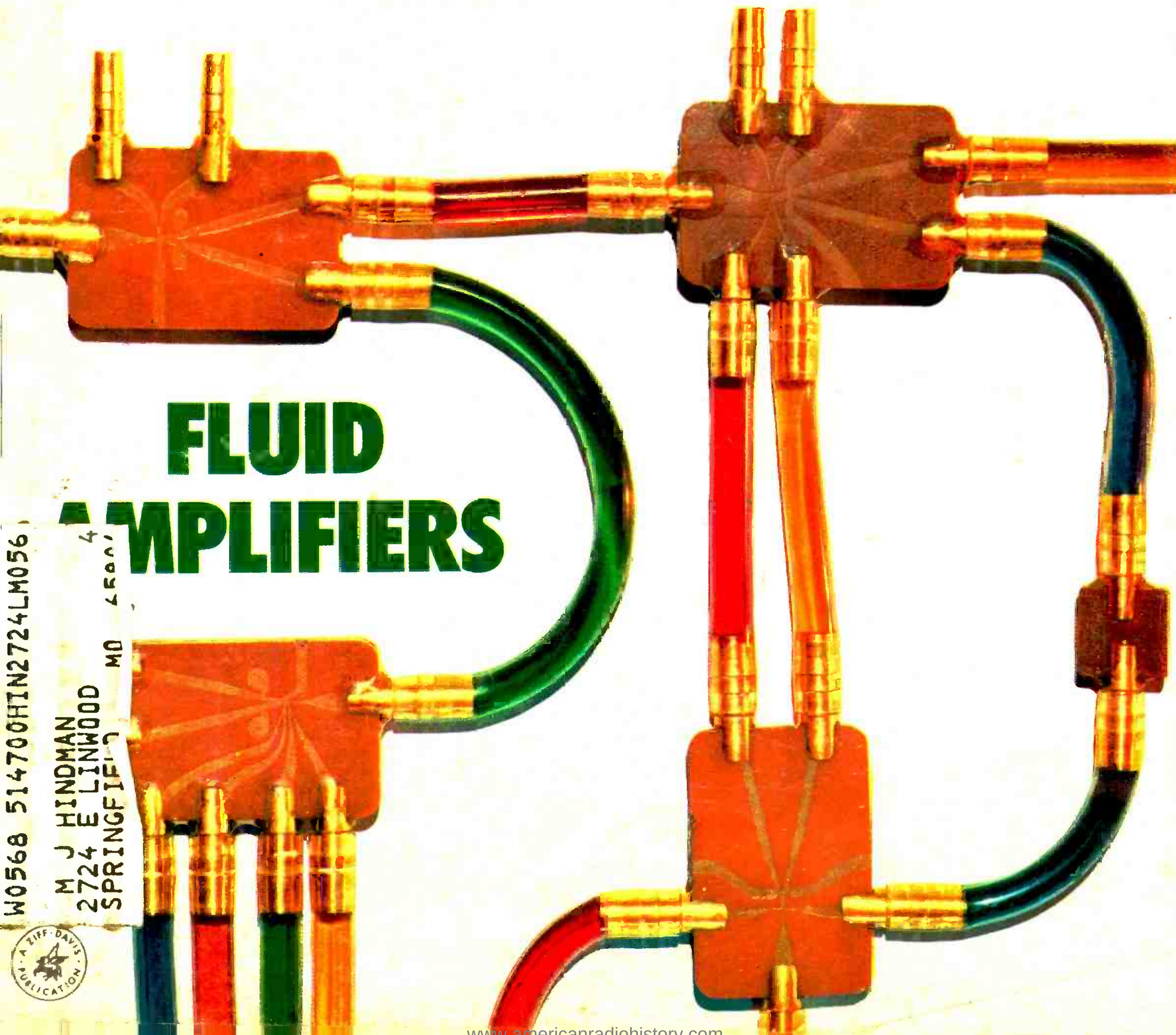
Electronics World

JUNE, 1967
60 CENTS

OCCUPATIONAL OUTLOOK FOR ELECTRONICS TECHNICIANS
EMERGENCY HIGHWAY RADIO—Which System?
COMMON-SENSE DESIGN OF TRANSISTOR AMPLIFIERS
SEMICONDUCTOR SWITCHING OF LOW-POWER CIRCUITS



FLUID AMPLIFIERS

A ZIFF-DAVIS PUBLICATION

Deluxe Heathkit® "295" Color TV... $479.95

- *New hi-fi rectangular RCA "Permachrome" color tube with 295 sq. inch viewing area, and built-in face protection*
- *New rare earth phosphors for brighter pictures, livelier colors*
- *27 tube, 10 diode, 1 transistor circuit*
- *25,000 volt regulated picture power*
- *Automatic degaussing & mobile degaussing coil*
- *Exclusive built-in self-servicing aids*
- *Dynamic pincushioning correction circuit eliminates picture edge distortion*
- *Extra B+ boost for improved picture definition*
- *3-stage video IF strip reduces interference, improves reception*
- *Exclusive Heath "Magna-Shield" improves color purity*
- *Gated Automatic Gain Control (AGC) for steady, flutter-free pictures even under adverse conditions such as airplane traffic*
- *Automatic Color Control circuit reduces color fading*
- *Deluxe VHF turret tuner with "memory" fine tuning & long-life nickel silver contacts*
- *2-speed transistor UHF tuner for both fast station selection and fine tuning individual channels*
- *Two hi-fi sound outputs* **. . .** *a cathode follower for play thru your hi-fi system, and an 8 ohm output for connection to special contained-field 6" x 9" speaker (included)*
- *Two VHF antenna inputs . . . a 300 ohm balanced and 75 ohm coax to reduce interference in metropolitan or CATV areas*
- *Circuit breaker protection*
- *1-year warranty on picture tube, 90 days on all other parts*
- *Tubes alone list at over $277*
- *Liberal credit terms available — details in FREE catalog*

Kit GR-295, all parts including chassis, tubes, mask, UHF & VHF tuners, mounting kit and special extended-range 6" x 9" speaker, 131 lbs. (REA or motor freight only) **$479.95**

GR-295 SPECIFICATIONS — Picture size: Rectangular viewing area approx. 295 sq. inches, (23" diagonally, 20" harizontal, 16" vertical). **Tube Size:** 25" overall diagonal measurement. **Deflection:** Magnetic 90°. **Focus:** Electrostatic. **Convergence:** Magnetic. **Antenna input impedance:** 300 ohm balanced, or 75 ohm unbalanced (VHF). **Picture IF carrier frequency:** 45.75 MHz. **Sound IF carrier frequency:** 41.25 MHz. **Color subcarrier:** 42.17 MHz. **Video IF bandpass:** 3.58 MHz. **Sound IF frequency:** 4.5 MHz. **Tuning range:** VHF channels 2-13, UHF channels 14-82. **Sound cathode follower:** Output impedance; 3 K. Frequency response; ±1 db, 50-15,000 Hz. Harmonic distortion, less than 1%. Output voltage; 2 v. **Audio output:** Output impedance, 8 ohms. Output power, 2 watts. Frequency response, ±2 db, 50-10,000 Hz. Harmonic distortion, less than 3%. **Power requirements:** 110-130 v., 60 Hertz AC, 330 watts. **Wall mounting:** 20" D x 21" H x 26" W inside. Control panel assembly, 6½" W x 7⅞" H x 7" D.

Install In A Wall Or These Assembled Heath Cabinets

Contemporary Styled Walnut Cabinet
Factory assembled of fine veneers and solids with oil-rubbed walnut finish. GR-295 speaker and convergence panel mount behind tilt-out grille cloth on right side. A slim 19" D x 31" H x 34½" W.
Assembled GRA-295-1, 56 lbs. (Express or motor freight) **$62.95**

Contemporary Styled Deluxe TV Cabinet
Constructed of the finest veneers and solids. GR-295 speaker and convergence panel mount behind speaker grille cloth on right side. Measures 19¼" D x 33⅞" H x 41" W. Walnut finish.
Assembled GRA-295-2, 65 lbs. (Express or motor freight) **$94.50**

Deluxe Early American TV Cabinet
Made of a special combination of veneers and solids . . . all beautifully finished in popular salem-maple. GR-295 speaker and convergence panel mount behind grille cloth on right side. Measures 19¼" D x 31" H x 36" W.
Assembled GRA-295-3, 67 lbs. (Express or motor freight) **$99.95**

Deluxe Heathkit® "180" Color TV... $379⁹⁵

- *Hi-fi rectangular color tube with 180 sq. inch viewing area and anti-glare safety glass*
- *Rare earth phosphors for brighter, livelier colors*
- *Extra B+ boost and smaller dot size for improved picture definition*
- *27 tube, 10 diode, 1 transistor circuit*
- *24,000 volt regulated picture power*
- *Exclusive built-in self-servicing facilities*
- *Exclusive Heath "Magna-Shield" improves color purity*
- *Automatic degaussing*
- *Automatic Color Control circuit to reduce color fading*
- *Gated Automatic Gain Control (AGC) for steady, flutter-free pictures even under adverse conditions such as airplane traffic*
- *2-speed transistor UHF tuner for both fast station selection and fine tuning individual channels*
- *Deluxe VHF turret tuner with "memory" fine tuning and long-life nickel silver contacts*
- *3-stage video IF strip reduces interference, improves reception*
- *Two hi-fi sound outputs . . . a cathode follower for play thru your hi-fi system, and an 8 ohm output for connection to special limited-field 4" x 6" speaker (included)*
- *Two VHF antenna inputs . . . a 300 ohm balanced, and a 75 ohm coax to reduce interference in metropolitan or CATV areas*
- *Circuit breaker protection*
- *1-year warranty on picture tube, 90 days on all other parts*
- *Tubes alone list at over $245*
- *Liberal credit terms available — details in FREE catalog.*

Kit GR-180, all parts including chassis, tubes, mask, UHF & VHF tuners, mounting kit, and special limited-field 4" x 6" speaker, 102 lbs. (REA or motor freight only)...................... **$379.95**

GR-180 SPECIFICATIONS — **Picture size:** Rectangular viewing area approx. 180 square inches (18" diagonally, 16" horizontally, 12" vertically). **Tube Size:** 19" overall diagonal measurement. **Deflection:** Magnetic 90°. **Focus:** Electrostatic. **Convergence:** Magnetic and Dynamic. **Antenna input impedance:** 300 ohm balanced, 75 ohm unbalanced VHF. **Picture IF carrier frequency:** 45.75 Meg. Hz. **Sound IF carrier frequency:** 41.25 Meg. Hz. **Color subcarrier frequency:** 42.17 Meg. Hz. **Video IF bandpass frequency:** 3.58 Meg. Hz. **Sound IF frequency:** 4.5 Meg. Hz. **Tuning range:** VHF channels 2-13, UHF channels 14-83. **Sound cathode follower:** Output impedance 3K ohm, frequency response ±1 db, 50-15,000 Hz. Harmonic distortion less than 1%, output voltage 2V. **Audio output:** Output impedance, 8 ohms. Output power, 2 watts; Frequency response, ±2db, 50-10,000 Hz. Harmonic distortion less than 3%. **Power requirements:** 110-130 V., 60 Hz AC, 330 watts. **Wall mounting (mask):** 15⁵⁄₁₆" H x 24³⁄₁₆" W. **Chassis room:** 17½" H x 26" W x 18" D (This is with ¼" clearance on both sides and the top).

Install In A Wall Or Either Assembled Heath Cabinets

Contemporary Walnut Cabinet

Factory assembled of beautiful solids and veneers with an oil-rubbed walnut finish. The GR-180 speaker is mounted behind right side of one-piece picture-control panel mask. Measures a compact 18¼" D x 28¼" W x 29" H.

Assembled GRA-180-1, 41 lbs. (REA or motor freight)................................ **$49.95**

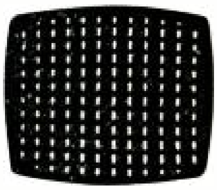
Deluxe Early American Cabinet

Factory assembled with a special combination of veneers and solids, finished in popular Salem-Maple. GR-180 speaker mounts on right side of one-piece face mask. Measures 18¼" D x 28¼" W x 31¾" H.

Assembled GRA-180-2, 48 lbs. (REA or motor freight)................................ **$75.00**

Regardless
Of What You Pay
For COLOR TV,
It Can't Perform
As Well As These
Two HEATHKIT® Models...

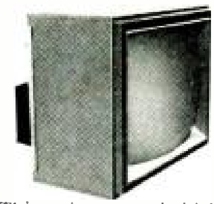
Exclusive Features That Can't Be Bought In Ready-Made Sets At Any Price!



All color TV sets require periodic convergence and color purity adjustments. Both Heathkit color TV's have exclusive built-in servicing aids, so *you* can perform these adjustments anytime . . . *without* calling in a TV serviceman . . . *without* any special skills or knowledge. Just flip a switch on the built-in dot generator and a dot pattern appears on the screen. Simple-to-follow instructions and detailed color photos in the manual show you exactly what to do and how to do it. Results? Beautifully clean and sharp color pictures day in and day out . . . and up to $200 savings in service calls throughout the life of your set. No other brand of color TV has this money-saving self-servicing feature!

Vertical Swing-Out Chassis!

All parts mount on a single one-piece chassis that's hinged to make it more accessible for easier construction, care and installation.



Exclusive Heath Magna-Shield!

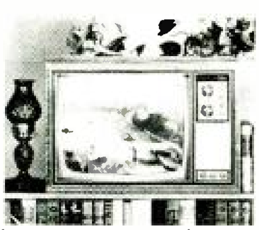
This unique metal shield surrounds the entire picture tube to help keep out stray external magnetic fields and improve color purity. In addition *Automatic Degaussing* demagnetizes and "cleans" the picture everytime you turn the set on from a "cold" start . . . also permits you to move the set about freely without any manual degaussing. A mobile degaussing coil is included for initial set-up.

Convergence Control Board

. . . for fast, easy dynamic convergence and gray scale adjustments any time *you* decide color purity needs it. If you install the GR-295 model in any of the 3 optional cabinets, this board is mounted behind the special "tilt-out" speaker grille section. If you install the GR-180 model in any of its optional cabinets, the board can be temporarily mounted on the bottom of the cabinet underneath the tube face when making adjustments. In either case, there's *no* awkward reaching around the back of the set, or mirrors to set up. In addition, the GR-295 has a *Universal Main Control Panel* that can be mounted at the bottom, top or right side of the picture tube for more flexible in-wall installation.

Here's Why!

Your Choice Of Installation!



Another Heathkit exclusive! Both color TV's are designed for mounting in a wall or your own custom cabinet. Or you can install either set in a choice of factory assembled and finished Heath contemporary walnut or Early American cabinets (see opposite foldout).

From Parts To Programs In Just 25 Hours!

And no special skills or knowledge needed. All critical circuits (VHF and UHF tuners, 3-stage IF assembly and high voltage power supply) are prebuilt, aligned and tested at the factory. The assembly manual guides you the rest of the way with simple, non-technical instructions and giant pictorials. It's like having a master teacher at your elbow pointing out every step of the way. You can't miss.

But Don't Take Our Word For It. Read What The Experts And Owners Say!

Hubert Luckett, Executive Editor, Popular Science Magazine: *"Building your own color TV from a kit is not as outrageously impractical as you might suppose. For those who tremble at the thought of tackling something so fantastically complicated, let me encourage you with a borrowed quote: 'The only thing you have to fear is fear itself'."*

"The second most impressive thing about the kit is the instruction manual (the most impressive thing is the viewing quality of the color picture). If you can read and understand ordinary English, the manual is like having a master teacher at your elbow pointing out every step."

"— the circuitry, features and performance match or exceed those of sets selling at twice the price. Some of the features, such as the built-in servicing aids, can't be bought in ready-made sets at any price."

"With the instructions supplied, your experience in assembling the kit, and the self-servicing features built-in, you'll be able to do most servicing yourself."

John Drummond, Technical Editor, Popular Electronics Magazine: *". . . we simply had to know how well a 25 hours-to-build color TV kit would stack up against the more expensive, well-advertised wired sets people are gobbling up. It didn't take us long to find out that the Heath GR-295 compares favorably with the best of them."*

Radio-TV Experimenter Magazine, Oct-Nov. '66: *"Over the life of a color set, repair and service call costs can exceed $200. But, build the color set yourself and you will save several hundred dollars in repairs plus wind up with better color as you'll align the color reception to what you — not a serviceman — thinks is good to look at."*

Robert E. Scott, Radio-Electronics Magazine: *"Friends who've seen my Heathkit GR-295 generally ask, 'Why can't I get a good picture like that on my color set?'"*

Audio Magazine, May '66: *". . . sets similar in appearance seem to run around $700, without the built-in service features like the dot generator. Add to this the saving in service costs which the average set would require, since the builder would undoubtedly service his own set throughout its life, and the Heathkit GR-295 is a real bargain." "Besides that, it is capable of a great picture".*

Mr. Robert D. Taylor, Sacramento, Calif.: *". . . it's the best TV on the market, nothing compares with it (I have been looking at and checking TV's over 2 years). The manual (service) is a 'gold mine' of savings."*

Mr. C. A. Petrarca, West Caldwell, N. J.: *"We are still getting oohs, ahhs, 'best I've ever seen', 'how bright the colors are', etc. from our friends and neighbors."*

Mrs. Joseph Gesswein, Bethesda, Md.: *"If a housewife with 3 children under 4 years old can successfully build it in her few spare moments, it has to be good."*

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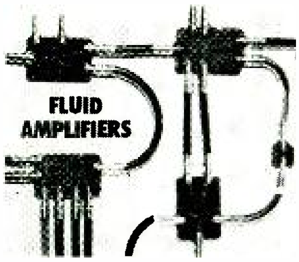
Electronics World



THIS MONTH'S COVER is tied in with our lead story on "Fluidic Systems." We have interconnected a number of fluidic-system components manufactured by Corning Glass Works. Normally the clear plastic tubing carries air under pressure from one component to another. We have taken a little artistic license, however, and have filled the tubing with water of various colors in order to more effectively dramatize the importance of this relatively new technology. Though these components cannot match the speed of electronic control systems, they have the advantages of simplicity and high reliability for a good many important applications . . . Photo: Louis Mervar.

