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DECEMBER 1968

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Mike with ears

The gadget in the photo may look a bit eerie, but it's described by its developers as the next step after stereo. Called Environ-Ears, it's basically a two-microphone assembly with an "integrated acoustical labyrinth that duplicates the localization and noise-reducing functions of the human ear." Developed by Listening, Inc., Arlington, Mass., and used in Navy-backed research, Environ-Ears resembles two human ears mounted at opposite ends of a rod.

It is claimed to be ideally suited for recreating the actual sounds at the original recording session—for everything from business conferences to symphonies—since it simulates in playback the actual physical positions of the sounds recorded. Used with a conventional stereo recorder, its developers say it permits the listener to differentiate between sounds from below, in front of, or behind the microphone, and eliminates reverberation and extraneous environmental noises as much as human ears do. It's currently priced at a rather steep $950, but lower-priced versions could be forthcoming.

FM on the rise

There's no let up in sight for the groundswell in the popularity of FM radio. In the first half of this year, 44 percent of the table, portable and clock radios purchased in the US contained FM, as compared with only 35 percent one year earlier. It now seems entirely possible that the majority of radios sold in the coming year will contain FM tuners.

Interestingly, the overwhelming majority of FM radios sold here—more than 86 percent in the first six months of 1968—were imported, mostly from Japan. Even FM radios carrying the trademarks of American radio manufacturers have a better than 50-50 chance of coming from abroad.

In the automotive market, FM is moving more slowly. For January through June 1968, a little less than 10 percent of all car radios sold as original equipment or after-market, "hang-ons" could tune the FM band. This represents a small increase over FM's 8.4 percent penetration of the car radio field in the first half of 1967.

Cassettes—how hi the fi?

Can a high-fidelity enthusiast find happiness with a tape that moves at 17% inches per second? Apparently some of the major component audio equipment manufacturers think he can and will, in the latest chapter of the amazing saga of the tiny, Dutch-born two-reel cassette. Although its original acceptance came in a battery-operated, voice-recorder format, such audio-philic manufacturers as Ampex, Fisher, Harman-Kardon and H. H. Scott have now embraced the cassette recorder.

Unquestionably, there's a trade off between fidelity and convenience in the use of the cassette, whose response is around 20-12,000 Hz. But many manufacturers feel this won't always be the case. The very success of the cassette is spurring an all out effort to extend its characteristics into the high fidelity range, while improving on its convenience as a music playback medium. Cassette units using high-density tape, such as DuPont's Crolyn, will soon be available. High-quality precision recorder mechanisms have already been developed to reduce flutter by maintaining very constant speed. One manufacturer, TEAC of Japan, soon will offer a two-speed cassette recorder, which will include a double-fast 3 3/4 ips for high-fidelity recording.

For greater convenience in music playback, several manufacturers are developing automatic-reverse cassette recorders and players. And there's a race on for an endless-loop cassette that never has to be rewound. Philips of Holland and Sony and TDK of Japan are among the leading entries in this effort.

Mail by phone

The increasing availability of low-cost facsimile systems which can send graphic material over regular telephone lines without the need for special treated paper or other supplies is giving birth to a new public "mail-by-phone" industry.

At least four "networks" of public facsimile stations are now in operation, under the names of Docu-Trans, Insta-Fax, Transceiver Corporation and Tele-Trans. They have set up shop in major US cities to offer long-distance document transmission facilities to the general public. Charges generally are around $2.50 to $3.00 per standard 81/2-by-11-inch page—plus the regular long-distance telephone charge for the 6 minutes required to send a page of copy.

All of the networks currently use a facsimile system developed by the Magnavox Company (photo), which is available on lease from the Xerox Corporation under the name of Xerox Telecopier or from Magnavox under the Magnafax name. A single machine is used for both transmission and reception. For transmission, the material to be sent is affixed to a revolving drum and the telephone handset placed in a special cradle. A photocell scanner converts the light and dark material on the page into audible signals. At the receiving end, a standard carbon-paper set (a sheet of carbon attached to a piece of manifold paper) is placed on the drum, and a stylus recreates the original copy. R-E
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NEW ARM WORKS WITH THOUGHT SIGNALS

Artificial arm is willed into operation, producing natural arm-like movements.

A new electronically controlled artificial arm that promises greatly increased dexterity for amputees has been developed. The system uses a solid-state, sensor-amplifier package and a unique feedback circuit that enables operators to sense how much weight they are supporting.

Amputees, by willing a non-existent arm into action, contract stump muscles that generate millivolt-level signals. Sensors in the system detect and amplify these signals, and the operator can apply varying degrees of force by “thinking” the amount of effort needed.

Developers believe that with a little experience amputees can use the new arm with no more conscious thought than is needed for a normal one. Similar systems under consideration may aid some 7000 Thalidomide children with above-elbow stumps.

The 2-lb arm is powered by a battery that can be worn around the waist. Although it is not available for general use, the arm could be mass-produced for less than $1000 each. The mechanism was developed in a joint project by MIT, Harvard, Massachusetts General Hospital and Liberty Mutual Insurance.

DIM LIGHT TV CAMERAS

Two highly sensitive TV-camera tubes have been developed independently by Bell Telephone Labs and Westinghouse. The new devices have potential applications for see-in-the-dark surveillance TV and Picture-phones that permit people to see each other as they talk. The Westinghouse system is an offshoot of similar devices used in military and space applications (“Starlight Scope Sees in the Dark,” August 1968). The camera tube uses the principle of secondary electron conduction, which “amplifies” light by accelerating electrons from a photocathode onto a sensitive target. The camera system shown here weighs only 12 lbs, draws 17 watts and can provide clear TV pictures under moonlight conditions.

Bell revealed a camera tube they plan to use in their Picturephone. A

Diagram shows how signals are detected by sensors and amplified to operate motors.

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(continued on page 12)

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<th>I.F. OUTPUT</th>
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</tr>
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<tr>
<td>CR6P</td>
<td>Parallel 6.3v</td>
<td>1¼&quot; 3&quot;</td>
<td>41.25 45.75</td>
<td>8.95</td>
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<tr>
<td>CR7S</td>
<td>Series 600mA</td>
<td>1¾&quot; 3&quot;</td>
<td>41.25 45.75</td>
<td>9.50</td>
</tr>
<tr>
<td>CR9S</td>
<td>Series 450mA</td>
<td>1¾&quot; 3&quot;</td>
<td>41.25 45.75</td>
<td>9.50</td>
</tr>
<tr>
<td>CR6XL</td>
<td>Parallel 6.3v</td>
<td>2½&quot; 12&quot;</td>
<td>41.25 45.75</td>
<td>10.45</td>
</tr>
<tr>
<td>CR7XL</td>
<td>Series 600mA</td>
<td>2½&quot; 12&quot;</td>
<td>41.25 45.75</td>
<td>11.00</td>
</tr>
<tr>
<td>CR9XL</td>
<td>Series 450mA</td>
<td>2½&quot; 12&quot;</td>
<td>41.25 45.75</td>
<td>11.00</td>
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*Selector shaft length measured from tuner front apron to extreme tip of shaft.

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NEWS BRIEFS

(continued from page 6)

by NASA scientists to determine if man can create artificial aurora light formations in the atmosphere. This electron accelerator system will be carried 120-180 miles into space by an Aerobee rocket to fire a stream of charged particles toward the atmosphere. The gun's reed-switching mechanism, which fits an 8"-deep gun platform assembly, is in the foreground. Device was built by Ion Physics Corp.

'FLIPPED' CRYSTAL DELAY LINE

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TELEVISION FROM SPACE

India is planning a pilot project for 1971 in which TV broadcasts from a satellite will be received directly by 10,000 community receivers and rebroadcast to three times as many sets by vhf stations. Plans call for eventually broadcasting directly to all of the country's villages and cities. NASA is cooperating with the Indian Government, and will provide communication channels for Indian use aboard a synchronous satellite to be orbited above the Indian Ocean in 1971.

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You can't get a better buy for your new hi-fi system than a Shure cartridge, whether it's the renowned "Super Track" V-15 Type II at $67.50 or the new M91E Easy-Mount "Hi-Track" at $49.95, made in the tradition of all fine Shure cartridges. If you're new to hi-fi, benefit from the published opinions of experts the world over: the Shure V-15 Type II Super Track makes a decidedly hearable difference. If you want to spend less, the M91E is right for you. You can always "trade-up" to a V-15 Type II at a later date. Shure Brothers, Inc., 222 Hartrey Avenue, Evanston, Illinois 60204.

NEW! M91E Hi-Track Elliptical Cartridge with optimized design parameters for trackability second only to the Incomparable V-15 Type II. Bi-radial .002" x .0037" diamond stylus. 20-20,000 Hz. Channel Separation: more than 25 db @ 1 kHz. Tracking force range ± 1/2 grams. Trackability specifications @ 1 gram: 25 cm/sec @ 400 Hz.; 28 cm/sec @ 1 kHz; 25 cm/sec @ 5 kHz; 18 cm/sec @ 10 kHz; 54 db.

Circle 15 on reader's service card
CONVERSATION PIECE.

Just look at the Pace Base! Forget for a second that it's the complete CB two way radio that needs no extras. What makes it more unusual is how it looks. So attractive, so decorative. With wood grained cabinet and elegant over-all appearance, even the lady of the house likes to have it around. The Pace Base Station is neat—and complete. Included in one unit are standing wave ratio meter, power meter, S meter and variable output control mike. All for $330.00.

See your electronic dealer or write us.

((P)) PACE COMMUNICATIONS CORP.
24049 S. Frampton Avenue, Harbor City, California 90710
ENGINEERED WITH THE ENGINEER IN MIND
Circle 16 on reader's service card

NEW RESISTANCE BRIDGE

Recently the United States Patent Office granted me a patent on a new resistance measuring bridge.

To measure the resistance of an ordinary carbon resistor, we normally use an ohmmeter. But an ohmmeter is unreliable when measuring the resistance of a 1/2% wirewound resistor. To measure the resistance of such precision wirewound resistors we use a Wheatstone bridge.

But resistance can be measured to a remarkable degree of perfection. Many instruments have been made that depend on resistance change to measure temperature, chemical composition, strain, etc. To measure the temperature from the planet Mars requires something more accurate than a Wheatstone bridge. The Bucher bridge, my invention will do it.

The Bucher bridge will measure as accurately one mile from the unknown resistor as it will three inches

I WANT AN INDEX

Just looked at the December 1967 index and from what I saw, I would very much like you to continue with your annual indexes.

In earlier indexes (1950's) the big problem was that you had to look under almost all the headings to find what you were after and even then you might only get part of what was covered in that year since the Correspondence, Noteworthy Circuits, and Try This One columns usually weren't listed.

One idea which I would like to see you incorporate is to publish the yearly index and also an index covering a period of five or ten years.

KEITH MUDDLE
Stratford, Ont., Canada

We'll compromise. There will be an index in the December 1968 issue. But it will be shortened somewhat. It will list all articles and monthly columns. However, it will not break down each department in detail. The space we save will be used to present you with an extra article.

14 RADIO-ELECTRONICS
Wouldn't you like your wife to give you a 160 VOM this Christmas?

Right now at participating Simpson distributors ... the 160 Christmas package. Your wife buys the 160 Handi-VOM® for you—and receives a bonus for herself. Two free pairs of famous Kayser gloves!

Kayser, as your wife knows, is the quality fashion glove sold in fine stores. She'll receive a black and a white pair, in stretch nylon, free with the Simpson 160.

And you will get the one hand-size VOM with full-size VOM accuracy and sensitivity. Its virtually friction-free Taut Band movement is protected by a varistor from even 200,000% overloads. The five resistance ranges, combined with low millivolt and microvolt ranges, are just what's needed for work on today's solid-state circuits.

Your Simpson distributor has been allotted only a limited supply of special 160 Christmas packages—so hurry!

Look for the special Simpson 160 Christmas Package at your local Electronic Parts Distributor

160 Handi-VOM® complete with batteries, test leads, and operator's manual...$53.00

SIMPSON ELECTRIC COMPANY
5200 W. Kinzie Street, Chicago, Illinois 60644 • Phone (312) 379-1121

DECEMBER 1968
IN ELECTRONICS CALCULATING

Still plodding through math and electronics problems the slow pencil-and-paper way? Smash the paperwork barrier with this new Electronics Slide Rule.

Even if you’ve never used a slide rule before, you can whiz through resonant frequency calculations and inductive or capacitive reactance problems. You can find reciprocals for resistance formulas instantly. You can even locate tricky decimal points in a jiffy.

You can also work regular math problems in a flash: multiplication, division, square roots, logarithms, trigonometry.

Anyone can use this sturdy 12-inch, all-metal slide rule. We show you how with our complete 4-lesson instruction course. Slide rule, course, and handsome leather carrying case deliberately priced low as our way of making friends with men in Electronics. FREE booklet gives full details. Mail coupon below today.

MAIL THIS COUPON FOR FREE BOOKLET

Cleveland Institute of Electronics
1776 E. 17th St., Cleveland, Ohio 44114

Please send me, without charge or obligation, your booklet describing the Electronics Slide Rule and 4-lesson instruction course. Also FREE if I act at once—a handy, pocket-sized Electronics Data Guide.

Name

Address

City State Zip

Accredited Member National Home Study Council A Leader in Electronics Training Since 1934 RE-129

Circle 12 on reader’s service card

Build this pipelike Schober Recital Organ for only $1725!

You couldn’t touch on organ like this in a store for less than $4,000—and there never has been an electronic instrument with this vast variety of genuine pipe-organ voices that you can add to and change any time you like! All four families of formal pipe tones are present in variety to delight players of classical and religious music. Yet you can change the entire organ for popular and theatrical sounds, or plug in special voices for baroque, romantic, or modern repertoires. If you’re dreamed of the sound of a large pipe organ in your own home, if you’re looking for an organ for your church, you’ll be more thrilled and happy with a Schober Recital Organ than you could possibly imagine—kit or no kit.

You can learn to play it—and a full-size, full-facility instrument is easier to learn on than any cut-down “home” model. And you can build it, from Schober Kits, world famous for ease of assembly without the slightest knowledge of electronics or music, for design and parts quality from the ground up, and—above all—for the highest praise from musicians everywhere.

Send right now for the full-color Schober catalog, containing specifications of all five Schober Organ models, beginning at $599.50. No charge, no obligation. If you like music, you owe yourself a Schober Organ!

The Schober Organ Corp., Dept. RE-61
43 West 61st Street, New York, N.Y. 10023

☐ Please send me Schober Organ Catalog and free 7-inch “sample” record.

☐ Enclosed please find $1.00 for 12-inch L.P. record of Schober Organ music.

NAME

ADDRESS

CITY STATE ZIP

Circle 18 on reader’s service card

from the same unknown resistor.

Fig. 1 shows a conventional Wheatstone bridge. Figs. 2, 3 and 4 are forms of the Bucher bridge. Fig. 2 is the hexagon bridge. Fig. 3 is the octagon bridge. Fig. 4 is the decagon bridge.

DR. J. F. BUCHER
2980 River Road
Eugene, Ore.

Hate to say it, Doctor, but you’re a tease. You’ve got to tell us more.

How does the bridge work? What’s your patent number? How do you make those long-distance measurements? Put it all together and you may end up with an article R-E readers would find fascinating.

EAVESDROPPING DROPOUT

Len Buckwalter’s article, “Eavesdrop on Aircraft, Fire & Police” was interesting (August 1968). But like all other articles on the subject, he neglected the 450-470-MHz band.

In Fig. 1 the band is listed and that’s about it. Not a word is mentioned about converters or receivers. A few converters are available for that band. They are not easy to locate, but do exist. The Ameco model CUT is probably the best on the market. Olsen sells one called the Clark 450. And the Electra Corp. makes two units called the Little Tiger and the Eavesdropper Jr.

KEN GREENBERG
Chicago, Ill.

Ok, Ken, you’ve filled that gap yourself. Thanks for the comments. But until 450-470-MHz gear is readily available at reasonable prices, many readers cannot get it.

R-E

www.americanradiohistory.com
Another benchwarmer?

Not this one. Our new B&K Diagnostic Oscilloscope is more than re-engineering of an old model to keep pace with TV technology. It is instead a basic departure from all other oscilloscopes. A departure that has simplified a complex instrument to make it easier for you to use. But there's something else. What this oscilloscope has is exclusive. An Intermittent Analyzer with electronic memory—and optional remote Audio/Visual Alarm.

With it, the elusive intermittent conditions that make so many TV sets tough dogs can now be detected and identified in your absence. Preset one control. When the faulty stage is detected, you'll know about it as soon as you come back from service calls. Then run the scope overnight to check another set for an intermittent condition. All this adds up to greater shop efficiency, more time for profit-making service calls and a lot more mileage out of a very fine diagnostic oscilloscope. An oscilloscope that shows vector patterns exactly as specified by color TV manufacturers. (All vectorscope inputs and controls are conveniently located on the front panel.) Also allows you to read peak-to-peak voltages in all ranges on a double-scale calibrated screen—just by turning a switch. (As the range is selected, the appropriate scale lights automatically.)

Automatic synchronization locks in all patterns at any signal level or frequency. There are also fewer controls and these are positioned for easier operation.

Give our Diagnostic Oscilloscope some thought. It's worth it not to be sidelined with a benchwarmer. See your B&K Distributor or drop us a note for detailed literature on Model 1450 and our full-line test equipment catalog, AP-24.

DIAGNOSTIC OSCILLOSCOPE
Model 1450, Net: $279.95

B & K Division of DYNASCAN CORPORATION
1801 W. Belle Plaine • Chicago, Illinois 60613
Where electronic innovation is a way of life.
Two more examples of how RCA Institutes provides up-to-the-minute Home Training in all phases of electronics:

NEW CATV LESSONS

The demand is heavy for technicians in the booming field of CATV (Community Antenna Television Systems).

CATV was initially used to make it possible for large numbers of television receiver users to get good reception in remote areas through the use of a common antenna. It now brings to more people more programs than are available from local stations. It also improves reception where multipath signal transmission exists.

RCA Institutes includes two comprehensive lessons, covering the practical phases of CATV systems and servicing in Television Servicing and Communications courses and programs at no additional total tuition cost. Get in on the ground floor of this rewarding and expanding field. Send for full information today!

NEW COLOR TV KIT

To make courses even more practical and to better prepare you for a more rewarding future, RCA Institutes now includes an exciting Color TV Kit in both the beginner's program and the advanced course in color TV servicing. The cost of the kit is included in the tuition—nothing extra to pay. You also get five construction/experiment manuals plus a comprehensive service manual.

You'll receive all the materials and components to perform over 50 information-packed experiments. When you finish you'll have constructed an 18" (measured diagonally) high quality, color TV set, complete with rich cabinet in wood grain design.

Get all the details on RCA Institutes' valuable new Color TV Kit!
Learn electronics at home faster, easier, almost automatically—with RCA AUTOTEXT

Are you just a beginner with an interest in the exciting field of electronics? Or, are you already earning a living in electronics and want to brush-up or expand your knowledge in a more rewarding field of electronics? In either case, AUTOTEXT, RCA Institutes’ own method of 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.

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

Thousands of well paid jobs in electronics go unfilled every year because not enough men have taken the opportunity to train themselves for these openings. RCA Institutes has done something positive to help men with an aptitude and interest in electronics to qualify for these jobs.

HOME STUDY CAN TRAIN YOU FOR REWARDING CAREER OPPORTUNITIES

To help fill the “manpower gap” in the electronics field, RCA Institutes has developed a broad scope of Home Training courses, all designed to lead to a well paying career in electronics in the least possible time. You also have the opportunity to enroll in an RCA “Career Program” exclusively created to train you quickly for the job you want! Each “Career Program” starts with the amazing AUTOTEXT Programmed Instruction Method. And, all along the way, your program is supervised by RCA Institutes experts who become personally involved in your training and help you over any “rough spots” that may develop.

