# Electronics World

OCT. 1962

## TRANSISTORS OR TUBES FOR HI-FI?
*Five leading design engineers discuss the problems.*

## NON-DIRECTIONAL STEREO EFFECTS
*Simple listening tests prove stereo is superior.*

## SERVICE TRANSISTOR SETS WITH V.T.V.M.

## NEON BULB FLIP-FLOP CIRCUITS

## "TELSTAR" COMMUNICATIONS

High above the earth, a 34½" diameter, 170-lb. experimental microwave repeater satellite is now relaying television and telephone signals between the United States and Europe. Complete technical details on the satellite, the system, and its operation.

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## USES UNLIMITED:

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- Electronic Technicians
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complete
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# POCKET SIZE V-O-M

### FEATURES:

1. Hand size and lightweight, but with the features of a full-size V-O-M.
2. 20,000 ohms per volt DC; 5,000 AC.
3. EXCLUSIVE SINGLE SELECTOR SWITCH speeds circuit and range settings. The first miniature V-O-M with this exclusive feature for quick, fool-proof selection of all ranges.

SELF-SHIELDED Bar-Ring instrument; permits checking in strong magnetic fields • Fitting interchangeable test prod tip into top of tester makes it the common probe, thereby freeing one hand • UNBREAKABLE plastic meter window • BANANA-TYPE JACKS—positive connection and long life.

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The most comprehensive test set in the Triplett line is Model 100 V-O-M Clamp-On-Ammeter Kit, now available at distributors. The world's most versatile instrument—a complete accurate V-O-M plus a clamp-on-ammeter with which you can take measurements without stripping the wires. Handsome, triple-purpose carton holds and displays all the components: Model 310 miniaturized V-O-M, Model 10 Clamp-On-Ammeter, Model 101 Line Separator, No. 311 Extension leads, and a leather carrying case, which neatly accommodates all the components. Model 101 literally makes it possible to separate the two sides of the line when using Model 10. Extension leads permit use of Model 10 at a distance from the V-O-M. Complete Model 100 is only $64.50

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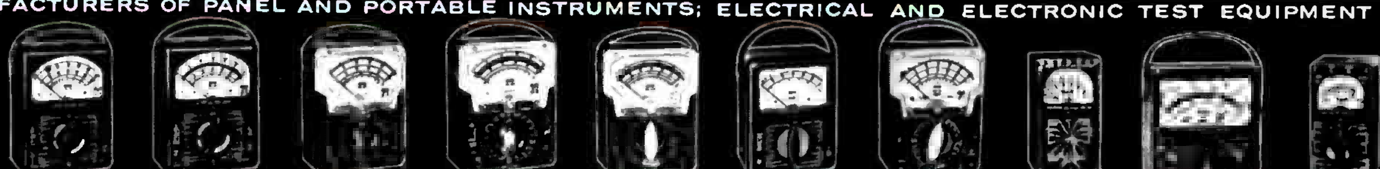

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FOR EVERY PURPOSE—THE WORLD'S MOST COMPLETE LINE OF V-O-M'S

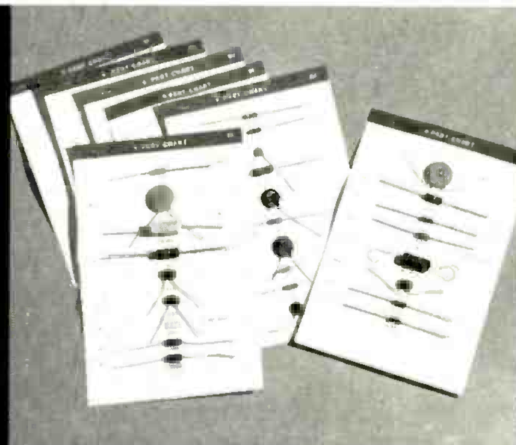
ELECTRONICS WORLD is published monthly by Ziff-Davis Publishing Company at 434 South Wabash Avenue, Chicago 5, Illinois. Subscription rates: one year United States and possessions $5.00; Canada and Pan American Union countries $5.50; all other foreign countries $6.00. Second Class postage paid at Chicago, Illinois and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash. October, 1962; Vol. 68, No. 4.

← CIRCLE NO. 155 ON READER SERVICE PAGE

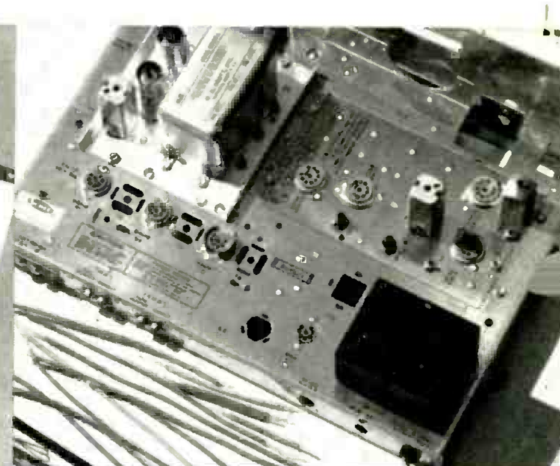
*Here's why Audio Magazine says Scott® Kits are*

# "Simplest to build..." and have "Engineering of the highest calibre" *

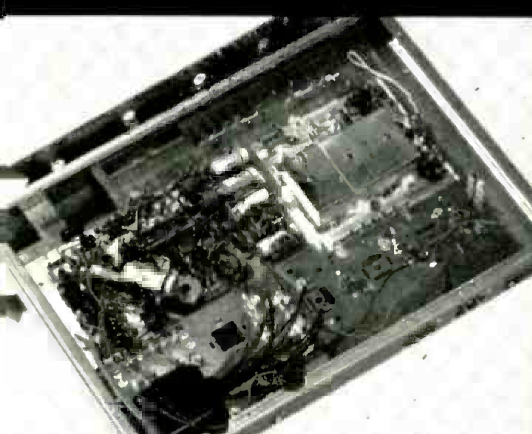

The exclusive Scott full color instruction book shows every part and every wire in natural color and in proper position. To make the instruction book even clearer, each of the full color illustrations shows only a few assembly steps. There are no oversized sheets to confuse you.



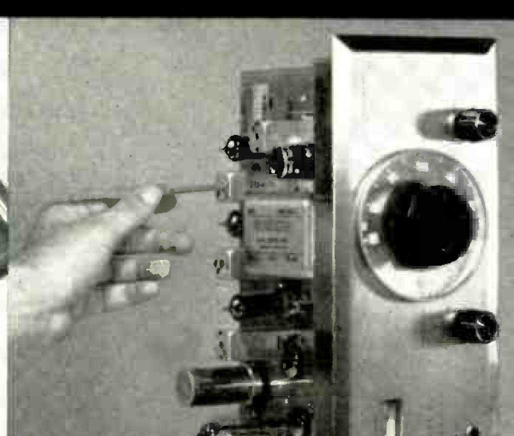
Each full color illustration is accompanied by its own Part Chart . . . another Scott exclusive. The actual parts described in the illustration are placed in the exact sequence in which they are used. You can't possibly make a mistake.



Much of the uninteresting mechanical assembly is completed when you open your Scott Kit-Pak. All the terminal strips and tube sockets are already permanently riveted to the chassis. To insure accuracy all wires are pre-cut and pre-stripped to proper length.



There are certain areas in every professional high fidelity component where wiring is critical and difficult. FM front ends and multiplex sections are an example. In Scott Kits these sections are wired at the factory, and thoroughly tested by Scott experts, assuring you a completed kit meeting stringent factory standards.



Tuners are aligned with the unique Scott Ez-A-Line method using the meter on the tuner itself. This assures perfect alignment without expensive signal generators. Amplifier kits require no laboratory instruments for perfect balancing.


The new Scott Warrantee Performance Plan guarantees that your kit will work perfectly when completed. If you have followed all recommended procedures and your kit fails to work Scott guarantees to put your kit in working order at the factory at minimum cost.

*Audio — February 1961, Pages 54-56

When you finish your kit you'll be delighted by its handsome good looks. And when you turn your Scott Kit system on you'll know for yourself why the expert editors of leading high fidelity magazines like Audio say . . . "only the most sophisticated engineering thinking could design a kit as simple and foolproof as this . . ." *

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OCTOBER 1962 / VOL. 68 NO. 4

Electronics World

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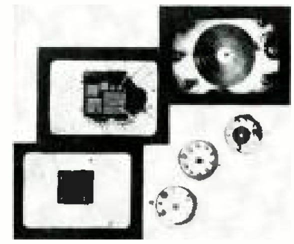

## Special Feature

**Integrated Circuits—A Revolution in Electronics**—Details on an exciting new manufacturing technique in which an entire circuit is fabricated without the use of conventional components. Extremely small size, greater reliability, and longer life are only a few of the advantages claimed for these components. Eventually reduced circuit costs will expand their applications in electronics. An exclusive story from Motorola Semiconductor Products Division, Phoenix, Ariz.

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*You can pull in weak signals nicely on all TV channels, u.h.f. as well as v.h.f., and FM transmission too, with a single antenna. What is more, you can assemble it of wire and wood and then hide it in your attic. A simplified adaptation of the log-periodic concept provides exceptional pick up from 54 to 890 mc. with superior directivity.*

**WHITE NOISE**

*Since "white noise" is a term frequently used but not always understood, Lon Edwards of Solitron Devices, Inc. develops the theory in detail. The construction of a white-noise generator and its uses in testing hi-fi components and systems are also covered in this article.*

**EVOLUTION OF THE COMMUNICATIONS RECEIVER**

*Part 1 of a 2-part series tracing circuit-design trends in amateur communications receivers from the very earliest crystal and regenerative sets up to the present-day sophisticated unit. Of interest to hams, service technicians, and everyone concerned with circuit techniques, the series covers the entire gamut of radio-receiver design.*

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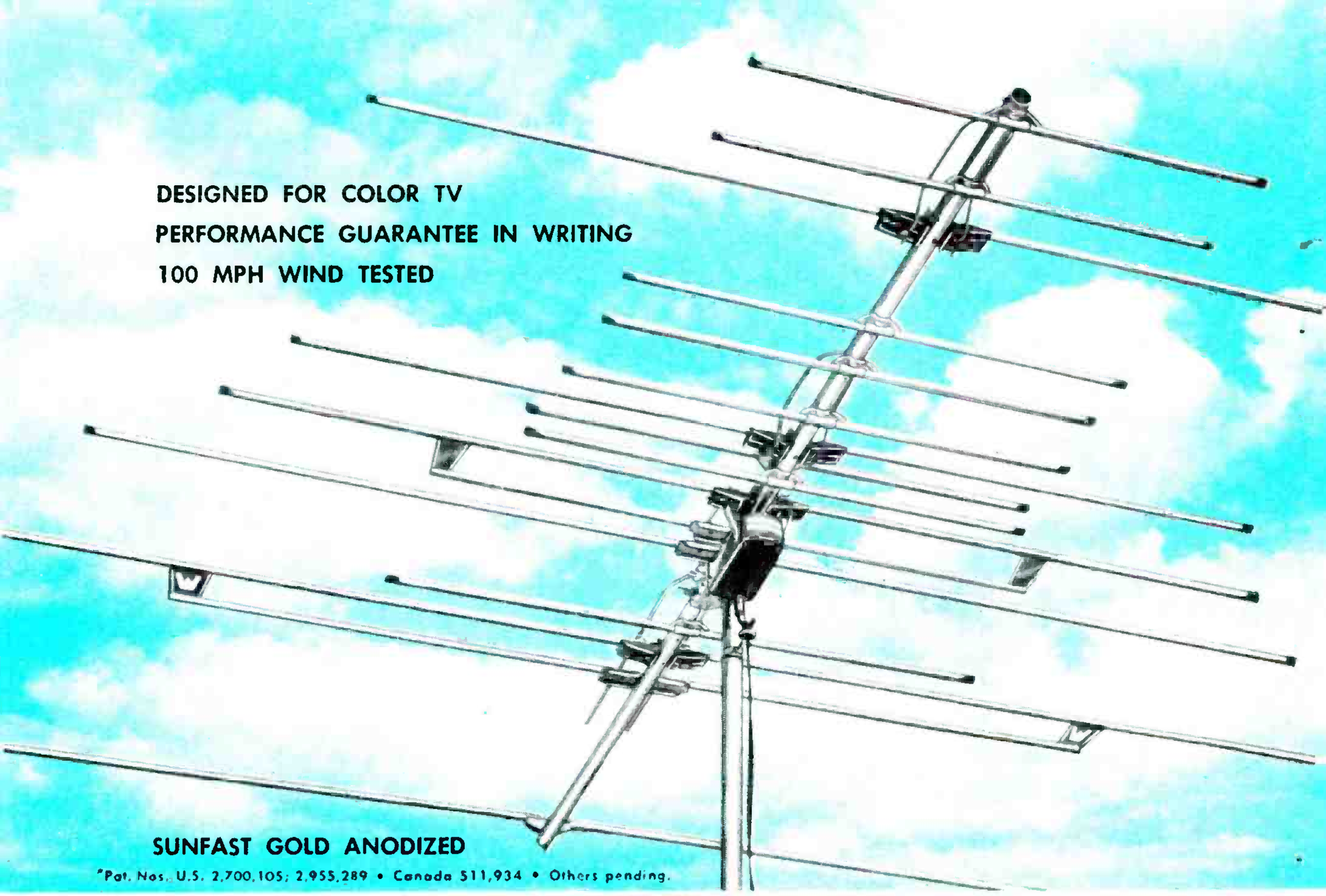


# NEW FOR COLOR Winegard COLORTRON

**EVOLUTIONARY** — The finest TV antenna design ever engineered is the time-proven Electro-Lens all channel Yagi. This patented basic design, with its cross-phased driven elements and intermixed director system, was introduced by Winegard to the industry in 1954 and has never been surpassed. Now, through continuous research and product development, a new, improved Electro-Lens Yagi has evolved—the NEW WINEGARD COLORTRON—bringing this acknowledged design to a new peak of perfection.

**4 COLORTRON MODELS $24.95 to $64.95**
There are 4 new COLORTRON yagis to cover every reception need, from suburbs to distant fringe areas . . . setting new industry standards for reception results and mechanical construction. They are the only outside antennas that carry a *written factory guarantee of performance* with full factory back-up of consumer satisfaction.

**PERFECT COLOR ANTENNA** — COLORTRONS have an almost flat frequency response (plus or minus ½ DB across any 6 MC channel), no "suck-outs" or "roll-off" on end of bands . . . accurate 300 ohm impedance match. (VSWR 1.5 to 1 or better) . . . unilobe directivity for maximum ghost and interference rejection. They deliver today's finest TV reception—COLOR or BLACK AND WHITE.

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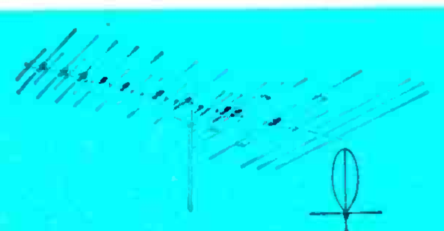
**POWERFUL ELECTRONIC ANTENNA** — Because the COLORTRON and the NUVISTOR amplifier were designed to match each other perfectly, electronically and mechanically, together they make the most efficient electronic TV antenna yet devised.

CIRCLE NO. 159 ON READER SERVICE PAGE



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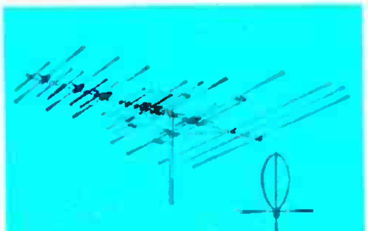

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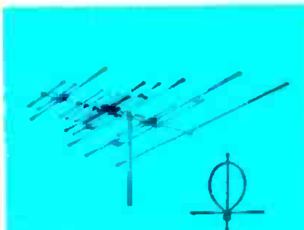

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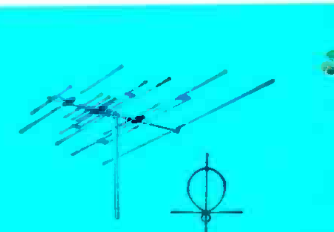

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# ANTENNA and **COLORTRON** AMPLIFIER

**REVOLUTIONARY**—Now a revolutionary new circuit, using two NUVISTORS enables the WINEGARD COLORTRON amplifier to overcome the limitations of other antenna amplifiers. For instance, oscillations, strong signal overloading and cross modulation picture interference are not problems with a COLORTRON AMPLIFIER because it will take up to 400,000 microvolts of signal input, 20 times more signal than other antenna amplifiers. *You can use it to amplify weak signals from far-away stations even though you have strong local signals from TV and FM stations. The* COLORTRON NUVISTOR *Amplifier is the only antenna amplifier that can do this!*

**"LIFESAVER" CIRCUIT GIVES NUVISTORS 4 TIMES THE LIFE OF ORDINARY TUBES**—A special "LIFESAVER" circuit has been designed to give the rugged LONG LIFE NUVISTORS an operating life many times that of tubes, and superior to transistors in similar use. The COLORTRON NUVISTORS will operate perfectly for years.

**PERFECT COLOR TV AMPLIFIER**—The COLORTRON amplifier *has what it takes* to give CLEAN, CLEAR COLOR PICTURES, sharp and bright without smear. On weak signals, it will effectively reduce snow and interference, often making the difference between a very good picture and a poor one. It has an ultra low noise circuit . . . high amplification . . . flat frequency response . . . accurate impedance match (VSWR 1.5 to 1 or better, input and output) . . . and no phase distortion. You can be confident it will improve color and black and white TV reception in any location. This amplifier is so powerful, it can easily drive 6 sets at once with gain to spare!

**WEATHER-SEALED POLYSTYRENE CASE . . . CORROSION-PROOF**—The COLORTRON NUVISTOR amplifier is completely weather-sealed! Nothing is exposed to corrode and cause trouble—even the terminals are protected. A rubber boot over the twin-lead keeps moisture out. A built-in heat sink controls temperature of NUVISTORS. Everything possible has been done to eliminate maintenance problems. It comes complete with an all AC power supply with built-in 2 set coupler. (Mod. No. AN-220, $39.95). The COLORTRON amplifier will give trouble-free performance for years. Install it and forget it!

**OTHER ANTENNA AMPLIFIERS**

FOR TV—2 Transistor (Mod. No. AT-220, $39.95) also available. Will take up to 80,000 microvolts of signal input without overload. This is 3 times the input of other transistor antenna amplifiers.

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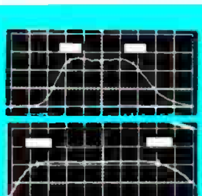

UNRETOUCHED PHOTO OF AMPLIFIER GAIN CURVE—FLAT RESPONSE ALL CHANNELS.

COLORTRON POWER UNIT WITH BUILT-IN 2 SET COUPLER.

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# ...for the Record

By **W. A. STOCKLIN**
Editor

## Our New Look

IT HAS been three months since our July issue was distributed and by now all of our readers have been exposed to our different covers, new typefaces, new layouts. The response has been most gratifying and, although we originally hoped to answer all your letters personally, the task has become too great and we would like to devote this space as a kind of "thank-you note" to all who have taken time to send us your comments.

As we had hoped, most of the letters were quite complimentary, but there were a few who posed the question: Why a change?

Outside of our name change from RADIO & TV NEWS to ELECTRONICS WORLD, there have been no major changes in our appearance in all the years we recall—and that has been some twenty years. Up to our July issue we were still using the same typeface and the same 3-column page as we did twenty years ago.

The decision to make a change wasn't just an overnight inspiration. We had been planning for over a year, experimenting with different layouts, typefaces and art work, with one thought in mind—can we improve our magazine? We came to the conclusion that the editorial content should remain the same. But in view of the availability of more modern typefaces and improved art techniques, there was no reason why we should not give you a more attractive and impressive package. People's tastes vary to a degree, but everyone appreciates good looks. There is absolutely no need for any publication, whether it be a service, hi-fi, or any other type of magazine, to be unattractive and difficult to read. Certainly a service technician and an engineer can both appreciate neatness and attractiveness.

Our typefaces have been modernized and made a little larger with the idea of making our editorial material easier to read. There is a psychological lift, resulting in greater appreciation, when eye fatigue is reduced. Enjoyment and comprehension are in an inverse ratio to the amount of eyestrain of the reader.

We have also changed from a 3-column page to a 2-column presentation, which, in itself, is not new as many of our old-time readers will recall. In the past, we have reserved this type of presentation for special issues or special articles. We don't think anyone would disagree with us in that this type of layout is much easier on the eyes, looks better, and therefore makes it easier for the reader to assimilate the information contained in our articles. This, in itself, has done more to alter the appearance of our publication than any other change we have made, and this may lead some to believe that our editorial content has changed.

This situation is quite similar to putting up vertically striped wallpaper. Were this paper to be hung horizontally, the room would look entirely different, but yet, it is the same paper. Similarly, our editorial content remains the same and we will continue to keep our readers up-to-date on the newest circuits and developments in areas of interest vocationally or avocationally. We will also continue our efforts to publish the most authoritative material available on any given subject.

The change in our covers should come, as we had planned, as a surprise to our readers. In place of our usual 4-color photographic covers, we are now using technical illustrations, in full color. This does not preclude future use of photographs, but the emphasis will be more toward the technical presentation. We feel that there is so much that cannot be shown in a photograph. It is our hope to convey a photographic image along with our own thoughts on the subject. Certainly our July, August, September, and October covers are good examples of what we are doing. We do not believe that any single photograph could have presented the subject more clearly. This type of presentation takes not only a good artist, but a lot more time and effort on our part, but we believe the results are worth it. We hope you agree. ▲

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***Turn Page For Facts On NRI Courses*** ➧

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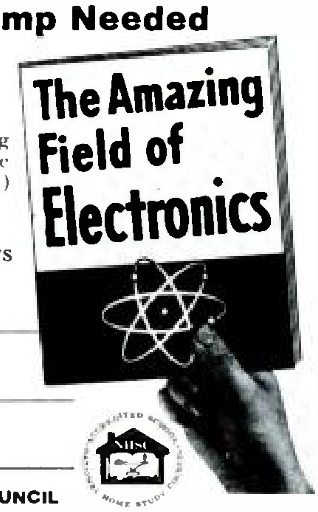


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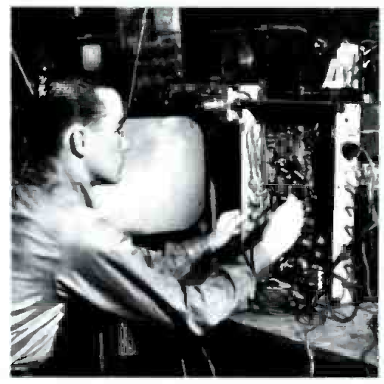
**(INCLUDES COLOR TV)**



NRI's time-tested course in Servicing not only trains you to fix radios, TV sets, hi-fi, etc., but also shows you how to earn spare-time money starting soon after enrolling. Fast growth in number of sets, color-TV, stereo, means money-making opportunities in your own spare-time or full-time business or working for someone else. Special training equipment included.

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## FCC COMMERCIAL LICENSE

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*For more complete technical information on Citation A write to the Citation Division, Dept. EW-10, Harman-Kardon, Inc., Plainview, N.Y.*

**harman kardon**

# LETTERS FROM OUR READERS

### TEST EQUIPMENT FOR 2-WAY RADIO

To the Editors:

On page 44 of your June issue, there was a very fine article entitled "Test Equipment for Communications Servicing". Our organization has been in this business for sixteen years and we are constantly setting up and working with service stations that handle mobile 2-way radio.

We would like permission to reprint this article and pass it out to some of our service stations in order that they will have a better idea of the test equipment required and its use.

THOMAS F. CARTER, President
Carter Communications Corp.
Dallas, Texas

*We are always glad to grant such permission. All we ask is that the source be credited.—Editors.*

° ° °

### TECHNICIANS AND AUTOMATION

To the Editors:

Mr. Jones' article "Technicians in the Computer Industry," which appeared in your June 1962 issue, was true enough as far as it went. In order to be completely fair to the people who might like to become computer technicians though, you must present the other view.

The other view being that all is not roses with the technician. There is a very real danger that the technician and perhaps even the engineer will one day find they are no longer in demand. This does not mean that there will not be someone called a "technician" or "engineer". This means that there will not be a need for as many.

This seems evident from two things. First, the speed of the computer, and second, the reliability.

The newer machines are much faster than the machines made five years ago (in some cases, perhaps by a factor of 7). Transistors are now very reliable. I understand that the Naval Ordnance Test Center (NOTS) has a machine that clocked 10,000 hours without a component failure.

These two things taken together paint a black picture for the technician and the engineer.

DONALD A. GREEN
Burbank, California

*Automation does produce some cutback in employment in certain areas. This is an important problem and many companies and our government are presently much concerned. In the long run, however, automation has invariably increased employment and raised the level of the worker. We feel that as equipment becomes more automated there will be a greater not a lesser need for technicians to operate, service, and maintain it. As a matter of fact, were it not for automation a good many of the technician and engineering jobs would not even exist today.—Editors.*

° ° °

### LOW-EFFICIENCY SPEAKERS

To the Editors:

I am a great booster of Mr. Villchur and of the speakers he designs. However, after reading his article on speaker distortion ("Distortion in Loudspeakers" in the June issue), I am beginning to have my doubts.

In the paragraph on page 68 which starts "At any one moment . . . ." the statement is made: "To throw away half of the voltage is to throw away three-quarters of the power since power varies as the square of the voltage."

It is quite true that one-half of the voltage falls across the dead part of the coil, but this voltage is being developed across one-half the impedance which gives us one-half and not three-quarters of the power being thrown away.

ANTHONY MCGOOKIN
Chicago, Illinois

*Reader McGookin is quite right. This was one of those statements that sounded so logical that no one stopped long enough to figure it out. Mr. Villchur's conclusion is still valid, however, namely that voice-coil overhang, which is used for decreased distortion, involves a major sacrifice in efficiency.—Editors.*

° ° °

### TRANSISTORIZED TV COMPENSATOR

To the Editors:

This letter is in reference to the comments of Mr. C. W. Martel (June "Letters" column) concerning my article "A Transistorized Television Compensator," which appeared in your March issue.

While the comments of Mr. Martel are true to a certain extent, it is evident that he has overlooked one fact.

The idea of using the unbypassed cathode of the output stage to feed audio to the hi-fi system is a reasonable and sound idea. However, this does not take into account the poor quality of the stages that precede it, or the poor low-

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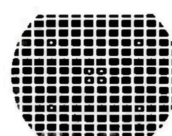
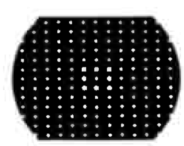
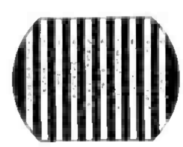


Enables you to troubleshoot and signal trace color circuits in color TV sets, or facilitate installation.



Generates white dot, crosshatch and color bar patterns on the TV screen for color TV convergence adjustments.



Generates full color rainbow display and color bar pattern to test color sync circuits, check range of hue control, align color demodulators. Demonstrates to customers correct color values.

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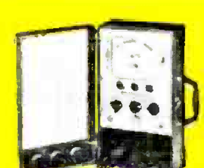

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frequency response obtained because of the use of small coupling capacitors. In some cases the roll-off due to these small capacitors could be 16 db at 100 cycles.

The compensator was designed with the express intent of eliminating these problems by providing an alternate audio path properly compensated, easily installed, and providing excellent quality for connection to high-quality systems.

Ronald H. Wagner
Franklin Park, Illinois

*Reader Martel suggested that Author Wagner's TV compensator was an unduly complicated and expensive way of getting good TV sound since all one had to do was to remove the bypass capacitor across the cathode resistor of the audio-output stage and pick up audio here. In addition to the loss of lows mentioned above, some TV sets have excessive high-frequency roll-off due to the use of de-emphasis networks having time-constants greater than the normal 75 μsec.—Editors.*

° ° °

### TECHNICIANS IN COMPUTER INDUSTRY

To the Editors:

I have recently seen the cover of your June issue. It is a very excellent color-reproduction job. We were glad to be able to contribute an article to your publication, and were happy to see it selected as a feature story in your June issue.

I have endorsed your check in payment for the article over to the general scholarship fund of the Student Aid Association at Broome Technical Community College in Binghamton, New York. Under the *IBM* matching-grants program to educational institutions, the college will be eligible for an equivalent amount from the *IBM Co.* Perhaps these contributions will aid some deserving young man to graduate as a qualified technician.

D. N. Jones
Director of Personnel
General Products Div., IBM
White Plains, New York

*Mr. Jones was the author of the article "Technicians In the Computer Industry."—Editors.*

° ° °

### SHIELDED IGNITION SYSTEM

To the Editors:

I was especially interested in the article "Reducing Citizens Band Ignition Noise" which appeared some time ago in your magazine although at that time I didn't have a need for the shielded ignition system described by the author. Now I do. Where can I get the *Hallett* shielded ignition system mentioned?

Paul Bradford
New York, N.Y.

Hallett Manufacturing Co. *is located at 5910 Bowcroft St., Los Angeles. In addition to this firm,* E. F. Johnson Co., *Waseca, Minn., and* Sprague Electric Co., *North Adams, Mass. are offering such shielded ignition system kits through their regular distributor outlets.—Editors.*

° ° °

### ANODE-FOLLOWER PREAMP

To the Editors:

There is an error in the parts list in my article "Anode-Follower Stereo Preamp," appearing in the July 1962 issue of your magazine.

Potentiometer $R_{23}$ should be a 250,000-ohm dual *linear-taper* potentiometer rather than the audio-taper control specified. This is important so that the channels are balanced at the mid-position of the control.

Charles P. Boegli
Director of Engineering, Acting
The Bendix Corporation
Cincinnati, Ohio ▲

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The streamlined Grantham course is designed specifically to prepare you to pass certain FCC examinations. All of the instruction is presented with the FCC examinations in mind. If your main objective is an FCC license and a thorough understanding of basic electronics, you want a course that is right to the point – not a course which is "padded" to extend the length of time you're in school. The study of higher mathematics or receiver repair work is fine if your plans for the future include them, but they are not necessary to obtain an FCC license.

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Some schools and individuals offer a "coaching service" in FCC license preparation. The weakness of the "coaching service" method is that it presumes the student already has a knowledge of technical radio. On the other hand, the Grantham course "begins at the beginning" and progresses in logical order from one point to another. Every subject is covered simply and in detail. The emphasis is on making the subject easy to understand. With each lesson, you receive an FCC type test so you can discover daily just which points you do not understand and clear them up as you go along.

## Is the school accredited?

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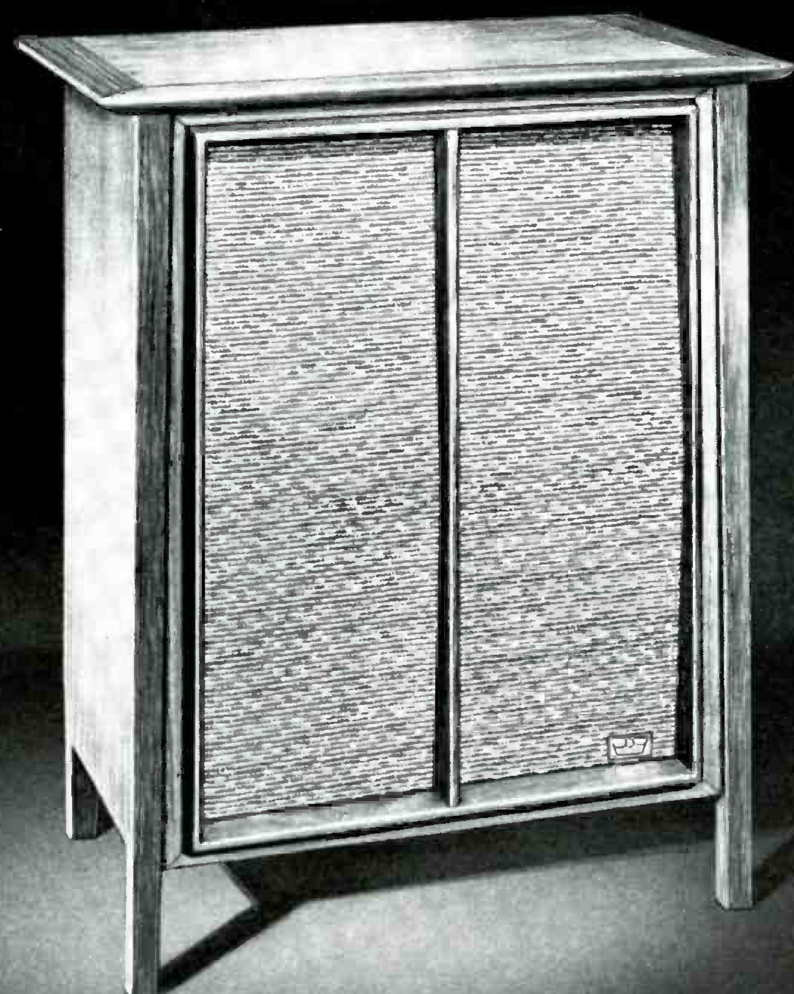
**this would be the finest speaker system of them all—**



# the new Classic Dual-12

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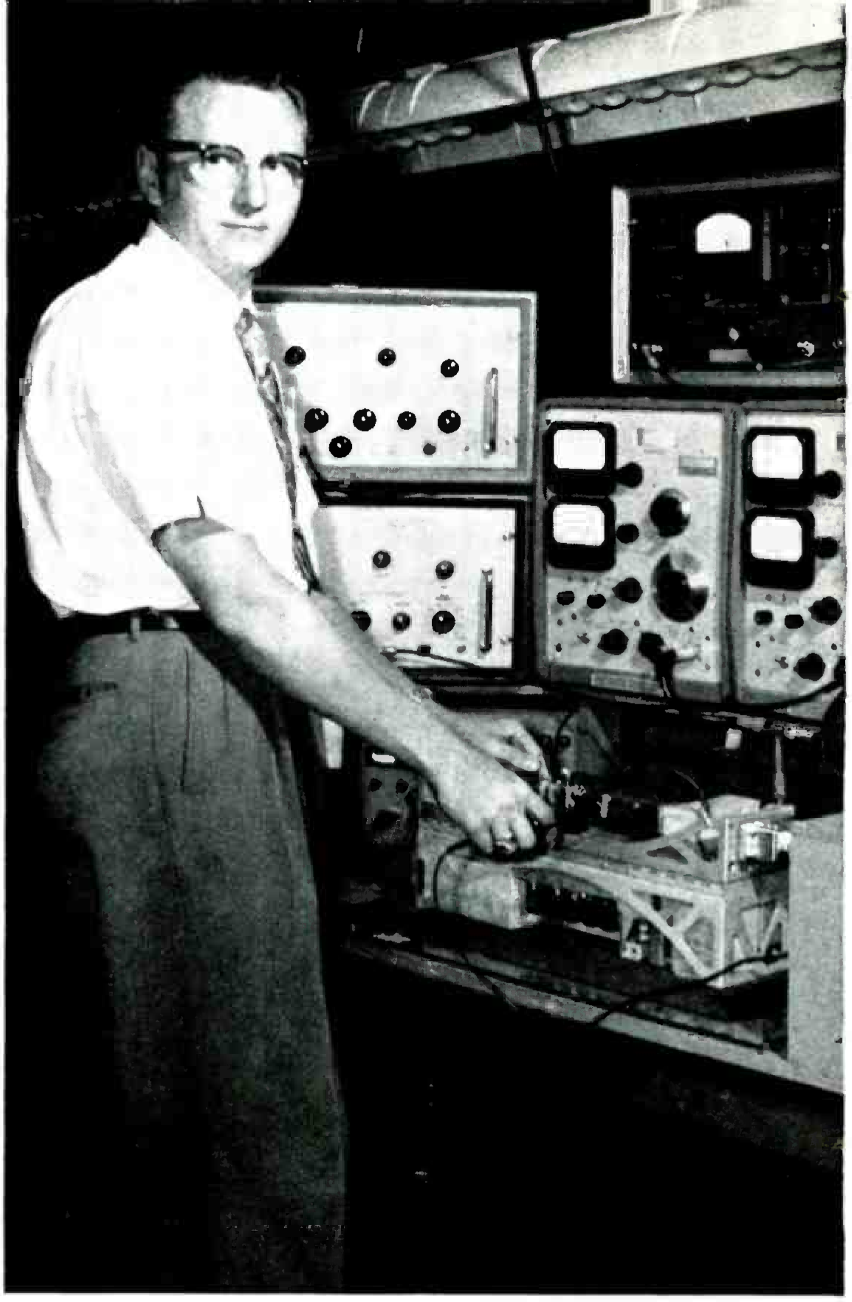

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If electronics is the "field of opportunity," how is this possible? No question about it, electronics offers many opportunities, *but only to qualified men*. In any career field, it is how much you know that counts. This is particularly true in the fast moving field of electronics. The man without thorough technical education doesn't advance. Even men with intensive military technical training find their careers can be limited in civilian electronics.

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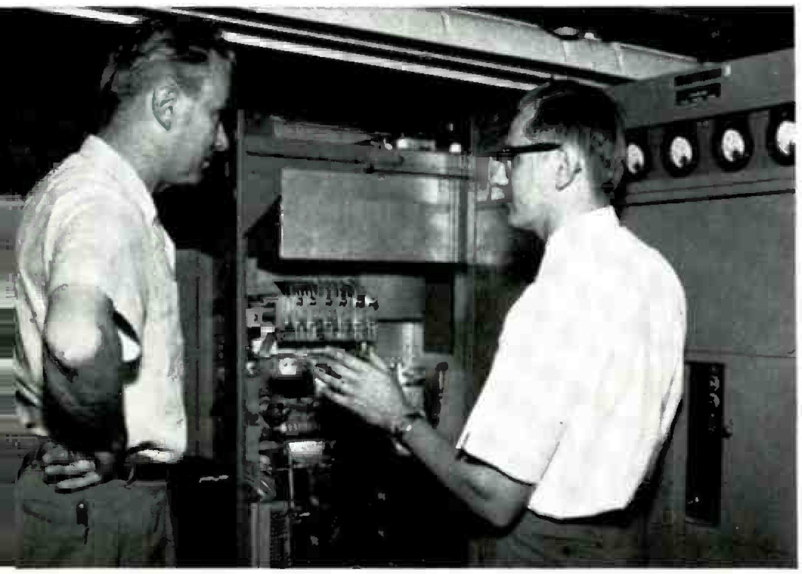

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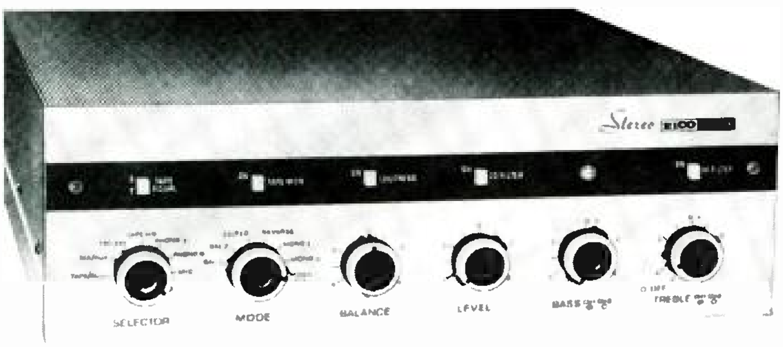
# EW Lab Tested

*AUDIO PRODUCTS TESTED BY HIRSCH-HOUCK LABS*



## Eico ST84 Stereo Preamplifier

*For copy of manufacturer's brochure, circle No. 57 on coupon (page 17).*




THE new *Eico* ST84 stereo preamplifier is a deluxe, highly flexible unit, styled to match other *Eico* audio components. The ST84 has three high-level inputs—for tape amplifiers, FM-AM tuners, or multiplex FM tuners. It has low-level inputs for microphones, tape heads, and two independent phono cartridges.

The "Mode" selector allows all possible combinations of inputs and outputs. There are settings for stereo (normal and reverse), balancing settings with the sum of both inputs going to either output, monophonic settings with either input going to both outputs, and finally, for mono record playing—the sum of both inputs going to both outputs. The balancing function is particularly useful for matching channel gains.

The "Balance" control has a limited range, −4 db to +8 db on either channel. There are no individual channel or input level controls so that all system level adjustments must be made externally. Tuners or tape decks usually have their own output level controls and *Eico* power amplifiers have input level controls. If this preamplifier is used with other power amplifiers, it may be necessary to insert level controls between the preamplifier and the power amplifier. The ST84 manual gives instructions for doing this.

The tone controls use feedback circuitry, with sliding inflection points. They can control the frequency response at the limits of the audio spectrum, where it is most likely to be required, leaving the middle range unaffected. Concentric knobs are used for the two bass controls and the two treble controls. One of the treble tone control knobs also operates the power switch.

The preamp has rumble and scratch filters, loudness compensation, tape-monitoring facilities, and tape playback equalization for either 3.75 ips or 7.5 ips. These functions are handled by a row of slide switches across the upper part of the panel.

The specifications listed below include the manufacturer's ratings (listed first) and our measured performance data as run on a kit which was assembled for us (construction time: about 18 hours).

*Frequency response:* 5-25,000 cps ± 0.3 db (tone controls electrically flat) *versus* 20-20,000 cps ± 1.5 db (tone controls mechanically centered).

*Hum and Noise (re. 1 volt):* low-level input −65 db, high-level input −75 db *versus* −62 db and −83 db.

*Sensitivity (at 1 kc., 1 v. out):* phono 1.6 mv., high-level inputs 170 mv. as against 2 mv. and 180 mv. respectively.

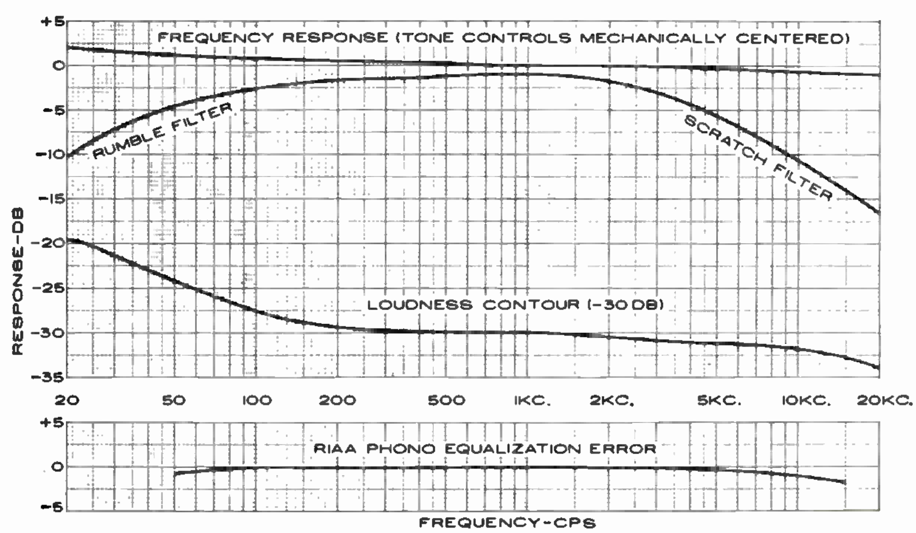
*IM distortion:* .04% @ 2 volts rated *versus* approximately .06% (below the residual distortion of our test equipment).

*Harmonic distortion:* rated .05% @ 2 volts as against approximately 0.06% (below the residual distortion of our test equipment).

*Tone-control range:* rated ± 15 db at both 10 kc. and 50 cps as against our figures of + 17 db, −15 db at 10 kc. and +15.5 db, −14.8 db at 50 cps.

*Stereo crosstalk:* not rated by the manufacturer. We measured −38 db @ 1 kc. and −29 db @ 10 kc.

The preamp makes extensive use of negative feedback. Phono and tape-head equalization is by means of feedback networks around the 12AX7 preamplifier stage. High-level inputs go directly to the level control, so that the following stages cannot be inadvertently overdriven. A two-stage (12AX7) amplifier with over-all negative feedback supplies the required gain. The tone-control circuits are in the output stage (½-12AX7). The feedback loop from the plate of this stage includes the tone-control circuits,



# SIMPLE ARITHMETIC:

## Uncompromising engineering + moderate price = best buy


# New Eico Stereo FM Multiplex Tuner ST 97

Semi-Kit **$99.95** Wired **$149.95** Includes Metal Cover AND FET

### BUILDING THE SEMI-KIT:

**The two most critical sections,** the front end and 4 IF's through to the detector, are entirely pre-wired and pre-aligned for best performance on weak signals (fringe area reception).

**For the third most critical section,** the heart of the stereo demodulator, you simply mount and solder the components on a high quality circuit board. Prealigned coils eliminate all adjustments. The rest is non-critical and easily accomplished with the clearest pictorial drawings and most thorough-going step-by-step procedure in the industry.

### THE CIRCUIT

**the front end** Consistent and reliable printed circuit. Ultra-sensitive, stable, and low-noise. Wide-band design. Rugged plated steel housing for protection and shielding. Meets FCC radiation requirements. Precise temperature-compensation for freedom from drift without AFC. AFC provided with defeat for convenience. Indirect gear drive is backlash-free and eliminates possiblity of microphony.

**the IF strip** Four IF amplifier-limiter stages (all that will do any good) and an ultra-wide-band ratio detector, all pre-wired and pre-aligned. Designed with the utmost practicality so that the simplest alignment is also the alignment for highest sensitivity and practically lowest distortion. (Important to you if a service alignment is ever required.) Output is flat to the limit of the composite stereo signal frequency spectrum to eliminate any need for roll-off compensation in the stereo demodulator.

**the stereo demodulator** Ten stages for unequalled performance capabilities. EICO's brilliantly-engineered zero phase-shift, filterless detection circuit (patents pending) eliminates loss of separation due to phase-shift in the stereo sub-channel before recovery. Complete rejection of storecasting interference. Cathode follower driven, sharp cut-off 15kc low pass filters in each output channel.

### THE OPERATION

Two slide-rule dials in a line: one, a station frequency dial with the famous EICO "eye-tronic"® tuning-eye travelling along it to indicate the exact center of each broadcast channel; the other a logging dial with an automatic stereo indicator lamp travelling along it in tandem with the tuning-eye to indicate when the station tuned in is broadcasting stereo.

### THE LOOK

Massive extruded aluminum panel and side rails, exquisitely brushed and anodized pale gold, with baked epoxy brown, perforated steel cover.

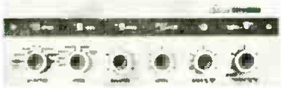
### PERFORMANCE

Pre-production field tests brought back the report "Definitely a fringe-area stereo tuner," which is simply the meaning of our laboratory measurements. We know, for example, that full limiting is achieved at 10uV input signal, meaning that the low distortion and noise specifications (the full benefits of FM) will apply to all but the most distant and difficult-to-receive stations. The sharp selectivity you need when a tuner is that sensitive is here also (a strong local station and a low-power station 100 miles distant separated by only 0.4 mc, each had its own sharp tuning-in point on the dial). While signal levels as low as 2.5uV will produce phase-locking for full stereo separation, very strong local signals will produce no higher output from the FM detector than a 10uV signal and will not be degraded in quality by overloading the stereo demodulator. Distortion is very low, both in mono and stereo, so that the sound you hear has that sweetness, clarity, and freedom from grating harshness that results from absence of distortion. The stereo output signals are so clean that there is not a sign of the 19kc pilot carrier or the re-inserted 38kc sub-carrier visible on a scope presentation.

### SPECIFICATIONS

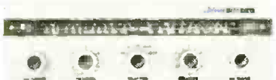
Antenna Input: 300 ohms balanced. IHFM Usable Sensitivity: 3uV (30db quieting), 1.5uV for 20db quieting. Sensitivity for phase-locking (synchronization) in stereo: 2.5 uV. Full limiting sensitivity: 10uV. IF Bandwidth: 280kc at 6db points. Ratio Detector Bandwidth: 1 megacycle peak-to-peak separation. Audio Bandwidth at FM Detector: Flat to 53kc discounting pre-emphasis. IHFM Signal-to-Noise Ratio: −55db. IHFM Harmonic Distortion: 0.6%. Stereo Harmonic Distortion: less than 1.5%*. IHFM IM Distortion: 0.1%. Output Audio Frequency Response: ±1db 20cps-15kc. IHFM Capture Ratio: 3db. Channel Separation: 30db. Audio Output: 0.8 volt. Output Impedance: low impedance cathode followers. Controls: Power, Separation, FM Tuning, Stereo-Mono, AFC-Defeat. Tubes: 1-ECC85, 5-6AU6, 1-6AL5, 1-12AT7, 2-12AU7, 1-6D10 (triple triode), 1-DM70 (tuning-eye), 1-EZ80 rectifier, 6 signal diodes, 1 neon lamp. Power Source: 117V, 60cps; 60 watts drain; extractor post fuse. Size (HWD): 5⅛" x 15⅞" x 11⅜". Weight 17 lbs.

*Actual distortion meter reading of derived left or right channel output with a stereo FM signal fed to the antenna input terminals.

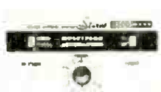


**70-Watt Integrated Stereo Amplifier ST70**
**Kit: $99.95 Wired: $149.95**
Includes Metal Cover

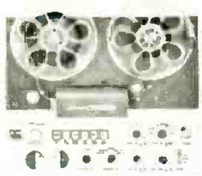
**40-Watt Integrated Stereo Amplifier ST40**
Kit: $79.95 Wired: $129.95
Includes Metal Cover



**FM-AM Stereo Tuner ST96**
Kit: $89.95 Wired: $129.95
Includes Metal Cover and FET



**FM Multiplex Autodaptor MX99** (Patent Pending)
Kit: $39.95
Wired: $64.95
Cover Optional $2.95



**Transistorized Stereo/Mono 4-Track Tape Deck RP100** (Patents Pending)
Semikit: $299.95
Wired: $399.95
Carrying Case $29.95
Rack Mount $9.95

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An EW Symposium *Conducted by CHARLES S. TEPFER*

# TRANSISTORS or TUBES for HI-FI?

## Five of the country's leading high-fidelity component design engineers offer their own answers in an open debate exclusively for the readers of Electronics World.

*EDITOR'S NOTE: Will transistors replace vacuum tubes in hi-fi equipment? To answer this question and to tell our readers the present and future role of the transistor, we solicited the viewpoints of a number of audio designers. After each man presented his case, he was asked to comment on or rebut the views set down by the other engineers. These additional comments and rebuttal are on page 33.*

IN 1948, *Bell Laboratories'* scientists threw a bombshell into the electronics industry with the announcement of the transistor. The fallout has not all settled yet, but the revolution in design nurtured by the transistor and its semiconductor cousins has touched all aspects of electronics—all, that is, except for high-fidelity.

To date, the number of manufacturers who have used transistors in their high-fidelity components can be counted on the fingers of one hand. To date, the sale of all transistorized high-fidelity components combined, from all manufacturers, has not made a significant dent in the marketplace. Why? This is what ELECTRONICS WORLD set out to answer.

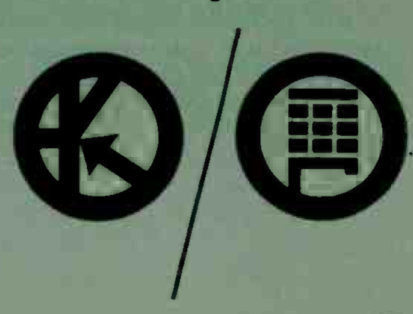
It was evident from the beginning that the answer was not to be found with the marketing people—they would welcome transistor equipment because the market is ready for it. The potential buyer now has transistors in his portable radio, auto radio, intercom, depth finder, tachometer, in fact almost any electronic item he uses. He's heard testimonials to their indispensability in our space exploration program. Now, salesmen could sell transistorized high-fidelity components if they had them to sell.

Where, then, is the bottleneck? All evidence pointed to the design engineer. And indeed, the conflicting answers given us by a large sample of design engineers indicates that there exists a hotbed of controversy behind the calm facade of the laboratory. ELECTRONICS WORLD asked five top designers in the high-fidelity components industry two questions:

"What role will the transistor play in component high-fidelity?

"Will the transistor replace the vacuum tube?"

Their answers to these questions and the comments each made on the answers of his colleagues follows.



4. Amplitude distortion due to nonlinear device characteristics cannot occur in an FM tuner except in the stages after detection. It is not too difficult to design a transistor amplifier for multiplex operation with a flat frequency response to 75 kc. and harmonic distortion of less than 0.5%.

A class B power amplifier design may at times show greater distortion at lower signal levels than at maximum power, but obviously this is not a disadvantage if the maximum distortion at any power level is low. A properly designed class B transistor amplifier generally requires a little less feedback for a given amount of distortion in the output than is required by tube amplifiers. Transistors are not inherently more nonlinear than vacuum tubes.

With some of the newer types of output transistors, such as the drift-field type, it is not difficult to obtain full power rating at frequencies as high as 50 kc., if this is desired. These transistors are now available at low enough prices to permit their use in high-fidelity equipment.

I do not mean to imply that transistors now solve all of the design problems in producing improved high-fidelity components. It is true that transistors create some new problems to plague the design engineer. New and different techniques are required for the design of transistor amplifiers. Greater emphasis must be placed on incoming inspection and quality control in order to assure the utmost in reliability and performance. However, the transistorized high-fidelity components on the market now, as well as the millions of transistorized pocket radios in use, demonstrate the economic feasibility of using transistors.