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MONTHLY FEATURES

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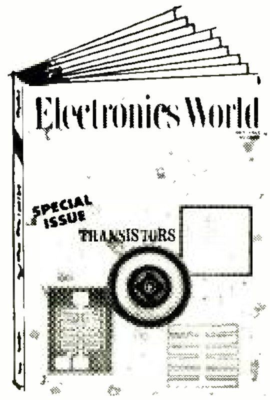
COMING NEXT MONTH

SPECIAL ISSUE: TRANSISTORS



This 24-page special section carries six feature articles covering various types of transistors and their applications. T.J. Robe of RCA offers valuable tips for selecting r.f. transistors in his article **Small-Signal High-Frequency Transistors.** Richard A. Stasior, manager of application engineering for G-E's Semiconductor Products Dept., covers the audio field with **Small-Signal Low-Frequency Transistors. Diffused Transistors,** including annular, mesa, epitaxial, and interdigitated, are discussed by Jack Haenichen, manager of Thyristor Operations for Motorola, while Ronald W. Vahle of Delco offers practical guidelines for selecting **Power Transistors.** Arthur D. Evans, vice-president and engineering manager of Siliconix, discusses the various types of **Field-Effect Transistors** while Lloyd Walsh and Steve Fierro of Fairchild Semiconductor cover **Switching Transistors.** Plus . . . shorter articles on **Selection of Transistors** by R.M. Ryder of Bell Labs and on **Alloy Transistors.**

STATIC ELECTRICITY
The space age's billion-year-old gremlin has been responsible for accidentally firing missiles, damaging semiconductors, and causing aircraft explosions. E.A. Lacy explains how the danger is detected and then minimized.

ELECTRONIC CHALLENGES IN THE SST PROGRAM
Flying faster than twice the speed of sound, and requiring close control of flight conditions for passenger safety and comfort, the SST will need more sophisticated and reliable electronics.

TROUBLESHOOTING INTEGRATED CIRCUITS
Trouble ahead for the TV technician? Will he be able to service an all-IC color-TV set? Here's what he'll have to know, the approach he'll have to take, and new test-equipment techniques he'll have to use to keep abreast of latest technology. This will be Part 1 of an important two-part article.

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

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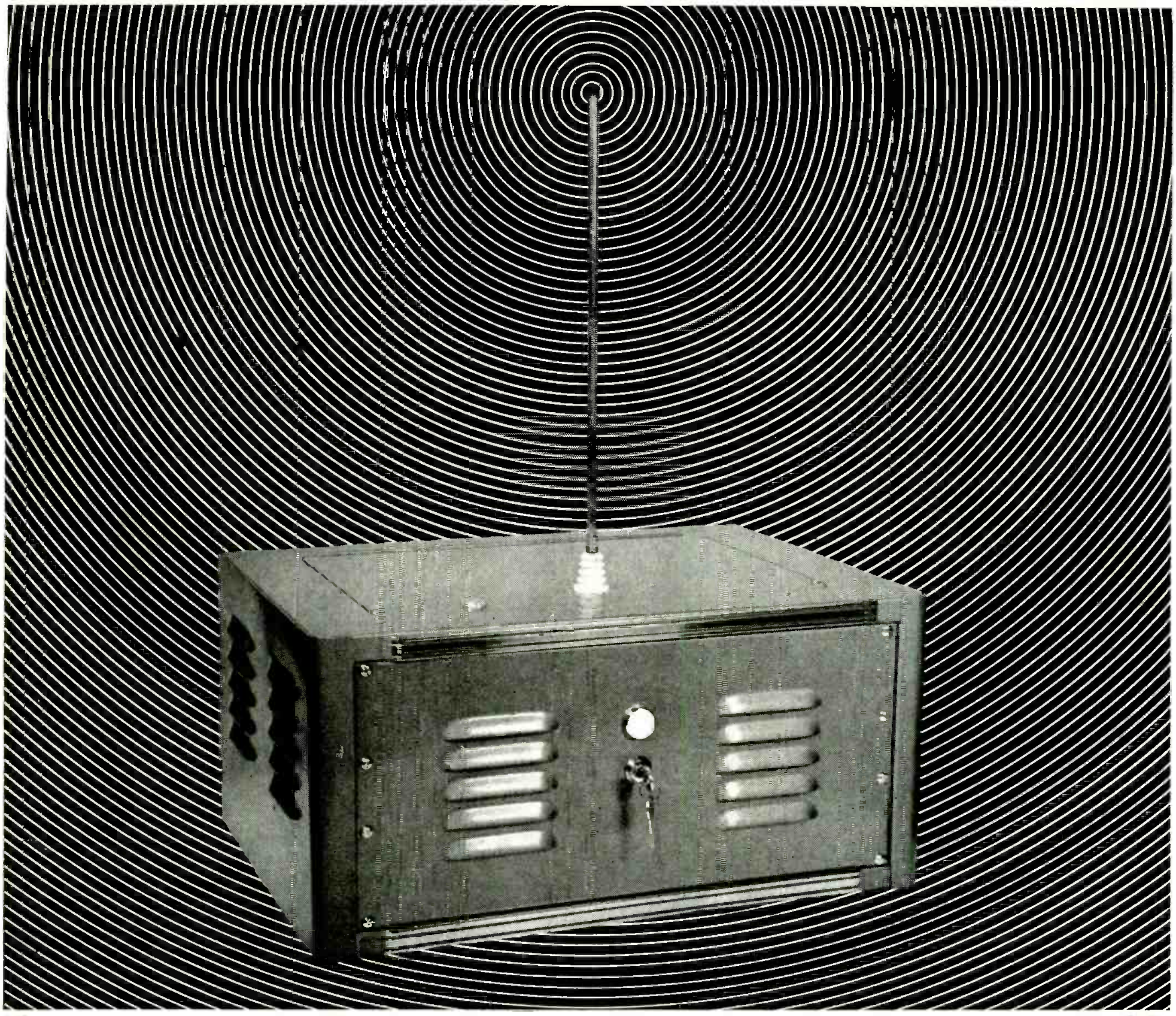

*Belden Trademark Reg. U.S. Patent Office †Belden Patent No. 2,782,251 ††Belden Patent No. 2,782,251 and Pat. Pending

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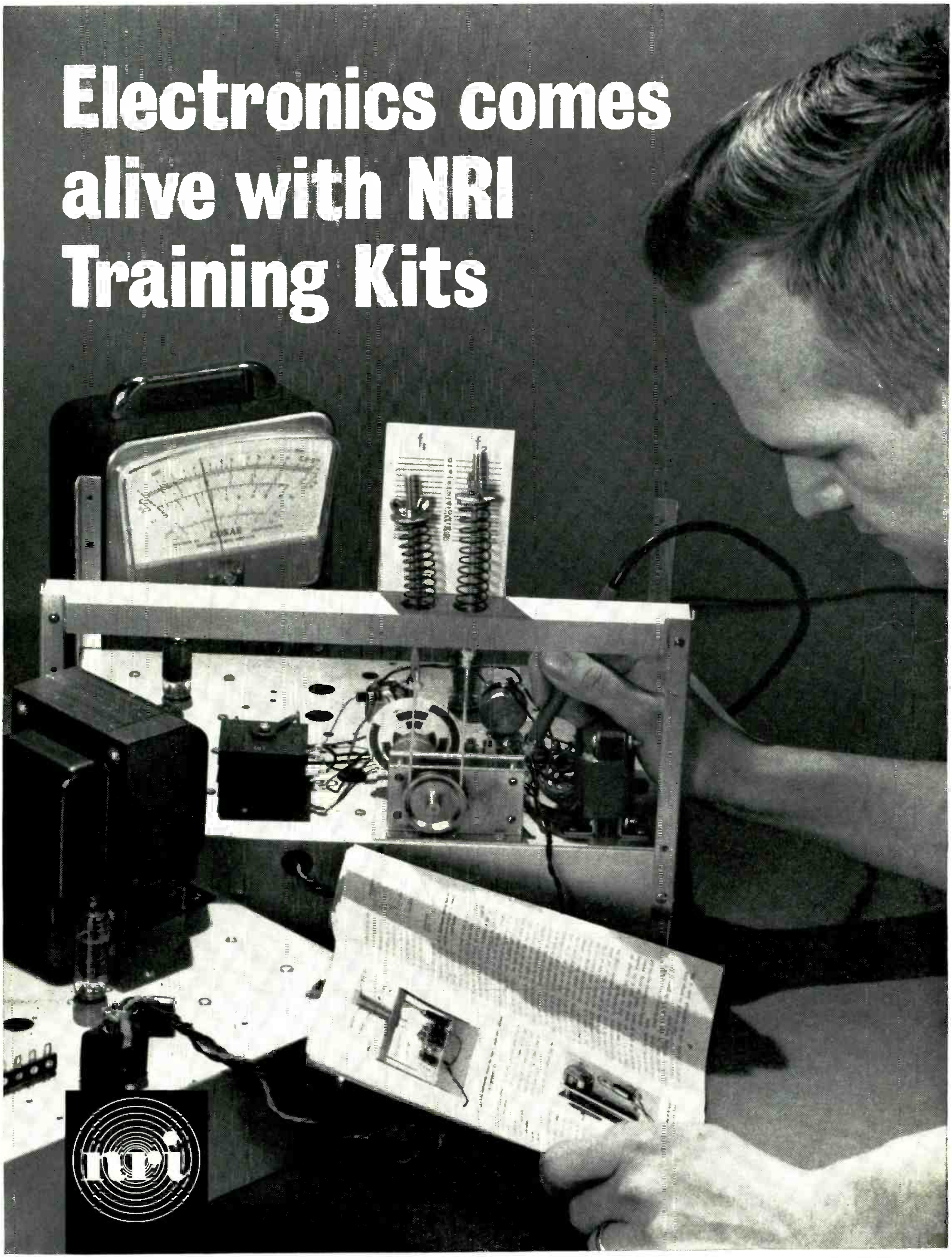
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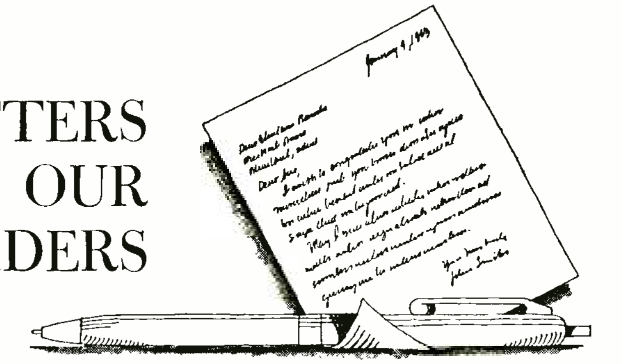


ELECTRONIC PERCUSSION UNIT

To the Editors:

I have just built the electronic percussion circuit on p. 36 of your February issue. The instrument works perfectly and I am very pleased with it. How can I change some of the components to produce the sounds of other percussion instruments, as mentioned in the article?

WILLIAM R. MURPHY
Boston, Mass.

According to our author, changing the emitter pot in the bongo circuit to a low-resistance unit and critically adjusting it just before oscillation results in a bell sound. Other sounds can be produced by experimenting with some of the parts values along the lines indicated in the parts list of Fig. 2.

Producing a cymbal sound is more complex. It requires a noise generator along with a time-delay circuit under push-button control.—Editors

* * *

PULSE-COUNTING FM DETECTOR

To the Editors:

I read with interest Mr. A. H. Seidman's article in the January issue of ELECTRONICS WORLD entitled "Pulse-Counting Detector for FM Tuners."

As you are aware, pulse-counting demodulators have been in use for several years in command and telemetry receivers designed for military and space applications. The extremely linear voltage *vs* frequency characteristic of this circuit renders it particularly well-suited to commercial FM as well.

Mr. Seidman references in this article a paper entitled "Theory of Stronger-Signal Capture in FM Reception" authored by the President and Technical Director of our company, Dr. Elie J. Baghdady. *ADCOM, Inc.* has been involved in characterization and measurement of FM-receiver capture performance for some time. Your readers may be interested in some of this company's other contributions in this particular area in addition to the paper cited in Mr. Seidman's article:

1. Baghdady, E.J.: Lectures on Communication System Theory, McGraw-Hill Book Co., New York, 1961, pp. 490-508.
2. ....: "Propagation Characteristics of the Space Channel," International Telemetering Conference Proceedings, Vol. 1, Washington, D.C., May 1965.
3. ....: "Signal Cancellation Techniques for Capturing the Weaker of Two Co-Channel FM Signals," presented at the International Conference on Electromagnetic Wave Propagation, Liege, Belgium, October 6-11, 1958. Published in Electromagnetic Wave Propagation, M. Desirant and J.L. Michiels, eds., Academic Press, London and New York, 1960, pp. 183-207.
4. ....: "FM Interference and Noise Suppression Properties of the Oscillating Limiter," 1959 IRE National Convention Record, Pt. 8, pp. 13-39. Also IRE Transactions on Vehicular Communications, Vol. PGVC-13, September 1959, pp. 37-63.
5. ....: "New Developments in FM Reception and Their Application to the Realization of a System of 'Power-Division' Multiplexing," IRE Transactions on Communications Systems, Vol. CS-7, September 1959, pp. 147-161.
6. ....: "Theory of Feedback Around the Limiter," 1957 IRE National Convention Record, Pt. 8, pp. 176-202.
7. ....: "Interference Rejection in FM Receivers," MIT Research Laboratory of Electronics Technical Report 252, September 24, 1956.
8. ....: "Frequency-Modulation Interference Rejection with Narrow-Band Limiters," IRE Proceedings, Vol. 43, January 1955, pp. 51-61.

D. BRADLEY CROW, Sr. Engr.
ADCOM, Inc.
Huntsville, Ala.

* * *

PERMANENT MAGNETS FOR METERS

To the Editors:

Your reply to Thomas F. McDonnell's question, "Will my v.o.m. lose its sensitivity due to loss of magnetism after being around for, say, 10 or 15 years?", which was based on information given by Portus M. Wheeler, President of *Crucible Magnet Division* of *Crucible Steel Co.* (p. 6, February, 1967 issue), is only partially true.

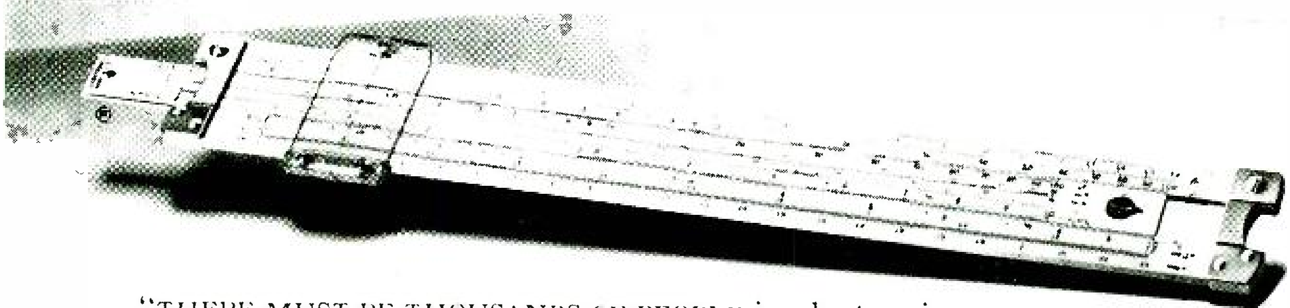
I agree that a permanent magnet should not lose more than 1% or 2% of its magnetism over 100,000 years *if* it is kept under ideal conditions. However, the permanent magnets used in v.o.m.'s will not always be maintained under ideal conditions. For instance, if the v.o.m. is placed in a tube caddy, carried to and from jobs, carried in and out during cold weather, and is otherwise subjected to vibration, temperature changes, and possible external magnetic fields, the magnet may lose strength. Witness the fact that any meter-repair shop working with v.o.m.'s has and uses a magnet charger.

My own experience in working with meters for the past fifteen years has been that laboratory meters do maintain their accuracy over extended pe-

(*Continued on page 90*)

Not just a slide rule, but the dawn of "a whole new era of quick calculations" for men in electronics

An expert reports on the CIE electronics slide rule



"THERE MUST BE THOUSANDS OF PEOPLE in electronics who have never had the marvelous adventure of calculating problems with a single slide rule: other thousands have had to content themselves with a slide rule not specifically designed for electronics. For both groups, the new slide rule designed and marketed by Cleveland Institute of Electronics and built for them by Pickett will open a whole new era of quick calculations.

"Even if you have never had a slide rule in your hands before, the four-lesson instruction course that is included takes you by the hand and leads you from simple calculations right through resonance and reactance problems with hardly a hitch. If you already use a slide rule, you'll find the lessons a first-rate refresher course. And it explains in detail the shortcuts built into this new rule."

From an article in Radio Electronics Magazine

EXPERTS AGREE this electronics slide rule is a "must" for men in electronics. It is offered exclusively by the Cleveland Institute of Electronics at an especially low price in order to attract ambitious men who might be interested in our regular courses. With the slide rule and four-lesson course you also get, as a special bonus, a genuine top-grain leather slide rule case with heavy-duty plastic liner and removable belt loop for easy carrying. For free booklet with complete details, mail coupon or write to: Cleveland Institute of Electronics, 1776 East 17th Street, Cleveland, Ohio 44114.

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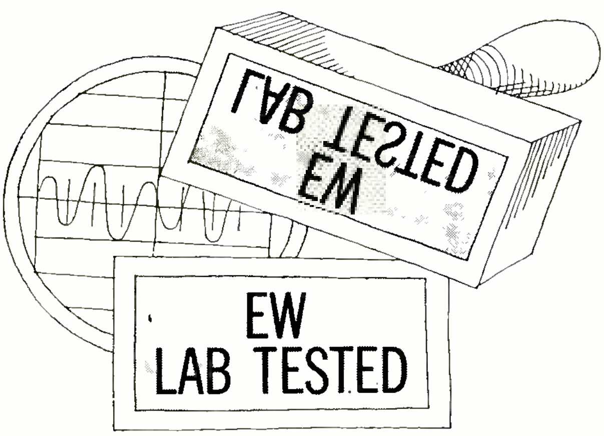


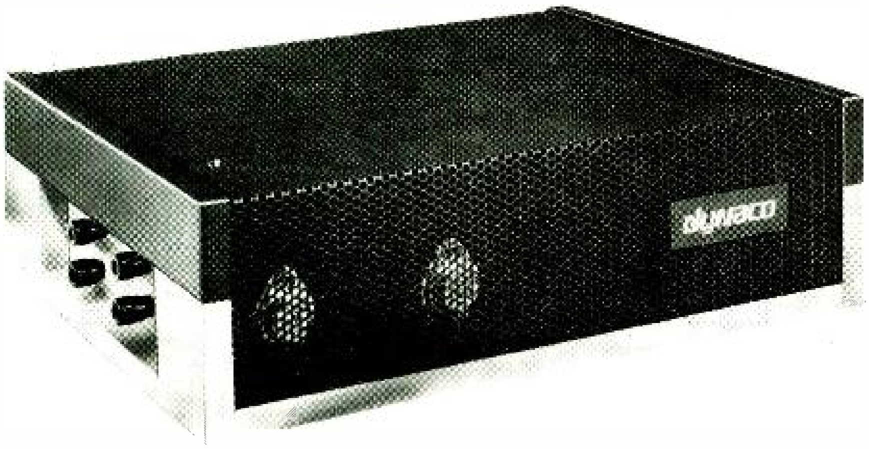
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Dynaco Stereo 120 Power Amplifier
Jensen X-40 and X-45 Speaker Systems

Dynaco Stereo 120 Power Amplifier

For copy of manufacturer's brochure, circle No. 25 on Reader Service Card.