VARIETY OF KITS ARE YOURS TO KEEP

To give practical application to your studies, a variety of valuable RCA Institutes engineered kits are included in your program. Each kit is complete in itself, and yours to keep at no extra cost. You get the new Programmed Electronics Breadboard for limitless experiments, including building a working signal generator, multimeter, and a fully transistorized superheterodyne AM receiver.

ONLY FROM RCA INSTITUTES—
TRANSISTORIZED TV KIT—
VALUABLE OSCILLOSCOPE

All students receive a valuable oscilloscope. Those enrolled in the Television program receive the all-new transistorized TV Kit. Both at no extra cost and only from RCA Institutes.

CHOOSE THE “CAREER PROGRAM” THAT APPEALS MOST TO YOU

Start today on the electronics career of your choice. Pick the one that suits you best and mark it off on the attached card.

- Television Servicing
- Telecommunications
- FCC License Preparation
- Automation Electronics
- Automatic Controls
- Digital Techniques
- Industrial Electronics
- Nuclear Instrumentation
- Solid State Electronics
- Electronics Drafting

ADVANCED TRAINING

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

2 CONVENIENT PAYMENT PLANS

RCA Institutes offers a unique tuition plan that lets you progress at your own pace. You only pay for lessons as you order them. You don’t sign a contract obligating you to continue the course.

There’s no large down-payment to lose if you decide not to continue.

However, if you desire, RCA Institutes also offers a convenient monthly payment plan.

CLASSROOM TRAINING ALSO AVAILABLE

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

JOB PLACEMENT SERVICE, TOO!

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

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

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

Accredited Member National Home Study Council
SIGNAL TRACING COLOR TV

There are a couple of color TV circuits that we ought to get straightened out. It'll make things easier, when you run into color trouble—all colors or any one color that isn't what it ought to be.

Check the picture tube first, of course, and try new tubes in the demodulators and bandpass amplifiers. After that, if you've still got the same trouble, try signal tracing.

The signal to check comes from the bandpass amplifier and goes through the three demodulators to the picture-tube grids. Put a color-bar signal into the set and follow it with—you guessed it—a scope. Incidentally, a wide-band scope is not absolutely essential for this, though it's nice. You can use a narrow-band scope, but a low-capacitance probe is necessary. What you follow is practically an audio waveform. The 10 color bars are basically a waveform with a fundamental of about 160 kHz. (Each "bar" is a pulse at 157.5 kHz.)

Take the red signal, for instance. Look at it on the grid of the red (R—Y) amplifier (Fig. 1). This odd-looking pattern means that the red gun conducts whenever the peaks of the "bar" signal drop below the imaginary center line of the waveform. Each pip is one bar. On that basis, the third bar from the left should be the brightest—pure red. If you kill the blue and green guns, that's what you'd see.

You're on the grid, so the negative signal peaks make the tube's plate current drop and the plate voltage rise. You get a positive voltage peak on the plate. Since this is de-coupled to the red CRT grid, it makes that gun conduct more, causing a brighter red bar.

The plate waveform should look exactly like the grid waveform but inverted (Fig. 2). Gain? Easy to check. First read the p-p amplitude of the grid signal. Then read the plate waveform the same way. The normal p-p amplitudes are usually on the schematic, but even if they aren't, you can tell from the ratio between the two.

In a Motorola 908 chassis, for instance, there's about 13 volts p-p on
Scott's new LR-88 receiver takes the
out of kit building

Building a kit used to be something you couldn’t do with ladies and children present, but Scott’s new LR-88 AM/FM stereo receiver kit has changed all that. First, there’s the instruction manual. In clear and simple language, it leads you, step-by-step, through every stage of the assembly process. And each stage is illustrated... full-size, full-color. Next, there’s Scott’s ingenious new Kit-Pak®. The parts for each assembly stage are in individual compartments, keyed to the instructions. All wires are color-coded, and pre-cut and pre-stripped to the proper sizes. Difficult or critical sections are pre-wired, pre-aligned, pre-tested, and factory-mounted on printed circuit boards. Is soldering your bugaboo? Scott has provided push-on solderless connectors for the hard-to-get-at spots.

About thirty painless hours after you’ve started, you’ve completed one great receiver. The LR-88 is the 100-Watt kit brother to Scott’s finest factory-wired beauties. It includes the famous Scott silverplated Field Effect Transistor front end, Integrated Circuit IF strip, all-silicon output circuitry... in fact, all the goodies that would cost you over a hundred dollars more if Scott did all the assembling. Performance? Just check the specs below... and you’ll be amazed at how great a receiver sounds after you’ve built it yourself. Treat yourself to a weekend of fun and years of enjoyment... see the Scott LR-88 at your dealer’s today.

**LR-88 Control Features:** Dual Bass and Treble; Loudness; Balance; Volume compensation; Tape monitor; Mono/stereo control; Noise filter; Interstation muting; Dual speaker switches; Stereo microphone inputs; Front panel headphone output; Input selector; Signal strength meter; Zero-center meter; Stereo threshold control; Remote speaker mono/stereo control; Tuning control; Stereo indicator light.

**LR-88 Specifications:**
- Music Power rating (IHF), 100 Watts @ 4 Ohms;
- Usable sensitivity, 2.0 μV; Harmonic distortion, 0.6%; Frequency response, 15-25,000 Hz ± 1.5 dB; Cross modulation rejection, 80 dB; Selectivity, 45 dB; Capture ratio, 2.5 dB; Signal/noise ratio, 65 dB; Price, $334.95.

**You’ll swear by it**

Write for complete information on the new Scott components and kits.

H.H. Scott, Inc., Dept. 570-10, Maynard, Mass. 01754
Export: Scott International, P.O. Box 277, Maynard, Mass. 01754

Walnut case optional extra © 1968, H. H. Scott, Inc.
The RCA WT-509A Picture Tube Tester is a precision instrument in the famous RCA tradition. It tests both color and black and white picture tubes for emission quality, interelectrode leakage, and shorted elements. It’s all solid-state AND IT’S ONLY $118.00.*

The RCA WR-64B Color-Bar/Dot/Crosshatch Generator has for years been the finest instrument of its type. Exceptionally stable, portable, it’s a precision instrument designed for use in the laboratory and factory as well as for servicing on-the-bench and in-the-home. AND IT’S ONLY $129.00.*

The RCA WR-502A "CHRO-BAR" color-bar generator has even more features than the famous WR-64B. It’s all solid-state, battery operated. It provides color bars, dots, crosshatch, vertical lines, horizontal lines, blank raster. It has rock-solid stability. All new circuit design. THE "CHRO-BAR" IS ONLY $168.00.*

*Optional Distributor resale price.
For a complete catalog of descriptions and specifications for all RCA test equipment see your RCA Test Equipment distributor or write RCA Electronic Components, Commercial Engineering, Department No. L-39WA, Harrison, N.J. 07029.
The RCA WR-50B RF Signal Generator with sweep features is versatile, portable, and exceptionally well suited for alignment and signal tracing of AM, FM, hi-fi and citizen's band receivers and trouble-shooting in nearly all sections of TV receivers. IT'S ONLY $65.00.* Also available in an easy to assemble kit, WR-50B(K).

The RCA WA-504A Transistorized Sine/Square Wave Audio Signal Generator covers a frequency range from 20 Hz to 200,000 Hz with exceptional frequency stability. For use in audio, hi-fi and general electronics applications, as well as in electronics training, demonstrations and lab work. ONLY $95.00.*

The RCA WR-70A RF/IF/VF Marker Adder is designed for use with conventional markers and sweep generators such as the RCA WR-39, WR-89 and WR-99 series calibrators and the WR-59 and WR-69 series sweep generators to produce clean, narrow markers on the sweep-response curve on an oscilloscope. AND IT'S ONLY $96.00.*

The RCA WP-700A and WP-702A Power Supplies are extremely reliable, solid-state, constant voltage DC power supplies that provide 0 to 20 volts dc at current levels up to 200mA. WP-702A is actually identical to WP-700A, except it is a dual unit with two complete power supply sections. WP-700A IS ONLY $40.00* in quantities over five, and WP-702A IS ONLY $73.00* in quantities over five. Prices on less than five units are $48.00* and $87.00* respectively.

The RCA WR-69A Television/FM Sweep Generator is designed for lab, service, and production applications for sweep-frequency alignment of color and black and white TV receivers and broadcast FM receivers. It's also used to align VHF tuners, picture-and-sound IF amplifiers, video amplifiers and chrominance circuitry in color TV receivers. AND IT'S ONLY $295.00.*

The RCA WR-99A Crystal-Calibrated Marker Generator combines in one compact, accurate, and stable instrument the functions of a multiple-marker generator, crystal calibrator and a heterodyne frequency meter. Ideal for servicing and aligning color and black and white TV receivers, communications and other equipment in the frequency range of 19 to 260 MHz ONLY $256.50.†

*Optional Distributor resale price.

†For a complete catalog of descriptions and specifications for all RCA test equipment see your RCA Test Equipment distributor or write RCA Electronic Components, Commercial Engineering, Department No. L-39WB, Harrison, N. J. 07029.

Look to RCA for Instruments to Test/Measure/View/Monitor/Generate

December 1968

Circle 23 on reader's service card

www.americanradiohistory.com
NEW DELTA DESIGN!
MODEL 3000 FET VOM

A unique and efficient instrument bridging the gap between a multimeter and a digital voltmeter!

Delta, pioneer of the famous Mark Ten® CD System, now offers a compact, versatile, and extremely sensitive VOM which combines FETS and ICs for extreme accuracy. Compact (6½" W x 8½ H x 3½" D), portable, wt. 3½ lbs. In full production at only $74.95 ppd.

Would you believe:
1. Mirror scale 200- A D'Arsonval meter
2. Integrated circuit (IC) operational amplifier for extreme accuracy
3. FET input stage with current regulator
4. Two stage transistor current regulator and Zener diode on OHMS for absolute stability and accuracy
5. Voltage clippers for protection of input stage
6. Fully temperature compensated for low low zero drift
7. Ten turns ZERO and OHMS adjust potentiometers
8. Epoxy glass circuit boards and metal case
9. Enclosed switches
10. Uses readily available type AA cells
11. Uses standard test leads for maximum flexibility and ease of measurement
12. 10 Megohms input impedance

Available in Kit form:
Feedback network with pre-selected components to eliminate all final calibration. Ready to use when assembled!

Kit: Only $59.95 ppd.

DELTA PRODUCTS, INC.
P.O. Box 1147, Grand Junction, Colorado 81501

I enclose $________________ Please send postpaid:
________________________________________ Model 3000 FET VOMs @ $74.95 assembled
________________________________________ Model 3000 FET VOMs @ $59.95 kit form

Name_________________________ Address________________________
City/State____________________ Zip_________________________

COMING NEXT MONTH
In January, Service Editor Jack Darr looks at some peculiar problems caused by faulty bandpass amplifier and burst circuits. What happens to scope patterns and color bars with weak burst or sync? How do you check interaction between the horizontal hold control and color sync?

Circle 24 on reader's service card

RADIO-ELECTRONICS 26
NEW FINCO
COLOR SPECTRUM™ ANTENNAS are "signal customized" for better color reception...

"the ANTENNA that captures the RAINBOW"

FINCO has developed the Color Spectrum Series of antennas — "Signal Customized" — to exactly fit the requirements of any given area.

There is a model scientifically designed and engineered for your area.

Check this chart for the FINCO "Signal Customized" Antenna best suited for your area.

<table>
<thead>
<tr>
<th>STRENGTH OF UHF SIGNAL AT RECEIVING ANTENNA LOCATION</th>
<th>VHF SIGNAL STRONG</th>
<th>VHF SIGNAL MODERATE</th>
<th>VHF SIGNAL WEAK</th>
<th>VHF SIGNAL VERY WEAK</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO UHF</td>
<td>CS-V3 $11.50</td>
<td>CS-V5 $18.50</td>
<td>CS-V7 $25.95</td>
<td>CS-V10 $37.95</td>
</tr>
<tr>
<td>NO VHF</td>
<td>CS-V5 $18.50</td>
<td>CS-V7 $25.95</td>
<td>CS-V10 $37.95</td>
<td>CS-V15 $50.95</td>
</tr>
<tr>
<td>UHF SIGNAL STRONG</td>
<td>CS-A1 $19.95</td>
<td>CS-B1 $31.50</td>
<td>CS-C1 $45.95</td>
<td>CS-C1 $45.95</td>
</tr>
<tr>
<td>UHF SIGNAL WEAK</td>
<td>CS-A2 $23.95</td>
<td>CS-B2 $41.95</td>
<td>CS-G2 $54.95</td>
<td>CS-B3 $73.50</td>
</tr>
<tr>
<td>UHF SIGNAL VERY WEAK</td>
<td>CS-A3 $32.50</td>
<td>CS-G3 $52.95</td>
<td>CS-D3 $62.95</td>
<td>CS-D3 $73.50</td>
</tr>
</tbody>
</table>

NOTE: In addition to the regular 300 ohm models (above), each model is available in a 75 ohm coaxial cable downlead where this type of installation is preferable. These models, designated "XC3", each come complete with a compact behind-the-set 75 ohm to 300 ohm balun-splitter to match the antenna system to the proper set terminals.

THE FINNEY COMPANY
34 West Interstate Street · Dept. RE · Bedford, Ohio 44146

Circle 25 on reader's service card
"He's a good worker. I'd promote him right now if he had more education in electronics."

Could they be talking about you?

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

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

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

CREI Programs cover all important areas of electronics including communications, radar and sonar, even missile and spacecraft guidance. You're sure to find a program that fits your career objectives.
You're eligible for a CREI Program if you work in electronics and have a high school education. Our FREE book gives complete information. Airmail postpaid card for your copy. If card is detached, use coupon at right or write: CREI, Dept. 1412G, 3224 Sixteenth St., N.W., Washington, D.C. 20010.

CREI, Home Study Division
McGraw-Hill Book Company
Dept. 1412G, 3224 Sixteenth Street, N.W.
Washington, D.C. 20010

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

NAME__________________________________AGE______________
ADDRESS__________________________________________________
CITY________________________STATE____________ZIP CODE________
EMPLOYED BY________________________________________________

TYPE OF PRESENT WORK___________________________☐ G.I. BILL
☐ Electronic Engineering Technology
c☐ Space Electronics  ☐ Nuclear Engineering Technology
☐ Industrial Electronics for Automation
☐ Computer Systems Technology

APPROVED FOR TRAINING UNDER NEW G.I. BILL
DIGITAL COMPUTERS ARE BEING USED IN EVER-INCREASING numbers in business data processing, in industrial control and in scientific laboratories. They are vital to the military as well as for the guidance systems of space explorations. With this sharp upward trend in computer use, the demand for computer programmers is at an all-time high. Estimates state that over 500,000 people are already engaged in some form of computer programming or operation, and another 250,000 will be needed within the next few years. And this is only in the United States.

A programmer tells the computer of the particular problem or data to be processed, indicates the methods to be used and debugs faulty programs. He communicates with the computer by using the "language" the computer understands or a mathematically oriented or business-type "language," which is translated into the computer's basic language.

The binary code

Digital computer circuits operate in only two states: the diodes or transistors are either on or off. This assures accuracy and reliability because changes in transistor characteristics or other solid-state devices do not affect the two states unless the component shorts or opens. The two states represent digits 1 and 0—hence digital computer.

The use of only 0 and 1 requires a binary-type math with a base 2 instead of base 10, as in our ordinary numbering system. This binary code is the basic language of all digital computers. The following table shows binary numbers ranging in value up to 19:

<table>
<thead>
<tr>
<th>Base 10</th>
<th>Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>Representation</td>
</tr>
<tr>
<td>0</td>
<td>00000</td>
</tr>
<tr>
<td>1</td>
<td>00001</td>
</tr>
<tr>
<td>2</td>
<td>00010</td>
</tr>
<tr>
<td>3</td>
<td>00011</td>
</tr>
<tr>
<td>4</td>
<td>00100</td>
</tr>
<tr>
<td>5</td>
<td>00101</td>
</tr>
<tr>
<td>6</td>
<td>00110</td>
</tr>
<tr>
<td>7</td>
<td>00111</td>
</tr>
<tr>
<td>8</td>
<td>01000</td>
</tr>
<tr>
<td>9</td>
<td>01001</td>
</tr>
<tr>
<td>10</td>
<td>01010</td>
</tr>
<tr>
<td>11</td>
<td>01011</td>
</tr>
<tr>
<td>12</td>
<td>01100</td>
</tr>
<tr>
<td>13</td>
<td>01101</td>
</tr>
<tr>
<td>14</td>
<td>01110</td>
</tr>
<tr>
<td>15</td>
<td>01111</td>
</tr>
<tr>
<td>16</td>
<td>10000</td>
</tr>
<tr>
<td>17</td>
<td>10001</td>
</tr>
<tr>
<td>18</td>
<td>10010</td>
</tr>
<tr>
<td>19</td>
<td>10011</td>
</tr>
</tbody>
</table>

Note the pattern of the binary sequence. In the right-hand column (first place) the 0's and 1's alternate; in the second column from the right the 0's and 1's are paired, while in the third column from the right the sequence down the column is four 0's, four 1's, etc. Subsequent columns follow the same pattern related to the sequence 1, 2, 4, 8, 16, 32, 64, etc. Thus the fifth column from the right will have 16 0's, followed by 16 1's, etc. Knowing this principle enables you to expand the table easily.

The computer uses this binary code to identify storage locations, to identify instructions from the programmer regarding how to process data and to make computations directly. Programs consist of a sequence of instructions, each accompanied by a storage address or explanatory number. Thus, the binary numbers 000100 and 000101 might mean, "add to the accumulator the number in storage location 5." The first binary number, 000100, is the "add" instruction and the second number the address of the number to be added. Another set, such as 101010 and 001000 may indicate a shift command. Thus, the binary 101010 instructs the computer to shift a number right, while the binary 001000 indicates an 8-place number shift.

Octal code

Since the early days of digital computers, design engineers have strived to simplify the programming processes. Binary code becomes cumbersome when large numbers are involved, such as 101101 = 45, and 1000110 = 70. Thus, if 70 meant "subtract" we would have to convert it to its binary form. While there are various methods (including conversion tables) to find binary equivalents, much time is wasted. A simpler method is to group the binary digits into sets of three to form what is known as the octal code, as shown in the following examples:

101 101 = octal 55 (true value = 45)
001 110 = octal 16 (true value = 14)
101 001 011 = octal 513 (true value = 331)

Thus, all instructions and storage addresses can be in octal coding to expedite entries. Often the pushbuttons on the computer console are in groups of three to facilitate punching in numbers. If the computer binary address value of 331 is needed, you would be given octal 513 instead. By entering a binary 5, followed by a 1, and a 3, we have 101 001 011. The computer senses this as 101001011, which has the true value of 331.
New Machine Languages

![Diagram of computer systems](https://example.com/diagram.png)

**Fig. 1—Step sequence for translating mnemonic and SPS programs into binary language. Initial program is punched on cards or tape, which are read by compiler. The computer then reads the object deck generated by the compiler.**

Binary and octal codes permit us to enter programs at the computer console and examine numerical binary displays for checking the status of a program or process. It would be much more convenient, however, if we could do without the binary or octal numbers for the programming instructions.