**Fred L. Mergner**
*Vice-President*
*Director of Engineering*
*Fisher Radio Corp.*

TRANSISTORS are now available, at fairly reasonable prices, permitting the design of practically any type circuit presently used in tube-type high-fidelity components.

### *Use In Amplifiers*

Let's start at the low-level input stages of an amplifier, for which transistors are ideally suited. Transistors do not exhibit hum or microphonics and can be operated as low-noise devices, when matched to low-impedance signal sources such as magnetic tape heads and magnetic phono pickups. In addition, their small dimensions, low heat dissipation, and adaptability to printed circuits encourage tight packaging and component size reduction.

The use of transistors in the power amplifier is particularly tempting. Ever since the tuner-amplifier combination was introduced, one particular problem has plagued the design engineer: the great amount of heat generated by high-power, dual-channel, push-pull output stages. Replacing the output tubes with transistors would, for an average power amplifier, reduce the power requirement by approximately 80 watts and, consequently, the heat dissipation by about 55 per-cent. In addition, a transistorized power output stage makes it possible to eliminate the output transformer, always a problem child and the weakest link in any amplifier. As transistors are basically high-current, low-voltage devices, they can easily be load-matched to the low-impedance voice coils of speaker systems rated between 4 and 16 ohms. Elimination of the output transformer greatly improves the transient response as well as the over-all stability and power handling capabilities of the amplifier at higher audio frequencies, where leakage inductance, stray capacities, and consequently, excessive phase shift can render any feedback amplifier unstable.

Unfortunately, conversion of the output stages—the biggest step forward—present, at the same time, the greatest problem, due to lack of transistors which both perform the task well and are economically feasible to use.

Output stages with power levels considered adequate to drive today's highly damped and low-efficiency speaker systems must deliver a minimum of approximately 25 watts per channel. This, in turn, requires transistors capable of handling currents of at least 1 ampere, based on 40 volts and 63 per-cent efficiency. Germanium alloy-junction power transistors can perform this job easily and are obtainable at prices comparable to those of the bigger power pentodes. Their large junction areas, however, exhibit a high capacitance and thus reduce the available power gain at higher audio frequencies. Germanium alloy-junction transistors normally have a cut-off frequency of between 3 and 10 kc. (This is the frequency at which the current gain in a common-emitter configuration drops to 70 per-cent of the maximum gain available at lower frequencies.) Circuit refinements permit extension of the useful power range beyond this frequency, but the distortion, for equal power output, greatly increases for frequencies higher than 5 to 10 kc. Recent advances in production techniques have resulted in diffused-junction r.f. power transistors which do not possess this drawback, but they are not yet as reliable and stable as the vacuum tubes used today.

The solution to all these problems is readily available—but only to the designer of military equipment, for only he can afford the price of diffused-junction *silicon* power transistors. The situation, however, does not look as bleak as it would seem, because manufacturers of the *germanium* diffused-junction (drift-field) power transistors are on the verge of solving the problems of stability and a phenomenon called secondary breakdown. We can therefore expect to find amplifiers in the near future using these new transistors, which are definitely capable of supplying high power outputs combined with low distortion at frequencies considerably higher that those obtainable with even the present-day highly refined vacuum-tube amplifiers.

### *Use in FM Tuners*

Turning now to transistorized FM tuners will reveal quite a different picture. Whereas in amplifiers the output stages present a major problem, in tuners it is the front-end which imposes limitations. Transistors, in general, are more prone to overload than are tubes, usually by a factor of 10:1. Overload, and consequent distortion in the r.f. and mixer stages of FM front ends due to strong antenna signals, results in cross-modulation, interference, and repeating of the same station at several points on the dial. Application of forward a.g.c. and antenna signal attenuation alleviate this problem greatly, but do not eliminate it completely.

One property inherent in transistors—their change of base-collector junction capacitance with a change of the collector voltage—is particularly bothersome in FM oscillators. This change in capacitance alters the frequency of the associated oscillator circuit, thus causing detuning and frequency drift. To prevent this, a voltage stabilized power supply must be used, increasing the price of the tuner. One further disadvantage of transistors is their low input impedance at the high FM frequencies. Power matching this impedance to the tuned circuits to achieve the highest possible gain will, in turn, greatly reduce their "Q," resulting in image and spurious response rejection figures substantially lower than those available from comparable vacuum-tube front ends. Strangely enough, the sensitivity of FM-transistor front ends can be made equal to that of today's highly sensitive tube front ends. This can be done using very low noise transistors, which are now available at fairly reasonable prices. The remaining sections of a tuner (including any multiplex circuits that may be used) do not present any particular design problems.

As we have seen, the situation at present is one in which transistors might be used in certain restricted sections of high-fidelity equipment, but without advantages in performance, on the whole, over comparable vacuum-tube circuits. The specific applications in which transistors would be clearly superior to vacuum tubes, such as amplifier power output stages, are beyond the reach of presently available, economically feasible transistors. Nevertheless, the near future could see the introduction of hybrid designs in which transistors and tubes "co-exist" side by side.

Ultimately, as new and better transistors become available at lower prices, all-transistor designs will dominate the high-fidelity field. This process will probably take a few years. In the meantime, it would be extremely unfortunate for the industry if hasty designs were to flood the market in the rush to get on the transistor bandwagon. The aim in the conversion to transistors should be part of the over-all search for increasing quality and refinement in design rather than a desire to "cash in" on an inviting promotional gimmick.

**Edward S. Miller**
*Vice-President*
*Sherwood Electronic Labs., Inc.*

OUR research at *Sherwood* has brought to light several idiosyncrasies peculiar to transistor high-fidelity amplifier and tuner design.

Despite the fact that transistors offer one of their greatest advantages over vacuum tubes in high-powered audio amplifiers (their lower heat dissipation), the problem of heat dissipation remains one of the greatest design headaches. Our experience and also evaluation of existing equipment on the market seems to indicate that in designs up to dual-20-watt music power, the heat dissipation problem can be adequately handled by practical heat-sinking techniques (usually mounting tightly to an aluminum chassis or laminated or extruded aluminum-finned heat dissipators).

Since today's market calls for higher powered designs, such as dual 30-, 40-, or even 50-watt amplifiers, we must consider them as well. Inevitably, in this more sophisticated design, we now find the additional heat load presented by a transistor regulator in the power supply. When the unknown environment (will it be mounted in a poorly ventilated, enclosed bookshelf near a vacuum-tube tuner?), plus unknown load conditions (will it be called upon to drive multiple low-efficiency speakers somewhat mismatched to the amplifier?), plus unknown signal conditions (will it be operated for a long duration with a continuous-tone test record to check out its high-frequency performance?) are all taken into consideration, the output transistor heat sink soon rises above the maximum design range of the low-level transistors in the same chassis. The reason for this seemingly anomalous situation is that although as much as 100 watts of wasted power may have been saved over an equivalent vacuum-tube design, there still remains 50 or more watts of power being dissipated directly as heat, which is sufficient, when continuously added to a 100 degree F ambient, to offer trouble in the more sensitive low-level transistors. Perhaps in this case, the design engineer will be forced to resort to a small cooling fan, a cut-out thermostat, or else severe operational restrictions.

Of the varied reasons offered for the superior sound of a transistorized amplifier, when compared to its vacuum-tube counterpart, the most obvious one is when the comparative

(*Continued on page* 114)

## ADDITIONAL COMMENTS & REBUTTAL

**Daniel R. von Recklinghausen**
*Chief Research Engineer, H. H. Scott, Inc.*

A high-fidelity music system is generally assembled from components coming from three or more different manufacturers. Through formal and informal standardization of voltages and impedances, all this equipment operates well together. Transistorized equipment, for the foreseeable future, will have to operate and be capable of installation with existing components and temperature rise caused by the other equipment.

Transistor tuner drift, due to junction capacitance change with temperature and voltage, is more than an order of magnitude higher than with tubes and remains a serious problem. FM front end cross-modulation, because of nonlinear transistor input impedance, is at this time at least 30 db poorer than in a well-designed tube tuner. Here, new linear devices are sorely needed.

It is true that high-input-impedance transistorized amplifiers can be designed. However, lowest noise results if the optimum source impedance, on the order of 1000 ohms, is used. This may be increased to somewhat higher values if collector current is reduced almost to the point of instability. Lower noise devices are needed and the field-effect devices are promising, although their very high price precludes their use in high-fidelity applications.

As long as high-fidelity equipment is operated from an a.c. power line, magnetic induction is the major cause of hum in tube and transistor equipment alike. Therefore, completely hum-free transistor-equipment operation is possible only from batteries.

**Robert E. Furst**
*Vice-President, Engineering, Harman-Kardon, Inc.*

I have followed with considerable bemusement the wide range of opinions expressed in this symposium. Our experiences are not in agreement with many of the arguments raised and I should like to mention some important ones.

1. Lack of transistor uniformity occurs only when standard transistors, designed basically for switching applications, are applied to audio circuits. We have been successful, in cooperation with some of the major transistor manufacturers, in developing and defining appropriate parameters. As a result, production transistors have equaled or exceeded the uniformity of the best tubes.
2. Transistors in preamplifier front ends are less noisy than tubes.
3. We have not found transistors to be more nonlinear than tubes. However, since they lend themselves to application of greater amounts of feedback with the same stability margin, there is an over-all net gain in linearity.
4. No difficulty was encountered in accurately matching any commercial loudspeakers between 4 and 16 ohms to the same transformerless output circuit.

**Fred L. Mergner**
*Vice-President, Dir. of Engineering, Fisher Radio Corp.*

All participants in this symposium seem to agree on several points:

1. Transistors would be preferable to tubes in power output stages, because this would reduce the amount of heat generated and allow the elimination of bulky and costly output transformers, with resultant improvement in stability, frequency and transient response.
2. The over-all reduction in heat is an important factor in designing long-life and stable equipment.
3. The FM front end still defies transistorization, if performance equal or superior to existing tube front ends is required.
4. Reduction in size is desirable and possible, but of secondary importance.

Here are some points on which I am in disagreement with one or several of the participants:

1. FM front ends should be able to handle more than 100,000 microvolts of signal without intermodulation distortion. We measured signals as high as 1 volt in many different places in the New York City area. This will present a problem even if not tuned to such a high powered station, due to the very low r.f. selectivity necessarily found in transistorized front ends.
2. There is no doubt in my mind that transistorized equipment, designed to equal in every respect the performance of presently available tube equipment, must be much more expensive. The example of transistor pocket radios is not indicative of the economic feasibility of conversion to transistors in high-fidelity equipment.

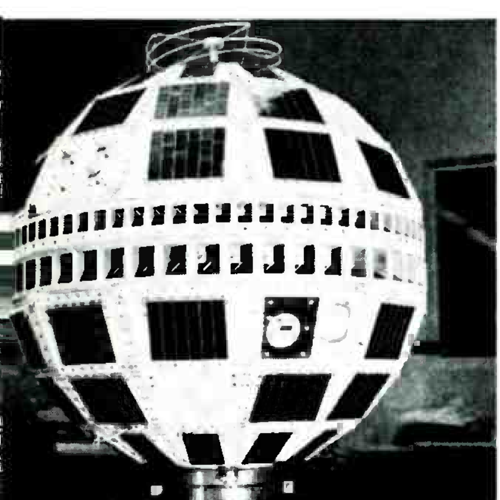


# 'TELSTAR' COMMUNICATIONS SATELLITE

By R. H. SHENNUM/ Head, Satellite Design Dept., Bell Telephone Laboratories, Inc.

**Complete technical details on the experimental microwave repeater satellite and the system that is now relaying TV and telephone signals between the U.S. and Europe.**

AT 3:35 on the morning of July 10th, a giant "Delta" rocket roared away from its launch stand at Cape Canaveral. Carried in the nose cone was a satellite that, before the day had ended, made possible the transmission of television pictures and telephone messages between the United States and Europe. On July 23, in the late afternoon, a live television program prepared jointly by the three U.S. TV networks was beamed to Europe by way of the satellite. A few hours later, a live European TV program, through the facilities of Eurovision, was seen in millions of American homes after having been relayed by the satellite. These historic, highly successful feats were called by some the first steps in establishing a world-wide communications system *via* space by way of a station that is orbiting in space.



The "Telstar" communications satellite is shown here mounted on a laboratory test stand. The satellite has 72 facets, 60 of which are covered with 3600 solar cells that provide the charging current for the nickel-cadmium storage battery that is used to power the electronic equipment in the unit.

The National Aeronautics and Space Administration provided the rocket, launching facilities, and initial tracking for "Telstar." NASA was paid back some $3-million for these expenses by the system sponsor, *American Telephone and Telegraph Co. Bell Telephone Laboratories* designed and built the satellite and the ground stations at Andover, Maine and Holmdel, New Jersey.

The satellite has been called a "microwave tower in the sky." Its primary purpose is to receive broad-band microwave signals from a ground station, amplify them, and re-transmit them so that they can be picked up at another ground station thousands of miles away. The microwave signals can handle TV, voice, data, facsimile, or any other service commonly handled by ground microwave circuits.

Wide-deviation FM is used to impress the desired information on the microwave carrier. From the ground station to the satellite, a center frequency of 6390 mc. is employed. From satellite to ground, the center frequency is 4170 mc.

Bandwidth for the broad-band TV channel is about 3 mc., with a peak-to-peak deviation of 14 mc. Sound for the TV program is handled by a separate subcarrier which is frequency modulated and then multiplexed onto the main carrier. Usable bandwidth of this audio channel is 8 kc.

When used for two-way telephony, separate carrier frequencies, spaced 10-mc. apart, are employed for each direction. For example, if telephone conversations are being carried on between the U.S. and England, the carrier frequency from the U.S. ground station may be 6384 mc. and from the English ground station 6394 mc. Both of these signals are received by the satellite, amplified, and re-broadcast so that both ground stations receive both signals.

In the experimental set-up used with "Telstar," it is possible to carry on 12 simultaneous two-way telephone conversations, or to carry an equivalent amount of data, teletypewriter, or facsimile circuits, or a mixture of all of these. With one-way, broad-band transmission, up to 600 voice circuits or their equivalent could be carried if suitable ground equipment were installed.

The "Telstar" satellite orbits the earth approximately nine times a day. The orbit has a perigee (lowest point, closest to earth) of 593 miles with an apogee (highest point, farthest from earth) of 3502 miles, with an inclination of 44.8 degrees with respect to the equator. The period of rotation is 157.8 minutes, which means that the nine passes are completed in just under 24 hours.

For a short time during four or five of these passes, it is "visible" from the ground station at Andover, Maine. Two or three of these passes have periods in which "Telstar" is also visible to Western Europe. Total visibility at Maine is as much as 250 minutes a day, and mutual visibility with Europe, 102 minutes a day.

The system was designed to be operative with the satellite as far as 5000 miles from the ground station, although satisfactory operation has been achieved at distances as great as 6100 miles. An automatic gain control circuit in the satellite holds the output constant with input signal variations of as much as 20 db. To prevent larger variations of the input signal, the output of the ground transmitter is varied according to the distance to the satellite. At a range of 5000 miles, power output at the ground is about 2000 watts; this power automatically decreases when the satellite is closer.

Ground facilities for the "Telstar" project are located at Andover, Maine and at Holmdel, New Jersey. The Andover station is the control point, and can both transmit and receive. Holmdel can receive only. Two foreign stations are in operation and both can transmit and receive. The British station, designed and built by British engineers, is at Goonhilly Down, England. France has a station at Pleumeur-Bodou which closely resembles the Andover station. These are the two stations which have been used so successfully with Andover for demonstrating transatlantic TV, telephony, and other data.

### *The Satellite*

The "Telstar" satellite is roughly spherical in shape, with a diameter of 34½ inches and a weight of 170 pounds. It has 72 facets, 60 of which are covered with solar cells which keep the storage batteries that power the electronic equipment charged. The satellite receives wide-band communications signals at one microwave frequency and transmits them back to the ground stations at a different microwave frequency.

In addition to the communications repeater, the satellite has several electronic subsystems: (*a*) microwave beacon, (*b*) telemetry system, (*c*) v.h.f. beacon transmitter, (*d*) command receiver, (*e*) solar power plant, and (*f*) radiation experiment.

These systems provide ground control of the satellite, aiding the ground station in its tracking operation, and providing qualitative and quantitative experimental data.

Two broad-band microwave antennas girdle the satellite—one to receive the communications signals at 6390 mc. and the other to transmit these signals to the ground at 4170 mc. These antennas are actually 2 belts of probe-excited cavities which are opened at the satellite's outer surface and produce omnidirectional radiation and reception patterns. The incoming signal is converted down to an i.f. center frequency of 90 mc. and amplified in a broad-band solid-state i.f. amplifier. It is then converted up to the output frequency of 4170 mc. and fed to a special broad-band, ruggedized traveling-wave tube amplifier. This is the only vacuum tube in the entire satellite, which also uses 1064 transistors and 1464 diodes. The tube provides an r.f. output of about 2¼ watts.

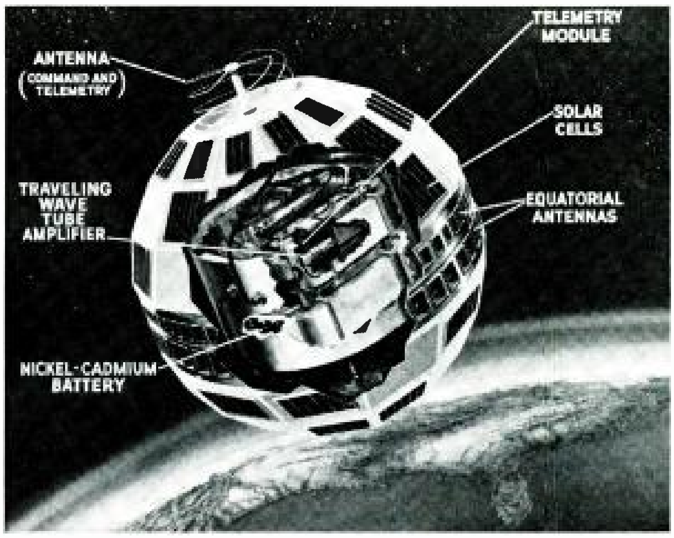
The local oscillator frequencies are produced from two relatively low-frequency crystal oscillators (15.9 and 17.3 mc.). These outputs are fed through transistor frequency multipliers and varactor diode multipliers to give the necessary frequencies—6300 mc. to beat with the incoming signal and 4080 mc. to beat with the 90-mc. i.f. and give the output of 4170 mc.

The bandwidth of the i.f. amplifier is 80 mc. It is provided with an automatic gain control to hold the output constant with input variations. The over-all bandwidth of the complete repeater is 50 mc. at the 1-db points. Total amplification of the communications channel is 10 billion times.

A microwave beacon transmitter (using the 4080-mc. oscillator) permits precise tracking from the ground. This transmitter puts out a signal of about 50 mw. at 4080 mc. when communications are being sent through the satellite and 80 mw. when the traveling-wave tube is on but no communications are being sent.

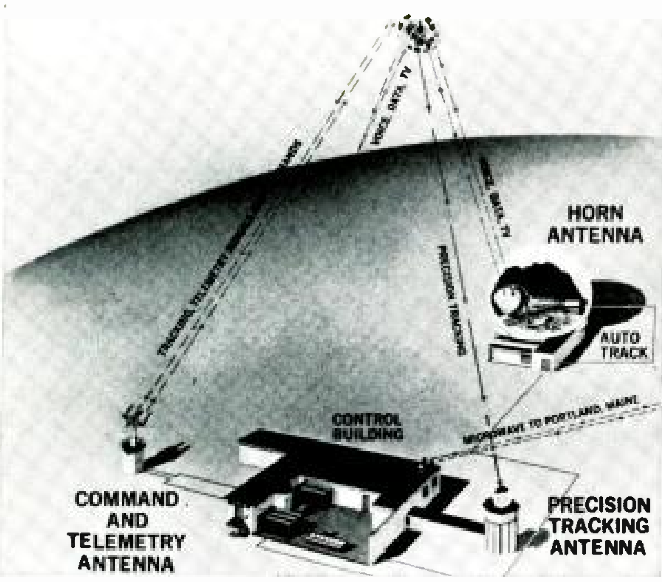
Much information on the space environment on and in the satellite is transmitted back to the ground station by means of the telemetry system which is located in the satellite. The telemetry transmitter operates at 136 mc. with an output power of 200 mw. A helical antenna is used to radiate this signal.

Narrow-band PCM-FM-AM is employed in the telemetry system. Pulsed FM at 3 kc. ± 225 cps is used to amplitude-

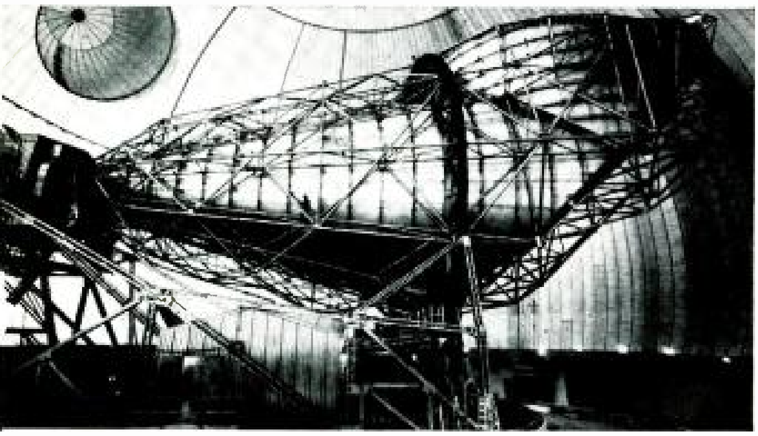



**Cutaway drawing of satellite interior. The belt of smaller antennas around the equator of the satellite receive broad-band TV signals from the ground at 6390 mc. The belt of larger antennas retransmit these signals with a power level of 2¼ watts at 4170 mc. A 4080-mc., 50-mw. precision beacon signal is also transmitted. The helical antenna atop the satellite transmits telemetry information and a coarse beacon signal at 136 mc. In addition, it receives coded pulses from the ground at 120 mc. for 2 command receivers that control communications and telemetry transmitters.**

**Technicians mating satellite to third stage of the "Delta" rocket.**



Artist's drawing of the earth station near Andover, Maine, showing some of its operating systems as used with the "Telstar" satellite.


Inside the huge radome at Andover is the 177-foot-long horn antenna. A similar installation is located at Pleumeur-Bodou in Brittany, France. Another elaborate ground station, using a large parabolic dish antenna is located in Goonhilly, Cornwall, southwest England.

modulate the 136-mc. carrier. A total of 115 different items are measured once each minute. Typical measurements include density and energy of electrons and protons, temperature of satellite skin and interior, condition of battery, and condition of electronic circuits.

The v.h.f. beacon transmitter radiates a constant 200-mw. signal at 136 mc. through the helical antenna to assist in acquisition and tracking. This transmitter is equipped with a timer which will turn it off after two years to avoid interference with future satellites operating on this frequency.

To conserve power and to operate the communications transmitter and telemetry equipment only when they are useful, a command receiver is provided to turn these circuits on and off as desired. Actually, two identical systems—each consisting of a receiver and a decoder—are employed to improve reliability.

These receivers operate in the neighborhood of 120 mc., and serve to turn the equipment on and off by means of properly coded signals from the ground. Both the communications transmitter and telemetry equipment are normally turned on when the satellite becomes "visible" to the Andover ground station, and are turned off just before the satellite disappears below the horizon. The same helical antenna which serves as the radiator for the telemetry transmitter also serves as the receiving antenna for the command receivers.

Power for all of the electronic equipment is obtained from a 19-cell nickel-cadmium storage battery. This battery is kept charged by the 3600 silicon solar cells mounted on the exterior of the satellite. These cells are divided up into 50 parallel groups of 72 cells in series, providing a total output of close to 15 watts initially and about 13.5 watts after a number of weeks of operation. Although these solar cells are shielded with sapphire, some radiation damage is expected and the output will gradually decrease with time.

With all electronic equipment in the satellite turned on, the total drain on the batteries is about 34 watts. Therefore, if this equipment were to be left on for a prolonged period of time, the storage batteries would become completely discharged. The planned duty cycle is more than adequate to keep the equipment performing properly and to prevent the batteries from becoming discharged.

A number of radiation experiments are being carried out by "Telstar" and these will produce valuable information about the effects of Van Allen belt radiation on various electronic components. Several *p-n* junction particle detectors are employed to measure protons with energies from 2 to 80 m.e.v. and electrons with energies from .2 to 1.25 m.e.v. Several transistors are used to measure the effect of radiation on their short-circuit current gain. Various thicknesses of shielding are employed on the transistors. Three solar cells, also with various amounts of shielding, are monitored to determine the degradation with continued exposure to Van Allen belt radiation. Six pre-irradiated solar cells are mounted in such a manner that the outputs can be used to determine the orientation of the satellite spin axis with respect to the sun.

The entire electronics package, with its components protected by foamed plastic, is suspended by nylon cords to provide thermal isolation from the frame and for protection from shock and vibration.

### *The Ground Station*

The principal ground station is at Andover, Maine. As mentioned previously, reception is possible at Holmdel, N.J. and two foreign stations are in operation, but we will confine our discussion to the Andover site. It includes a means for tracking the satellite, computing its orbit, sending commands, receiving telemetry information, and carrying out broad-band communications experiments.

To scoop up as much of the energy radiated by the satellite as possible, and to keep out unwanted radiation, the largest horn antenna ever built was constructed. It has a mouth opening of about 3600 square feet, is 177 feet long, and weighs about 380 tons. It tracks the satellite smoothly to a precision of better than a fiftieth of a degree. It is covered with an inflated radome to protect it from wind and weather.

The same horn is also used as the ground transmitting antenna. By means of suitable diplexing equipment, a very weak incoming signal and a very powerful outgoing signal are kept from interfering with each other.

To get the necessary 2000 watts of r.f. power for the transmitter, a special high-power traveling-wave tube was developed. The driver for this output stage consists of modified microwave radio-relay equipment. Power can be adjusted manually from .2 watt to 2000 watts, or the power output can be adjusted automatically to compensate for the distance to the satellite.

The minute energy picked up by the horn antenna (perhaps a fraction of a billionth of a watt) is first amplified by a ruby maser, which has the ability to amplify very weak signals while introducing a minimum amount of noise. In fact, the over-all noise temperature, including losses in the radome and antenna, and sky noise, is about 50° K when the antenna is pointed 4.7° above the horizon.

Other equipment at the ground station includes two tracking antennas. One is a quad-helix which picks up the satellite's 136-mc. beacon and telemetry and transmits commands on about 120 mc. The other antenna, an eight-foot dish, tracks the microwave-beacon signal at 4080 mc. The main

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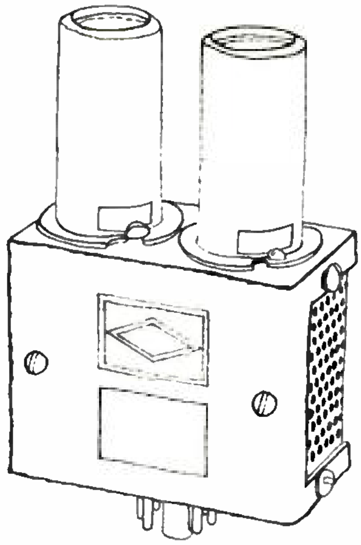

A typical two-tube operational amplifier.

# OPERATIONAL AMPLIFIERS

By ALVIN F. RYMSHA

*Description, applications of small plug-in direct-current amplifiers that are widely employed in industrial control circuitry.*

IT is comparatively easy to block-diagram a control circuit, but filling in the blocks could be a real problem but for one simplifying component; the operational amplifier. Originally developed for computer application, it has become an all-purpose electronic tool. Need a decade amplifier? A slow sweep? Comparator? Want to add two voltages in different ratios? This is only a partial list of possible functions.

### *What It Is*

Defined briefly, an operational amplifier is a d.c. amplifier of very high gain, whose output polarity is inverted with respect to the input. Leaving, for this article, the problems involved in designing an amplifier with a gain of over a million, a response from d.c. to 250,000 cps (or more), and a drift of possibly 10 millivolts (or less) per day, how does the amplifier do its job? Let us draw a block diagram of an amplifier, with a feedback loop between output and input (Fig. 1).

By Ohm's Law:

$$\frac{E_i - E_g}{R_i} + \frac{E_o - E_g}{R_f} = I_g$$

and $A$ (gain) is: $E_o = -AE_g$ or $(E_o/E_g = -A)$. $A$ is shown as negative because the amplifier *inverts* the signal. Now $I_g$, the input current, is very small; for all practical purposes it is zero. (In a vacuum-tube amplifier, the input will be an open grid.) The two equations can be combined:

$$E_o = -\frac{R_f}{R_i} \times \frac{E_i}{1+\left(\frac{1}{A}\right)\left(1+\frac{R_f}{R_i}\right)}$$

and if $A$ (gain) is in the range of $10^4$ to $10^7$; and the ratio $R_f/R_i$ is comparatively small (say, less than 100 or possibly 1000), the equation can be written:

$$E_o = -\frac{R_f}{R_i} \times E_i$$

or in other words, the output ($E_o$) is strictly determined by the ratio of the input and feedback resistors times the input voltage. *The high gain of the amplifier reduces the error to a negligible value.*

### *Applications*

Vacuum-tube amplifiers will commonly use resistors in the range of 100,000 ohms to 10 megohms, one megohm being the common "gain-of-one" resistor. Transistor amplifiers operate in the region of 10,000 ohms. Of what use is an amplifier with a gain of one (or rather, minus one)? For one thing, it can provide a high input impedance, as a cathode-follower would, without loss of gain. It can add two sources: in Fig. 2 the output is the algebraic sum of the inputs. By changing ratios, the gain may be increased or decreased (Fig. 3). The gain of the amplifier is $-R_f/R_i$. Not only can we easily arrange a decade amplifier with gains of 0.1, 1, 10, or 100, but its response will go down to d.c. Of course, by making $R_i$ a variable, the gain can be changed without affecting input impedance.

Now we come to the most interesting (and useful) of applications; the integrator. If we substitute a capacitor for $R_f$, the output $E_o$ will rise at a uniform rate for a step input, de-

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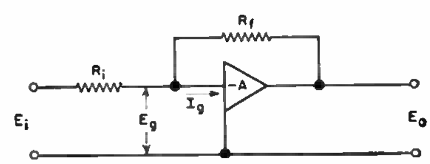



Fig. 1. Basic amplifier circuit diagram.

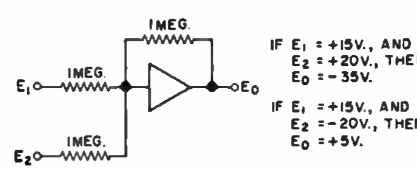



Fig. 2. Using amplifier to add voltages.

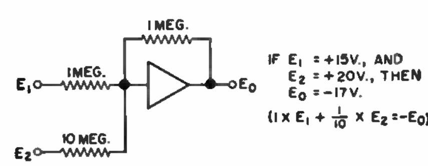
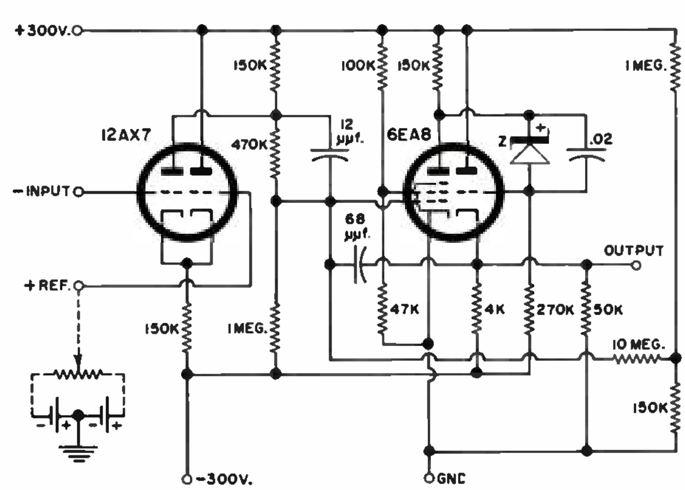



Fig. 3. Changing resistors alters gain.

Fig. 4. Schematic diagram of a typical operational amplifier.



# Coaxial Cable Communications Systems

By LEE CRAIG

*A single coax cable can carry two-way multi-channel communications as well as TV and data information. Recent developments make coax more versatile and less expensive than many present microwave systems.*

COAXIAL cable looms on the horizon as a formidable competitor of microwave systems. Recent developments make coaxial cable systems less costly than microwave in many cases and far more versatile.

A single coaxial cable is capable of simultaneous two-way multi-channel communications and TV and data transmission. Unlike a microwave system, it can be tapped at any point. But, to use a coaxial cable system, a right-of-way is needed.

Coaxial cable systems will appeal to railroads, pipe lines, rapid transit systems, and express highway authorities because the need for off-line microwave repeater station sites is eliminated. Furthermore, maintenance is confined to the right-of-way.

The use of coaxial cable systems is not necessarily limited to organizations possessing a right-of-way. A major university, for instance, is planning a two-way, intercity closed-circuit TV transmission system utilizing coaxial cable buried along the right-of-way of a railroad. A large manufacturer is looking into the possibility of utilizing the right-of-way of three railroads for a long-haul coaxial cable system which is to be used for two-way TV transmission. A community TV antenna company is considering the installation of a coaxial cable along a railroad right-of-way to pipe TV programs from a mountain-top TV receiver to the community it serves.

More than 500,000 miles of coaxial cable are in use. But, until recently the cost of coaxial cable systems was so high that only major telephone companies could afford to use them.

Most of the existing coaxial cable transmission systems employ two cables for duplex transmission, one cable for each direction of transmission, as illustrated in Fig. 1.

At regular intervals, an amplifier is inserted into each cable circuit to make up for the cable transmission losses.

### *Duplexed Single Cable*

Now, however, it is possible to transmit in both directions through a single coaxial cable. Signals below 11 mc. are transmitted in one direction and signals between 12 mc. and 22 mc. are transmitted in the opposing direction.

Simultaneous two-way transmission through a single coaxial cable is made possible by means of a unique cable repeater amplifier.

Only a single amplifier is required for providing 20 db gain in both directions simultaneously. Filters within the cable repeater assembly separate the eastbound and westbound signals, route them through the single amplifier, and feed them back into the cable in the appropriate direction.

Eastbound signals under 11 mc., as shown in Fig. 2, pass from the cable through low-pass filter LP-1 into the amplifier and through LP-2 into the cable on the other end of the repeater. Westbound signals between 12 mc. and 22 mc. are blocked by LP-2 from entering the output of the amplifier, and are routed through high-pass filter HP-1 to the input of the amplifier. The amplified 12-22 mc. signals appearing at the output of the amplifier are passed through HP-2 around LP-1 to the cable leading west.

One of these repeaters is inserted into the cable at intervals of one-half to several miles, depending on the attenuation characteristics of the cable used.

A cable repeater of this type can be built into a tubular casing less than a foot long. Since it can be totally encapsulated, the cable repeater can be buried with the cable, or suspended in the air when aerial cable is used. When submarine

Fig. 1. (A) Two-cable and (B) single-cable duplex system.

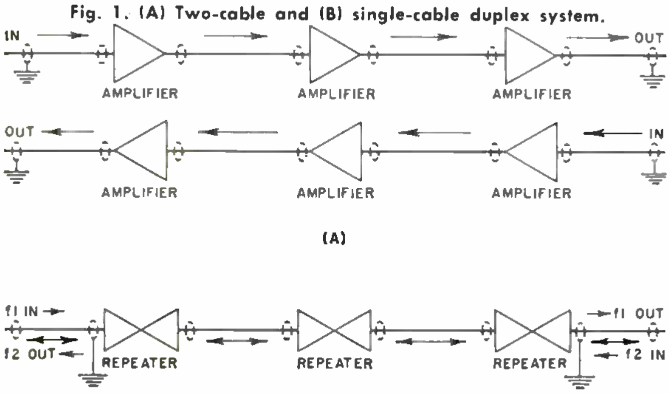
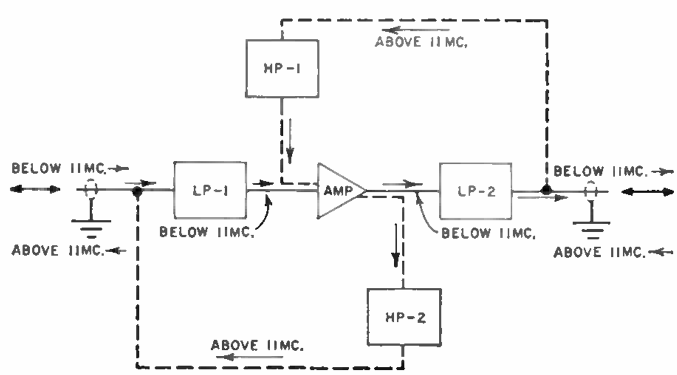



Fig. 2. Single-line duplex cable repeater block diagram.



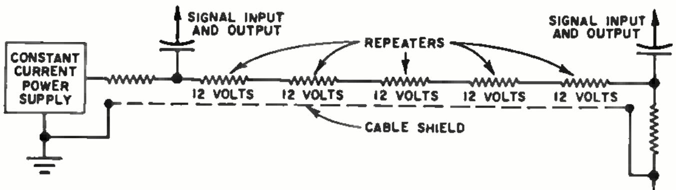
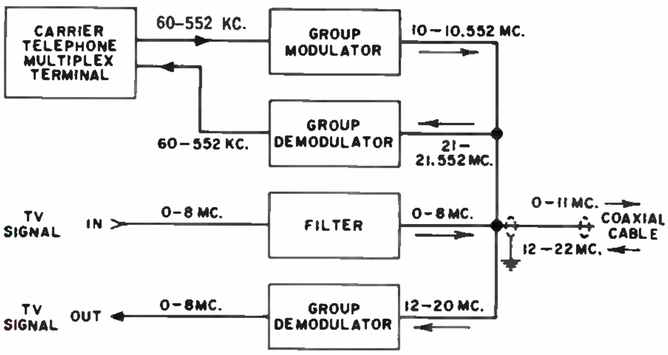



Fig. 3. The d.c. power supply circuit in simplified form.

Fig. 4. Simultaneous voice and TV over a single cable.




cable is used, the repeater may be submerged with the cable.

### *Equalization and Regulation*

Equalizers are included in the cable repeater to offset the frequency characteristics of the cable. The loss in the cable increases with frequency and varies with temperature. To further improve the frequency response, mop-up equalizers are inserted in the cable at various points as required. To maintain constant signal levels, automatic regulators are also inserted in the cable at various points, as shown in Fig. 5.

The cable, when equipped in this manner, appears to have zero end-to-end loss over its intended transmission frequency band. Changes in cable characteristics due to temperature variations are corrected by the automatic regulators and mop-up equalizers.

### *D.C. Power Circuits*

Unlike a microwave system, a local source of electric power is not required for operation of repeaters. Instead, d.c. is transmitted through the cable itself, as shown in Fig. 3, from a constant-current power supply at one end of the cable. The transistorized repeaters are connected in series for d.c. The voltage drop across each repeater is about 12 volts d.c. and power consumption is about 12 milliwatts.

### *Multiplexing*

Conventional single-sideband suppressed carrier telephone multiplex equipment may be utilized to derive individual telephone channels. As shown in Fig. 6, eastbound signals (left) $f_1$ and $f_2$ from a carrier telephone terminal are fed directly into the cable. Westbound signals (right) $f_1$ and $f_2$ are fed into the other end of the cable through a group modulator. These signals are thus transmitted as $f_3$ at frequencies above 12 mc.

At the east terminal, the incoming signals $f_1$ and $f_2$ are fed directly into the carrier telephone terminal. And, at the west terminal, the incoming signal $f_3$ is fed through a group demodulator to convert them back into $f_1$ and $f_2$. While Fig. 6 shows only two duplex voice channels, several hundred channels can be handled in this manner.

Because of the wide transmission band, it is possible to employ other types of frequency-division multiplex equipment, such as FM and double-sideband AM.

Telegraph, data, and other digital information may be transmitted by employing frequency-shift keyed or "on-off" tone transmitters and receivers. Up to 18 tone channels may be transmitted over a single voice channel.

Since only a part of the available transmission band is utilized by even a 600-channel SSB multiplex system, there is ample space for a TV channel or high-speed data channels in each direction. When TV is to be transmitted, the video signal may be transmitted above or below the voice channels. Consideration must be given to the effects of modulation products of the multiplex voice signals and TV signals on each other. Fig. 4 shows the equipment requirements at one of the terminals.

Voice, data, teletypewriter, and TV signals may be dropped and inserted at any point along the cable by providing suitable blocking filters and multiplex equipment.

### *Cable Types*

Many kinds of coaxial cable, including foam types, are available for use in coaxial cable transmission systems. For aerial suspension, coaxial cable (similar to RG-8/U, RG-11/U, and RG-58/U) is available equipped with a steel messenger. The cable is suspended by clamping the messenger to poles or other supports.

While ordinary antenna lead-in type coaxial cable may be buried, special cables with an additional wrap of copper alloy over the insulation covering the shield braid outer conductor are sometimes used. The copper alloy tends to keep vermin from eating through the cable. Sometimes an additional wrap of steel is provided to insure magnetic shielding.

While cable may be buried to a depth of several feet, trenching it in the ground to a depth of only several inches makes it easier to retrieve the cable when repairs are required.

### *Cost*

The cost of burying cable varies greatly. Estimates run as low as $500 per mile. Cost can run much higher when pipes have to be installed to run cable under roads which are intersected by the right-of-way. Cable costs vary from a few cents a foot to more than a dollar per foot depending on the type of cable selected.

Recent cost studies reveal that the over-all cost of a coaxial

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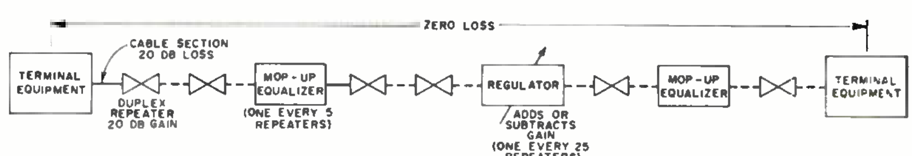
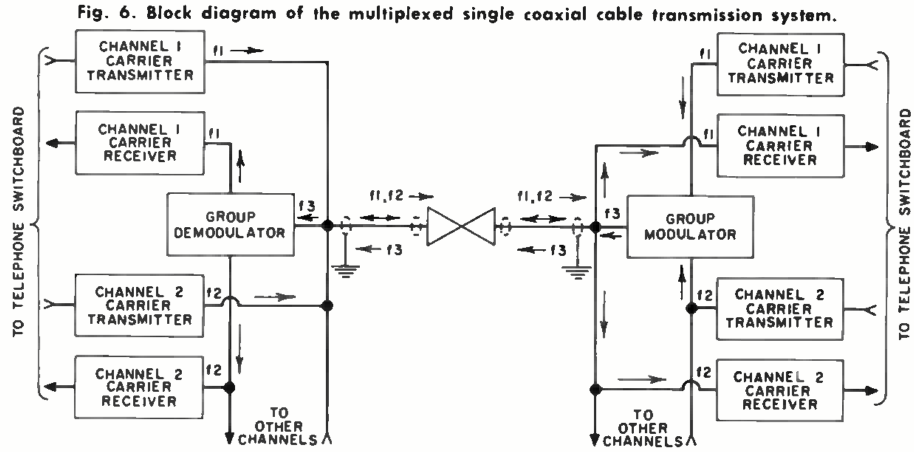
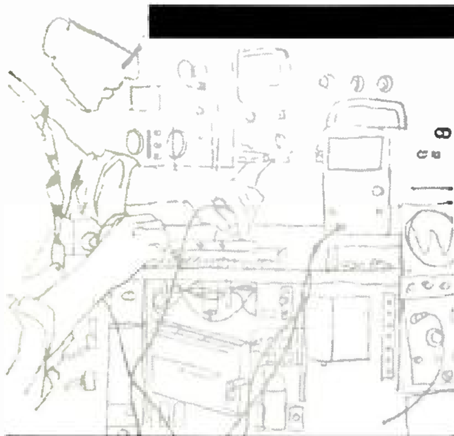



Fig. 5. A simplified block diagram of a single coaxial cable transmission system.

Fig. 6. Block diagram of the multiplexed single coaxial cable transmission system.





# MAC'S ELECTRONICS SERVICE

By JOHN T. FRYE

## The Thing that Counts

BUSINESS was a little dull in the shop. Warm weather lingered, and folks were taking full advantage of the dwindling number of porch-sitting evenings. All too soon the cold would drive them indoors to start their winter TV watching, but they were not worrying about that yet.

Mac was cleaning up the bench, checking and calibrating test equipment, beefing up the parts stock, and in general getting ready for the influx of work he knew would start with the first few frosty nights. Barney, his assistant, was frowning as he doodled on a scratch pad.

"What's the matter? Einstein's theory giving you a little trouble?" Mac asked sympathetically.

"No, I'm just being tortured by my new love affair," Barney replied.

"Hey! What's this? You mean you and Margie have split up?"

"Oh no; she doesn't even know about this new affair," Barney replied smugly.

"This doesn't sound like you at all," Mac said with a frown. "When did this thing start?"

"Last Armed Forces Day when I attended the open house out at Bunker Hill Air Force Base. They had displays of various equipment used on the base, and one of these was the electronic booth. When I saw a *Hewlett-Packard* Model 524C Electronic Digital Counter in operation, I fell head over heels in love with it; and I've spent most of my spare time since trying to understand it."

"Well," Mac said with obvious relief, "that's better. What fascinates you so about the counter?"

"The precision and speed with which it works, for one thing. In my sheltered service technician and radio amateur life, I never came in contact with anything like that. Frequency measurement in my experience has always been a tedious, painstaking, complicated affair with dubious end results—especially when the frequency measured is in megacycles. But with this counter all you do is run the unknown frequency into it and watch the display read-out. In one second it will *actually count the cycles* of any frequency from 10 cps to 10.1 mc. and show the total number of cycles taking place in that second. Measuring a frequency with this instrument is as easy and quick as taking a voltage reading with our v.o.m."

"But how accurate is the result?"

"Before going into that, let me give you a rough idea of how the thing works. I wrote *Hewlett-Packard* and asked for some dope on the operation of the 524C, and they sent me a lot of literature. Some of it is over my head, but I think I've managed to grasp the basic operation of the gadget.

"Actually it consists of three major parts: a time-base section, a gate section, and eight cascaded counter units. The time-base section generates accurate reference frequencies for frequency and period measurements. The gate section opens and closes the signal path to the counter units, controls display time, and resets the counter units to zero. The counters total signal cycles or pulses applied to them and display the total on the front panel.

"The electronic circuits for doing all this are pretty hairy with Schmitt triggers, phantastron frequency dividers, delay lines, etc.; but I believe I've got a toe-hold on the theory behind it all by recalling how my retired railroading uncle used to check the speed of his old steam locomotive that had no speedometer. He counted telegraph poles whizzing past his cab window for six seconds. He knew that on his division these poles were set 52 to the mile, or roughly 100 feet apart. A count of a little better than five poles in the six seconds meant he was going 60 mph. A more accurate method was to check the time elapsing between mile posts. He had a chart that translated seconds-between-posts into miles-per-hour. Sixty seconds was 60 mph; 120 seconds was 30 mph, etc. Counting the poles or mile posts was easy. Measuring the time involved precisely was where error was likely to creep in.

"The same is true with the electronic counter. Counting pulses and adding them, even up to ten million a second, is easy for those eight lightning-fast cascaded counter units. But making sure the signal gate is held open to the counters for a precise number of seconds or fractions of a second is something else. In the *Hewlett-Packard* counter, the time-base reference is a crystal-controlled, oven-regulated 1-mc. oscillator. Frequency dividers and multipliers operate on this to produce available frequencies of 10 cps, 1 kc., 100 kc., and 10 mc. The oscillator is stable to within 5 parts in $10^8$ per week or within 3 parts in $10^9$ for a short term. This accuracy makes the output frequencies excellent secondary frequency standards.

"Interesting testimony to the stability of this oscillator is contained in the instructions for checking it against WWV. Since WWV frequency is maintained within several parts in $10^{10}$ at the transmitter, you might suppose it would be perfectly safe to adjust the counter oscillator so a harmonic fell precisely on WWV, but this is not the case unless you are within 150 miles of Beltsville, Maryland, where you can receive the ground wave from the 5-mc. transmitter of WWV. Beyond the range of this ground wave, Doppler frequency shifts caused by atmospheric conditions reduce the accuracy, often by several parts in $10^7$. You can average out these Doppler shifts by comparing the 524C with WWV for several days running and plotting the results. When possible, readings should be taken when noon or midnight is midway between WWV and the receiving station, as minimum Doppler shift occurs then. By comparing the oscillator with the 20-mc. frequency of WWV, any error in the 524C is multiplied twenty times."

"Is 10.1 mc. the upper limit of frequencies you can measure with the 524C?"

"With the basic unit, yes; but three additional frequency converter units extend the range to 500 mc. In a frequency converter unit, the input signal is mixed with a selected harmonic of 10 mc. so that the difference between the signal and the harmonic is not more than 10.1 mc. The difference frequency is counted and displayed. Adding the displayed count to the known 10-mc. harmonic gives the measured frequency. The accuracy is still that of the basic unit. For example, to measure an input frequency of 100 mc., you would tune the ninth harmonic of 10 mc. with a frequency converter unit and mix this with the input frequency. The 10-mc. difference frequency would be counted and displayed. Adding this 10 mc. to the 90-mc. harmonic frequency would produce the 100-mc. measured frequency. The accuracy would be plus or minus 8 cycles in the week following calibration or plus or minus 13 cycles in the second week. To this must be

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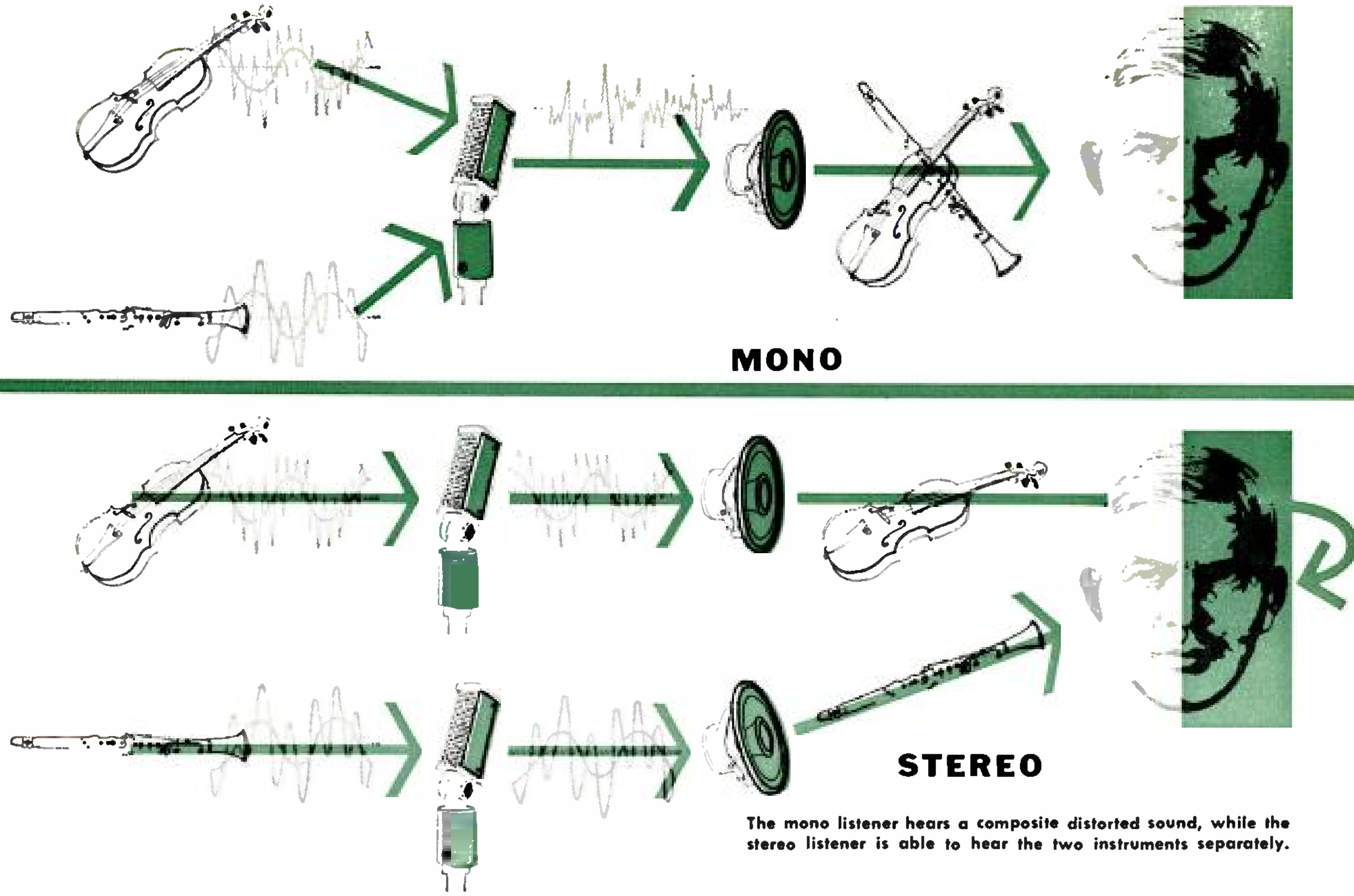


The mono listener hears a composite distorted sound, while the stereo listener is able to hear the two instruments separately.