THE outstanding performance and reliability of its vacuum-tube amplifiers over the years has no doubt made *Dynaco* reluctant to join the switch to transistors. Since such a transistorized amplifier would, at the very least, have to match the performance and ruggedness of existing models, *Dynaco* engineers were wary of the pitfalls of solid-state design. Their labor has now borne fruit, in the form of the new Stereo 120 power amplifier—and it was well worth the wait.

The Stereo 120 is a dual 60-watt amplifier, with all silicon transistors. It has no controls or adjustments, either internal or external, except for the power switch. Although it is equivalent in performance to a pair of the company's "Mark III" amplifiers, it measures a compact 13" x 10½" x 4" and weighs only 20 pounds. The input impedance is 100,000 ohms, somewhat lower than tube amplifiers. Current models of the manufacturer's PAS-2X, PAS-3X, and PAT-4 preamplifiers will drive it without modification. Older versions of *Dynaco* preamplifiers require a simple change in their output circuits to drive the Stereo 120.

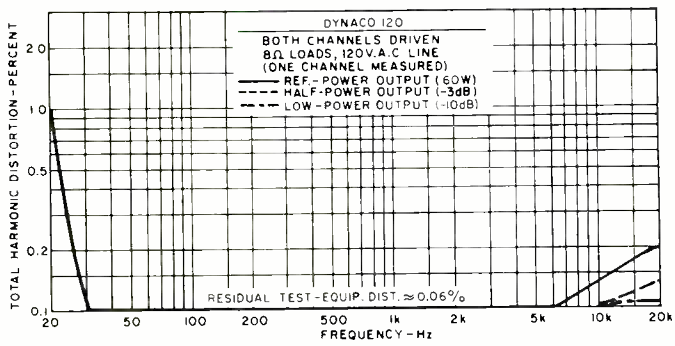
The Stereo 120 is rated with 8-ohm loads. It will work satisfactorily with 4-ohm or 16-ohm speakers, with a possible loss of maximum power capability at some frequencies.

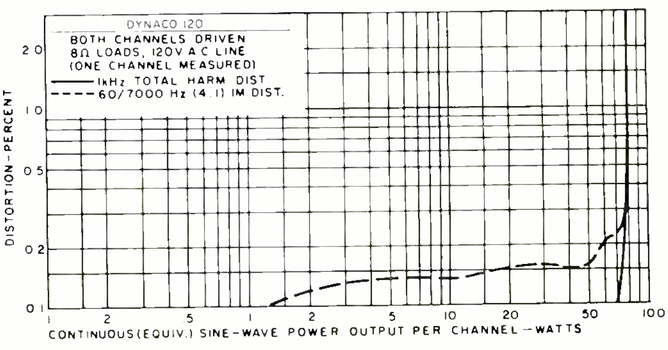
The amplifier is constructed, for the most part, on three printed-circuit boards—one for each channel, and one for the power supply. Each amplifier consists of a direct-coupled two-transistor amplifier, with d.c. feedback to stabilize the transistor operating points, and a four-transistor driver and class-B power amplifier section. This, too, has d.c. feedback, and there are both a.c. and d.c. feedback paths around the complete amplifier. By virtue of careful design, the amplifier is stable under any conditions of drive or load.

The amplifier features a patented protection circuit which limits the peak current drawn by the output transistors to a pre-determined maximum value. The limiting action occurs abruptly, together with a reduction in drive to the output stage. The protective circuit operates when the amplifier is called upon to deliver excessive power into a too-low load impedance, such as a short-circuited speaker line. Removing the short instantly restores normal operation.

The heavily regulated power supply insures the availability of full power for any line voltage from 110 to 130 volts. This is in sharp contrast to amplifiers with unregulated supplies, which often lose much of their power capability when operated with low line voltage. The regulated supply also results in an amplifier whose output is essentially the same whether rated in terms of continuous power (as rated) or with a music-power rating used by many manufacturers. The power supply is protected against shorts or overloads by a circuit similar to that used in the output stages. It may be operated short-circuited indefinitely without damage.

In our laboratory tests, the Stereo 120 lived up to its promise. Except at 20 Hz, where the distortion was 1% at 60 watts per channel (with in-phase signals simultaneously driving both channels),





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the measured distortion was under 0.2% at any power level up to 60 watts, and at any frequency from 30 to 20,000 Hz. Over most of the frequency range it was unmeasurable, even at full power, since the residual harmonic distortion of our test instruments is about 0.06% and our measured figures on the amplifier were typically 0.07 to 0.08%.

At 1000 Hz, the distortion was unmeasurable up to about 70 watts, where it reached 0.1%. The IM distortion was under 0.2% up to 60 watts. It is obvious that in order to measure the distortion of this amplifier with any validity, one must go beyond ordinary commercial laboratory instruments, few of which can be trusted below 0.1%.

Driving the amplifier to the point where the output clipped, we measured 66 watts per channel into 8 ohms, 90 watts into 4 ohms, and 37.5 watts into 16 ohms. The 90-watt power into 4 ohms represents, in practice, a sort of "music-power" rating, since the amplifier will not sustain that power for any significant time. It does offer a welcome, and most useful, power for driving low-efficiency 4-ohm speakers.

Dynaco, quite logically, claims that the Stereo 120 should be indistinguishable sonically from a pair of "Mark III's". This is no small achievement in itself. We did not make the comparison, but can testify that the Stereo 120 sounded like the powerful, virtually distortionless amplifier that it is. It had the clarity and effortless quality at all levels that we have come to expect from a very powerful, clean amplifier. Its small size and weight and cool operation should make it especially suitable for installation in limited space where vacuum-tube amplifiers would require forced cooling.

The Stereo 120 sells for $159.95 in kit form or $199.95 in the factory wired version. ▲

Jensen X-40 and X-45 Speaker Systems

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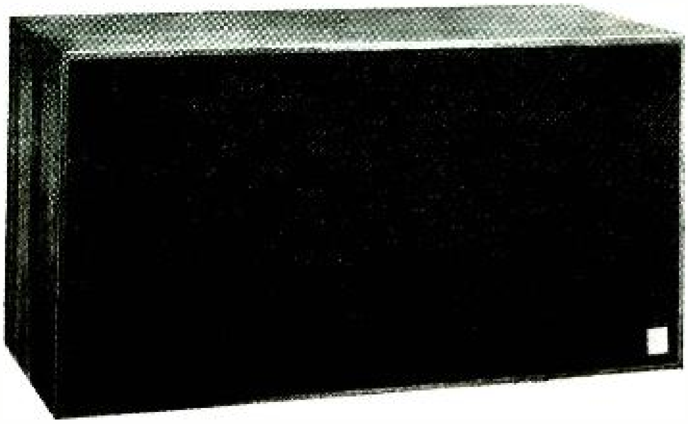
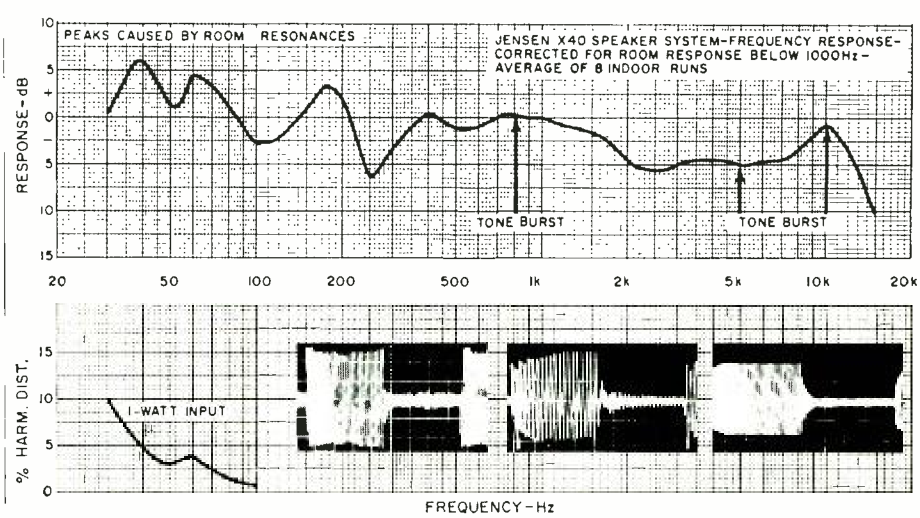


BEFORE the advent of compact or "bookshelf" speaker systems, it was rare to find a speaker of any reasonable size which could deliver an audible 30-Hz fundamental output. Much of the supposed "bass" response of the big speaker systems that were prominent 10 or 15 years ago consisted of distortion products.

The acoustic suspension speaker systems, with their highly compliant, long-throw cones in small, fully sealed enclosures, brought true bass to large (*Continued on page 84*)

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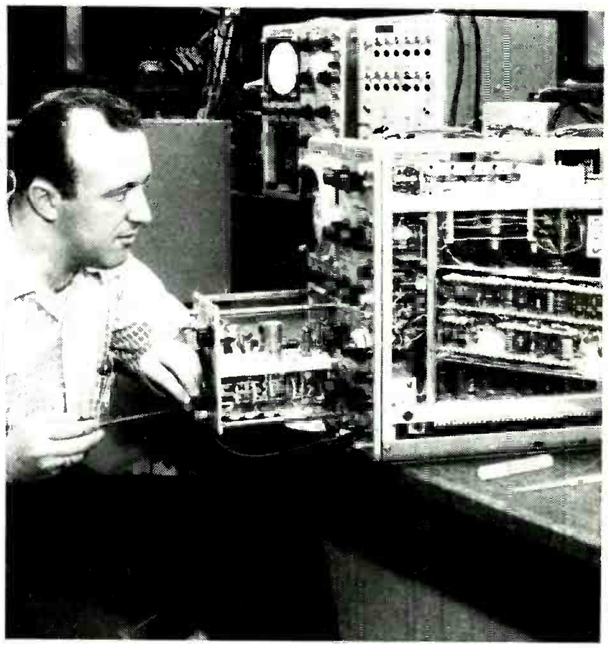

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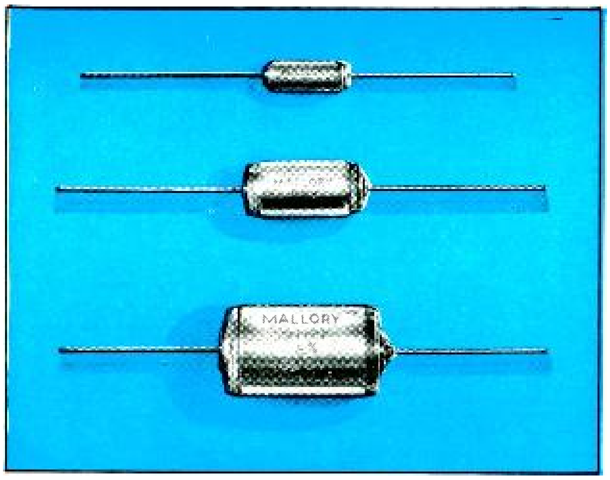
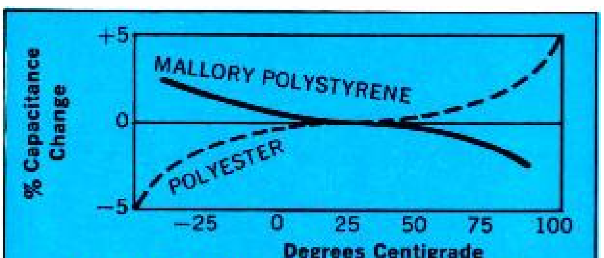
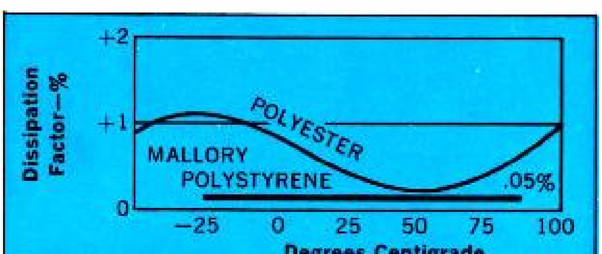
MALLORY Tips for Technicians

When you need a stable capacitor...

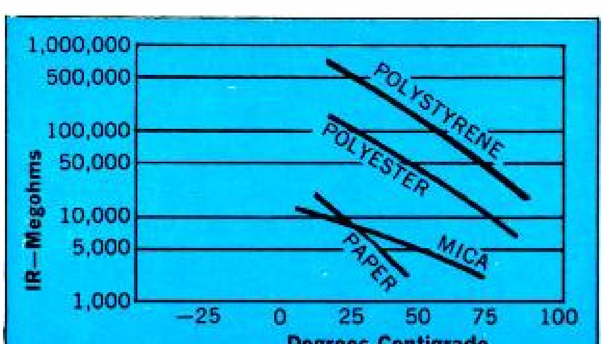




Capacitance vs. Temperature



Dissipation Factor vs. Temperature



Insulation Resistance vs. Temperature

Temperature makes most capacitors wander. For electrolytics, capacitance goes down when temperature gets colder, goes up when things get hot. But this usually doesn't cause trouble, because most electrolytic applications are in filtering—and as long as you have low enough AC impedance, you get the filtering you need. Where drift can bring problems is in tuned circuits, timing and differentiator circuits; here you've got a paper, film, ceramic or mica capacitor, in the fractional-microfarad range. If it changes value due to temperature variations or just plain old age, you're going to have some headaches.

Today's tip: when you need extra stability, try the *new* Mallory polystyrene capacitors. They're the most stable you've ever seen. They look different, and they act different. They're made of a unique kind of stretched polystyrene film and high purity aluminum foil, wound up in a compact roll and then fused together in a self-sealed case of solid clear plastic.

What's extra special about these new capacitors is the way they hold their original microfarad value while temperature varies all over the lot. Temperature coefficient is considerably lower than that of polyester film capacitors—under 150 parts per million per degree C. And it's negative—which means that instead of going up with temperature, capacitance goes down. This is the direction you need to change capacitance in order to compensate for the effect of temperature on the inductive part of a tuned circuit. From −10°C to +70°C, their *total* capacitance change is less than 1.3%. And brother, that's *stable!*

And that's not all. These little dandies don't grow old. They hold their characteristics month after month. You just connect 'em and forget 'em.

One more thing. Mallory Polystyrene Capacitors have the lowest dielectric loss in the business. Their dissipation factor (similar to power factor, a measure of efficiency as a capacitor) is extremely low . . . only 0.05%, which is a small fraction of that of other capacitors. And it stays at this low value over the whole temperature range. This means that they're high Q capacitors, ideal for tuned circuits. And their insulation resistance is way higher than polyester, mica or paper capacitors.

In case you were wondering how much dough you would have to lay out to get such wonderful capacitors—here's the best news of all. They are really low priced. You can get them in values from 5 pF to .01 mfd, all rated 600 volts, from your Mallory Distributor. See him soon—and ask for your copy of the 1967 Mallory General Catalog. Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

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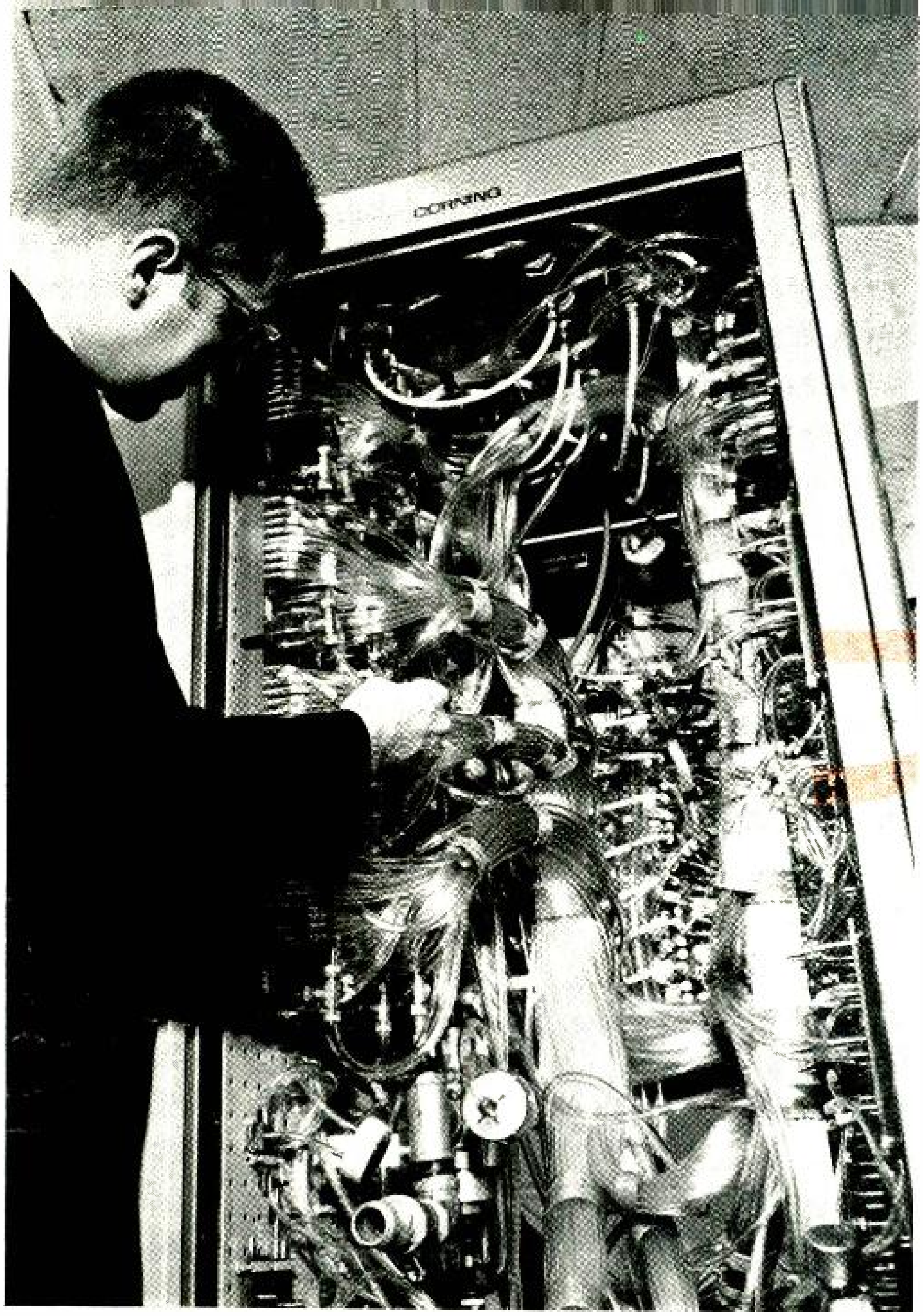


A fluidic time-based sequencer used to control a glass press is shown here. This digital control system, the most complicated fluidic system ever assembled, contains 1050 standard active and passive devices in a relay rack two feet square by six feet high. It will replace an electromechanical press control that requires manual adjustment of valve-actuating cams taking more than an hour for setup. Fluidic control setup time is under 15 min.