**Mnemonic or SPS language**

We could save programming time if we could use the actual words add, multiply and divide, or abbreviations of them in our instructions to the computer. To do this we must use some sort of translating system to tell the computer that add means binary 100, and shift means binary 101010, etc. This is done by using capitalized abbreviations such as MPY for multiply, DIV for divide, etc. We could also use just A for add, S for subtract, M for multiply or D for divide. Such coding is also known as mnemonic (aid-to-memory) or SPS (symbolic program system). Thus, a simple program for adding of 5 + 3 would be:

```
LDA 50 (Put the 5 into accumulator)
ADD 51 (Add 3 to accumulator contents)
STP 00 (Stop computation)
```

In this example, the 5 would have had to be placed into storage location 50 and the 3 into 51. Also, the entire program would have been stored within the computer's memory earlier. Once the data and program are loaded, the program initiating button is depressed and the program run. Thus, the addresses in which the program itself is stored must also be indicated, as shown in the following example, where a print-out instruction is also included:

<table>
<thead>
<tr>
<th>Program</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Instruction</td>
</tr>
<tr>
<td>00</td>
<td>LDA</td>
</tr>
<tr>
<td>01</td>
<td>ADD</td>
</tr>
<tr>
<td>02</td>
<td>PRT</td>
</tr>
<tr>
<td>03</td>
<td>STP</td>
</tr>
</tbody>
</table>

The translating of mnemonic and SPS programs into machine (binary) language is done by assembler programs, which also select storage locations automatically. The program is punched on cards or paper tape and fed into the assembler. Another deck of cards is automatically punched containing the binary-language equivalent, and these cards are read by the computer. The initial stack of cards which contains the mnemonic program is called the source deck, and the resultant cards from the assembler program are called the object deck. These terms are also used for other language procedures, as shown in Fig. 1.

**FORTTRAN language**

The word FORTRAN is an acronym formed by using the letters from the phrase: FORMula TRANslator. It is a mathematically oriented computer language that permits us to make math statements almost in the same form as the original equation. A special translator (called a compiler) selects appropriate storage locations and converts the FORTRAN into machine language to be processed by the computer.

Though programming math with FORTRAN is easier than with the mnemonic coding method (particularly for complex math equations), a number of rules must be observed. Among them are that all capital letters must be used, and that multiplication is expressed by an asterisk (*). Divide is shown by using the slash (/) and exponents are identified by a double asterisk (**). Thus, if we wanted to indicate the equation \((a - b)c^2\) it would appear as:

\[(A - B) \times C^{**2}\]

Similarly, the **FORTRAN** expression for the equation

\[y = \frac{a + b}{c}\]

would be written as:

\[Y = (A + B)/C\]

Such statements are not, however, the complete program—but only the mathematical portion. The computer must be told what values \((a, b, \text{etc.})\) to read, in what manner, and what is to be printed out. The complete program would have the following:

```
READ 1, A, B, C
Y = (A+B)/C
PRINT 2, Y
STOP
1 FORMAT (3F10.4)
2 FORMAT (F12.4)
END
```

The **READ** statement tells the computer to read three variables (from cards or tape) designed as A, B and C, in the manner designed by a later FORMAT statement identified by the 1 preceding it. Thus, if we check with the FORMAT statement identified by the "1" we find that three variables are involved (the "3" in 3F10.4) and that the field width (F) is 10 characters, with four characters pointed off. The PRINT statement indicates the answer (Y) is to be printed out as identified by FORMAT 2. The latter states that 12 total characters are to be allocated, with four decimal places.

A compiler is used to translate, and the program (on the source deck) is translated into machine language on the object deck. As with the assembler, the object deck is fed into a card or tape reader and then into the computer for processing. In the FORTRAN program, STOP tells the computer when to stop computation, and END tells the compiler the program is finished.

Other statements are used in FORTRAN to permit the computer to undertake "decision" type operations, modify...
the program as required and perform other manipulations. Program errors are sensed by the compiler and clues printed out so that the programer can locate the errors or note the use of incorrect statements.

COBOL language

As with FORTRAN, the word COBOL is an acronym made up of the initial letters of the phrase: Common Business Oriented Language. Like FORTRAN, COBOL can be used with any computer if the proper compiler is used for translating it into machine language.

COBOL uses the English language directly and is made up of selected words to express the series of operations which the computer is to execute in business data processing. Hence, COBOL uses letters, numbers and punctuation marks to form descriptive or instructional sentences. However, COBOL must be written by following certain rules, just as our English language uses rules of grammar. Curiously, when a written COBOL program is examined by a nonprogramer he can understand most of the commands and data descriptions, but could not write such a program without knowing the rules.

Verbs are used for instructional commands, and nouns for denoting the nature of the data to be processed. Capital letters are used, such as READ, WRITE, OPEN, CLOSE, DISPLAY, etc. for verbs. Nouns would include FILE, PAYROLL, INVENTORY, etc. The verbs ADD, SUBTRACT, MULTIPLY and DIVIDE can also be used, or as in FORTRAN, for PL/I must, of course, be used for translating this language into machine language.

In PL/I statements are written on a single line as in FORTRAN, and parenthesis are used (not brackets). Thus, Y = a + b/a - b becomes:

\[ Y = (A + B)/(A - B); \]

Note that a semicolon is used to indicate statement end instead of the period. As with COBOL, verbs and nouns are used to indicate instructions or descriptions. For example:

\[ DECLARE (COST, PRICE, DISCOUNT); \]
\[ COST = PRICE - DISCOUNT; \]

These two statements tell the computer that we are “declaring” that the program concerns cost, price and discount rates. Then we tell the computer that it determines cost by subtracting the discount from the price. Actually you could declare any name you wish and the computer will reserve a storage area for it and act accordingly when the same word is used again later in the program. Thus, you could even declare PHILODENDRON or OSHKOSH and the computer will accept them on your say-so and process them as you wish!

Also, in PL/I the programer may insert any comments he wishes into a program and can specify that such comments are not to be acted on by the computer, but are just for the programer's information. He does this by using the symbols "/*" before the comment and ending it with "/**". Thus, anything stated within these "/*" and "/**" signs is ignored by the computer.

Other languages

The most widely used computer programing languages today are FORTRAN and COBOL. PL/I is making some inroads, but is still too new to be universally accepted or used. In certain specialized areas, however, other programing languages are used. ALGOL (algebraically oriented language) has been popular in Europe and also used to some extent in America. FORTRAN IV, however, incorporates some aspects of ALGOL and is, of course, also a mathematically oriented computer language. Others are MAD (Michigan Algorithm Decoder) and JOVIAL (Jule's Own Version of International Algebraic Language). All have specific rules and the written program must follow them to be valid.

A mathematical programer does not have to solve an equation (the computer does this) but he should know how to set it up in the algorithm (format) most suitable to computer processing. Similarly, a data-processing programer doesn't have to know accounting, but a fundamental knowledge of business operations and basic bookkeeping is certainly helpful.

Where can you learn programing? At trade schools (advertised in this magazine); at technical schools, community colleges, business colleges, and many other institutions of learning. Leading computer companies also offer courses and often give aptitude tests in logic to determine your ability and leanings toward this interesting and lucrative profession.

Numerous textbooks are available from various publishers on all aspects of programing. Many such books are of the "programed" type, which are intended for self-instruction. (Actual exposure to the operating principles of a computer is, of course, extremely helpful.) If you like checkers or chess as well as other games of logic, you might be a natural.

See page 98 for a list of schools offering courses in computer technology and programing.
Stereo Headset Control Center

Easy-to-build battery-powered transistor circuit costs about $10.
Just feed in a 0.1-volt stereo signal

By WAYNE LEMONS

Ever try to find a simple, inexpensive, high-fidelity, stereo headphone amplifier circuit? It isn't easy. Stabilizing diodes, specially matched transistors, unusual parts and exotic feedback circuits may be nice to have, but they aren't always needed.

It was with economy (around $10) and simplicity in mind that this circuit was evolved. It uses no unnecessary parts (unless you think tone and volume controls are unnecessary). The transistors are inexpensive (about 40¢ each), and there are no transformers.

It works with either low- or high-impedance phones about equally well. The frequency response is slightly better with low-impedance phones, but your ears will have to be pure gold to tell the difference.

Current drain is low, and lower still if the vol-
Volume control is not turned up full. Even at full volume a set of penlight cells will last 200 hours or more.

There's no on-off switch because unplugging the phones automatically disconnects the battery. Ganged volume controls are used, but they could have been separate. Individual tone controls are used, but they could have been ganged.

A 0.1-volt input produces ample headphone volume. Input may be up to about 0.5 volt at full volume before noticeable distortion occurs. For higher input voltages, turn down the volume control to remove any overload distortion in the circuit.

The 220,000-ohm base resistors prevent the bias from going to zero when the volume is turned all the way down. Depending on its position, the volume control varies the bias. This permits the circuit to draw less current at low volume and still operate with very good fidelity.

A single resistor (R6) bypassed by a 100-pF capacitor (C5) provides protective bias for all four transistors.

Fig. 1—Emitters of input transistors Q1 and Q3 are direct-coupled to the output transistors. Collector voltage is fed through the earphones. The setting of the tone controls determines both the amount and frequency of inverse corrective feedback.

Front panel of the headphone amplifier was made from ¼"-thick colored plastic. Lettering was placed on white cardboard, which is beneath the plastic. Flat sides of transistors face each other for one channel, away for the other as shown in Fig. 2.
Amplifier gain is ample for all cartridges except low-output phono types. It is an ideal amplifier for turntables with ceramic cartridges or for use with a stereo FM tuner.

Incidentally, you can use npn silicon transistors by simply reversing the battery connections. Germanium transistors will not work without modifying the circuit. Many germanium transistors will work if you will add a 1000-ohm resistor from point A in the schematic to ground.

**How it works**

The two amplifiers are identical, so consider only the operation of the left channel in Fig. 1. Signal is coupled into the base circuit through C1, the 0.01-μf isolation capacitor. A 2-megohm volume control adjusts the input level to the 220,000-ohm base resistor. Transistors connected this way have a fairly high input impedance, so large input resistances can be used.

Transistor Q1's emitter is direct-coupled to the base of transistor Q2. Collectors of both transistors are tied together. Bias for the circuit is supplied through the 1-megohm tone control. The 220,000-ohm base resistor and the lower part of the volume control act as a bleeder on the bias voltage.

When the volume control is turned all the way down, R2 is grounded and bias is reduced. As the volume control is turned up, bias on Q1 increases, causing it and transistor Q2 to draw more current.

Collector voltage is fed through the earphones from the battery. The connection of the bias resistor to the collector also results in some inverse feedback. The amount of feedback and its frequency is dependent on the tone control setting.

With the tone control adjusted so that C3 is at the collector end, there is maximum feedback of high frequencies. This in turn, because of the inverse feedback, reduces the amplifier gain at high frequencies and appears to improve bass response.

When the tone control is adjusted with C3 at the base end, feedback is essentially the same for all frequencies. The inverse feedback tends to provide a "leveling" action on higher-frequency signals, which are enhanced by earphone inductance so that response is essentially flat when C3 is at the base end of the control.

**Construction hints**

A perforated board can be used to mount the transistors (see Fig. 2). Other parts are also mounted on the board except those that can be mounted elsewhere more conveniently. Figure 3 shows dimensions of the front panel. Layout is not critical and a different arrangement can be chosen if desired. For example, by using a printed circuit and miniature controls, this amplifier could be built into a very small area.

If you want to go "electric," use any filtered 6-10-volt dc power supply with an output current of 12 mA or more. Figure 4 shows a simple supply you can build yourself, but any of the small power supplies designed for transistor radios will work. By rearranging parts you could install the power supply in the amplifier box.

Any way you do it, you'll be pleased with the performance and stability of this unpretentious little amplifier.

---

**Fig. 2**—Transistors are mounted directly on perforated board and the leads soldered together. Parts layout is not critical. The board used is 13/8" x 2". A PC board can be made even smaller.

**Fig. 3**—Panel layout of amplifier. An ac/dc power supply can be installed.
BUILD FOR YOUR CAR

50-Watt Portable AC Outlet

By Jack Jaques Technical Manager
HEP Motorola Inc., Phoenix, Arizona

Here's an inexpensive, efficient, convenient, compact source of 115-Vac, 60-Hz power from your car, camper or motorboat 12-Vdc battery. It offers an opportunity to eliminate the inconvenience of battery, propane and gasoline lights in boat, camp or camper. The 50-watt rating is ample to operate the HEP Guitar Amplifier (see RADIO ELECTRONICS, November 1968, p. 37) and other utilities such as a small TV set, portable hi-fi, soldering iron, electric shaver, lights, radio, etc. For example a 25-watt light, a 14-watt fan and a 3-watt radio can be used simultaneously without exceeding the 50-watt rating. Thus, by using this inverter and the battery in your vehicle, "boondock" or beach-party singouts are a lot more fun.

A pair of power transistors operated as a magnetically coupled multivibrator are the heart of this device (Fig. 1). Transformer T1 provides the coupling. It is a standard 24-volt, 2-amp, center-tapped filament transformer. However, it is modified by adding another center-tapped secondary winding on the periphery of the existing wire bundle. The new winding consists of 12 turns of No. 22 plastic-covered hookup wire. The space between the frame and the existing wire bundle of the transformer permits installing the new winding (Fig. 2).

The added winding forms the base circuit of transistors Q1 and Q2. The 12-Vdc input from the auto or boat electrical system is applied via TS1 to the secondary center taps of the transformer. The original secondary winding forms the collector circuit of Q1 and Q2. Its center tap provides the negative or return circuit to TS1, and the dc supply. Resistor R1 establishes the turn-on bias voltage for Q1 and Q2. The value of R1 (180 ohms) assures that the transistors will begin oscillating (alternately turning on and off) under all conditions. R2 and C1–C2 set the frequency of oscillation, approximately 60 Hz. Diode D1 prevents unwanted voltage spikes from appearing at the bases of Q1 and Q2.

When voltage is applied to T1's new 12-turn secondary, Q1 and Q2 turn on and off (oscillate) in an alternate sequence. As each
**PARTS LIST**

- **C1, C2**: 1000 µF, 15 V, electrolytic
- **D1**: 1 amp, 1000 piV, silicon diode, HEP-160 (Motorola)
- **J1**: Chassis mounting ac receptacle
- **Q1, Q2**: HEP-230 (Motorola)
- **R1**: 180 ohms, 1/2 W, 5%
- **R2**: 3300 ohms, 1/2 W, 5%
- **T1**: Filament transformer; pri 115 vac; sec 25.2 V, 2 A (Triad F-41X)
- **TS1**: Terminal strip, barrier type, 2-terminal
- **Chassis**: 5" x 7" x 2"
- **Cigarette lighter cable** (optional)
- **Power transistor mounting kit** (2) HEP-450 (Motorola)
- **Terminal strip, 10 lugs**
- **Misc. wire, hardware**

---

**Fig. 1**—Inverter circuit is conventional and straightforward. It converts 12 volts dc into 115 volts ac. You can draw up to 50 watts of ac power from the compact unit.

---

1. Stretch two 6’ lengths of No. 22 insulated wire side by side (use two colors, say blue and green). Place the blue wire above green wire.

2. Refer to Fig. 2. Position T1 so the side with two black leads faces you. This side will be considered the front in these instructions.

3. Leave 4” of leads and pull the remainder of both wires toward the back through the left slot between the frame and wire bundle. Start near the bottom.

4. Bring the wire around the back of wire bundle and through the slot between it and the frame on right side toward you.

5. Continue to wind wires in this manner until 12 turns are wound on the back side (6 blue, 6 green). Keep the blue wire on top in each pair of turns. Keep turns parallel, uncrossed and snug to the wire bundle.

6. Pull turns 11 and 12 through the slot at the top of the wire bundle on right side. Ample length should remain for leads.

7. Label leads per Fig. 2, using small pieces of masking tape.

8. Apply liberal amount of coil dope or cement to hold winding in place.

---

**Fig. 2**—How to add a winding to the inverter transformer.
transistor conducts, current flows alternately between the extremes and the center tap of the original T1 secondary, first in one half, then in the other. This conduction causes a magnetic field to build up in the alternate halves of the winding, which collapses when the current flow ceases due to transistor turnoff. This alternating buildup and collapse of the magnetic field in the secondary causes an alternating voltage to be induced across T1's original primary. The ratio of the number of turns in the two windings is chosen so that the transferred output is stepped up to 115 volts. The 115 volts, which is still at the same frequency as the oscillating input circuit (60 Hz), is delivered to output connector J1, where it is available for operation of the amplifier, lights or other low-wattage appliances as desired.

**Using the inverter**

Operating the inverter is extremely simple. There are no controls. Just connect TS-1 to a source of 12-volt dc. Then plug the 115-Vac appliance into J1.

**CAUTION**

Correct polarity of the 12-Vdc input must be maintained. The inverter cannot be used in a car with the positive post of the battery connected to the body (ground). Check foreign cars in particular if the cigarette lighter adapter is used.

A cable with a plug that mates with the cigarette lighter receptacle is available and is recommended as one convenient way to connect the unit to the dc source. Be sure the auto battery is in good condition. Do not overload the inverter with appliances requiring more than 50 watts of power. Do not use excessively long power cords since this added resistance will reduce the power available for operating appliances.

**CAUTION**

Do not attach the inverter directly to the auto body. For rigid mounting to the auto, use insulating sleeves and isolate the inverter chassis with a mat of foam rubber ⅛" thick.
It's Easy To Fix Solid-State TV

The circuits may be different but they do tend to be simpler

By MATTHEW MANDL
CONTRIBUTING EDITOR

TRANSISTOR TVs ARE NOT FAILURE-proof. They operate at lower voltages than tube types, but component ratings are correspondingly lower, and failures do occur. We still run into sweep faults, mistuned circuitry and an occasional transistor failure.

Often, when low-gain transistors are used, extra stages are needed to get maximum performance. As a result, additional trouble possibilities exist. So we still have average run-of-the-mill faults, some troublesome intermittentts and even the occasional multiple-trouble conditions of tube TV. Basic circuit knowledge always expedites servicing, as the following case histories emphatically indicate.

An even half-dozen

A good example of visual multiple troubles is shown in Fig. 1. Here, five faults are easily recognized. At the upper right we have corner shadow, at the center screen we have ghosts, at the left we have dark vertical bars, throughout the screen we have adjacent-channel interference (changing diagonal line segments) and poor focus. When the brightness control was turned up, the picture bloomed, making a total of a half-dozen faults at once.

Even though six faults are in evidence, circuit knowledge would indicate only two defective areas are contributing to the symptoms. The ghosts and dark vertical bars could be antenna troubles, as could the adjacent-channel interference lines. The blooming, focus and corner shadows could be caused by troubles in the high-voltage system.

A high-voltage check showed only 15 kV at the second anode of the pix tube, instead of the 20 kV specified for this Zenith 1Y21B55 receiver. Using a scope and working back toward the horizontal oscillator we tried to localize the bad stage.

The horizontal sweep system for this set is shown in Fig. 2. Note how much simpler these transistor circuits...
are than tube types. Because of the output transistor's low output impedance no transformer is needed between it and the deflection coils. Both the damping and focus rectifier diodes connect directly to the output transistor's collector.

To develop enough drive, however, a horizontal driver stage follows the horizontal oscillator. Note the ferrite sleeve around both the base and emitter leads of the output transistor. It is an inductive-type shield for stabilizing sweep function.

The scope pattern at the collector of the output transistor was some 100 V below normal. While this might indicate a defective transistor, before changing it, the scope was attached to the collector of the driver transistor. Here, the waveform was not only low in amplitude but differed from the normal waveshape. Distortion appeared at the flat-top section (see Fig. 3). A check at the horizontal driver input base, however, showed normal drive signals (2.1 V peak-to-peak). Thus, the trouble was localized to the driver stage.

Resistors and capacitors were checked and found good, but an in-circuit check of the transistor showed poor emitter—collector conduction and reduced gain. A new transistor returned normal high voltage and focus voltage and eliminated the blooming and corner shadow. The interference lines, left vertical bars and ghosts were still there.

A check of the antenna system revealed that the antenna did not turn when the antenna-rotator control-box bar was depressed. The trouble was a defective 80-pF ac type capacitor in the control box. (Always check this item first before deciding that the rotator motor is defective.)

Now, with the antenna free to rotate, the ghosts and vertical left bars disappeared. Remaining, however, were the wiggling adjacent-channel interference lines, though only on channel 10. A slight readjustment of the lower adjacent-channel trap (4.75 MHz) eliminated this interference.