# Non-directional STEREO Effects

By CHARLES J. HIRSCH / Corporate Staff for Engineering, Radio Corporation of America

***More of the music is reproduced with less distortion when two channels are employed. Results of simple, easily reproduced experiments and listening tests indicate that stereo reproduction provides reduced cancellation of tones and reverberation effects.***

UNTIL very recently, our knowledge of stereophonic reproduction was limited to its directional effects; its non-directional effects were largely unknown, although they are at least of equal importance. The stereo reproduction of music played by a large orchestra is so much richer than the best monophonic reproduction that it appears to be played by an orchestra having a greater number and variety of instruments, which play more completely in tune, in a hall with better reverberation. This superiority occurs because some of the tones heard on stereo are annulled when reproduced monophonically. Stereo is better because it reproduces more of the music with less distortion.

In the recent past, the superiority of stereo was attributed to a mental image which helped to locate each instrument among many, produced a sense of direction to the reverberation, and thereby gave the ambience of being in the concert hall. The term *ambiophonic* was coined to describe this effect. While stereo can create such an image, often to good advantage, this explanation is believed to be an incomplete reason for stereo's superiority, which is enjoyed by many music lovers who never go to concerts and who cannot tell one instrument from another. The superiority of stereo is also evident in large orchestras where the ability to locate instruments by their sound is blurred or even absent. Music heard in the concert hall, or by stereo, is superior to its monophonic reproduction, not because stereo reminds the listener of the concert hall, but because the same desirable effects occur in both cases.

The greater enjoyment provided by the concert hall is not due to technical limitations in the quality of sound reproduction. High-fidelity phonographs can reproduce as wide a gamut of bass, middle, and treble tones, and as high a ratio of *fortissimi* to *pianissimi* as the ear can perceive; and they can do so with negligible distortion. Yet lovers of orchestral music prefer stereo, even when its range of tones and intensity are limited, to the best monophonic hi-fi. Older, more experienced listeners, who cannot hear the highest notes of mono hi-fi, enjoy stereo. Stereo is not necessarily hi-fi, but hi-fi can add to the enjoyment of stereo.

For the purpose of this article, the non-directional effects of stereo are those which are produced in addition to, and independently of, its ability to create a spatial image. These effects are stressed because they have been appreciated and understood only recently. They are largely responsible for the more complete reproduction of all tones and for the

*OUR AUTHOR was chairman of Panel 1 of the National Stereophonic Radio Committee, which examined and recommended various systems of stereo broadcasting to the FCC. He was also chairman of the U.S. Department of State delegations to international meetings on color-TV standards. At present, he is chairman of both the EIA Broadcast Television Systems Committee and the IRE Television Systems Committee. Prior to his present position as Administrative Engineer on the Corporate Staff of the Vice-President for Research and Engineering of RCA (with special interest in home instruments), he was Executive Vice-President of Hazeltine Research Corporation.*

superior reproduction of the reverberation in the record. They are desirable for all kinds of music.

*Directional* effects are wanted when it is important to know the approximate location of performers on the stage. A spatial image is desirable for operas and plays because it reveals "who is saying, or doing, what to whom." The location of voices or instruments is important for music that tells a story as, for example, "The Scheherazade Suite" in which each instrument symbolizes a different person. It enhances the pleasure of hearing small orchestras, such as chamber music, especially for people who listen intellectually to discern the structure of the music and to evaluate the virtuosity of the performers. Only those who know an opera or a play well can distinguish one actor or singer from another on a monophonic recording. The monophonic reproduction of a round-table conference or a house party is confusing. One gets all mixed up when several people talk on a party telephone line; it is almost impossible to tell who is talking. *Stereo separates one voice from another by making each appear to come from a different direction.*

Stereo, because of the non-directional effects, reproduces more of the recorded music with less distortion. Notes are heard by stereo which are unheard monophonically. The instruments are more clearly identifiable and the reverberation of the recording studio is superior. The more complete reproduction of musical tones by stereo is especially desirable when listening to large orchestras where the sense of direction is unimportant and often disturbing.

When listening to "absolute" music, the listener often objects to exaggerated directional effects. He may not care if, for example, a violin is at the left or right; and, if the violin reveals its position too blatantly, his attention is diverted from the sheer abstract beauty of the music to the practical mechanism of its creation. For this reason, some music lovers who have been exposed only to the more spectacular directional effects of stereo, such as ping-pong games, often state that stereo is a musical sacrilege. They are very mistaken!

"Live music" or stereo adds greatly to the pleasure of listeners who are happiest when they feel totally immersed in the pure abstraction of disembodied music, who are unconscious of the instruments, and who don't care where they are. For this kind of music, the fuller reproduction of all tones, the reduced dissonances, and the deeper studio reverberation are provided by the *non-directional* effects of stereo.

Both the directional and non-directional effects of stereo are caused by the independence of our two ears. Differences in the time, or amplitude, of the reception of a sound by the two ears are interpreted by the brain and produce *psychological* clues to the location of the source of the sound. The independence of the two ears from each other prevents the cancellation and interaction of two sounds heard by them individually. The *non-directional* effects are due to the *physiological* properties of hearing in a manner to be described later.

### *Listening Tests*

In order to establish in what way stereo reproduction is superior to monophonic reproduction, listening tests were made on a stereophonic phonograph to compare: (1) a stereophonic disc reproduced stereophonically, (2) the same disc reproduced monophonically by interconnecting the left and right outputs of the stereo pickup, and (3) a monophonic disc, reproduced by a monophonic pickup, of the same selection recorded from the same tapes as the stereo disc.

The outputs of all pickups were reproduced by the same music system consisting of two amplifiers and two loudspeakers. Switches allowed the listener to select at will any one of the three forms of reproduction. The test setup is shown in Fig. 1. The selections chosen were symphonies recorded by large, well-known orchestras.

Little, if any, difference could be detected between the monophonic disc and the stereophonic disc played monophonically; both were excellent. However, the stereophonic reproduction of the stereophonic disc was so superior to its monophonic reproduction that it seemed to be played by another orchestra. More notes were heard; the bass and recorded reverberation were richer; and the instruments were more clearly identified. By contrast, the monophonic reproduction seemed to consist of fewer, but more powerful and less readily identifiable instruments. In addition, the monophonic music, although reproduced by two spaced speakers, seemed to come from a hole in front of the listener; while the stereophonic music was spread out over the entire distance between the speakers.

*The advantages of stereophony were lost when one ear was closed or when the distance between speakers was greatly reduced, such as by placing one speaker above the other.*

Since both the mono and stereo were produced from the same stereo disc, the reduced quality of the mono version must be due to the cancellation of some tones and of the recorded reverberation which are reproduced when the disc is played stereophonically. That this might be the case was first suggested by the results obtained from field tests conducted by the National Stereophonic Radio Committee (NSRC), on the broadcasting of stereophonic programs by the FM-multiplex system later adopted by the FCC.

In this system, the *signal intended for reception by monophonic receivers consists of the sum (L + R) of the left (L) and right (R) outputs of a stereophonic pickup or of two directional microphones.* For stereophonic receivers, a second signal consisting of the difference (L − R) of these outputs is also transmitted. Stereo receivers intercept both signals and can reproduce the original left (L) and right (R) signals in many ways such as by adding and subtracting the transmitted signal as follows: $(L + R) + (L - R) = 2L$; and $(L + R) - (L - R) = 2R$.

It was soon found that a sizable number of stereo discs, made in the early days of stereo recordings, gave very poor monophonic reproduction when the outputs of the left and right tracks were added to produce (L + R); the tone was abnormally thin, most of the reverberation was lost, and whole instruments were occasionally missing. *Yet the stereo reproduction of the same disc was acceptable.* Investigation revealed that the left and right tracks were recorded accidentally with opposite polarities so that the combined signal became (L − R) instead of (L + R) and tones on the two tracks partly cancelled each other. The error was not discovered earlier because the discs were only tested stereophonically.

The field test suggested that tones which can cancel each other when mixed into a single (L + R) signal do not cancel

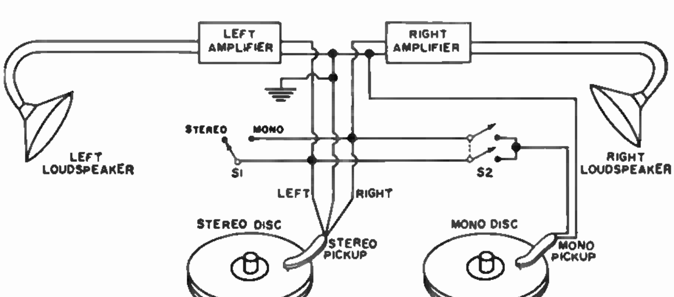


**Fig. 1. The listening test setup that is discussed in the text.**

when heard individually by each ear, as is the case in stereo.

Stereo is freer of these cancellations because the two ears are independent of each other and produce two non-interacting channels directly to the brain. To determine the nature of this independence, experiments made long ago and half forgotten were repeated.

The first experiment is illustrated in Fig. 2. An audio-frequency generator produces a single tone in two earphones.

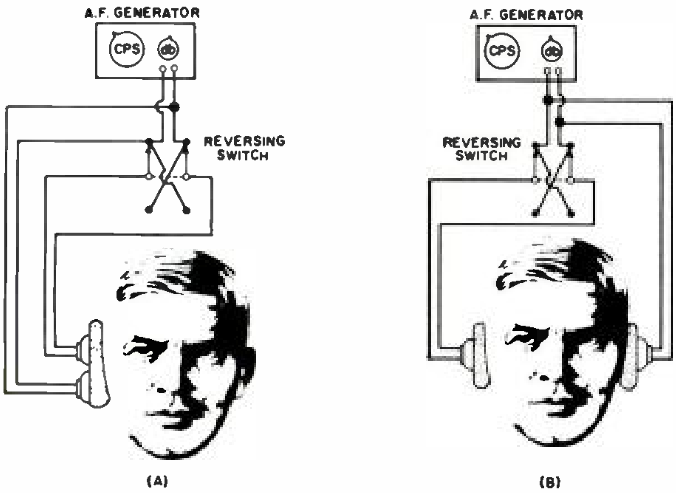


Fig. 2. The first experiment, showing result of phase reversal.

The polarity of the input to one earphone can be reversed with respect to the other by a switch. When both earphones are applied to the same ear, as in Fig. 2A, reversing the excitation to one of them causes the intensity heard to increase or decrease as the two polarities are made to add or subtract. When the earphones are applied to separate ears, as in Fig. 2B, the intensity does not change, no matter whether the polarities add or subtract.

The second experiment is shown in Fig. 3. Two audio-frequency generators are connected to individual earphones and

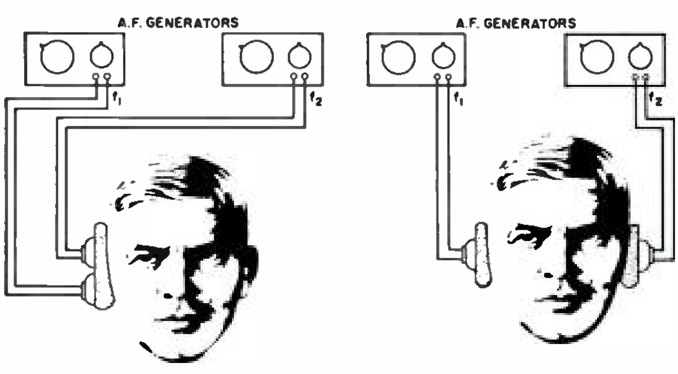


Fig. 3. The second experiment which concerns itself with beats.

their frequencies adjusted to differ by only a few cycles, say 5, from each other. When the two earphones are applied to a single ear, as in Fig. 3A, a strong beat note, whose frequency is equal to the difference in the original frequencies, is heard. When the two earphones are applied to separate ears, as in Fig. 3B, *no beat note is heard;* instead, there is a sound of constant intensity which travels within the skull between the two ears at a rate equal to the difference-frequency.

The third experiment is shown in Fig. 4 and produces two results: (1) A single note of constant frequency applied to one ear produces a subjective pitch whose apparent frequency depends on the intensity. (2) In addition, a single note can produce a subjective pitch in the left ear which is different from the subjective pitch it produces in the right ear even if the intensities are equal. In most cases, this difference amounts to only a few cycles; 0 to 3 to 4 cycles. In some listeners, one ear produces different harmonics than the other so that true comparison of pitch is not possible. Moreover, the difference in subjective pitch between the two ears does not produce a beat note between them.

### *Experimental Results*

The result of these experiments can be summarized as follows:

1. A tone picked up exclusively by one ear does not add or subtract, or modulate, or in any way interfere with the tone picked up exclusively by the other ear except that the two tones give the sensation of traveling between the two ears at the rate of one complete round trip for each phase change of 360 degrees.

2. A tone picked up by one ear may produce in some listeners a sensation of pitch which is different from the sensation produced by the same tone in the other ear.

### *Interpretation*

The result of these experiments is used to explain why stereo reproduces more of the tones on the record with less distortion and with better reverberation.

Two sine waves of equal frequency and amplitude can only double their intensity when their phases add, but they can

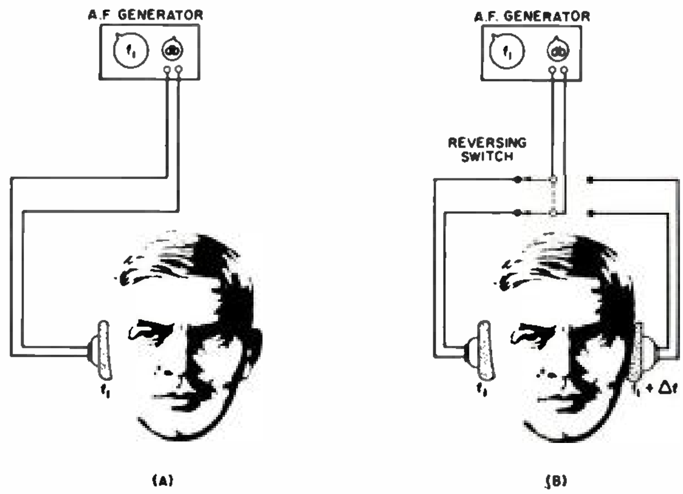


Fig. 4. The third experiment, which shows that pitch is not the same as excitation frequency. In (A) a constant-frequency signal is applied to one ear. As the intensity is raised, the pitch is lowered. (B) indicates that the pitch perceived by the left ear may be different from that perceived by the right ear, even though the same frequency and intensity are used.

completely annul each other when their phases oppose.

When several waves are transmitted over a single channel, the result is the sum of all the instantaneous values of the waves, many of which oppose each other in polarity and tend to cancel. It does not matter if the single channel is produced by a single electrical path, as when a single microphone is used to pick up disseminated sounds, or when the outputs of several microphones are added to produce a single output; or by a single acoustic path, as when the two speakers are placed close together; or a single aural path as when one ear is closed.

The phase with which the sound of identical instruments playing the same note reaches the microphones is random with frequency changes because the phase for each instrument depends on the instant of attack, such as the moment of application of the bow to a string, and obviously two musicians cannot synchronize this instant within the millisecond or less required to reverse the phase of a 500-cycle note. The phase also depends on the distance of the instrument to the microphone. A difference of path length of only two feet in the distance of two instruments will completely reverse the phase of "middle C" (261.6 cps).

When playing the same note over a single channel, two instruments, such as a violin and a clarinet, may cancel their fundamentals and leave only their overtones. The result is neither violin or clarinet, but an emaciated composite of the two which sounds like neither, as shown in the drawing on page 41. Since the phase of each instrument varies frequently and randomly, such cancellations are numerous. For a large orchestra this alters the continuous nature of the music.

In the case of stereo, two identical notes, differing only in phase, so that one is heard *mainly by the left ear* and the other *mainly by the right ear*, do *not* cancel when their phases oppose. They are heard individually and the relation of the fundamental to the overtones is not disturbed. Thus a violin on the left and a clarinet on the right are clearly heard as individual instruments with their character undisturbed even when they play the same note, no matter what their phase happens to be.

Studio reverberation is preserved more fully by stereophonic reproduction because those sound waves that are reflected out-of-phase from opposite walls reach the ears separately and therefore do not cancel each other.

When one ear receives two notes which differ in frequency, the tones add or cross-modulate each other to produce a beat note whose frequency is equal to the difference in frequency of the originals. Beat notes of very low frequency are especially rough. For example, let two instruments attempt to play middle C, at 261.6 cps, but let one instrument be *off-tune* and play 265.0 cps instead, together they produce a beat whose frequency is 265.0 — 261.6 = 3.4 cps, which is very unpleasant. *Discords are unpleasant because they produce such beats.*

In the case of stereo, if the two tones (261.6 and 265.0 cps) are heard by the two ears respectively, they are perceived individually as 261.6 and 265.0 cps and do not produce beat notes with each other, even if the difference in their frequencies (3.4 cps) is small. The fundamental, overtones, and chords heard exclusively by one ear do not interfere with those heard exclusively by the other ear. Therefore, two instruments slightly mistuned, as in the case cited, do not produce unpleasant beats when they are heard by the two ears separately.

As stated previously, a single note may produce a different *subjective pitch* when heard by one ear than when it is heard by the other. The difference helps further to separate identical notes coming from the left and right. Since the two ears do not cross-modulate, the difference in pitch produces no beat note. The harmony in each ear is consistent with itself and with that in the other ear.

The cause of the difference in the tonal quality of monophonic and stereophonic reproduction can be summarized as follows:

In monophonic reproduction all tones occurring simultaneously are added together in a single channel. Pairs of these tones at the same frequency often cancel each other and, when they differ slightly in frequency, produce beats which may be rough and unpleasant.

In stereo the music is divided into left and right channels that are applied to the left and right ears respectively. The tones heard predominantly *by the left ear* cannot cancel or produce beats with those heard *predominantly by the right ear*. It is true that all tones heard simultaneously by the left, or right, ear can and do produce the effects just mentioned. However, stereo suffers *appreciably fewer* annulments of tones and creates appreciably fewer beats. This difference produces the tonal difference between mono and stereo reproduction.

Stated another way, stereophony uses binaural hearing to produce *two unrelated effects*. One effect is psychological; it isolates individual sources of sound from each other by providing clues about their directions from the listener. The other effect is physiological; it prevents interference between tones by separating them until they reach the brain.

The spatial image *is only incidental* when listening to the stereophonic reproduction of orchestral music; although it is essential for the reproduction of operas, theater, parties, and conferences. The directional effect is only a byproduct, and not the cause, of superior orchestral reproduction; it must not be exaggerated into a stunt.

Stereo systems and equipment have, up to now, been evaluated solely for their ability to create a spatial image. This effect is only a part, perhaps the least important, of the contribution stereo makes to the pleasure of listening.

### *Inferences*

The foregoing discussion permits us to make the following inferences:

1. Except for greatly enhanced directional effects, there seems to be no reason to use more than two electrical, or acoustic, channels for stereo because we have only two channels from the ears to the brain.

2. Binaural reproduction by means of earphones should result in better tonal reproduction than stereo because it results in even fewer cancellations and beats. In the case of stereo, each ear picks up sounds from both loudspeakers to some degree and, to that extent, the reproduction is partly monophonic.

Because the two ears are independent, it should be possible to write special music which would be harmonious when heard binaurally with earphones but which would be discordant, and less fully reproduced, when heard monophonically and, to a lesser degree, stereophonically.

However, many people find binaural listening with earphones distracting because the whole orchestra seems to move when the head is turned. In that case the spatial image is actually distracting.

3. The tonal (non-directional) improvements of stereo reproduction are maximized when the listener locates himself midway on the line between the two speakers which are made to face each other, because this position, although not critical, results in the maximum binaural separation.

However, this position results in an impaired sense of direction. A compromise position for the listener, which should result in tonal improvement and maintain a fair sense of direction is at the apex of a 120-degree (or greater) isoceles triangle formed by himself and the two speakers which, in this case, are made to face the listener.

4. Because the direction from which very low tones are heard is not readily perceived, some so-called "three-channel stereo" phonographs mix the bass tones, occurring on the left and right channels, and reproduce them by a single loudspeaker located in the center. However, the tones of a bass viol and contrabassoon, for example, can and will cancel each other when mixed into a single channel but will be unaffected if each is heard respectively by one ear. For this reason, the practice of so-called "three-channel stereo" mixing of bass results in poorer bass than does the usual two-channel stereo.

5. A distorted spatial image may result in better music by providing more binaural separation and therefore fewer cancellations and less distortion. This point may be at the bottom of the controversy between coincident and spaced microphones. The use of coincident microphones, preferred in Europe, is claimed to give a truer spatial illusion. Spaced microphones are favored in the United States and are claimed to give better music.

6. A stereo system recently proposed in Great Britain consists of a monophonic signal which is differentially proportioned in amplitude and in the time of arrival, between two spaced loudspeakers to produce directional information. This one-channel system cannot give as good a stereo service as two-channel systems which make fuller use of the independence of the ears to reduce the cancellation of tones and the number of dissonances.

7. Extension of the tonal range into the highest register, which is demanded vociferously by hi-fi enthusiasts, can be achieved with less distortion and dissonance with stereo because it produces fewer beats.

8. The addition of stereophonic sound to television was not considered practical because the small screen does not provide

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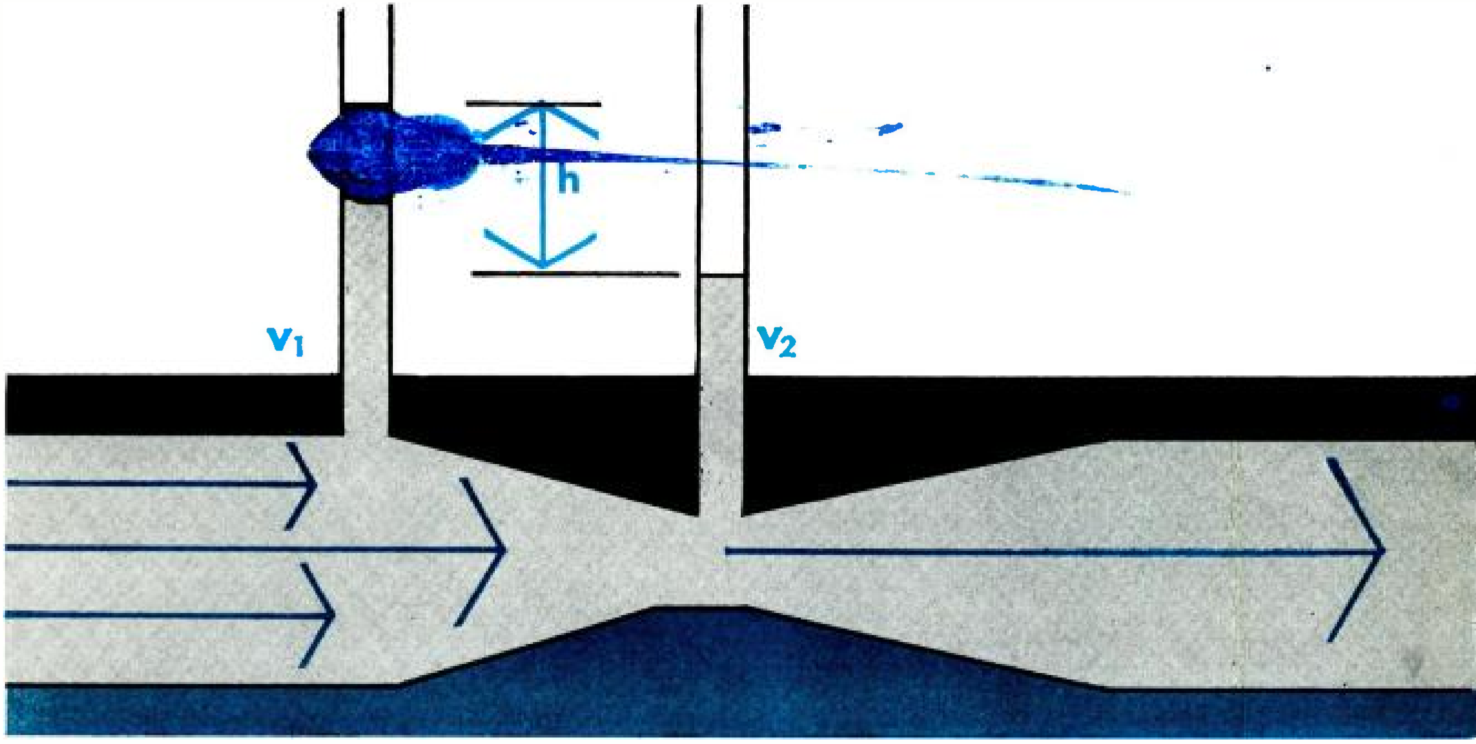



# FLOW MEASUREMENT
## ELECTRONIC TECHNIQUES & DEVICES

By WALTER H. BUCHSBAUM, Industrial Consultant, ELECTRONICS WORLD

*Precise gauging of liquid flow is essential in many industrial processes and in such diverse applications as control of fuel to rocket motors and of blood during surgery.*

ALTHOUGH not spectacular devices, electronic flowmeters are found in such widely divergent applications as regulating the fuel flow to the rocket motors of the "Nova" super-missile and in the delicate control system that governs the flow of human blood during an artificial-heart–lung operation. Flowmeters are not new devices and do not necessarily employ electronics. With the advent of automation, however, the measurement of flowing liquid had to be more precise and controllable by an electrical signal. A survey of the flowmeters now in use shows that there are two types that employ electronics: those which are really mechanical and convert a mechanical motion into an electrical signal and those that use electronic principles to measure the flow as well as indicate it with an electrical signal.

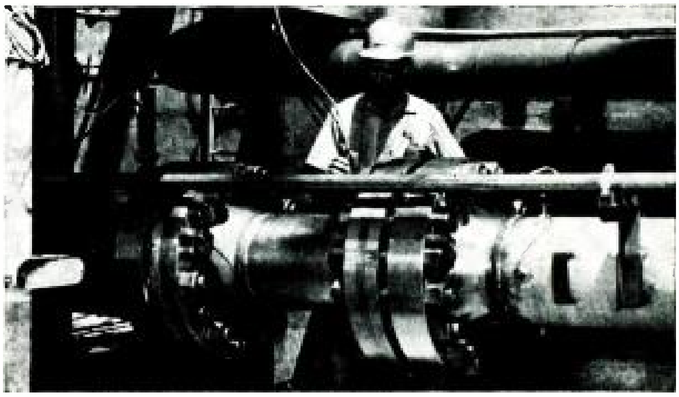
Many technicians who work in industrial electronics will come into contact with these flowmeters as part of an electronic control system. Understanding how a particular type of flowmeter works will enable you to at least determine if it is working correctly or not. The troubleshooting and repair of some specific flowmeters require special training in this type of equipment.

### *Mechanical Flowmeters*

The most obvious way to measure the flow of a liquid is to insert a propeller or turbine into the stream and measure how fast the flowing liquid turns it. Turbine flowmeters combine a mechanical motion with an electronic sensing device to produce an electrical signal output. As shown in Fig. 2, the propeller inside the pipe is turned by the liquid or gas flowing through it. A sensing coil is located outside the pipe to pick up the magnetic flux variations due to the motion of the propeller vanes. When the flow is fast, the propeller turns rapidly and the frequency of the output signal is high. The stationary vanes at both ends of the metering section are necessary to prevent the swirling effects of the liquid which would affect the propeller speed and result in false, low readings. Turbine meters are available in a wide range of sizes from the miniature version shown in Fig. 2 to units several feet in diameter. They are used in many industrial installations, but one of the more spectacular applications is measuring the flow of liquid oxygen ("lox") to missile engines. A 14-inch turbine flowmeter which controls the fuel going to the F-1 engine, one of eight, of the new "Nova" super-rocket is shown in Fig. 1. One obvious drawback of turbine flowmeters is that the vanes and propeller obstruct the flow of liquid. Another is that they are limited in their applications to non-corrosive liquids because their bearings and the propellers will corrode.

Another mechanical-type flowmeter is the differential-diaphragm type shown in Fig. 4. By varying the cross-section of a length of pipe, making one section narrower than the rest, a pressure difference is developed. The magnitude of this difference, which determines the position of a sensitive

Fig. 1. A 14-inch turbine flowmeter controls rocket-motor fuel.



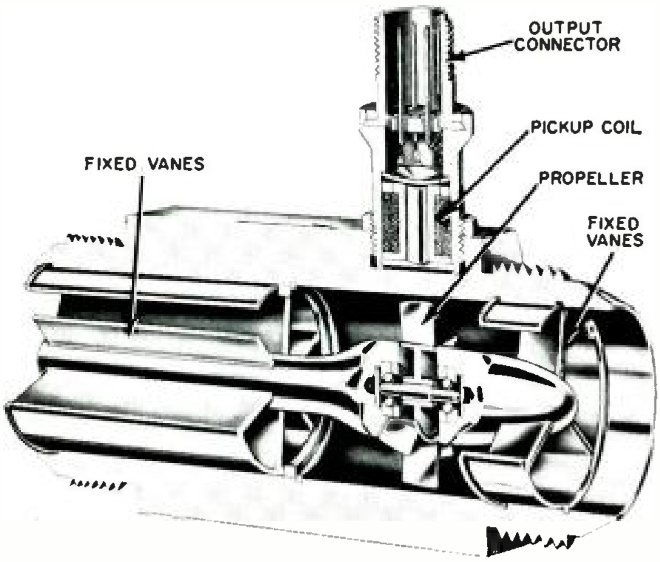



**Fig. 2. Cutaway drawing of typical small turbine flowmeter.**

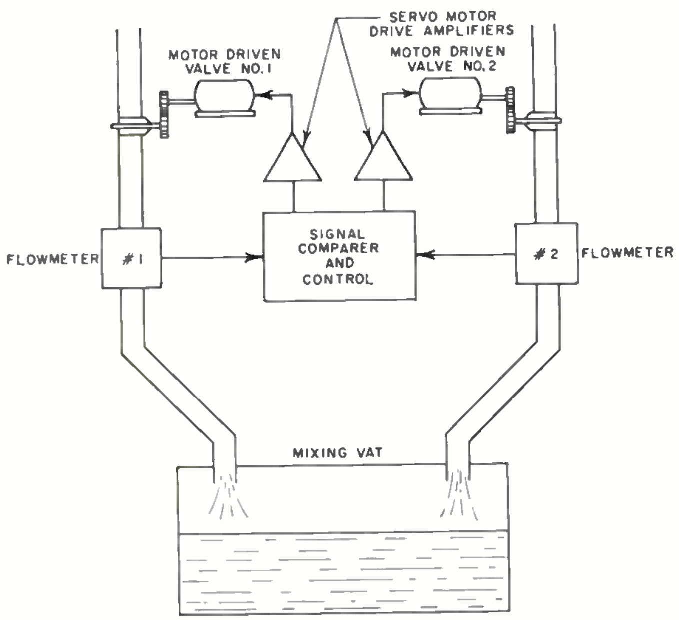



**Fig. 3. Typical flowmeter application. Signals from flowmeters are compared to generate a control signal that adjusts valves 1 and 2 which maintain desired flow into mixing vat.**

diaphragm, depends on the flow rate. An arm is attached to the diaphragm and the position of the arm is measured electronically. The most frequent method of measuring the arm displacement is by connecting it to the movable core of a differential transformer. Different circuits are in use but essentially they just measure the output-voltage variation between the two windings. If each of these windings is connected to the inputs of a differential amplifier, the amplifier output will be an a.c. signal whose magnitude is proportional to the diaphragm displacement or to flow of material in the pipe. The creation of an area of pressure difference means that the flow itself is reduced. This type of meter is suitable for non-corrosive liquids and gases.

In another type of mechanical flowmeter called a "rotameter," (Fig. 5) a specially shaped float rides within a tapered tube in which the differential pressure determines the position of the float. (The float guide-rod assembly is held in position in the pipe by perforated discs.) Flow determines the position of the float and, in electronically sensed rotameters, the float controls the inductance of an external coil so that either the frequency of an oscillator or the output amplitude of a transformer will be proportional to the flow rate. The rotameter is widely used for non-corrosive liquid metering and in relatively small-diameter pipes and tubes.

The electronic portions of the control and indicating systems usually contain a servo amplifier, differential amplifiers, milliammeters, and other conventional devices. Signals are either 60 cps or below 10 kc, which means that transmission over ordinary cables is possible and r.f. or high-frequency pulse techniques are not involved. This greatly simplifies system design, installation, and servicing.

### *Electronic Flowmeters*

Although many types are in use and more are being developed, there are three basically different types of electronic flowmeters. One type is used for electrically conducting liquids, such as salt water, and is generally called a magnetic flowmeter. Another type uses ultrasonic techniques, and the third type is really a temperature-sensing device. The magnetic flowmeter's operation is based on the principle of the electric generator: when a conductor moves in a magnetic field, a current will be induced in the conductor. Fig. 6 shows the elements of a magnetic flowmeter. A magnetic flux $B$ is produced between the upper and lower coils. When the conducting liquid $V$ moves through this flux, a voltage $E$ will be produced at right angles in that portion of the liquid moving through the field. With a fixed conductivity and cross-section, this voltage will be proportional to the speed of the liquid flow.

In order to measure a voltage across the liquid, the inside of the pipe must be insulated over a short length to avoid shorting out the small induced potential. The frequency of the excitation field will depend on the conductance of the metered liquid. For poorer conductors, a higher frequency will produce a greater signal voltage.

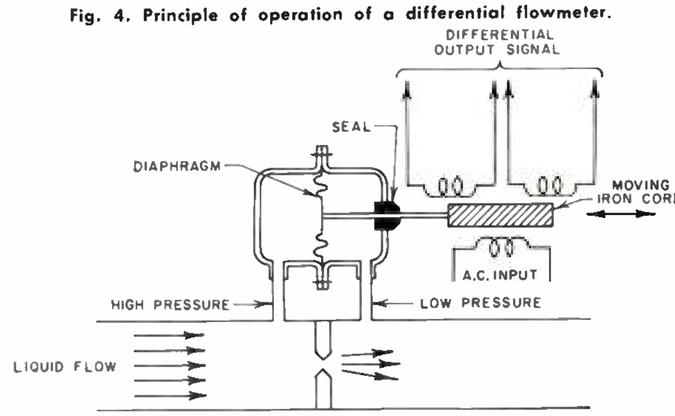
The flowmeter illustrated in Fig. 6 uses an a.c. field and is found in many liquid-flow control systems in the chemical industry especially where strong acids are used. The Teflon or fiberglass pipe lining and the lack of internal obstructions makes this flowmeter ideal for such applications. Surprisingly many liquids are sufficiently good electrical conductors to be measured with an a.c. flowmeter. Human blood, for example, is an electrical conductor and is monitored by magnetic flowmeters during artificial-heart–lung operations.

In addition to a.c. magnetic flowmeters there are also some that use a d.c. excitation field, usually produced by permanent magnets. In order to be effective, the liquid, such as liquid sodium, must have a relatively high electrical conductance. One of the more recent applications of d.c. flowmeters has been in nuclear reactors where the flow of liquid metal is to be measured.

The second type of electronic flowmeter uses ultrasonic techniques to measure flow. In this area there are several different designs and many meters in the field are custom-made rather than mass produced. Ultrasonic techniques have been applied to flowmeters only recently and it seems too early for standardization. The principle underlying any of these meters, however, is basically the same: a flowing liquid produces changes in a beam of ultrasonic energy.

The simplest configuration of ultrasonic flow measurement

**Fig. 4. Principle of operation of a differential flowmeter.**



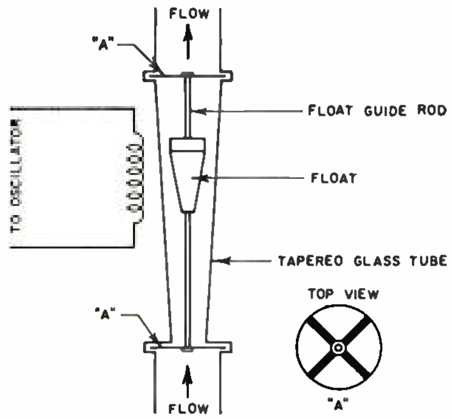



Fig. 5. Schematic shows principle of operation of electronically sensed rotameter.

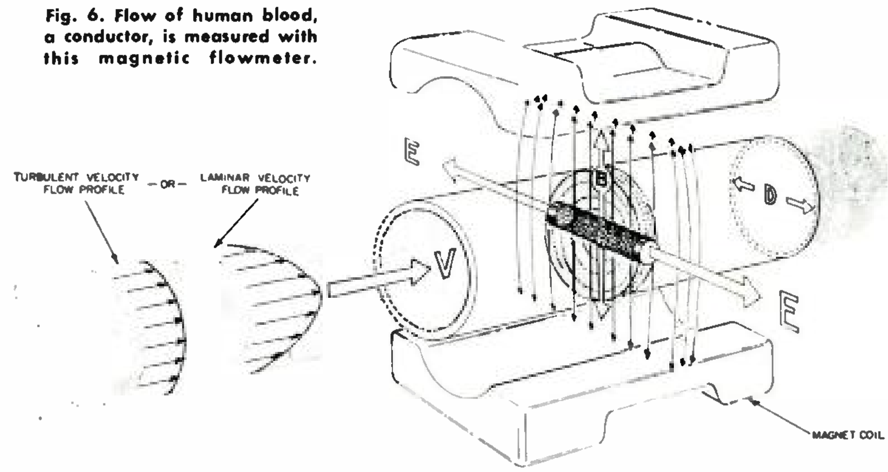



Fig. 6. Flow of human blood, a conductor, is measured with this magnetic flowmeter.

is shown in Fig. 7. An ultrasonic signal is beamed from the transmitter to the receiver. The transit time is simply the distance divided by the speed of sound in the particular liquid. If the liquid flows in the direction of propagation then the transit time is modified by adding the velocity of the flow to the speed of sound. This is somewhat similar to the well-known Doppler principle and, in fact, the measuring circuits are similar to those used in Doppler radar systems. The transmitted and the received signals are compared in frequency; the difference signal is proportional to flow in the pipe.

Because the transit time changes over a distance of ten inches are relatively small, a more sophisticated arrangement than the one shown in Fig. 7 is usually used. Fig. 8 is typical of a more complex measuring system. This system is pulsed, with the pulse-repetition rate dependent on the transit time since each received pulse starts a new transmission.

Each received pulse is fed to an amplifier which drives the transmitter. This closed loop oscillates at a frequency dependent on the transit time through the liquid. Note that the two sets of transmitters and receivers are opposed in direction so that one pulse rate will increase as the other decreases. The measurement of flow is a function of the difference between the two pulse-repetition rates.

Still another configuration is shown in Fig. 9 where one transmitter feeds two receivers. The difference in signal amplitude between the two receivers is then a measure of the flow. Naturally this arrangement will be most effective in larger diameter pipes.

All ultrasonic flowmeters suffer from one major drawback: The liquid must be homogeneous because air or gas bubbles or particles of any kind alter the sound transmission characteristic of the liquid and cause considerable inaccuracy. On the other hand, most ultrasonic flowmeters do not have internal flow obstructions and can be used with any liquid irrespective of its electrical conductance or viscosity. In actual practice, ultrasonic flowmeters have so far been used mostly in defense applications and special purpose industrial installations. They have not yet found universal industrial acceptance.

### *Electro-Caloric Flowmeters*

The third type of electronic flowmeter is generally referred to as an electro-caloric or boundary-layer type and is little more than a thermocouple and a heat source.

A heated element is cooled by the flow of liquid or gas which itself has a lower temperature. If we measure the amount of this cooling effect, a measure of the flow is obtained. Fig. 10 shows the basic circuit of a widely used thermal-flowmeter. Inside the pipe are three thermocouple junctions two of which, *A* and *B*, are heated by the a.c. source. The cooling effect of the gas or liquid in the pipe causes a change in the temperature of thermocouple *A* and *B* and therefore causes a change in the d.c. voltage across the meter. The third element, *C*, is unheated and is included to compensate for slight changes in ambient temperature. Since it is unheated, any change in ambient temperature will have the opposite effect on *C* and tend to cancel d.c. changes which are due only to ambient temperature. Element *C* is at whatever temperature the metered liquid or gas is and is therefore not part of the actual flow measurement.

Fig. 11 shows a complete thermal flowmeter, typical of those used in small pipes. These flowmeters are especially useful for gases, including pneumatic systems, and are found mostly in laboratory, pilot plant, and special metering installations. They are not suitable for outdoor piping where large temperature variations can occur, nor will they be found in industries where the liquids contain coarse particles, are corrosive, or where large pipe diameters are used.

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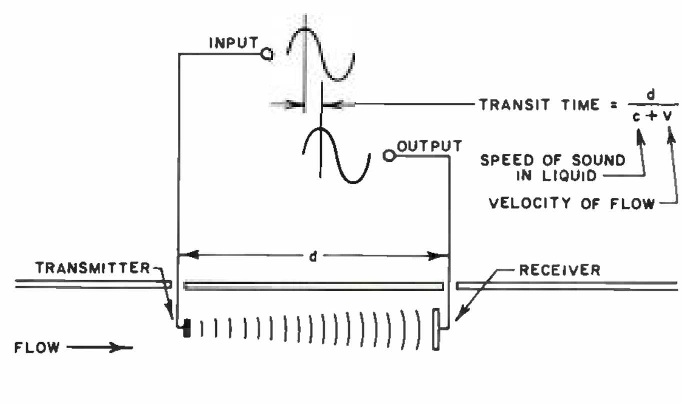
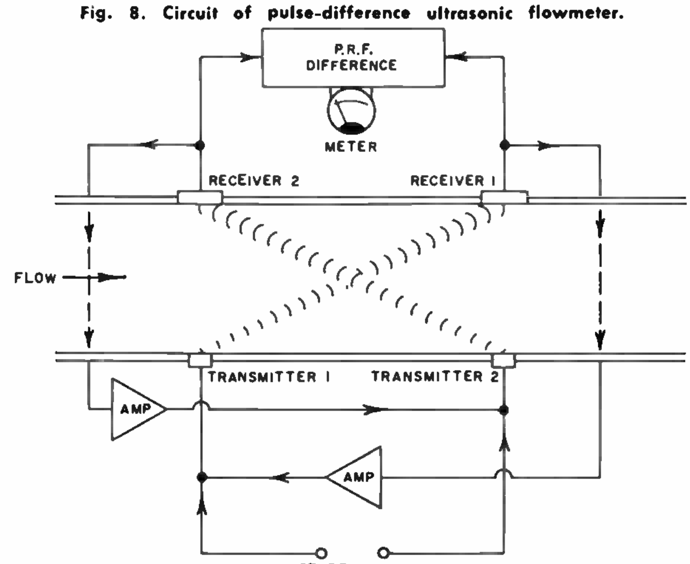



Fig. 7. Simplified schematic of the ultrasonic flowmeter.

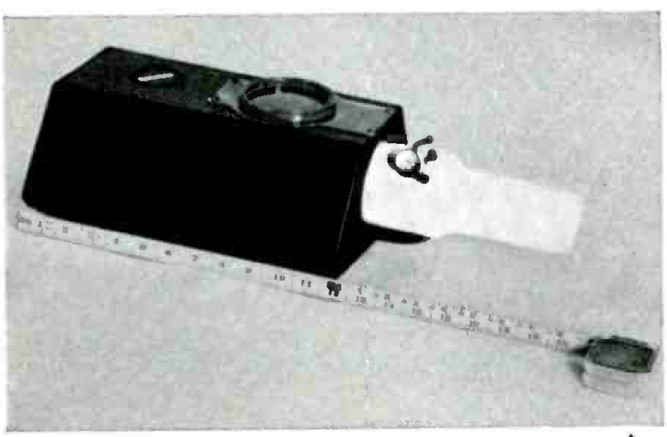
Fig. 8. Circuit of pulse-difference ultrasonic flowmeter.



### ◀ Dead Room Used to Check Car Radios

An anechoic or "echoless" room is being used here to check the performance of an automobile radio. All room surfaces use 30-inch fiberglass wedges to swallow sound reverberation. Walls are more than five feet thick. In addition to the wedges, walls also have 2-inch dead air space, 12-inch concrete blocks, 4-inch fiberglass, 1-inch plaster, and 12-inch concrete blocks. A "floating" floor, used for sound isolation, supports the entire 100-ton structure. The room is air-conditioned with four ducts equipped with special noise silencers. This laboratory is part of a new 132,000-square-foot research and engineering building opened by Delco Radio at its headquarters at Kokomo, Ind.

# RECENT DEVELOPMENTS in ELECTRONICS

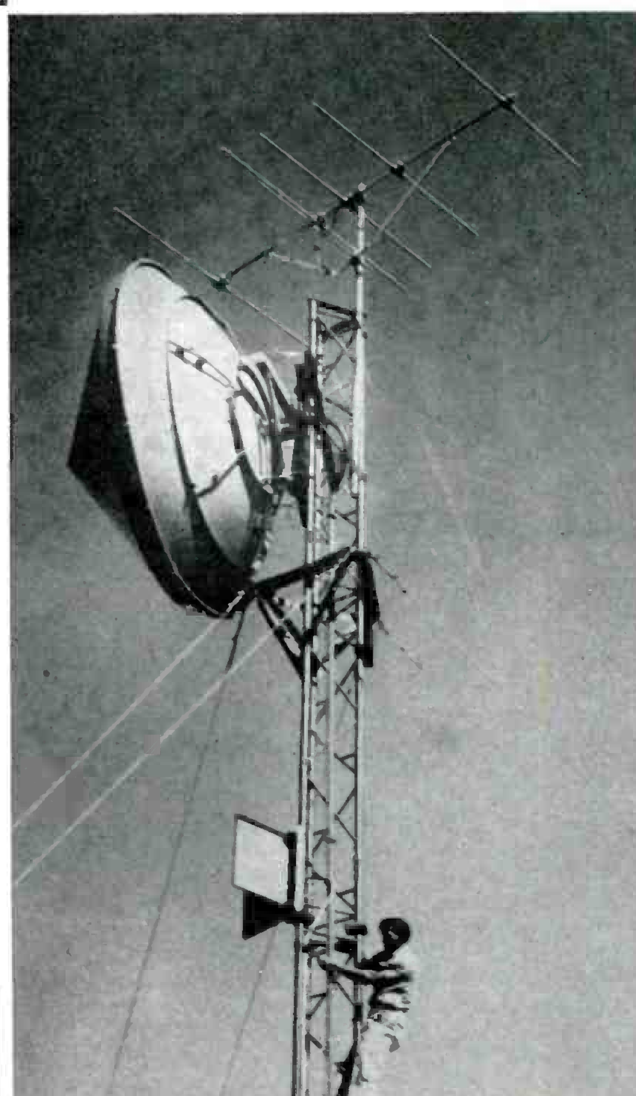


### ▲ Gasoline-Run Thermoelectric Generator

A light weight (10-pound), portable thermoelectric generator which runs on ordinary gasoline is being developed by General Instrument Corp. for the U.S. Army Signal Corps. Designed as a compact power source for field applications, the new unit will produce 45 watts of electricity for 12 hours on 1½ quarts of ordinary gasoline. The supply is silent so that it cannot be located by enemy sound-detection devices, and it will operate at arctic-to-tropical temperature extremes. A specially designed burner, used to avoid lead fouling, provides the heat that is converted to electricity by thermocouples.

### Thermometer for Fishing ▶

The "Fish-o-therm" is a Minneapolis-Honeywell electronic instrument that locates for the angler the depth at which he is most likely to find the type of fish he is after. The device consists of a temperature-sensing element at the end of a line marked to show depth. The fisherman sets the dial for the proper temperature and then lowers the line into the water until the indicator comes on.

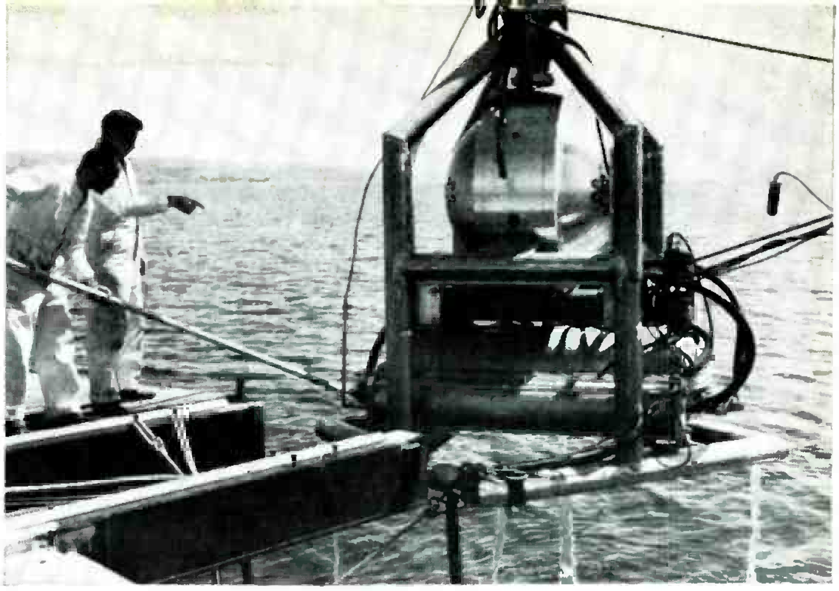


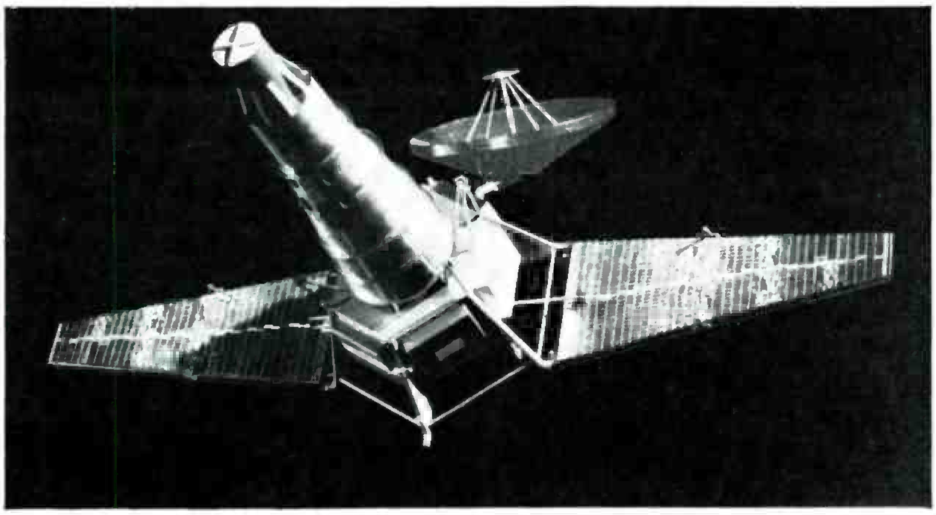
### ▲ Microwave TV Relay Tower

Microwave tower in the network TV relay system used by KOAT-TV, Albuquerque, N.M., supports both off-the-air pickup equipment (top) and a microwave transmitting antenna. Signals originating in Phoenix, Ariz., 70 miles away, are received at this station on 7850-foot Pinal Peak, amplified, and sent along to another mountain peak relay station 305 miles away. The system was designed and built by RCA in conjunction with the station's engineering staff. The repeaters have automatic fault reporting and standby switching equipment.

## Underwater Sound Source

Experimental six-ton hydroacoustic transducer is hauled from the waters of Seneca Lake, N.Y., where it is undergoing tests and evaluation. To be used as a massive source of sound in antisubmarine warfare research, the new device, developed by General Dynamics for the U.S. Navy, employs pressurized hydraulic fluid to produce vibratory energy which is transmitted through water as acoustic waves.



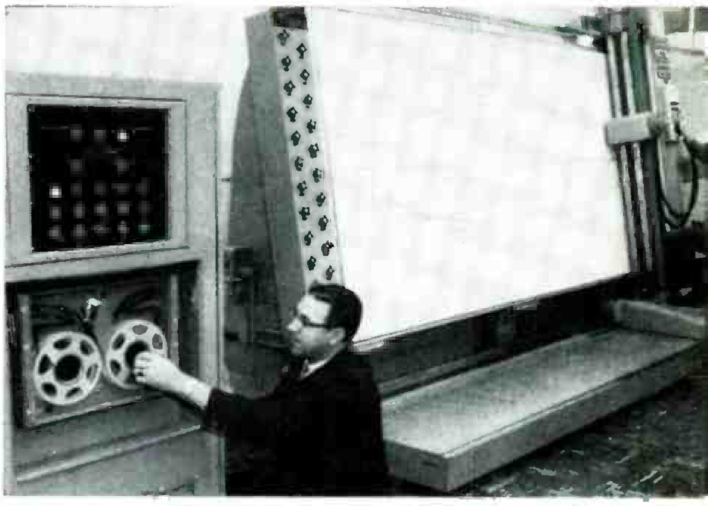


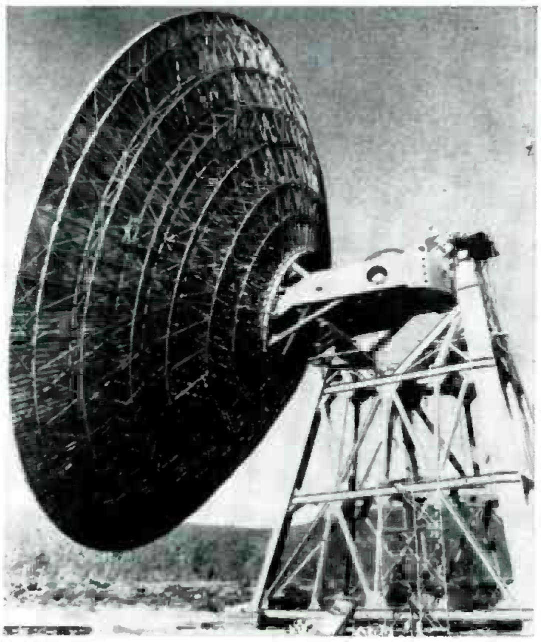
## Lunar TV Satellite

Pictured is a model of a "Ranger" spacecraft with 350-pound, six-camera television package that will provide close-range pictures of the moon's surface. The cameras are housed in the tubular superstructure of the spacecraft with apertures for each camera. The TV sub-system was designed and manufactured by RCA for the Cal Tech Jet Propulsion Lab satellite, the first of which is to be launched in 1963.