FLUIDIC SYSTEMS

By C. J. MILLER/Fluidic Products Dept., Corning Glass Works

Air flowing through plastic tubing can be made to perform many of the very same functions as electrons flowing in conductors. Although far slower than electronic components, fluidic systems are much simpler and more reliable in a good many applications.

FLUIDIC systems, the newest and most promising type of control, may at first glance seem to be the province of mechanical rather than electronics engineers. This is because the operating principles of fluidic devices involve aerodynamics and fluid mechanics. But, since fluidic devices can sense, count, amplify, and control, it is natural for the technology to be of interest to those in the electronics fields concerned with control systems.

The terminology is the same as in electronics, *i.e.*, there are fluid amplifiers, *nor* gates, *and* gates, resistors, flip-flops, binary counters, and Schmitt triggers. Although fluidic devices operate on somewhat different principles, the functions performed are the same as those handled by their electronic counterparts. As a matter of fact, about 90 percent of all fluidic applications are in areas where electronic components or systems perform similar functions.

Fluidics involves the passage of a fluid—usually air—through mechanical components having carefully made channels and passages. These components are usually interconnected with plastic tubing. The fluid (air) in the system is maintained at some constant low pressure by means of some type of compressor. Fluidics will never replace electronics entirely, but can, however, function in environments and in certain applications where electronics is incapable of performing well. Let us take a look at some of the advantages and limitations of fluidic devices.

Advantages & Limitations

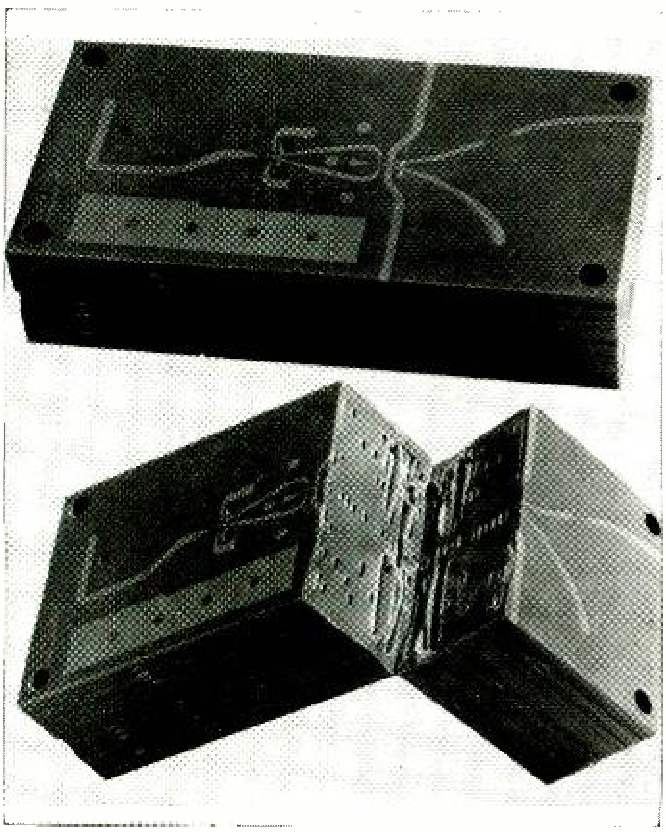
Pure fluidic devices have no moving parts. Longer component life can be expected since there is minimal wear which provides a decided advantage over electro-mechanical parts.

Nuclear radiation has no effect on fluidic devices and such units can operate in an atmosphere where electronic components would have limited life. Fluidic instruments used to detect thickness, erosion, and liquid level with *gamma* and *beta* radiation sources are now employed in both commercial and military applications.

Since fluidic devices are explosion-proof, control panels may be located in the explosive area rather than in some remote place. Since such devices are operated by fluids—usually air—there is no need to house them in explosion-proof enclosures.

Other advantages include the fact that fluidic devices are free from vibration and have been known to perform up to 15,000 G's with negligible change in output. Environmental heat can be readily handled by most fluidic devices

Fig. 1. This integrated fluid-amplifier circuit is part of a machine control. The structure consists of a monolithic glass-ceramic block that is composed of separate plates with various channels for the passage of the fluid. The plates are fused together. The bottom photo shows the fluidic block after being broken apart to display completeness of seals.



—some commercially available devices function at 700 to 1400 degrees C, well within most commercial and military requirements. Some fluidic devices are made from heat-fused ceramic material which is not affected by humidity or other adverse environments. And, since fluidic devices do not generate heat, system components are not damaged.

Since fluidic devices are immune to electrical noise generated from electrical and electronic devices, they are not susceptible to "stray pickup".

Fluidics do have limitations—for one thing, response time is slower. Fluidic devices perform at millisecond speed while some electronic components operate in the nanosecond range. However, response time of fluidic devices is more than adequate where the large masses controlled by fluids are to be moved since fluidic units are capable of speeds better than 1000 Hz.

Fluidic devices can be affected by oil and direct contamination since the channels through which the fluid flows are normally only about 0.010-inch wide. Such oil and dirt particles can be eliminated from the system by proper plant air conditioning or by filtering the input air. If the device should become clogged with oil or dirt particles, common household detergent can be used to clean the channels.

The amount of plastic tubing needed to interconnect fluidic devices can sometimes be disconcerting. While not a problem in circuits consisting of a moderate number of components, large amounts of tubing can cause problems, *e.g.*, disconnections, bulkiness, and an unattractive appearance. This problem is eliminated, however, when fluidic circuitry is integrated (see Fig. 1). Circuits can be placed in layers and fused into a monolithic block. All interconnections, with the exception of the power-supply inputs and outputs, are within the block, thus eliminating the possibility of crimped hosing and leaks.

What about cost? It depends on the application. Fluidic devices sense, amplify, count, and compute and should, therefore, be compared to other devices that perform the same functions—relays, limit switches, solenoid valves, integrated circuits, and the like. Another way of evaluating the cost of fluidic circuitry is to compare it with other types of control systems on the basis of expected life, purchasing cost, installation, maintenance, and down time. For example, a typical fluidic gate costs about $20, but in large quantities this figure may drop to as low as $1.

Digital Devices

Some fluidic components operate on what is called the Coanda or wall-attachment effect. This principle can be easily grasped by observing water pouring from a faucet. If a velocity profile were taken of the stream, it would be noted that velocity causes a pressure difference between the stream and the ambient pressure around the stream. Since pressure tends to equalize, air is entrained in the stream.

If a finger is held near the stream but pointed away from it, water will follow the finger. The stream can entrain air from one side, but the finger creates a wall or barrier to entrainment on the other side. A low pressure pocket is de-

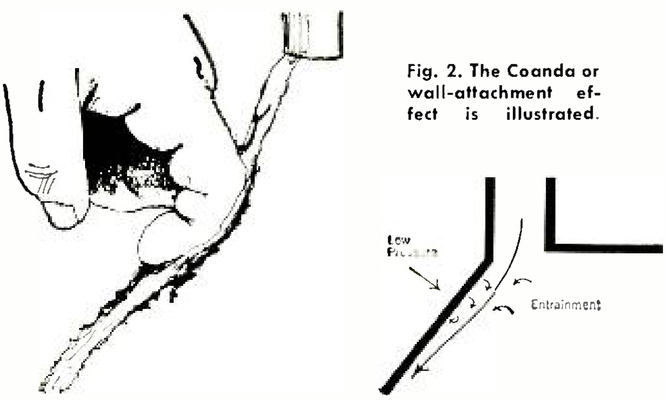


Fig. 2. The Coanda or wall-attachment effect is illustrated.

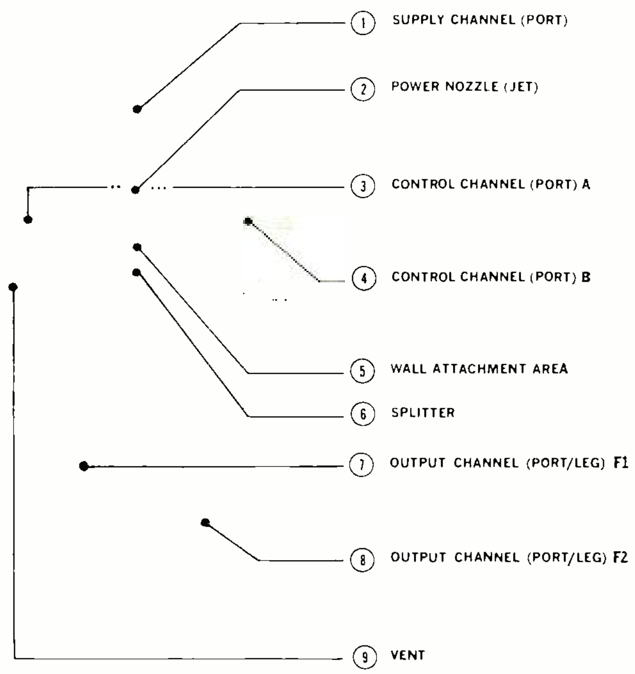


Fig. 3. The design of the channels or passages through which the fluid is made to flow in a fluidic flip-flop component.

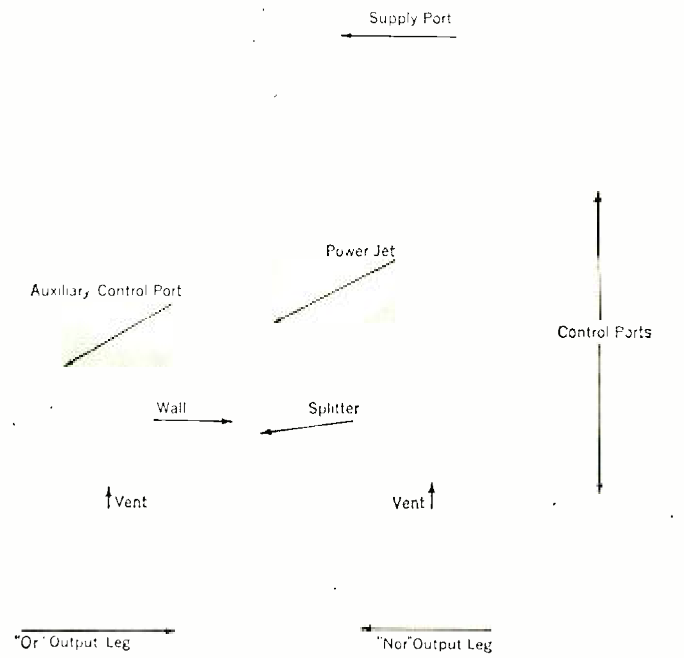


Fig. 4. Design of the channels in monostable "or/nor" gate.

veloped against the finger and the higher ambient pressure on the other side of the stream will hold it against the finger, or similarly, the wall of a fluidic device. See Fig. 2.

The first fluidic devices were designed on this basic principle. Fig. 3 shows a flip-flop or bistable device in which the fluid (usually air) enters through the power nozzle and attaches itself to one of the walls and then exits through one of the output legs. For example, if the stream attaches itself to output leg F1, it will continue on that side as long as the power nozzle is operating or until a control signal which is large enough to detach the fluid from the wall is introduced at control port A. The sream will then attach itself to the opposite wall and exit through output leg F2. It will continue in this direction even if the control signal is removed. The device is bistable, that is, it is stable with output from either of the two output legs.

A monostable fluidic device is designed to exit the air stream out one leg unless a control signal is introduced to switch its output (Fig. 4). The stream, however, will return to its biased or preferred output leg if the control signal is off. The device can be compared to a spring-return valve without a spring.

This device is an *or/nor* gate. If a control signal is introduced through either one of the two control ports, the stream will exit by the *or* output leg. The stream switches to the *nor* output leg when both of the control inputs are off.

A one-shot multivibrator creates an output pulse for a fixed period of time no matter what the duration of the input signal (Fig. 5). It is a *nor* gate arranged so that the input signal is split in two, one stream going direct to the control input, the other to a delay line and then to the auxiliary control port. When the control signal is applied, input is switched from the *nor* output leg to the *or* leg. The same control signal then reaches the auxiliary control port and balances the pressure signal through the control port. Since the two pressures are now equal, the device sees zero control pressure and switches back to the *nor* leg. The fixed duration of the pulse out of the *or* leg is determined by the length of the delay line used.

In addition to these basic devices, single and multi-stage binary counters, *and* gates, half and full adders, shift registers, majority gates, Schmitt triggers, binary-to-decimal converters, and other such fluidic (*Continued on page* 78)

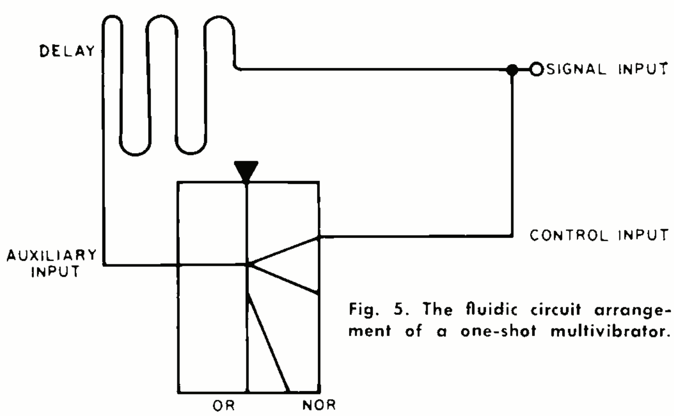


Fig. 5. The fluidic circuit arrangement of a one-shot multivibrator.

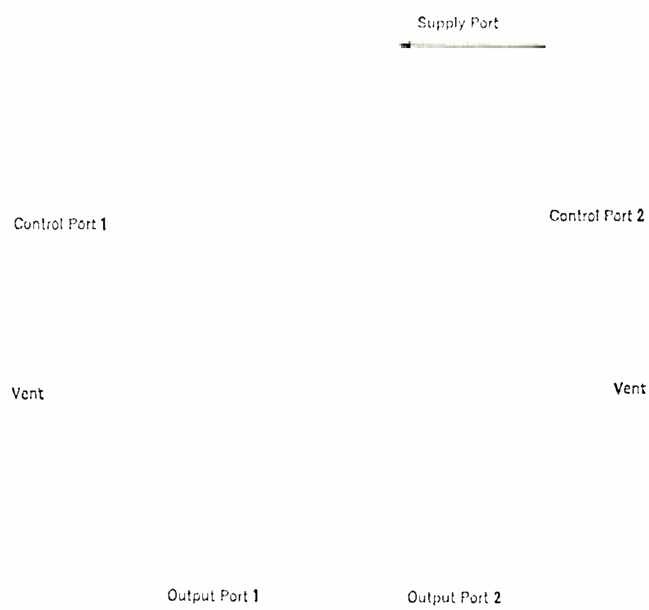
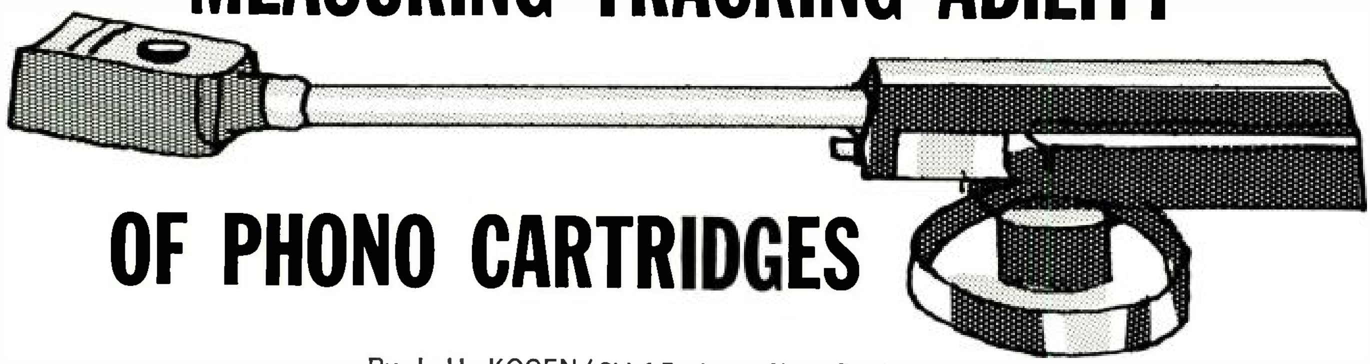


Fig. 6. The fluid channels in a proportional-design component

MEASURING TRACKING ABILITY OF PHONO CARTRIDGES



By J. H. KOGEN/Chief Engineer, Shure Brothers, Inc.

To avoid distortion when tracking records with high peak modulation levels, the stylus tip must not lose contact with the record groove. Here are a number of present and proposed methods of measuring this important cartridge parameter, including a new variable-speed turntable method, CCIF technique, and the use of tone bursts, scope observations, and special test records.

ONE of the most difficult problems encountered by a phonograph cartridge is that of maintaining proper contact between the stylus tip and the record. The need for maintaining this contact is obviously one of the fundamental requisites for proper performance of the phonograph system. Solving this problem has become more and more difficult in recent years because of the improvements in record-cutting techniques, in amplifiers and speakers, and the increased expectations of the sophisticated listener.

A number of terms have been used to describe the ability of a phono cartridge to maintain proper contact between stylus tip and record. These include: trackability, impedance, admittance, and a host of flowery adjectives which relate primarily to subjective evaluation. In this article, we will use the term "tracking ability".