An Admiral 2H5 receiver had the symptoms shown in Fig. 4. While the general appearance is similar to Fig. 1, the trouble indications are not all the same. Again, some interference lines are present as is some defocusing. The overly dark areas indicate video signal overload, possibly age troubles. If so, this could also contribute to the poor focus.

Adjusting the age control had no effect. Voltage readings were taken at the age gate circuit shown in Fig 5 next. Base and collector voltages were ok, but the emitter voltage was several volts above normal. A component check in the emitter circuit showed, not only an open 0.47-µF bypass capacitor, but a increased-value resistor. Instead of 220 ohms, it read several thousand ohms. Such a large change in resistance in a low-voltage, low-current circuit is not common. It is more likely for a resistor worked near its wattage rating continuously to develop such a change.

New components in the age circuit cleared up most of the trouble. In this receiver there are three terminal settings for focus—A, B and C. Changing from B to C improved focus. With normal age function and no video overload, the faint interfering lines also disappeared.

In the early production runs for this receiver, some parasitic oscillations would occur on occasion when component values in the third video i.f. amplifier were off far enough to affect critical circuit operation. Later production receivers incorporated a 100-pF capacitor across the 1000-ohm base resistor shown in Fig. 6. When servicing such sets, this capacitor should be added, even though no symptoms of picture instability or cut-off appear.

Intermittent sound and sync

In a Magnavox T921 9" portable, both sound and sync were intermittent. The sound would fade for a few seconds, then return for several minutes. Both vertical and horizontal sync would be lost for several minutes, then return to normal for a half-hour or more.

In this receiver a sync amplifier and phase splitter npn transistor followed the sync separator, as shown in Fig. 7. The sync amplifier feeds the horizontal phase detector diodes (connected across emitter and collector). The vertical oscillator is fed from the collector. All voltages and components checked ok in both the sync separator and the amplifier, as did the transistors with an in-circuit tester.
A scope was attached to the collector of the sync amplifier to observe the waveform (see Fig. 7). We wanted to note any change when the intermittent occurred. Any intermittent in the sync separator would also be noted here, and since both horizontal and vertical sync were affected, the trouble had to be ahead of the sweep oscillators.

After a while the intermittent recurred and the scope pattern changed to that shown in Fig. 8. A transient signal appeared along the positive base line of the sync pulses. This oscillatory condition in the sync amplifier was most likely caused by a change in characteristics of the transistor rather than of circuit resistors and capacitors. Thus, even though a checker indicated no faults in the transistor, it was thought that the collector and ground to read —11.2 V, but little difference was noted during the intermittent.

Next, a vtm was placed between the collector and ground to read —11.2 V, but little difference was noted during the intermittent. The vtm was placed between the base and the ground. Now, when the intermittent occurred, we lost the —1 V at the base. This is a pnp transistor and forward bias requires that the base be negative with respect to the emitter. Normally the —1 V at the base and the —0.8 V at the emitter provide a negative voltage at the base (—0.2 V). When base voltage drops to zero the forward bias is lost. In some transistors cutoff occurs for zero forward bias (or reverse bias where the emitter is negative with respect to the base).

Since collector voltage (—11.2 V) was not affected, it appeared obvious that the 47,000-ohm dropping resistor was causing the trouble. While we expect intermittents to occur in transistors, capacitors and diodes, it is unusual for resistors to act intermittently, particularly in low-voltage circuits. A new resistor, however, cured this trouble.

**Fig. 7—Sync amplifier used in Magnavox T921 chassis. Defects in this circuit were causing intermittent sound and sync.**

**Fig. 8—Scope pattern revealed a transient along the base line of the sync pulses. A defective transistor was the problem.**

**Fig. 9—Intermittent sound was the problem, but the circuit appeared normal. Careful monitoring with a vtm revealed that the 47K voltage-dropping resistor was bad.**
ABC's of Transistors

Here's how they work

Transistors have puzzled technicians for nearly a decade and there appears to be no sign of easing the strain. Each year more transistorized equipment is introduced in both television and hi-fi equipment. To keep up to date we must learn efficient transistor servicing procedures.

Many articles have been devoted to transistor troubleshooting and all of them have leaned heavily on theory. But many successful technicians working on vacuum-tube circuits do not have a solid foundation in vacuum-tube theory, so perhaps the solid-state troubleshooter does not necessarily need theory. Let's look at transistors from a troubleshooter's standpoint and minimize the theory.

For those of you with experience with tubes here is a comparison of transistors and tubes: A transistor is somewhat like a tube: Corresponding elements are:

- **Tube**—Transistor
- **Cathode**—Emitter
- **Grid**—Base
- **Plate**—Collector

There are two important differences:
1. The tube is a voltage amplifier.
2. The transistor is a current amplifier.

The grid of a tube usually has an opposite potential to the cathode and plate of a tube, but the transistor base potential is between the emitter and collector potentials.

Just two diodes

Transistors are further complicated as there are two types which operate with opposite bias and supply voltage polarities.

Yet it is easy to determine proper polarities for bias and supply voltages and what voltages we can expect in standard circuit configurations for each type.

The two basic types are, of course, pnp and npn. Physical and electrical characteristics of pnp and npn transistors are shown in Fig. 1. Both transistors are shown electrically as two diodes wired back to back. In the pnp type the cathodes are tied together, in the npn type the anodes are connected. The junction represents the base connection with the emitter or collector at either end.

Two common symbols for both pnp and npn transistors are in Fig. 2. Note that the arrows in both the diodes and the transistor symbol point in the same direction. Remember this and you cannot go wrong.

**Normal circuit parameters**

In conventional circuits a small forward bias, normally 0.2 to 0.7 volt, is applied to the emitter junction. An easy way to remember which polarity is required to forward-bias a junction is to note that, when a negative voltage is applied to an n-element and a positive voltage to a p-element of a pn junction, it is forward-biased. This is shown in Fig. 3. The letters tell you the crystal type in each element. That is, pnp stands for p-type (crystal) emitter, n-type base and p-type collector. Npn stands for n-type emitter, p-type base and n-type collector.

In other words, for a forward-biased emitter junction, a pnp transistor requires a negative voltage on the base with respect to the emitter. To forward-bias an npn transistor emitter junction a positive voltage on the base, with respect to the emitter, is required.

The collector circuit, on the other hand, requires a back-bias or reverse bias. So in a pnp transistor, a negative voltage

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is required on the collector with respect to the base and the opposite for an npn transistor. Circuits with these typical configurations are shown in Fig. 4. Note that the bias batteries are connected so they aid one another.

The need for biasing

Biasing is used in transistor circuits for the same reason that it is used in tube circuits—to set up a static operating point. Without proper bias, what was intended to be a class-A amplifier might operate class-B.

The simplest bias is accomplished with a single-resistor network. A common-emitter amplifier with a single bias resistor is shown in Fig. 5. Since the emitter-junction resistance is quite low, the base bias current can be calculated by dividing the bias voltage by base bias resistor. The base resistance is ignored because it is very small compared to the base bias resistor.

In Fig. 6-a, the negative terminal of the power supply is grounded. In Fig. 6-b, the positive terminal of the power supply is grounded. Each circuit’s operation is identical. The resistors form a voltage divider network and selection of various values can result in any voltage between the supply and zero volts to appear at the base of the transistor. If there is a 0.7-volt difference between base and emitter, the transistor is turned on and emitter-collector current flows. If this voltage difference is reduced, less collector/emitter current flows. Conversely, if this voltage difference is increased, collector/emitter current increases.

In Fig. 6-a, if a 10-volt supply is used, R2 will be approximately 9 times as large as R1 and +0.7-volt appears at the base. In Fig. 6-b, the values of R1 and R2 stay the same, but their relative positions are reversed to effect a +9.3-volt potential on the base. Either way, the base is +0.7-volt with respect to the emitter. The voltages shown are typical for a silicon transistor. Note that the base voltage is closest to the emitter voltage and between collector-emitter voltage.

An important consideration is the polarity and magnitude of voltage that must be applied to the base/emitter junction to turn the transistor "on" and cause electron flow between emitter and collector. While a tube requires bias voltage to reduce electron flow, the transistor requires bias current to cause electrons to flow. A tube with zero bias between grid and cathode generally has heavy current flow, while a transistor with zero bias between base and emitter is shut off and no current flows between collector and emitter.

To forward-bias or "turn on" a transistor, a small voltage is applied between the base and emitter elements. When measured from the emitter, the polarity of this bias voltage is the same as the collector voltage but its value is much lower.

Remember, as the voltage on the base element changes in the direction of the collector potential, the emitter/collector current increases. If the voltage on the base element moves in the direction of the emitter potential, the emitter/collector current decreases. This is true regardless of whether the transistor is silicon or germanium and npn or pnp.

In Fig. 7, resistor R3 is in series with the emitter. It stabilizes collector current and is referred to as a stabilizing resistor. As collector current flows through emitter resistor R3, a voltage is developed which opposes the forward bias voltage. The effect of R3 is to oppose any change in current flow since the voltage across it is in series with the forward bias voltage. For example, if collector current increases, the voltage drop across R3 increases and reduces the effective forward bias which, in turn, reduces collector current.
Conversely, if collector current decreases, less voltage is developed across R3 and the effective forward bias increases. This, in turn, increases collector current. Adding an emitter resistor stabilizes a transistor with respect to collector-current variations which occur for a variety of reasons. The most common cause is an increase in collector current as a result of temperature increase.

When troubleshooting, the voltage drop across the emitter resistor is an important test point for checking circuit operation. A higher than normal emitter voltage generally indicates excessive collector current. This can be caused by a shorted transistor or a bias defect. A lower than normal emitter resistor voltage would indicate an open transistor or bias defect.

Class-A Amplifier

A transistor stage set up for class-A or linear operation is shown in Fig. 8. In this stage, bias resistor R3 is shown as an adjustable unit, so some desired collector current will flow. This control can be used to show how the transistor amplifies the input signal.

The base voltage-collector current curve in Fig. 8 shows the collector current for several bias voltages. The horizontal line shows bias voltages developed across bias resistor R3. The vertical line shows values of collector current for each value of bias and we will neglect the effect of emitter resistor R4.

Note the mark on the bottom line indicating 2.4 V. This actually means 0.1 V between the base and emitter since the emitter is at +2.3 V. This mark corresponds with a line on the vertical column marked “minimum” as indicated by the dotted lines. This means that, with 0.1 V forward bias, only a small amount of collector current will flow.

If R3 is adjusted to make the base voltage become 3 V (0.7 V between base and emitter), the collector current increases. Referring again to the curve, we see that the collector current has increased to the mark on the vertical column marked “normal.”

If R3 is adjusted to make the base voltage become +3.6 V (1.3 between base and emitter), there will be an increase in collector current. The collector current has increased to the “maximum” level.

From this we can see that by varying the base voltage, we can produce any desired value of collector current. In practice, the emitter voltage would not remain constant with different values of collector current. This action is similar to cathode-voltage variation in a tube.

An ac signal fed to the base element can also cause collector-current changes. Referring again to Fig. 8, we adjust R3 to make the base voltage become +3.3 V. This causes a collector current that corresponds to “normal” on the curve. The collector current through R2 causes a voltage drop so that half the supply voltage appears at the collector. These are the necessary conditions for a linear stage (amplification without distortion).

An ac generator supplies a signal between the base of the transistor and chassis ground in Fig. 9. This signal at any instant will add or subtract from the dc bias supplied by bias resistors R1 and R2. Capacitor C2 provides an ac bypass across R3 at the signal frequency.

In Fig. 9a the generator is passing through its maximum positive excursion and is producing a peak +0.05 V. This voltage will add to the +1.69 Vdc bias voltage and cause a total instantaneous voltage between base and ground of +1.74 V. From the curve in Fig. 8, we see that this corresponds to maximum current through the transistor. This is indicated by the current meter connected in series with the collector of the transistor.

The increased current through R4 causes a larger voltage drop, so that for an instant the collector voltage drops to approximately 2.5.

The result of the negative half-cycle of the generator is shown in Fig. 9b. This negative 0.05-V excursion subtracts from the 1.69-V bias, so that for an instant the voltage between base and ground is 1.64 V. The curve in Fig. 8 shows that this corresponds to minimum collector current. The reduced current causes a smaller voltage drop across R4 and allows the collector voltage to rise to approximately +15.5.

From this we can see that an input signal of 0.1 V peak-to-peak can cause a collector or output signal of 13 V peak-to-peak. Also, phase inversion occurs. The dc and ac voltage excursions shown demonstrate amplification of the transistor. Capacitor C2 is large enough to bypass R3, so that no ac signal is lost across this resistor. The voltage at the emitter will reflect any average current change through the transistor. Emitter voltage is a good indicator of transistor conduction. If this voltage is too high, the transistor current is too high. If it is low, the current is too low.

Diode Stabilization

Some amplifiers require a different type of bias stabilization since their primary purpose is to increase power. The circuits discussed are designed to maintain constant current. This would defeat the purpose of the push-pull amplifier, so another method is used.

The most common stabilization method used for these amplifiers is to use bias elements which are temperature-sensitive. One method, shown in Fig. 10, is to use a diode made from the same material as the transistor.

The diode is fed with a constant current through R1. The voltage drop across the diode biases the transistor and is inversely proportional to its temperature. In other words, as the temperature of the transistor and diode increases, the resistance of the diode decreases and the voltage drop across the diode decreases lowering the bias voltage the necessary amount.

Push-Pull Stabilization

Thermistors are frequently used to stabilize push-pull output stages. Thermistors have a negative temperature coefficient of resistance. A circuit using a thermistor for bias stabilization is shown in Fig. 11. The current through the thermistor is held relatively constant by the high series resistance. The voltage drop across the thermistor supplies the actual transistor bias. Since the compensation in this circuit is often greater than desired, a parallel resistor is sometimes added to the circuit to decrease its sensitivity.

Note that the purpose of the temperature sensing element is not to compensate for ambient temperature, but to compensate for the junction temperature of the transistor. Consequently, whether the sensing element is a diode or a thermistor it should be located intimately with the transistor or transistors that it controls.
Build–Stereo Tape/Slide Controller

Solid-state control module lets you program stereo slide shows. Inaudible signals change slides automatically

By Earl T. Hansen

WHY NOT RELAX WHILE YOU'RE showing slides? Let your tape machine provide stereo background music, narrate the show and change the slides.

You can do this by linking your tape playback equipment and automatic slide projector together with this controller.

An inaudible signal on the tape actuates the controller, but does not interfere with recorded audio. Using readily available components—including 5 inexpensive transistors—the controller can be built for about $20. It has a high input impedance and relatively low output impedance.

A low-level 15-kHz signal is added to one channel during initial recording of the tape program. During playback, a notch filter in the controller attenuates this control signal.

Circuit operation

First let's look at the playback control mode selected by switch S1 (Fig. 1). Program and control signals from the tape preamplifier enter the control module at J1.

Low frequencies are passed through R1 to Q1, which has a voltage gain of about 1. High frequencies, including the control signal, pass through R2 and C2 for a higher gain in Q1. The 15-kHz control signal is routed through C3 and C4 to T1. The control signal does not appear at the output (J2) because it is rejected by the parallel-tuned trap, C5 and L1, and low-pass filter R7–C6. The low-pass filter also compensates for preemphasis added by R2 and C2.

As a result, this part of the circuit passes the program through unchanged, while amplifying and rerouting the control signal. The control signal is fed through double-tuned transformer T1, which rejects all other frequencies. The other secondary feeds emitter follower Q2, which drives sensitivity control R13.

Transistor Q3 amplifies the control signal and drives a peak-to-peak rectifier (C12–D1–D2–C13). When voltage on C13 is great enough to cause base current in the Q4–Q5 Darlington pair, they conduct and energize relay RY1. Resistor R17 discharges C13 when the control signal has stopped. Since C13 is a relatively large capacitor and requires some time to charge, it provides excellent noise immunity and prevents unwanted relay operation from speech consonants or music harmonics. The delay is from 0.1 to 0.5 sec, depending on the setting of sensitivity control R13.

In the record command mode, Q1 has a flat frequency response from input to output. The high-frequency pre-emphasis network (R2 and C2) is opened and the rejection filter (L1–C5–R7–C6) bypassed. The function of Q2 is changed to a Hartley oscillator, which is inoperative until the emitter current path is completed by pressing S2.

When S2 is pressed the oscillation frequency is determined by the resonance of T1, normally 15 kHz to 17 kHz. Part of this signal is fed from the secondary tap, through S1–C6, R6, and R5 to the base of Q1, where it is added to the program material. The signal from Q2 is also fed through the sensitivity adjustment, R13, and the relay amplifier to actuate the relay.

Construction

An aluminum box is used for construction. Mount the large components on the sides and front. Secure T1 with self-tapping screws in the side of the can. Remove the coil assembly before drilling the pilot holes.

A perforated circuit board and push-through terminals were used for mounting most small components. The relay specified needs an insulated mounting and should be put on the perforated board.

Test and adjustment

Adjustment is much easier with an audio oscillator and ac vtvm. A scope and dc vtvm are essential.

Apply power and check the dc voltages shown on the schematic. Measure them with no signal in and S1 to playback. A 20% variation is acceptable. Collector voltages on Q1 and Q3 can fall between 5 and 12 volts with no loss of performance.

Next, apply a 1-kHz audio signal to the input and check the gain at the output. There should be approximately a gain of 1, which is controlled by the ratio of resistor R1 to R3.

Now select a control-signal frequency. This is nominally 1.5 kHz, but may be higher if your tape machine has excellent high-frequency response and you want the highest possible point for the playback rejection filter. It should be lower if the tape machine has poor high-frequency response.

Set the audio oscillator to the control frequency and feed approximately 1 volt to the input, J1. With the switch set to playback, connect a scope or ac vtvm to the output and adjust L1 for minimum output. The output should be 10% or less of the input amplitude (20 dB down).

Reduce the input to 50 mV (140 mV p–p), and connect the scope or ac vtvm to the emitter of Q2. Adjust both T1 slugs for maximum indication. This signal should be at least 50% greater than the input signal amplitude. Adjust sensitivity control R13 so the relay just closes.

Remove the audio oscillator and connect the scope or ac vtvm to the output. Press the ACTUATE button and adjust R6 for an output signal of 100 mV rms (240 mV p–p). This puts the control signal 20 dB below a program signal of 1 volt, as recorded, and the rejection filter gives an additional 20 dB attenuation during playback.

If an audio oscillator is not available, set the adjustment of R6, L1 and T1 about mid-range. Set S1 to the RECORD mode, and connect the output...
Fig. 1 — Control signals are filtered from the output (J2) by parallel-tuned trap C5-L1, but amplified and routed to T1, tuned to the selected control frequency. Voltage on C13 triggers Darlington pair Q4-Q5, which energizes relay RY1 and advances slide changer or, with an extra unit, automatically shuts off the system. Q2 generates the command signal when S1 is in RECORD mode.