## Electronic Drafting Machine

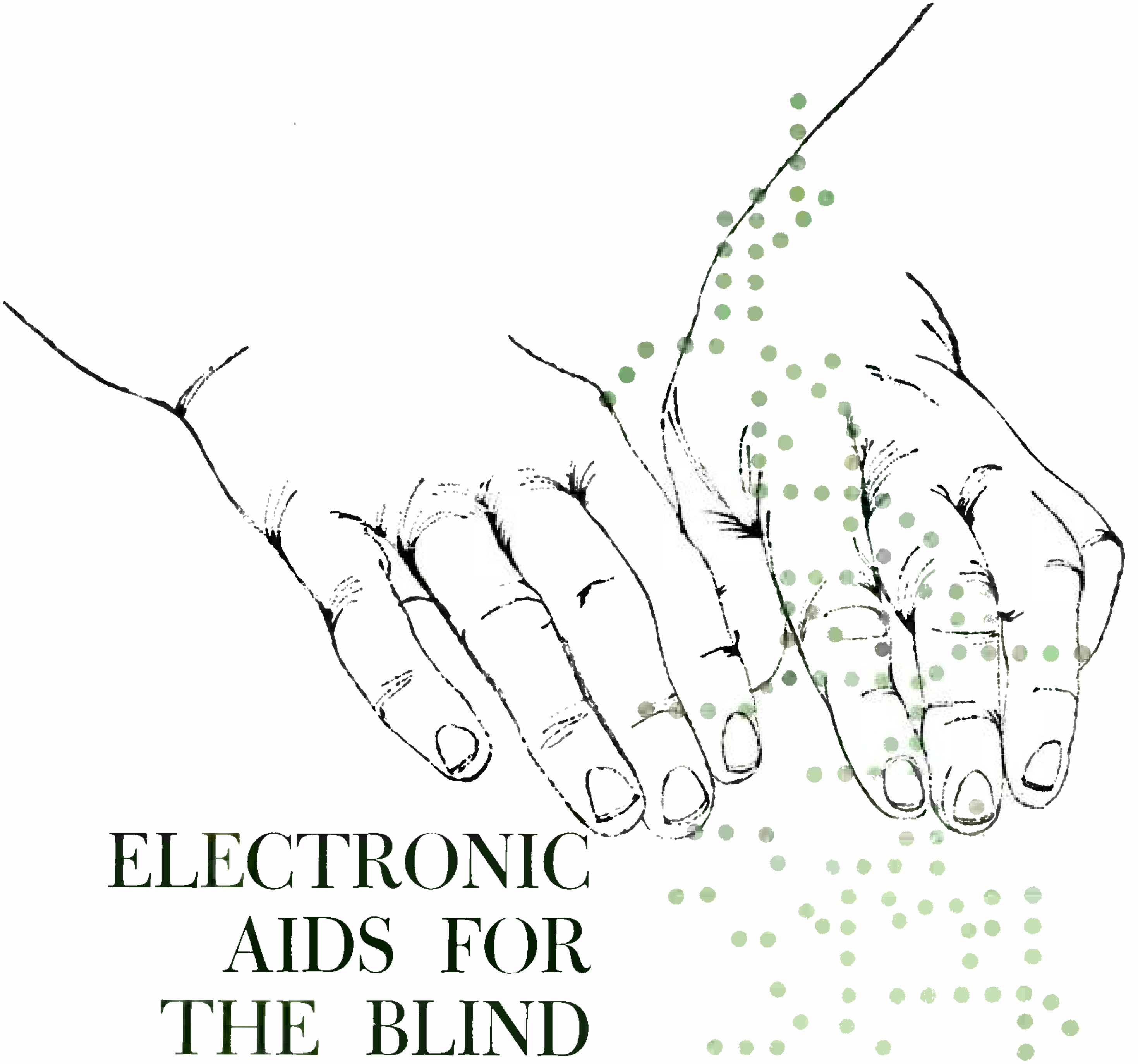
Drawings for aircraft and missile parts and assemblies are produced automatically by this new numerically controlled engineering drafting machine recently put into operation at General Dynamics/ Fort Worth. From information fed into it by punched paper tape, the device can make design and full-scale drawings more quickly and accurately than can human draftsmen, and at less expense.





## 200-Ton Radiotelescope Antenna

Workmen put finishing touches on the new Philco-built 85-foot radiotelescope antenna at the University of California's radio astronomy laboratory in Hat Creek, Calif. The truss structure, mounting ring, and polar-axis drive, able to point the dish at any spot in the sky, are all shown. The project is largely supported under a contract with the U.S. Office of Naval Research. If you look closely, you may be able to make out the tiny figure of one of the workmen atop the pedestal at the extreme right.



# ELECTRONIC AIDS FOR THE BLIND

***Ultrasonics and photoelectric techniques are used in new guidance devices. Auditory test equipment can open jobs for blind technicians.***

THE WHITE cane and heavily harnessed guide dog, familiarly associated with our sightless citizens, may soon be replaced by small, hand-held electronic devices that will accurately locate obstacles and provide a greater degree of safety and freedom for the blind traveler.

Exact figures aren't available, but it has been estimated that there are about 370,000 blind people in the country today. Roughly 10% are under 21 years old, and over 50% are over 65. Perhaps their greatest difficulty is traveling confidently on their own. It is difficult to know what this problem is really like. However, you might get an idea of it by blindfolding yourself and walking in a strange room. Notice how quickly obstacles get in your way and how everything suddenly closes in.

Electronics has made great strides as a medium of entertainment and in helping to restore hearing and the voice. Now there are devices on drawing boards, in laboratories, and in the field being tested which will someday make travel for the blind freer, safer, and considerably less of a problem.

Recent demonstrations at the International Congress on Technology and Blindness, in New York, showed that several guidance aids hold promise for the future. ELECTRONICS WORLD attended the Congress and witnessed the operation of three aids and examined a number of electronic test instruments designed especially for use by blind electronics technicians.

### *Guidance Aid Requirements*

While both the guide dog and cane are a great help, the dog cannot be used by the very young who are not mature enough to assume the responsibility of working with it, or by older people who may not have the physical stamina to undertake the training program or to maintain the normal walking speed of the dog. The cane cannot warn the blind person of obstacles beyond its length.

Ideally, an electronic guidance aid, to be of any help beyond that of a cane or dog, should be able to locate many different obstacles and indicate their distance, shape, and direction with respect to the user. Larger obstacles, such as walls can be easily detected by auditory sensing, but chairs, posts, fire hydrants, mailboxes, and doorsteps cause considerable apprehension in the blind traveler. The aid should also be able to detect step-ups and step-downs, such as stairs, curbs and holes, edges of train platforms, open manholes, and cellarways. Another very important consideration is that if the aid is to provide auditory information about the surroundings to the user, it do so in a way that will not interfere with his normal hearing. Also, it must be able to operate well in noisy or crowded environments where other normal auditory cues are absent or useless. Last, but not least, the guidance aid must encourage the blind person to develop strong psychological factors such as courage and the desire to travel independently.

### *Ultrasonic Guidance Aid*

One of the demonstrations at the Congress was conducted by Leslie Kay of the University of Birmingham, Birmingham, England. Mr. Kay has made a study of the guidance methods used by bats and has applied his findings to the design of a guidance aid that operates on similar principles.

As is well known, bats produce an inaudible tone and employ a system similar to radar in which an echo determines the distance to nearby objects. As a result of laboratory experiments, Mr. Kay found that a wide-band, continuous FM system was superior to a pulsed system. The reason is that the human ear can discriminate between signals that differ in frequency more easily than it can between signals that arrive at different time intervals.

The principle of operation is based on the fact that a beat note, produced by heterodyning the transmitted signal with that of an echo, will have a pitch proportional to the distance of the reflected object. Information about the surroundings in the form of simple and complex sound patterns produced by the instrument can be interpreted or made into a "picture" by the blind person.

The guidance aid transmits a 10° beam at one of two sweep rates to provide a 10- or 30-foot detection range. The circuit transmits a signal that sweeps from 60 kc. to 30 kc., and produces a maximum-frequency audible tone of 3 kc. The system is silent until an echo is received. The character of the audible signal indicates the distance and direction of obstacles.

Ordinary hearing-aid phones are worn but instead of placing them over the ears, a small-diameter plastic tube is used to feed the sound directly into the outer ear. Thus, normal hearing is not affected. Both ears are used to maintain auditory balance and normal binaural perception.

The aid can detect a smooth wall 30 feet away, a two-inch diameter post at ten feet, or a one-millimeter wire at four feet. In addition, it will detect ascending and descending steps, shrubbery, and other pedestrians. Several blind people have used the aid after only a short training period and found no difficulty in determining the distance of an object by the frequency of its echo. Obstacles of different shape and size produced what could be called a "sound picture." Further work, however, must still be done before the aid can be marketed.

### *Infrared-Optical Guidance Aid*

An infrared obstacle detector was described and demonstrated by T. A. Benham of Haverford College, and J. M. Benjamin, Jr. of *Bionic Instruments, Inc.* The detector, whose operating principle is based on infrared/optical triangulation, is now being evaluated by several blind people. The hand-held device (Fig. 1) contains, among other things, a lamp-drive circuit and a xenon lamp which produce bright pulses of light that are focused on the ground ahead of the person. Some of the light rays striking an object are reflected back and are concentrated by a lens on one of two photo diodes. If the obstacle and the detector are brought closer together, the reflected light strikes the other photo diode. If the obstacle is, say, 30 feet away, the upper photo diode will be struck by some of the reflected light. If the distance is less, the light will strike the lower photo diode. The output of the photo diodes is amplified to actuate a stimulator, in the instrument's handle, which pokes the holder's finger.

By depressing a switch in the handle, the far-range photo diode is removed from the circuit to facilitate traveling in crowded areas. A shortcoming of this guidance aid is that it cannot detect step-ups or step-downs.

### *The Electronic Cane*

An experimental "electronic cane" was demonstrated by Robert J. Gibson of the Franklin Institute, Philadelphia, Pa. It is adjusted so that when its tip is two inches away from the ground it does not produce an auditory signal. If the ground drops away more than two inches at a curb or a hole, a signal warns the holder.

### *Special Test Equipment*

In the area of special test equipment, Robert W. Gunderson, an instructor in electronic theory and practice at the New York Institute for the Education of the Blind, has designed special auditory test equipment that can be used effectively by blind electronics technicians. Bob, who has been blind since birth, won the 1955 *General Electric* Edison

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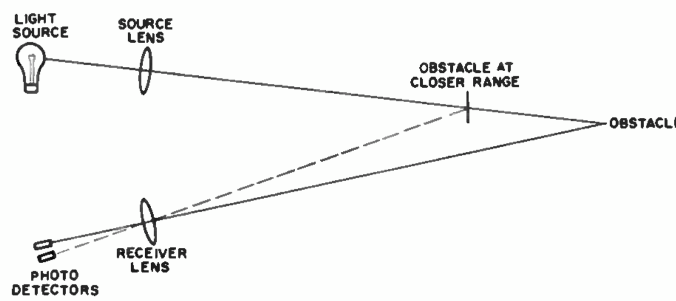
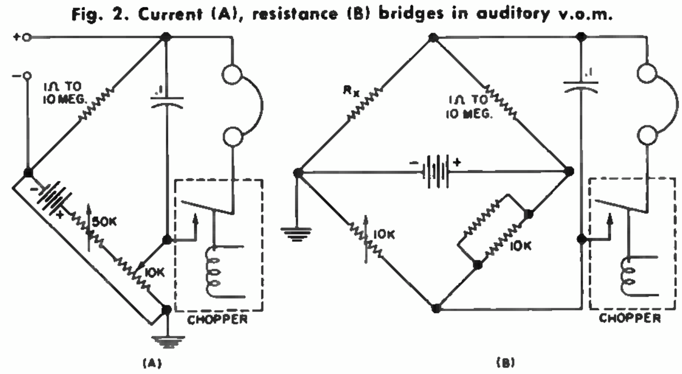
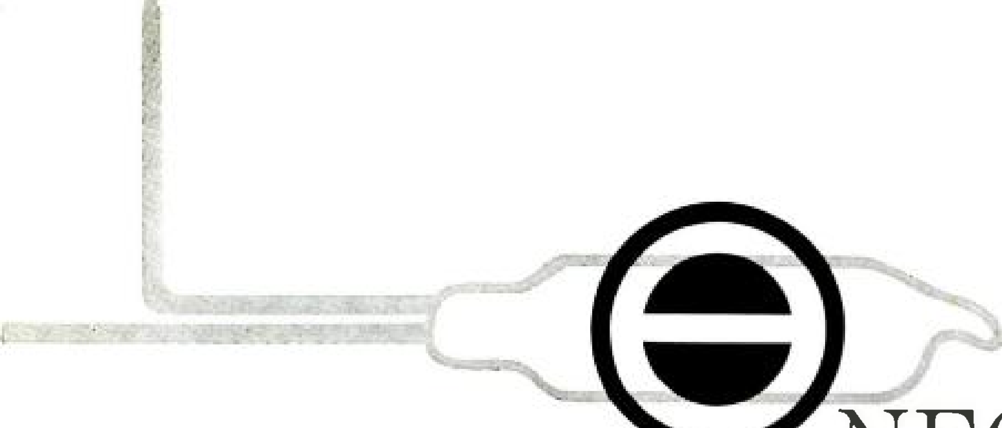



**Fig. 1. Operating principle of infrared obstacle detector is optical triangulation. Hand-held prototype is shown below.**

**Fig. 2. Current (A), resistance (B) bridges in auditory v.o.m.**





# NEON BULB FLIP-FLOP CIRCUITS

By MAURICE E. SCHERER, Jr.

*Inexpensive, readily available neon glow lamps can be employed to construct simple counters using design data collected by author.*

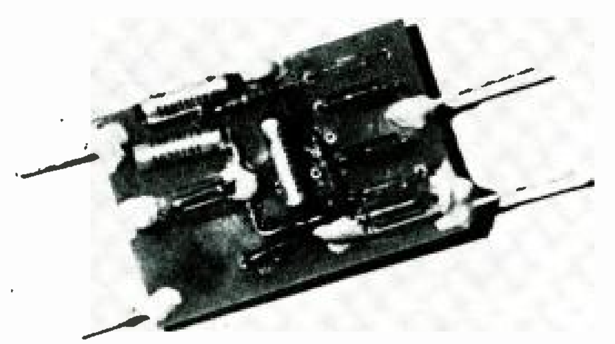
IN commercially built flip-flop circuitry, the familiar fractional-power neon lamp is often used merely to indicate the conduction state of the tubes or transistors which are the active elements of the bistable circuit. However, these same small indicating lamps can be used as flip-flop circuit elements themselves, and quite economically if performance at high frequencies is not important.

Such arrangements may be put to various slow-counting tasks or may also be slightly modified and used for storing binary information either permanently or as self-erasing devices. When designed with transistor compatibility in mind, neon bulb flip-flops are particularly useful in combination with conventional circuits. For example, since the frequency of a specific flip-flop stage as a counter or an accumulator is lowered below the input frequency as a negative exponential function of the number of preceding stages, the last few stages operate at a comparatively slow rate.

The use of neon lamp flip-flop counters in the last permissible stages is quite practical since they perform adequately and cost little more than the indicators and diodes for the other stages alone would cost. Hybrid logic circuits, consisting of neon bulb flip-flops supplied with transistorized gates and pulse inverters (gating and pulse inversion can be accomplished using only gas-bulb and diode networks, but the circuits are complex and costly), are easily constructed and provide inexpensive units for digital computer experimentation and game theory mockups.

In these applications the bulbs rival their transistor counterparts for compactness and low current drain and, of course, they require no external indicator lamps because the glow produced by the active lamps is suitable even for direct panel display in such permanent gear as counters, numerical converters (binary-to-decimal, octal-to-binary, etc.), and accumulators.

**Printed-circuit version of a basic neon bulb flip-flop counter constructed by author from circuit shown at the left in Fig. 2.**



### *Bulb Characteristics*

To determine the exact limitations of the neon bulb in an unbuffered bistable circuit, as well as to fix circuit parameters, several characteristics of the easily obtained NE-2 were investigated. Important among these are firing time, firing and cut-off voltages, and current drain. This data is not available to the required accuracy in manufacturers' bulletins, so it was determined experimentally in the lab.

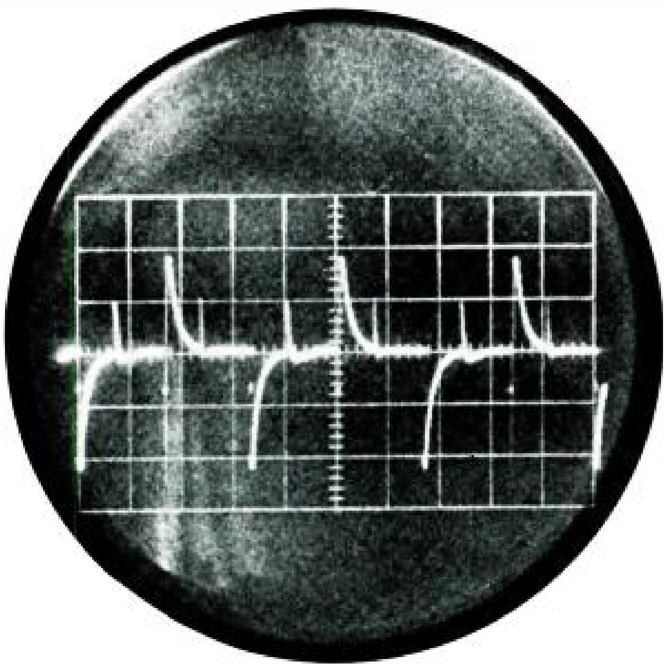
Firing time was measured with a *Tektronix* 545 scope by pulsing the bulb under test with the horizontal sweep output through a series resistor. The vertical input was connected across the resistor, and the trace was externally triggered so that the resultant curve would show bulb current *versus* time for any desired time interval. As an arbitrary standard, when the curve reached 80% of its maximum value, the bulb was considered to be "conducting" and the firing time was read directly below this point from the horizontal axis.

At 100 volts pulse voltage across the bulb a typical NE-2 could fire in as little time as 4 μsec., operating at a maximum frequency of 20 kc. At 85 volts the same bulb would fire in 5 μsec. at 10 kc. However, at voltage around 10 volts above cut-off, most bulbs fired in 10 μsec. but could operate only up to a frequency of 200 cps. Beyond this frequency the energy of the input pulses was not enough to ionize the neon and allow the bulb to conduct.

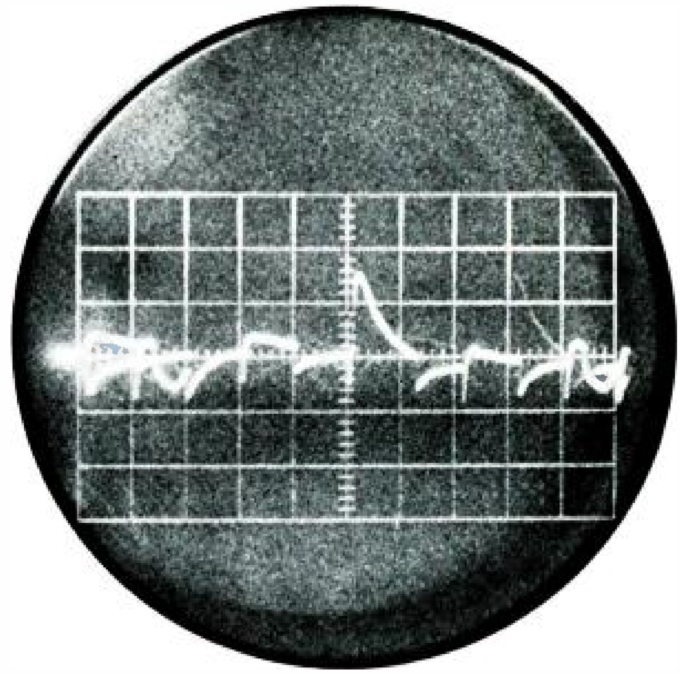
Since the firing time measurement setup also measured bulb current, a precision resistor was used in the circuit and the current read directly from the scope. A large sampling of NE-2's showed surprisingly little current variation from bulb to bulb. Careful testing proved a random collection of fifty lamps to be rated at 0.4 ma. ±0.03 ma. at firing voltage.

Voltage characteristics, on the other hand, cover quite a wide range, as shown in Table 1. $E_1$ is the minimum firing voltage and $E_3$ is the cut-off voltage. $E_2$ could be called the "operating" voltage because it is the potential across the bulb after it has started drawing current through a load resistor. The importance of $d_1$ and $d_2$, which are simply the differences $(E_1-E_2)$ and $(E_2-E_3)$ respectively, will be seen later.

In order to construct neon bulb flip-flop circuits having predictable specifications, the reader will want to determine



Output of series of neon bulb flip-flops counting in binary. Note small positive pulses which leak through to the output from preceding stage. Negative pulses from preceding stage cause the flip-flop to change state. (1 cm.div.=5 volts)



Output of "nor" gate gives high positive pulse (center) when flip-flop inputs are simultaneously negative. Other combinations produce insignificant voltages which appear in the waveform photo as a number of random pulses. (1 cm.div.=5 v.)

$E_1$, $E_2$, $E_3$, and $d_1$ and $d_2$ for purposes of bulb matching and capacitor selection. A simple testing arrangement is shown in Fig. 1. If a regulated d.c. supply is not available, a potentiometer voltage divider connected across a 90-volt battery can be used, although the results will be slightly erroneous because of imperfect regulation. $E_1$ is the voltage registered by the v.o.m. the instant before the bulb fires and is determined by trial and error by increasing the supply voltage very slowly until the bulb fires. As soon as the bulb starts to conduct, the v.o.m. reading will fall to the level of $E_2$ with no change in the supply voltage because of the voltage drop across the 27,000-ohm load resistance. $E_3$ may then be found by decreasing the supply potential until the bulb flickers off and noting the meter reading at that point.

### *The Circuit*

In the flip-flop configuration the bulbs are biased so that only one of them can be "on" at a time. Suppose that bulb A of the fundamental counting circuit (Fig. 2) is conducting. The load resistor common to both bulbs ($R_5$) has a voltage drop across it equal to $E=IR_5$, where $I$ is the bulb current. This drop holds bulb B below firing potential. Another potential difference, the voltage difference between the circuit which is conducting and the unloaded "open" circuit of the unionized bulb, charges the capacitor $C_1$. Now if a sufficiently large pulse is fed into the flip-flop input, raising the potential difference across bulb B and causing it to fire, bulb B starts to conduct, discharging $C_1$. Attempting to recharge, $C_1$ draws current for an instant from the circuit of bulb A. The additional current drain through $R_1$ causes the voltage across bulb A to fall below cut-off, and bulb A goes out. However, bulb B remains on since the other bulb is no longer conducting and it, in turn, keeps the potential of bulb A below firing. $C_1$ charges again, this time in the opposite direction as before because the bulbs' states are reversed, and the process can be repeated every time a suitable pulse is fed into the input.

Each time the flip-flop state is shifted, an exponentially damped impulse of initial magnitude equal to $d_1$ and a polarity alternating as first one and then the other bulb conducts is developed at the output. The positive output pulse will not affect the following stage, but the negative pulse acts as a trigger. Therefore, the circuit shown in Fig. 2 will count negative input pulses in binary, each stage firing the next every other time it receives an input impulse. Bulbs A, C, and E are indicator lamps for the binary registers; they glow to indicate a "one" in that register, or do not glow to indicate a "zero." Other counting circuits are similarly devised using one or more feedback loops and gates, but these usually require flip-flop circuits with additional inputs.

A more sophisticated flip-flop device has "set" and "reset" inputs as well as a single "trigger" input. The functions of these inputs (see "Computer Registers and Accumulators," ELECTRONICS WORLD, November 1961) are easily obtained by a slight modification of the basic counter circuit. The set and reset pulses are simply fed to appropriate sides of the flip-flop, as shown in Fig. 3A. Irrespective of the previous state of the circuit, a standard negative pulse fed into the set input will fire bulb B; similarly, the state of bulb A is con-

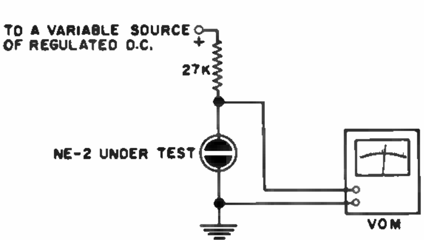



Fig. 1. Test setup for checking voltages.

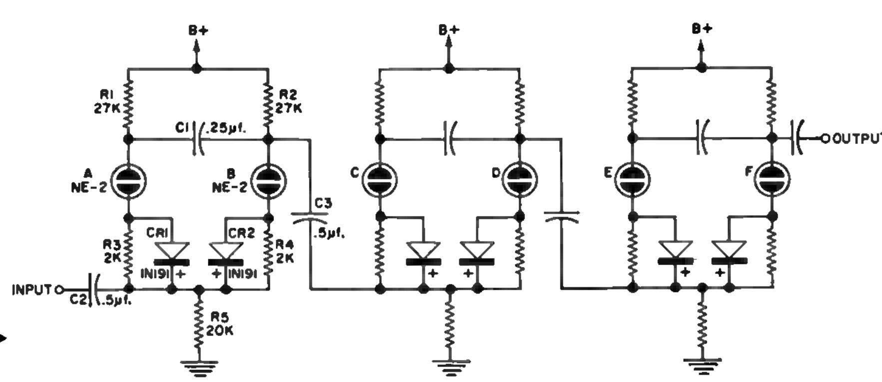



Fig. 2. Neon bulb flip-flop circuits employed in binary counting arrangement. ▶

| $E_1$ | $E_2$ | $E_3$ | $d_1$ | $d_2$ |
|---|---|---|---|---|
| 74 | 65 | 56 | 9 | 9 |
| 73 | 63 | 55 | 10 | 8 |
| 73 | 64 | 55 | 9 | 9 |
| 72 | 61 | 56 | 11 | 5 |
| 72 | 64 | 57 | 8 | 7 |
| 72 | 60 | 56 | 12 | 4 |
| 71 | 63 | 55 | 8 | 8 |
| 70 | 63 | 54 | 7 | 9 |
| 70 | 62 | 55 | 8 | 7 |
| 70 | 60 | 55 | 10 | 5 |
| 70 | 59 | 54 | 9 | 5 |
| 69 | 60 | 54 | 9 | 6 |
| 69 | 60 | 53 | 9 | 7 |
| 69 | 60 | 54 | 9 | 6 |
| 68 | 60 | 56 | 8 | 4 |
| 68 | 58 | 55 | 10 | 3 |
| 67 | 58 | 53 | 9 | 5 |
| 67 | 55 | 50 | 12 | 5 |
| 67 | 57 | 52 | 10 | 5 |
| 67 | 57 | 52 | 10 | 5 |
| 67 | 57 | 54 | 10 | 3 |
| 66 | 57 | 52 | 9 | 5 |
| 66 | 56 | 51 | 10 | 5 |
| 66 | 56 | 51 | 10 | 5 |
| 64 | 55 | 52 | 9 | 3 |

**Table 1. Characteristics of random sampling of G-E NE-2 neon bulbs. All figures given in table are in d.c. volts.**

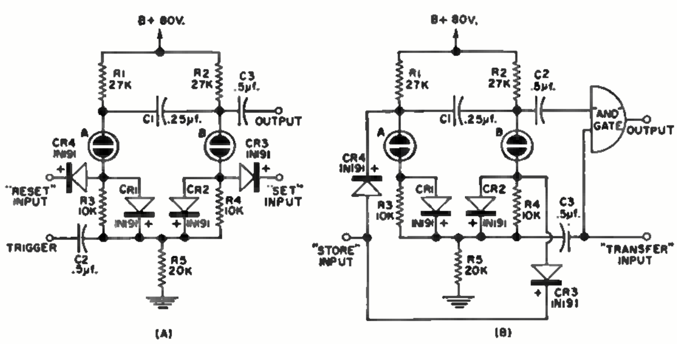



**Fig. 3. (A) Neon bulb flip-flop with "set" and "reset" inputs. (B) Circuit of a self-erasing neon bulb memory circuit.**

trolled by the reset input. But as in the counter circuit, the bulbs are biased so that it is impossible for both of them to conduct at once. In the basic counter, the diodes $CR_1$ and $CR_2$ prevent instability and oscillation caused by small backwash voltages; however, in the set-reset flip-flop these diodes keep the set and reset signals from getting mixed up. The values of $R_3$ and $R_4$ are increased to prevent resistive feedthrough.

Other modifications of the basic bistable circuit include the self-erasing memory unit shown in Fig. 3B. A pulse to be stored, either positive or negative (high level or low level) is fed, depending on its polarity, to bulb A or bulb B. As in the set-reset flip-flop, the appropriate bulb fires and remains on. When the transfer pulse arrives, the circuit changes state and generates an output signal whose polarity depends on what the polarity of the stored pulse was. Depending on the choice of bulb for "output bulb," *i.e.*, the bulb in the circuit which feeds the output capacitor, the memory unit will store pulses and release pulses of the same polarity as the input pulse or automatically invert its "memorized" binary bit.

Additional alterations of the neon flip-flop for numerous flip-flop applications are limited only by the ingenuity of the experimenter, especially since the voltage pulses which the neon bulb circuits generate and to which they respond are on the order of 10 volts, and therefore fully compatible with transistorized circuits. Two such circuits designed by the author especially for use with neon bulb devices are shown in Fig. 4 as models for interested readers, although going into details of their operation would be straying from the topic.

One circuit is a pulse inverter (Fig. 4A) which merely changes the polarity of an input signal with very little delay. The other circuit (Fig. 4B) is a "nor" gate which generates a positive output pulse if and only if it receives two simultaneous negative input impulses. (Note that an inverter-follower connected to the output of this "nor" gate would convert it to an "and" gate, suitable for accumulator construction.) The transistors used by the author were a special computer edition which will probably be unavailable to most readers; however, less-rare prototypes may be used just as well as long as biasing conditions are met. The *Raytheon* 2N662 is one possible substitute.

All the neon bulb circuits described will operate at a maximum frequency determined essentially by their $R_1C_1$ networks, but limited by the characteristics of the bulb. Obviously smaller values of $C_1$ will increase the frequency capability of the systems, but speed must be compromised for the sake of reliability, as the capacitor must be large enough to cut off the appropriate bulb completely when it charges. Calculating the optimum value of capacitance for a given circuit involves an exercise in integral calculus which can be reduced to a simple formula for finding approximately values of $C_1$. This is: $C_1 = 2I_n t/3d_2$ where $I_n$ is the current drain of the bulbs, $t$ is the reciprocal of the desired frequency $(1/f)$, and $d_2$ is $E_2 - E_3$, found by experiment. After $C_1$ has been calculated it is substituted into: $T = R_1C_1$. This equation checks the feasibility of the calculated capacitance. If $t$ is smaller than $T$, the circuit cannot possibly work, simply because the capacitor is too small to do its job in the circuit.

From these equations it is seen that for higher frequency work, bulbs with low values for $d_2$ are desirable if not necessary. Do not try to increase the operating frequency of a neon bulb flip-flop by increasing the value of $R_1$ and $R_2$ as this will upset the approximate transfer impedance match inherent in the author's suggested circuits and cause poor performance. And keep in mind that circuits pulsed at rates greater than their allowed frequency of $f = 1/R_1C_1$ will generate electrical garbage which is unintelligible to following stages.

## *Construction Hints*

Modular printed-circuit design was preferred because of the ease of interchangeability and mounting convenience it afforded. Although this type of construction has good mechanical strength *per se*, epoxy resin was used for additional component rigidity and insulation of the printed-circuit backside. By using tantalum capacitors, the author was able to keep the neon bulb units fairly small. However, physical layout is not important and the reader has complete freedom to expand

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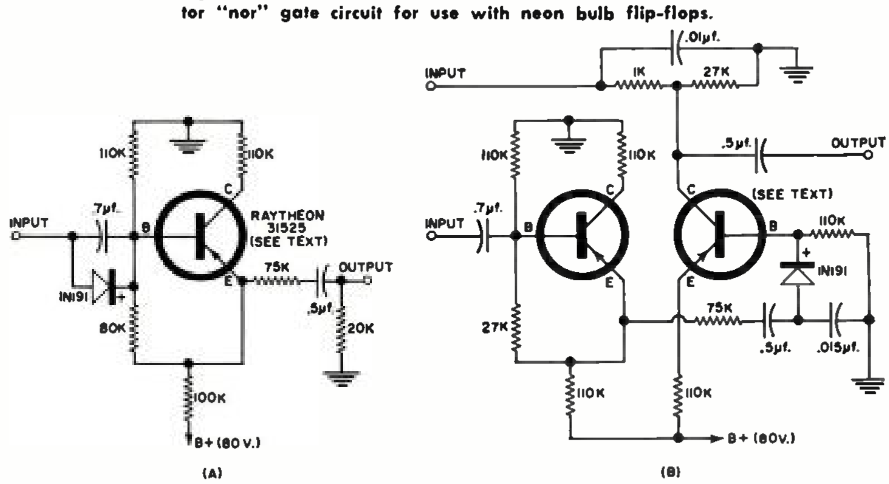
**Fig. 4. (A) Transistor inverter circuit and (B) transistor "nor" gate circuit for use with neon bulb flip-flops.**



# UNIQUE OUTPUT CIRCUIT in TRANSISTORIZED HI-FI AMPLIFIER

By NORMAN KRAMER / Project Engineer, Allied Radio Corp.

*Description of some of the unusual circuitry that is employed in an 18-watt-per-channel all-transistor stereo amplifier unit.*

SMALL size, low power consumption, and low heat dissipation have already been demonstrated in a wide variety of transistorized equipment. In the field of high-fidelity equipment, however, the real advantages of solid-state components have been very slow in coming to the surface. Some of these advantages are: negligible phase shift with frequency response practically to d.c., very low hum levels because of the reduced pick up in the inherently low-impedance circuits of transistors, and the elimination of the output transformer, always one of the primary limiting factors in amplifier performance.

The purpose of the design used in the "Knight-Kit" KG-60 amplifier was to show that medium to high power is possible at low over-all cost in a complete stereo unit which provides all the versatility and functions required by the audiophile.

### *Output Circuitry*

The amplifier design began with the choice of output circuitry. Since conventional class B operation requires both output and driver transformers, it was to be avoided. Some variations eliminate the use of the output transformer while still others omit the driver transformer as well. The use of a center-tapped voice-coil could not be considered from the standpoint of compatibility with existing hi-fi speakers. Capacitor coupling to the voice-coil was ruled out because an extremely large coupling capacitor would be needed to insure frequency response down to 20 cps. In view of these limitations, it was decided to use half-bridge circuitry.

It was further decided to use the driver transformer. Since the transistor is a current amplifier and power would be needed to drive the output circuit, the effective gain of the primary-to-half-secondary turns ratio would produce the gain which would otherwise have had to be obtained elsewhere in the amplifier. Proper choice of the output and driver circuitry circumvented the usual design problems inherent in the use of a driver transformer, such as reduced low-frequency performance due to nonlinearity and the adverse effects on high frequency due to leakage inductance and interwinding capacitance.

Actually, transformer efficiency of less than 50% was all that was required to drive the output circuit. This permitted considerable copper losses and allowed many primary turns, hence better low-frequency response. In addition to this, transformer steel was better than that usually found in driver applications. Bifilar winding of the transformer greatly reduced the leakage inductance and the undesirable effects on high-frequency performance. The transformer employed was a special dual-secondary unit with a 66-ohm primary and a 6-ohm secondary impedance.

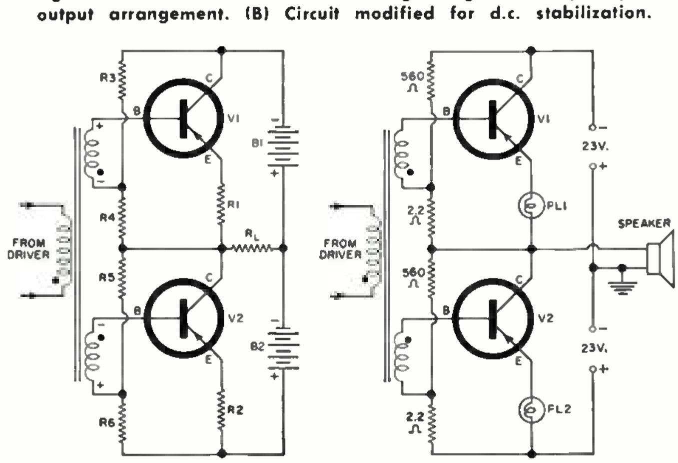
Fig. 1A shows the basic circuit of a single-ended push-pull output-transformerless amplifier. Class B transistor output circuits require some quiescent collector current to flow, with no signal applied, to avoid crossover distortion. $R_3$ and $R_4$ establish bias voltage for $V_1$ while $R_5$ and $R_6$ bias $V_2$. The value of this idling current is critical because too low an amount could cause severe distortion in the crossover region while too high an amount could result in excessive transistor dissipation with the likelihood of permanent damage. $R_1$ and $R_2$ provide d.c. stabilization and set the transistors' operating points to levels where they are fairly independent of their individual characteristics and ambient as well as junction temperatures.

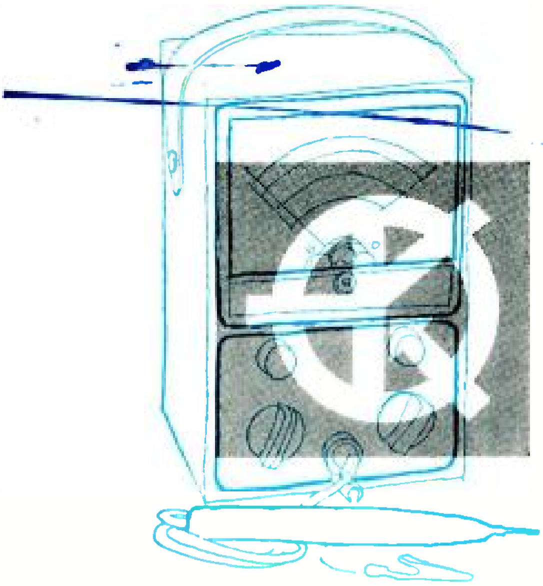
Both transistors are in common-emitter circuits and appear in series across the split power supply. They are, however, in parallel across the single-ended load. When a signal is fed to the amplifier, equal and out-of-phase voltages are fed from the driver transformer secondaries to the base of each output transistor. Thus each transistor is driven to conduction on alternate half cycles of the signal. Both transistors see their driving signal from base to emitter and deliver their output signal from collector to emitter. This parallel condition with respect to the load means that the load impedance necessary to match the transistors is only a fraction of that required by a conventional push-pull circuit.

In actual operation, reasonably balanced transistors and supply voltages balance the bridge and no current flows through $R_L$. If an input signal causes either transistor to conduct more than the other, the bridge becomes unbalanced and current flows through the load. If $R_L$ is replaced by the speaker voice-coil, the incoming signal will be faithfully re-

(*Continued on page* 92)

**Fig. 1. (A) Basic circuit of half-bridge single-ended push-pull output arrangement. (B) Circuit modified for d.c. stabilization.**





# SERVICE TRANSISTOR SETS WITH A V.T.V.M.

By J. B. STRAUGHN / National Radio Institute

*When the set goes dead, this single instrument offers a comprehensive set of checks, including stage isolation.*

FEW OF US have ever tried to skin a cat by any method, yet it is known that there are many different techniques that may be employed successfully. The same is true in servicing. The method used by the technician is the one he has found consistently successful. When it comes to transistor radio troubleshooting, particularly when the receiver is dead, the author has his own pet system.

Whatever the ultimate technique, there are certain preliminaries that should always be followed. In a tube receiver, there is a quick visual check to make certain that all tubes light; in a transistor set, the battery voltage is measured under load and, if possible, the load current is observed. With the preliminaries out of the way, a method must be chosen to localize trouble to a section or stage of the dead receiver. Some form of signal tracing, signal injection, or circuit-disturbance testing is used. Each of these systems is based on the fact that a normal stage will act on a signal in a specific way—that is, amplify it or change its frequency—and then pass the signal on to the next stage.

### *Injection and Tracing*

Fig. 1 highlights the signal-injection technique on a semi-block diagram of a transistor radio circuit. By introducing an appropriately chosen signal successively from points 1 to 8, somewhere along the line you will pass from a point where injected signal produces output in the loudspeaker to another where no output results. When this change occurs, you know you have just passed through the defective stage. As shown, a multiple-output generator, whose output must be adjusted from point to point, is used.

With a signal tracer, you observe signal first at the input of the receiver or stage, then check to see whether it has arrived at the output, amplified or otherwise altered in the way it should be, to locate the defective stage. The tracer itself must be adjusted as you proceed from point to point, for amplitude and for modulated or demodulated signal.

### *The Disturbance Technique*

Perhaps the least familiar to the modern practitioner is the third method, circuit-disturbance testing, although it dates back to the mid 1920's. Some early genius discovered that touching the grid of a grid-leak detector would produce a sound in the speaker or headphone if everything following the detector was in order. A further step was shorting the grid of an amplifier tube to ground. Again, the resulting sharp change in plate current would send a pulse traveling through all operating circuits to the loudspeaker.

Plate current would not always change and results were therefore uncertain until the advent of tubes with top cap connectors to the control grids, when it was only necessary to remove and replace the top cap to cause the required disturbance. Even when single-ended tubes became popular, touching the control grid with the metal shank of a screwdriver produced the desired click in the speaker.

When transistor sets became popular, touching the base of a stage, or even the volume control, was seldom of any avail. Circuit impedances were too low for such methods to disturb circuit behavior. Shorting the base to the emitter would produce the desired click by changing collector current, but this method was too tricky for fast work. The signal tracer and signal generator came to be the accepted methods for localizing dead stages.

While preparing to take voltage readings on a transistor set, the author once inadvertently left his v.t.v.m. set to its ohms function and, touching the instrument probe to the base of a transistor, noted a loud click in the speaker. The ohmmeter battery had changed the transistor's forward bias, producing a sharp pulse in the collector circuit. The possibility suggested by this occurrence was analyzed.

Similar oversights had occurred many times in the past on tube receivers, where the voltages are considerably higher, without damage to the v.t.v.m.; certainly the instrument could not be damaged by the low voltages in a live transistor set. On the other hand, the battery-powered ohmmeter circuit of the v.t.v.m. could not damage a transistor, particularly if a high enough resistance range were used.

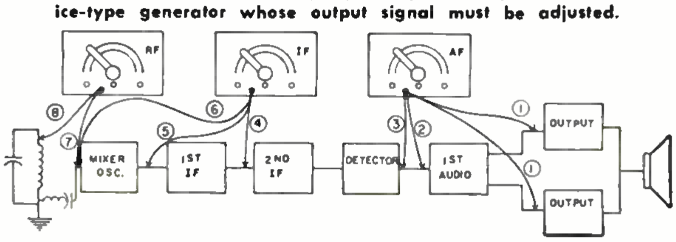
Check the typical v.t.v.m. ohmmeter circuit in Fig. 2. When the external test leads are touched across a circuit, the 1.5 volts internally available divides between the external circuit and the ohmmeter's internal calibrating resistor. Since transistor circuit impedances and resistances are low, the internal 10,000-ohm resistor in series with the battery on the "$R \times 1000$" ohmmeter range permits only a very small and safe portion of the battery voltage to reach the transistor.

Here was a means for introducing positive circuit disturbances in a transistor stage to localize troubles. The v.t.v.m. was already being used for such static checks as voltage and resistance. This meant that a rapid method for making a comprehensive series of checks on the receiver was possible with nothing more than a single piece of equipment—the v.t.v.m. Let us see how the v.t.v.m. alone can go through a receiver.

### *Preliminary Checks*

First the instrument is used to measure the battery voltage.

Fig. 1. Stage localization by signal injection requires a service-type generator whose output signal must be adjusted.



The set is then turned on, to provide a load. If battery voltage is low but within 20 per-cent of normal, the battery may be used during subsequent tests before replacement after repair. If output is too low, it is good practice to use a separate power supply, if one is available.

A metered supply that can read either voltage or current output is preferable. You should always be able to check current drain. If you have a noisy power line and the supply is not adequately filtered, obtain a commercial filter or make one up to insert between the a.c. line and the supply.

If you have an unmetered supply, you can insert a 10-ohm, 1-watt resistor in series with one lead of the supply and the transistor set. Then adjust your supply, with the v.t.v.m. across the voltage input to the receiver, to produce normal voltage. Next measure the drop across the 10-ohm series resistor. Read this voltage and move the decimal point two places to the right to obtain current drain in milliamperes. For example, .15 volt read across the resistor means 15 ma. is being drawn, while .06 volt indicates 6 ma.

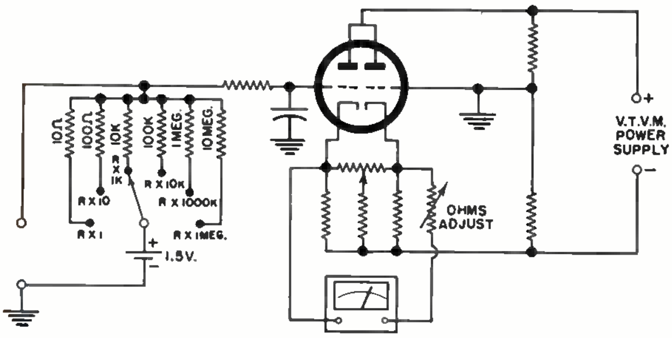



Fig. 2. Ohmmeter circuit of the Conar 211 v.t.v.m. is typical.

If the set is not dead, measure current with no signal applied for the most reliable indication and compare with the minimum current given in the service data or anticipated in the type of circuit. A 20 per-cent variation is within limits.

If drain is excessive, there may be a wiring short or a transistor is drawing too much current. If no wiring or circuit-board shorts are noted, "remove" transistors, one at a time. (How this may be done with wired transistors will soon be noted.) Always turn off power before removal. A large drop in current when one transistor is removed probably indicates collector-emitter leakage. The author simply connects a replacement temporarily. If current is still excessive, it is then time to check base and emitter voltages. More on this check later. No change in current at all suggests an open base.

As to removal, there is no problem with plug-in transistors. With wired-in types, opening the collector lead provides effective removal. On printed boards, simply cut the foil of the lead cleanly with a razor or knife. You can flow solder over this break later. In wired circuits, don't be afraid to unsolder or resolder transistor leads. Despite contrary notions, as long as you keep solder or the iron off the case itself, you can usually work on the leads without a heat sink and do no damage.

If the power supply is normal and there is no sign of excess current, proceed to defect localization.

## *Finding the Stage*

Consider the radio whose schematic is shown in Fig. 3. The collector has the most negative voltage of each transistor, so they are all *p-n-p* types. (A positive collector means an *n-p-n* type.) With a *p-n-p* type like those shown, connecting the ground or common (negative) clip of the ohmmeter (like the one shown in Fig. 2) to receiver chassis and touching the positive probe to the transistor base will decrease forward bias. This will produce a sudden change in collector current. To increase forward bias, reverse probe connections. Where a chassis is not employed, use the positive terminal of the supply as the ground point. The frame of the tuning capacitor can also be used.

First, with the set on and the ohmmeter on its "$R\times1000$" range, touch the positive probe to the base of $V_5$ and then $V_6$. A click in the speaker should be heard in each case. If it isn't, trouble is between input to the push-pull stage and the speaker. Check the following: collector voltages; $C_{11}$ for a short; and the secondary of $TR_5$ for continuity. The last check should also produce a click, unless the voice coil is open.

If the output stage clicks properly, touch the probe to the $V_4$ base. No click indicates the $V_4$ stage should be checked. The transistor may be defective. $C_{10}$ or the $TR_4$ primary may be open. Check the values of $R_{11}$, $R_{12}$, $R_{13}$. If this stage is normal, the click is louder than at the output stage.

Now touch the probe to the $V_3$ base. A normal click here will be less loud than at the $V_4$ base. If there is none, suspect the following: an open condition in $C_6$, $C_9$, or $TR_3$; a defective detector diode, a short in $C_8$, a value change in $R_7$, $R_8$, $R_9$—or a faulty transistor. If the stage responds, move to the $V_2$ base. The click should be louder than the preceding one.

The next point for the probe is the base of $V_1$. With no click, check collector voltage. If it is present, there is no open component from this point to the supply. Check emitter voltage. If it is normal, normal current through the transistor is indicated.

## *Oscillator Troubles*

If a click is produced at the $V_1$ base but the set seems dead, suspect oscillator failure. To check, short out the oscillator tank while monitoring emitter voltage. A change in reading indicates the oscillator was working before the tank (tuning capacitor) was shorted out. This change will be small. If the high-frequency response of your v.t.v.m., like the one shown in Fig. 2, extends far enough to read oscillator frequency, you can make a direct, positive check on a low a.c. scale. Tank r.f. voltage, measured by touching the probe to

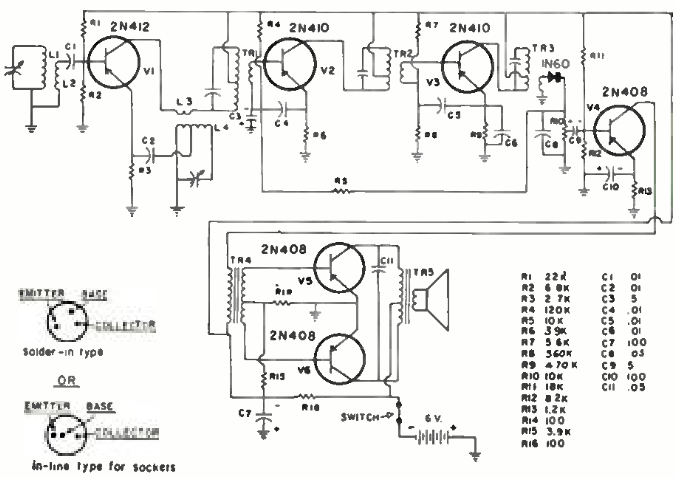



Fig. 3. An example of the popular 6-transistor "p-n-p" circuit.

the stator of the tuning capacitor, reads about 2 volts in most sets. If v.t.v.m. response is not adequate, you can use an r.f. probe or check with a scope.

If the oscillator is working, check the loop for continuity and the r.f. section of the tuning capacitor for a possible short. If there is no oscillation, suspect open conditions in $C_1$, $C_2$, $L_2$, $L_3$, or $L_1$, or a short in the oscillator section of the tuning capacitor. Sometimes lead reversal in a replaced coil will prevent oscillation, as will an improperly installed replacement loop. Remember that a shorted turn or two in an oscillator coil, which will not show up on an ohmmeter test, can also kill oscillation. Before replacing $V_1$, go over all circuit connections with a hot iron. Deteriorating solder joints often cause oscillator failure.

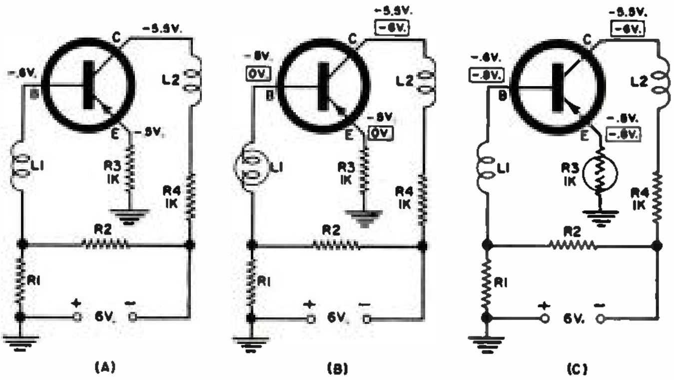



Fig. 4. Typical electrode voltages (A) in a transistor stage. Changes due to open conditions in the base (B) and emitter (C) circuits are shown in boxes. Circles highlight type of fault.

## *Transistor Voltages*

Suppose your disturbance tests have brought you to a suspected stage. There are various ways of proceeding from this point. One way is based on the fact that there are three critical voltages involved—at base, emitter, and collector—and the ability to interpret these can be most helpful. Take a stage whose normal voltages are as shown in Fig. 4A. The normal forward (base-emitter) bias is normally .1 volt. Since this bias controls emitter and collector currents, it also determines emitter and collector voltages. Every deviation has its own meaning.