The availability of high-quality records with higher and higher peak modulation levels has created the need for better tracking ability. Records are being made today with peak modulation levels as high as 20 centimeters per second at 15 kHz. Such modulation requires acceleration of about 1800 G's. For example, the *Nonesuch* record "Four Concertos for Harpsichord and Orchestra" has levels of roughly 25 cm/s at 10 kHz. Another example of a highly modulated record is *London's* "Kismet" which shows levels of 18 cm/s at 11 kHz. Many other records containing high modulation peaks can be cited. This places the onus on the phono cartridge to reproduce what has been impressed on the grooves.

One very important factor which must be considered in defining phono-cartridge tracking ability is the tracking force used during normal play. Minimum tracking force, consistent with good tracking ability, should be used. This is done to minimize wear on both record and stylus. Tracking ability can be improved, especially at lower frequencies, by increasing the tracking force. However, this reduces stylus and record life. When checking the tracking ability of the cartridge or when comparing cartridges, evaluation should be made on the basis of a specified tracking force and an assumption that the lower the tracking force, the longer the life (when proper tracking is assured).

Tracking Ability vs Frequency

A further consideration is that tracking ability varies with frequency. A phono cartridge is expected to reproduce frequencies in the range of 20 to 20,000 Hz. The tracking ability of the stylus is directly related to its mechanical impedance. This impedance acts like a multi-mesh electrical circuit or a complex mechanical circuit and, as such, its impedance varies with frequency. The modulation levels on records also change as a function of frequency, as specified by the RIAA recording characteristic, and because of the spectral content of the program material.

The problem is to provide suitable tracking ability to match the modulation levels at all frequencies within the audio spectrum. This should be considered when making measurements since a reading at one frequency won't permit a prediction about operation throughout the spectrum.

What Does Loss of Tracking Do?

Loss of tracking occurs when the dynamic force applied to the stylus tip exceeds the tracking force. When this happens, the tip leaves the surface of the record and later comes bouncing back onto the record surface. During the period when the stylus is not touching the record it obviously is not reproducing the material on the record but is producing some uncorrelated signal, probably related to the free-air dynamic characteristics of the stylus. When the stylus returns to the record a broad band of noise is produced. Subjectively, this result can be heard even by the untrained listener. The sound of bells becomes dull thuds; the staccato sound of castanets resembles sandpaper being rubbed on a blackboard; while the sound of an "s" in a word like "service" comes out as an exaggerated hiss.

In terms of measurement, if one were to plot distortion *versus* modulation level, a curve much like that shown in Fig. 1 would be obtained. Distortion would remain at a relatively low level up to the point where the cartridge could no longer track the modulation. At this point, which in Fig. 1 would be around 25 cm/s, distortion increases at a very rapid rate. Distortion products at modulation velocities above 25 cm/s, for this particular example, would definitely be discernible to the listener.

Methods Used in the Past

For many years now, manufacturers have tested the tracking ability of their cartridges at low frequencies. The measurement was normally made using a record with several bands of constant low-frequency (100 Hz or 400 Hz) modulation at varying levels. The output of the phono cartridge was fed to a scope and the sine wave observed. The waveform was observed while the cartridge played each band at

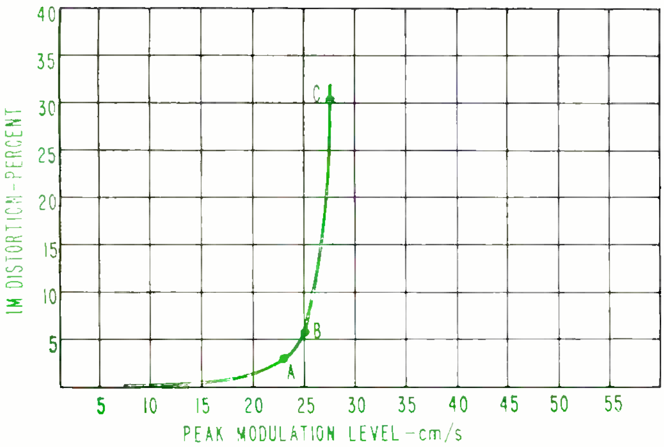


Fig. 1. Intermodulation distortion for various peak modulation levels (actually recorded velocities) for phono cartridge tracking at 1 gram. Frequencies are 400 and 4000 Hz on RCA 12-5-39 test record. Although level is fairly high at point A, distortion is still acceptably low. At point B distortion begins to rise rapidly ultimately reaching excessively high value at C.

BAND	CHANNEL	PEAK VELOCITY (cm/s) 33 r/min	78 r/min	FREQUENCY (Hz) 33 r/min	78 r/min
1	L	6.8	16.1	5,000	11,800
2	R	6.3	14.9	5,000	11,800
3	L	7.0	16.6	10,000	23,600
4	R	7.0	16.6	10,000	23,600
5	L	4.5	10.7	10,000	23,600
6	R	5.0	11.8	10,000	23,600
7	L	1.8	4.3	10,000	23,600
8	R	1.9	4.5	10,000	23,600
9	L	0.8	1.9	10,000	23,600
10	R	0.8	1.9	10,000	23,600

Table 1. Characteristics of laboratory test record used.

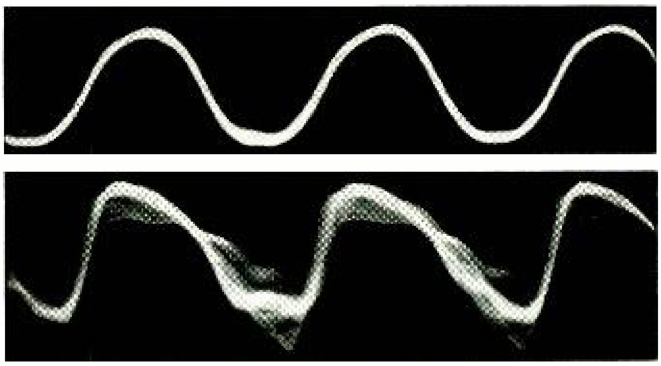


Fig. 2. Upper waveform is from a cartridge that is just barely tracking the sine-wave modulation. Lower waveform shows distortion produced when cartridge is not tracking.

higher modulation velocities until a band was found where the waveform showed breakup. The maximum velocity at which the cartridge would track without breakup was designated as its "tracking ability".

Such a reading at a single frequency provided what was essentially a low-frequency rating of tracking ability. The test made no evaluation of high-frequency tracking ability, say in the 5-kHz region and above, and gave a relatively poor indication of performance in the region between 1 kHz and 5 kHz.

A more refined method of measuring tracking ability would involve an evaluation of performance across the entire frequency spectrum rather than only at 100 or 400 Hz. Some of the means for doing this will be described.

Variable-Speed Turntable Method

One problem in developing a suitable means of measuring tracking ability is cutting the test record. The high peak modulation levels which exist on modern, good-quality records are always found under transient conditions. In order to take a reading, one needs a signal for a reasonable period of time, say at least two seconds and preferably five seconds. Present-day cutters can't cut such high modulations at high frequencies for any such extended periods of time.

One solution to this problem is to cut the record at slow speed and play it back at a higher speed. For example, if the record is cut at 1000 Hz with a modulation level of 5 cm/s at 33 r/min and is then played back at twice the speed (66 r/min), the electrical output from the cartridge will be 2000 Hz at a level proportional to 10 cm/s. Using this principle, *Shure* cut a record for laboratory use (not available for general sale) with the bands shown in Table 1. This record is used in conjunction with a variable-speed turntable which is continuously adjustable from 25 to 100 r/min. The turntable is fitted with a vacuum system which holds the record absolutely flat against the turntable surface. A vacuum is created between the under surface of the record and the turntable, and the record held against the turntable by atmospheric pressure.

At the start the phonograph cartridge is placed in the lowest frequency band while the table is turning at 25 r/min. The sine-wave output of the cartridge is observed on a scope. The turntable speed is then slowly increased until breakup is seen on the CRO screen. The turntable speed is then reduced to the point where the sine wave returns and the reading (in r/min) is recorded. Scope patterns before and after breakup are shown in Fig. 2.

Frequency and modulation velocity for the measured point is then determined from a graph such as the one shown in Fig. 3. Such a graph is provided for each band on the record and, with r/min known, frequency and peak modulation velocity can be determined.

This procedure is followed for all bands on the record. The record of Table 1 provides measurements above 5 kHz while another record is used for frequencies below 5 kHz. A series of points is thus determined which can be plotted on a curve like that of Fig. 4 which shows the peak modulation velocity the cartridge will track at the specified tracking force. The locus of the points is a curve of the cartridge's tracking ability at the specified tracking force. Fig. 5 plots the tracking ability of a number of cartridges using this method of measurement. It also demonstrates the variation among cartridges in this respect.

CCIF Method

There are two disadvantages to the method just described. First, it requires a variable-speed turntable equipped with a vacuum attachment. Second, the means of detecting the point of loss of tracking ability is not as well defined as it could be. It may be possible to resolve both of these problems using the CCIF (International Telephonic Consultative Committee) method of determining distortion.

This method involves the use of two frequencies separated by a constant frequency difference, usually on the order of a few hundred Hz. As these two frequencies are swept across the audible spectrum, the output is measured as the difference frequency. This can be done quite simply by using a filter tuned to the difference frequency and a voltmeter. If no distortion exists, the output at the difference frequency should be zero. When distortion is encountered, intermodulation will occur and output will be obtained at the difference frequency. A block diagram of a setup for making such a test is shown in Fig. 6. Using a record with several bands (of CCIF frequency sweeps) at increasing modulation levels, provides a means for measuring tracking ability.

The measurement is made as follows. Assume the record is cut with a series of bands having frequency sweeps from 1000 to 20,000 Hz, with each band cut at a peak modulation velocity 1 cm/s higher than the previous band. Assume fur-

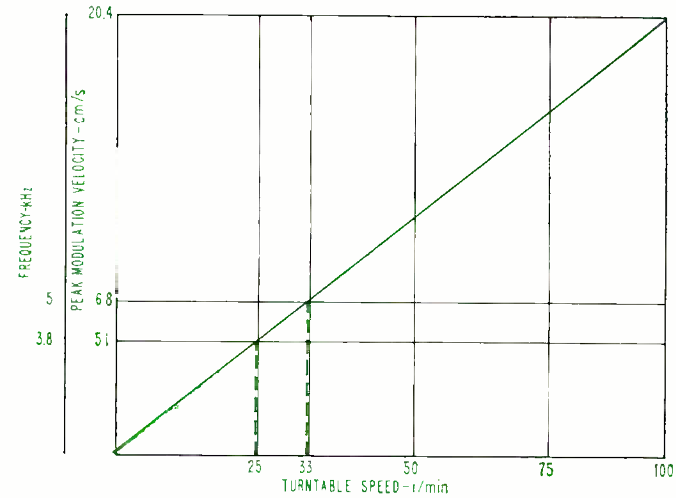


Fig. 3. Typical calibration chart for one band of special test record. Frequency and velocity vary as turntable speed.

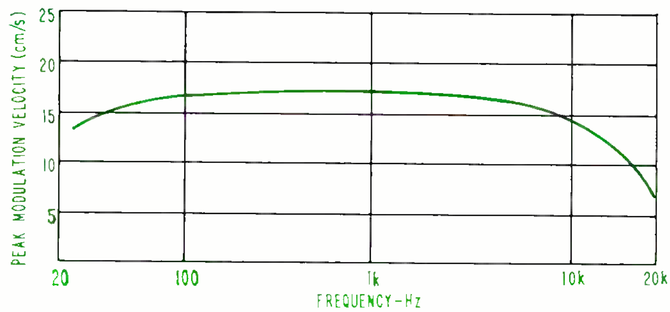


Fig. 4. Typical tracking-ability curve showing maximum modulation velocity the cartridge can track as function of frequency.

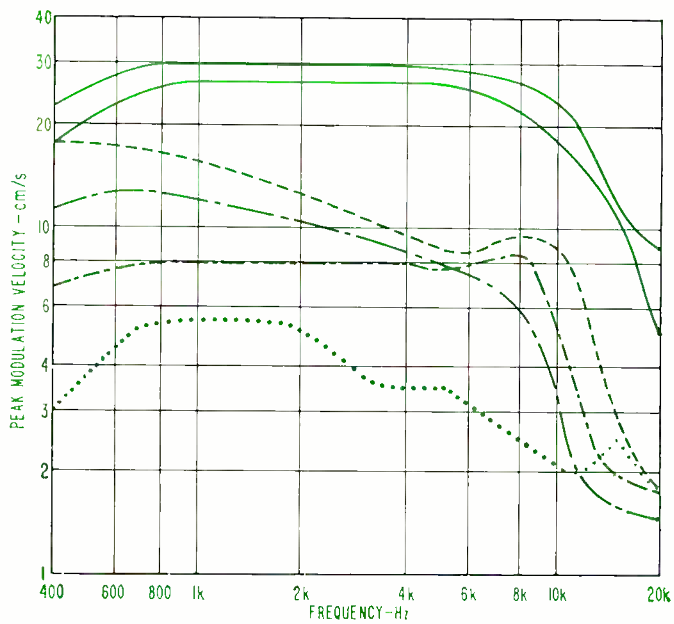


Fig. 5. Tracking ability of a grouping of current cartridges.

ther that there are 20 bands running from 5 cm/s to 24 cm/s. Measurements are made through a filter which passes only the difference frequency. The recorder speed is synchronized with the frequency sweep to provide frequency calibration. The resulting graph plots the difference intermodulation products as a function of frequency for each of the modulation levels.

At this point some arbitrary statement must be made as to how much distortion constitutes an indication that the cartridge is no longer tracking properly. Referring to Fig. 1, we would have to choose a value of distortion for point *B*. Let us arbitrarily say that distortion at *B* should have a value of 10% of the peak output of the cartridge when it is tracking properly at 1 kHz for the modulation level at which the measurement is made. We might then pick points from the graphs recorded in the setup shown in Fig. 6 and replot them in a fashion similar to that shown in Fig. 4. In this case, the ordinate of Fig. 4 could be defined more specifically as the tracking ability, in terms of modulation velocity which the cartridge is able to track properly with less than 10% CCIF distortion.

An alternative might be to have the bands on the record cut with pairs of fixed frequencies, with sub-bands at increasing modulation levels. The advantage here would be that one would only have to count up the number of sub-bands to determine the modulation level at which distortion exceeded 10%.

One of the advantages of the CCIF method is that the only special equipment required is a band-pass filter at the difference frequency. In addition, loss of tracking is indicated as a definite percentage of distortion rather than as a judgment of the scope pattern as is the case with the variable-speed technique. The CCIF method allows measurement up to the maximum frequency of interest, a thing that is quite difficult to do if the amount of total harmonic distortion were measured.

RCA has recently issued test record No. 12-5-105* which includes most of the facilities for making a sweep frequency CCIF measurement. This record has several sweep bands from 2 kHz to 20 kHz with a difference frequency of 400 Hz at modulation levels of 3.54 cm/s, 5.6 cm/s, 8.85 cm/s, and 14.0 cm/s. The only limitation we have noted in this

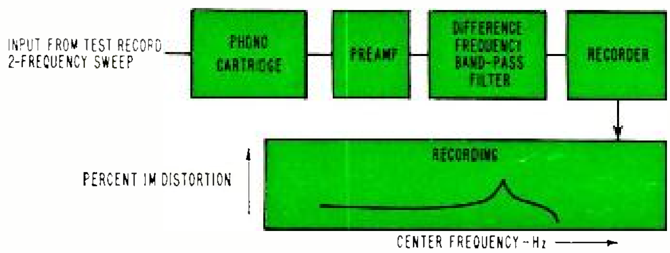


Fig. 6. Setup used for making the CCIF distortion measurement.

record is that the maximum modulation velocity is 14.0 cm/s which is not high enough to cause severe mistracking across the frequency spectrum with better cartridges. If a record could be made extending the modulation velocity through about 30 cm/s, we believe this would cover the full range that is required for making adequate tracking-ability measurements.

Tone-Burst Measurements

Another proposed method of making tracking-ability measurements involves the use of tone bursts. Short tone bursts on the order of 5 milliseconds would provide sufficient time for the transient to die out and for the cartridge to assume some steady-state response before the end of the tone. To make a measurement of this nature would require a record with repeated bursts which could be synchronized with the scope sweep. This response could be viewed in the same way as the variable-speed turntable technique, that is, visual indication of the output could be used to detect a severe change in the sine wave. While this would not be suitable for measuring distortion, it would provide a good "go/no-go" indication of a rapid rise in distortion, indicative of loss of tracking. By playing these tone bursts at increasing modulation levels, one might then pick the level just below that at which mistracking occurs and plot points for a series of frequencies as was done in Fig. 4. (*Continued on page* 61)

*A definitive paper on distortion tests using this record was presented to the Audio Engineering Society in October 1966 by Dr. J. G. Woodword & R. E. Werner of RCA. The paper is entitled "High Frequency Intermodulation Testing of Stereo Phonograph Pickups". The record can be obtained from RCA Custom Record Sales for about $6.50 each.

LSA DIODES: NEW SOURCE OF MICROWAVE POWER

The LSA diode has produced c.w. power of 20 mW at 88 GHz, the highest frequency ever obtained from a solid-state oscillator.

THE discovery of a new mode of oscillation for gallium arsenide diodes now makes possible solid-state oscillators that operate at higher frequencies and with higher power at any frequency than other solid-state devices including Gunn diodes. The new mode, called "limited space charge accumulation" (LSA), was discovered by John A. Copeland of *Bell Telephone Labs.*

LSA oscillators are not subject to rapidly decreasing powers at millimeter-wave frequencies, a characteristic previously thought to be a fundamental limitation of all solid-state oscillators. The lack of a solid-state source of millimeter-waves has been a major barrier to the use of these frequencies (30 to 300 GHz), which has about nine times the communications capacity of all lower frequencies combined.

Operating LSA diodes at room temperature, c.w. power of 20 mW at 88 GHz was obtained, the highest frequency ever reported for a c.w. solid-state oscillator. LSA oscillators operating at 51 GHz have produced .7 W of pulsed power and 40 mW of c.w. power. The highest c.w. power obtained from other solid-state oscillators at comparable frequencies is about 3 mW at 40 GHz from an IMPATT diode.