PARTS LIST
All capacitors 100-V paper unless noted
C1, C3, C10—0.1 µF
C2, C12—270 pF, mica or ceramic
C6—0.01 µF
C7, C8—0.015 µF
C9, C13—8 µF, 6-V electrolytic
C14—500-µF, 25-V electrolytic
C15—100 µF, 25-V electrolytic
All resistors 1/4-watt 1% unless noted
R1, R5—220,000 ohms
R2—47,000 ohms
R3—330,000 ohms
R4, R7, R9, R11, R16—4700 ohms
R8, R12—22,000 ohms
R10—27,000 ohms
R13—10,000-ohm linear potentiometer (Mallory
105 MTC or equal)
R14—350,000 ohms
R15—100 ohms
R16—220 ohms
R18—720 ohms
R19—470 ohms
Q1, Q2, Q3, Q4—2N2924 transistor
Q5—2N304 transistor
D1, D2—1N914 silicon diode
D3, D4, D5, D6—1N3639 silicon rectifier

R6—1-megohm linear potentiometer (Mallory
105 MTC or equal)
R7—4.7 K
R17—100,000 ohms
R18—220 ohms
R19—470 ohms
R20—220 ohms
R21—470 ohms
Q1, Q2, Q3, Q4—2N2924 transistor
Q5—2N304 transistor
D1, D2—1N914 silicon diode
D3, D4, D5, D6—1N3639 silicon rectifier

Using your controller
The controller is designed for use with a tape playback deck that has a 1-volt output and an external amplifier. For playback control use, the controller is connected between one tape output channel and the amplifier.
It may be left connected at all times even though its control function is not being used. Set the switch to the RECORD COMMAND mode, and frequency response will be flat beyond 100 kHz.
If you do not have a separate tape deck and amplifier, the controller may be connected to your all-in-one tape machine. Connect the controller in the path of the signal feeding the volume control, as shown in Fig. 2. If the same volume control is used for recording and playback, the controller will operate in both modes without changing connections.
In preparing a slide sound program I've found it easiest to record the music and commentary on a master tape, disregarding the controller. Then I borrow a second tape machine and play the master tape.

to your tape recorder.
Press the ACTUATE button and record several minutes of the control signal at a relatively low level. Most tape machines will not record a 15-kHz signal at the normal record level and, therefore, frequency response runs are usually made at from 15 to 25 dB below the normal record level.
When this recorded control signal is played back, it will be a control signal source to make the above adjustments. You may skip the gain check using the 1-kHz signal, if the other tests look good.
through the controller to make a tape copy, adding the slide-change command signal as I go.

In the record command mode, the relay is operated by the actuate button as the control signal is added to the program. If the projector is connected and loaded with slides it affords a good chance to rehearse the program and keep track of the slide sequence as commands are recorded.

In the playback control mode, it may be necessary to readjust the sensitivity control for your particular equipment. If it is set too high, it will operate from "print through" from the adjacent tape. If set too low, operation will be erratic.

When recording the command signal, the recording level indicator should indicate a level about midway or less from the normal record level, even though the signal is about 20 dB down. The relatively high indication is caused by the high-frequency preemphasis in all tape recording equipment.

**Automatic shutoff**

When not being used as a slide controller, I have found the unit very useful as an automatic shutoff for all equipment at the end of a tape. This requires an extra box containing a holding relay, outlet and on button (Fig. 3).

Record the command signal at the end of each tape. The normally closed contacts are used for this function. When the signal occurs at the end of the tape, the relay opens and the ac hold relay turns the system off.

To disable the controller, operate it in the record command mode. It will not affect your tapes or record anything unless your recorder is in the record mode. With a stereo system, either channel may be used for the command signal, but you should be consistent to avoid confusion. The controller can monitor only one channel at a time.

The controller inverts signal polarity 180°. If you feel phasing is critical, reverse the speaker leads on the controller channel.

Although designed for 1-volt input and output, the controller will accept signals up to 4 volts rms without distortion or clipping. Signals as low as 50 mV rms may be used without noticeable internal noise from the controller, which is down 68 dB from the 1-volt level.

When connecting the controller to your projector, locate the two leads to the regular remote pushbutton and extend these to connect to the normally open contacts on the controller.

You'll never cease to amaze people with this "magic" gray box. R-E

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**Fig. 2**—Controller can be connected to tape recorders (self-contained) by wiring the controller into the signal path from the preamplifiers feeding volume control.

**Fig. 3**—An additional box with holding relay can be used to turn off your hi-fi system. When a control pulse occurs at end of tape, relay opens and removes power.
Brighten your home this season with rainbow lighting

Dancing Christmas Lights

By R. W. Fox

REMEMBER THE COLOR WHEEL YOU bought last year, and the blinking lights from the year before? They’re obsolete. Here’s the color blender, the latest in special lighting for this Christmas season. No more sudden flashes; no more monotonous repetition of red, yellow, green, for hours. This year you can get every color of the rainbow with a cycle time of—well, it still hasn’t been measured. All of this in a tiny box, waiting to please both family and friends.

The Color Blender consists of three identical circuits, one for blue, one for red, and one for green. Combinations of these colors will produce every color in the rainbow. Figure 1 shows graphically what is happening and, by the way, the first time you turn it on could very well be a happening! Due to the variation in component tolerances, these circuits will not be identical in performance. One may come on faster than the rest; one may stay off longer. This will give a true randomness to the colors, which is not possible with a color wheel or two, three or even fifty color wheels, since they operate similarly.

Figure 1 shows the output of the three channels as a function of time. At the start the green light is on while the others are off; the red then comes on and the color changes to yellow; then the red and green go off and the blue comes on. As this is happening the color of the display passes through a violet portion and then to pure blue. In this picture the next scene is all the lamps out or dark. Then the red comes on, followed by the green to give yellow, then the blue to give white light since all the channels are at full intensity. At the end the red lamps go out to leave a blue-green scene.

With Christmas just around the corner, the Color Blender would be the perfect addition to your home decorations, inside and out.

Inside, the Color Blender will handle up to 25 miniature lights (6 watt) per outlet on your Christmas tree. If you intermingle these strings, one each of red, blue and green, with balls and tinsel to reflect the light, your tree will seem to come to life. Or, as another way, you could use up to 150 watts per outlet of flood lamps with color filters shining on a metallic tree.

Outside, you could use strings of lights on a tree (be careful not to exceed the load limit on your circuit), or flood lights on the house or on a door covered with wrinkled foil. The wrinkling keeps the colors separated but allows them to blend in some areas to give a multiple color effect.

After Christmas, there is no need to put the Color Blender away. Just build a foil reflector with a large picture frame and shine floodlights on it for a great addition to your game room.

How it works

The G-E type D13T1 Programmable Unijunction Transistor, allows us to build this unique circuit. The D13T1 can be thought of as a complementary SCR. When the gate voltage drops below the anode voltage, current flows from anode to cathode. This circuit uses this feature to phase-fire the C106BI SCR (see Fig. 2). When the Color Blender is initially turned on, both C1 and C3 have no charge. Capacitor C4 quickly charges to a voltage greater than the D13T1 gate voltage and triggers the D13T1, which in turn triggers the SCR, causing the light to come on brightly. On each succeeding cycle of operation capacitors C1 and C3 have a higher initial charge so that C4 cannot charge to a voltage which would trigger the D13T1 until much later in the cycle. Since C3 charges at a faster rate through R7-R8 than C1 and through R5, R6, R4, the lamp dims slowly. When the lamp goes dark, C1 discharges faster than C3 and the triggering angle of Q1 is advanced and the light brightens again.

The purpose of R1 in the circuit is solely for the protection of the C106BI SCR. This resistor keeps the peak current through the SCR within its ratings. Although it wastes a considerable amount of power, about 4 watts at full load, it is better than replacing the SCR whenever a lamp burns out.

In addition to adding to the beauty of your Christmas display, the Color Blender also increases lamp life at least 25 times. This increase in life is due to operating the lamp on half wave. An added consequence of half wave operation is lower bulb temperature, decreasing the chance of fire, hence giving greater safety.

With the board mounting, all three circuits can be built at the same time, reducing the chance for mistakes. Since one side of the line is common to many components, a single bus running the entire length of the board may well be a good way to start. To make the circuit compact, R1 should be left off the board and wired directly to the outlet. This also

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RADIO-ELECTRONICS
keeps R1 far enough away from the SCR. Watch the connections of the SCR and Programmable Unijunction Transistor. Reversing the lead order could very well destroy these units. The polarities should also be observed on the electrolytic capacitors and the three diodes.

For safety's sake do not ground the box to the line, for a reversal of the plug could be dangerous. If you have a three wire system, though, by all means use that third wire as a ground for the case.

Figure 3 shows the board as it was constructed with all three circuits so that it would fit in a 5 x 2 x 3 inch box (Bud-CU-2106-A or equal). You will note in Fig. 3 that the leads and tab of the CI06B1 are bent. CAUTION: The tab should be held by long-nosed pliers between the body and the bend while you are forming the device.

To prepare your box, punch three 1/4 inch diameter holes in the top, one small hole in one end for the line cord, one for the switch and the box is ready. Insert into the box the three outlets and fasten them in place with spring clips. The R1 resistors can be attached on one terminal and their free ends connected to the switch. Use heavy bus wire from the other outlet terminals to the board, and no other supports should be needed to hold the board in place.

Once the circuit board is mounted in the box and the final connections are made, but before you put the Color Blender to use, you may have to adjust the R8 resistors. If an associated light comes on but damps out to a level between full on and off, R8 should be decreased. If the lamp snaps on, R8 should be increased.

References For Further Reading

PARTS LIST
Capacitors—50 volts unless noted
C1—33uF, electrolytic
C2—1uF, 25 V, electrolytic
C3—10uF, electrolytic
C4—0.05 uF, paper
D1, D2, D3—IN5059
Resistors—1/2-watt, 10%, carbon unless noted
R1—5 ohms, 5 watts
R2—1000 ohms
R3—82,000 ohms
R4—22,000 ohms
R5—220,000 ohms
R6, R7, R9—100,000 ohms
R8—50,000 ohms, potentiometer
Q1—DI3TI
SCR1—CI06B1
Miscellaneous hardware—box, line cord, outlets (Amphenol 61-F1 or equiv.) circuit board, switch (Except for the box and line cord, three sets of parts will be needed to build a three-lamp controller)

Fig. 1—Output amplitude of three light channels as a function of time. Variation in component values cause each channel to randomly vary lamp pattern and intensity.

Fig. 2—Unijunction transistor Q1 is used in conjunction with the DI3TI SCR to turn the lamps on and off. The charging relationship between C1, C3 and C4 set the pattern.

Fig. 3—Component layout for all three identical control channels. Parts are identified on one channel only. Resistor R8 is adjusted to establish proper "on" sequence.

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Jobs For Electronic Testers

Find out what know-how you need to start a fascinating career

By L. L. FARKAS

What should an electronic tester know to get a job in industry? The first prerequisite of course, is knowledge of basic electronic theory. This can be obtained through reputable electronic schools.

He should be familiar with the theory of transmission, reception, detection and amplification of radio signals, and with circuits used to handle audio and video frequencies. He should also know something about the different types of power supplies and various antennas.

Moreover, an electronic tester should be capable of calculating voltages and currents. In testing, he may have to find the value of a certain voltage-dropping resistor or determine the amount of current flowing through a circuit. This is particularly true when working with current-sensitive devices whose current must be limited to protect them from burnout.

The tester should be able to calculate the frequency response and impedance of a circuit, since he may need to match input and output impedances to obtain maximum energy transfer.

With the advent of solid-state technology, the tester must know something about diode and transistor characteristics, as well as the types of circuits in which they are used. In fact, by outside reading, he should bring his knowledge up to the state-of-the-art on all semiconductor devices. This is especially useful in a research and development job where, as a technician, he will have to hook up and check such devices.

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Focusing on one thing . . . better reception
of-the-art familiarity is the ability to use test equipment. While technical school students get some practice in using test equipment, this function is not always stressed. Furthermore, the number and types of equipment may be limited.

Remember that a tester's or a technician's tools are the meters, bridges, generators and oscilloscopes with which he feeds signals into equipment and checks the output of the equipment.

Where will he use this test equipment? At a component plant, the tester must check the electrical characteristics of resistors, capacitors, diodes, transistors, coils and transformers. He may have to check complete subassemblies such as i.f. or rf strips, power supplies, amplifiers, or chassis of radio or television receivers.

If he is working for a firm that buys such equipment, he may have to test components or equipment to make sure they meet purchase specifications.

On the production line, the tester will again test components, subassemblies, chassis, subsystems or complete systems. Here, not only the basic types of test equipment are used, but often the more complex digital voltimeters, frequency meters, counters, dual-beam oscilloscopes and electronic tools built especially to test hardware parameters.

Other areas where the tester uses equipment include standards and calibration laboratories, anechoic chambers, environmental test areas and various engineering laboratories where electronic equipment is developed.

To use test equipment correctly, the tester must know its characteristics. What are the limits to which it can test hardware, parameters such as voltage, current, frequency? What is its impedance? How accurately will it measure a certain value? What are its usable scale factors?

One quality the tester must acquire is the ability to follow test procedures. On a production line, test procedures are used to insure each component or chassis is tested in the same way. Deviating from procedure might facilitate a test or make it shorter, but there is always the danger an important part of a test may be omitted or equipment may be tested to the wrong parameter. Once test procedures have been established, the tester must learn to follow them implicitly. Then, should test procedures be wrong, it is the tester's duty to point them out to his supervisor so they can be remedied.

Testers must also be able to read and record production test data. This
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Circle 28 on reader's service card
One of a series of brief discussions by Electro-Voice engineers

THE PLUS OF PLUG-INS
CARL G. COY
Senior Electronics Engineer

While most people think of a computer as a vast mathematical machine, its advantages go beyond its ability to handle numbers. The design needs of the computer itself have posed an astronomical number of components, in as small a volume as possible.

One of the techniques developed to fulfill this need was the creation of circuit modules, composed of separate etched circuit boards with a complete sub-circuit on each board. Large numbers of modules could be combined to form a complete device of virtually any power. Initially the modules were connected by wires, but this created bulky wiring harnesses that required lengthy testing, and often were the source of poor or mis-wired connections.

In order to eliminate interconnections as a source of trouble, wiring was transferred onto a master etched circuit board, and each module plugged directly into the wiring board. Development of highly reliable phosphor bronze connectors simplified construction and assembly while reducing faults due to interconnection, to a minimum. Several new Electro-Voice stereo receivers (Models E-V 1181, E-V 1182, E-V 1281, and E-V 1282) are among the first to use this computer-derived assembly technique.

Male connectors are staked into the main wiring board wherever needed, then flow-soldered. Receptacles are located on each of the circuit modules and soldered along with the individual components on the module. Each module is then simply plugged into the wiring board, and locked in place with suitable mechanical fasteners.

Since wiring is identical for each receiver, the exact capacitive, inductive and resistive parameters of every production receiver can be predicted in advance. This permits optimizing circuits (especially RF and IF circuits) without the need to test each receiver individually. The use of discrete circuit modules, since virtually all circuit connections are flow-soldered, cold or hot, is virtually eliminated by the rigors of shipment and mishandling. A higher level of performance can be assured with no increase in cost.

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Test station for electronic modules.

Automatically testing a module "card."

may sound simple, and it is, provided the tester pays particular attention to the way he determines the data. Are the meters on the correct scale, the switches on the right setting? Are the data read directly? Are the multipliers taken into consideration? Is the right extrapolation made when the results are between calibration points? These are some of the factors that must be kept in mind when reading data.

In recording the data, the tester must also insure he does not list results erroneously. Here a little extra time checking that data are placed in the right columns, that records are legible, and that decimal points are not misplaced will prove invaluable when the time comes to refer to test results.

It also helps to write down any unusual test conditions, particularly when these affect test readings. The more information a test evaluator has about a specific test, the better he will be able to analyze problems and correctly interpret test results.

A tester must also have experience in troubleshooting hardware. Normally, troubleshooting is a fairly simple function. Faced by malfunction in equipment, the tester first plans the method he will use to isolate the defect. Then he selects the test equipment required to execute his plans.

However, to troubleshoot properly, the tester must have a good idea how the defective hardware should operate. He should know what voltages, currents or types of signal the hardware should produce. He then selects test equipment that will correctly show these characteristics.

Finally, he must determine where to connect this test equipment so it will record the desired data without affecting normal hardware operation. Of course, troubleshooting complex equipment cannot be done without training in its theory and operation. But the basic methods used for troubleshooting such items as receivers, transmitters, power supplies and displays should be part of every tester's education. As long as he knows basic troubleshooting methods, he will be able to adapt these to solving problems in more complex hardware.

Know your schematics

One basic requirement for troubleshooting is the ability to read schematics and line drawings. Only by being familiar with circuit symbols, drawing methods and print references can the tester hope to trace the operation of the circuits he's investigating.

Once he isolates the defects, he must record his findings. (There is nothing more frustrating to the corrective-action engineer than to find the record of a component replacement without an indication of the problem encountered, or with a description of the defect so garbled that he can't decipher it.)

So it is extremely important that the tester who troubleshoots does a good job of documenting his findings. Only by providing such definite and clearly understandable data can the tester help provide the required corrective action.

Thus, testers must not only know the basic theory of the equipment they are testing, but they should also be thoroughly familiar with the characteristics of their test equipment. They should be capable of following test procedures implicitly, know how to isolate defects and have the ability to record data accurately. With the capabilities, a tester should have no difficulties in obtaining and maintaining a job in industry.

RADIO-ELECTRONICS
For the Experimenter

9 Digital Readout IC Instruments

Start with digital readout modules, add a power supply, then try these devices.

By Ralph Genter

Would you like to build a frequency counter, a digital voltmeter, an electronic piano tuner, and half a dozen other typical digital instruments? You can, and rather easily. First though you'll need some digital readout modules—complete instructions on how to build them at $10 each appeared in November's Radio-Electronics.

Powering the modules

The first order of business is a power supply. For a 4-digit readout, we'll need a regulated 40 mA at 18 V; around 0.5A at 3.6 V; and possibly a split, low current dual 6-V supply. The circuit is in Fig 1.

Driving the modules

Now we can connect our four modules in cascade.
powering them off the supply. Each module directly drives the next digit over, simply by connecting the carry output of the first to the count input of the next, and so on. As we pointed out last month, the input signal must be normally positive by about 2 V or so and must very abruptly drop to zero, once and only once, per desired count. Any other form of count input will simply be ignored or will cause very erratic operation.

An alternative is a Schmitt trigger (Fig. 3). This one takes two 2-input gates, three resistors, and a diode, and provides a snap action anytime the dc level on its input goes above 1.5 V or drops below -1.2 V. If either of these two circuits is driven by a capacitance-coupled input, you’ll have to add a diode dc restorer to the input and have to be sure your capacitor has a low reactance at the lower frequency you’ll be concerned with.

If we switch to an integrated-circuit comparator (Fig. 4), we can get much better performance, but not without adding $6.75 worth of IC, and another $5 worth of parts to the circuit. Either of the simpler circuits takes about 4 V peak-to-peak drive. The comparator will operate on a few millivolts. Further, we can pick the highest peak on a lumpy input signal, or establish a threshold level that ignores noise and concentrates on the input signal we are trying to measure. Another big benefit of the comparator is that it works well with a wide range of input signals and voltage levels. You will need an input sensitivity potentiometer. A simple 0.1, 1, 10, 100 V switched divider will do as well and handle any signal.

**Mechanical contacts**

Ordinary pushbuttons have considerable contact bounce and noise. So much, in fact, that if you connected one to the input of a counting module chain, you’d most likely get several hundred counts each time you hit the button. Mechanical contacts of any sort must be made bounceless before they can be used with an electronic counter! Two simple anti-bounce techniques are illustrated in Fig. 5. If you can use a spdt pushbutton, you can connect two gates into a set-reset flip-flop combination that latches in one state the instant the button is pressed and snaps back the moment it is released (Fig. 5-a). A 80e integrated circuit is needed.

If you are stuck with a single make contact, you’ll have to use a monostable circuit (Fig. 5-b). This takes an additional resistor and capacitor. It produces a constant-width output pulse after the first contact is initially made. Normally a 10-msec pulse width is desirable, but certain applications [slot car track trips, for instance] might require a 1-second pulse width. Just use the larger capacitor and resistor values to get the longer time.

**Gating**

So far, we have no way to turn the decimal counting modules on and off. This is fine if we are counting events. But for most counter applications, we want to know how many events happened during some known exact period of time [electronic frequency counters, digital voltmeters, etc. . .], or else how many pulses of known frequency occur during the presence of an input event [ballistic velocity meters, piano tuners, etc. . .]. Either method takes an electronic switch called a gate, to “start” and “stop” the counter in a predetermined sequence.