*Open in base circuit:* If an open develops in its external circuit (Fig. 4B), the base is floating, or disconnected from its voltage source. Since the transistor's internal base-emitter resistance is low, the floating base will take on the potential of the emitter. With bias removed, there is no emitter or collector current flowing through $R_3$ or $R_4$. Voltages will thus tend to be as shown in the boxes of Fig. 4B. If a base-to-ground reading is taken, however, with a meter whose input resistance is low enough, meter loading may produce conditions close enough to normal so that the change can pass unnoticed. This is a good argument for using a v.t.v.m. here. There may be another cause for slight deviation from the abnormal readings in Fig. 4B. A small amount of emitter-collector leakage current will flow.

*Open in emitter circuit:* See Fig. 4C. The stage is dead because collector current cannot flow. Since there is no drop across $R_4$, the collector potential goes to −6 volts. The floating emitter assumes the base voltage, which is about −.8 volt in this case. The incorrect collector voltage, along with a lack of forward bias between base and emitter, although base voltage is fairly normal, throws suspicion on the emitter circuit.

*Open in collector circuit:* With the collector floating (Fig. 5A), there can be no collector current. The small base current, now passing to the emitter, maintains a slight voltage drop across emitter resistor $R_3$. The open collector element takes on the emitter voltage. Although base and emitter are not far from normal (forward bias is still present), the highly abnormal collector voltage and its correspondence to emitter voltage provide the clue.

*Open base lead in the transistor:* A defect in the transistor itself can also disturb electrode voltages. For example, if the base lead opens internally (Fig. 5B), the open base (bias removed) causes a reduction in collector current. The absence of normal current through $R_3$ and $R_4$ reduces the voltage across these resistors so that the emitter goes nearly to zero and the collector rises nearly to the supply voltage. Note,

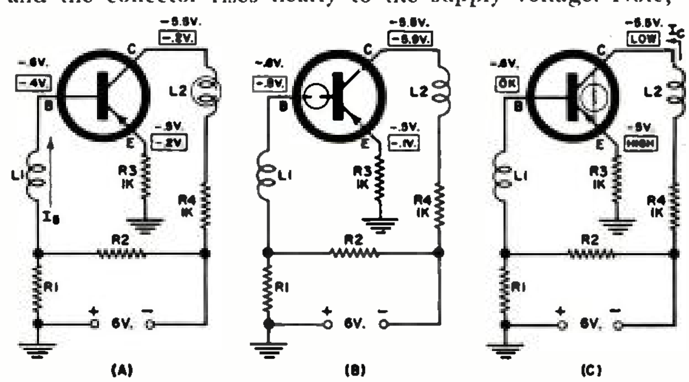



Fig. 5. Normal electrode voltages are compared with altered readings (in boxes) for an open condition in the collector circuit (A), an open base lead (B), and internal leakage (C).

however, that base voltage, which can only be measured outside the transistor case, is not far from normal. This clue distinguishes the defect from the case of an open condition in the external circuit of the base (Fig. 4B), in which the abnormal readings at collector and emitter are similar. Readings at the latter two electrodes show that the transistor is not conducting even though it seems that it should because base and emitter readings indicate forward bias.

Under such conditions, a "diode" check of the transistor (described later) is in order. That will be done with the ohmmeter section of the v.t.v.m., which means that there will still be no need to involve any other instrument.

*Leakage in the transistor:* Sometimes excessive leakage develops between emitter and collector (Fig. 5C). Increased collector-emitter current produces a larger than normal voltage drop across emitter resistor $R_3$, causing the emitter voltage to rise. In fact, emitter voltage may go several tenths of a volt higher (more negative, with the *p-n-p* types shown) than base voltage. This reverse bias will cut off the transistor as far as signal is concerned, resulting in a dead stage in disturbance testing. Nevertheless, leakage maintains high collector current, $I_c$, through $R_4$, causing collector voltage to drop—unless no collector resistor is present. Relative changes rather than typical abnormal voltages are indicated in Fig. 5C because actual readings will depend on the degree of leakage.

As described, the preceding conditions may be difficult to remember. These simple rules, then, will be useful when checking transistor voltages: 1. Watch for proper *relationship*

(*Continued on page* 113)

Table 1. Some common symptoms and causes. Refer to Fig. 3.

| SYMPTOM | POSSIBLE CAUSES |
|---|---|
| Stations tune in only on low-frequency end of dial. | $V_1$ defective. |
| Stations tune in only on high-frequency end of dial. | Tuning capacitor plates shorting. |
| No signal; no random noise in speaker with volume control at maximum. | Open base in $V_1$, $V_2$, $V_3$, or $V_4$. |
| No signal; random noise in speaker with volume control at maximum. | $V_1$ not oscillating. Open $L_1$, $L_2$, $C_1$, or $C_2$. Check for open leads or broken connections. |
| Very low volume on strong signal; d.c. voltages normal. | Open $C_8$, $C_9$, or $C_{10}$. Prodding them may restore normal signal intermittently. |
| Low or no voltage at battery terminals. | Dirty or corroded terminals; weak spring contacts; weak batteries. |
| Audio distortion. | One side of $TR_3$ primary open. $V_5$ or $V_6$ defective, poorly matched, or unbalanced. Weak batteries. $C_{11}$ open. $R_{15}$ or $R_{16}$ increased in value. Speaker defective. |
| Motorboating on stations with full volume. | $C_7$ open or has high power factor. |

# SHOULD YOU PULL THE CHASSIS?

By ART MARGOLIS

*Whatever general policy you have laid down on home and shop repairs, you can't rule out the need for judgment based on the special circumstances of each case.*

AT WHAT POINT and after how much effort, during a house call, do you rise to your full height, sigh, and break the sad news that the chassis must go to the shop for further repair?

The TV service technician is caught in an ethical bind between trying to charge no more than is necessary and wanting to do a job he is proud of. Admittedly we can do a better job in the shop, where we are surrounded by a more favorable repair environment. But that job may cost considerably more than would be the case if it were confined to the customer's home. Somewhere between these two considerations, the decision to pull the set is made.

In the broadest terms, we pull all jobs that need more than tubes, fuses, and adjustments to complete the repair. There are inevitable exceptions to this rule. There are circumstances in which we will change components in the home. There are others in which a TV set is pulled when tube replacement appears to be all that is necessary. Some of these exceptions are dictated by common sense, based on a peculiarity in the individual case. Others will be influenced by the type of set under consideration. Let me show you what I mean.

### *The "Monsters"*

Many sets simply do not lend themselves to easy transportability to the shop. These include color sets where you have to pull the CRT assembly as well as the chassis, also "home theater" units that have a power supply and other circuits in common. In such cases, we go out of our way to avoid a "pull."

Take this three-way combination we service. It belongs to an elderly fellow on the third floor of a walk-up, and, since he rarely goes out, it is his main companion. It has a common power supply, separately mounted CRT, and many connectors and switches, as it comes apart into six sections. Reinstallation requires soldering.

The owner's last call for service was handled this way: getting a description over the phone that sounded like high-voltage arcing, I took the schematic with me when I left for his place. With the high-voltage cage open, the flyback was found to be arcing out of its insulation—a clear-cut symptom. A call to the shop established that the replacement was in stock. I picked it up, returned, installed it, and left with the receiver working.

About two weeks later the owner called again and described the same symptom. Since the first replacement might have been defective, I took another flyback with me. Sure enough, I had to install it, as the fault had recurred.

But was some other defect causing flyback breakdown? Now alert to the possibility, I noticed a low, ticking sound in the high-voltage area when I turned the set on. The ticking would stop only when the second-anode lead was disconnected from the CRT.

With suspicion thrown on the picture tube, I restored the high-voltage lead and inspected the picture. Streaks resembling ignition noise, in step with the ticking sound, could just be perceived. Originating in the CRT itself, this arcing drew enough excess current from the flyback to induce gradual breakdown. The set has been fine ever since I installed a new picture tube.

The cause of transformer breakdown would not have become more obvious if the set had been brought in to begin with. Can you imagine pulling this monster, lugging it to the shop, and re-installing it *twice*? It was easier and more sensible to handle it as we did.

### *Portables Pull Easily*

On the other hand, consider the many compact models around today. Their physical design does two things: it makes them harder to work on but easier to carry. With any inducement to pull them, we yield. We do so because the system we use for pick-up and delivery avoids building up the charge to the customer. Let me show you how this works.

I was out servicing a 23-inch *Sylvania* whose owner had experienced bad CRT's before. As I entered, he said, "Hope you have a picture tube with you, 'cause that's what it is."

Since there was nothing else to do, I nodded and turned the set on. The picture came up, but dimly. Turning the brightness control from one extreme to the other had no effect whatsoever. The "experienced" customer nodded emphatically and said, "See? Fixed brightness!"

He had a point, but there was no sign of gas or other indicative symptom. Picture quality seemed good except that it wasn't bright enough. I checked tube condition with my CRT tester and could find nothing wrong.

"Those machines are sometimes wrong, you know," the owner suggested. I knew, but I didn't feel like making an extra trip for a picture tube that might be unnecessary and which would involve still more follow-up. I tested some other tubes, announced the job could best be handled in the shop, and carried the compact set out with one hand.

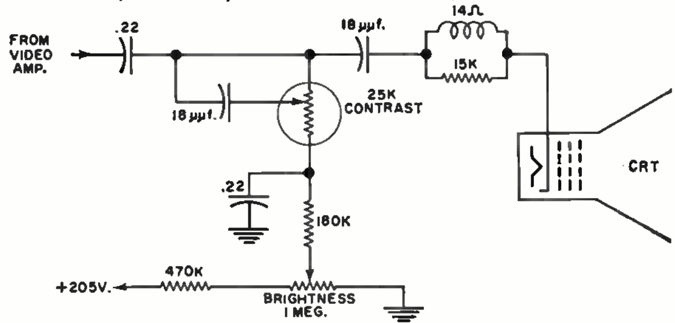
On the bench, the job went smoothly. A routine ohmmeter check of components in the CRT cathode circuit (Fig. 1) showed the contrast control was open. The voltmeter showed that this fault left 30 fixed volts at the cathode. With 5 volts on the grid, the 25-volt bias was almost enough to cut the CRT off, but not quite. Hence the dark picture.

As Fig. 1 shows, the brightness and contrast controls are in series in the cathode circuit. The open condition of the latter blocked any effect the former should have in changing bias to control brightness.

While this was a legitimate shop job in any case, it illustrates how transportability can cut costs to the customer.

(*Continued on page* 86)

Fig. 1. Symptoms suggesting a defective picture tube were actually caused by a fault in the contrast control (circled).



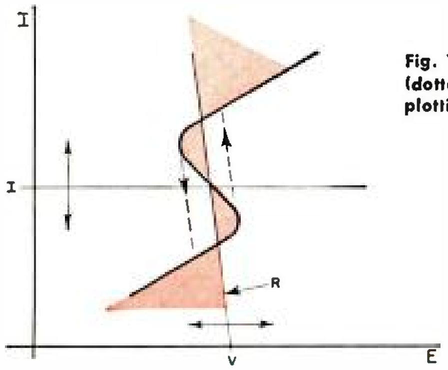



Fig. 1. Constant-current source prevents jumping (dotted lines) from one point to another when plotting curve of negative-resistance devices.

*Not restricted to just circuit analysis, constant-current sources, which are available as commercial instruments, have several interesting and practical applications.*

# CONSTANT-CURRENT POWER SOURCES / THEIR CHARACTERISTICS & APPLICATIONS

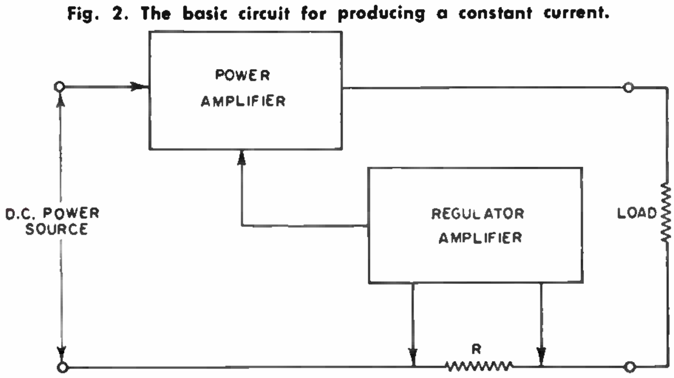
By GENE H. LEICHNER, Leichner Mfg. Co., and K. C. SMITH, University of Illinois

SINCE constant-current power supplies are becoming readily available as commercial instruments, it is worthwhile to study some of their basic properties and applications. While most technicians are somewhat familiar with current sources, there has been a tendency in the past to concentrate on the ideal voltage source in analysis and design; probably because batteries and the a.c. line are essentially constant voltage in character. Then, of course, the use of electronic regulator circuits has made it possible to attain even better approximations to a true voltage source. However, once electronic regulator circuits are introduced, they can just as easily be made to regulate output current instead of terminal voltage, so that high-performance, constant-current power supplies can also be built. From a practical viewpoint this means that the constant-current source which so often proves useful in analysis need not be confined to that application. Instead it is now available as a physical device for which there are many interesting and time-saving applications. We will describe a number of these as specific examples of situations where it is advantageous not only to *consider* current as the independent variable, but to *make* it so.

Fig. 2 shows a circuit for producing a constant current. The regulator amplifier measures, and causes to be held constant, the voltage across a series resistor ($R$). The terminal voltage of the supply is consequently adjusted, not to a fixed value relative to some reference, but to whatever value may be required to keep the voltage across resistor $R$ constant. The value of the current is controlled by varying $R$.

A specific circuit based on this elementary configuration is shown in Fig. 3. Since the load current through $R$ directly

Fig. 2. The basic circuit for producing a constant current.




affects the tube's grid bias, the tube will adjust its operating point to keep the current near a fixed value, approximately equal to $V/R$. In this simple case there is only one stage of amplification, but even so, the circuit performs remarkably well. As an example suppose the tube has a *mu* of 75 and that $V$ is 100 volts. The performance of the circuit can be evaluated by determining the variation in output current when

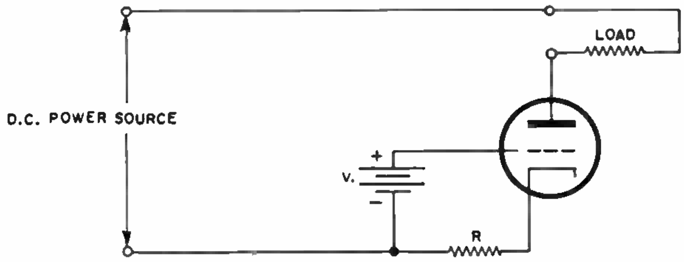



Fig. 3. Practical example of single-stage current regulator.

sufficiently different loads are attached to cause, say, 150 volts variation in terminal voltage.

Since *mu* = 75, a 150-volt change in plate voltage requires a two-volt bias change to fully counteract it. That is, the cathode voltage must change by two volts or 2% of the 100 volts across $R$. The current therefore changes only about 2% for the assumed load variation. While this performance is not astounding, the circuit is a very simple one, being essentially equivalent to a cathode-follower voltage source; it can be improved as much as desired by using more stages of amplification. Now that we have shown that constant-current sources aren't hard to make, let's look at their applications.

## *D.C. Applications*

The simplest applications of constant-current sources involve d.c. situations and two-terminal devices. Several of these are shown in simplified form in Fig. 4. Several others will be described in detail here to indicate the reasons as well as the procedures for using constant-current sources.

Consider first the problem of checking the reverse voltage rating of semiconductor diodes, as shown in Fig. 5. If the rated reverse voltage (Fig. 5A) is applied to verify the reverse current specification, any diode which has its knee at too low a voltage will probably be damaged by excessive current and the resulting dissipation. However, a constant applied current set at the maximum reverse value allowed not only protects the diodes from excessive current, but also allows them to be sorted according to reverse voltage with only a single v.t.v.m. measurement on each one.

Another important point when choosing between voltage or current sources in data taking is also shown in Fig. 5. If data points are to be taken beyond the knee of the curve where the slope is steep, current readings would be very dependent on the exact setting of a voltage source. Small-setting errors could cause intolerable variations in current readings. The use of a current source reverses the sensitivity situation, however, and permits accurate voltage readings to be taken without precise current settings.

One further observation may help clarify the nature of constant-current sources. The $I_{max}$ line on the graph in Fig. 5B can be thought of as a load line describing the source to which the diode is attached. When considered in this way, a constant-current source is seen to be equivalent to an infinite resistor in series with an infinite voltage. In fact a common way to simulate a true current source is to use a large resistor with a large voltage. It is thus natural to describe the performance of constant-current regulators in terms of their equivalent resistance. The limited range of voltage over which the regulator can simulate a large resistance is called the *compliance voltage* and must be given to complete the description of the source.

An exploitation of the large effective resistance of a current source is shown in Fig. 1 where it is desired to trace out the negative-resistance characteristic of some device. In order to be able to trace out the curve smoothly, without jumping from one portion to another, it is necessary that the load line of the driving source always intersect the curve at only one point. An adjustable voltage supply, $V$, with a series resistance $R$ would, as shown, lead to the jumps indicated by the two dotted lines depending on the direction of travel. To avoid jumps on this particular curve it would be necessary to use a rather large resistance, and therefore a large voltage, with the consequent dissipation of considerable power. A constant-current source solves the problem nicely without requiring the large voltage and power to be generated, even internally.

As an example of a more sophisticated application of a constant-current regulator, consider the design of a precision voltage standard. Fig. 6A shows a possible circuit in which a temperature-compensated zener diode is to be used as a reference element. In this simple circuit, however, the inevitable variation of the a.c. input will produce a variable voltage across the dropping resistor $R$, with corresponding variations in the zener diode current. Since the diode has a small, but not zero, dynamic impedance the output voltage will also vary.

Rather than regulate the input voltage, as might be considered, the diode current may be established directly by means of a constant-current source, or rather a current regulator to convert the available source. In this way, the diode current is held nearly fixed and the non-zero dynamic impedance of the diode causes very little error. The effect of using the regulator, illustrated in Fig. 6B, is to simulate a very large series resistance between the points X-X so that the input-voltage variations now cause almost no current change. The advantage, as in the previous example, is that this large resistance, with its large d.c. drop, is not actually inserted. Thus the input source does not have to be made excessively large to obtain superior stability over the original design.

| APPLICATION | PROCEDURE | COMMENTS |
|---|---|---|
| SEMICONDUCTOR DIODE TESTING; FORWARD, REVERSE, ZENER CHARACTERISTICS | SET TO CURRENT OPERATING POINT; V.T.V.M. READ FORWARD OR REVERSE VOLTAGE; FORWARD OR REVERSE AS REQUIRED | NO DANGER OF EXCESSIVE CURRENT IN CASE DIODE VOLTAGE IS LOWER THAN EXPECTED<br>VOLTAGE CAN BE READ ACCURATELY SINCE SLIGHT VARIATIONS IN CURRENT SETTING CAUSE VERY LITTLE CHANGE IN OBSERVED VOLTAGE |
| VOLTAGE REFERENCE TESTING; VR TUBES, GLOW TUBES, NEON BULBS | VARY CURRENT OVER OPERATING RANGE; READ SMALL VOLTAGE VARIATIONS; V.T.V.M.; BUCKING SOURCE FOR HIGH ACCURACY | SMALL VOLTAGE CHANGES CAN BE OBSERVED AS CURRENT IS VARIED USING DIFFERENTIAL OR POTENTIOMETER METHODS IF DESIRED<br>CURRENT LIMITING DURING STRIKING AUTOMATICALLY ACCOMPLISHED BY CURRENT SOURCE |
| ELECTROLYTIC CAPACITOR LEAKAGE TEST | V.T.V.M.; READ TERMINAL VOLTAGE; SET TO SMALL VALUE AND INCREASE AS NECESSARY | CURRENT AUTOMATICALLY LIMITED IN CASE CAPACITOR IS EXCESSIVELY LEAKY<br>CAN RE-FORM CAPACITOR, IF IT HAS NOT DRIED OUT, BY LEAVING IT ATTACHED UNTIL VOLTAGE RISES TO NORMAL RATING WITH ONLY SMALL APPLIED CURRENT |
| METER MOVEMENT SENSITIVITY AND RESISTANCE TESTS | ADJUST TO REDUCE READING FROM FULL TO HALF SCALE. R IS THEN EQUAL TO MOVEMENT RESISTANCE; START AT LOW VALUE AND INCREASE | CURRENT IS AUTOMATICALLY LIMITED REGARDLESS OF RESISTANCE OF MOVEMENT<br>CAN USE PRESET SWITCHED CURRENT SETTINGS FOR RAPID ACCURACY CHECKS, NO CORRECTIONS NEEDED FOR METER RESISTANCE<br>RESISTANCE TEST USES MOVEMENT ITSELF AS AN INDICATOR |
| METER DAMPING TESTS | SET FOR 2/3 TO 3/4 FULL SCALE DEFLECTION; SWITCH TO INITIATE RESPONSE; DAMPING R | IMPEDANCE OF CURRENT SOURCE IS SO HIGH IT CAN BE IGNORED. EFFECT OF DAMPING RESISTOR ON SENSITIVITY CAN ALSO BE SEEN DIRECTLY |
| PRODUCTION TUBE TESTER | SET TO DESIRED PLATE CURRENT; V.T.V.M; READ PLATE VOLTS; R | METER NOT DAMAGED BY SHORTED TUBES. HIGH PLATE VOLTAGE INDICATES LOW EMISSION<br>BIAS SET BY R. NO DEGENERATION EFFECT SINCE CURRENT IS FIXED BY SOURCE |

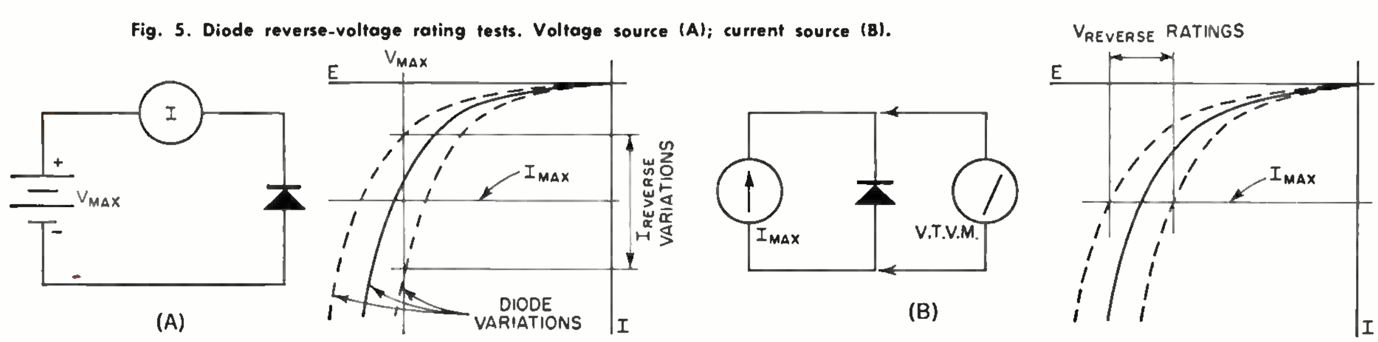
Fig. 4. Examples of d.c. applications of constant-current sources.

### A.C. or Incremental Measurements

Even more interesting than the d.c. applications are those where a.c. measurements are to be made. If the current source is built in such a way as to retain its usual high impedance properties over a reasonable range of frequencies, it can be used to superimpose d.c. during a.c. tests. Such measurements are quite awkward to accomplish using voltage sources.

As an illustration, consider the second example in the a.c. applications summarized in Fig. 8, namely the measurement of inductance and saturation effects. The a.c. impedance of the current source, in most cases, will usually be of sufficiently

Fig. 5. Diode reverse-voltage rating tests. Voltage source (A); current source (B).



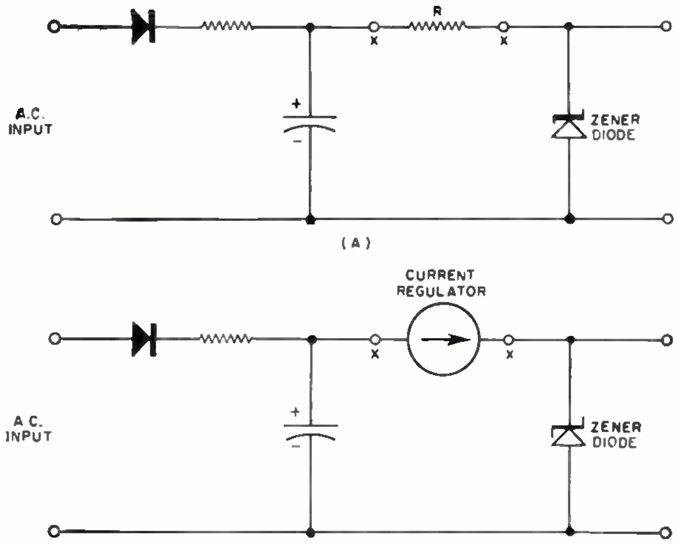


Fig. 6. Example of precision voltage standard application.

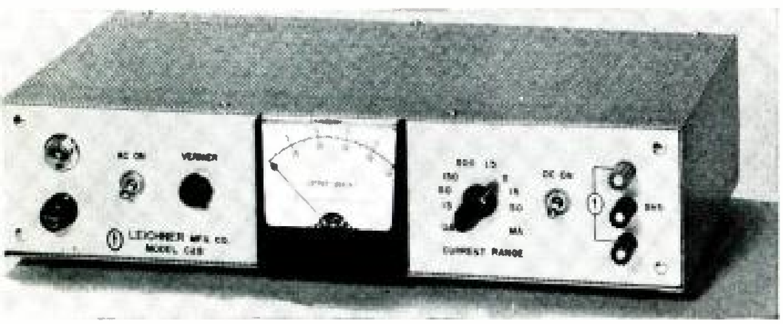


Fig. 7. Complete source with meter, vernier, and range switch.

high value that it can be neglected, while the low impedance of a voltage source would completely upset the circuit. To use a voltage source successfully it would be necessary to insert a series resistance between the source and the inductor in order to make the source impedance high enough to be neglected. Usually a compromise must be reached between the error introduced and the power which must be dissipated in a large resistor. Since the current source dynamically simulates the large source voltage and series resistance, without actually using them, it is much more naturally suited to the job.

The ability of a current source to exhibit a high a.c. impedance depends on two factors: the capacity across the output terminals must be kept small, and the regulator must maintain its usual high gain over a reasonable bandwidth. The circuit in Fig. 3 has these properties inherently since the only capacity contributed by the circuitry is the relatively small plate-to-grid and cathode capacity. If carefully constructed, the source can have a terminal capacity as low as 10 to 20 μμf. and thus would exhibit a high enough impedance to permit measurements up to several kilocycles.

One word of caution is necessary here. Current-limited voltage sources, such as the new solid-state supplies, seldom exhibit a high a.c. output impedance unless the output filter capacitor is removed. Even then, this type of supply is not usually suitable for several reasons. The total shunt capacity is probably large since there is no reason for making it small for voltage-source use; the regulator may oscillate when the output capacitor is removed; and the regulator does not usually have an adequate bandwidth since it does not need it in normal use with the output capacitor in place.

### *Modulated-Source Applications*

Once the current source has been designed with adequate regulator bandwidth to retain a high impedance to a.c. signals, it is often possible to arrange for the injection of a modulating signal. Even if the highest modulating frequency that can be used is that of the a.c. line, the result is most useful. Suppose, for example, that the current source in the second example of Fig. 8 has a 10% a.c. modulation. That is, suppose the output varies sinusoidally about the d.c. value with an r.m.s. component of 10% of the d.c. value. It would then be necessary to measure only the a.c. component of the voltage across the choke to determine its impedance or inductance at the chosen operating point. The a.c. component of current can be calibrated by substituting a known resistance in place of the inductor. Such an arrangement is actually doubly convenient since a.c. v.t.v.m.'s are readily available and make voltage signals caused by applied currents easier to measure than currents caused by applied voltages. A d.c. measurement in this case would indicate the d.c. resistance and would modify the impedance calculations if it were large enough. Increasing the test frequency would make $X_L$ larger and might allow $R$ to be neglected.

The use of a modulated source greatly simplifies all dynamic-impedance tests. For each of the devices in the first two examples of Fig. 4, dynamic impedances can be determined simply by using an a.c. v.t.v.m. to measure the a.c. component of terminal voltage. However, there are even more advantages to be gained in the case of three-terminal devices. Fig. 9 shows a simple and accurate way of measuring the most often needed transistor parameters, both d.c. and a.c., using a single test circuit. Suppose the current source is set to I ma. with 10% r.m.s. modulation. It will then be equivalent to an a.c. and a d.c. source in parallel. Under this condition a number of parameters can be found as follows:

$$h_{FE} = \beta_{DC} = \left(\frac{I}{V_{1dc}/R} - 1\right), \qquad h_{fe} = \beta = \left(\frac{0.1I}{V_{1ac}/R} - 1\right)$$

$$h_{ib} = h_{11b} = \frac{V_{2ac}}{0.1I} \text{ (measured with } R \text{ shorted)}$$

and $V_{EB} = V_{2dc}$ (measured with $R$ shorted) where: $V_{1dc}$ is the d.c. component of $V_1$; $V_{1ac}$ is the a.c. component of $V_1$.

(*Continued on page* 84)

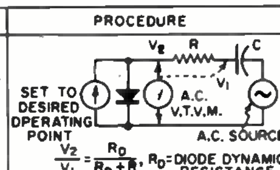
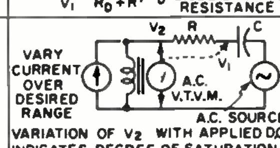
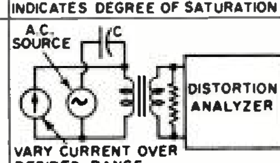
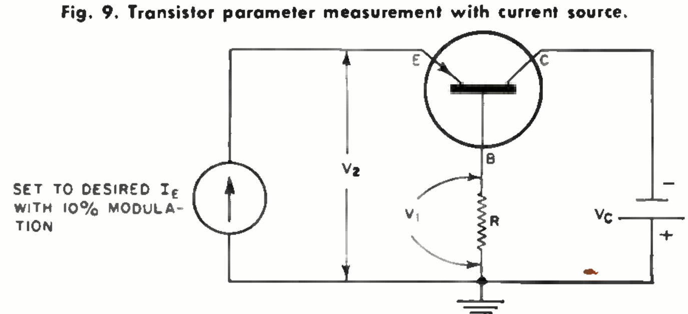
| APPLICATION | PROCEDURE | COMMENTS |
|---|---|---|
| DYNAMIC IMPEDANCE TESTS OF DIODES: FORWARD, REVERSE AND ZENER |   $\frac{V_2}{V_1} = \frac{R_D}{R_D + R}$, $R_D$ = DIODE DYNAMIC RESISTANCE | C BLOCKS D.C. FROM ENTERING A.C. SOURCE; SHOULD HAVE NEGLIGIBLE REACTANCE AT THE TEST FREQUENCY<br>R CHOSEN ABOUT EQUAL TO EXPECTED VALUE OF DYNAMIC IMPEDANCE FOR MAXIMUM ACCURACY |
| SATURATION TESTS OF INDUCTORS |   VARIATION OF $V_2$ WITH APPLIED D.C. INDICATES DEGREE OF SATURATION | $V_1$ AND $V_2$ CAN BE USED TO EVALUATE $X_L$ FOR THE INDUCTOR AT THE TEST FREQUENCY. D.C. READING AT $V_2$ GIVES R OF COIL |
| DISTORTION TESTS OF TRANSFORMERS WITH D.C. SUPERIMPOSED |   | C BLOCKS D.C. FROM ENTERING A.C. SOURCE<br>A.C. SOURCE SHOULD BE CHECKED FOR HARMONIC CONTENT (WHILE LOADED) BEFORE READING OUTPUT VALUES |

Fig. 8. Examples of the a.c. applications of current sources.

Fig. 9. Transistor parameter measurement with current source.



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# CLOSE TALKING WITH A RIBBON MIKE

By LEE BEEDER

**Simple circuit that can be employed to roll off the boosted bass frequencies produced by this type of mike.**

A GOOD ribbon microphone will usually have low distortion, an extended frequency response, a wide dynamic range, smoothness, and a characteristic that can best be described as "warmth."

However, a ribbon microphone also exhibits a characteristic known as "proximity effect." A sound source closer than 4 to 5 feet (although some manufacturers claim the "proximity effect" is not bothersome at over 2 feet) will accentuate the bass frequencies unnaturally.

Fig. 1 shows graphically how the bass frequencies are changed by an average ribbon microphone as the sound source is brought closer and closer to the ribbon.

Because of this it is usually impossible to talk or sing with the lips 6 inches from the mike unless some corrective measures are taken. When such corrections are made, it is possible to use a ribbon mike for good reproduction of a close-up sound source.

Fortunately, it is quite easy to effect such corrections. This article will describe a two-way attack on the problem.

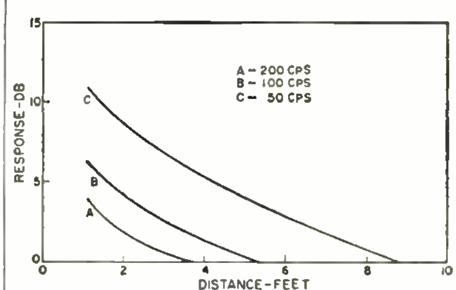



Fig. 1. Bass boost produced close to mike.

First, some sort of screen is indicated for the microphone since, at very close distances, the explosive "p" sound hits the ribbon with a great deal of force.

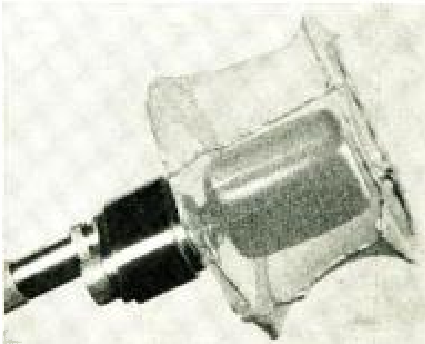
The photograph shows a perfectly adequate screen. It doesn't look very elegant as it was a first try. However, it worked so well it was never changed. It consists of a piece of nylon hose pulled over a small wire cage approximately 4 inches in diameter. This serves the dual purpose of keeping the sound source at least 2 inches from the mike and shielding the ribbon from the explosive "p" sound.

The cage was made from doubled #20 wire which was soldered to give added strength. This operation is obviously so simple that no further explanation is required. Neither does the author feel it necessary to suggest possible sources for discarded nylons.

Now while this screen corrects for "windage," the proximity effect is still troublesome. So it is necessary to attenuate the bass response at the rate it rises as the distance to the ribbon is reduced. This can be done by selecting the proper values of capacitor and resistor for the circuit shown in Fig. 2A.

It was decided to attenuate the signal at 50 cps to about −16 db. So, in one transistor preamp used by the author, a value of .15 µf. was selected for the capacitor and 5000 ohms for the resistor. Thus the slope started at about 210 cps and was down around 16 db at 50 cps.

This circuit was placed across the



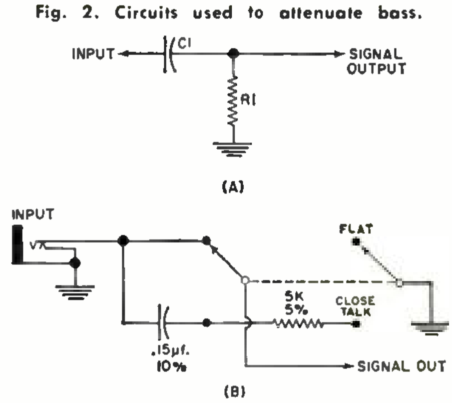
Improvised wind screen for the microphone.

470-ohm output impedance of the preamp. A d.p.d.t. switch allowed the selection of a flat response or a response corrected for close talking. Fig. 2B shows how to connect the very simple circuit and suggested values for the components. This circuit turned out very well. Voice reproduction was natural, even when speaking at a distance of 6 inches or less from the mike.

So successful was this experiment that the author decided to modify two other preamps. As their output impedances were much higher than the 470 ohms of the first transistor preamp, another approach was indicated.

Since the impedance of the mike was 50 ohms, a network was placed across the input of the two additional transistor preamps. The same values were employed for the capacitor and resistor in the network, but other values giving the same slope would be okay. ▲

Fig. 2. Circuits used to attenuate bass.



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## Non-Directional Stereo

(*Continued from page 44*)

enough room for spatial separation. The non-directional stereo effects will result in better musical quality, although the spatial illusion may cause the instrument to appear to be off the screen.

It is now possible to explain the superiority of music heard in the concert hall over its monophonic reproduction.

The music hall provides the psychological clues to direction which assist in the identification of performers and, in addition, through the physiology of binaural hearing, permits more of the music to reach the brain. There is still considerable cancellation between the tones heard by each ear. Since most music is meant to be heard in concert halls by people with only two ears, two-channel stereo is a good approximation of the music heard in the front-center seats of the theater.

Music heard in the back seats of the concert hall resembles monophonic reproduction because any one sound directly transmitted from the stage is more likely to affect both ears equally. However, reverberation reduces the number of cancellations because reflections, from different parts of the walls, result in each tone being reproduced several times and in being heard repeatedly by each ear. In addition, individual tones which arrive from opposite walls in opposite phase are heard separately by the two ears and do not cancel.

Orchestra conductors have learned from experience where to place musicians to obtain the optimum effect. In some orchestras first violins and cellos are located on one side of the stage, while the second violins and violas are on the other side. The central position of the conductor provides him with a maximum binaural separation for those instruments which are played in the same register. It helps him, in addition, to keep them separated in his mind and minimizes the interference between them.

The more complete and superior reproduction of orchestral music which stereo provides, in addition to the spatial illusion, should increase the enjoyment of the most discriminating listener. ▲

## AUTO RADIO HINT

By CHARLES ERWIN COHN

**MOST late-model cars have the radio speaker mounted horizontally under a grille at the top of the dashboard. Here dirt, dust, and grit tend to fall through the grille and get into the speaker, causing considerable deterioration.**

**To protect the speaker from this, remove it from its mounting and place a piece of polyethylene or other thin plastic over it before replacing. Upon replacing, the mounting bolts will pierce the plastic and hold it firmly in place.** ▲

# The new Weathers "66" weighs 96 ounces

# ...and every ounce is pure performance!

The Weathers "66" is the finest achievement in uncompromising design and performance. The low mass of the Weathers "66" makes it the proper turntable for today's high compliance stereo cartridges and tonearms. In appearance alone, the "66" is radically different. It is 16" long, 14" deep, but only 2" high, including the integrated base. It is the closest approach to rotating a record on air. It achieves this ideal through unique engineering design and precision manufacturing.

The Weathers "66" uses two precision hysteresis synchronous motors mounted on opposite sides of the deck. Virtually vibration-free, they directly drive two soft rubber lathe-turned wheels which in turn drive against the inside rim of the platter. This is the quietest, most accurate and dependable drive system yet designed. Its -60 db. rumble is the lowest of all turntables.

Eliminates Feedback Problem—Because the new high compliance cartridges and tonearms track at extremely light pressures, they can pick up floor vibrations which are transmitted into the music as audible distortion. The "battleship" type of turntable more easily picks up room vibrations and transmits them with greater amplitude. When a high compliance pickup system is used with the heavier turntable, acoustic feedback is apt to occur. And there is no practical, effective way to acoustically isolate these heavier units.

The Weathers "66" is suspended on 5 neoprene mounts which produce an isolation from floor vibrations of more than 500 to 1. Paul Weathers calls this system a "seismic platform" (implying that only a violent earthquake could cause any vibrations or feedback).

On Pitch—The speed constancy of the Weathers "66" is so accurate that a special test record had to be made to measure its 0.04% wow and flutter content. It reaches 33⅓ rpm immediately, and will be accurate within one revolution in 60 minutes. Most heavy turntables will usually deviate 4 or more revolutions in 60 minutes—a painfully obvious inaccuracy to anyone with perfect pitch. You hear only the music—no rumble, no wow, no flutter, no feedback, no noise of any kind.

The "66" is a strikingly beautiful turntable that you can use anywhere, without installation. And you need not buy a base—it's an integral part of the turntable! ■ Turntable—$75.00 net. With viscous-damped arm—$99.50 net. Turntable and Arm with new Weathers LDM Pick-up—$129.50 net. At your high fidelity dealer, or write: Desk ET

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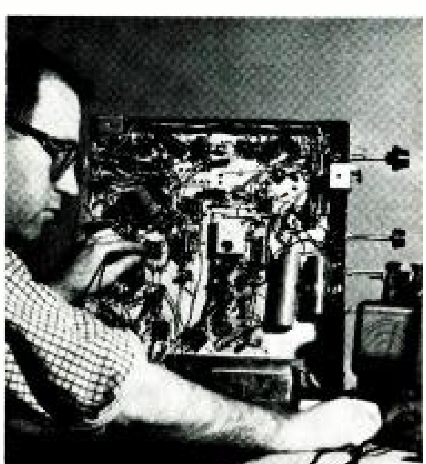

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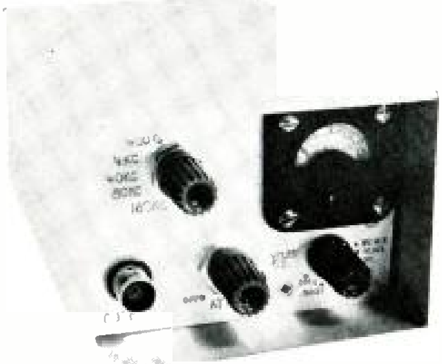


# TRANSISTOR SINE-WAVE GENERATOR

By THOMAS J. BARMORE

*Construction of a compact, four-transistor instrument with five output frequencies within the range of from 20 cps to 160 kc.*

THIS compact, four-transistor, sine-wave generator produces five fixed frequencies determinable by the builder. Its output is calibrated, metered, and variable from 1 mv. to 3 v. r.m.s. The output impedance is 600 ohms from 1 mv. to 300 mv. and 10,000 ohms at 1 v. and 3 v. Harmonic distortion does not exceed 0.6%.

### The Circuit

The generator consists of a push-pull oscillator, an amplifier, and an emitter-follower output stage. The oscillator uses two 2N190's, in grounded-emitter configuration, operating in push-pull class A. Bias is furnished for each transistor by resistors $R_1$ and $R_5$; capacitors $C_1$ and $C_2$ provide feedback. The oscillation level is controlled by potentiometer $R_3$ in conjunction with $R_1$ and $R_2$. The output of the oscillator is coupled to the amplifier stage by transformer $T_1$, whose secondary is tuned by a .05-µf. capacitor, $C_4$, to improve the waveshape. In addition to $C_4$, a loading resistor ($R_{30}$-$R_{33}$), selected by switch $S_2$, is connected from the secondary of $T_1$ to ground. $S_2$ also determines the oscillator operating frequency by connecting a capacitor ($C_5$-$C_9$) between the collectors of $V_1$ and $V_2$. The signal at the secondary of $T_1$ is coupled by $R_6$ to the base of $V_3$, a class A amplifier. The bias for $V_3$ is provided by $R_7$; the output is taken from across $R_8$ and coupled by $C_{10}$ to the base of $V_4$.

Bias for $V_4$, an emitter-follower, is provided by $R_{12}$; the output appears across emitter resistor $R_{10}$. $C_{11}$ blocks the d.c. level of the signal from attenuator potentiometer $R_9$. From this point the signal goes to two places: the meter-bridge network ($R_{28}$ and $R_{29}$, diodes $SR_1$ and $SR_2$, and series-dropping resistor $R_{11}$) and through $S_1$ to an eight-step attenuator network comprising $R_{14}$ through $R_{26}$. $R_{14}$-$R_{26}$ were selected to give a 10-db attenuation to the output at each switch position starting with an r.m.s. output of 3 v. and terminating at 1 mv.

If the fact that the generator requires a 45-volt supply seems strange, it is for this reason: the voltage developed by $V_1$ and $V_2$ is about 80 volts p-p. However, this is reduced to about 0.5 volt by the stepdown ratio of $T_1$. Since the voltage gain of the amplifier stage ($V_3$) is about 20, $V_3$ will feed a 10-volt p-p signal to $V_4$. Since $V_4$ has a gain of about 0.9, the final output will be about 9 volts. Nine volts p-p is about 3 volts r.m.s., the maximum output of the generator.

Capacitors $C_5$-$C_9$ were selected for frequencies of 400 cps, 4 kc., 40 kc., 80 kc., and 160 kc. However, these frequencies are arbitrary—others may be chosen. For audio work you

Fig. 1. Relationship of $C_5$-$C_9$ and $R_{30}$-$R_{33}$ to the frequency.

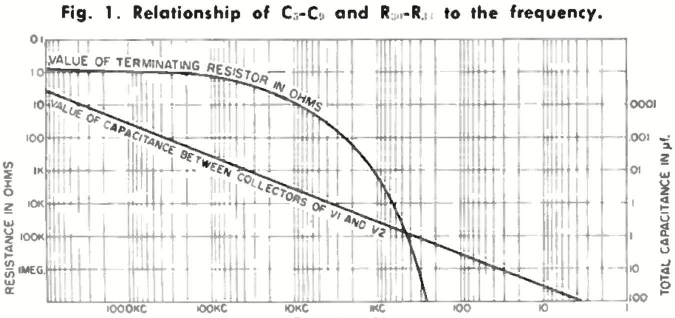
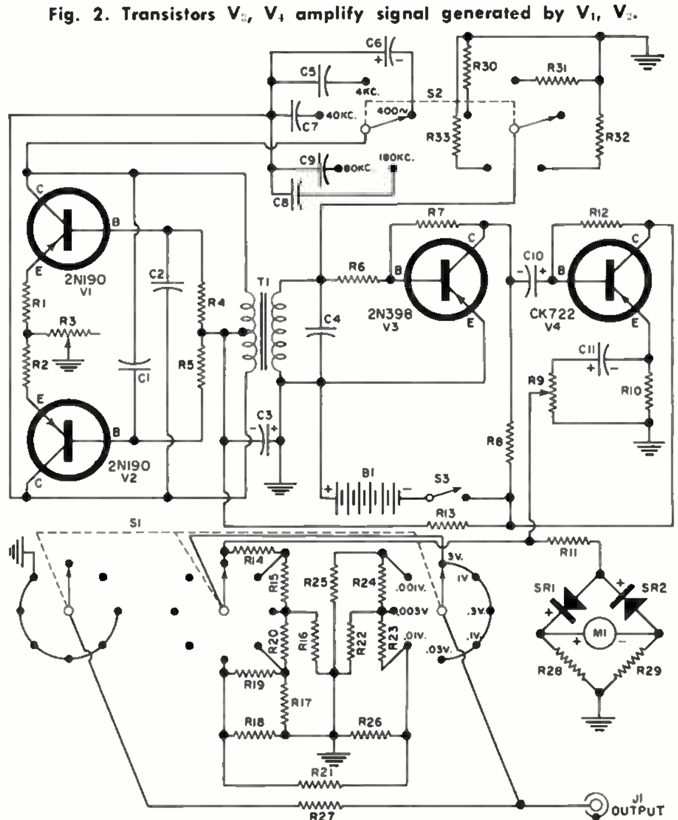



Fig. 2. Transistors $V_3$, $V_4$ amplify signal generated by $V_1$, $V_2$.




*$R_1$, $R_2$—68 ohm, ½ w. res.*
*$R_3$—3000 ohm linear-taper pot*
*$R_4$, $R_5$—100,000 ohm, ½ w. res.*
*$R_6$—470 ohm, ½ w. res.*
*$R_7$—56,000 ohm, ½ w. res.*
*$R_8$—8200 ohm, ½ w. res.*
*$R_9$—10,000 ohm linear-taper pot ("Att")*
*$R_{10}$—3300 ohm, ½ w. res.*
*$R_{11}$—220 ohm, ½ w. res.*
*$R_{12}$—33,000 ohm, ½ w. res.*
*$R_{13}$—4700 ohm, ½ w. res.*
*$R_{14}$—2200 ohm, ½ w. res.*
*$R_{15}$—390 ohm, ½ w. res.*
*$R_{16}$, $R_{17}$, $R_{18}$, $R_{22}$, $R_{26}$—1000 ohm, ½ w. res.*
*$R_{19}$, $R_{20}$, $R_{21}$, $R_{23}$, $R_{24}$, $R_{25}$, $R_{29}$—1500 ohm, ½ w. res.*
*$R_{27}$—680 ohm, ½ w. res.*
*$R_{28}$—560 ohm, ½ w. res.*
*$R_{30}$—22 ohm, ½ w. res.*
*$R_{31}$—33 ohm, ½ w. res.*
*$R_{32}$, $R_{33}$—3.3 ohm, ½ w. res.*
*$C_1$, $C_2$—.02 µf., 100 v. capacitor*
*$C_3$, $C_{10}$—10 µf., 50 v. elec. capacitor*
*$C_4$—.05 µf., 50 v. capacitor*
*$C_5$—.1 µf., 50 v. capacitor*
*$C_6$—1 µf., 20 v. elec. capacitor*
*$C_7$—.01 µf., 50 v. capacitor*
*$C_8$—.002 µf., 50 v. capacitor*
*$C_9$—.005 µf., 50 v. capacitor*
*$C_{11}$—10 µf., 10 v. elec. capacitor*
*$S_1$—3-pole, 8-pos. rotary switch ("Volts F.S.")*
*$S_2$—2-pole, 5-pos., rotary switch*
*$S_3$—S.p.s.t. switch (part of $R_9$)*
*$J_1$—Miniature coax connector (BNC)*
*$M_1$—0-1 ma. meter (see text)*
*$SR_1$, $SR_2$—Germanium diode (Sylvania 1N69A)*
*$B_1$—45-volt battery (two Burgess K30P-K or equiv. in parallel)*
*$T_1$—Transistor output trans. pri: 500 ohms, c.t., sec: 3.2 ohms (Thordarson TR-27 or equiv.)*
*$V_1$, $V_2$—"p-n-p" transistor (G-E 2N190)*
*$V_3$—"p-n-p" transistor (RCA 2N398)*
*$V_4$—"p-n-p" transistor (Raytheon CK722)*

might want 30 cps, 400 cps, 1000 cps, 10 kc., and 20 kc. The corresponding capacitor values, determined from Fig. 1, would be 12 $\mu$f., 1 $\mu$f., .6 $\mu$f., .06 $\mu$f., and .025 $\mu$f. The related terminating resistor values would be infinity, infinity, 1100 ohms, 10 ohms, and 5 ohms.

Greater output voltage may be obtained by eliminating the meter circuit or by using a higher-impedance meter circuit, since this one tends to load the output of $V_1$.

### *Construction*

The author's generator was built in a 2" x 3" x 6" welded aluminum case. About half of the space is used for batteries (two *Polaroid* "wink-lite" 45-volt batteries in parallel) and the other half is used for circuitry. The oscillator, amplifier, and output stages are mounted on a piece of 2" x 3" phenolic board; $J_1$, $S_1$, $S_2$, $S_3$, and $M_1$ are mounted on the recessed front panel. The phenolic board and front panel are held together by two aluminum spacers and two 6-32 machine screws.

### *Calibration*

With an oscilloscope connected to the output, adjust $R_3$ for a clean, symmetrical waveform at all frequencies. To calibrate $M_1$, connect an accurately calibrated v.t.v.m. to output jack $J_1$ and set $S_1$ to the 3-v. position. Adjust $R_9$ until the v.t.v.m. indicates 3 v. Make a mark opposite the point of needle deflection on $M_1$'s scale. Set $S_1$ to 1 v. and adjust $R_9$ until the v.t.v.m. indicates 1 v. Again, mark this point on the scale of $M_1$. Continue this procedure for each of the remaining positions of $S_1$. ▲

## LOOSEN UP YOUR "FIST"

By HOWARD S. PYLE, W7OE

MANY ham novices, during their code learning period and generally during the first several months of active operation, have a strong tendency to grasp the knob of the sending key as though they had a "bear by the tail" and were afraid to ease off.

