348 N. Santa Cruz, Dept. 116, Los Gatos, Calif. 95030.

MAGNETS

MAGNETS. All types. Specials—20 disc magnets, or 2 stick magnets, or 10 small bar magnets, or 8 assorted magnets, $1.00. Maryland Magnet Company, Box 192H, Randallstown, Maryland 21133.

REAL ESTATE

FREE . . . NEW SUMMER CATALOG! Describes and pictures hundreds of farms, ranches, town and country homes, businesses coast to coast! Specify type property and location preferred. Zip Code, please. **UNITED FARM AGENCY,** 612-EP West 47th St., Kansas City, Mo. 64112.

PERSONALS

MAKE FRIENDS WORLDWIDE through international correspondence. Illustrated brochure free. Hermes, Berlin 11, Germany.

INVESTIGATORS, LATEST ELECTRONIC AIDS. FREE LITERATURE. CLIFTON, 11500-K NW 7th AVE., MIAMI, FLORIDA 33168.

MISCELLANEOUS

WINEMAKERS: Free illustrated catalog of yeasts, equipment. Semplex, Box 12276, Minneapolis, Minn. 55412.

LIGHT bulbs, thousands sizes, specify—Jetronics, Box 67015ZD, Century City, Calif. 90067.

YOGURT MAKER, $8.95—Delicious, economical. Free brochure. FOODKITS, BX 111, Monmouth Junction, New Jersey 08852.

PROTECT Yourself Against Crime! Powerful Aerosol protection spray —legal to carry—$2.00; 3 for $5.00. Authentic Electronic Alarm Decals for auto, home, windows, etc. Two for $1.00; 12 for $5.00. J. Ross, 80-34 Kent St., Jamaica, New York 11432.

YOUR Classified or Display Classified Ad in these columns will be seen, read and regularly responded to by America's largest audience of Electronics Hobbyists. The cost is low—the results are high! Plan your campaign now by sending copy and payment to: Hal Cymes, Class. Adv. Mgr., POPULAR ELECTRONICS, 1 Park Ave., New York, N. Y. 10016.

POPULAR ELECTRONICS

MAY 1971

ADVERTISER'S INDEX

BUILD 20 RADIO

Reg. U.S. Pat. Off.

and Electronics Circuits

PROGRESSIVE HOME RADIO-T.V. COURSE

Training Electronics Technicians Since 1946

Now Includes
- ★ 12 RECEIVERS
- ★ 3 TRANSMITTERS
- ★ SQ. WAVE GENERATOR
- ★ SIGNAL TRACER
- ★ AMPLIFIER
- ★ SIGNAL INJECTOR
- ★ CODE OSCILLATOR

- ★ No Knowledge of Radio Necessary
- ★ No Additional Parts or Tools Needed
- ★ EXCELLENT BACKGROUND FOR TV
- ★ SCHOOL INQUIRIES INVITED
- ★ Sold in 79 Countries

YOU DON'T HAVE TO SPEND HUNDREDS OF DOLLARS FOR A RADIO COURSE

The "Edu-Kit" offers you an outstanding PRACTICAL HOME RADIO COURSE at a rock-bottom price. Our Kit is designed to train Radio & Electronics Technicians, making use of the most modern methods of home training. You will learn radio theory, construction practice and servicing. THIS IS A COMPLETE RADIO COURSE IN EVERY DETAIL.

You will learn how to build radios, using regular schematics; how to wire and solder in a professional manner; how to service radios. You will work the standard type of punched metal chassis as well as the latest development of Printed Circuit chassis.

You will learn the basic principles of radio. You will construct, study and work with RF and AF amplifiers and oscillators, detectors, rectifiers, test equipment. You will learn and practice code, using the Progressive Code, Oscillator. You will learn and practice trouble-shooting, using the Progressive Signal Tracer, Progressive Signal Injector, Progressive Dynamic Radio & Electronics Tester, Square Wave Generator and the accompanying instructional material.

You will receive training for the Novice, Technician and General Classes of F.C.C. Radio Amateur Licenses. You will build Receiver, Transmitter, Square Wave Generator, Code Oscillator, Signal Tracer and Signal Injector circuits, and learn how to operate them. You will receive an excellent background for television, Hi-Fi and Electronics.