An on-off gate is shown in Fig. 6. Here signal A is passed only when signal B is grounded. This takes a dual 2-input gate, or else one 2-input gate and an inverter. All signals must be conditioned properly before they reach this point in the circuit. Another gate form is the start-stop gate (see Fig. 7). Here input signal B starts the gate and allows signal A to pass. Signal C stops the gate. Thus signal A gets through only in the time between signal B and signal C. Usually the on-off gates are used in electronic counters, while the start-stop are used in instru-

**Fig. 2—Internally cascaded hex inverter converts subaudio.**

**Fig. 3—Schmitt trigger will also shape input signal pulses.**

**Fig. 4—Best, but costly, an IC comparator works on millivolts.**

We can directly drive the count input with a good fast-fall square wave, or with pulses that have a good fall time. We can also use sine-waves, if their frequency is above 100 kHz. Any other form of input signal MUST be conditioned by one of the circuits described below.

We speak of the process of getting the signals we have into the desired form as conditioning. There are several ways we can condition our inputs. The easiest is to simply amplify and limit our input enough to obtain the necessary fall time. A hex inverter can have all six of its internal gates cascaded together, giving a one-piece, $1.08 limiter that will even handle sub-audio sine-waves (see Fig. 2).

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Fig. 5-a—A spdt switch can be made " bounceless" with a μL914.
b—External circuit connections to IC for single make contact.

Fig. 6—Module on-off gate. If B is grounded, input A is passed. If input B is positive, output stays positive.

Fig. 8—Scaling circuits divide input signals for easy counting. Divide by 2 circuit is a binary divider; two JK flip-flops with feedback form the divide by 3 circuit. The divide by 10 is a "Modulo ten minimum hardware circuit" without gates.
ments that take two inputs, such as a drag-strip trap speedometer.

**Scaling**

We will also need a way to divide down signals, perhaps for a 10-MHz input signal that needs reduction to 100 kHz so it is easily counted, or a 60-Hz power-line signal that is divided by 6 to get 0.1-second pulses, or by 60 to get 1-second pulses. These are called scaling circuits and are easily built from the same JK flip-flops we used in the decimal counting modules. The most common factors we would like to scale by are 2, 3, 6, and 10. The required connections are shown in Fig. 8. The divide by 2 is simply a binary divider, while the divide by 3 uses two JK flip-flops and feedback to produce the division by three. A divide by 6 is nothing but a divide by three followed by a divide by two. The divide by 10 is called a “Modulo ten minimum hardware” circuit, and requires no gates to produce a division by ten.

**Time and frequency bases**

All but the straight counter applications of the decimal counting modules require either a source of a stable reference frequency or some gate of precisely known time widths. The accuracy of the instrument depends entirely upon the accuracy and stability of these references. A 4-decade instrument is inherently capable of 0.1 to 0.01% accuracy—if the references used exceed these figures.

The 60-Hz power line is a handy source of accurate time gates. In most parts of the country, the line is held to within 0.05% of 60 Hz, and the short-term stability is even better. This time base is good enough for most three- and four-place digital instruments, and far cheaper than starting with a high-frequency crystal and dividing down. Fig. 9-a shows how we borrow a 6.3 V ac reference off the power supply, filter it to remove noise, Schmitt trigger it, and divide it by six. This gives us a 10-Hz square wave. Two scalings by ten will then give us 1 Hz and 0.1 Hz, with their equivalent periods of 0.1, 1 and 10 seconds.

For a frequency reference [You'll rarely need both references in a single instrument], we can turn to a crystal, possibly 100 kHz, 500 kHz, or some other frequency that is the magic number that makes the readout and the answer fit the measuring problem. This oscillator (Fig. 9-b) produces a square wave that will directly drive any of our circuits without conditioning. Capacitor C is adjusted to insure the crystal is oscillating on the proper mode and not on an unwanted overtone.

**Synchronizing**

This is a tricky little problem. How do we produce one precise time gate, say one second long, on the command of some totally random event, such as a pressed button? We cannot just use a gate, for we may only get a quarter second's worth of gating if we hit the button at the wrong time. And, if we stay on the button too long, we might get several 1-second gates in a row, piling up the numbers in the decimal counting modules. The required circuit is called a synchronizer, and lets one complete cycle of the input pass upon a random command. The output is a grounded signal that lasts the time between negative transitions of the input signal, and one only is produced upon command. The circuit is shown in Fig. 10. It takes two gates connected as a set-reset flip-flop that drives a synchronizing JK flip-flop.

**Voltage to frequency**

You'll need a voltage-to-frequency converter anytime you wish to digitally measure an input voltage, such as in a digital voltmeter, ohmmeter, or thermometer. In a digital voltmeter for example, you scale your input voltage, convert it to a frequency, and then measure the frequency in an events-per-unit-time setup.

You'll find the 0.1% accuracy you need too tight for a conventional voltage-controlled oscillator or multi-
Let's build some instruments

We now have all the pieces and parts we need for most any digital instrument. Now, how do we put them together? Anything we build will take three or four decimal counting modules, a power supply, and a box. You might like to try a package similar to the one shown in the photo—it's a deep drawn aluminum case about 3 x 4 x 9 in., and with some careful layout, can house almost any digital instrument you like. If you are careful, you can get by on $\frac{1}{3}$ the size, $\frac{1}{4}$ the cost, and $\frac{1}{4}$ the weight of all but the newest equivalent commercial gear!

Let's start with a straight 0-9999 counter built up like Fig. 12. With square-wave electronic input or mechanical contacts with set-reset conditioning, you can count as fast as 10 MHz. The monostable conditioning circuits are limited to a top speed of 20 counts or so per second. The reset pushbutton need not be conditioned. Resetting a counter 193 times is just as good as resetting it once.

Group your counting modules by twos, and you have a lap counter for a slot car race that not only keeps track of the laps, but provides an output signal on the 100th lap. Details are in Fig. 13. You can arrange a mechanical, photoelectric, or weight sensitive track pickoff and run it through 1 second contact conditioning, just to be sure the car's bouncing does not register a false lap.

The heart of many of the instruments is an electronic stopwatch, or events-per-unit-time instrument. The simplest type is shown in Fig. 14. All we do is add a gate to the basic counter, and open and close the gate with the event we wish to measure. We obtain an input from a reference frequency source. Your choice of frequency determines the range and resolution. A 1-MHz clock gives you 1-µsec resolution and a 10-µsec range, while a 10-Hz clock gives you 0.1-second resolution and a 100-second range. Make sure your event measuring has an accuracy commensurate with your resolution. Your gating waveform must come up in less than one clock cycle and stay there without noise or breaks for the entire time. Then it must fall in less than a clock cycle. Any other response limitations must be taken into account. You're not about to measure a 10-µsec pulse with a cadmium sulfide photocell with a 10-µsec rise time. Nor is anything you do requiring human response on a pushbutton going to be much more accurate than 0.1 second.

**Photographic shutter tester**

This is a snap. We just put a good photocell in front of our counter connected as an electronic stopwatch and shine light on it only when the shutter is open. Of course you'll need a good quality silicon photocell with a 50-µsec rise time or so. A 5-kHz clock is a good choice, as it will cover $\frac{1}{5000}$ second down to $\frac{1}{2}$ second. The $\frac{1}{5000}$ second accuracy will only be 20%. If this is not good enough, a faster clock may be switch selected. Details are in Fig. 15.

A start–stop gate is needed for either the ballistic
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3¼", 2% accurate 800µa D'Arsonval type meter. One zero adj. for both res. ranges. High impact bakelite case. 5 AC voltage ranges: 0-12-120-600-1200-3000v. 5 DC voltage ranges: 0-6-60-300-600-3000v. 5 db ranges: -4 to +64db. 5 AC current ranges: 0-30-150-800ma. 4 DC current ranges: 0-6-30-120ma. 0.1A. Resistance: 0.1, 0.1 meg. 3¼". W x 6½". H x 2½". D.

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RE-12
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Electronic piano tuner

The note is picked up with a contact microphone, and is this time to measure the time between zero crossings of the fundamental component of a piano note (Fig. 18). The note is picked up with a contact microphone, and is well filtered to pick out the fundamental frequency. It is then amplified and limited with a high-quality limiter. After the limiting, a binary divider chain octave selector reduces all the notes to square waves having a fundamental frequency between 28 and 56 Hz. A note detector [a monostable of some sort] resets the counting modules [four are needed for sufficient accuracy] and waits till the middle of the note. In the middle of the note, a synchronizer is told to produce a gate exactly two positive zero crossings wide. This routes a 250-kHz clock to the decimal counting modules, producing a number which is converted into frequency by consulting a conversion chart or table.

There are two important advantages to this method compared to conventional instruments. First, no skill at beat detection is required, and second, with a carefully calibrated chart, it is possible to "stretch" the piano tuning in exactly the manner a professional tuner does.

Frequency counters

It, you can measure any frequency from 10 MHz on. This is perhaps the most useful digital instrument. With

Fig. 16—Ballistic velocity meter needs a start-stop gate.

Fig. 17—Similarly, drag-strip speedometer measures time.

Available through your local distributor, or write to:

RYE INDUSTRIES INC.
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Circle 31 on reader's service card

RADIO-ELECTRONICS

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That’s you. When you turn on your B & K tester / rejuvenator, a real customer pleaser (even the tough ones). At the same time, it ups your income and quickly pays for itself. This has been proved time and again:

First, by showing your customer, right in the home, the true condition of his picture tube. And how long it will last. (New picture tube sales are easier to justify when your customer is right there to see for himself.)

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Special B & K time-controlled rejuvenation-process safeguards the picture tube. Adjustable heater voltage is metered and continuously variable from 0 to 13 volts. G-1 and G-2 voltages are completely and continuously variable. All this enables you to pinpoint the desired voltage and make the most accurate possible tests, even on future CRT types.

(How’s that for non-obsolescence in an era of planned obsolescence?)

Color picture tubes are checked by testing each color gun separately just as the manufacturer would do it. (In fact, this CRT tester has become the commonly used diagnostic tool of the industry.)

The B & K 465 is the professional serviceman’s tester. If you would like to enlist the aid of this “customer relations specialist,” see your B & K Distributor or drop us a note and ask for Catalog AP-24.

CRT Tester/Rejuvenator
Model 465 Net: $89.95

B & K Division of DYNASCAN CORPORATION
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Where electronic innovation is a way of life.

DECember 1968
By FRED SHUNAMAN

WHEN THE OPPORTUNITY CAME TO
add the Band Box and Playmate to the
"Thomas by Heathkit" organ my
daughter Ellen and I had put together
two years ago, I was interested. The
additions would, in effect, make it a
theater organ, and I had played around
a little with an ancient theater-type or-
gan of the pre-electronic days. It must
have been about 30 feet long, and it
played the actual instruments (en-
closed in glass-fronted compartments),
pounding on the bass drum and strik-
ing cymbals together on command of a
perforated paper music roll.

Ellen was enthusiastic—again. "A
Viennese waltz with bongo drums!"
The very incongruity appealed to her.
"I'd like to play that!" But I noted
carefully that her enthusiasm didn't in-
clude a promise to "do all the work,"
as it had when we built the organ.

What were the Band Box and
Playmate I was ordering? Briefly, the
Band Box is a way of adding—elec-
tronically—ten percussion instruments
to the Heathkit organ. These can be
played together with the regular note
from either the great keyboard or the
pedals.

Two of the ten percussion voices
—the drum roll and cymbanets—sound
continuously as long as the key is held
down; the others sound once each time
the key is pressed. Any combination of
the ten (crash cymbal, brush cymbal,
bass drum, snare drum, drum roll, two
bongos, block, clave and castanets) may
be played at the same time, on ei-
ther pedals or keyboard or—in one
position of the switch—on both at the
same time. Thus you can have the
crash cymbal and bass drum sound
when you press the pedal, while actu-
ating one or more of the others with
the keys. (Drum roll and snare drum
do not sound at the same time.)

The Band Box has its own key-
board—a set of fingertip tabs that can
be played independently of the organ.
So you can use it to accompany other
instruments or as part of a dance en-
semble where the rock might be con-
sidered too hard for organ music.

A little drawer that slides under
the knee rail of the GD-983 organ
houses the Band Box, or it can be in-
stalled integrally in the newer TO-67.
The electronic part consists of three
circuit boards mounted in a flat frame
that also mounts under the great man-
ual shelf on the GD-983 or installed
inside the newer-model organ.

Playmate

And what is the Playmate? Auto-
mation applied to the Band Box! With
the Playmate installed and connected
to the Band Box and organ, a supply of
rhythms ranging from the Viennese
waltz to the watusi can be created.
Tempo can be varied with a thumb
wheel on the Playmate. Pushing down
the key marked ORGAN RHYTHM
and using any of the Band Box voices,
you can have a simple percussive or-
gan note repeated in the desired
rhythm.

Adding any Band Box voice lets
you add any of the instruments to the
keyboard note. For automatic accom-
Coming in January, 1969:

PHOTOFACT® SET NO. 1002

When the first PHOTOFACT Folder Set appeared in May, 1946, we made this pledge to the radio servicemen of America:

"PHOTOFACT will provide complete, accurate, uniform service data, and present that data on a current and continuing basis, to keep up with the production of the industry."

We have kept that pledge. We covered all of the post-war AC-DC, AM-FM, Auto Radio, and Phonograph models. With the appearance of the first black-and-white TV, we were there with exclusive PHOTOFACT TV coverage. We kept pace as the industry introduced new types of products and poured them out in thousands of models: Automatic Record Changers, High-Fidelity Instruments and Components, Tape Recorders, Stereo Instruments, Transistor Radios, Color TV, Citizens Band Radios—right down to the introduction in 1968 of PHOTOFACT coverage of Home Cartridge Tape Players.

Today, the electronic serviceman has at his command complete PHOTOFACT service data coverage of more than 78,000 different models.

Moreover, the electronic serviceman can buy PHOTOFACT in the form which best meets his needs. Those who service all types and makes of instruments own the complete PHOTOFACT Library and stay current with a subscription to P. O. M. (Photofact-of-the-Month Club). Those who have a need for specialized service data, have the choice of subscriptions to the five Specialized PHOTOFACT Series: Auto Radio, Tape Recorder, Transistor Radio, CB Radio, and Home Cartridge Tape Players.

We made a second pledge in 1946: "PHOTOFACT will be the world's finest and most complete electronic service data, providing new and exclusive features in a uniform format, to make the serviceman's work quicker, easier, and more profitable."

We have kept that pledge. PHOTOFACT introduced full photo coverage of all chassis views, keyed to the famous Standard Notation Schematic, with its wealth of vital information; disassembly instructions (including auto radio removal); tube location charts; troubleshooting charts; a superior alignment system; terminal identification; dial cord stringing; field servicing notes; alternate tuner data; complete replacement parts lists; exploded views for record changers and tape recorders; actual waveform photographs on the TV schematics, and a host of other invaluable features. With the appearance of printed circuitry, PHOTOFACT introduced CircuiTrace® for fast tracing of printed boards. Forthcoming PHOTOFACT Folders will feature techniques for rapid servicing of such new developments as the "Quasar" circuit TV models.

In January, 1969, PHOTOFACT Set No. 1002 will appear. It is eloquent testimony to the continuous loyalty of thousands of electronic servicemen, and solid proof of the ability of PHOTOFACT to boost their earnings day-in and day-out through faster, better repairs.

One final word: In 1946, a PHOTOFACT Set sold for $1.50. Today, twenty-two years later, on a P. O. M. Subscription, PHOTOFACT costs only 50¢ more per Set. Think about it, and you'll agree that's holding the line.

PHOTOFACT is sold by more than 1800 Electronic Parts Distributors from coast-to-coast

Howard W. Sams & Co., Inc.
INDIANAPOLIS, INDIANA 46268

The Service-Minded Organization with the Service Technician in Mind
Dialalarm, the automatic telephone alarm, can be programmed to dial pre-selected numbers and deliver a pre-recorded emergency message. Any sensor can trigger Dialalarm. A rate-of-rise indicator can be used to call the fire department; a motion detector (microwave, ultrasonic, etc.) can trigger a message to the police department.

A single alarm can be activated by two different sensors because the unit has two channels. And each channel is capable of delivering 6 different messages to 6 different numbers. There is a total of 10 minutes of message time on each channel.

Other advantages: no leased lines are required, for economy; the owner can program it and change messages on the spot. There's no need to bring the unit to the dealer—a drawback of other dialing alarms.

Your electronic know-how opens the door to an excellent income in the growing security field. You can discuss the product with confidence; suggest ways of installing it for most effective protection; tie it into existing security systems. Easy to install, it has the approval of police and fire departments and local telephone companies. For details on how to put your skill in electronics to work in a lucrative field, write: Record-O-Fone Division of ElectroSpace Corp., 408 Concord Ave., Bronx, N.Y. 10454.

Patents Pending

Circle 39 on reader’s service card

The best TV deserves the best antenna!
Install a Zenith Quality-Engineered Antenna!

These features help a Zenith outdoor antenna provide the superior reception that makes for satisfied customers:
- Capacitor coupled cap-electronic VHF dipoles.
- Tapered UHF grid driver.
- Staggered square UHF directors.
- Low-impedance, triple boom construction.

You can choose from 12 all-new Zenith VHF/UHF/FM or VHF/FM antennas. All are gold color alodized aluminum for better conductivity, greater corrosion resistance and longer service. Ask your Zenith distributor for a free technical manual. He has charted the reception characteristics of your area, so he can recommend the best antenna for each installation.

BEST YEAR YET TO SELL THE BEST

The quality goes in before the name goes on

Circle 40 on reader’s service card

RADIO-ELECTRONICS
Two New SK Devices Simplify Servicing of TV Deflection Circuits

More than a dozen solid-state TV sets—RCA and others—can use these two new RCA SK-Series transistors—specifically designed for replacement use in deflection circuits.

The RCA SK3034 is for replacement use in horizontal driver and in vertical-deflection-output circuits; the SK3035 is for replacement use in horizontal-deflection-output circuits.

Both units are germanium p-n-p devices in hermetically-sealed TO-3 packages, and are for use in domestic and imported TV sets with anode voltages to 18 KV and with picture tubes having deflection angles up to 114°.

Add both to your stock of RCA "Top-Of-The-Line" SK-Series replacement transistors. See your RCA Distributor today about your supply of RCA SK-Series replacements...33 individual units that can replace approximately 11,800 solid-state devices.

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

Now available...a comprehensive and accurate source of solid-state replacement information! It's RCA's Solid-State "Top-of-the-Line" Replacement Guide, SPG-202F. Cross-referencing RCA SK-Series Transistors, Silicon Rectifiers, and Integrated Circuits, the Guide provides replacements for nearly 12,000 solid-state devices— including U.S. industry standard EIA types, foreign types, and types identified only by device-manufacturers' or equipment manufacturers' parts numbers. SPG-202F is available through your RCA Distributor. Ask him about it. Today.

*Ask your participating RCA Distributor for details.
RADIO-ELECTRONICS READER SERVICE

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1. Tear out the post card on the facing page. Clearly print or type your name and address. Include zip code!

2. Circle the number on the card that corresponds to the number appearing at the bottom of the New Products, New Literature or Equipment Report in which you are interested.

For literature on products advertised in this issue, circle the number on the card that corresponds to the number appearing at the bottom of the advertisement in which you are interested. Use the convenient index below to locate quickly a particular advertisement.

3. Mail the card to us (no postage required in U.S.A.)

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NEW PRODUCTS

More information on new products is available free from the manufacturers of items identified by a Reader's Service number. Turn to the Reader Service Card facing page 76 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

COLOR ORGAN SYSTEMS control groups of colored lamps which respond to a certain frequency band and blink in variety of brightness to the intensity of the music. Smallest, Model 1900, weighs 24 oz. Costs $39.95. Model 71,102, 200 W, features an indicator light and brightness control for each channel as well as a master control. Costs $99.95. Model 71,104, 1000 W, has base, treble and mixer controls and features both line input and a built-in mike for $149. Above units are all 3-channel. Model 71,103, 2000 W, 4-channel, includes gain controls and weighs 10 lb 11 oz. Costs $195. Single-channel Do-It-Yourself Kit, Model 60,759, costs $9.95.—Edmund Scientific Co.