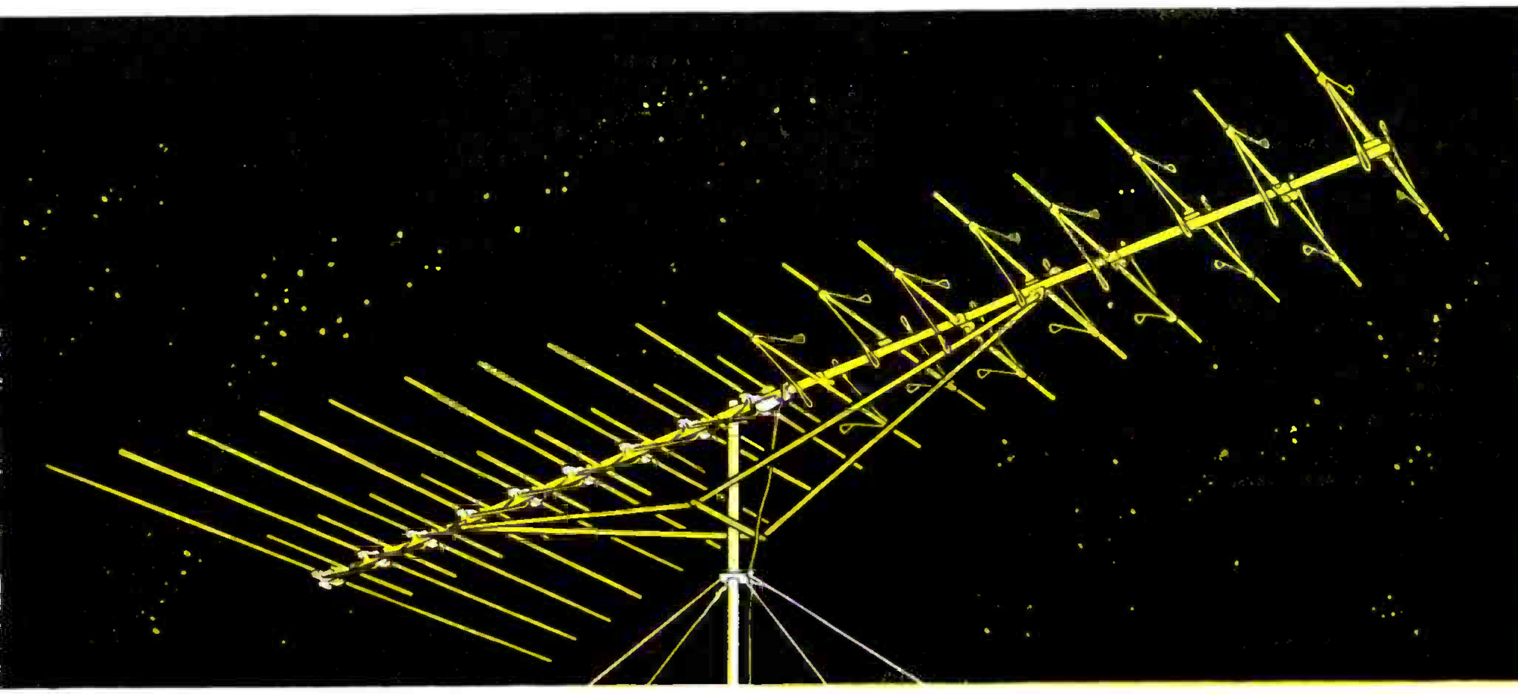
Fingers and wrist all tense and stiff make the manipulation of the key resemble driving nails with a hammer. It sounds like it on the air too! The trick is to keep the fingers curved and the wrist relaxed and free-moving like a hinge—don't use the elbow for this purpose.

Here is a good way to develop the proper grip. While sending, hold a small orange, a golf ball, child's small rubber ball, or even a crushed wad of newspaper in the palm of your sending hand. Rest your forearm on the desk and let your hand and wrist handle the movements used in code character formation with the sending key, using the muscle of your forearm as a "cushion."

This is also a good technique for the traffic man or others who do a great deal of sending and suffer at times from "glass arm" . . . fatigue and cramping of the hand and muscles of the forearm. This is an old trick with professional radio and telegraph operators and it works every bit as well for the ham. ▲

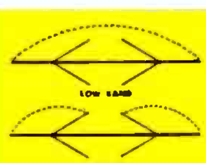
# 6 NEW SPACE-

# BY CHANNEL MASTER



# All new Telstar Crossfire

## Electronic Antenna combines unequalled performance of new Super-Crossfire Antenna with new built-in Telstar Booster



IN PHASE CURRENT DISTRIBUTION ON DB DIRECTOR

**World's most powerful antenna features exclusive, advanced DB Director System with "Phase Control." Gives up to 82% more gain —plus tremendous added gain of Telstar Booster.**

In the Crossfire Antenna, Channel Master gave you Proportional Energy Absorption—the most effective principle yet for achieving top picture power in picture-poor areas. Now, in the **Telstar Crossfire,** we've teamed this principle with two new exclusive developments—to make this far and away the most powerful antenna in the world.

Basically, the Telstar consists of our brand new Super-Crossfire—an antenna with a brand-new Director system. The DB (Dual Band) Director System—exclusive with Channel Master—enables each DB Director to receive both low and high bands on a single element. Thanks to a unique Phase Controller, each director—on the high band —functions as 2 half-wave co-linear elements with in-phase current distribution. In effect, simplified directors make it possible to use more directors—for increased effectivenss. Result?

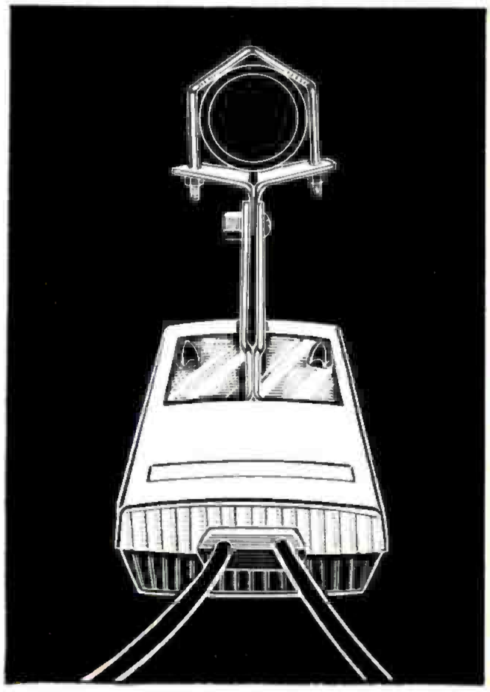
**...In the Super-Crossifire Antenna** (Model 3607... available separately)... you get up to 82% more gain than the 28-element Crossfire, plus the same high front-to-back ratios.

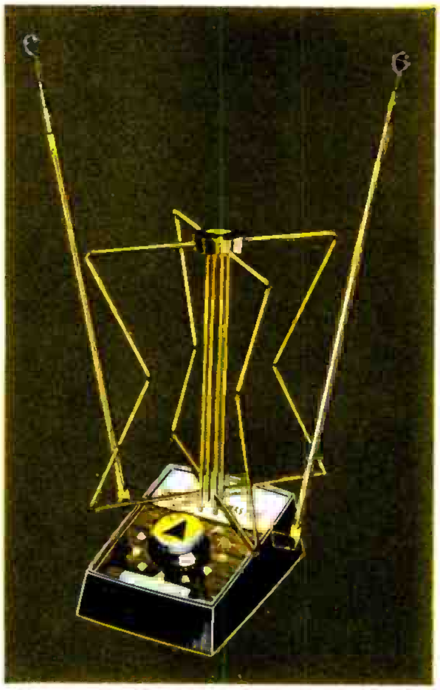
**...In the Telstar Crossfire Antenna** (Model 3606)... you get all the outstanding features of the Super-Crossfire... plus the extra-powerful gain and low noise-figure of the brand new Telstar Booster (see right). No other antenna even comes close.

- **Exclusive New!** Both Telstar and Super-Crossfire feature still another Channel Master first: New 2-way boom bracing... stops cross-arm bounce and horizontal wind-whip.
- **Exclusive!** All Channel Master outdoor antennas are fully protected against corrosion by E.P.C. "Golden Overcoat."

# AGE TRIUMPHS

## BEST-PERFORMING OF ALL ANTENNAS AND BOOSTERS! AND MOST PROFITABLE FOR YOU! BEST FOR BLACK-AND-WHITE AND COLOR TV. FM STEREO, TOO!





### NEW Telstar BOOSTER-COUPLER

***features peak-power plus lightning-resistant circuit!***

TV and FM Stereo get the biggest performance boost yet with a booster that is miles ahead of the "second best" booster. The Telstar Booster is especially engineered to pour more **usable** power than any other booster to 1, 2, 3, or 4 sets! The latest circuitry and advanced low-noise transistor result in highest gain and highest signal-to-noise ratios yet.

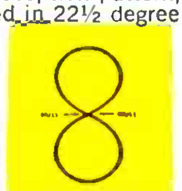
Lightning-resistant, too—because circuit utilizes the lightning rod principle to prevent **transistor burnout** caused by induced atmospheric lightning. Laboratory-tested by 250,000 lightning volts! Beautifully styled in blue-and-white. **Model 0023**

### New OMNI-RAY TV/FM STEREO ANTENNA

**GHOST-KILLER EXTRAORDINARY!**

A brand-new outdoor antenna with directivity electronically controlled by an indoor switch. (No rotator needed). Solves most common problems of metropolitan and secondary signal areas with these important exclusives:

**1.** Perfect figure-8 reception pattern, electronically rotated in 22½ degree steps.



**2.** Deep side nulls; 10:1 rejection ratio.

**3.** "Aim the beams" for top power; "aim the nulls" for top ghost and interference rejection.

**4.** Special "Duo-Twin" Transmission lead prevents mutual coupling.

A completely preassembled stacked antenna. **Model 3622**

### Handsome New CANAVERAL

**FIRST INDOOR DIPOLE ANTENNA WITH TRUE ELECTRONIC CIRCUITRY.**

Unique "Pix-Power" switch and impedance-compensating circuit give you these exclusive advantages:

**1. On low band**—resonates on all channels (even 2 and 3) by electronically lengthening or shortening elements—**without need for manual dipole adjustment.**

**2. On high band**—Greatly increases gain by functioning as 2 co-linear half-wave dipoles—**without manual adjustment.**

**3.** Has balanced system with 300-ohm impedance-matched output to eliminate standing waves.

Has the longest elements anywhere (96" tip to tip) for greater pull-in power.

Smartly-styled, with tremendous merchandising possibilities. **Model 3720**

### NEW! Rechargeable BRIGHT-MITE.

The revolutionary tiny miracle light that outshines big flashlights. Powered by the Permanent Energy Cells that power the Satellites. Ask about our terrific Display Pack deal.

**See your Channel Master distributor for literature on all these products.**



CIRCLE NO. 112 ON READER SERVICE PAGE

## Coax Cable Communications

(*Continued from page 39*)

cable system is approximately the same as for a microwave system of lesser channel capacity. Of course, cost can be greater in difficult terrain.

Operating cost of a coaxial cable system should be lower than for microwave because there are no expensive klystrons to replace. Electric power costs will be substantially lower since the cable repeaters consume extremely little power and there is no requirement for tower lighting and repeater station shelter heating.

### *New Era in Communications*

While one-way transmission through coaxial cable is old hat to telephone companies and CATV operators, bi-directional single coaxial cable transmission systems make cable highly competitive with microwave.

Since the use of cable is limited to those who have right-of-way, or access to a right-of-way, microwave will still find an ever-expanding market. There are many possible applications for systems employing both microwave and cable to permit serving both on-line and off-line points.

In addition to intercity and interplant communications, coaxial cable can be used within large buildings and ships for distribution of TV signals, data transmission, and communications. The problem of signal attenuation can be licked by use of simple cable repeaters, level stability is achieved by use of regulators, and the required flat-frequency characteristics of the transmission medium can be obtained through the use of mop-up equalizers and properly designed repeaters.

The coaxial cable repeater described here is an analog device, best suited for use with frequency-division multiplex. Another development under way is a digital cable repeater which will permit use of PCM (pulse code modulation) multiplex. Since this type of repeater regenerates the pulse signals at every repeater, the quality of the signal at the far end of the cable will be almost as good as at its insertion point.

The practical transmission distance of an analog-type coaxial cable system is limited by the channel loading and the amount of distortion and phase delay of the system. The digital-type system is considered to be superior for long-haul purposes.

The transmission capabilities of both analog and digital coaxial cable systems are so great that a single cable can accommodate the requirements of more than one typical user. A cable system can be shared by two or more users without the restrictions imposed by the FCC on shared use of private microwave systems.

With millions of miles of railroad, pipe line, power line, and highway right-of-way available for exclusive and shared use, the future of coaxial cable systems is indeed bright. ▲

# ANGLES QUIZ

**By JOE TERRA**

**THE "angles" involved in the understanding of electronics are as numerous as they are interesting. The first column below contains a listing of terms pertaining to both the concepts and the application of angles in the field of electronics. The second column contains their definitions. Can you match them? (Check your answers on page 89)**

1. Amplifier operating angle
2. Angle of deflection
3. Angle of divergence
4. Angle of radiation
5. Critical angle
6. Cutting angle
7. Dig-in angle
8. Drag angle
9. Electrical angle
10. Phase angle
11. Operating angle
12. Wave angle

A. A means of specifying a particular instant in an alternating-current cycle.
B. Represents voltage lag or lead with respect to current.
C. The angle at which radio propagations leave a transmitting antenna or arrive at a receiving antenna.
D. The angle between the stylus and the record surface.
E. Opposite of dig-in angle.
F. In cathode-ray tubes, the angle at which the electron stream deviates.
G. The portion of a cycle during which plate current flows in an amplifier or an electronic tube.
H. In cathode-ray tubes, the angle formed by the edge of the electron stream and a longitudinal line drawn through its center.
I. In optics, that angle from the vertical beyond which a beam of light from below, on striking the surface of a liquid, will be totally reflected downward.
J. The angle measured between a beam of radio energy from an antenna and the earth's surface.
K. Proportionate part of the exciting grid voltage cycle during which plate current flows.
L. A stylus cutting angle such that the point is driving into the disc.


[illegible]

**Soundcraft Golden Tone** [illegible] A bold claim? Yes. Warranted? Yes. Here's why. Golden Tone is a very special tape... designed just for those who demand the finest performance from today's advanced recorders. Unless you have the discerning ear and the exacting equipment which ordinary tapes can't satisfy, there is no reason for you to buy Golden Tone.

A special magnetically-active FA-4 oxide formulation increases Golden Tone's high frequency output by 25%. Its signal-to-noise ratio is 7 db better than other brands to give your recordings **the greatest dynamic range possible with a tape.** Precision-slit Golden Tone is free of edge burrs and skew. These physical defects can be cruelly exposed by the narrower tracks in 4-track recording. Microscopic burrs prevent the tracks on the edge of the tape from making intimate head contact, resulting in loss of "highs."

Skew, another hidden defect, produces cross-talk and loss of recording level. Golden Tone's oxide formulation and base are balanced to prevent cupping or curling, an effect which can also prevent tape to head intimacy. Golden Tone's oxide surface is Micropolished. This patented Soundcraft process removes any surface irregularity, prevents drop-outs, promotes high frequency response and minimizes head wear.

From this physically perfect tape, comes musically perfect sound. Golden Tone costs more, but it's worth more. It is produced in small quantities with infinite care and rigid quality control. It is the world's finest tape for those who demand the ultimate in sound reproduction. Offered for the first time anywhere is low cost Golden Tone tape on 1 mil Mylar*. [illegible]


*DuPont T.M.

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FM and FM Stereo in a handsomely styled low-cost package. Features a stereo indicator light to show when an FM station is broadcasting stereo; a stereo phase control for maximum separation, minimum distortion; adjustable AFC for drift-free reception; bar-type "eye" tuning indicator; illuminated slide-rule dial and special filtered outputs for stereo tape recording. Easy to build with circuit boards and factory assembled and aligned tuning unit. 16 lbs.

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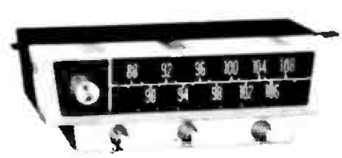
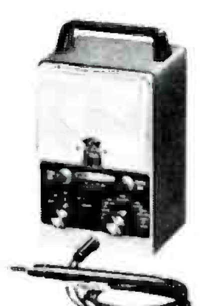


### New Heathkit 10 Transistor FM Car Radio

This easy to build kit brings you FM car radio entertainment at lowest cost. Tuner and amplifier are separate for installation ease, and broad band circuitry for true hi-fi performance. Features 10 transistor circuit; 88 to 108 mc FM coverage; better than 1.25 microvolt sensitivity; push-pull audio output; AFC for drift-free FM reception; factory assembled and aligned tuning unit; circuit board assembly and built-in circuit breaker protection. Styled in black & chrome. 7 lbs.

**Kit GR-41**...no money down, $7 mo.........................**$64.95**

### Big Volume of World's Largest Selling VTVM, Heathkit IM-11 Permits New Special-Value Price, Just $24.95



Famous performance, now an even greater value! Measures AC volts (RMS), AC volts (peak-to-peak), DC volts, resistance and decibels. Has 4½" 200 ua meter, precision 1% resistors and 11 megohm input. Slim, all-purpose test probe provides switch selection of AC-ohms or DC functions. Component circuit board assures stable circuitry and easy assembly. Test leads included. Less battery. 5 lbs.

**Kit IM-11**...no money down, $5 mo.
..............................**NOW $24.95**
**Assembled IMW-11**...
no money down, $5 mo............**$46.75**

### New Heathkit Special CB Transceiver

Most advanced CB unit on the market! Now, with exclusive Heathkit 4-tone selective-call circuitry and five crystal-controlled transmit and receive channels, it provides up to 20 different switch-selected tone calling and receiving channels, all built-in . . . no extra wiring. Up to 92 combinations are possible using various CB crystal frequencies. Also features sensitive superhet receiver with RF stage; high efficiency transmitter; built-in squelch and automatic noise limiter functions; improved push-to-talk circuitry and more, for versatile CB operations. 12 lbs.

**Kit GW-32A (117 v. AC)**...no money down, $9 mo. .........**$84.95**
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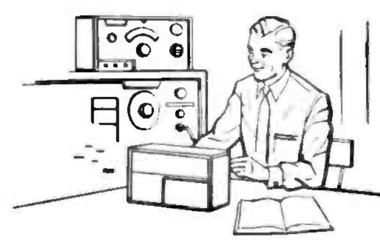
# *Over 250 different electronic servants at savings up to 50%*

## Another Heathkit First! A Real Organ in Kit Form! only $329.95 (less bench)

The exclusive Heathkit version of the all-new Thomas Transistor Organ now, for the first time, offers you a real two-manual organ at the market-shattering low price of just $329.95. Compare these fine features that until now have appeared only on organs costing up to $400 more: two 37-note keyboards; 10 true organ voices; 13-note bass pedals; variable vibrator; expression pedal; variable pedal volume; manual balance control; correctly positioned overhanging keyboards; built-in 20-watt peak power amplifier and speaker system; beautiful factory assembled and finished walnut cabinet and optional bench . . . no chords, no reeds, but true organ features and sound! The new transistorized tone generators on circuit boards assure clear, undistorted tone, long life, and easy assembly (they're warranted for five years). An ideal instrument for family fun, chapel or school. Organ Kit GD-232 will be ready for shipping Nov. 15. Send for full details and LP demonstration record today or reserve your Heathkit organ now!

**Hear the New Heathkit Version of the Thomas Transistor Organ for Yourself** . . . SEND FOR DEMONSTRATION RECORD . . . listen to its beautiful voices, rich mellow tone and astounding range of expression. Use the coupon at the right and enclose just 50c to cover handling and postage on this 7"—33⅓ rpm demonstration record. Ask for Record GDA-232-3.



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## Operational Amplifiers

(*Continued from page 37*)

termined by the value of capacitor $C_f$, $R_i$, and $E_i$. The relationship is simple:

$$\textit{volts-per-second} = E_i \times \frac{1}{R_iC} \text{ or } E_i/RC.$$

To obtain a rise of one volt-per-second, therefore, an input of one volt, with a one-megohm input resistor and a one-microfarad capacitor may be used; or 10 volts, one megohm, and 10 μf., or even one millivolt, 100,000 ohms, and 0.01 μf.

When the output has reached the maximum value allowed by the amplifier, 100 to 150 volts in most cases, it is necessary to discharge the capacitor, returning $E_o$ to zero, or a starting value known as the initial condition. For this purpose, a switch or relay is used, the complete circuit being shown in Fig. 5.

In a computing application, the junction of $R_{i2}$ and $C_f$ will be grounded during reset to provide a constant input impedance. A variation of this circuit may be used as a peak-holding, or memory circuit. If a voltage is applied to point *IC* and no resistor $R_{i2}$ is connected, the output $E_o$ will remain at the last value applied to *IC* when the switch is opened. A high-quality capacitor may hold the value constant for many minutes while the amplifier is delivering this voltage *into a load*. Even with a garden-variety capacitor, a variation of less than 1% in 15 minutes is not unusual. By inserting a diode between A and B the circuit may be used to remember the highest peak reached at *IC*. Fig. 6A illustrates a simple peak-reading voltmeter using this principle.

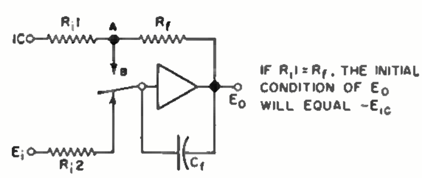



Fig. 5. Basic integrator circuit diagram.

Another circuit use is as a comparator. It is often useful to determine when a voltage $E_1$ reaches a certain value, or equals another voltage $E_2$. If a diode is substituted for $R_f$, for one polarity of $E_o$ the gain will be near zero, while for the opposite polarity it will approach the open-loop gain of the amplifier. In Fig. 6B, under normal conditions, $E_1$ is the opposite polarity and slightly lower in absolute value than $E_2$. The input of the amplifier (summing junction) will be at a potential slightly negative, due to the summing network $R_1$-$R_2$; and the output $E_o$ will be slightly positive. The diode will, therefore, be forward-biased and have an effective $R_f$ value of a few ohms. If $E_1$ rises to a value only slightly in excess of $E_2$, then $E_o$ will swing negative, the diode will be reverse-biased and assume a very high value $R_f$; the gain simultaneously rises, causing a very sharp swing from $E_o$ = (very small→0) to $E_o$ = $-E_{out}$. A relay may be connected from $E_o$ to ground to operate when the desired condition is reached, or the output may be used directly.

Commercial amplifiers can deliver from 3 to 50 ma., depending on model. Sensitivities of a millivolt or so may be achieved with high-resistance diodes. A zener diode may be used to limit the absolute value of $E_o$ to that of the amplifier linear operating range, or any other desired value. Input $E_2$ may be connected to a reference voltage through a potentiometer, and the operating point adjusted as desired. If it is desired to compare two voltages of like polarity, a unity gain inverter is used to reverse one of them.

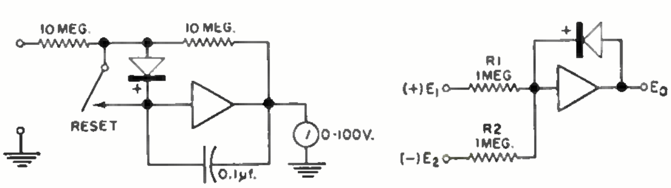
### *Commercial Units*

Operational amplifiers are available from commercial sources, at prices from $22 to $150, with specialized instrument amplifiers at higher prices. A typical two-tube plug-in amplifier costing $35 and with a gain of about 30,000 is shown in the drawing on page 37 and schematically in Fig. 4. Typical drift characteristics average 15 mv./day, with an output of ± 100 volts at 3 ma.

Power supplies for operational amplifiers have been rather well standardized at 300 volts regulated with, usually, two heater lines, one at ground and the other biased to about −175 volts to reduce heater-to-cathode potential difference. Generally speaking, for simple applications, a VR-tube regulator using four 0A2 regulators may suffice. In computers, electronic regulators capable of 0.01% regulation are commonly found.

It is beyond the scope of this article to detail the methods by which operational amplifiers may be used to multiply, divide, square, extract a root; convert to log or antilog; produce a sine, damped, or triangular wave; or perform many of the other mathematical functions required in an analog computer—but any or all of these functions may be equally well applied to industrial control uses. ▲

Fig. 6. (A) Circuit arrangement employing an operational amplifier acting as a peak-reading voltmeter. (B) Circuit used as comparator.

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- Employs a rugged, accurate, highly damped meter movement with sealed air-damping chamber.
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## Constant-Current Sources

(*Continued from page 62*)

The connection shown avoids a common difficulty in test circuits. Since the emitter current is directly controlled by the source, transistors with unusually high $\beta$ will not be damaged by excessive current. Some test circuits which use a base-drive source will damage the very transistors which have the highest $\beta$. The only restriction on the choice of parameters is that $R$ should not be made any larger than necessary to obtain reliable voltage readings. Otherwise transistors with low $\beta$, but not necessarily completely bad, will develop an unnecessarily large collector voltage. This results because the drop across $R$ adds to the $V_c$ supply as seen by the collector-base junction.

A practical consideration in production testing is the large open-circuit voltage which would occur if the transistor happened to be open or were removed during the test. Also since the surge from the charged stray capacity could damage a transistor if it were inserted with the current source open-circuited, suitable voltage-limiting diodes or a normally closed push-button switch should be built into the test fixture as a safety precaution.

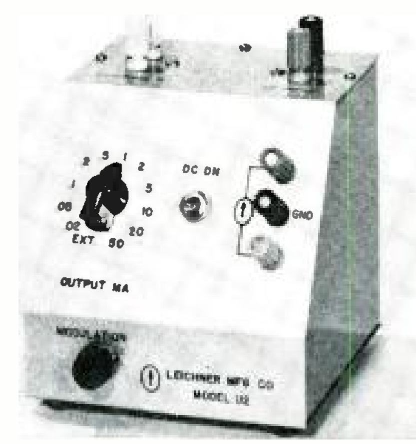



**Fig. 10. Constant-current regulator with 11 preset current values. Line-frequency modulation is adjustable from zero to an r.m.s. value of 10 per-cent of the d.c. output.**

Many other applications can be found for constant-current sources once one gets used to thinking in terms of current in the first place. The examples given here have been oriented toward measurement techniques primarily, but there are other situations where current is simply the most sensible thing to regulate, such as in magnetic focus and deflection coils of precision CRT equipment. In general, then, constant-current supplies are just as useful, and necessary as constant-voltage supplies. The job to be done determines which is more appropriate. ▲

## Flow Measurement

(*Continued from page 47*)

Flowmeters and their electrical output signals form the sensing elements for complex automatic process control systems in the oil and chemical industry. Most of the servicing of such systems is concentrated in the computing and control circuits, but an understanding of how flowmeters work helps when their output signals must be evaluated. Once the flowmeter is eliminated as the possible source of trouble, you should consider the system as a whole.

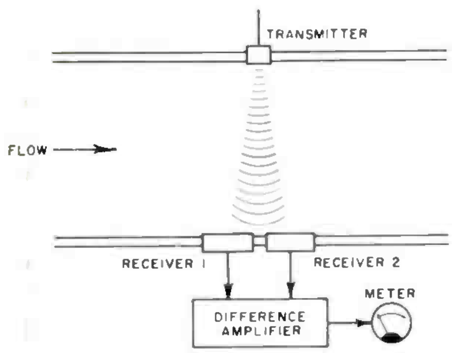



Fig. 9. Dual-receiver ultrasonic flowmeter. Signal difference is proportional to flow.

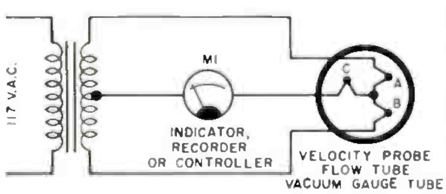
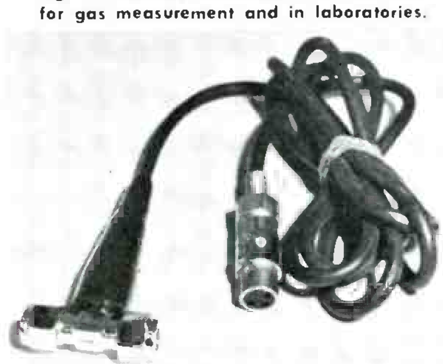



Fig. 10. Thermal flowmeter. Flow is determined by cooling effect of gas, liquid.

In the typical flowmeter application shown in Fig. 3, you will note that there are several spots to consider, namely: the motor-driven valves, the servo-motor drive amplifiers, or the signal comparer and control circuits.

Several different principles are used to measure flow in various applications. Knowing the application will often enable you to judge what kind of flowmeter is probably used and how its signals should behave. ▲

Fig. 11. Thermal flowmeters are often used for gas measurement and in laboratories.



## Should You Pull the Chassis?

(*Continued from page 59*)

So far, travel had been limited to the single pick-up trip that is included in every house-call fee. The repair charge would be added wherever the work was done. Only return delivery had to be considered. I got the owner on the phone. He dashed right over to pick up his set. Having received quick service and fair treatment, he was satisfied. So were we.

### *Easy Component Replacement*

I already mentioned that we do not usually replace components in the home. Let's clarify that. The rule covers components best located by the trouble-shooting procedures ordinarily used on the bench, involving service data and the scouring out of a circuit for faulty parts.

If we have a definite idea which component is defective, we will replace it in the house. For the most part, this includes clear-cut familiar troubles involving such common, standardized parts as selenium and silicon rectifiers, globar and power resistors, or others that we run into time and time again. As long as the defect is reasonably clear and the danger of recall doesn't seem great, we stay in the home. To back this up, we carry along a stock of the parts likely to be involved in such cases.

For instance, I was checking a recent-vintage *Philco* console that uses a voltage-doubler power supply. The heaters were lighting, but there were no other signs of life—no high voltage, no raster, no audio, no "B+." The fusible resistor was sound. This meant "B+" was being lost elsewhere.

You have probably run across this trouble, too. Nine times out of ten, the large-value electrolytic capacitor in series with the "B+" line of the doubler has opened. As a rule, it runs about 150 μf. at about 150 working volts d.c. I always carry a few 200-μf. units rated at 200 volts.

In this set, the capacitor is located in a tight spot behind the chassis. Strictly speaking, we should get the chassis out of the cabinet, dislodge the electrolytic, and test it to verify the open condition—even though we *know* the thing is open. From the practical standpoint, the procedure is almost certain to be a waste of time. I skipped it.

A mirror and flashlight were used to locate the capacitor. I reached around with my small, diagonal cutters and snipped off its leads, letting them hang loose. A quarter-inch bolt was then used to mount a replacement on the side of the upright chassis, and the dangling leads were connected.

I turned the set on. It went into normal operation and has given no trouble since. Technically ideal? I'm not so sure. Happy customer? You bet.

### *Tough Tube Jobs*

The ease with which a compact set can be pulled has been noted. Even if it's just a tube, I feel it's right to do it as long as you don't have to charge any more than for a job completed in the home. That applies especially to the "squeezed together" compacts involving tubes not likely to be in your caddy because they are not used frequently.

However, there are other occasions when neither ethics nor good judgment is violated by pulling sets that basically end up as tube-replacement jobs. I had one the other day. The first thing that greeted me when I walked in was the back cover of the set lying on the floor, surrounded by tubes all over the place. I looked into the chassis. Every tube socket was empty.

I collected the tubes and looked for the layout sticker on the set. It had long since vanished: scraps of it were still stuck to the cabinet where the glue hadn't yielded. I looked at the tubes. One was milky. Another had a crack on the bottom. Type numbers on several had disappeared.

Technically—and psychologically, as well—I wasn't in good shape for completing a repair. Back on the bench, I knew I had all the data I needed. I pulled the chassis.

Once I got the tubes back into their sockets, replacing only those that were obviously damaged, I turned the set on. Sound was good, but there was no raster. In fact, there was no high voltage. All tubes in the horizontal and high-voltage sections tested good.

When checking tubes in such a fault, I keep the vertical-output stage in mind. It often gets its voltage from the damper's boosted "B+" output, as was the case here. A short in the vertical tube can kill the boost output, thus killing high voltage too. After I replaced the 12BH7 vertical amplifier, high voltage whined on and the set worked. No other troubleshooting or repair was needed. No hand tools were touched.

Hoping it was "just a tube" but unaware of the vertical circuit's possible involvement, the do-it-yourselfer blundered ahead until he fouled up his set. Simple tube replacement was all it took to restore order. Should it have been done in the home? Under the handicaps, what chance did we have of completing a repair quickly enough to be covered by a money-saving house-call fee?

Any general policy on home-vs-shop repair must be tempered by the circumstances of each case. We're not out to gouge people, but we don't want to lose money either. The eternal question—to pull or not to pull—must be asked and answered separately each time. ▲

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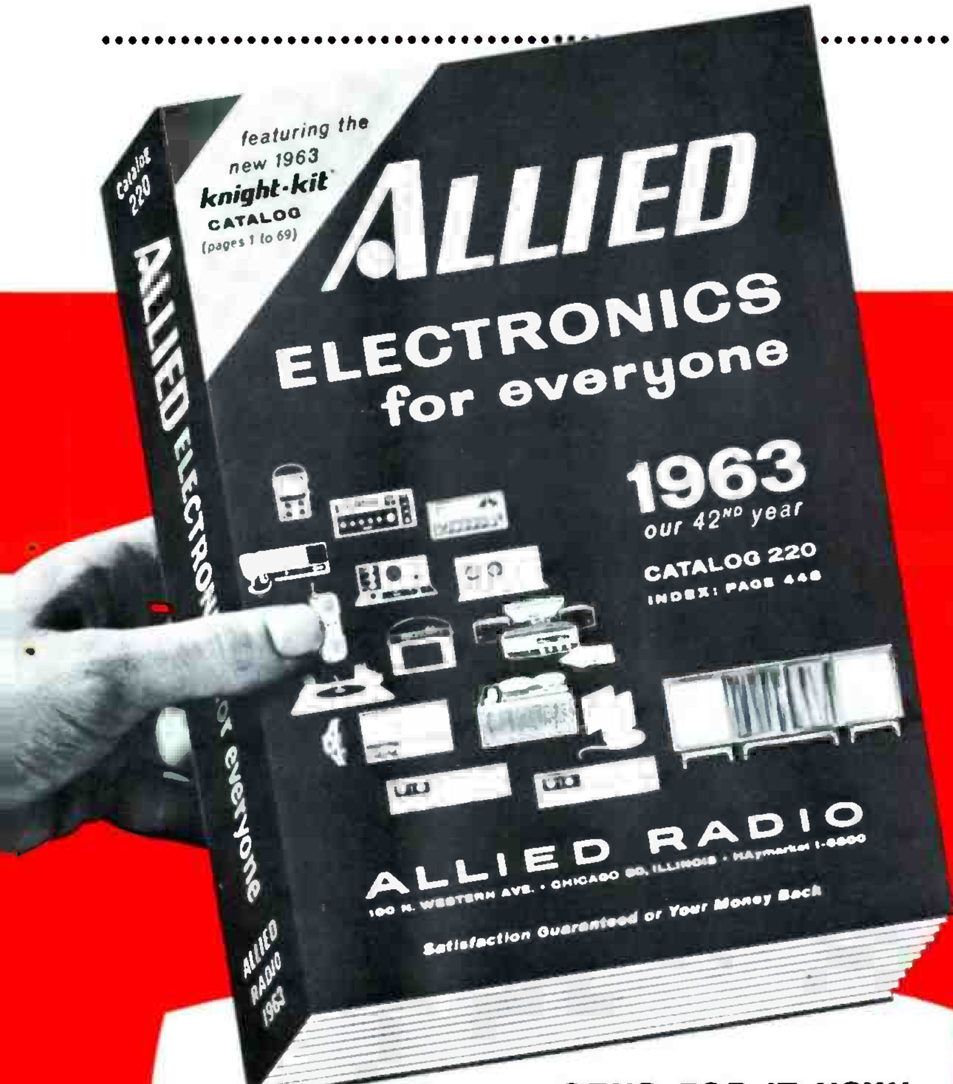


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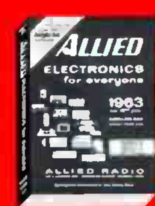

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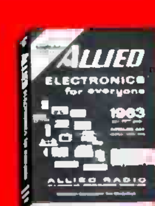

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## Neon Bulb Flip-Flops

*(Continued from page 54)*

or further miniaturize the author's version.

Diode specifications are not critical. 1N191's were used in the illustrated counting circuit because of their small size. But any general-purpose diode with a forward resistance of about 300 ohms may be used instead. Needless to say, the high resolution rate of the 1N191 is not required in circuits whose maximum pulse rise time is about 10 μsec. at a frequency of about 200 cps.

Insofar as possible, component values for individual stages should be matched. Bulbs may be selected by matching firing voltages ($E_1$) and drop voltages ($d_2$). Individual supply voltage controls should be provided for initial adjustment of bias for each stage. These controls may be part of a decoupling network for the "B+" supply, such a network being required in the absence of a regulated power supply. Ordinary 5% carbon resistors and bulbs matched within one volt may be used for operating frequencies up to about 100 cps.

Beyond this frequency care must be exercised to avoid intrinsic instabilities of the NE-2, which after all was not designed to be a particularly stable device in the first place. Leads from bulbs and interstage links should be kept as short as possible. Closer component tolerances and selection of bulbs with extremely low $d_2$'s are factors contributing to higher frequency response.

Remember that strong light or even the induced stray a.c. pickup in one's finger in contact with the bulb glass can trip the delicately balanced higher frequency circuits. If neither of the flip-flop bulbs has to be used as a visual indicator, both of them should be shielded with a grounded coating of "Aqua-dag" or silver paint. In counting circuits where one of the bulbs in each stage serves as a register indicator, optical contrivances which protect the naked bulb from bright light, such as masks and translucent output panels, are recommended. And even with interference from cosmic rays, which also affect the ionization of the neon bulbs but which cannot be stopped with shields, reliable performance up to rates of 200 cps can be obtained from the neon bulb flip-flop. ▲

**ANSWERS TO ANGLES QUIZ**

(Appearing on page 76)

| | | |
|---|---|---|
| 1. K | 5. I | 9. A |
| 2. F | 6. D | 10. B |
| 3. H | 7. L | 11. G |
| 4. J | 8. E | 12. C |

# Radio & TV News

## *Events in the Service Industry*

THE LICENSING issue would not be a simple one to resolve even if that one word, licensing, always meant the same thing. But there are compulsory, voluntary, self-regulatory, and countless other variations concerning which there is much disagreement. Just as there are some service people who do not want part of any plan that carries the slightest suspicion of regulation, there are others who would welcome any of the types mentioned, for a start, because any degree of control is considered better than the anarchy they otherwise see. Yet even these will oppose some forms of licensing. There are still questions concerning who is to be granted or denied a license, who decides, how the decision is to be reached, whether a "license" bill is simply a non-regulatory fund-raising measure, and others.

Consider the position of the Electronic Technicians Guild of Massachusetts, long an exponent of licensing. It rallied impressive representation from its various chapters to *oppose* a state license law, not so long ago. The bill would have placed TV service dealers and technicians under the jurisdiction of the existing State Board of Electrical Examiners, rather than create a new body to deal with the service industry. ETG felt that "electricians are no more qualified to rule on our problems than we would be on theirs." This factor, along with other shortcomings, raised doubts as to whether the law would do more good than harm. Some spokesmen, however, made it clear that they did want a bill and suggested modifications to the one proposed that would make it acceptable.

### One Law in Action

Despite such problems, it seems possible that a regulatory bill can be worked out that is acceptable to most service people involved, not only while it is on paper, but after the industry has had ample opportunity to feel its effects. Such a one is Detroit Ordinance #110F, which has been on the books for several years.

During the past year, the license board has handled close to 60 court cases. All but one resulted in fines, generally about $50 but ranging as high as $294.44 with restitution in one case. Does this mean that Detroit service dealers live constantly under a cloud of legalized persecution? Not necessarily. For one thing, complaints to the license department by set owners have dropped more than 90 per-cent since the law was adopted. For another, active associations in the Detroit area, whose membership tends to be composed of the more responsible and ethical segment of the industry, continue to laud the healthy effects of the bill.

### Tips for Set Owners

The board's advice to consumers is that they try to find reliable service dealers and to stick with them, without hopping about; avoid low price advertisers; demand the return of all parts removed from repaired sets, except for the picture tube; and ask to see the man's license before allowing him to do any work. The latter takes into account a serious enforcement problem. There are, to this day, a large number of Detroit servicers who never had licenses or who have failed to renew licenses properly.

Even where unlicensed dealers operate with good intent—and the board acknowledges there are some such—they are more likely to displease their customers because they do not observe certain requirements of the law, of which they may be ignorant. For example, set owners are cautioned to ask for itemized repair bills, for their own protection. A licensed dealer is required to render such a bill in every case, whether requested or not, and keep it on file for two years.

### The Billing Problem

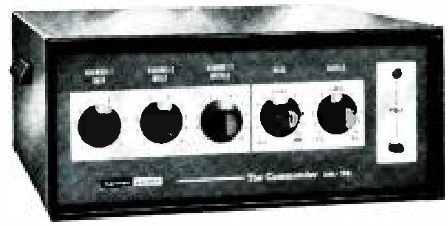
Reluctance to present the customer with an itemized statement does not necessarily indicate dishonest intent. Still hanging over the heads of many technicians is the failure of set owners to understand that honest labor is entitled to just reward, no matter how low the cost of replaced parts may be. A report from Massachusetts, in a lighter vein, highlights the hazard.

While pulling the set of a new customer, the dealer involved learned from her why she was trying a new man. The furious set owner had received a bill from her previous technician, on the last job, that listed one replaced resistor at 15¢ and labor at $15.

The forewarned dealer concluded that diplomacy was just as important as honesty and that the two were not necessarily in conflict. *His* bill read, "Located and replaced dual phase-detector crystal diode unit (imported) with silvered leads—$15.50." The customer was so satisfied that she gave him a tip!

Perhaps our hero overdid things a bit, but the principle is sound. This proves you can still succeed in service if you have a solid technical background, a good business sense, a pleasant personality, the mathematical facility of an accountant, lots of luck—and talent as a psychologist! ▲

# For your next P.A. job, for every P.A. job,



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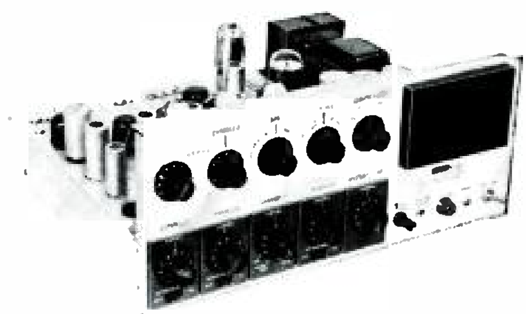

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CIRCLE NO. 126 ON READER SERVICE PAGE

## Unique Output Circuit

(*Continued from page 55*)

produced and, since no d.c. flows through it, no distortion is introduced here.

### *Temperature Problems*

Perhaps one of the main design considerations in high-power transistor circuits is the limitation imposed by temperature. The temperature problems of transistors are inherent, due to the electrical considerations involved in their construction. At high temperature, control of the transistor current is necessary to avoid developing a runaway condition which can lead to destruction of the device. The power transistor has a maximum collector junction temperature rating which has been assigned by the manufacturer and observance of this limit can extend the useful life of the unit almost indefinitely. Exceeding this limit can lead to permanent loss of gain or early failure of the transistor. Adequate heat-sinking of the transistor and stabilization of the d.c. operating point of the device will control the transistor current so as to prevent a rapid rise in junction dissipation as temperature rises.

**Front-panel view of the all-transistorized stereo amplifier unit.**

In the common-emitter circuit, stabilization can be obtained by d.c. degeneration or by thermistor control of the bias circuit. The first method can easily be obtained by inserting resistance into the emitter lead of each transistor, as in the case of $R_1$ and $R_2$ of Fig. 1A. The larger the value of $R_1$ and $R_2$, the greater the degeneration and the greater the temperature control and stability. On the other hand, maximum power capabilities are seriously curtailed.

However, if a resistor of positive temperature coefficient is used for $R_1$ and $R_2$, the ultimate in stabilization can be obtained without great sacrifice of total power. It was found that the resistance characteristics of a tungsten filament bulb were ideally suited for this application. The bulb chosen in the amplifier is one similar to a 6-volt automotive tail light. This not only provided the necessary d.c. stabilization but also provided the speaker protection of a "quick-blow" fuse. (See Fig. 1B.)

The tungsten lamp is extremely sensitive to applied voltage since the life varies inversely as the 12th power of applied voltage. In this way the normal 200-hour life at 6 volts would be reduced to $200/(23/6)^{12}$ hours in the circuit, if a wiring error or component failure placed the full 23 volts on the lamp. This corresponds to approximately 70 milliseconds and provides adequate protection for both speaker and transistor. By the same formula, since the lamp is normally only exposed to few tenths of a volt, its life is extended thousands of hours beyond its normal 200-hour life at 6 volts. In addition to the stabilization and protection afforded by the emitter lamps, there is a measure of self-balancing provided for the output circuit since they are sensitive to the current through them and seek an equilibrium with the transistors with which they are in series, balancing the bridge and keeping any d.c. from flowing through the speaker.

Several 6-volt automotive lamps were investigated for their characteristics before this lamp (a special dual-filament type, similar to two type 1129's in a single small envelope) was chosen. The life *versus* over-voltage characteristic is virtually the same for all the lamps examined, therefore they would all provide the desired speaker protection. However, a lamp with a design current rating in the range of the maximum load current in the 4-ohm load condition would cut the 4-ohm power capability approximately in half. On the other hand, the lamp with maximum design current far greater than the load current encountered at rated power in the 4-ohm load condition would provide only marginal d.c. stabilization on 4-ohm loads and virtually no protection for 8- and 16-ohm load connections where far less load current normally flows.

Hence, having selected the proper bulb and having provided stabilization on 4-, 8-, and 16-ohm loads, the amplifier tends to approach a constant-power device rather than the more typical constant-voltage device since the 4-ohm load current will be limited more than the 16-ohm load current. This is evident by the fact that the total maximum continuous sine-wave power is 36 watts for 4-ohm loads (18 watts per channel) and more than 30 watts for 16-ohm loads (15 watts per channel).

Further thermal protection must be provided for in the heat-sinking of the power transistors, since as ambient temperature increases, junction temperature increases a like amount provided that power dissipation remains constant. However since $h_{FE}$ (d.c. current gain) and $I_{CO}$ (collector current) increase with temperature, the collector current can rise with increasing temperature which, in turn, can result in increased power dissipation. To assure that the heat sink can dissipate sufficient energy to prevent junction temperature build-up, the six power transistors are mounted directly to the .093" thick 250-square-inch aluminum chassis. ▲

## "Telstar" Satellite

(*Continued from page 36*)

horn antenna itself can track this beacon signal with extreme precision.

In the control building there is an assortment of equipment and consoles so necessary for carrying out the program for which the system was designed. There are computers to assist in the tracking operations, and microwave links with the outside world. There are TV monitors and measuring equipment of various kinds.

### *The Results*

Much valuable scientific information has been obtained since "Telstar" was placed in orbit on July 10, 1962. All of the equipment is operating normally, and the telemetry data so far has not shown any significant deviations from the expected results. The solar batteries are delivering ½ ampere at 27 volts, and show no signs of major damage. Deterioration of special test semiconductor devices is about as expected.

Temperature inside the satellite averages about 75° F and skin temperatures range from 18° to 48° F.

From the communications standpoint, "Telstar" has been used successfully as a repeater for television, both monochrome and color; for one-way and two-way phone calls; and for the transmission of photofacsimile and high-speed data.

In all of these tests and demonstrations, performance has been as expected, and is the same as the measured performance on the ground before the launching. Thus it appears that our first privately owned experimental communications satellite is completely successful and is living up to all expectations. ▲

"How many leaking capacitors do you usually find with this scientific method?"

# ADJUSTABLE CURRENT FUSE

By MICHAEL H. KAUFMAN

**Service technicians and experimenters should use this device to prevent transistors from being destroyed by excessive current.**

FOR THE experimenter, freedom from the worry of destroying expensive transistors is necessary to allow wide design latitude. The circuit described here is a current-limiting device whose cut-out point can be adjusted over a wide range. It prevents transistors from burning out no matter what the cause of the overload: reversal of power-supply leads, excessive forward bias, or overheating due to thermal runaway. In each case, power will be removed in time to save the transistor.

The circuit is not complicated and few parts are required if it is to be used with an existing power supply. The advantage this circuit has over cartridge fuses is apparent—a control knob is more convenient to work with than a large stock of different size fuses

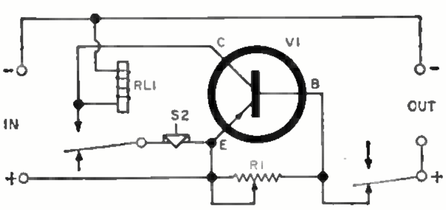



Fig. 1. Circuit to be used with external supply. See Fig. 2 for part values.

that would be necessary to protect a variety of devices with different loads. As for cost, the replacement of one burned out high-frequency transistor will set you back the same amount as the cost of the parts for this unit.

## The Circuit

Fig. 1 is a schematic of the basic fusing circuit. $V_1$ is an inexpensive power transistor that controls $RL_1$. The control or base current of $V_1$ is developed by the voltage drop across $R_1$. The greater the resistance of $R_1$, the smaller the current that can be drawn from the power supply before $RL_1$ is energized. Making $R_1$ adjustable allows a wide variation in current that will energize $RL_1$. $S_2$ is a push-button switch used to unlatch $RL_1$ which is kept closed, once energized, by a set of contacts shown at the left in the diagram.

The circuit shown in Fig. 2 includes a 12-volt power supply and another resistor, $R_2$, that limits the maximum current the power supply can deliver should $R_1$ be set to zero ohms.

If this fusing circuit is to be added to an existing power supply, the parts can be fitted in the power supply's case. Placement of the components is not critical. As a separate piece of equipment, it should be built in a metal case.

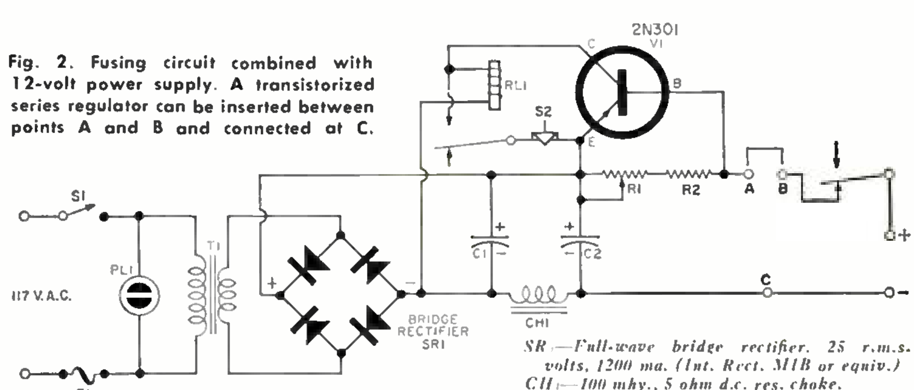
$V_1$, an entertainment-type transistor such as a 2N301, energizes $RL_1$. It does not have to be mounted on a heat sink. However, if a more sensitive relay and a 300-mw. transistor are used, the transistor may have to be mounted on a heat sink. The transistor spec sheet should be consulted to determine if this is necessary. $V_1$ must be able to pass enough current, without overheating, to keep $RL_1$ energized. If $V_1$ overheats, thermal runaway will cause $RL_1$ to energize though excessive load current is not being drawn. One set of contacts on $RL_1$ latches it closed and the other set of contacts removes power from the output terminals.

$R_1$ should have a log taper, although a linear-taper pot will work. If the ratio of change from minimum to maximum cut-out current is 1:50 (10 ma. to 500 ma.) a 50-ohm linear-taper pot set at 1 ohm to deliver 500 ma. may require critical adjustment.

## Calibration

The exact value for $R_2$ must be determined first. Since it is one ohm or less, it can be wound with a piece of wire from a discarded low-resistance wire-

Fig. 2. Fusing circuit combined with 12-volt power supply. A transistorized series regulator can be inserted between points A and B and connected at C.




$R_1$—50 ohm, 2 w. log-taper pot (see text)
$R_2$—1 ohm, 1 w. res. (see text)
$C_1$—1000 µf., 15 v. elec. capacitor (Cornell Dubilier BRH-1510 or equiv.)
$C_2$—2000 µf., 15 v. elec. capacitor (Cornell Dubilier BRH-1520 or equiv.)
$S_1$—S.p.s.t. toggle switch
$S_2$—S.p.s.t. normally closed push-button switch
$SR_1$—Full-wave bridge rectifier, 25 r.m.s. volts, 1200 ma. (Int. Rect. M1B or equiv.)
$CH_1$—100 mhy., 5 ohm d.c. res. choke.
$F_1$—1 amp "Slo-Blo" fuse and holder
$RL_1$—D.p.d.t. relay, 12 v. d.c., 50 ohm coil (Guardian 1R-505-G12 or equiv.)
$PL_1$—Neon indicator lamp with built-in resistor (Drake type 105 or equiv.)
$T_1$—Power trans. 117 v. pri., 12.6 v. @ 2 amp sec. (Stancor P8130 or equiv.)
$V_1$—"p-n-p" transistor (2N301)

wound resistor. With $R_2$ shorted out, turn $R_1$ counterclockwise so it is at a low resistance setting. Connect a 0-1 a. meter across the output terminals. Adjust $R_1$ for a meter reading of 500 ma., remove power, and measure $R_1$'s resistance. With parts listed, 500 ma. will be the maximum. The value of $R_2$ could be calculated from the setting of $R_1$ when the relay trips at 100 ma. If it takes 5 ohms for 100 ma., a one-ohm resistor will be required to limit the current to 500 ma. The current/resistance products have to be equal. The actual values of $R_1$ and $R_2$ depend on the gain of $V_1$ and the sensitivity of $RL_1$. Experimentation will produce the fastest results.