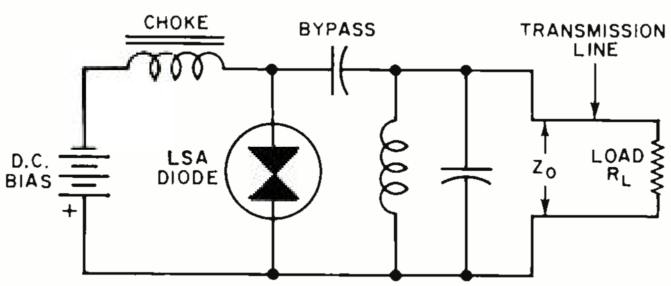
LSA diodes derive their name from a unique operating characteristic that allows them to oscillate at very high frequencies. The maximum frequency of other solid-state devices is limited by an effect called "transit time" (also found in vacuum tubes), which is the time it takes a space charge of electrons or holes to travel through the device. The smaller the transit time, the higher the frequency. As higher frequencies can be attained in transit-time limited devices only by making their active region smaller, this, in turn, limits their power at the higher frequencies.

In LSA diode oscillators, the space charge is dissipated within the material (n-type gallium arsenide) during each cycle before it builds up appreciably, hence the name "limited space charge accumulation".

Above a certain threshold voltage, the material becomes a negative resistance, that is, the current through it decreases as voltage increases. LSA diodes are operated as part of a resonant circuit which is tuned to the desired frequency. If a fixed bias voltage which is above a threshold level is applied to the diode, the diode presents a negative resistance. An oscillating voltage is then developed which causes the total voltage across the diode to swing first well above and then below the threshold field during each cycle.

It is necessary that the resonant circuit be lightly loaded initially for LSA oscillations to start. Once oscillation has started, the resonant circuit can be more heavily loaded and the output power and efficiency increased appreciably. A circuit which has an automatic loading delay is shown in Fig 1. Initially, the diode sees a load equal to the characteristic impedance of the transmission line (Z_0) Only after the signal has travelled to R_L and back to the resonant circuit, does the diode see the steady-state load. This load is R_L transformed by the length of the mismatched transmission line.

Fig. 1. Automatic loading delay for the LSA oscillator.

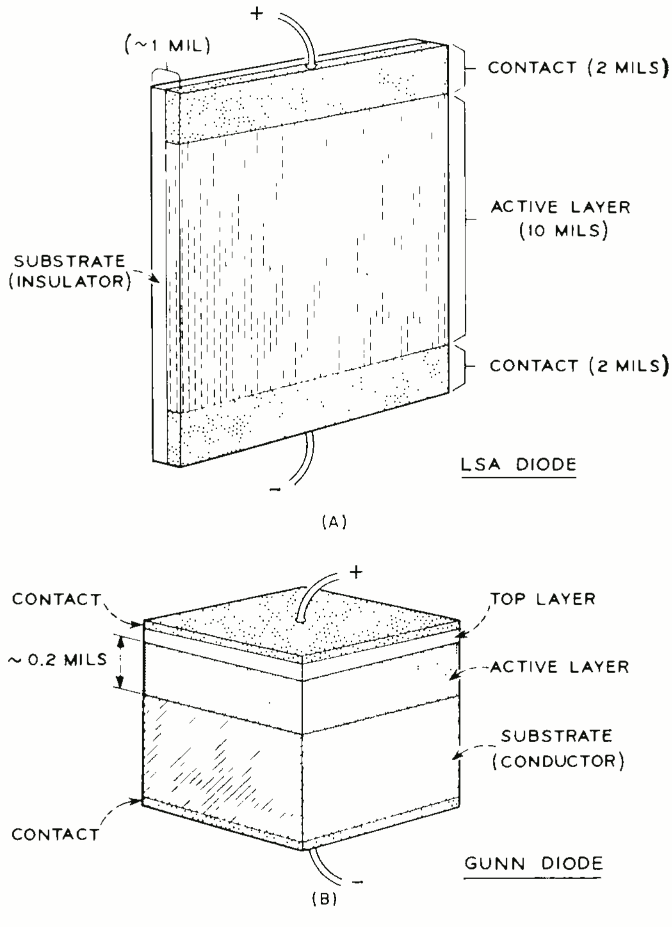


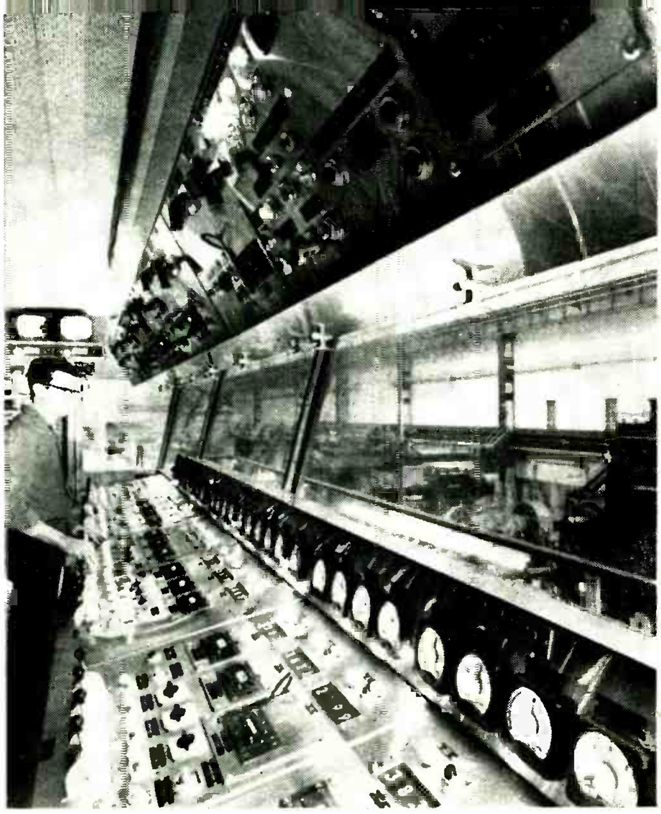
Because LSA diodes are not transit-time limited, they can be made thick enough to withstand relatively high applied voltages. Since the frequency of an LSA diode is determined primarily by a resonant circuit (not by its thickness, or by transit time), the power from an LSA diode oscillator is practically independent of frequency.

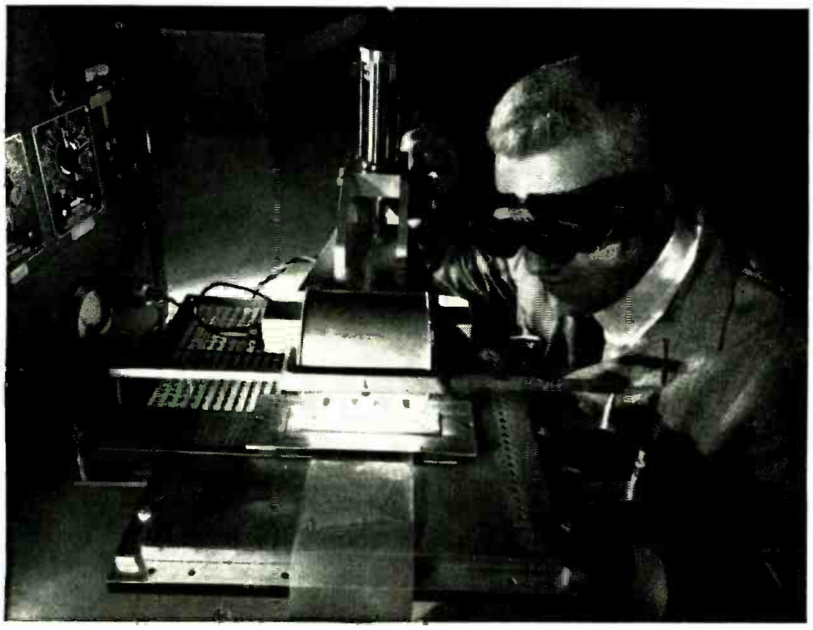
Referring to Fig. 2, Gunn diodes are made thin in the direction of current flow (because they are transit-time devices). To take full advantage of the fact that the LSA effect is not transit-time limited, LSA diodes are made long in the direction of current flow, and thin in a direction perpendicular to current flow.

LSA diodes are being tested as replacements for klystron tube oscillators, which require hundreds of volts from a large, highly regulated power supply. An LSA diode and its power supply can easily fit into a space as small as a cigarette pack. Because LSA diodes are bulk semiconductor devices, their potential operating lifetime is comparable to that of transistors and is orders of magnitudes greater than that of vacuum tubes operating in the same frequency range. ▲

Fig. 2. Comparison of LSA and Gunn diodes. (A) The active region of an LSA diode can be made long in the direction of current flow. (B) The active region of Gunn diodes and other solid-state oscillators must be made thin (a fraction of a mil) in the direction of current flow. This limits amount of power they can develop at high frequencies.







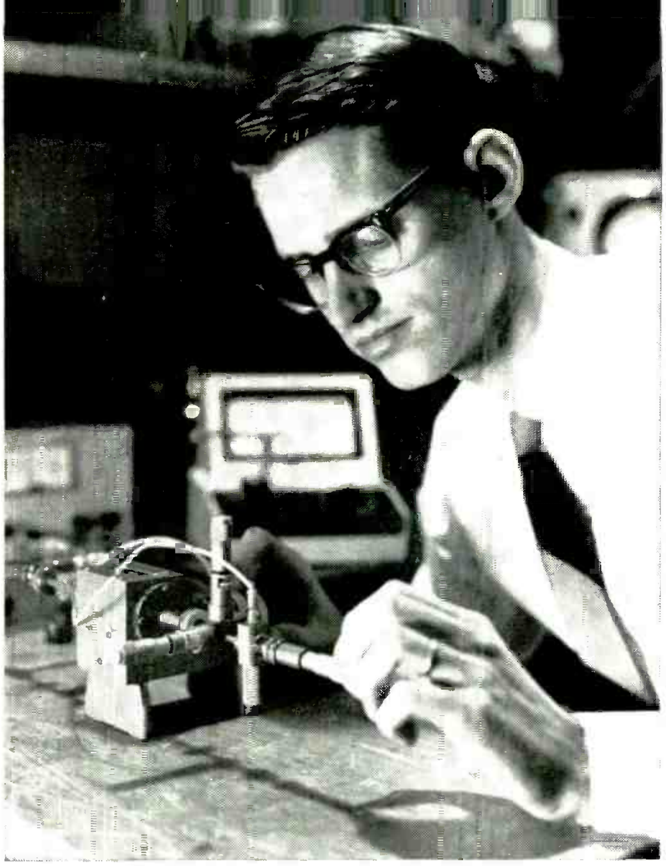
RECENT DEVELOPMENTS IN ELECTRONICS

Computer-Controlled Hot Sheet Mill. (Top left) The nation's first completely computer-controlled hot sheet mill has been put into operation at Bethlehem Steel's new $400 million plant at Burns Harbor, Indiana. The computer system tracks production from the time the huge slabs enter the mill until the hot rolled sheet coils reach the delivery area. Communications between the computer and the operators are flashed through this control pulpit. As the nation's most powerful hot sheet mill, the facility uses motors totaling 108,000 horsepower and is capable of speeds of 3750 feet a minute. The 80-inch mill's own electrical substation could supply the needs of a city of 100,000 persons. The computer used and systems engineering are by Westinghouse.

Infrared Soldering. (Center) A new technique makes it possible for the first time to bond simultaneously large numbers of flexible cables to printed circuits or other cables. The technique permits soldering flexible cable with focused infrared energy. Although infrared soldering has been used in the past, its application to flexible cable is a new development. The soldering process is easy and provides a quick and inexpensive method for interconnecting circuit boards, such as those containing miniaturized solid-state components. The infrared source is a tungsten halogen lamp inside an elliptical gold-plated reflector which focuses the energy on the cable. The energy is transmitted through a quartz window and through the insulation onto the copper parts to be bonded. The thin coating of solder plated onto the cable beforehand is melted and forms a joint. The quartz window protects the insulation by acting as a heat sink, serves as a clamp to hold the components in registration, and permits visual alignment of the parts. The technique was developed by Bell Labs and Western Electric.

Oscillograph Aids Veterinary Research. (Bottom left) A direct-writing oscillograph is helping these professors of veterinary physiology at Ohio State's College of Veterinary Medicine to learn more about animal hearts. The instrument is shown here making a simultaneous record of electrical impulses, pressure, and sound in two chambers of the horse's heart. The same kind of equipment is used for medical research on humans, to record bio-medical data on astronauts during flight, to monitor manufacturing processes, and to perform hundreds of high-precision measuring operations. The instrument shown is made by Clevite Corp.

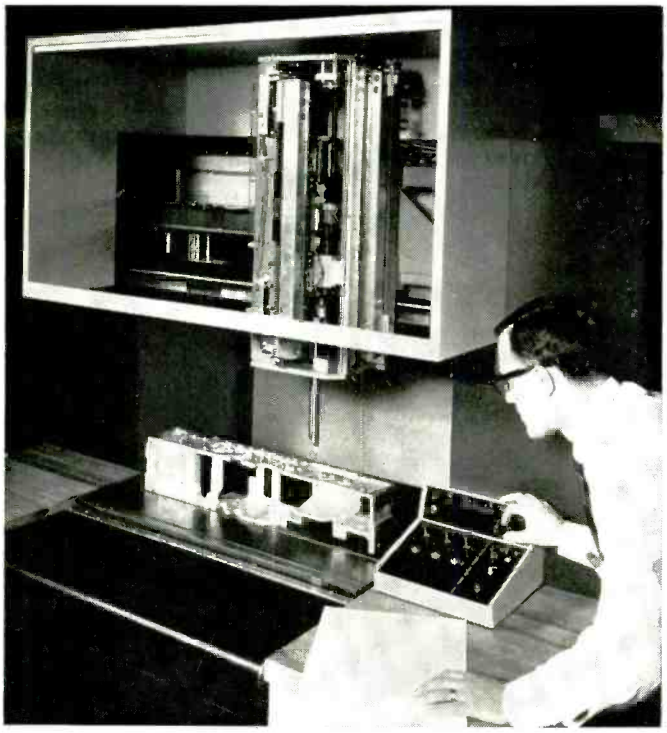
Highest Frequency Solid-State Oscillator. (Top right) An experimental gallium arsenide oscillator that operates at higher frequencies and higher powers than any other solid-state device is shown here. A new mode of oscillation in n-type gallium arsenide has produced frequencies as high as 88 gigahertz at 20 milliwatts of continuous-wave power. The new oscillators are being tested by Bell Labs in an experimental millimeter-wave communications system, replacing previously used klystron tubes.

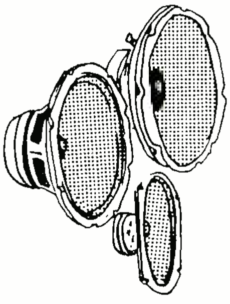


Portable Magnetometer Locates Buried Skiers. (Center) Skiers and mountain climbers now have greatly increased chances for rapid discovery and survival when buried in a snow avalanche if they wear a special small but powerful magnet. The location of the magnet is quickly detected by rescue crews equipped with a portable magnetometer, such as this one made by Varian Associates. The instrument detects the variation in the earth's magnetic field which is caused by the magnet worn by the buried skier.

New Battery for Electric Car. (Below right) A zinc-air battery capable of an energy storage density of five to seven times greater than conventional lead-acid storage batteries is being developed for vehicle propulsion. The battery consists of metallic zinc plated on inert backing sheets. The zinc is oxidized by air that is pumped in from the atmosphere through porous nickel electrodes. An electrolyte of potassium hydroxide is used. The cell stack shown in the photo is of the size required for an energy storage capacity of 7 kWh of electricity. Development of the system is being done by Edison Electric Institute and General Dynamics Corp

Computerized Precision Measuring Machine. (Below left) This three-axis measuring machine is linked to a computer to obtain automatic precision measurement and processing of data. Measurements are analyzed and summarized in a report that can be studied a few seconds after the measurements are taken. The machine automatically corrects for skew of the workpiece and results in increased accuracy from the mechanical system. The machine is now being utilized at IBM's Kingston, New York development laboratories.





LOUDSPEAKERS FOR ELECTRONIC MUSICAL INSTRUMENTS

BY KARL KRAMER / Product Manager, Jensen Mfg. Div., The Muter Co.

Very rugged speakers are required to handle the high power and transients. Here is how some of the special speaker design problems have been solved.

TEN years ago, electronic amplification of musical instruments was pretty much limited to electronic organs and to helping the guitar compete on a more equal footing with brasses and reed instruments. It was necessary to boost the guitar voicing a little to allow it to be heard along with the other instruments.

The amplification requirement wasn't great—perhaps 10 to 25 watts—because the guitar wasn't supposed to overpower, merely blend with the group. There were 50-watt amplifiers, of course, but they were seldom used at even half their rated power.

Speakers were the same kind as used for regular listening, slightly beefed up, and they performed well. Once in a while someone would turn the volume all the way up and a speaker would fail, but since the amplifiers were seldom driven to full output, this didn't happen too often.

Then came the revolution. Bands changed along with the boys' haircuts (or lack of them). Brasses and reeds were replaced by guitars and more guitars. Music groups amplified their sound to approach the threshold of pain and still their followers cried for more. Bass guitars, guitars, electronic organs, accordions, and string basses were equipped with giant amplifiers. Ironically, the point has now been reached where a saxophone must be amplified in order to hold its own with the guitars. The effect on speakers has been devastating.

Hi-Fi Speakers Won't Do the Job

Full-range, hi-fi speakers rated at 50 watts would appear to meet the demands of this electronic musical instrument craze. But they simply are not equal to the job. Your hi-fi amplifier may be rated at 100 watts but you rarely play it that way. For average listening with fairly efficient speakers you may use less than one watt of amplification, with the balance held in reserve for musical surges. Even then, full power rating is seldom, if ever, attained and the reserve prevents clipping or distortion.

Today, the conditions of musical instrument amplification are completely different. Guitars maintain a constant 50-watt amplification with surges far in excess of the ratings. A few years ago you would be lucky to find a speaker that could last a week operating at 50 or 100 watts. We now have speakers rated at 100 watts and guaranteed for life. However, the speakers had to be modified drastically in many areas to make them rugged enough to do the job.

Frequency-response characteristics of electronic musical instrument loudspeakers differ radically from those of hi-fi speakers. But total response range is not too different because most musical instrument speakers are designed to respond from 40 or 60 Hz up to 8000 Hz. This is somewhat below the top end of the hi-fi system but high enough to provide full tone with only the very top overtones removed.

The big difference in speakers is in the response curve. Hi-fi units produce a very flat curve, with little difference in response from bottom to top of the speaker range. Musical instrument speakers give heavy emphasis to the frequency range from 1000 to 5000 Hz. In other words, these speakers are designed to emphasize the upper middle range and create added fullness or presence, rather than to produce tone fidelity.