Circle 46 on reader's service card

STEREO HI-FI SYSTEM, solid-state RK-570, combines a 12-watt FM receiver, 4-speed record player and a cassette tape recorder for recording and playing 4-track stereo or 2-track mono. Two detached, acoustically matched 2-way speaker systems, each containing a 5" woofer and 3" tweeter. FM section features an FET front end at 2.5 μV (1HF) sensitivity. Amplifier is rated at 12 watts output into 8 ohms with a response of 20-30,000 Hz ±2 dB, $249.95. Plastic cover and mike available at $7.95 and $5.95, respectively.—Lafayette Radio Electronics.

Circle 47 on reader's service card

AUDIO CONNECTOR ADAPTERS, four models. Nos. 383P1 and 384P1 accept a standard 2-conductor phone plug and adapt it to a 3-contact audio connector. The former adapts phone plug to a 3-pin receptacle, and the latter to a 3-contact connector. The other two adapters connect a standard 2-conductor jack to a 3-contact audio connector. No. 390P1 adapts the jack to a 3-pin re-

---

DISGRACEFUL

"Isn't it? The way Mercury shamelessly offers top quality test equipment at such low prices. Compare the features with costlier models and see how Mercury gives you top value for your dollar. It's Wonderful."

Model 2000—MUTUAL CONDUCTANCE TUBE TRANSISTOR TESTER
Tests all tube types, old and new, plus transistors. Tests Magnovas, Nuistors, All Popular Picture Tubes and most other receiving tube types. Checks tubes for dynamic cathode emission, shorts, grid leakage and gas. Picture Tube Adapter. Exclusive 2-point test principle safeguards against obsolescence. Automatic line voltage regulation. $109.95

Model 1101—DELUXE TUBE TESTER
For new Magnovas, Decals, Nuistors. All Popular Picture Tubes and most other receiving tube types. Checks tubes for dynamic cathode emission, shorts, grid leakage and gas. Picture Tube Adapter. Exclusive 2-point test principle safeguards against obsolescence. $359.95

Model 1102—TUBE TESTER
Tests more tube types than any other tester in its price range. Tests for dynamic cathode emission, shorts, grid leakage and gas. Exclusive meter bridge circuit found only in more expensive testers. Professional quality at an economical price. $124.95

ALL MERCURY TEST EQUIPMENT GUARANTEED FOR ONE FULL YEAR!
UPDATED TUBE TEST DATA AVAILABLE ON ALL UNITS.

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EXPORT: SINGER PRODUCTS CO., INC., 95 BROAD ST., N. Y. C. 10006, U. S. A.

Circle 106 on reader's service card
ceptacle, while No. 387P1 adapts to a 3-contact receptacle. All units include a separate ground terminal and ground contactors. All completely shielded.—Switchcraft Inc.

Circle 48 on reader's service card

REGULATED POWER SUPPLY, Model IP-18, can be programmed for ac or dc. Voltage is regulated to a 40-mV variation; output change: less than .05%; input change: from 105–125 Vac. The unit is current-limiting and continuously variable from 10 to 500 mA. Noise distortion: under 0.1 mV; transient response time: 25 µsec. Output impedance is 0.5 ohm or less up to 100 kHz. The all-silicon transistor power supply and circuit board construction. $19.95.—Heath Co.

Circle 49 on reader's service card

Screwdriver Set, No. PS-89, contains 8 midget hex-type socket screwdrivers in sizes from 0.025” to 3/16”. Included is a “piggyback” torque amplifier handle to provide larger gripping surface, extended reach and increased driving pow-
to 20,000 Hz, both channels operating. IM distortion is less than 0.2% at 120 watts or any lower power level. Noise is 85 dB below rated output from high-level inputs, 72 dB from low-level inputs. Special features include concentric bass and treble controls for optimum response from both channels and built-in stereo balancing system. $435.—James B. Lansing Sound Inc.

Circle 52 on reader's service card

ANTENNAS, two models: Model GA-3 (Gamma 233), is a 3-element Yagi, comes with all its parts preassembled and color-coded and has a forward gain of 7.5 dB (over reference dipole), maximum length 141" and boom length 108".

Brought to you by the same engineering team that designed the famous Messengers "I" and "Two", the Messenger 223 has the same rugged circuitry and even greater "Talk Power" capability. With at least 15 db more audio gain than the "I" and "Two", the "223" punches out a clear, penetrating signal. As with all Johnson radios, your signal will stand out compared to all others.

Ten tubes, eight diodes and six transistors form a rugged base station transceiver that can't be beat for reliable day-in, day-out performance. A built-in illuminated "S" meter/power meter measures input strength of RF signals and relative power output of the transmitter. Ready to go on all 23 channels, the Messenger 223 is FCC Type Accepted and DOT Approved.

S199.50 $214.95
(without mike) (with mike)

Circle 107 on reader's service card
a combined twin-lead and coaxial unit. Prices range from $30 to $65.—JFD Electronics Co.

Circle 55 on reader's service card

KEYBOARD SWITCH, Model SB-033, suitable for test equipment, communication gear and many other applications has the following features: Rating—100 mA @ 48 V, Operating force—5 oz. Mechanical life—1,000,000 cycles; electrical life, 10,000,000 cycles. Full stroke travel 7/32", travel contact 5/32" and 3/16" high black symbols. All switch positions contain a “positive lockout” between sections and rows. An extra “decimal” button provided. $28.50.—Alco Electronic Products Inc.

Circle 56 on reader’s service card

CB TRANSCEIVER, Model CWT-10, 100 mW, 11 transistors, 3 channels. Unit puts out and pulls in clear signals. No license required. Crystals supplied for channel 9. Other features include beep-tone caller, strong-signal limiter, separate mike and speaker, squelch control, battery-life meter, earphone jack and external power jack. Measures 10½" x 1¾" x 2¾" and weighs 1½ lb. $29.95 with earphone, hand strap and shoulder strap.—Courier Communications Inc.

Circle 57 on reader’s service card

CONVERTIBLE CABINET provides a rugged enclosure for delicate instruments and systems and can be placed on a table or bench or on top of a cabinet. All-welded 14 gauge steel frame has adjustable front and rear mounting rails tapped 10-32 with W.E. spacing. In 3 sizes with several optional construction features.—Bud Radio Inc.

Circle 58 on reader’s service card

AM-FM FM-MPX RECEIVER, Model RA-999, 150 W, has a tuning range of 88–108 MHz FM/535–1605 kHz AM. Sensitivity: 1.5 µV for 30 dB quieting. Stereo separation: more than 30 dB. Frequency response: 30–20,000 Hz ±3 dB.

Tone compensation: bass, 50 Hz ±12 dB; treble, 10 kHz ±10 dB. Hum and noise: —55 dB. Output impedance: 4, 8 and 16 ohms. Transistors: 25 plus 14 diodes. Size: 18 7/16" x 14 3/8" x 5 ö. 110–120 volts ac, 50/60 Hz. $250 with a walnut-finish wood cabinet.—Olson Electronics Inc. R.E.

Circle 59 on reader’s service card

easy answers to common color complaints

Perma-Power puts back Color TV Quality!

Puts back brightness
Color-Brite Picture Tube Briteners
Color-Brite brings out lost sharpness and details of fading color picture tubes. Provides increased filament voltage to boost electron emission, returns full contrast and color quality.

MODEL C-501 for round tubes Dealer Net. $5.85
MODEL C-511 for rectangular tubes Dealer Net. $5.85

Put Back Profit—Use Perma-Power Briteners

Put Back full voltage
Automatic Voltage Regulator
Automatically boosts voltage 10 volts when line voltage drops below 110 volts. Eliminates shrinking, loss of brightness, loss of convergence. Combats poor line voltage regulation, overloaded circuits.

MODEL D-210 for appliances rated up to 400 watts Dealer Net. $14.95
NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 76 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

LIGHTING GUIDE, LG-468, consists of four main sections, designed to aid in the selection of lamps and lamp holders best suited to particular applications or products. Sections are titled Lamp Selection Guide, Lampholder Selection Guide, Bracket Guide and a Con- demned Catalog. Detailed drawings and specs provided.—Leeraft Mfg. Co.

Circle 60 on reader's service card

175 SEMICONDUCTORS. books and accessories in the Motorola HEP line of devices for hobbyists, experimenters and professional service techs are listed in Catalog MH-427-4. Of special interest to technicians is the "Equal- on-Better" replacement series.—Motorola Semiconductor Products Inc.

Circle 61 on reader's service card

BOOK CATALOG. 16 pages, describes over 100 current and forthcoming books covering broadcasting, basic technology, CATV, electron motors, electronic engineering, television, radio and electronics servicing, audio and hi-fi, hobbies and experiments, test instruments and transistors.—Tab Books

Circle 62 on reader's service card

CROSS-REFERENCE GUIDE, HMA07-4, 64 pages, lists almost 18,000 semiconductors with their equivalents from the HEP line as well as tips on using replacement devices and outline drawings and dimensions. For hobbyists, experimenters and professional service technicians.—Motorola Semiconductor Products Inc.

Circle 63 on reader's service card

LOUDSPEAKER SYSTEMS. Three models in the New 10 Series, LS-15, LS-20 and LS-30, designed to reproduce music in anechoic chambers, are described with frequency charts, pictures and specs in Catalog No. 549.—Bogen Communications Div.

Circle 64 on reader's service card

AUDIO CATALOG NO. 680, 20 pages, illustrated with diagrams and charts, contains technical data on magnetic heads for drum, disc or tape use. Application form provided for information on any desired magnetic head not listed.—Michigan Magnetics, Div. of VSI Corp.

Circle 65 on reader's service card

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

ELECTRONIC COMPONENTS AND EQUIPMENT of over 500 major product lines are detailed in this 720-page 1969 catalog. Prices for all items and availability in industrial quantities are indicated.—Newark Electronics Corp., 500 No. Pulaski Road, Chicago, Ill. 60624

VIDEO RECORDING for professional broadcasters and amateurs with techniques of TV tape production is outlined, with photographs and diagrams, in the 44-page Producers Manual. A glossary of terms used in video recording practice is included.—Magnetic Products Div. of EM Co., Marketing Services Dept., 3M Center, St. Paul, Minn. 55101.

Circle 110 on reader's service card

DECEMBER 1968

FAR SUPERIOR TO ANY VTVM OR VOM

--and for less money

NEW FIELD EFFECT MULTIMETER

Here is the revolutionary new approach to circuit testing, the solid state Sencore FIELD EFFECT METER. This FE14 combines the advantages of a VTVM and the portability and versatility of a VOM into a single low-cost instrument. This is all made possible by the use of the new space age field effect transistor that is instant in action but operates like a vacuum tube in loading characteristics. Compare the features of the FIELD EFFECT METER to your VTVM or VOM.

Minimum circuit loading — 15 megohm input impedance on DC is better than a VTVM and up to 750 times better than a 20,000 ohm per volt VOM — 10 megohm input impedance on AC is 20 times better than a standard VTVM. The FIELD EFFECT METER is constant on all ranges, not like a VOM that changes loading with each range.

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NEW HEATHKIT IM-18 VTVM

The new IM-18 is a direct descendant of the world's most popular VTVM—the Heathkit IM-11, and continues the features that made the IM-11 famous... 7 AC and 7 DC voltage ranges that measure from 0.1 to 1000 volts full scale... 7 ohms range for resistance measurements from 0.1 ohm to 1000 megohms... single probe convenience that ends tangled leads & enables you to change from AC to DC/Ohms measurements with a flip of the switch on the probe... the light circuit loading of 11 megohm input impedance... ±1 dB 25 Hz to 1 MHz response... precision 1% resistors... DC polarity reversing position on the function switch... measurement capability for RMS and Peak-To-Peak AC voltages and dB... precision 4½, 200 uA meter for extra sensitivity. In addition, the new IM-18 includes wiring options for 120V or 240V operation and a three-wire line cord for added safety. 5 lbs.

NEW HEATHKIT IM-28 "Service Bench" VTVM

The new Heathkit IM-28 bears the proud tradition of the IM-13, and it has the same performance specifications as the new IM-18 above—an unbeatable combination! But it also has a number of features that put it in a class by itself, like a large 6" meter with easy-to-read markings... extra ½ and 5 volt AC ranges for additional accuracy... a secure gimballed mounting that allows you to put the IM-28 above, below or in front of your most convenient mounting surface... "Set and Forget" calibration— all calibration controls are screwdriver adjustable from the front panel to eliminate disassembly... smooth ten-turn vernier control of zero and Ohms Adjust for greater accuracy and easier setting... dual primary transformer for 120/240 VAC operation... safe 3-wire line cord as well. The new look of Heathkit instrument styling is evident too—handsome beige & brown color scheme, and new knobs that are easy to turn and fast to read. 7 lbs.

NEW HEATHKIT IM-38 Laboratory AC VTVM

For all around general service work, audio design and troubleshooting or laboratory analysis, you couldn’t find a better value than the new Heathkit IM-38 AC VTVM. Here’s why—10 voltage ranges measure from 0.01 to 300 volts RMS full scale... an extended frequency response of 10 Hz to 500 kHz ±1 dB... 10 megohm input on all ranges for higher accuracy and minimal circuit loading... wide dB range: 10 to +2 on the meter and ten switch-selected ranges from 40 to +50 in 10 dB steps... Vu-type ballistic meter damping... amplifier filament voltage transformer winding that’s balanced to ground for low AC noise... 120/240 VAC wiring options and new Heathkit styling in sharp beige & brown with an easy-to-grasp, easy-to-read knob. Heathkit engineering has made assembly easy and performance tops. 5 lbs.

HEATHKIT IM-17 Solid-State Volt-Ohm Meter

Another very popular volt-ohmmeter from Heathkit engineering and it's easy to see why—all solid-state circuitry... high impedance FET input, 11 megohms on DC, 1 megohm on AC... 4 AC voltage ranges... 4 DC voltage ranges... 4 ohm ranges... 4½, 200 uA meter... 3 built-in test leads... DC polarity reversing switch... zero-adjust & ohms-adjust controls... continuous 12-position function switch. And that’s not all—the IM-17 is battery powered for complete portability and comes in a rugged polypropylene case with built-in handle. Simple circuit board assembly. 4 lbs.

HEATHKIT IT-18 In-Circuit Transistor Tester

In-Circuit transistor testers don’t have to be expensive, and the IT-18 is proof of that... tests DC Beta 2-1000, in or out of circuit... leakage Ebc and Lecc current 0-5000 uA out-of-circuit... Identify NPN or PNP devices... tests diodes in or out of circuit... includes NPN or PNP transistors. The IT-18 is completely portable—runs on just one "D" cell. Easy to use too... rugged polypropylene case, attached 3" test leads, big 4½, 200 uA meter, all front panel controls, 10-turn calibration control. 1 lbs.

HEATHKIT IP-18 1-15 VDC Power Supply

If you work with transistors, this is the power supply for you. All solid-state circuitry provides 1-15 VDC at up to 500 mA continuous. Features adjustable current limiting, voltage regulation, floating output for either + or - ground, AC or DC programming, circuit board construction, and small, compact size. 110 or 220 VAC. 5 lbs.

HEATHKIT IG-57 Solid-State Post Marker/Sweep Generator

The new IG-57 plus a 'scope is all you need... no external sweep generator required. Switch selection of any of 15 crystal-controlled marker frequencies (you can view up to six different frequencies on one 'scope trace). Select the sweep range and you’re ready to instantly see the results of any changes you make. Four markers for setting color bandpass, one for TV sound, eight at IF frequencies between 39.75 & 47.25 MHz plus picture and sound carrier markers for channels 4 & 10. Three sweep oscillators produce the 5 most-used ranges... color bandpass, FM IF, color & 1K&2IF and VHS channels 4 & 10. Save hundreds of dollars in alignment facilities in your shop too—order your IG-57 now. 14 lbs. Kit IG-14, same as IG-57 w/o the sweep, 11 lbs. $99.95.

HEATHKIT IO-18 Wide-Band 5” 'Scope

The New Heathkit IO-18 is destined to be the world’s most popular ‘scope, just as its predecessor, the IO-12 was. Features 5 MHz bandwidth, the famous Heath patented sweep circuit—10 Hz to 500 kHz in 5 ranges, two extra sweep positions which can be preset to often-used rates, frequency compensated CRT attenuation, built-in P-P calibration reference, Z-axis input, retrace blanking, wiring options for 120 or 240 VAC operation and new Heathkit styling in beige and brown. 24 lbs.
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Fine-Tuning - Model GR-681

kit GR-681  $499.95 (less cabinet)

The new Heathkit GR-681 is the most advanced color TV on the market. A strong claim, but easy to prove. Compare the "681" against any other TV - there isn't one available for any price that has all these features. Automatic Fine Tuning on all 83 channels... just push a button and the factory assembled solid-state circuit takes over to automatically tune the best color picture in the industry. Push another front-panel button and the VHF channel selector rotates until you reach the desired station, automatically. Built-in cable-type remote control that allows you to turn the "681" on and off and change VHF channels without moving from your chair. Or add the optional GRA-681-6 Wireless Remote Control described below. A bridge-type low voltage power supply for superior regulation; high & low AC taps are provided to insure that the picture transmitted exactly fits the "681" screen. Automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs... plus the built-in self-servicing aids that are standard on all Heathkit color TV's but can't be bought on any other set for any price... plus all the features of the famous "295" before. Compare the "681" against the others... and be convinced.

GRA-295-4, Mediterranean cabinet shown $119.50
Other cabinets from $62.95

Deluxe "295" Color TV... Model GR-295

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Big, Bold, Beautiful... and packed with features. Top quality American brand color tube with 295 sq. in. viewing area... new improved phosphors and low voltage supply with boosted B+ for brighter, livelier color... automatic degaussing... exclusive Heath Magna-Shield... Automatic Color Control & Automatic Gain Control for color purity, and flutter-free pictures under all conditions... preassembled IF strip with 3 stages instead of the usual 2... deluxe VHF tuner with "memory" fine tuning... three-way installation — wall, custom or any of the beautiful Heath factory assembled cabinets. Add to that the unique Heathkit self-servicing features like the built-in dot generator and full color photos in the comprehensive manual that let you set-up, converge and maintain the best color picture at all times, and can save you up to $200 over the life of your set in service calls. For the best color picture around, order your "295" now.

GRA-295-1, Walnut cabinet shown $62.95
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Deluxe "227" Color TV... Model GR-227

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(less cabinet)

Has same high performance features and built-in servicing facilities as the GR-295, except for 227 sq. inch viewing area. The vertical swing-out chassis makes for fast, easy servicing and installation. The dynamic convergence control board can be placed so that it is easily accessible anytime you wish to "touch-up" the picture.

GRA-227-1, Walnut cabinet shown $59.95
Mediterranean style also available at $99.50

Deluxe "180" Color TV... Model GR-180

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(less cabinet)

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GRS-180-5, table model cabinet and cart $39.95
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Now, Wireless Remote Control For Heathkit Color TV's

Control your Heathkit Color TV from your easy chair, turn it on and off, change VHF channels, volume, color and tint, all by sonic remote control. No cables cluttering the room... the handheld transmitter is all electronic, powered by a small 9 v. battery, housed in a small, smartly styled design plastic case. The receiver contains an integrated circuit and a meter for adjustment ease. Installation is easy in older Heathkit color TV's thanks to circuit board wiring harness construction. For greater TV enjoyment, order yours now.

kit GRS-681-6, 7 lbs., for Heathkit GR-681 Color TV's... $59.95
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For GR-295, GR-227 & GR-180

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New Wireless TV Remote Control
For GR-681

$59.95
NEW HEATHKIT AD-27 FM Stereo Component-Compact

This new Heathkit AD-27 compact FM stereo has features not found in other units costing twice as much for one very simple reason. It wasn't engineered to meet the usual level of compact performance. Instead, Heath took one of its standard stereo hi-fi receivers, the AR-14, and re-rigged it physically to fit a compact configuration. The result is performance that is truly high fidelity without compromise. It features 31 transistor, 10 diode circuitry with 15 watts per channel dynamic music power (enough to let you choose most any speakers you prefer), full-range tone controls, less than 1.5% distortion, and 12 to 60,000 Hz response. The pre-assembled FM stereo tuner section with 4-stage IF offers 5 volt sensitivity, excellent selectivity, AFC, and the smoothest inertial tuning. The BSR McDonald "500" turntable offers a smooth, low-cost平民, expensive units...like low mass tubular aluminum tone arm, anti-skate control, cueing and pause control, plus a Shure magnetic cartridge with diamond stylus. It's all housed in a smart oil-finished walnut cabinet with sliding tambour door that disappears inside the cabinet. For value and performance choose the AD-27, the new leader in stereo compacts. Sglp. wt. 41 lbs.