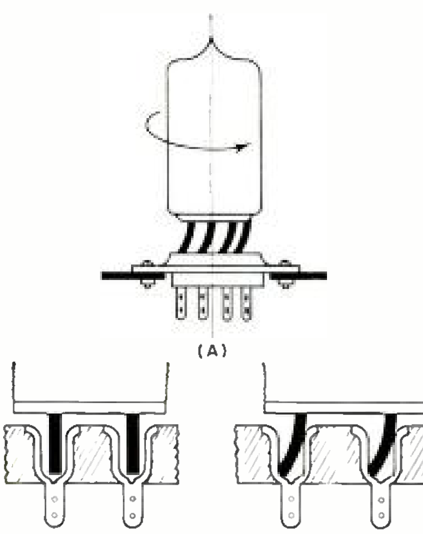
To calibrate $R_1$, wire $R_2$ in the circuit and connect a variable-load resistor in series with a milliammeter across the output. By changing the value of the load resistor from its minimum to maximum, you can obtain a complete set of calibration points for $R_1$. If, for example, the load resistor is set so the milliammeter reads 50 ma., adjust $R_1$ until $RL_1$ closes. Mark 50 ma. on the potentiometer dial at this setting. Do the same for 10 other values of current. ▲

# OUTSMARTING LOOSE TUBE SOCKETS

By R. G. MINARIK

SOCKETS for miniature tubes occasionally lose their gripping power, with the result that the tubes are not securely seated and contact with the pins is not reliable. An obvious remedy is replacement of the socket, but this chore can be avoided.

Partially insert the tube itself in a tube straightener or the loose socket itself, so that the tips of all the tube pins are just barely engaged. Then the tube itself is given a slow, discreet twist, as shown in part (A) of the illustration, so that the pins are slightly spiralled rather than straight. While the socket may not be tight enough to grip straight pins (B), the slight spread (C) provides tightness. ▲




A twist of the wrist, correctly administered, improves seating of a loose tube.

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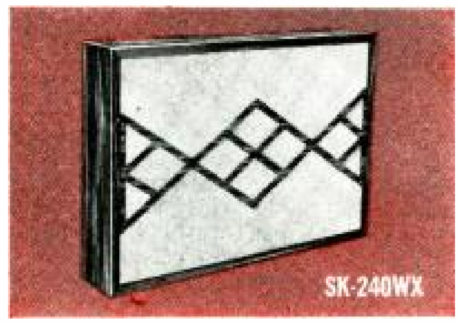


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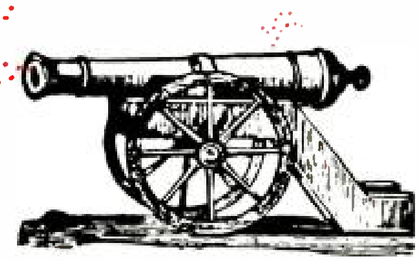


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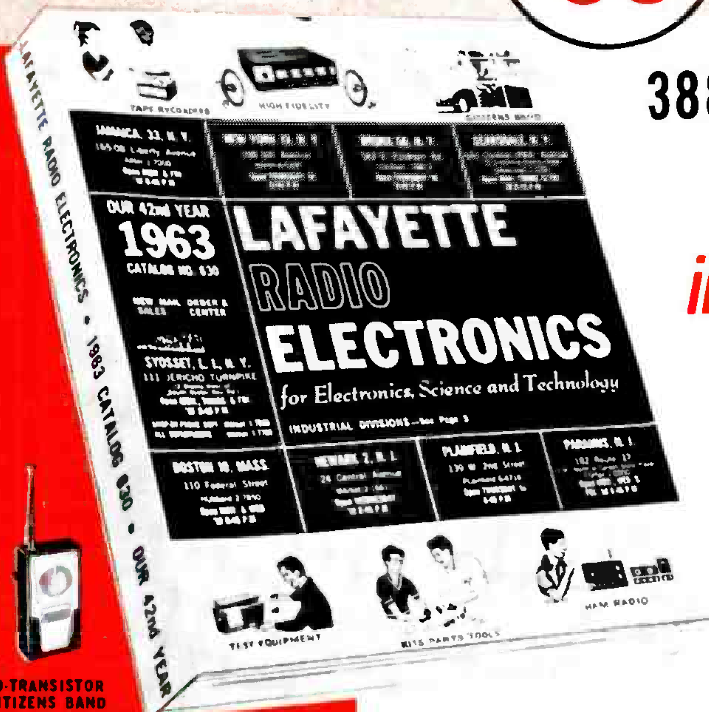


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## EW Lab Tested

*(Continued from page 26)*

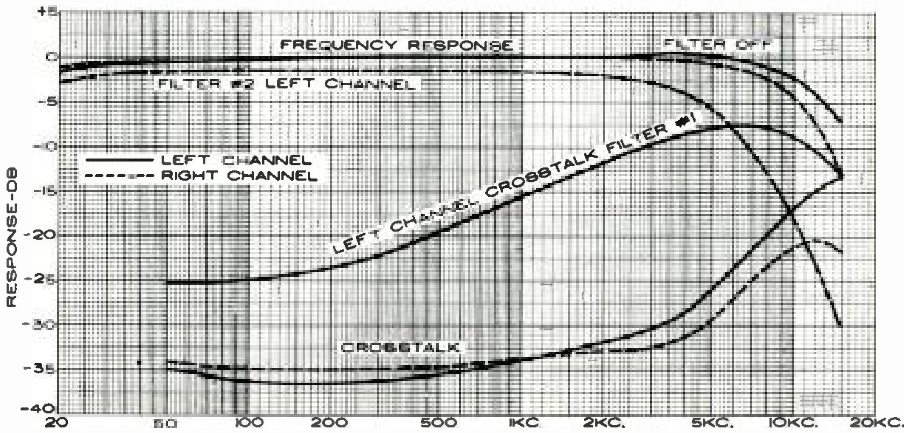
put amplifier having a 15-megohm input impedance, to minimize detector loading. The 19-kc. pilot carrier is selectively amplified and synchronizes a 38-kc. oscillator. The composite signal, after removal of any SCA program by a 67-kc. trap, feeds two diode switches which are keyed by the 38-kc. oscillator. Each switch uses four matched diodes. At any given instant, one switch is open and the other closed, with these conditions reversing every half-cycle. The switching action effectively separates the composite signal into the original left- and right-channel programs, which are individually amplified and de-emphasized. They are then passed through 15-kc. low-pass filters to remove any 19-kc. or higher frequency components. The audio outputs are taken from low-impedance amplifiers.

The adapter has the *Fisher* "Stereo Beacon," which is a relay-operated switching system. In the absence of a 19-kc. pilot carrier, a relay is actuated, disabling the 38-kc. oscillator and closing both diode switches to supply the full monophonic signal to both audio outputs of the adapter. The pilot carrier, when present, is rectified and used to cut off the relay driver tube. The relay releases, restoring the 38-kc. oscillator and diode switches to normal stereo operating conditions. Additional contacts are used to increase the gain about 6 db to produce the same volume from both stereo and mono broadcasts, and to light a green light on the front panel, indicating stereo operation.

One of the two operating controls of the MPX-100 is a four-position selector switch on the front panel. In its "A.C. Off" position, the power to the unit is removed, and a pair of left- and right-channel input jacks in the rear are connected directly to the corresponding output jacks. In this position FM and AM monophonic programs from the normal tuner outputs may be heard as though the adapter were not connected. In the "Tuner" position, the signal paths are the same, but the MPX-100 is powered and fully operating. In this mode, the "Stereo-Beacon" light is operative to show the presence of a stereo program, but the adapter remains out of the circuit. In the "Stereo-Mono Automatic" position, the adapter operates in its automatic mode, as previously described. Since, under weak signal conditions, the "Stereo-Beacon" relay may operate erratically, a fourth, "Stereo Manual," position disables the automatic circuits, leaving the adapter in stereo operation.

Background noise on stereo programs is always higher than in mono reception. The MPX-100 has two degrees of filtering to reduce the effects of this noise. In position 1 of the "Noise Filter" knob, the noise on the sub-carrier is filtered out. This does not affect frequency response, but reduces channel separation. Position 2, in addition to this, rolls off the high-frequency response above 5 kc. In the "Off" position, there is no filtering.

One requirement of a universal multiplex adapter is the ability to handle a wide range of signal input levels. This unit has high-level and low-level inputs, which allow synchronization of the 38-kc. oscillator from pilot-carrier levels of 30 mv. and 10 mv. respectively. The over-all maximum gain of the adapter is 6 db through the high-level input and 15 db through the low-level input. There are individual channel level adjustments to set the gain to any desired value.



The measured frequency response of the MPX-100 was flat up to about 7 kc., rolling off at higher frequencies. The 15-kc. response was down 7.5 db on one channel and 13 db down on the other, due to the action of the 15-kc. low-pass filters in the output amplifiers. Channel separation was 35 db at low and middle frequencies, decreasing to about 30 db at 5 kc., 15 db at 10 kc., and 5 to 7 db at 15 kc. The noise filter, in position 1, reduced the separation to 5 to 10 db above 3 kc.

The separation control at the rear of the unit must be set for the particular tuner with which it is used. Approximate settings are given for a number of tuners in the instruction manual. Optimum adjustment requires listening to a stereo broadcast known to be on one channel only, and is quite critical. Fortunately, there is little loss of stereo effectiveness even with a considerable reduction in separation. This adjustment should be made with the adapter fully warmed up, since we observed some variation in separation during the first hour or so of operation.

We used the adapter with several older mono FM tuners, with uniformly excellent results. Owners of good mono tuners can convert them into top quality, fully flexible stereo tuners by the addition of this attractive, compact adapter.

Unit sells for $119.50, less cabinet. ▲

## Precision ES-150 Oscilloscope

*For copy of manufacturer's brochure, circle No. 60 on coupon (page 17).*

NOT too long ago a factory-wired oscilloscope with high sensitivity and wide bandwidth would have been fairly expensive. The Precision ES-150 is an extremely versatile scope with just these characteristics and at quite a moderate price. The instrument has a vertical-channel response all the way from d.c. (for very-low-frequency industrial measurements) up to about 5 mc. (for color-TV and other video waveforms). In addition to the usual controls, this scope has quite a few extras that increase its usefulness. These include a polarity-reversing switch, special fixed sweep positions for TV vertical and horizontal waveforms, provision for an external capacitor for very slow sweep speeds, front-panel Z-axis input and saw-tooth output, line-phasing control for sine-wave sweep, graticule illumination adjustment, and a built-in voltage calibrator.

Missing from the front panel is a sync amplitude control. This is because the scope employs automatic synchronization of all waveforms. To accomplish automatic sync, the sync signal is amplified and limited and then is applied to the sweep generator in order to lock it to the frequency of the waveform or to a submultiple of that frequency. Because of the limiting, the amount of sync signal is just sufficient to do its job well without producing the distorted waveforms that would occur with excessive sync.

The circuit is built around two printed boards on which are mounted all components except power-supply parts, the 5-inch CRT, and the operating controls. Signals are applied to the vertical amplifier through a four-step compensated attenuator. The amplifier itself is push-pull throughout, the first stage being a pair of pentodes, the second stage triode cathode-followers, and the last stage another pair of push-pull pentodes. Frequency compensation and direct coupling are used throughout in order to obtain wide-band response. The horizontal channel consists of a single-ended cathode-follower feeding a push-pull triode output amplifier stage. A multivibrator sweep generator is used to produce linear sweeps from about 10 cps to 100 kc. This circuit is synchronized by a pentode limiter-amplifier. A neon-lamp circuit is used to produce a 60-cps square-wave of 200 mv. (p-p) amplitude for voltage checks. A retrace blanking amplifier and high- and low-voltage rectifier tubes complete the circuit.

We were very pleased with the scope's performance on our bench. The needle-sharp trace was free from hum modulation and the sweep had good linearity even at the highest sweep speeds. There was plenty of gain to spare, even in the horizontal channel, so that the trace could be expanded to about twice the screen diameter and any part of the expanded waveform could be positioned on the screen for viewing. The automatic sync worked well even with the sweep generator operating at a far lower frequency than that of the incoming signal. There was some shift in the d.c. balance of the scope's vertical amplifier after a couple of hours of use. Although this could not be completely compensated with the front-panel d.c. balance screwdriver adjustment, there are internal bias adjustments that should take care of this.

We then proceeded to test the maximum vertical sensitivity of the scope. This checked out to be

24 mv. r.m.s. per inch of deflection, slightly better than the manufacturer's specification for a.c. sensitivity of 25 mv. r.m.s. per inch. Next, we checked the accuracy of p-p measurements taken with the scope by applying a wide range of sine-wave input voltages from about 1 v. p-p to several hundred volts. Although most of our readings were somewhat low, the accuracy was satisfactory for the usual service-type applications.

We then measured the frequency response of the vertical channel by applying a constant-amplitude 1 volt r.m.s. sine-wave signal to the scope. Although the scope's low frequency extends down to d.c. and, even with the built-in blocking capacitor switched in, the manufacturer claims response down to 1 cps, we checked down only to 20 cps, the low limit of our oscillator. Using unshielded leads to avoid capacitive loading, the scope measured flat from 20 cps all the way up to 2.5 mc. before a gradual roll-off began. At 3.58 mc., the color-burst frequency, response was down only 1½ db. At just over 4 mc., response was down about 3 db, and at 4.7 mc. it was down about 6 db. We then took measurements through a low-C probe and were able to extend high-frequency response slightly.

All in all, the ES-150 is a most useful and versatile instrument that will be invaluable to the technician in solving some of his TV "tough dogs" or in checking waveforms in industrial gear. The scope is priced at $149.95. ..... E.W.

"Are you the people who called Tip-Top TV Service?"

## Aids for the Blind

(*Continued from page 51*)

Amateur Award, and is editor of the Braille Technical Press.

The equipment, which is basically conventional test equipment to which has been added a bridge and tone generator, produces a null in tone when the bridge is balanced. In another type instrument a tone is produced, the frequency of which is proportional to the quantity being measured.

At the present time, a v.o.m., with all the ranges of a standard instrument and a sensitivity of 20,000-ohms-per-volt, is commercially available. It is shown in Fig. 3. The bridge circuits that produce the auditory output for current and resistance measurements are shown in A and B of Fig. 2. The instrument is operated in this manner: the function and range selector switches are positioned with the aid of Braille scales as they would be in a conventional instrument. Positioning the range switch roughly balances the bridge. The large center dial is then adjusted for final balance. When this is achieved, you no longer hear the sound produced by the chopper. The position of the large pointer over a Braille scale indicates the exact voltage, current, or resistance.

Fig. 3. Auditory v.o.m. has conventional ranges, 20,000 ohms-per-volt sensitivity.

In addition to this instrument, Bob has built a phase meter, "Q" meter, transistor checker, r.f. wattmeter, r.f. antenna bridge, an in-circuit capacitor checker, and a resonance meter using similar bridge/null circuits. In some instruments a small amplifier and speaker are used instead of phones so normal hearing would not be interfered with.

Because of this auditory test equipment, many blind technicians have been able to get jobs in the incoming inspection, test, and assembly departments of several large electronics firms throughout the country.

While work still remains to be done on the guidance aids, progress to date has been encouraging and offers hope for tomorrow. This, coupled with improved vocational opportunities made possible by special test equipment, is a gratifying sign of considerable progress in this area. ▲

# ELECTRONIC CROSSWORDS

By MARGARET LeFEVRE

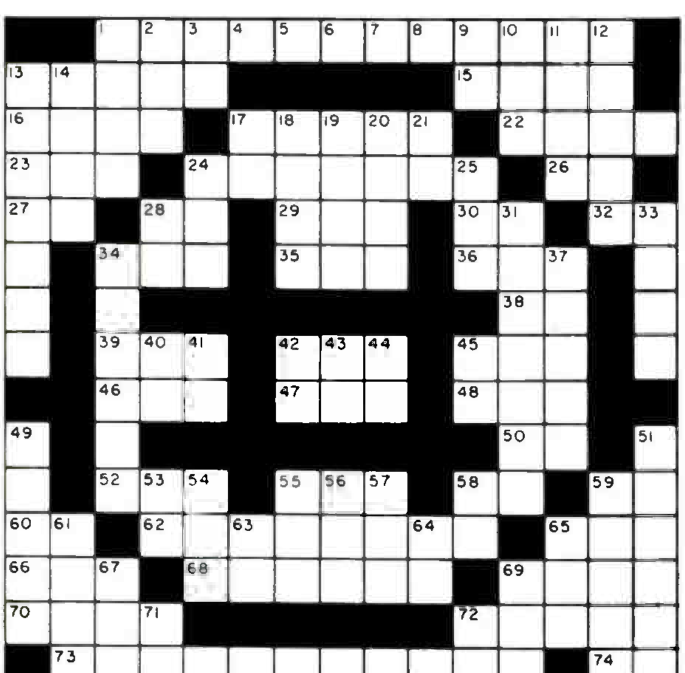
(*Answer on page* 120)

ACROSS

1. Means of obtaining desired frequency response.
13. A sudden increase in the amount of normally constant current.
15. Master oscillator—power amplifier (abbr.).
16. Formerly.
17. Television picture defect.
22. Prefix meaning $10^{-9}$.
23. Born.
24. High cyclic distortion.
26. Familiar circuit ratio (abbr.).
27. Symbol for target.
28. Medico.
29. Favorite grain in Scotland.
30. Chemical abbreviation.
32. Period of time (abbr.).
34. Channel for combining two stereophonic channels.
35. —— Prinz (foreign car).
36. Frequency (abbr.).
38. This thing.
39. Ovum.
42. Undesirable quality in a hi-fi system.
45. In whatever quantity or number.
46. Mathematical abbreviation.
47. Outside edge of turntable.
48. 1550 (Rom. numeral).
50. Fifty-one (Rom. numeral).
52. Unit.
55. Indium phosphide (abbr.).
58. English digraph.
59. Hawkeye State (abbr.).
60. No wire to this point (schematic notation).
62. Piezoelectric material (pl.).
65. Electronic locating device (abbr.).
66. Before (poetic).
68. Basic food.
69. Young cow.
70. To make an oscillating device come to rest.
72. Sheet on which the operating controls are mounted.
73. Device for combining two or more signals.
74. Second note of the scale.

DOWN

1. Otherwise.
2. General code call for ARRL members.
3. Vowel combination.
9. Abbreviation for transverse magnetic wave.
10. Charged atom.
11. Semiprecious stone.
12. System of visual communications using infrared rays.
13. Five-element tube.
14. Type of plastic used for radio cabinets.
17. Without place (abbr.).
18. Mu meson.
19. Greek letter (pl.).
20. Aleutian Island.
21. Chemical abbreviation.
24. Frequency-division multiplex (abbr.).
25. Legendary bird.
28. Greek letter.
31. Shaft for positioning the record on a turntable.
33. Container for magnetic tape.
34. "Dimensional" sound reproduction.
37. Phonograph needles.
40. Southern State (abbr.).
41. Chemical symbol.
42. Box score abbreviation.
43. Vowel combination.
44. Unit of measure (abbr.).
45. Type of transmission (abbr.).
49. Adjusted for resonance at a desired frequency.
51. Cabinet or partition used with a loudspeaker.
53. Schematic notation.
54. Those who perform (suffix).
55. Professional society (abbr.).
56. Normal pressure and temperature (abbr.).
57. Boon companion.
58. To such a degree.
59. Wheel used to transmit power from motor to turntable.
61. To stuff.
63. Part of Alaska (abbr.).
64. French adverb.
65. Fled.
67. Large, flightless bird.
69. Means of transportation.
71. More than one (abbr.).
72. An oil expert (abbr.).



# Short History of Semiconductors

By DON TAYLOR

Brief resume of some of the early uses of crystals that have led up to the modern transistor and diode.

THE formal study and investigation of semiconductors began in 1874, without fanfare, and without the elaborate tools of modern-day physics. Those were the days when lightning and solar radiation ruled the radio-frequency spectrum. Although this was 73 years before *Bell Labs* invented the first real transistor, men like Dr. Braun learned some amazing things about crystals.

Ferdinand Braun was born June 6, 1850. He received his PhD in 1872 at Berlin University. Later, he taught mathematics and physics at universities in Marburg, Carlsruhe and Strassburg.

Braun's fertile imagination turned to electricity and rocks in 1874. He studied the electrical properties of crystals of galena and other metallic sulphides. He found that these crystals exhibited a unilateral conductivity, that is, they had rectification properties. He looked further. He found that they showed no evidence of electrolytic conduction or of thermoelectric effects which would account for this one-way conductance. But man-made electromagnetic radiation had not yet been devised! So, with no radio-frequency signals to detect, Braun laid his crystals aside.

As early as 1835, Joseph Henry had observed, but could not explain, spark transmission and detection by coherence of a magnetic needle detector. In 1879, a vertical water jet was found to have a reaction (by molecular cohesion) to a charged sealing-wax stick. The water cohered by electrical disturbance. *ergo*, it detected electricity and could detect r.f. signals. Frog-leg nerves were used with some success as sensitive current meters; as such, they could detect the presence of an r.f. signal. But, of all things, a prehistoric tribolite probably utilized the first r.f. detector; it had an organic cavity in its skin which could detect lightning flashes.

An r.f. detector that retained popularity for many years was the coherer —made of substances that would cling together and change their internal conductivity in the presence of an r.f. signal. Metal filings in a glass tube cohered by molecular welding in an r.f. field, which lowered the impedance to a bias current through the coherer, but they had to be tapped to regain their previous high impedance. Marconi used the coherer as late as 1906.

Crystals abounded in nature. Galena could be found at the nearest lead mine; silicon literally lined the ocean beaches, but the hardy pioneers persisted in the use of other devices. Around 1900, responders were made of two metal plates placed very close together, with an intervening electrolyte which formed little bridges for low impedance conduction. These bridges were broken by boiling hydrogen in the electrolyte. The bridges would soon re-form, giving a detectable noise in a telephone receiver. Notice that this device provided a low impedance *until* it was disturbed by an r.f. signal. This was opposite to the cohered devices, and was naturally called an "anti-coherer."

Shortly after the turn of the century, L. W. Austin studied silicon-steel junctions. He found that an e.m.f. of 2.5 volts would pass 25 milliamps from steel to silicon, but would only pass 6 milliamps in the opposite direction. He concluded that silicon, at least with a steel junction, had rectification properties.

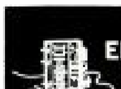
After these preliminary studies by Braun and Austin, little was done with crystals until about 1905. At this time, Braun made further studies of crystals, and persuaded the *Telefunken Radio* station to use psilomelane (hydrated barium manganate) as a detector. In this case, the crystal was placed between two metal electrodes under *light* pressure, and was one of the first commercial uses of the crystal detector. Still, few people had faith in crystals, probably because they did not understand them. What is the magical property of these rocks? How do they perform their mysterious task? The thermoelectric theory was popular, but it had many deficiencies.

Consider the crystal galena. It was used as a detector, rather infrequently, until about 1920, when germanium and silicon became predominant. Galena is a lead sulphide crystal, about 86% lead and 13% sulphur, with a trace of silver, or antimony, or gold, or selenium. Nothing really impressive. But today it is seen as an *n*-type crystal, having an excess of electrons in its internal structure.

Pierce, Dunwoody, Pickard, Eccles and other notable "radio engineers" studied crystals in the period from 1905 to 1910. In 1906, General H. H. C. Dunwoody studied carborundum (an artificial silicate of carbon). He found that it had unilateral conductivity, with or without a bias, and used it successfully as an r.f. detector. However, these men considered crystals as *thermal* detectors. A fine metal point was required to contact the crystal, and it was believed that this fine point heated the crystal in a small area and changed the impedance of the contact area. They used such devices as tellurium wire contacting galena, tinfoil-galena, graphite-galena, and other crystal-metal detectors.

The crystals worked fine; but there were complaints about their delicacy





and the difficulty of "tickling" them into operation. The crystals were far from pure and homogeneous. It took a steady hand to find a good semiconducting area. Since no one understood the crystal as a concept of pressure contact, it was pure coincidence that they got the right pressure and the right area.

Some later observations proved that pressure had some effect. A successful detector was made with a plumbago (graphite) point in *light* contact with a piece of galena. Amateurs used carborundum crystals in special jigs, and regulated the pressure by a thumbscrew until the signals in the telephone receivers were the loudest. Other crystals used in this period were galena, silicon, germanium, zirconium, chalcopyrites (copper iron sulphide), and many more. The best performers were those containing iron or sulphur.

In 1915, J. A. Fleming observed that rectification depended in some cases on a surface action and in others upon the internal structure of one of the materials. He suggested that a distinction be made between "surface" and "body" rectification. Another conclusion of this period was that oxygen and oxides were necessary at the contact area to produce rectification. This is seen today as a matter of providing an environment necessary to give the required pressure by the conducting wire. The pressure at the surface of the crystal changes the internal structure of the crystal in a small area.

And so it went. The crystal was good: it was bad; it was thoroughly understood; it was a complete mystery. As the 1920's roared and went, the "cat whisker" crystal detector bowed to the superior vacuum-tube diode.

About 1947, after much success in WW II as a radar wave detector, the marvelous crystal was taken into *Bell Labs* for study and experimentation. After much discussion, the following theory was expounded. The crystal, when refined, had certain impurities in it. Germanium, for example, had some impurities in it that gave it a slight excess of electrons when it was in a relaxed state. When pressure was applied with a metallic contact, the material suddenly developed a *deficiency* of electrons in the small area under pressure. This created a junction within the crystal between the region under pressure and the unstressed region. A second electrode (a metallic contact also providing slight pressure) was found to have the ability to control the action of the other junction. This effected amplification; a small input current controlled a large output current.

The point-contact transistor came into being. This electron-excess and electron-deficient condition was later reproduced *without* pressure in a crystal, and the junction transistor was born. The junction transistor is rugged, dependable, and reasonably inexpensive.

Much has been learned about the crystal since that first formal study, but even greater secrets remain locked in the rocks. ▲





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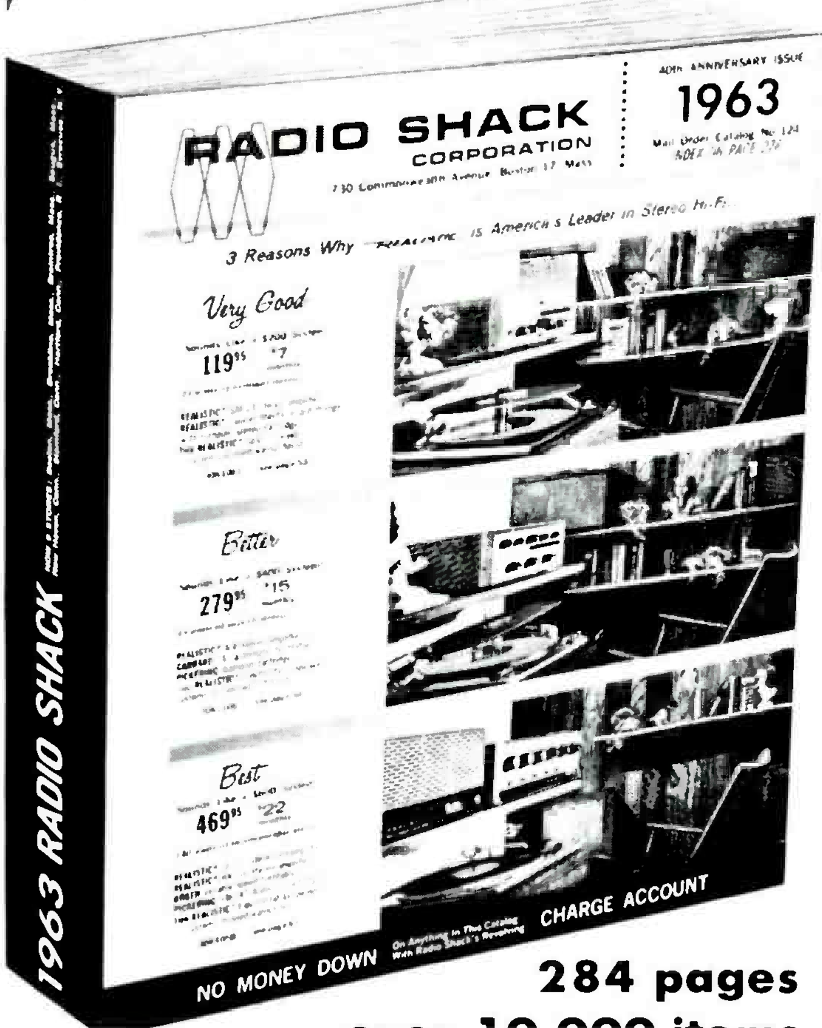


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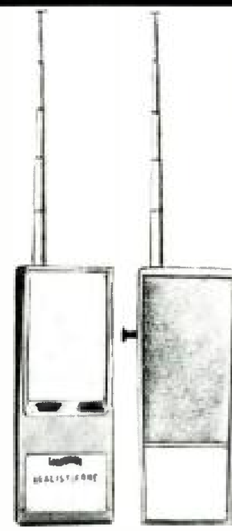

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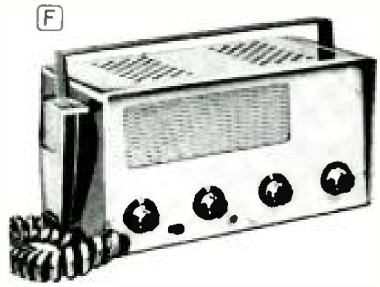

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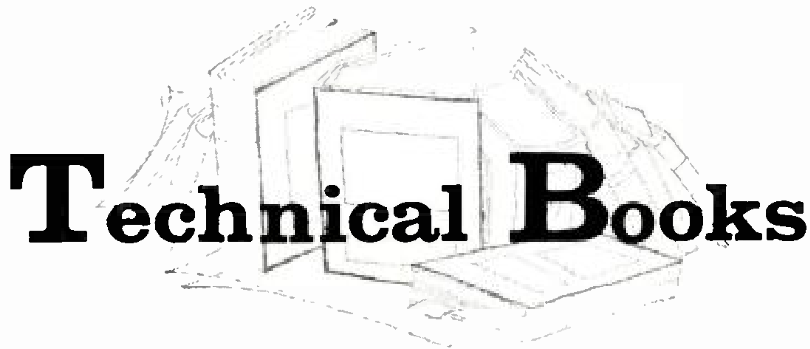

# Technical Books

**"SINGLE-SIDEBAND COMMUNICATIONS HANDBOOK"** by Harry D. Hooton, W6YTH. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 278 pages plus schematics. Price $6.95.

As the spectrum becomes more crowded those involved in communications are casting around for better ways of utilizing the available space. For this reason single-sideband stands a good chance of becoming more popular not only with amateur radio operators but with communications technicians and engineers.

The text, which is divided into thirteen chapters, covers the origins of SSB, derivation of signals, carrier-suppression techniques, sideband selection, carrier generators, speech amplifiers and filters, SSB generators, balanced mixers and converters, low-power SSB transmitters, linear r.f. power amplifiers, SSB communications receivers, tests and measurements, and trends. In addition the volume includes foldout schematics and hundreds of illustrations and circuit diagrams.

* * *

**"HIGH-QUALITY SOUND PRODUCTION AND REPRODUCTION"** by H. Burrell Hadden. Published by *Iliffe Books Ltd.*, Stamford Street, London S.E.1. Price 43 s/5 d by mail.

This is another in the *BBC* Training Manual series and covers the basic principles of sound and electricity, the theory of musical instruments, studio acoustics, studio equipment (microphones, speakers, studio control desks, remote broadcasting and p.a. equipment), microphone placement for different types of programming, volume control, and stereophony.

Although almost all of the equipment discussed is European in origin, the basic principles involved are universal hence this volume can prove valuable to U.S. broadcast engineers. The text is lavishly illustrated with line drawings and photographs of actual installations and equipment.

* * *

**"COMMUNICATIONS DICTIONARY"** by James F. Holmes. Published by *John F. Rider Publisher, Inc.*, New York. 88 pages. Price $1.50. Soft cover.

This handy little reference work contains more than 2500 terms in the field of telecommunications and data processing. Up to seven definitions are included for a single term to encompass all possible meanings for the word.

In addition to those actually working in the field, this volume will be of help to those who are only secondarily involved in telecommunications and/or data-processing equipment.

* * *

**"AVIATION ELECTRONICS HANDBOOK"** by Keith W. Bose. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 216 pages. Price $4.95. Soft cover.

This volume has been prepared for the benefit of aircraft owners, pilots, technicians, engineers, and others concerned with specifying, installing, and maintaining the electronic equipment in planes.

The text is divided into eleven chapters covering standard Comm/Nav systems, the aviation radio spectrum, communications systems, v.h.f. omnirange, instrument landing systems, automatic direction finders, distance-measuring equipment, radar beacon transponders, airborne radar, shop facilities and regulations, and aircraft installations.

In addition to providing complete instructions for the use, operation, and maintenance of such equipment, the book describes in detail many of the circuits used in the most popular commercial units.

* * *

**"TRANSISTOR RADIO SERVICING MADE EASY"** by Wayne Lemons. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 121 pages. Price $1.95. Soft cover.

This is a no-nonsense approach to the servicing of transistor receivers to eliminate waste motion and increase profits. Written by a practicing technician for the benefit of his fellow service technicians, the text is presented at a professional level and is designed for those with a good background in radio theory.

The twelve chapters provide basic coverage of transistors; mixer-oscillator circuits; i.f. circuits and their repair; detector and a.g.c. circuits; servicing the audio stages; over-all service techniques; rapid diagnosis and repair; alignment and tracking; repairing "under par" radios; noise, oscillations, squeals, and motorboating; tools and equipment; and where to get replacement parts, plus a list of the importers of Japanese transistor receivers.

* * *

**"COMPUTER ARITHMETIC"** by Henry Jacobowitz. Published by *John F. Rider Publisher, Inc.*, New York. 118 pages. Price $3.00. Soft cover.

Anyone involved with computers will probably find this small volume invaluable as a brush-up text on basic arithmetical operations of positional number systems. There are detailed explanations of the fundamental operations of binary, octal, hexadecimal, and ternary arithmetic and a variety of practice exercises by means of which the reader can test his comprehension.

* * *

**"TRANSISTOR CIRCUITS"** by Thomas M. Adams. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 132 pages. Price $2.95.

This is the fourth volume in this publisher's "Basic Electronics Series" which features the firm's unique four-color diagrams to explain circuit operation.

The text material is divided into five chapters covering transistor physics, basic transistor configurations, oscillator and amplifier circuits, and detector circuits.

While some prior experience with electronic circuitry would be helpful, this text is written in such a way that the volume can be used as a refresher for the experienced as well as a basic course for the beginner.

* * *

**"PRINCIPLES AND PRACTICE OF ELECTRICAL ENGINEERING"** by Alexander Gray & G. A. Wallace. Published by *McGraw-Hill Book Company*, New York. 592 pages. Price $9.50.

It will be good news to a new generation of students to know that this tried-and-true text has been revised and up-dated and offered in its Eighth Edition.

In keeping with the changing emphasis on electronics, the book has been revised to place new stress on semiconductors, junction rectifiers, transistors, and magnetic amplifiers as well as providing additional data on control circuits of various types.

Since this is primarily a classroom text, the volume carries a number of problems and experiments for the student, all of which have been re-evaluated and up-dated in the light of present practice.

* * *

**"RADAR POCKET BOOK"** by R. S. H. Boulding. Published by *D. Van Nostrand Company, Inc.*, Princeton, N.J. 244 pages. Price $4.50.

This small volume fills the need for radar information which was heretofore available only in bits and pieces from various sources.

The coverage is fairly complete and discusses the electronic principles and formulas forming the basis of radar, typical circuit diagrams of various units comprising a radar installation (transmitters, receivers, transmission lines, waveguides, cavity resonators, antenna systems, data transmission, servo systems, and cathode-ray tube and display systems), testing and required test gear, and a discussion of secondary radar.

For those involved in the design, installation, operation, or maintenance of radar gear, this handy manual should come as a blessing.

* * *

**"TUBE SUBSTITUTION HANDBOOK"** by Sams Staff. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 112 pages. Price $1.50. Soft cover.

This is Vol. 4, a completely up-dated and expanded handbook covering over 1400 more tubes than its predecessor volume. There are now 6627 recommended substitutes covering receiving tubes, industrial, foreign-to-U.S., U.S.-to-foreign, picture-tubes, and subminiature types.

Compact enough to be carried in the tube caddy or used on the service bench, this handbook should help speed repairs by eliminating delays involved when special tubes have to be ordered. ▲

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*The American Federation of Information Processing Societies has announced the availability of copies of its "Proceedings of the 1962 Spring Joint Computer Conference," a compilation of papers of interest to students of computers and technical libraries. Copies are available from The National Press, 850 Hansen Way, Palo Alto, Cal. $6.00 a copy, postage prepaid.*

# Calendar of Events

## OCTOBER 1-3

*Eighth National Communications Symposium.* Sponsored by PGCS, Rome-Utica Section of IRE. Hotel Utica & Municipal Auditorium, Utica, New York. Program details from George Baldwin, Paris Road, R.D. #2, Clinton, New York.

## OCTOBER 2-4

*Eleventh Annual Symposium on Space Electronics and Telemetry.* Sponsored by PGSET. Hotel Fontainebleau, Miami Beach, Fla. Program details from Otto A. Hoberg, George C. Marshall Space Flight Center, NASA Redstone Arsenal, Ala.

## OCTOBER 2-6

*New York Hi-Fi Show.* Sponsored by Institute of High-Fidelity Manufacturers, Inc. New York Trade Show Building. Open to public Oct. 3-6.

## OCTOBER 8-10

*National Electronics Conference.* Sponsored by IRE, AIEE, et al. McCormick Place, Chicago, Illinois. Dr. Thos. W. Butler, Jr., E.E. Dept., University of Michigan, Ann Arbor, Michigan, for program information.

## OCTOBER 12-13

*Seventh Annual Electronics Symposium.* Sponsored by North Carolina Section of IRE. Greensboro Coliseum, Greensboro, N.C. Program information from H. W. Augustadt, 2818 Regency Dr., Winston-Salem, N.C.

*19th Annual Meeting of American Medical Writers Assn.* Sheraton Park Hotel, Washington, D.C. Details from John Sargeant, Medical and Chirurgical Faculty of Maryland, 1211 Cathedral St., Baltimore 1.

## OCTOBER 15-17

*URSI-IRE Fall Meeting.* Sponsored by URSI, PGAP, CT, I, IT & MTT sections of IRE, PGGE. Ottawa, Canada. Program information from Dr. J. H. Chapman, Def. Res., Telecom Est., Shirley Bay, Ottawa, Canada.

## OCTOBER 15-18

*International Symposium on Space Phenomena and Measurement.* Sponsored by PGNS. Statler-Hilton Hotel, Detroit, Michigan. Program details from Michael Ihnat, Avco Corp., 201 Lowell St., Wilmington, Mass.

*1962 Instrument-Automation Conference & Exhibit.* Sponsored by ISA. New York Coliseum, New York City. Information from ISA, 530 William Penn Place, Pittsburgh 19, Pa.

## OCTOBER 15-19

*Fourteenth Annual Fall Convention & Exhibit.* Sponsored by Audio Engineering Society. Barbizon-Plaza Hotel, New York City. Program information from AES, P.O. Box 12, Old Chelsea Station, New York 11, N.Y.

## OCTOBER 19-20

*Denver Stereo Hi-Fi Show.* Writers' Manor Hotel, 1730 S. Colorado Blvd., Denver. Full details from Norman J. Murfield, Producer, 7930 Maria St., Westminster, Colo.

## OCTOBER 22-24

*East Coast Conference on Aerospace & Navigational Electronics.* Sponsored by PGANE and Baltimore Section of IRE. Emerson Hotel, Baltimore, Md. Details from W. C. Vergara, Dept. 466-2, Bendix Radio, Towson, Md. ▲

## Mac's Electronics Service

(*Continued from page* 40)

added a plus or minus 1 count error that is inherent in gate-and-count type of instruments. A maximum error of 9 cycles in 100,000,000 cycles is darned good counting in my book!"

"And in mine, too. I suppose the gate-time is regulated by the time-base."

"That's right. The gate can be held open for .001, .01, .1, 1, or 10 seconds or can be opened and closed manually. The read-out is in kilocycles, and the decimal point is moved automatically as the gate-time is shifted. For example, in reading a 10-mc. frequency with a 1-second gate-time, the counter reading would be 10000.000. At .1 second, it would be 010000.00; at .001 second it would be 00010000."

"Can the thing do anything else but check frequencies?"

"Oh yes. You remember my uncle could either count telephone poles for a given length of time or he could see how much time passed between mile posts. The 524C will do the same thing. You can reverse connections and feed a standard frequency from the time-base into the counter circuits while an unknown frequency is fed to the gate circuit. The gate is opened on one cycle of this unknown frequency and closed on the next. During the time the gate is open, the counters total the cycles of the standard frequency fed to it and display the count in time units of microseconds, milliseconds, or seconds with proper decimal notation. This method of measuring the period of a frequency gives more accurate results with very low frequencies.

"For that matter, the gadget will count pulses of any sort up to a maximum of 10.1 million per second. The gate can be opened and closed manually for any length counting period desired."

"I still don't understand your sudden interest in this rather exotic instrument."

"It's not so exotic. Now I can recognize them. I've seen several electronic counters by various manufacturers in the engineering departments of factories when I've been on industrial service calls. My thinking is this: the service technician of the future will be using such an instrument in his everyday work. True the price will have to come down some before he can afford one of these instruments, but that will happen. Already the use of transistors is making counters lighter and more compact. A new *Hewlett-Packard* unit, the 5243L, weighs less than 40 pounds and can be easily carried in one hand; yet it has a maximum counting rate of 20 mc. and retains the accuracy of the heavier, bulkier tube type.

"You've told me the cathode-ray oscilloscope was once considered an 'exotic' instrument; yet now it is a necessity. The same thing will happen to electronic counters. Think how nice it would be to be able to check quickly and really accurately the burst frequency of a color TV set or the critical output frequency of a signal generator. Electronic equipment is growing more complicated and sophisticated every day, and test equipment is going to have to keep pace."

Barney paused a few seconds and then went on:

"I think it does me good now and then to study and try to understand some of the wonderful things being done with electronics outside the field of radio and TV service. Whenever I start thinking I'm a hotshot electronics technician, all I have to do is take a look at some of the circuitry of that counter and this shrinks my ego back to size."

"That's the thing that counts!" Mac said with an approving grin. ▲

## Service Transistor Sets

(*Continued from page* 58)

of base, emitter, and collector voltages. 2. A far from normal base voltage usually means trouble in the base circuit. 3. An open emitter circuit causes a loss of forward bias between emitter and base. 4. An open collector circuit puts emitter and collector at the same voltage. 5. A leaky transistor will cause abnormally high collector current and may reduce or reverse the forward bias.

### *Checking Transistors*

Many service-type transistor testers are on the market. On the other hand, some receiver manufacturers recommend in their service data that such units should not be relied on. While the various checkers vary in their capability, we have often found transistors that operate satisfactorily in their circuits but test "bad." We prefer to rely on voltage measurements and elimination checks to spot a defective transistor quickly.

Resistance measurements also help. You can locate open base connections and, with experience, recognize excessive emitter-collector leakage. A transistor is actually two back-to-back diodes (Fig. 6) with the base common to each: the emitter-base and collector-base diodes. For each diode, your ohmmeter should measure a lower resistance with one polarity of the meter leads than is

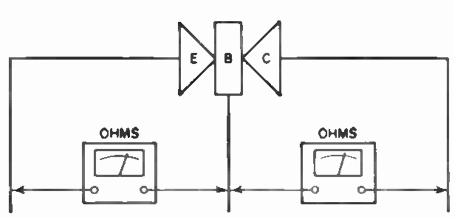



Fig. 6. Forward and reverse resistance of transistor "diodes" can be checked.

measured when the leads are reversed.

If both diodes have a high resistance without regard to polarity, the base is open. Emitter-collector resistance should be high in either polarity, but considerably higher in one direction than in the other. If a low emitter-collector resistance reading is obtained, the transistor is leaky. *(For an elaboration of this technique with a v.o.m., see "Transistor Test Techniques with an Ohmmeter," page 66, in our July 1962 issue. The different ohmmeter configuration used in most v.t.v.m.'s will alter typical readings, but the principle is the same.—Ed.)*

To use the ohmmeter, you must remove the transistor from the circuit, so it may be just as well to try a replacement transistor if one is handy.

### *Replacing Transistors*

If you do not have an exact duplicate for a suspected transistor, you may be able to find a satisfactory substitute. There is no interchangeability, of course, between *p-n-p* and *n-p-n* types. The voltage ratings for the substitute should not be exceeded by those applied in the circuit. The substitute should also be designed for the same type of service as the original. For example, replace a mixer with a mixer type, an i.f. unit with an i.f. transistor, and so on.

In a few cases, you may have to vary emitter bias, either to bring up gain or suppress oscillation, in the case of i.f. substitutes. If a new mixer does not oscillate in a *p-n-p* configuration like that of $V_1$ in Fig. 3, reduce value of the emitter resistor ($R_3$). The transistors shown in this conventional circuit are widely used types compatible to many receivers. It may facilitate substitution to know that they are solder-in versions of otherwise identical plug-in types: mixer, 2N411; i.f., 2N409; a.f., 2N407.

The troubleshooting chart in Table 1 is a convenient reference for many common troubles. It is referred to the typical circuit of Fig. 3. For the rest, remember that a good general procedure is to check batteries first and substitute a satisfactory supply, if necessary; confirm the customer's complaint; inspect for surface defects; localize trouble to a stage; and make voltage measurements with a v.t.v.m. to narrow down the defective part. ▲

"I have a feeling we lost the job the minute you kicked that cat."

## Transistors or Tubes for Hi-Fi?

*(Continued from page 33)*

amplifiers are being pushed to slightly overdriven peak signals. Here, the transistor unit has evidently greater clarity and performs more like a vacuum-tube unit with *twice* the output rating. This effect is primarily due to the lower driving impedance with negligible bias shift offered to the output transistors such that the overloaded signal has its peaks cleanly clipped. This condition is much less evident to the human ear than is the overload signal output of a vacuum-tube amplifier where the waveforms are collapsed and violently distorted in the central regions as well as on the waveform tips. This latter waveform distortion is clearly audible.

In tuner design, transistors can furnish performance almost equal to that of tubes in every respect. Unfortunately, however, some of the recent highly refined tube developments, which have assisted in obtaining such amazing performance in tuners, are lost to the designer using transistors. These include the use of a gated-beam limiter tube with its zero-time-constant limiting characteristic and, of course, the widely used tuning eye.

Finally, the audio technician, high-fidelity dealer, and customer will be immediately faced with less standardization of replacement transistors and greater dependence on the high-fidelity manufacturer for direct replacements. For example, despite the fact that the number of transistor manufacturers is nearing the hundred mark and the number of registered transistor types is up in the thousands, only a couple of these manufacturers offer the reasonably priced specialized types suitable for high-fidelity output stage design. Further, types finally selected for inclusion in amplifiers will undoubtedly carry type numbers unique with that particular design and not readily available at electronic parts distributors.

Furthermore, the amplifier designer will have to bear in mind that should an installation be operated carelessly with shorted speaker leads, the output transistor overload currents could be extremely high, endangering the weaker of these output transistors. Frequently if one of these output pairs fails for any reason, the other is likely to go bad soon afterward. Thus the owner is faced with a $25 replacement service charge which is hard to take even if it is due to his own negligence.

As the above indicates, there will inevitably be important changes in the high-fidelity industry as the audio dealer, manufacturer, and consumer make the gradual transition from tube to transistorized high-fidelity equipment. ▲

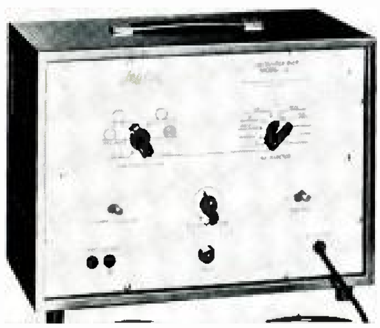
# New Products and Literature

*Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 17.*

### NTSC COLOR-BAR GENERATOR

1 **The Hickok Electrical Instrument Company** has recently introduced a new compact, lightweight, portable NTSC color-bar generator designed for use in the installation and maintenance of color TV receivers in the home or shop.

Known as the Model 661 "Chrom-Aligner," the



unit weighs just 9 pounds. It produces 100% saturated color bars to NTSC standards as well as all standard alignment signals, white dot, and cross-hatch patterns. It generates the following NTSC color signals: yellow, red, magenta, blue, cyan, and green as well as the standard alignment signals R-Y, B-Y —(G-Y), and G-Y at 90 degrees.

### ANTENNA COUPLERS

2 **Winegard Company** has announced a new series of low-cost v.h.f. TV and FM yagi antenna couplers which provide new flexibility of arrangement.

The 300-ohm couplers enable the dealer to make up his own combination of antennas on the same mast with a single down-lead running to the TV set or amplifier.

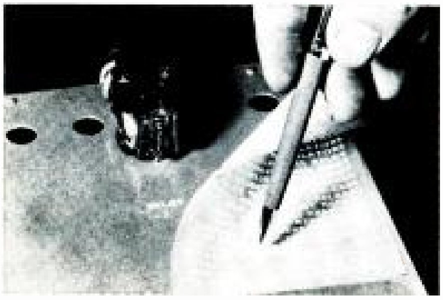
The couplers are available in 12 v.h.f. TV models (each individually tuned to a single channel) and in one FM model. The FM antenna coupler makes it possible to connect an FM antenna with a TV antenna on the same mast, running a single 300-ohm down-lead. The FM coupler can also be used as a "signal splitter" inside the house.

### INSTANT LETTERING

3 **The Datak Corp.** is handling the distribution of a new dry transfer lettering set which permits engineers, designers, manufacturers, technicians, experimenters to add a professional touch to their prototype equipment.

"Letraset," which requires no water, tapes, or screens, goes on quickly and adheres permanently. The letters can be placed on any surface such as glass, paper, wood, metal, and plastic.

Available in black or white printing, each set contains 24 sheets in 3" x 5" size with multiples



of hundreds of words in the area of electronics, ranging from "AC" to "Zooms." Each set gives up to 95% of all electronic panel markings. Complete sheets of alphabets and numerals are included for odd words and designations.

### POWER INVERTERS

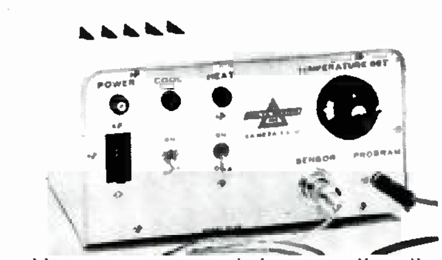
4 **Terado Corporation** has added two new power inverters to its line of emergency power sources. Known as the "Continental" series, the line includes the Models 50-191 and 50-202. Both units have copper-clad steel cases, come complete with remote control, cables, and battery leads. Both have electric fans for cooling. The Model 50-191 is 10¾" wide x 6" deep x 6" high while the 50-202 is 10¾" wide x 13" deep x 7¼" high.

The units convert 12 volts d.c. to 110 volts, 60 cycles. Remote control has a variable a.c. output switch and a signal light indicating proper a.c. output voltage. The output is completely filtered for use with tape recorders and the 60-cps frequency is maintained to an accuracy of ± 1 cps irrespective of changing load or input voltage. Both units are transistorized. The Model 50-202 has a capacity of 550-600 watts while the Model 50-191 will handle 275-300 watts.

### BRIDGE CONTROLLER

5 **Delta Design, Inc.** is offering a new solid-state temperature controller which combines advanced circuitry and a platinum resistance probe to give dependable temperature control.

A unique bridge arrangement compensates for




ambient temperature variations as well as line voltage fluctuations. A novel anticipator circuit prevents overshoot and virtually eliminates temperature offset when the heat load of the system is changed. The anticipator feature is adjustable.

### HIGH-SPEED DATA RECORDER

6 **RCA's** Surface Communications Division has announced the development of a "mile-a-minute" tape recorder which is capable of recording 15 channels of information on a tape running at a speed of nearly 60 miles an hour.

Developed for radar applications, the tape is guided through the recorder by compressed air to allow the seven miles of tape stored in the machine's 30-inch reels to travel at such a fast rate without undue mechanical wear.

"Emergency brakes" are automatically applied the moment trouble is sensed and, if the trouble is loss of power, an auxiliary air system is cut in.

### COLOR TV ANALYST

7 **B&K Division** has added a new color analyst to its line of equipment for the servicing and repair of electronic gear.

The Model 850 provides dot patterns, cross-hatch, vertical and horizontal lines, burst signal, and individual colors one at a time on the instrument panel and the color TV set for fast, easy

checking. Probing into the color set is eliminated.

A window-viewer on the front panel enables the technician to see each pattern and color as it should be. The instrument produces R-Y, B-Y, I, Q, burst, yellow, red, magenta, blue, cyan, and green. Color phase angles are maintained in accordance with NTSC specifications.

### U.H.F. TV TUNER

8 **General Instrument Corporation** is in production on a new u.h.f. tuner which is said to provide four times longer tube life with less drift than heretofore available.

The circuit incorporates a new miniaturized nuvistor tube, designed jointly by the company and **RCA** for the new circuitry and for operation at ultra-high frequencies. A new oscillator circuit in the tuner operates at only one-quarter the anode power previously required. In addition, a new tube basing in the tuner allows a more efficient arrangement of connections and a new tube retainer. The latter device is a ring which provides additional grounding at the periphery of the nuvistor tube in the form of extruded dimples.

### COMPACT CAPACITOR TESTER

9 **Watsco, Inc.** is now marketing a compact dynamic capacitor tester, the "Cappy" Model E-2. The instrument will test paper, Mylar, and electrolytic capacitors.


A three-range selector switch facilitates leakage detection in conformance with manufacturers' minimum specifications and standards. Leakage ranging from 1000 megohms to 5000 megohms is indicated.