Absolutely no previous knowledge of radio or science is required. The "Edu-Kit" is the product of many years of teaching and engineering experience. The "Edu-Kit" will provide you with a basic education in Electronics and Radio, worth many times the low price you pay. The Signal Tracer alone is worth more than the price of the kit.

THE KIT FOR EVERYONE

You do not need the slightest background in radio or science. Whether you are interested in Radio & Electronics because you want an interesting hobby, a well paying business or a job with a future, you will find the "Edu-Kit" a worth-while investment.

Many thousands of individuals of all ages and backgrounds have successfully used the "Edu-Kit" in more than 79 countries of the world. The "Edu-Kit" has been carefully designed, step by step, so that you cannot make a mistake. The "Edu-Kit" allows you to teach yourself at your own rate. No instructor is necessary.

PROGRESSIVE TEACHING METHOD

The Progressive Radio "Edu-Kit" is the foremost educational radio kit in the world, and is universally accepted as the standard in the field of electronics training. The "Edu-Kit" uses the modern educational principle of "Learn by Doing." Therefore you construct, learn schematics, study theory, practice trouble shooting—all in a closely integrated program designed to provide an easily-learned, thorough and interesting background in radio.

You begin by examining the various radio parts of the "Edu-Kit." You then learn the function, theory and wiring of these parts. Then you build a simple radio. With this first set you will enjoy listening to regular broadcast stations, learn theory, practice testing and trouble-shooting. Then you build a more advanced radio, learn more advanced theory and techniques. Gradually, in a progressive manner, and at your own rate, you will find yourself constructing more advanced multi-tube radio circuits, and doing work like a professional Radio Technician.

Included in the "Edu-Kit" course are Receiver, Transmitter, Code Oscillator, Signal Tracer, Square Wave Generator and Signal Injector Circuits. These are not unprofessional "breadboard" experiments, but genuine radio circuits, constructed by means of professional wiring and soldering on metal chassis, plus the new method of radio construction known as "Printed Circuitry." These circuits operate on your regular AC or DC house current.

THE "EDU-KIT" IS COMPLETE

You will receive all parts and instructions necessary to build twenty different radio and electronics circuits, each guaranteed to operate. Our Kits contain tubes, tube sockets, variable, electrolytic, micra, ceramic and paper dielectric condensers, resistors, tie strips, hardware, tubing, punched metal chassis, Instruction Manuals, hook-up wire, solder, selenium rectifiers, coils, volume controls and switches, etc.

In addition, you receive Printed Circuit materials, including Printed Circuit chassis, special tube sockets, hardware and instructions. You also receive a useful set of tools, a professional electric soldering iron, and a self-powered Dynamic Radio and Electronics Tester. The "Edu-Kit" also includes Code Instructions and the Progressive Code Oscillator, in addition to F.C.C. Radio Amateur License training. You will also receive lessons for servicing with the Progressive Signal Tracer and the Progressive Signal Injector, a High Fidelity Guide and a Quiz Book. You receive Membership in Radio-TV Club. Free Consultation Service, Certificate of Merit and Discount Privileges. You receive all parts, tools, instructions, etc. Everything is yours to keep.

Progressive "Edu-Kits" Inc., 1189 Broadway, Dept. 698D, Hewlett, N. Y. 11557.

FREE EXTRAS

• SET OF TOOLS

- SOLDERING IRON
- ELECTRONICS TESTER
- PLIERS-CUTTERS
- VALUABLE DISCOUNT CARD
- CERTIFICATE OF MERIT
- TESTER INSTRUCTIONS MANUAL
- HIGH FIDELITY GUIDE • QUIZZES
- TELEVISION BOOK • RADIO TROUBLE-SHOOTING BOOK
- MEMBERSHIP IN RADIO-TV CLUB: CONSULTATION SERVICE • FCC AMATEUR LICENSE TRAINING
- PRINTED CIRCUITRY

SERVICING LESSONS

You will learn trouble-shooting and servicing in a progressive manner. You will practice repairs on the sets that you construct. You will learn symptoms and causes of trouble in home, portable and car radios. You will learn how to use the professional Signal Tracer, the unique Signal Injector and the dynamic Radio & Electronics Tester. While you are learning in this practical way, you will be able to do many a repair job for your friends and neighbors, and charge fees which will far exceed the price of the "Edu-Kit." Our Consultation Service will help you with any technical problems you may have.