Electronic musical instrument speakers vary somewhat in size and range but, as a general rule, the ranges are as follows: bass guitar and string bass, 40-8000 Hz; guitar and accordion, 60-8000 Hz; and electronic organ, 40-8000 Hz. The 1000-5000-Hz range is boosted for all instruments.

Tests and Design Problems

One problem in designing speakers for continuous heavy duty was to first develop a test procedure. After trying musical programs and noise inputs, we found that sine-wave warble tests at 50 watts would provide conditions more severe than field use. Put to this test, every speaker failed.

Speakers were then designed to withstand 100-watt sine-wave warble testing. It was felt that if a speaker could pass this torture test, it could cope with any field use.

The initial difficulty was finding a speaker cone and suspension material capable of withstanding the violent motion while still producing clean sound. Ordinary short-fiber paper used in most speakers was too brittle and fell apart when subjected to continuous heavy-duty use. Many other materials that could withstand the strain were too soft to produce adequate upper-range tones. A specially developed long-fiber paper proved to be the ideal compromise, giving excellent high-end extension without any sign of disintegration.

After solving the speaker cone and suspension problems, the next stumbling block was the lead wires from the voice coil to the junction and the junction to the terminals. High-amplitude movement caused by the extreme power concentrated stress and fatigue failure. Wire with improved fatigue characteristics was an improvement but still not good enough.

The next step was to change the basic design, distributing stress uniformly instead of concentrating it at one point. The combination of new wire and new design provides permanent lead wires without noticeably interfering with speaker reproduction quality.

Another highly sensitive area was the voice coil. The tremendous heat generated, well into hundreds of degrees Fahrenheit, quickly melted the polyurethane insulation used in the voice-coil wire and permitted fusing. A special high-temperature enamel insulation that remains effective under all expected conditions was used to solve this problem.

Heat also was the source of two other major problems in the voice coil. At elevated temperatures, the varnish holding the coil to the bobbin broke down and allowed the coil to slide completely off the bobbin. By switching to a synthetic heat-setting cement that bonds tighter as heat increases, this problem was solved.

We also found that intense heat charred the paper bobbin and disintegrated it. Several substitute materials were tried and a glass-fiber bobbin emerged as the ideal solution. The speakers can now be played with extremely hot voice coils without speaker failure. These speakers will withstand continuous 100-watt sine-wave warble tests and will last indefinitely. ▲

SEMICONDUCTOR SWITCHING OF LOW-POWER CIRCUITS

By AUBREY HARRIS/Staff Engineer, Ampex Corporation

Semiconductors can be used in place of relays to control d.c. loads up to 35 A and a.c. loads up to 10 A. Advantages include no contact bounce, wear, or maintenance, along with increased reliability, reduced noise generation, and economy of space.

SEMICONDUCTORS are now replacing relay contacts in many low- and medium-power d.c. and a.c. power switching circuits. These solid-state devices are available for the control of d.c. loads ranging from a few milliamperes to 35 amperes, and of a.c. loads as high as 10 amperes.

The principal advantages offered by semiconductors include no contact bounce, increased reliability, no contact wear, no contact maintenance, reduced generation of RFI and noise, and economy of space.

The less desirable characteristics of semiconductors include a voltage drop across the devices that may be as much as 1 volt, a requirement for multiple-pole switching that adds complexity, and possible damage by voltage surges.

However, these disadvantages may be overcome quite readily by careful design of the circuits in which the semiconductors are used. A few areas of application are automatic programmers, motor control, indicator-lamp switching, control of high-power lighting and heating, timing circuits, and traffic control. Other applications will probably suggest themselves to the readers.

Semiconductor switching is now used in many types of magnetic tape recorders, business machines, vending machines, small electric tools, and material-handling apparatus. It is to be expected that a great many industrial and domestic appliances and tools will be controlled by semiconductors in the very near future.

Solenoids

Solenoids, or electromechanical drivers, are commonly used in magnetic tape recorders, for the printing hammers of electric typewriters and Teleprinters, in electric paper punches, in brake actuators, and in many other electromagnetic devices. In all of these, the use of semiconductor switching is entirely feasible.

The simple solenoid driver circuit of Fig. 1A may be used for switching loads up to 5 amperes. In this circuit, emitter follower Q1 provides the base current required by coil driver Q2. In the quiescent state, the emitter of Q1 is virtually at ground potential and, because there is no voltage across base-emitter junction Q2, no current flows into the load. When switch S1 is closed, current flows into the base of Q1 and its emitter "follows" the base voltage, which in this case is held at approximately +15 volts by voltage divider $R1/R2$. This action causes Q2 to saturate, thus energizing the load.

When an inductive load is de-energized, a voltage transient is developed by the rapid decay of current flow through the inductance. This voltage may reach an amplitude of several hundred volts, which may destroy Q2 unless it is suppressed. Diode $D1$ provides the needed transient suppression by conducting during the transient condition only. The 1N4005 diode chosen is capable of carrying the full load current of the inductance.

The circuit of Fig. 1A may be converted to a latching arrangement by the addition of Q3 and associated components as shown in Fig. 1B. Switches S1 and S2 are momentary contact types; S1 is normally open while S2 is normally closed. When S1 is actuated, the load is energized and held in this condition until S2 is actuated.

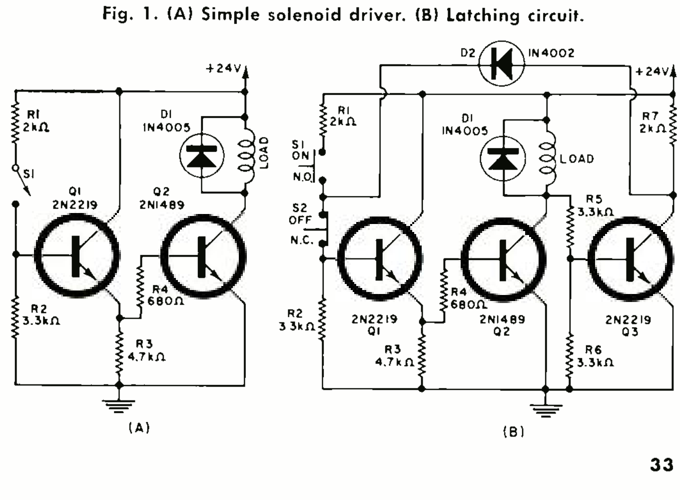
When the load is not energized (*i.e.*, Q2 is cut off), the supply voltage (applied to the base of Q3 by way of the load and resistor $R5$) causes Q3 to saturate. The collector voltage of Q3 then approaches ground potential, no current flows through diode $D2$, and no feedback voltage is applied to the base of Q1, which is therefore cut off. When the load is energized (by the actuation of S1), Q2 saturates, collector voltage Q2 swings to approximately 1 volt, and Q3 is cut off. Under this condition, the supply voltage is fed back to the base of Q1 through $R7$, diode $D2$, and switch S2 and holds Q2 saturated. This is the latching action characteristic of this circuit. When S2 is actuated, no supply voltage can reach the base of Q1, which then turns off, causing Q2 to cut off and Q3 to saturate, thus restoring the initial condition to the circuit.

Silicon Controlled Rectifiers

Many applications require the switching of a large load by means of a small control current. The silicon controlled rectifier is ideal for this application. Fortunately, an SCR requires a minimum of associated components and is available in a wide range of power-handling capabilities, permitting switching loads of one ampere to several hundred amperes. The trigger or gate current that controls an SCR is always a small percentage of the load that is switched and ranges from a few microamperes to 5 amperes (for the heaviest loads).

The SCR is inherently a latching device. When an SCR is gated on, the current flow (I_L) from cathode to anode continues until the supply voltage is removed or until the current flow is reduced to less than the holding current (I_H) required by the device. Stated more directly, at any time that I_L does not exceed I_H, the latching action is disabled. Typical holding-current values are 1 or 2 milliamperes for

Fig. 1. (A) Simple solenoid driver. (B) Latching circuit.



SCR Type Number	Forward Blocking Voltage (V_{FOM}) (volts)	R.M.S. Forward Current (I_F) (amperes)	Forward Blocking Current (I_{FX}) (microamperes)	Holding Current (I_H) (milliamperes)	Gate Trigger Current (I_{GT}) (milliamperes)	Gate Trigger Voltage (V_{GT}) (volts)
2N2323 (C5F)	50	1.6	2 - 10	1 - 2	.01 - .2	.5 - .8
2N2323A	50	1.6	2 - 10	1 - 2	.002 - .02	.4 - .6
2N2326 (C5B)	200	1.6	2 - 10	1 - 2	.01 - .2	.5 - .8
C22F	50	7.4	1000 - 10000	10 - 30	4 - 25	.8 - 1.5
2N688	400	35	6500	10 - 100	15 - 40	1.5 - 3.0

Table 1. Useful design characteristics of a group of typical silicon controlled rectifiers.

a 1.6-ampere device, and 10 to 30 milliamperes for a 7.4-ampere device. (Table 1 includes the more useful design characteristics of typical SCR's.)

The basic latching circuit of an SCR is shown in Fig. 2A. When momentary contact switch S1 is actuated, a pulse of the gate voltage (V_g) is applied to gate terminal *G*, causing the SCR to saturate. The gate voltage may range from +3 to +6 volts; the minimum gate current for a sensitive, low-current SCR (*e.g.*, the 2N2323A) is on the order of 10 to 200 microamperes. The SCR will remain saturated until the power supply is disconnected. Because removal of the power supply involves handling the total current required by the load, other means of reducing I_L to a level below I_H are necessarily employed.

The latching circuit shown in Fig. 2B provides controlled turnoff by the addition of commutating capacitor *C* and switch S2. The SCR is gated on by the momentary actuation of switch S1, causing the potential at point *A* to swing to approximately 1 volt above ground. Capacitor *C* then charges from the power supply through *R*2. When *C* is fully charged, the voltage at point *B* is positive with respect to point *A* by the difference between the supply voltage and the voltage drop across the SCR.

The SCR is turned off by actuation of switch S2, which grounds point *B*, causing the charge on capacitor *C* to decay toward ground potential. Because *C* cannot discharge instantly, the potential at point *A* swings below ground potential by the amount of the charge, causing the anode of the SCR to be negative with respect to the cathode. The result is that the SCR turns off and remains off until another gate pulse is applied.

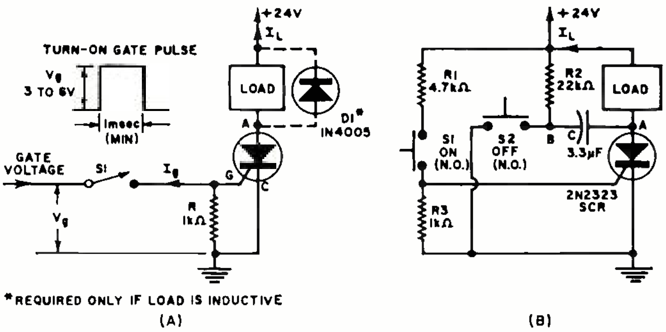
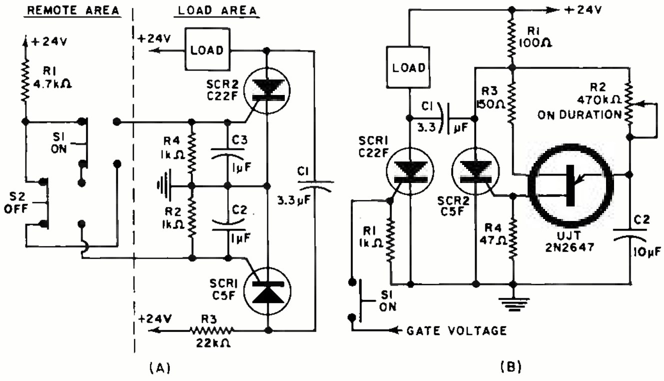


Fig. 2. (A) Basic SCR latching circuit. (B) An SCR latching circuit using a commutating capacitor to assist operation.

Fig. 3. (A) Load control by remote power feed. (B) A load control which provides turn-off of load power at some predetermined time interval following the turn on (via R2).



The approximate capacitance (in microfarads) of commutating capacitor *C* may be computed by the formula $C = (1.5 t_{off} I_L)/V$ where V is the supply voltage, I_L is the load current in amperes, and t_{off} is the turnoff time of the SCR in microseconds.

In the typical case where the supply voltage is 24 volts, the load current is 1 ampere, and the SCR turnoff time is 50 microseconds, the computation is $C = (1.5 \times 50 \times 1)/24 = 3.1$ μF.

In practice, the next larger standard value of 3.3 μF is selected. The resistance of *R*2 is not critical; a typical choice of resistance is in the range of 10,000 to 100,000 ohms.

A variation of the SCR latching circuit of Fig. 2B appears in Fig. 3A. The principal differences include the addition of low-power *SCR*1 and the use of normally closed (instead of normally open) momentary contact switches. The capacitance of commutating capacitor *C*1 remains unchanged at 3.3 μF.

When switch S1 ("On") is actuated, load *SCR*2 is gated on from the power-supply voltage through *R*1 and normally closed switch S2. Capacitor *C*1 then charges between ground (through *SCR*2) and the supply voltage through *R*3. When switch S2 ("Off") is actuated, *SCR*1 is gated on and commutating capacitor *C*1 lowers the anode voltage of *SCR*2, which turns off *SCR*2. Capacitor *C*1 then charges in the opposite direction between ground (through *SCR*1) and the supply voltage through the de-energized load. When S1 ("On") is again actuated, the cycle just described is repeated. It is thus apparent that *SCR*1 and *SCR*2 operate in flip/flop action so that when one is conducting, the other is cut off.

The resistance of *R*3 is calculated by the formula (1/50) $(V_{BR}Fx/I_{Fx})$ where $V_{BR}Fx$ is the forward breakover voltage in volts and I_{Fx} is the leakage current in amperes.

Capacitors *C*2 and *C*3 prevent noise pulses in the remote gate lines from inadvertently firing *SCR*1 or *SCR*2. If switches S1 and S2 are actuated during an overlapping period of time, the first one depressed may affect the states of *SCR*1 or *SCR*2, but the second one depressed will have no effect until the other is released. If both are depressed simultaneously, no trigger pulses will be generated and the states of *SCR*1 and *SCR*2 will not be affected.

The circuit of Fig. 3B provides the feature of an adjustable period during which the load is energized by a trigger pulse. When switch S1 is actuated, *SCR*1 is gated on and the load is energized. Commutating capacitor *C*1 then charges between ground (through *SCR*1) and the supply voltage through *R*1, and *SCR*2 is turned off. Under this condition, relaxation oscillator *UJT* produces one cycle of oscillation, the duration of which is a direct function of the setting of variable resistor *R*2. At the conclusion of the cycle, *SCR*2 is gated on by the pulse formed across resistor *R*4, the *UJT* is disabled, and *SCR*1 is turned off by the charge on *C*1.

An SCR is also useful as a lamp driver. In this application the SCR controls a bank of high-wattage lamps by means of a small amount of gate power. For instance, a 2N688 will handle a load of 35 amperes r.m.s. up to a peak of 400 volts by means of a gate drive of 3 volts at 40 milliamperes (see Fig. 4A).

Because an SCR is a unidirectional device, the lamp power must be full-wave rectified a.c. However, the resulting pulsating d.c. waveform is not filtered because the return of each positive excursion to zero volts is useful when the lamps are to be turned off.

The positive gate voltage is applied to the SCR gate by the closing of switch S1. When the lamps are to be turned off, S1 is opened, and the lamps are de-energized at the next return to zero of the d.c. waveform.

Triacs

The gated bi-directional controlled rectifier (or the gate-controlled a.c. switch) is a recent development in the field of SCR design and is known as a Triac. This device is capable of switching a.c. loads as high as 400 volts at 10 amperes and may be used in parallel for higher current loads. (Table 2 includes the more useful design characteristics of typical gate-controlled a.c. switches.)

The Triac may be gated on by either a negative or a positive voltage and will conduct until the end of the half cycle during which the gate drive is removed (or until the a.c. power is disconnected). The basic application (see Fig. 4B) uses a d.c. gate voltage (V_g); the Triac conducts during both the positive or the negative excursion of the sine-wave power. Polarity of the gate drive is not significant.

In order to drive an a.c. motor or device, the power line itself may be used as a trigger to cause the Triac to deliver a.c. power to the load. The basic circuit of this application appears in Fig. 4C. Assume that the initial conditions are that a.c. power is present, the Triac is not conducting, and point *L* is positive with respect to point *M*. At this time, the full supply power is applied to the Triac, and point *A2* is positive with respect to point *A1*. If switch S1 is then closed, current will flow through *R1* (and S1) to gate terminal *G*, which will turn on the Triac. The potential between *A1* and *A2* will then drop to a very low value that will cause the flow of gate current to cease. The Triac will conduct through the half-cycle, cut off momentarily at the zero crossover of the power-supply waveform, and resume conduction as soon as the opposite excursion of the waveform has started. This cycle of events will repeat as long as switch S1 remains closed. When S1 is opened, the Triac will cut off at the next zero crossover of the waveform and remain off until S1 is again closed.

It is often necessary to isolate the control circuit from a line-operated load. Fig. 5A illustrates one means of providing this isolation by the use of a grounded relaxation oscillator and a small 1:1 pulse transformer. The gate and terminal *A1* of the Triac are connected to opposite terminals of the *T1* secondary winding. Components *R1*, *C1*, *Q1*, *R2*, and the primary winding of *T1* form the *UJT* relaxation oscillator.

Under initial conditions, switch S1 is open, the relaxation oscillator is dormant, the power-line voltage is present, the Triac is not conducting, and the load is not energized. When S1 is closed, the oscillator begins generation of its nominal frequency which may be in the range of 600 to 6000 Hz. The resulting pulses are coupled through *T1* to the gate of the Triac. The first pulse received causes the Triac to saturate during the remainder of the first half-cycle of power; succeeding pulses within this period are ignored. At the first zero crossover of the power waveform, the Triac cuts off momentarily but is triggered on again by the first pulse received after the next half-cycle of power begins. This action repeats as long as switch S1 remains closed. Obviously, slightly more of the full waveform of the line power will be delivered to the load if the oscillator operates in the region of 6000 Hz rather than in the region of 600 Hz because the off time at the zero crossover will be slightly more brief.