In addition to dynamic testing of electrolytics, the unit can perform a quick and accurate check of silicon and selenium rectifiers, motor capacitors, r.f. high voltage, and insulation leakage of cable and appliances. It comes complete with a.c. cord and test leads.

### ELECTRONIC DIMMER

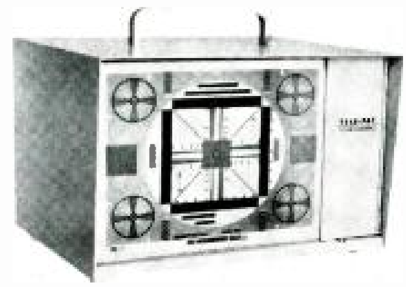
10 **Hunt Electronics Company** is now offering an electronic control to provide flexible, full-range dimming of all incandescent lighting fixtures up to 600 watts. The "Duo-Trol 600" will handle the control from any standard wall box without special wiring or separate attachments.


The unit is a solid-state full-wave proportional power control which conserves power in exact proportion to the light intensity used. It features a combination tap/dial which may be tapped on and off at any pre-dialed light level.

### TV ADJUSTMENT SLIDES

11 **Tele-Measurements, Inc.** has recently introduced a portable "Tele-Pat" system which is designed to improve television pickups through rapid and accurate signal evaluations and adjustments of all television performance characteristics in closed-circuit and broadcast TV, monochrome or color.

The system consists of six 8 x 10 precision test slides and a test pattern illuminator engi-



neered for proper display of the slides, irrespective of camera location. The illuminator, which provides uniform light intensity and correct color temperature, can be plugged into any 110-115 volt a.c. outlet and is equipped with a built-in dust-free slide storage space.

## HI-FI—AUDIO PRODUCTS

### ELECTRONIC COLOR ORGAN

12 **Colortron Company** is introducing a color organ designed to be used with the musical output of a speaker connected to any stereo or mono record or tape player, radio, electronic organ, or live music played through an amplifier.

The colors are in direct relation to the music.

Red lights respond to the high frequencies while green and blue lights are generated by the medium and low frequencies. The brilliance of light increases with volume of sound and a kaleidoscope of geometric patterns is created. The system operates from 115 volt a.c. power lines.

### CERAMIC STEREO CARTRIDGE

13 **Sonotone Corporation** has announced specifications on its new ceramic stereo phono cartridge, the 9TA. The new unit features extremely low stylus mass, high compliance, and critically correct vibration damping. According to the company, the cartridge has flat response ± 1 db over the entire audible recording range from 20-17,000 cps, with smooth roll-off beyond. Output voltage is 0.4 volt, compliance is 5.5 x $10^{-6}$ cm./dyne. Tracking pressure is as little as 2 grams for professional arms and 3 grams for changers. Channel separation is 30 db.

### STEREO PLAYBACK DECK

14 **Lafayette Radio Electronics Corporation** has added a stereo playback tape deck, the RK-141WX to its line.

The two-speed deck is equipped with its own six-transistor dual stereo playback preamplifiers that are equalized to the NAB curve. Hum and noise levels are engineered to professional standards.

Frequency response is 50-15,000 cps ± 2.5 db

at 7.5 ips and 50-9000 cps ± 2.5 db at 3.75 ips. Wow and flutter is 0.15% at 7.5 ips and .2% at 3.75 ips. The deck operates from 110-120 volts, 60 cycles only. It measures 14⅜"x5"x10⅛" and comes complete with hookup cables. A walnut base or portable carrying case is available at extra cost.

### HIGH-VOLUME P.A. SYSTEM

15 **Perma-Power Company** is in production on a new high-volume portable public-address system which is housed in a single case. Known as the "Roving Rostrum," the system is battery operated and weighs under 30 pounds. It has a 10-watt push-pull amplifier of all-transistor design and comes with an Astatic dynamic low-impedance microphone with response of 60-10,000 cps. The two loudspeakers are 6" x 9" units with 10-ounce ceramic magnets. Either speaker can be used alone or they can be used together for greater audience coverage. Each speaker can handle full amplifier power.

### MULTIPLEX FILTER

16 **Viking of Minneapolis** is now in production on an LC-type low-pass filter for use in the music system to eliminate distortion and interference when tape recording from FM multiplex stereocasts.

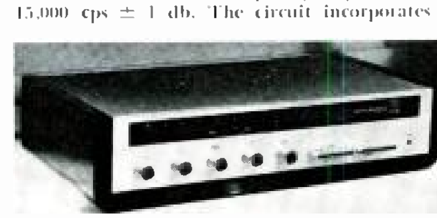
Designated Model MX-10, the filter removes all extraneous signals produced by the interaction of the 38-kc. FM multiplex carrier or other r.f. interference with the bias oscillator of the tape recorder or recording amplifier. The filter passes the multiplex signal but provides sharp cut-off at 20 kc.

The unit is designed for patch-cord connection between the output jacks of any stereo FM tuner and the high-level or tuner inputs of a high-fidelity tape recorder. The filter has no adjustments or controls.

### TRANSISTORIZED MULTIPLEX TUNER

17 **Omega Electronics Corporation** has announced the development of an all-transistor FM-multiplex tuner, the Model 1650.

IHFM usable sensitivity is 1.8 μv., stereo separation is 33 db, while frequency response is 30-15,000 cps ± 1 db. The circuit incorporates a

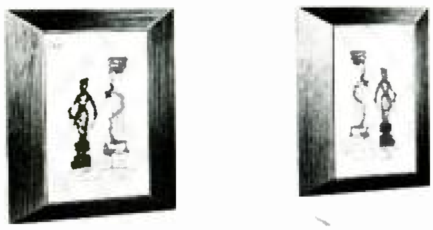


subcarrier filter for tape recording off the air, an SCA filter, and three limiters. There are seven front-panel controls, four indicators, and three outputs including a switched a.c. outlet. Antenna is 300 ohms balanced and 75 ohms coaxial. The unit also incorporates a built-in antenna for strong-signal areas.

The instrument uses 28 transistors and 23 diodes. It is housed in a cabinet 3"x 15½"x 9". The tuner operates on 117 volt, 60-cycle a.c.

### ULTRA-THIN SPEAKER SYSTEM

18 **University Loudspeakers** has just introduced the "Syl-O-Ette" two-way speaker system which measures 23" wide x 29" high x 4" deep. The system is housed in an "art frame" cabinet with tapered, sloping front to provide a three-



dimensional appearance. The enclosures offer a choice of easily interchangeable grille fabric frames including floral designs, silk-screened neo-classic art grilles, and decorator cane.

The speaker system incorporates an 8" woofer, special 6½" mid-range, and subsidiary tweeter-radiator. Frequency response is 40-20,000 cps and the system will handle 30 watts maximum of integrated program material. The speakers can be driven by amplifiers of as little as 10-watt rating.

### STEREO TAPE RECORDER

19 **3M Revere Camera Co.** has just introduced the "Wollensak 1580," a stereo unit which will record and play back stereo sound. It incorporates two identical record and playback amplifiers, plus two matching, self-contained speakers. The system provides 22 watts of audio power output, 11 watts per channel.

Frequency response is 40-18,000 cps ± 3 db at 7.5 ips and 40-13,000 cps ± 3 db at 3.75 ips (NAB standard equalization). The unit will handle 2-

and 4-track stereo and mono record-playback; sound-on-sound; operates by means of four tab controls; has automatic shut-off; and independent volume control on each channel.

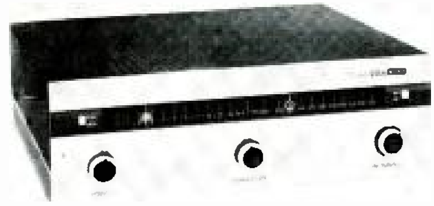
The instrument comes with two microphones, a slip-over vinyl protective cover, and accessory cords.

### FM MULTIPLEX TUNER

20 **Eico Electronic Instrument Co., Inc.** has just added the ST97 FM multiplex stereo tuner to its line of high-fidelity components available in both kit and factory assembled form.

Frequency response is 20-15,000 cps ± 1 db; IHFM usable sensitivity is 3 μv. for 30-db quieting and 1.5 μv. for 20-db quieting. Input is 300 ohms balanced. The IHFM signal-to-noise ratio is −55 db, channel separation is 30 db, with harmonic distortion 0.6% and IM distortion 0.1%. There are five controls, 13 tubes, 6 signal diodes, and a neon lamp. The automatic stereo indicator and station tuning indicator travel in tandem on twin slide-rule dials.

No test or alignment instruments are needed



by the kit builder since the front-end and the four-i.f.-stage circuit board are pre-wired and pre-aligned for fringe area reception.

### REMOTE SPEAKERS

21 **Oxford Electric Corp.** is now offering two new speakers, an 8¼" and a 12", which incorporate the "hidden magNet" feature. The ceramic magnet is mounted between the basket and the cone in conventional design permitting use of a dual cone for extended range. The speakers are designed to fit into any narrow space or area, being especially suited for narrow walls, stereo wings, and picture frame mountings.

The speaker is designed with solderless metal binding posts with green dot indication to show voice-coil start for phasing. The baked enamel wrinkle gray finish will not chip, crack, or flake.

### PORTABLE P.A. SYSTEM

22 **Wm. A. Holmin Corp.** has recently introduced a portable, transistorized, and completely self-contained public address system.

Featuring two high-efficiency trumpet-type speakers, the unit is fully weatherproofed and temperature compensated. It may be used indoors

or out and, since the volume is controllable, it is suitable for small groups as well as large gatherings.

The system is equipped with a new type of noise-cancelling microphone which minimizes feedback problems and enables the operator to use the full 20 watt peak power of the system. The Model 120 consists of microphone, transistor amplifier, speakers, and battery power supply all in one unit. It weighs 12 pounds and measures 8" high x 11" deep x 14¾" wide. It can be tripod mounted or carried by its handle or over the shoulder.

### INTERCOM SYSTEMS

23 **Webster Electric Co.** has announced a new series of compact intercom systems for office and plant applications.

The Series 1500 is housed in an all-metal, dust-protected cabinet, has a spring-loaded rotary talk-listen switch, interconnections for as many as 144 stations, and high-power switch for contacting noisy areas.

The Series 2700 is an administrative model with printed circuitry, a three-position spring-load rotary talk-listen switch with provision for remote relay, and facilities for connecting from 6 to 60 or more stations. The cabinet is walnut-finished wood.

The Series 3900 "Executive" line has the same

features as the Series 2700 but includes a built-in microphone atop the cabinet.

### SPEAKER BAFFLE LINE

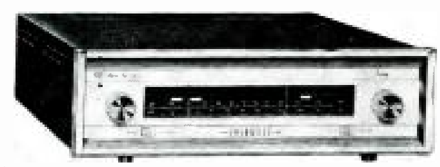
24 **Wald, Inc.** has added to its line of speaker baffles and enclosures for sound systems in homes, offices, and commercial buildings.

All of the 23 models now available feature ease of installation. The baffles have a one-piece plaster ring for new construction, incorporating flanges that nail directly to adjoining studs. Baffle mounting tabs are located away from the plastering area to prevent plaster fill up. On existing construction, the ring has retaining tabs that bend to the thickness of the plaster. All models are available as baffles only or as complete assemblies of baffle with speaker and components, pre-wired and ready to install.

### AM-FM-MULTIPLEX TUNER

25 **Sherwood Electronics Laboratories, Inc.** is now in production on the Model S-2100 AM-FM-multiplex tuner. The circuit features the company's "Stereo-lite" which indicates when a multiplex signal is being broadcast.

Other features include a 1-mc.-wide ratio detector, a light-bar tuning indicator, flywheel tun-



ing, front-panel-controlled a.f.c., FM interchannel hush, and wide/narrow AM selectivity.

IHFM sensitivity is 1.8 $\mu v$. for noise and distortion 30 db below 100% modulation. AM sensitivity is 2 $\mu v$. at 60% modulation for .5 volt output and 6-db S/N ratio. Response is 20-20,000 cps ± ½ db on FM, 20-15,000 cps ± ½ db on multiplex, and 20-7500 cps @ — 6 db in the wide-band AM mode. The instrument is housed in a 14" x 4" x 12½" walnut-tone leatherette case.

### SMALL FULL-RANGE SYSTEM

26 **Neshaminy Electronic Corp.** is now marketing a compact new high-fidelity speaker system which is being marketed as the Z-500.

Featuring the JansZen electrostatic mid/high range tweeter paired with a special 11" Model 350A dynamic woofer, the system covers the range from 30-30,000 cps. A special reflective tweeter housing provides a unique way of acoustically "curving" the flat surfaces of the electrostatic radiator. It provides broad 72-degree sound dispersion and high electrical efficiency.

The cabinet measures 23¾" long x 13½" high x 11⅜" deep. It is available in oiled or lacquered walnut, mahogany, maple, or birch finishes.

### AUDIO ROBOT

27 **Royce Electronic Developments, Inc.** has come out with a new remote-control device, for use with high-fidelity systems, which is being marketed as the "Audio Robot."

The unit controls the on-off switch of any mono or stereo hi-fi component from an extension or remote speaker. The basic system consists of a robot control and a remote-control unit. The robot control is installed at the main system while the remote control, which has a light to indicate when the power is on, is installed in a room where an extension speaker is located.

### TRANSISTORIZED P.A. AMPLIFIER

28 **Harman-Kardon, Inc.** has recently introduced a new line of transistorized public-address equipment which is being marketed as the "Troubador" series.

Currently available are the Model TR-1 15-watt and the Model TR-2 30-watt amplifiers both designed for mobile, portable, and general use on 6 to 15 volts d.c. Plug-in converters are available to adapt these amplifiers to a.c. operation.

Model TR-1 includes a microphone and a music channel, both of which can function simultane-

ously. The TR-2 is a four-channel amplifier. Both units incorporate facilities to turn the amplifiers on and off from the microphone or other remote locations.

## CB-HAM-COMMUNICATIONS

### CB TRANSCEIVER

29 **International Crystal Manufacturing Co., Inc.** has brought out a new CB transceiver, the Model 100A, which features a transistor power supply for improved reliability in mobile operation.

The new unit incorporates a crystal filter for improved reception, twelve crystal-controlled transmit positions, two crystal-controlled receive positions, dual-conversion superhet receiver tuning 23 channels, built-in calibration circuit, provision for connecting external speaker and "S" meter, push-to-talk operation; and a transistorized power supply that operates from 6/12 volts d.c. or 115 volts a.c.

### MONITOR RECEIVERS

30 **Hammarlund Manufacturing Company, Inc.** has announced the availability of two new low-cost monitor receivers for high- and low-band use. Designated the MR 51X (147 to 174 mc. on any single channel) and the MR 61X (25 to 54 mc. on any single channel), both units are crystal-fixed to any predetermined channel within their respective frequency ranges. If more than one channel is required, an optional channel selector kit may be added, permitting the selection of up to 6 channels within 1% of channel frequency.

### PERSONAL PAGING RECEIVER

31 **General Electric Company** has developed a new pocket radio receiver which permits both tone signalling and voice messages in a single unit.

This v.h.f.-FM personal paging receiver has been called "Message Mate." It is fully transistorized and measures .8" wide x 1.06" thick x 5.1" long. It weighs 10 ounces. The unit will operate with any standard FM radio base station from 15 to 330 watts. It is compatible with and can be tied into conventional low- or high-band two-way FM radio systems. When the paging system is combined with the company's new "Encoder 100" selective calling system, the user is first alerted by the sound of a tone and then receives his voice message through the same receiver.

### BASE-STATION TRANSMITTER

32 **Browning Laboratories, Inc.** is now marketing a new economy priced base-station transmitter which is designed to be used with the firm's R-2700-A base-station receiver.

Tradenamed "Compact," the new unit delivers a clear powerful signal with 100% modulation

and 5-watt input power. Also included are an efficient pi-network assuring maximum transfer of energy to the antenna, self-contained audio circuitry, crystal-controlled transmitting channels, push-to-talk ceramic microphone, on-the-air indicator, and front-panel switching of ten channels with an auxiliary socket for seldom-used frequencies.

### BASE-STATION ANTENNAS

33 **Communication Products Company** has announced the availability of four new broadband base-station antennas, each antenna consisting of an array of four radiating elements mounted on a 2⅜" o.d. by 5/32" wall 6061T6 aluminum support pipe fed by a sealed binary phasing and matching harness.

The folded dipole radiating elements are made of solid aluminum rod mounted on high-strength pressure-cast-aluminum alloy bases. The radiating element assemblies are attached to the support pipe with 5/16" stainless steel hex head machine screws.

The four units in the line cover: 148-162 mc., 6-db omnidirectional; 160-174 mc., 6-db omnidirectional; 148-162 mc., 9-db offset; and 160-174 mc., 9-db offset.

### DEPTH FINDER

34 **The Bendix Corporation** has added the Model DR-20 "White Line" depth recorder to its line of marine navigation and safety equipment.

The new unit was developed primarily for fishermen to distinguish schools of fish near the bottom at depths up to 200 fathoms. The "White Line" feature clearly defines the bottom as a thin dark line followed by a blank portion or white area. Echoes from fish near the bottom will show up in a normal manner as a dark trace above the bottom.

Four scales of 50 fathoms give a total range of 200 fathoms on a 7" chart. In addition, the range selector can be placed in the "all" position for

coverage of the entire 200-fathom range. The heavy cast aluminum case is waterproofed to permit mounting on an open bridge or other unprotected location.

### UNIVERSAL CB TESTER

35 **Globe Electronics** is now offering a new signal optimizer and universal tester for Citizens Band equipment. Designed to provide a complete check of CB installations and to provide maximum performance and utilization of equipment, the instrument tests and checks such features as antenna power in watts, modulation, field strength, antenna output, harmonics, standing-wave ratio, base-station and mobile-antenna efficiency.

The instrument is housed in an 8½" x 5" x 1⅞" portable case that weighs no more than two pounds.

### MIKES FOR MOBILE USE

36 **The Astatic Corporation** has just released two new microphones designed especially for mobile applications.

The Model 511 is a ceramic unit with push-button operation. It features high output ranging from −52 db below 1 volt dyne cm.², with a ceramic element able to withstand a temperature range from −40 to +300 degrees F.

The second unit, Model 513H, is a dynamic type with push-button operation, high impedance, high output, and constructed of high-impact plastic with spun aluminum grille. The unit is designed to be operated either horizontally or vertically.

## MANUFACTURERS' LITERATURE

### TESTER BROCHURE

37 **RD Instruments Division** is offering a new 8-page technical brochure which describes its Model 1885 dynamic beta power transistor tester. The two-color brochure, RD1885, includes technical specifications, simplified schematic diagrams, and circuit descriptions of the beta and leakage tests, the variable duty cycle pulsing system, and the variable power supplies.

### MINIATURE SLIDE SWITCHES

38 **Oak Manufacturing Co.** has prepared a four-page brochure which highlights a new series of low-cost miniature slide switches.

The brochure lists general features of the Series 200, choice of models, electrical ratings, operating characteristics, dimensions, performance tolerances, plus special options. A detailed schematic of the Series 200 is included.

### CCTV MONITORS

39 **Kin Tel Division** has issued a single-page data sheet describing its closed-circuit TV monitors.

The two-color sheet (6-256) describes twelve monitors from 14 to 21 inches with complete specifications, dimensions, and performance.

### D.C. TORQUE MOTOR

40 **Aeroflex Laboratories Incorporated** is offering a new brochure giving full technical and application data on its brushless d.c. torque motor.

In addition to describing the equipment in detail, the publication lists such applications as direct-drive servo motors and tachometers, actuating devices for gimbals, control instruments, aerospace control surfaces, and remote-positioning devices and a multi-input summing transducer.

### CABLE TIES AND CLAMPS

41 **Panduit Corporation** has published Bulletin SS-1 which describes a new method of cabling by means of its "Sta-Strap" tools, ties, and clamps.

The brochure gives details on the method of using the products and lists the military specifications met by the products.

### POWER-SUPPLY CATALOGUE

42 **Perkin Electronics Corporation** is offering copies of its new illustrated catalogue covering an extensive line of d.c. power supplies. The publication lists new silicon controlled rectifiers-transistor series regulated TVCR and TVR type d.c. supplies of advanced circuit design. In addition, the catalogue shows MTR magnetic transistor series regulators, magnetic amplifier transistor preamplifier regulated units, and semi-regulated power supplies for industrial applications.

### INDUSTRIAL MICROPHONE

43 **The Astatic Corporation** has issued a comprehensive bulletin covering its new Model 551 industrial microphone. The two-color data sheet gives complete details including impedance, transformer, immersibility, ease of cleaning, impedance change on service, type of switch, blast-proof feature, and temperature resistance. Complete mechanical and electrical characteristics, including a polar pattern, are also given.

### SHIELDED SWITCHING DEVICE

44 **Cooke Engineering Co.** is now offering a four-page illustrated folder which describes in detail its Model 22B "Cojax," a miniaturized shielding switching device for entering coaxial or shielded transmission lines.

Dimensionss and performance characteristics are included.

### TAPE RECORDER DATA

45 **Citroen Electronics** has literature available on its new portable two-speed, remote-control tape recorders which it will supply on request. The bulletin details specifications on the Models 550 and 660 tape recorders and available accessories which include an a.c. adapter, foot control for stenographic use, and auto cigarette lighter adapter.

### MILITARY DIODES

46 **National Transistor** has just issued a two-page data sheet describing a line of military type "Gold Bonded" germanium diodes. Specifications are given for seven diodes including the JAN-1N128, 1N198, 1N270, 1N276, and 1N277. Absolute maximum ratings and performance characteristics are given for all seven types in addition to the mechanical characteristics. The catalogue is identified as AM-100.

### CONTROL & TORQUE SYNCHROS

47 **Vernitron Corp.** is supplying detailed specifications on its Size 23 60-cycle "Thru-Bore" synchros for servo applications in a new data sheet CS/TS 5-23-1.

More than 25 vital characteristics are listed for transmitters, transformers, differential transmitters, and receiver transmitters, all engineered and manufactured to MIL-S-20708A specifications. Schematics, with dimensions, show body terminal block, spline, and other data.

### TRANSISTORIZED POWER SUPPLIES

48 **Electronic Research Associates Inc.** has issued a short-form catalogue (No. 1208) listing over 100 types of transistorized power supplies, modular power sources, laboratory power supplies, transistor test equipment, power simulators, and control accessories.

The information is provided in concise tabular form and the products covered are illustrated.

### TAPE DEGAUSSERS

49 **Aerovox Corp.'s Hi-Q Division** has issued an information bulletin describing in detail three models of tape and film degaussers. Data on the Types 9205A, 61221, and 8905 is provided with mechanical and electrical specifications included.

### DIRECTION FINDER DATA

50 **Bendix-Marine** has issued a four-page, two-color brochure which describes its recently introduced automatic visual radio direction finder in considerable detail.

In addition to providing complete specifications on the instrument, the brochure pictures typical installations, front panel view with controls pinpointed, and CR tube patterns under different operating conditions.

### WING-NUT CATALOGUE

51 **Central Screw Company** has released an 8-page, three-color catalogue which illustrates and describes standard and special low-cost versions of stamped and pressed wing nuts for a wide variety of applications.

Charts and diagrams show wing spread, wing height, wing base, stock thickness, and thread sizes suitable for manufacture in both steel and brass and the weights per 1000 pieces.

### PARABOLIC REFLECTORS

52 **The Conics Co.** has prepared a four-page brochure which describes and pictures several of its "off-the-shelf" sizes of parabolic reflectors and details its facilities for the rapid custom fabrication of special purpose curves based on conic sections, either concave or convex. While the company is prepared to make reflectors for any purpose, it specializes in paraboloids and ellipsoids designed for use in sound and ultrasonics. ▲

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### Answer to Electronic Crosswords

(Appearing on page 103)

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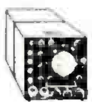

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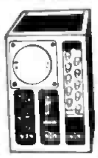
Conversion instructions for 110V 60 cys. AC ........ 65¢

## SPECIAL! BC-603 FM RECEIVER



**CONVERTED FOR FREQ. RANGE 35 to 50 Mc. BRAND NEW! Checked out, perfect working condition, ready for operation. Continuous or Push-button tuning in 35 to 50 Mc. range. SPECIAL** .......... **$34.50**

EXTRA SET OF 10 TUBES FOR ABOVE brand new in original boxes ........ $3.95

**FT-237 MOUNTING BASE** for BC-603 Rcvr and BC-604 Xmitter. Brand New ........ $5.95

12 or 24V Dynamotor for Above. Exc. Used $4.25 ............ Brand New $5.50

**BC-683 FM Receiver.** 27 to 38.9 Mc. Complete with all tubes. Exc. Used ........ $33.33

**4-Section Antenna for BC-603. 683 Receivers.** Complete with mounting base. BRAND NEW ........ $4.95

**AC POWER SUPPLY FOR BC603. 683**

Interchangeable, replaces dynamotor. Has On-Off Switch. NO RECVR CHANGE NEEDED. Provides 220 VDC @ 80 Ma. 24VAC @ 2 Amps ........ $12.95

**Complete 240-page Technical Manual for BC-603. 604** ........ $3.15

**BC-604 TRANSMITTER**—Companion unit for BC-603 Rcvr. above. With all tubes. BRAND NEW $8.95
**4-Section Antenna for BC-604. 684 Transmitters.** Complete with mounting base. BRAND NEW ........ $4.95
We carry a complete line of spare parts for above.

## TS-100AP 'SCOPE

EXC. USED (worth $750)
OUR LOW PRICE **$39.50**
Brand New $69.50

Can be used with linear sweep or general purpose test scope. Cables included. Also used with circular sweep as precision range calibrator. Self-contained in metal case 8" x 12½" x 16" deep. For 110 V 50 to 1200 cycles AC. Excellent used, like new, with all tubes including crystals and C.R. Tube.

## LM FREQUENCY METER

Crystal calibrated modulated. Heterodyne. 125 Kc to 20,000 Kc With Calibration book. **Complete. Like New** ........ $58.50

## BC-906 FREQ. METER—SPECIAL

Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. **BRAND NEW. OUR LOW PRICE** ........ $11.88

## BC-221 FREQUENCY METER

**SPECIAL BUY! This excellent frequency standard is equipped with original calibration charts, and has ranges from 125 Kc to 20,000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book. Crystal. and all tubes—LIKE NEW!**

Unmodulated $72.50 Modulated ........ $99.50
BC-221 1000 Kc Crystal Brand New ........ $8.95

## TS-16/APN TEST SET

For aligning and calibration of radio altimeters. May be used to check calibration of count or circuits and modulator sweep freq. and bandwidth of transmitter. Audio-oscillator range: 340 to 7250 cycles. 24 V.D.C. input. Complete with tubes, connecting cables, instruction summary. **BRAND NEW** ........ $14.50

**TEST SET TS-175/U.** Portable crystal controlled heterodyne type unit used in field testing of CW or MCW RF Transmitters and Signal Generators. Range 85 to 1000 Mc. Power requirements: 6V DC and 135 VDC. Exc. Cond. ........ $169.50

**TEST SET TS-174/U** Frequency Meter similar to above but for 20 to 250 Mc. Power Input 3.5V DC and 121.5 V DC. Exc. Cond. ........ $169.50

**TS-170/ARN-5 TEST OSCILLATOR**, portable, battery-operated, crystal controlled, for frequencies: 332.6 Mc., 338.6 Mc., and 335 Mc. Power input 1.5 VDC and 90 VDC. Less Batteries. Exc. Cond. ........ $22.50

## SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New **$27.50**

## WESTERN ELECTRIC MERCURY RELAY

Single Pole Double Throw. 4500 ohm coil with 24 volt heater. Operating Current: 8 Ma. Release Current: 5.2 Ma. High Pressure Hydrogen Sealed. Uniform high speed operation assured even at subzero temperatures by heater enclosed in housing. Western Electric #D-171584. (equivalent to 275-D) **BRAND NEW** ........ $2.95

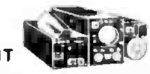
**SCHEMATIC DIAGRAMS** For most equipment on this page, each ........ 65c

## ATTENTION: IMPORTERS-EXPORTERS of ELECTRONIC EQUIPMENT

We specialize in the export of electronic equipment, Parts, and Electronic Tubes at LOWEST prevailing prices. All packing and shipping is made directly from our own warehouses in NYC, to give you substantial savings in handling costs! Your inquiries invited.

## LORAN APN-4

### FINE QUALITY NAVIGATIONAL EQUIPMENT



Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.

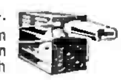
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes. Exc. used $49.50

Receiver-Indicator as above, BRAND NEW $88.50

INVERTER POWER SUPPLY for Loran. Made by Eclipse—Pioneer Div. INPUT: 24 V DC @ 75 A. OUTPUT: 115 V AC @ 10.5 Amps. 800 cycles. Complete with two connecting plugs BRAND NEW $49.50

12-Volt Inverter Power Supply, Like New. P.U.R.
Shock Mount for above ........ $2.95
We carry a complete line of spare parts for above.

## LORAN R-65/APN-9 RECEIVER & INDICATOR



Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. Exc. used.

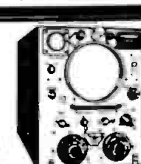
Value $1200.00. Our Price ........ $79.50

Used, less tubes, crystal and visor, but with 3BP1 C.R. tube $29.50

INVERTER POWER SUPPLY. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. BRAND NEW ........ $49.50

12-Volt Inverter Power Supply, Like New ... P.U.R.
Shock Mount for above ........ $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of spare parts for above.

## LORAN APN/4 OSCILLOSCOPE



Easily converted for use on radio-TV service bench.
LIKE NEW! Less tubes, but including 5" Scope, type 5CP1 only ...... $14.50

## BENDIX DIRECTION FINDERS

For commercial navigation on boats.

MN26Y 150-325 Kc: 325-695 Kc: 3.4-7 Mc. Complete with tubes, dynamotor. BRAND NEW ........ $19.50
MN28Y Receiver Control Box ........ $ 4.95
MN26C Receiver 150-1500 Kc continuous tuning with 12 tubes and dynamotor. Used ........ 18.95
MN26C Receiver as above. BRAND NEW ........ 27.50
MN20E Rotatable Loop for above ........ 4.95
MN52 Azimuth Control Box ........ 2.95

## SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

| Type | Description | Used | Like NEW |
|---|---|---|---|
| BC-453 | Receiver 190-550 KC | $12.95 | $14.95 |
| BC-454 | Receiver 3-6 Mc | 12.45 | 17.95 |
| BC-455 | Receiver 6-9 Mc | 11.50 | 13.95 |
| 1.5 to 3 Mc. | Receiver Brand New | | $17.95 |

**110 Volt AC Power Supply Kit, for all 274-N and ARC-5 Receivers.** Complete with metal case, instructions ........ $8.95
Factory wired, tested, ready to operate .. $12.50

**SPLINED TUNING KNOB** for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. Only ........ 49c

2.1 to 3 Mc. Transmitter, Brand New ........ $12.95

**BC-457 TRANSMITTER**—4-5.3 Mc. complete with all tubes and crystal, BRAND NEW ........ $9.75
Like New ........ $7.95

**BC-458 TRANSMITTER**—5.3 to 7 Mc. Complete with all tubes and crystal.
BRAND NEW ........ $10.95
Like New ........ $7.95

**T19 TRANSMITTER** ¾ m.c. complete with all tubes and crystal. Exc. Used ........ $9.95

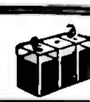
**BC-696 TRANSMITTER** 3-4 Mc Complete with All Tubes & Crystal. Like New ........ $11.95

BC-456 Modulator ........ USED 3.45 NEW 5.95
**MD7 Modulator**, Like New ........ $9.95
ALL ACCESSORIES AVAILABLE FOR ABOVE

## 2 VOLT BATTERY "PACKAGE"

1—2V. 20 Amp. Hr. Willard Storage Battery. Model #20-2. 3" x 4" x 5½" high ........ $2.79
1—2V. 7 prong Synchronous Plug-in Vibrator ........ 1.49
1—Quart Bottle Electrolyte (for 2 cells) ........ 1.45
**ALL BRAND NEW!** Combination Price ........ $5.45

## WILLARD 6-VOLT MIDGET STORAGE BATTERY



3 Amp. Hour. **BRAND NEW.** 3⅝" x 1-13/16" x 2⅜". Uses Standard Electrolyte ........ Only $2.95

Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50c Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse, N.Y.C. All Merchandise subject to Prior Sale and Price Change.

## G & G RADIO SUPPLY CO.

Telephone: CO 7-4605
77 Leonard St.
New York 13, N. Y.

## AN/ART-13 100-WATT XMTR

11 CHANNELS
200-1500 Kc
2 to 18.1 Mc

**$69.50** exc. used

Complete with Tubes

Famous Collins Autotune Aircraft Transmitter. AM, CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PP811s modulate 813 in final up to 90%, class "B." A Real "HOT" Ham buy at our low price! Orig. cost $1800.

**AN/ART-13 XMTR as above. Like New** .. $79.50

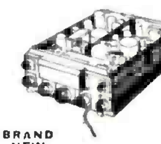
0-16 Low Freq. Osc. Coil for ART-13 ........ 7.95
24V Dynamotor for ART-13 ........ 11.95
Same as above less meter ........ 39.50
We carry a complete line of spare parts for above.

**APR-1** Navy VHF-UHF radar search Receiver, 80 Mc to 950 Mc in 2 bands. **BRAND NEW** ........ $79.50
**TUNING UNITS** for above: TN1, TN2, TN3, **BRAND NEW**, each ........ $39.50

**AN/APR-4 RECEIVER** only, 38 to 1000 Mc in 5 tuning unit ranges. High precision lab instrument. Input 115 V60 cy. **Like New** ........ $79.50
Tuning Units TN16, 17, 18 each ........ $39.50
Tuning Unit TN19, **Brand New** ........ $89.50
Tuning Unit TU54 ........ $149.50

## FAMOUS BC-645 TRANSCEIVER

### 15 Tubes 435 to 500 MC



Can be modified for 2-way communication, voice or code, on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.

BRAND NEW

Shipping weight 25 lbs. **SPECIAL!** .... **$19.50**

**PE-101C Dynamotor.** 12/24V input ........ $7.95
**UHF Antenna Assembly** ........ 2.45
**Complete Set of 10 Plugs** ........ 5.50
**Control Box** ........ 2.25

**SPECIAL "PACKAGE" OFFER:**
BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE, BRAND NEW. While Stocks Last ........ **$29.50**

## APN-1 FM TRANSMITTER-RECEIVER

420 to 460 Mc Aircraft Radio altimeter equipment. Tubes: 4-955, 3-12SJ7, 4-12SH7, 2-12H6, 1-VR150; Complete with tubes, brand new **$9.95**
APN-1 exc. Used ........ $6.95

## RCA GEIGER COUNTER MODEL WF-16A

Highly sensitive portable instrument, uses bank of ten bismuth-type Geiger-Counter Tubes, measures up to 200,000 counts per minute in three ranges. A professional tool: measures 11-4-7/8x7⅛". Wt. approx. 8 lbs. with batteries. Original List Price $750.00.

**BRAND NEW. Complete. our price. Special** $89.50

## LIMITED QUANTITY SPECIALS!

**BC-312 MOBILE RECEIVER** 6 bands, 1500 Kc to 18 Mc. With Tubes and 14 V Dynamotor. Like New $79.50
**BC-312 for AC operation** ........ $89.50

**BC-348 SUPERHET RECEIVER** 200 to 500 Kc and 1.5 to 1800 Mc. Voice, Tone, CW. Self contained dynamotor for 24 V DC. Like New ........ $89.50

**AN/APT-5 AIRBORNE RADAR SET**, with tubes, Like New ........ $49.50

**TG-34A KEYER**, exc. used, like new ........ $24.50
**Complete set of 15 code practice tapes. New.** P.U.R.

## MOBILE-MARINE DYNAMOTOR

### Model DM35

Input 12V DC. Output: 625 V DC @ 225 Ma. for press-to-talk intermittent operation. Shpg. wt. 14 lbs.

**BRAND NEW** ........ **$14.95**

**OTHER DYNAMOTOR VALUES:**

| Type | Input | Output | Excellent Used | BRAND NEW |
|---|---|---|---|---|
| DM-32A | 28V 1.1A | 250V .05A | 2.45 | 4.45 |
| DM-33A | 28V 5A | 575V .16A | | |
| | 28V 7A | 540V .25A | 1.95 | 3.75 |
| DM-34D | 12V 2A | 220V .080A | 4.15 | 5.50 |
| DM-53A | 28V 1.4A | 220V .080A | 3.75 | 5.45 |
| DM-64A | 12V 5.1A | 275V .150A | | 7.95 |
| PE-73C | 28V 20A | 1000V .350A | 8.95 | 14.95 |
| PE-86 | 28V 1.25A | 250V .050A | 2.75 | 3.85 |

**DM-42A DYNAMOTOR.** Input 12 V DC @ 36 Amps. Output 515 V DC @ 215 Ma, and 1030 V DC @ 260 Ma. Wt. 38 lbs. BRAND NEW, each ........ $6.95

**DM-37 DYNAMOTOR.** Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each $3.25

## CARTER GENEMOTOR

INPUT: 5.9 V DC @ 32 Amps.
OUTPUT: 405 V DC @ .270 Amps.
**BRAND NEW, special** ........ $8.95

## MICROPHONES

| Model | Description | EXC. USED | BRAND NEW |
|---|---|---|---|
| T-17D | Carbon Hand Mike | $4.45 | $7.95 |
| RS-38 | Navy Type Carbon Hand Mike | 3.95 | 5.75 |

## HEADPHONES

| Model | Description | Excellent Used | BRAND NEW |
|---|---|---|---|
| HS-23 | High Impedance | $2.19 | $4.49 |
| HS-33 | Low Impedance | 2.69 | 4.59 |
| HS-30 | Low Imp. (featherwt.) | .90 | 1.65 |
| H-16 U | High Imp. (2 units) | 3.75 | 7.95 |

**TELEPHONICS**—600 ohm Low Impedance HEADSETS. BRAND NEW. PER PAIR ........ $3.25
**CD-307A** Cords, with PL55 plug and JK26 Jack .99
Earphone Cushions for above—pair ........ .50

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## Gives You More For Your Money!

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**TERMS: 25% deposit must accompany all orders, balance C.O.D. Orders under $5: add $1 handling charge plus postage. Orders over $5: plus postage. Approx. 8 tubes per 1 lb. Subject to prior sale. No C.O.D.'s outside continental U.S.A.**

**EACH TUBE ATTRACTIVELY BOXED & BRANDED RAD-TEL**

| Qty. Type | Price | Qty. Type | Price | Qty. Type | Price | Qty. Type | Price |
|---|---|---|---|---|---|---|---|
| 0Z4 | .79 | 6AU8 | .87 | 6K6 | .63 | 12CU5 | .58 |
| 1AX2 | .62 | 6AV6 | .41 | 6S4 | .52 | 12CU6 | 1.06 |
| 1B3 | .79 | 6AW8 | .90 | 6SA7GT | .99 | 12CX6 | .54 |
| 1DN5 | .55 | 6AX4 | .66 | 6SH7GT | 1.02 | 12D4 | .69 |
| 1G3 | .79 | 6AX5 | .74 | 6SJ7 | .88 | 12DE8 | .83 |
| 1J3 | .79 | 6BA6 | .50 | 6SK7GT | .95 | 12DL8 | .88 |
| 1K3 | .79 | 6BC5 | .61 | 6SL7GT | .84 | 12DQ6 | 1.04 |
| 1R5 | .77 | 6BC8 | 1.04 | 6SN7GT | .65 | 12DS7 | .84 |
| 1S5 | .75 | 6BE6 | .55 | 6SQ7 | .94 | 12DT5 | .76 |
| 1T4 | .72 | 6BF5 | .90 | 6T4 | .99 | 12DT7 | .79 |
| 1U5 | .65 | 6BF6 | .44 | 6T8 | .85 | 12DT8 | .78 |
| 1X2B | .82 | 6BG6 | 1.70 | 6U8 | .83 | 12DW8 | .89 |
| 2AF4 | .96 | 6BH8 | .98 | 6V6GT | .54 | 12DZ6 | .62 |
| 3AL5 | .46 | 6BJ6 | .65 | 6W4 | .61 | 12ED5 | .62 |
| 3AU6 | .54 | 6BJ7 | .79 | 6W6 | .71 | 12EG6 | .62 |
| 3AV6 | .42 | 6BK7 | .85 | 6X4 | .41 | 12EK6 | .62 |
| 3BC5 | .63 | 6BL7 | 1.09 | 6X8 | .80 | 12EL6 | .50 |
| 3BN6 | .75 | 6BN6 | .74 | 7A8 | .68 | 12EZ6 | .57 |
| 3BU8 | .78 | 6BQ6 | 1.12 | 7AU7 | .65 | 12F8 | .66 |
| 3BY6 | .58 | 6BQ7 | 1.00 | 7EY6 | .75 | 12FA6 | .79 |
| 3BZ6 | .56 | 6BU8 | .70 | 7Y4 | .69 | 12FM6 | .50 |
| 3CB6 | .56 | 6BX7 | 1.11 | 8AU8 | .90 | 12FR8 | .97 |
| 3CS6 | .58 | 6BZ6 | .55 | 8AW8 | .93 | 12FX8 | .90 |
| 3DG4 | .85 | 6BZ7 | 1.03 | 8BQ5 | .60 | 12GC6 | 1.06 |
| 3DK6 | .60 | 6C4 | .45 | 8CG7 | .63 | 12J8 | .84 |
| 3DT6 | .54 | 6CB6 | .55 | 8CM7 | .70 | 12K5 | .75 |
| 3GK5 | .99 | 6CD6 | 1.51 | 8CN7 | .97 | 12L6 | .73 |
| 3Q4 | .63 | 6CG7 | .61 | 8CS7 | .74 | 12SF7 | .69 |
| 3S4 | .75 | 6CG8 | .80 | 8EB8 | .94 | 12SK7 | .95 |
| 3V4 | .63 | 6CL8 | .79 | 8FQ7 | .56 | 12SL7 | .80 |
| 4BQ7 | 1.01 | 6CM7 | .69 | 9CL8 | .79 | 12SN7 | .67 |
| 4CS6 | .61 | 6CN7 | .70 | 11CY7 | .75 | 12SQ7 | .91 |
| 4DT6 | .55 | 6CQ8 | .92 | 12A4 | .60 | 12U7 | .62 |
| 4GM6 | .60 | 6CR6 | .60 | 12AB5 | .60 | 12V6 | .63 |
| 5AM8 | .79 | 6CS6 | .57 | 12AC6 | .55 | 12W6 | .71 |
| 5AN8 | .90 | 6CS7 | .69 | 12AD6 | .57 | 12X4 | .47 |

**RAD-TEL TUBE CO. NOT AFFILIATED WITH ANY OTHER MAIL ORDER TUBE COMPANY**

| Qty. Type | Price | Qty. Type | Price | Qty. Type | Price | Qty. Type | Price |
|---|---|---|---|---|---|---|---|
| 5AQ5 | .54 | 6CU5 | .58 | 12AE6 | .50 | 17AX4 | .67 |
| 5AT8 | .83 | 6CU6 | 1.08 | 12AE7 | .94 | 17DQ6 | 1.06 |
| 5BK7 | .86 | 6CY5 | .70 | 12AF3 | .73 | 18FW6 | .49 |
| 5BQ7 | 1.01 | 6CY7 | .71 | 12AF6 | .67 | 18FX6 | .53 |
| 5BR8 | .83 | 6DA4 | .68 | 12AJ6 | .62 | 18FY6 | .50 |
| 5CG8 | .81 | 6DE6 | .61 | 12AL5 | .47 | 19AU4 | .87 |
| 5CL8 | .76 | 6DG6 | .62 | 12AL8 | .95 | 19BG6 | 1.39 |
| 5CQ8 | .84 | 6DJ8 | 1.21 | 12AQ5 | .60 | 19EA8 | .79 |
| 5EA8 | .80 | 6DK6 | .59 | 12AT6 | .50 | 19T8 | .85 |
| 5EU8 | .80 | 6DN6 | 1.55 | 12AT7 | .76 | 21EX6 | 1.49 |
| 5J6 | .72 | 6DQ6 | 1.10 | 12AU6 | .51 | 25AX4 | .70 |
| 5T8 | .86 | 6DT5 | .81 | 12AU7 | .61 | 25C5 | .53 |
| 5U4 | .60 | 6DT6 | .53 | 12AV6 | .41 | 25CA5 | .59 |
| 5U8 | .84 | 6DT8 | .94 | 12AV7 | .82 | 25CD6 | 1.52 |
| 5V6 | .56 | 6EA8 | .79 | 12AX4 | .67 | 25CU6 | 1.11 |
| 5X8 | .82 | 6EB5 | .73 | 12AX7 | .63 | 25DN6 | 1.42 |
| 5Y3 | .46 | 6EB8 | .94 | 12AY7 | 1.44 | 25EH5 | .55 |
| 6AB4 | .46 | 6EM5 | .77 | 12AZ7 | .86 | 25L6 | .57 |
| 6AC7 | .96 | 6EM7 | .82 | 12B4 | .68 | 25W4 | .68 |
| 6AF4 | 1.01 | 6EU8 | .79 | 12BD6 | .50 | 32ET5 | .55 |
| 6AG5 | .70 | 6EV5 | .75 | 12BE6 | .53 | 35C5 | .51 |
| 6AH4 | .81 | 6EW6 | .57 | 12BF6 | .60 | 35L6 | .60 |
| 6AH6 | 1.10 | 6EY6 | .75 | 12BH7 | .77 | 35W4 | .42 |
| 6AK5 | .95 | 6FG7 | .69 | 12BK5 | 1.00 | 35Z5 | .60 |
| 6AL5 | .47 | 6FV8 | .79 | 12BL6 | .56 | 36AM3 | .36 |
| 6AM8 | .78 | 6GH8 | .80 | 12BQ6 | 1.16 | 50B5 | .69 |
| 6AQ5 | .53 | 6GK5 | .61 | 12BR7 | .74 | 50C5 | .53 |
| 6AS5 | .60 | 6GK6 | .79 | 12BV7 | .76 | 50EH5 | .55 |
| 6AT6 | .49 | 6GN8 | .94 | 12BY7 | .77 | 50L6 | .61 |
| 6AT8 | .86 | 6H6 | .58 | 12BZ7 | .86 | 70L7 | .97 |
| 6AU4 | .85 | 6J5GT | .51 | 12CN5 | .56 | 117Z3 | .85 |
| 6AU6 | .52 | 6J6 | .71 | 12CR6 | .67 | 807 | .75 |

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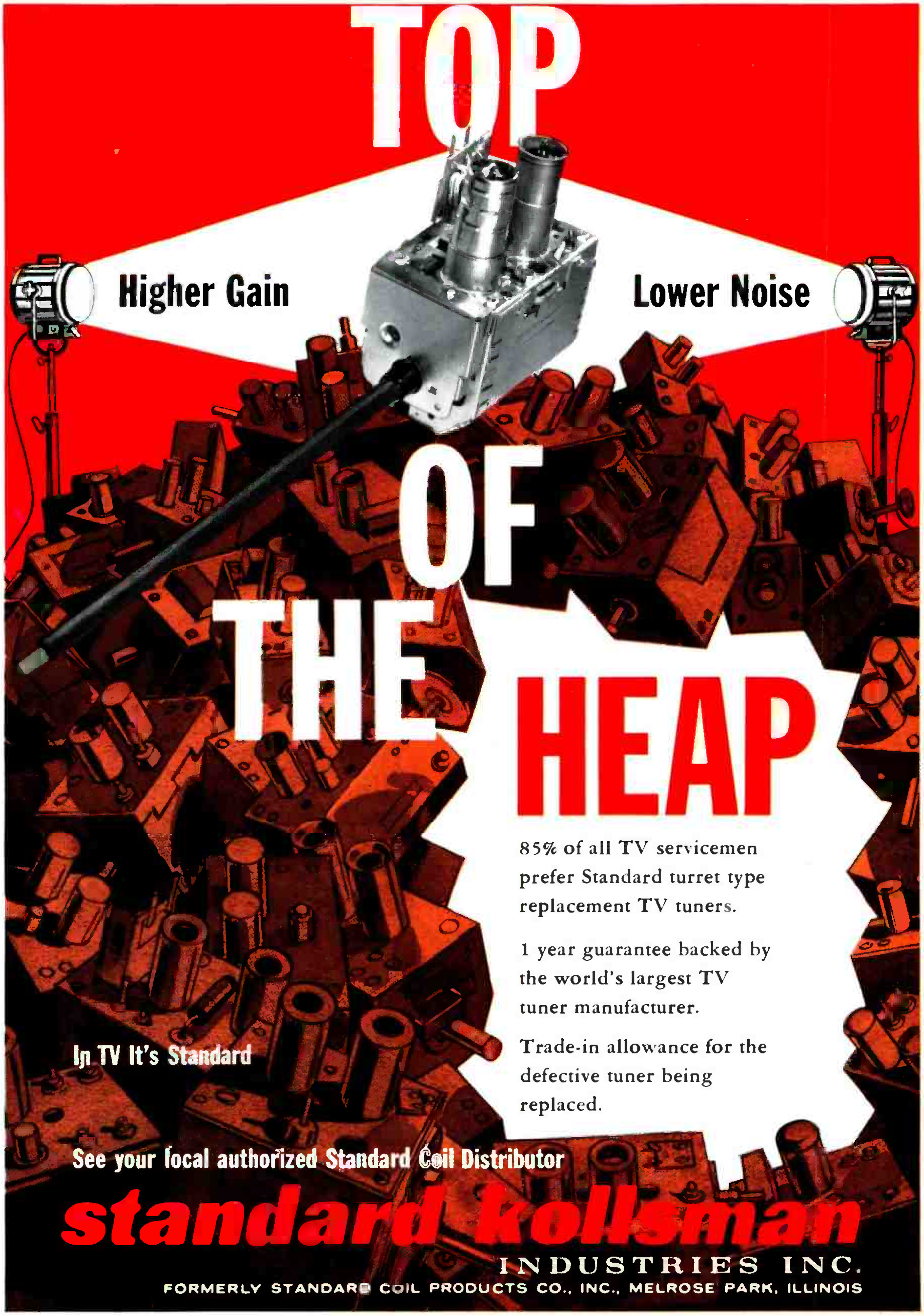


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# Get Extra Value at No Extra Cost

## with this RCA WV-38A (K)

# VOLT-OHM-MILLIAMMETER KIT

Now you can get a professional-caliber V-O-M in kit form. Enjoy the self-satisfaction and sensible savings that kit assembly offers you. No professional know-how required. Clear step-by-step directions to follow. The result: years of precision service at low cost.

Whatever your reason for choosing a V-O-M kit, there's one basic reason for making that choice an RCA WV-38A (K)... extra value at no extra cost. Want examples?

- Extra 0.25-volt and 1-volt ranges
- Frequency response of low a-c ranges is flat within 1 db to 800,000 cycles
- Spring clips on handle for extra carrying convenience
- Jacks below switches keep leads out of way
- DB scale clearly marked: no squinting
- Easy-to-read meter measures 5" wide
- Non-breakable, sealed plastic window
- Red test lead has probe and slip-on alligator clip for added versatility

RCA WV-38A available factory-wired and calibrated: $43.95*

ONLY **$29.95***

Attractive, scuff-resistant laminated-vinyl carrying case, $4.95* extra

## OTHER OUTSTANDING RCA KIT VALUES

RCA WV-77E (K)

### VOLTOHMYST® KIT

Famous VoltOhmyst® quality and performance at a low price! Special test features include: separate 1.5-volt rms and 4-volt peak-to-peak scales for accurate low AC measurements. Tests AC and DC voltages to 1500 volts; resistance from 0.2 ohm to 1000 megohms. Complete with ultra-slim probes, long flexible leads, special holder on handle to store leads.

ONLY **$29.95***

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RCA WO-33A (K)

### SUPER-PORTABLE OSCILLOSCOPE KIT

Here is a rugged, compact oscilloscope that weighs only 14 pounds. Easily portable for in-the-home or shop troubleshooting. Ideal for servicing black-and-white and color TV, radio, hi-fi components, tape recorders, etc. Ample gain and bandwidth for the toughest jobs. 3" graph-scale screen and internal calibrating voltage source for direct reading of peak-to-peak voltage.

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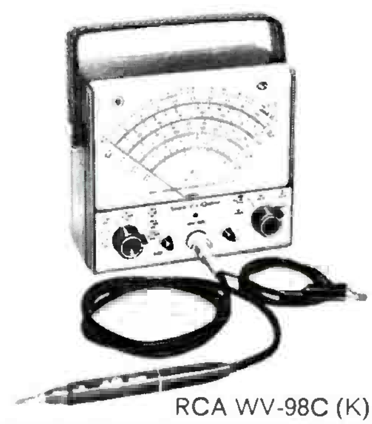

RCA WV-98C (K)

### SENIOR VOLTOHMYST® KIT

A new 0.5-volt full-scale DC range permits accurate measurement of low voltages used in transistor circuits. AC DC-ohms probe comes completely assembled at no additional cost. Separate color-coded scales measure DC voltages, 0 to 1500 volts; AC voltages, 0 to 1500 volts rms or 4200 volts peak-to-peak. Resistance from 0.2 ohm to 1000 megohms. 200-microampere meter movement with less than 1% tracking error. Precision multiplier resistors accurate to ± 1%.

NEW LOW PRICE **$57.95***

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