FROM OUR MAIL BAG

J. Stataitis, of 25 Poplar Pl., Waterbury, Conn., writes: "I have repaired several sets for my friends, and made money. The "Edu-Kit" paid for itself. I was ready to spend $240 for a Course, but I found your ad and sent for your Kit."

Ben Valerio, P. O. Box 21, Magna, Utah: "The Edu-Kits are wonderful. Here I am sending you the questions and also the answers for them. I have been in Radio for the last seven years, but like to work with Radio Kits, and like to build Radio Testing Equipment. I enjoyed every minute I worked with the different kits; the Signal Tracer works fine. Also like to let you know that I feel proud of becoming a member of your Radio-TV Club."

Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va.: "Thought I would drop you a few lines to say that I received my Edu-Kit, and was really amazed that such a bargain can be had at such a low price. I have already started repairing radios and phonographs. My friends were really surprised to see me get into the swing of it so quickly. The Trouble-shooting Tester that comes with the Kit is really swell, and finds the trouble, if there is any to be found."

UNCONDITIONAL MONEY-BACK GUARANTEE

Please rush my Progressive Radio "Edu-Kit" to me, as indicated below:

Check one box to indicate choice of model

- ☐ Deluxe Model $31.95.
- ☐ New Expanded Model $34.95 (Same as Deluxe Model plus Television Servicing Course).

Check one box to indicate manner of payment

- ☐ I enclose full payment. Ship "Edu-Kit" post paid.
- ☐ I enclose $5 deposit. Ship "Edu-Kit" C.O.D. for balance plus postage.
- ☐ Send me FREE additional information describing "Edu-Kit."

Name ....

Address ....

....

PROGRESSIVE "EDU-KITS" INC.

1189 Broadway, Dept. 698D, Hewlett, N. Y. 11557

PRINTED CIRCUITRY

At no increase in price, the "Edu-Kit" now includes Printed Circuitry. You build a Printed Circuit Signal Injector, a unique servicing instrument that can detect many Radio and TV troubles. This revolutionary new technique of radio construction is now becoming popular in commercial radio and TV sets.

A Printed Circuit is a special insulated chassis on which has been deposited a conducting material which takes the place of wiring. The various parts are merely plugged in and soldered to terminals.

Printed Circuitry is the basis of modern Automation Electronics. A knowledge of this subject is a necessity today for anyone interested in Electronics.

CIRCLE NO. 20 ON READER SERVICE PAGE

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

RCA-3A3C HIGH VOLTAGE RECTIFIER

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

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

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

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

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

RCA

The moving sound of moving sound.

The kind you get from Mallory's new lightweight, go everywhere cassette tape recorders.

They're pushbutton simple. And built to fit in with the excitement of living.

We have three solid-state models in three price ranges . . . something for everybody. And they come with a whisper-sensitive dynamic microphone, automatic recording level circuit, power-packed Duracell® batteries and a full-fidelity Duratape® cassette.

Mallory portable cassette tape recorders . . . when you're going places.

MALLORY

MALLORY DISTRIBUTOR PRODUCTS COMPANY

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

MCR 1204
Slim, neat, light. Battery operated. 3½" dynamic speaker and dynamic mike. For kids, teenagers . . . even Mr. Businessman.

MCR 1232
Total go-anywhere entertainment. Recorder and superb AM/FM radio. AFC, pop-up cassette ejector, built-in antenna. In a slim, tough case. The music-maker.

MCR 1209
Great everywhere. Batteries or AC plug-in. Pushbutton operation. Slim, easy to carry, pack. Dynamic speaker and mike. The perfect gift.

Batteries • Capacitors • Controls • CRIME ALERT® • DURATAPE® | Recorders | Resistors • Semiconductors • SONALERT® • Switches • Timers

CIRCLE NO. 4 ON READER SERVICE PAGE