NEW HEATHKIT AD-17 Budget-Priced Component-Compact

Heath engineers took the stereo amplifier from the AD-27 above, matched it with the top rated BSR McDonald 400 Automatic Turntable and put both of these able performers in an attractive walnut cabinet. The result is the high performance, low cost AD-17. The all solid-state circuit delivers 15 watts music power per channel — more than enough to drive any reasonably efficient system. Wide response of 12 Hz to 60 kHz ±1 dB and harmonic & IM distortion both less than 1% at full output are your guarantee of clean, full range sound. Stereo headphone jack, filtered tape outputs and Tuner & Auxiliary inputs too. The BSR McDonald 400 Automatic Turntable features a cueing and pause control, adjustable stylus pressure, variable anti-skate control and manual or automatic operation on all four speeds. Comes complete with a famous Shure magnetic cartridge. The Heathkit manual makes it easy to build...the sound makes it a pleasure to own. Order yours now. 27 lbs.

NEW HEATHKIT AS-18 Miniature Acoustic Suspension System

The new AS-18 features famous high quality Electro-Voice® speakers — 6" woofers and a 2 1/2" tweeter. The wide frequency response of 60 Hz to 20 kHz and the clear, natural sound of the electro-acoustic systems will really set your system apart. For the ideal performance matches to the Component Compacts above and are especially suited for apartments, mobile homes, offices, etc.— anywhere that you need superior stereo sound from a small space. Handles up to 25 watts program material and has a high frequency balance control so you can adjust the sound to your liking. Order 2 for superb stereo now. 16 lbs.

HEATHKIT AR-15 Deluxe Stereo Receiver

The World's Most Sophisticated, Most Praised Stereo Receiver. And here are just a few of the reasons why leading audio critics and testing organizations, as well as thousands of owners rate the AR-15 as THE stereo receiver. The all solid-state circuit with 69 transistors, 43 diodes and two integrated circuits has many new design concepts to deliver superior performance. The amplifier section has 150 watts of music power...75 watts per channel. Harmonic and IM distortion are both less than 0.5%. The special design FET FM tuner boasts sensitivity of 1.8 uV, selectivity of 70 dB and harmonic & IM distortion both less than 0.5%. The Crystal Filters provide an ideally shaped bandpass and are a Heath first in the high fidelity industry. You'll hear stations you didn't know existed in your area, and the Noise-Operated Squelch, Adjustable Phase Control, Stereo-Only Switch, Stereo Threshold Control and FM Stereo Noise Filter Switch will let you hear them in the clearest, most natural way. Other features include two front panel stereo headphone jacks, positive circuit protection, loudness switch, speaker switch, front panel input level controls, recessed outputs, two external FM antenna connectors and one for AM, Tone Flat control, electronically filtered power supply and "Black Magic" panel lighting. Seven circuit boards and nine wiring harnesses simplify assembly and you can mount your completed AR-15 in a wall, your own cabinet or the Heath assembled walnut cabinet. For the ultimate in a stereo receiver, order your AR-15 now. 44 lbs. *Optional walnut cabinet AE-16. $434.95.

HEATHKIT AJ-15 Deluxe Stereo Tuner

For the man who already owns a fine stereo amplifier, Heath now offers the superb FM stereo tuner section of the AR-15 receiver as a separate unit. The new AJ-15 FM Stereo Tuner has the exclusive FET FM tuner for remarkable sensitivity, exclusive Crystal Filters in the IF strip for perfect response curve and no alignment; Integrated Circuits in the IF for high gain, best limiting; Noise-Operated Squelch; Stereo-Threshold Switch; Stereo-Only Switch; Adjustable Multiplex Phase, two Tuning Meters; two Stereo Phone jacks; "Black Magic" panel lighting. 18 lbs. *Walnut cabinet AE-18. $19.95.

HEATHKIT AA-15 Deluxe Stereo Amplifier

For the man who already owns a fine stereo tuner, Heath now offers the same or similar amplifier of the AR-15 receiver separately. The new AA-15 Stereo Amplifier has the same superb features: 150 watts Music Power; Ultra-Low Harmonic & IM Distortion (less than 0.5% at full output); Ultra-Wide Frequency Response (±1 dB), 8 to 40,000 Hz at 1 watt; Front Panel Ind. Level Controls; Transformerless Amplifier; Capacitor Coupled Outputs; All-Silicon Transistor Circuit; Positive Circuit Protection. 26 lbs. *Walnut cabinet AE-18, $19.95.
**Heathkit MI-18 Solid-State Tachometer**

The Professional Tach. That's the new Heathkit MI-18. In Design: breaker point, "tach" lead or unique inductive pickup connection; use it with any spark-type engine and any ignition system, 2 cycle 1-6 cyl. engines or 4 cycle, 2-8 cyl. engines ... all electronics are in the tach itself. In Performance: 0-6000 & 0-9000 RPM ranges ... 250° edge-lighted dial ... temperature-compensated, ±4% accuracy from 0° to -120° ... adjustable red line pointer ... 10.5 to 17.5 VDC operation. The HW-30 has sensitivity for reception over greater distances than you would expect from a portable. The 4" x 6" speaker and an audio output of 350 mW provides clean sound and the GR-17 will keep you entertained for up to 300 hours on a single set of batteries. For the greatest sound everywhere, get your GR-17 today. 5 lbs.

**NEW HEATHKIT HW-100 SSB-CW 5-Band Receiver**

The new Heathkit HW-100 has all the features and performance of the competition at a money saving kit price. And here's what it delivers: the receiver portion has sensitivity of less than 0.5 uV for a 10 dB S+N/N ratio for SSB. Crystal filter selectivity is 2.1 kHz at 6 dB down, 7 kHz at 60 dB down. Image & IF rejection is better than 50 dB. The transmitter has a 100 watt input on either USB or LSB and 170 watts on CW. It operates PTT or VOX on SSB and break-in CW work is provided by operating VOX from a keyed tone, using grid-block keying. Outstanding frequency stability — less than 100 Hz per hour drift after 30 minute warmup ... less than 100 Hz variation under a 10% line voltage variation. The HW-100 is a really loaded rig — solid-state (FET) VFO ... 80-10 meter coverage ... patented Harmonic Drive™ dial mechanism ... built-in 100 kHz calibrator ... TALC and much more. Put this hot rig in your shack — order your HW-100 today. 22 lbs.

**HEATHKIT GR-104A Solid-State Portable B&W TV**

The perfect portable ... that's the GR-104. Small and light enough to carry from room to room ... rugged enough to take it ... and the picture is the sharpest, most realistic you've ever seen, thanks to Heathkit total engineering. 74 sq. in. viewing area ... all solid-state circuit for extra reliability and performance. Covers all VHF and UHF channels. 2-83 ... 2-speed UHF tuning ... "memory" VHF fine tuning ... 3-stage IF for maximum gain with controlled bandwidth ... gated AGC for steady, jitter-free pictures ... transformer regulated power supply ... circuit breaker protection ... one-piece swing out chassis for easy assembly and servicing ... runs on house current or battery power with the optional GRA-104-1 rechargeable battery pack. 27 lbs.

**HEATHKIT GD-325C Low Cost Solid-State Organ**

This money-saving kit form of the popular Thomas "Artistic" Organ can have you playing songs after just 50 hours of interesting, enjoyable assembly, thanks to the clear, easy-to-follow Heathkit manual and exclusive Thomas Color-Glo teaching method. Features 10 true organ voices ... variable repeat percussion ... 13 note heel and toe bass pedals ... 2 overlapping 37 note keyboards, range C2 thru C5 each ... 75 watt peak music power amplifier ... 12" full response speaker ... Vibrato ... manual balance control ... and the solid-state plug-in tone generators — the heart of the organ, are guaranteed for 5 years. Assembled walnut-finish cabinet included. Discover the fun and enjoyment of live music in your home ... order your Heathkit/Thomas organ today. 172 lbs.

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Service Clinic

By JACK DARR
SERVICE EDITOR

Chronic sound drift; triple image

This Admiral 16R12 needs a sound realignment every couple of months. I've checked components, but no luck. Also, in a Magnavox CT-214, I get a triple image; I've checked capacitors around the horizontal circuits, including the yoke capacitor. I guess the next step would be a new yoke. What would you suggest.—J. H., Baltimore, Md.

I believe your trouble in the Admiral could be cured by replacing the discriminator transformer. This is the cause of most complaints of this kind, that is, slow drifting off alignment. It is probably due to aging of the base assembly with its tiny capacitors.

In the Magnavox, the triple image is basically due to the horizontal oscillator running away off frequency. A triple image means that the oscillator is running at someplace normal speed, or somewhere around 5,250 cycles. This could be the fault of a leaky capacitor, a resistor somewhere in the frequency-determining circuits that has drifted off value, or to a defective horizontal oscillator coil or transformer. Grid resistors are always prime suspects for this kind of trouble. This series uses a synchro-guide oscillator circuit. Follow the standard procedure for realigning it. Short out the “waveform” coil, set the hold control in the center of its range, and tune the frequency slug for a single floating picture. If you cannot get a single picture with this procedure (and all coils, capacitors and resistors are good), then the transformer is bad and you'll have to replace it.

Sound, No Picture

I'm afraid I'm stuck. I have raster and sound but no picture on a G-E M6 chassis. Tubes and other parts check okay. If I clamp the ave, I lose the sound. What's going on here?—E. D., N. Y., N. Y.

Most likely possibility is a bad video detector diode. Note the detector is not in series but shunted from the signal path to ground (see diagram). Works just the same, of course, but can have different symptoms.

You can check this with an ohmmeter. Take a resistance reading from the last rf choke outside the detector can (point 1) to ground. Reverse the leads and you should have a “diode reading”—high resistance one way, comparatively low the other. If you get a high reading both ways the diode is open; low resistance both ways, it's shorted.

Possible reason for getting sound through bad detector stage: With a shunt detector, the signal could go on through to the video amplifier. There, it could be “grid-rectifying,” thus developing a sound-off signal. Incidentally, if this chassis has the small glass diode, you'll get better results by using a 1N34 or any of the older, bigger video-detector diodes.

R-E

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

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.

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![Diagram](image-url)

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# COMPUTER SCHOOLS

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Chicago, Ill. 60611

**Business Electronics**
209 W. Jackson Blvd.
Chicago, Ill. 60606

**Canadian Institute of Science & Technology**
263 Adelaide St. W.
Toronto, Ont., Canada

**Capitol Radio Engineering Institute**
3224 16th St., N.W.
Washington, D.C. 20010

**Central Technical Institute**
1644 Wyandotte St.
Kansas City, Mo. 64108

**Cleveland Institute of Electronics**
1776 E. 17th St.
Cleveland, Ohio 44114

**Commercial Trades Institute**
1400 W. Greenleaf Ave.
Chicago, Ill. 60626

**Cook's Institute of Electronics Engineering**
P.O. Box 1064
Jackson, Miss. 39209

**DeVry Institute of Technology**
4141 Belmont Ave.
Chicago, Ill. 60641

**Elkins Institute**
2603 Inwood Rd.
Dallas, Texas 75235

**Grantham School of Electronics**
1505 N. Western Ave.
Hollywood, Calif. 90027

**Hill's Business University**
920 N. Robinson Ave.
Oklahoma City, Okla. 73102

**International Correspondence Schools**
Scranton, Pa. 18515

**LaSalle Extension University**
417 S. Dearborn St.
Chicago, Ill. 60605

**Massey Technical Institute, Inc.**
148 East 7th St.
Jacksonville, Fla. 32206

**Midwest Automation Training—Kansas City, Inc.**
2022 Main St.
Kansas City, Mo. 64108

**National Radio Institute**
3939 Wisconsin Ave., N.W.
Washington, D.C. 20016

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The resonant frequency of the filter equals \( \sqrt{\frac{2}{\pi RC}} \) where \( R \) equals the sum of the fixed resistor and drain-source resistance of the FET in each series leg. \( C \) is the value of the grounded capacitor and \( n \) is the ratio of the two capacitors. The value of \( n \) is determined by the desired attenuation, the characteristics of the associated amplifier and other factors. The author, M. Bronzite, selected a value of 18 which yields a peak attenuation of 20 dB.

The FET’s are driven to saturation and to full off by a modulating voltage in the range of 100–500 kHz. They have an impedance of around 100 ohms when on. The value of the fixed series resistors should be around fifty times the on impedance of the FET’s to minimize the effects of variations in transistor characteristics. In the spectrum analyzer, the effective resistance of each series leg varied over a range of 1 to 20 with modulation.

**R-E**

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EDUCATION/INSTRUCTION

EXPERIENCED RADIO-TV TECHNICIANS
WANTED. Salary $125-$150. VOICE AND VISION, West Lebanon, N. H.

ACCREDED CANADIAN ELECTRONICS TRAINING DAY, NIGHT, HOME STUDY COURSES. FREE BOOKLET. RADIO COLLEGE OF CANADA, 461 King St. West, Toronto 2, Ontario Canada.

COMPUTER PROGRAMMING—the big opportunity career—new recognized correspondence course. No math needed. Free brochure. CANADIAN INSTITUTE OF SCIENCE AND TECHNOLOGY, 622 Adelaide St. W., Toronto.

RADIO ANNOUNCING, learn by tape $1.00. JACK, 207 King Drive, Jackson, Mississipi, 39208.

CHEMTRONICS
COLOR-LUBE
SPECIALY FORMULATED CLEANER FOR COLOR TV TUNERS
Accept no substitutes.

CLASSIFIED COMMERCIAL RATE (for firms or individuals offering commercial products or services). 70¢ per word ... minimum 10 words.
NON-COMMERCIAL RATE (for individuals who want to buy or sell personal items) 30¢ per word ... no minimum.

Payment must accompany all ads except those placed by accredited advertising agencies. 10% discount on 12 consecutive insertions, if paid in advance. Misleading or objectionable ads not accepted. Copy for February issue must reach us before December 13.

WORD COUNT: Include name and address. Name of city (Des Moines) or state (New York) is counted as one word each. Zone or Zip Code numbers not counted. (We reserve the right to omit Zip Code if space does not permit.) Count each advertisement, initial, single figure or group of figures or letters as a word. Symbols or groups such as 8-10, COD, AC, etc., count as one word. Hyphenated words count as two words. Minor over-usage will be edited to match advance payment.

CLASSIFIED COMMERCIAL FORMAR ORDER

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No. of Words Total Enclosed Payment must accompany order unless placed through accredited advertising agency.

| Insert time(s) |
Starting with Issue |

Govenment Surplus

JEEPS Typically From $53.90 ... Trucks From $78.40 ... Boats, Typewriters, Airplanes, Multimeters, Oscilloscopes, Transceivers, Electronics Equipment. Used. 100,000 Bid Bargains Direct From Government Nationwide. Complete Sales Directory and Surplus Catalog $1.00 (Due 30 days First $10.00 Order). SURPLUS SERVICE, Box 820 REL, Holland, Michigan 49443

Give...so more will live the Heart Fund

WRITE NOW FOR FREE 1969 CATALOG McGee Radio Company 1001 BARGAINS IN SPEAKERS-PARTS TUBES-HIGH FIDELITY COMPONENTS RECORD CHANGERS-TAPE RECORDERS-KITS EVERYTHING IN ELECTRONICS. 1901 McGee St., Kansas City RE, Missouri 64108

GOVERNMENT SURPLUS

JEEPS Typically From $53.90 ... Trucks From $78.40 ... Boats, Typewriters, Airplanes, Multimeters, Oscilloscopes, Transceivers, Electronics Equipment. Used. 100,000 Bid Bargains Direct From Government Nationwide. Complete Sales Directory and Surplus Catalog $1.00 (Due 30 days First $10.00 Order). SURPLUS SERVICE, Box 820 REL, Holland, Michigan 49443

Heavy Duty Welder

Welds, pumps, vdlrs or cut most anything made of metal. No experience needed. Follows simple instructions. 210 volt $18.95, 310 volt $21.95, S.I.D. $28.95, broom, aluminum oven, other tools $18.95 each. Write McGee Radio Company, 1901 McGee, Kansas City, Missouri 64108. NO NEW or PERFECT. NO 53%.
The Model 6000 Modular Frequency Meter will measure frequencies 10 KHz to 600 MHz with .000125% accuracy. Special plug-in modules allow the instrument to be used as an audio frequency meter from 500 Hz to 20 KHz full scale and in addition to be used as a dc voltmeter (10,000 ohms/volt).

The wide variety of plug-in oscillator accessories and range modules makes the Model 6000 adaptable to a number of jobs in the field and in the laboratory. Portable, battery operated with rechargeable batteries.

Model 6000 with 601A charger, less plug-in modules .......................................................... $195.00

INTERNATIONAL MODEL 6000 FREQUENCY METER

measures frequencies 10 kHz to 600 MHz with accuracy as close as .000125%

INTERNATIONAL CRYSTAL MFG. CO., INC.
10 NO. LEE • OKLA. CITY, OKLA. 73102

where accuracy counts!

a. Range Modules
b. Oscillator Modules

...For complete information write International today.

Circle 149 on reader's service card

RADIO-ELECTRONICS
In hundreds of Pioneer franchised high fidelity dealers across the country, the SX-1500T is drawing enthusiastic attention because it is a no-compromise receiver. Its highly sensitive front end pulls in the most difficult stations... and is consequently pulling in the crowds. The SX-1500T was made for the thousands who wanted the finest receiver possible... at a reasonable price.

The specifications and quality of the SX-1500T are substantiated by its performance and, more importantly, its sound. It boasts an output of 170 watts of music power, an extraordinary capture ratio of 1 dB, a signal-to-noise ratio of 65 dB, and harmonic distortion actually below 0.1% at half rated power (0.5% at full rated power). FM sensitivity is outstanding at 1.7 µV. Frequency response is 20 to 70,000 Hz ± 1 dB.

If you want a better receiver, don't be misled — pick the one with the honest price. You owe it to yourself to compare the SX-1500T with any other receiver on the market regardless of price.

See and hear the SX-1500T now. Or write for literature and name of nearest dealer.

PIONEER ELECTRONICS U.S.A. CORP., 140 Smith Street, Farmingdale, L.I., New York 11735

PIONEER'S NEW SX-1500T AM-FM STEREO RECEIVER
170 WATTS, FET FRONT END, AND 4 IC's

* (The SX-1500T Price, only: $380.) Shown with PIONEER CS-88 Speaker Systems at $175-each.

PIONEER ...More Value All-Ways!
RCA HI-LITE respects and protects ...a well-earned service reputation

A good service reputation takes time to come by. It's put together call by call, customer by customer, day after day. So why shouldn't you expect the color picture tubes you rely on every day in your business to have earned a good reputation for themselves, too.

That's what you get when you specify RCA HI-LITE. It's the replacement picture tube with OEM specs ... the same quality ... the same tube that goes into original equipment sets. With all-new glass, gun, the works! And such technical advancements as PERMA-CHROME and Unity Current Ratios. Plus the broadest line of types in the industry.

Insist on HI-LITE, the picture tube that respects and protects your service reputation.

RCA Electronic Components, Harrison, N. J.