A Triac may be connected in a latching circuit as shown in Fig. 5B. Assuming that the Triac is initially cut off, if S1 is closed, current will flow through *R1* and *R2* to the gate and the Triac will saturate. During the first half-cycle of the power waveform, capacitor *C1* charges through *R2* and the Triac toward the load voltage; at the end of the half-cycle, capacitor *C1* discharges through the gate, which triggers the Triac into saturation for the next half-cycle. This process continues until S2 is closed, which causes *C1* to discharge through the load, leaving no current flow through the gate. The Triac then cuts off at the next zero crossover of the power waveform and remains off until S1 is again operated. ▲

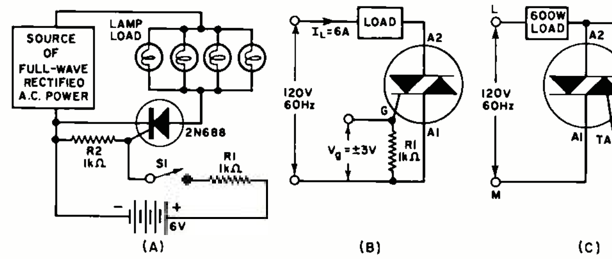


Fig. 4. (A) Basic application of SCR in a lamp-driver circuit. (B) Basic application of a gated bi-directional controlled rectifier. (C) The power line triggers the gated bi-directional controlled rectifier when switch S1 closes.

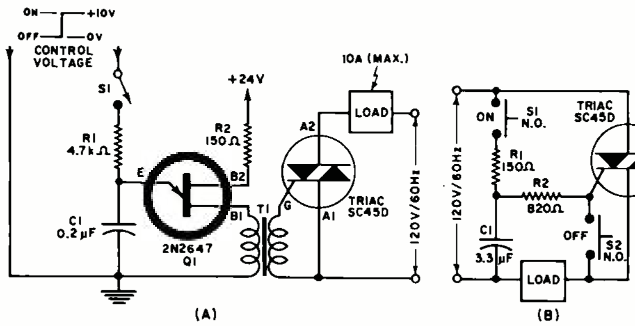


Fig. 5. (A) Low current isolated control of a large power load. (B) Triac connected in a typical latching circuit.

Table 2. Useful design characteristics of typical gate-controlled a.c. switches (Triacs).

Triac Type Number	Forward Blocking Voltage (V_{FOM}) (volts)	R.M.S. Forward Current (I_F) (amperes)	Holding Current (I_H) (milliamperes)	Gate Trigger Current (I_{GT}) (milliamperes)	Gate Trigger Voltage (V_{GT}) (volts)	Manufacturer
SC 40 B	200	6	25 - 50	25 - 100	1.5 - 3.0	G-E
SC 45 B	200	10	25 - 50	25 - 100	1.5 - 3.0	G-E
SC 45 D	400	10	25 - 50	25 - 100	1.5 - 3.0	G-E
TA 2892	100	2.5	1 - 5.5	1 - 4.5	1 - 2.6	RCA
TA 2893	200	2.5	1 - 5.5	1 - 4.5	1 - 2.6	RCA
TA 2918	200	6	5 - 36	15 - 35	1 - 2.4	RCA
TA 2919	400	6	5 - 36	15 - 35	1 - 2.4	RCA

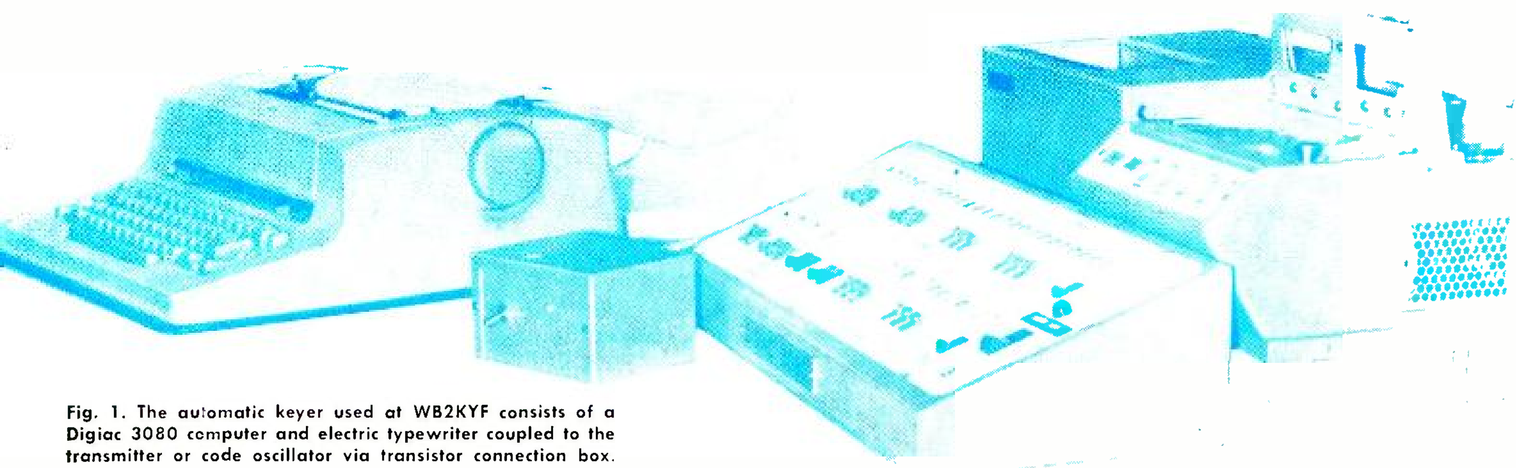


Fig. 1. The automatic keyer used at WB2KYF consists of a Digiac 3080 computer and electric typewriter coupled to the transmitter or code oscillator via transistor connection box.

The Penultimate Automatic Keyer

By PETER A. STARK, K2OAW, STEPHEN GORDON, WA2CPE and ANTHONY MANFREDONIA

Dept. of Electrical Technology, Queensborough Community College

Tying a digital computer to a ham transmitter or code oscillator may be an expensive way to add an automatic electronic keyer; however, this setup not only sends code but it can also practically conduct the entire QSO.

HERE is an automatic keyer that does almost everything but tune up the rig and think. It not only completes dots and dashes (as any good keyer should), but also forms complete letters, words, and sentences automatically. It has an internal memory that can store entire sentences and paragraphs, such as QTH descriptions, and can transmit them at will. The input into the keyer is from an electric typewriter, with Morse code generated entirely by the keyer at any speed from 1/10 to 100 words-per-minute. It can even generate start-stop teletypewriter code.

The heart of the keyer is a digital computer, which is coupled to the transmitter through a simple transistorized connection box. The unit, shown in Fig. 1, is the keyer we have set up at WB2KYF, the club station at Queensborough Community College of the City University of New York.

The computer used in our installation is the DE3080 made by *Digital Electronics*. Although this particular computer costs about $20,000, the keyer can also use the $10,000 PDP-8S computer, made by *Digital Equipment Corp*. The PDP-8S is substantially faster and can easily reach 100 words-per-minute speeds, while our DE3080 is presently somewhat slower.

The price of $10,000 for a mere automatic keyer may seem somewhat steep, even considering its features. But remember that the keyer can also do other things. In its spare time, the computer can balance the YL's checkbook, do the junior op's homework, or play tic-tac-toe with your neighbor. During a dull party it makes an excellent conversation piece, and can even be taught to tell your guests things you would never dare tell them yourself!

The Digital Computer

As mentioned earlier, the heart of the keyer is the digital computer. Since this is a new piece of gear in the ham shack, let us spend a little time describing it.

A digital computer is really nothing but a lightning-fast calculator with a memory for numbers and instructions. By means of these instructions, it can go through a long procedure which can be quite involved. The typical computer has five basic sections, shown in Fig. 2. These are called the input unit, the memory unit, the output unit, the arithmetic unit, and the control unit.

The input unit is used to feed information into the computer. On our computer it consists of an electric typewriter, a punched paper tape reader, and a card reader.

The memory unit is used to store information fed into the computer through the input unit. Each separate piece of information is located in a specific place in the memory. To keep the information straight, each of these locations in the memory has an *address*, which is used to identify what is where. The computer used at WB2KYF has 4096 separate memory locations. Since each location can store up to four letters, numbers, or punctuation marks, this means we can store over 16 thousand letters in the memory. But since the instructions telling the computer what to do are also stored in the memory, the space left for words is somewhat less. Still, this is quite an impressive storage for useful information. We could, for example, store an entire page from a telephone book in the memory and transmit it, without error, at any code speed beyond the ability of any operator to copy. Great for the times when you cannot think of anything else to say!

The output unit of our computer is normally the electric typewriter and a paper tape punch; in addition, the lights on the control panel shown in Fig. 1 can also be used for output. In order to use the computer to generate Morse code, we have to add another output circuit to energize a fast relay to key the transmitter. The most efficient way to do this would be to dig into the computer and modify the circuits. But since this is likely to void the guarantee, there is an easier way. Since the lights on the control panel can be used for output, it is simple to connect the code output circuitry directly across the lamp bulbs.

The arithmetic unit of a computer can take numbers from the memory and perform simple operations like addition, subtraction, division, and multiplication. The results can then be fed into the memory and saved for later calculations, or can be fed out through the output unit.

Finally, the control unit of a computer takes the instructions which have been stored inside the memory and converts them into electrical signals which, in turn, operate the various computer circuits. The instructions are stored in the memory as numbers, and are called the *program*. By means of the program we can tell the computer exactly what to do.

How the Keyer Works

The code output from the computer is taken from the lights on the control panel. To see how this is done, let's look at how the memory addresses are numbered.

Our computer has 4096 different memory addresses, which would normally be numbered 0000 through 4095. But the computer works in the binary number system instead of in the decimal system. Instead of numbering the addresses in decimal, it numbers them in binary.

The binary number system uses only two digits, 0 and 1, instead of the digits 0,1,2, through 9. Since this means we can give much less information per digit, we need many more digits for any number. For example, the decimal number 9 is really a binary 1001. The four-digit number 4095 is really a binary 111111111111, the number 4093 is really 111111111101, and so on. To identify all of the 4096 addresses, we then need twelve binary digits, where any one of the digits can be either a 0 or a 1.

Inside the computer is a circuit called the *address register*. This address register can store a 12-digit binary number consisting of zeros and ones. Whenever any number inside the memory must either be pulled out or put back, the address register contains the address of that number. This register then generates electrical signals which tell the memory the exact address desired.

To help the computer operator, the circuits in the address register are connected to twelve indicator bulbs on the front panel. These are at the lower right corner of the control panel. Any time the computer reaches into the memory to take out a number or place it into the memory, the address register lights on the front panel indicate the number of the address. A lighted bulb stands for the binary digit 1, while a bulb turned off stands for binary 0. Normally, the computer works so fast that the lights flicker on and off extremely quickly. In fact, the delay in lighting the bulb is so great compared with the computer speed that often the bulbs, instead of flickering, just seem half-bright, and get slightly brighter or dimmer, depending on what the computer is doing.

Now suppose that we write a computer program which only uses computer addresses 0 through 7. Since the binary number for decimal 7 is 000000000111, only the right three bulbs will ever light. The other nine bulbs will be off. In the same way, we can write a program which will light any combination of bulbs we want. This is the trick needed to generate Morse code.

Let's look at the last nine memory locations. In decimal they might be numbered 4087 through 4095. But since the computer numbering is in binary, the numbers go this way:

Decimal	Binary
4087	111111110111
4088	111111111000
4089	111111111001
4090	111111111010
4091	111111111011
4092	111111111100
4093	111111111101
4094	111111111110
4095	111111111111

Remembering that a 1 in the address register lights the bulb and a 0 keeps it off, we see that the numbers 4088 through 4095 all light the nine left bulbs, while the number 4087 only lights the eight left bulbs. As it happens, only the numbers 4088 through 4095, of all the computer addresses, light the nine left bulbs. Any other address results in at least one of the nine left bulbs being off. To key our transmitter, we use a circuit called an "and" circuit which keys the transmitter only if all of the nine left bulbs are on.

You may ask why we don't use just one bulb. The reason is simple. Look, for example, at the right hand digit in the preceding table. Every even decimal number results in a 0 while every odd number results in a 1. Thus every odd address in the computer would light the right-most light. We then couldn't use the odd addresses for any information, since we would accidentally key the transmitter whenever we wanted to reach that piece of information. This is true for every other bulb. The second bulb from the right lights for every two addresses, the third bulb for every four, and so on. If we used only one of the twelve bulbs, we would have to leave half the memory empty so as not to accidentally key the transmitter. By using nine bulbs in combination, we have only 8 addresses which key the transmitter, and can use the other 4088 addresses in the computer for storing information.

But how do we key the bulbs on and off in Morse code? This part is simple too. Suppose that the computer has a program located between addresses 4088 and 4095, which merely does some counting from 1 up to some higher number. For example, the computer might add

$$1+1=2$$
$$1+2=3$$
$$1+3=4$$
$$1+4=5$$
$$1+5=6$$

and so on. The computer can be programmed to count up to, say, 100, and then do something else such as go to another program at address 0000. As long as the computer is counting, the nine left bulbs are continuously lit; when the computer stops counting the lights go out.

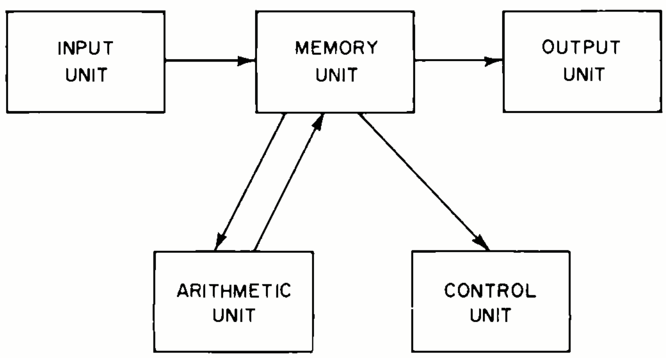
To send the letters and numbers in code, we merely tell the computer how high to count. Suppose the computer can count to 1000 in one second. Then the program to send the word MAT very slowly would go like this:

1. Count to 1500
2. Wait
3. Count to 1500
4. Wait
5. Wait
6. Wait
7. Count to 500
8. Wait
9. Count to 1500
10. Wait
11. Wait
12. Wait
13. Count to 1500

This program would lead to 1½-second dashes and ½-second dots. To speed up the program, we merely tell the computer to count less. Counting to 300 for a dash and to 100 for a dot would result in a 0.3-second dash and a 0.1-second dot.

In reality, this program would have to be a little longer.

Fig. 2. Block diagram of a typical digital computer.



We would also have to change the length of the wait intervals depending on code speed. Then there would have to be a program to recognize the letters typed on the typewriter and translate them into the proper instructions to send the code, or to take whole sentences out of memory and convert them into the instructions needed to get the code. This is an interesting project in itself. But since it depends on the exact computer you use to build your penultimate automatic keyer, we won't go into it here.

You will notice that a simple change of program can also change the code. Since the program is stored in the computer's memory and placed there just by typing it on the typewriter, we do not have to change any wiring to get the different code. We can easily get any code we want. By typing in a new program, we can get teletypewriter code.

How to Connect to the Computer

The keying portion of the keyer connects to the nine left bulbs on the address part of the control panel. This connection is made in such a way that the keying relay closes only if all of these lights are on.

Fig. 3 shows how the lights are connected inside a typical computer. Each bulb is in the collector circuit of a transistor; if the transistor is turned off, the light is also off. If the transistor is on, the light is on. In this way, the transistor acts like a switch to turn the light on and off.

When the transistor is on and acts as a short circuit to the lamp current, the voltage at the collector is very low—quite close to 0 volts. When the transistor is open and there is no lamp current, the collector voltage is about −10 volts (assuming *p-n-p* transistors and a −10-volt supply). The collector voltage then indicates whether the bulb is on or off.

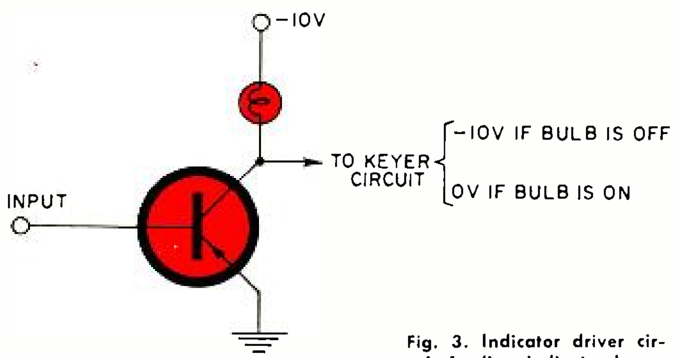
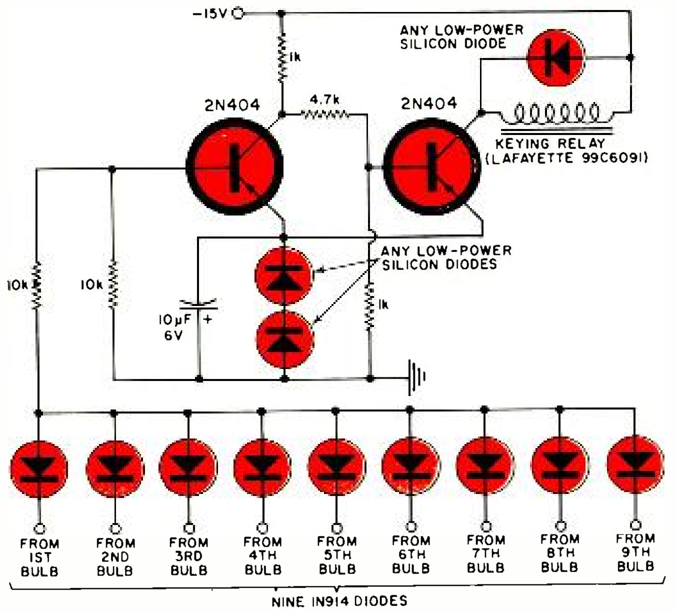


Fig. 3. Indicator driver circuit feeding indicator lamp.

Fig. 4. "And" circuit used to sense which lamps are on and drive the keying relay (5000-ohm, 1.4-mA pull-in radio-control type).



To monitor the nine left-most bulbs in the address register, we feed the signal from the nine indicator driver transistors to a circuit called an "and" gate. The word "and" implies that we get an output from the circuit only if the first signal is there, "and" the second signal is there, "and" the third signal is there, "and" so forth. The "and" circuit driving the relay is shown in Fig. 4.

The nine signals from the indicator driver transistors are connected to nine diodes. Let's assume that some of the nine bulbs are off. Then some of the inputs to the diodes are negative. Since this makes the cathode of the corresponding diode negative, this diode conducts through the two 10,000-ohm resistors to ground. This places a negative voltage on the base of the first transistor. The first transistor is therefore on and its collector voltage drops to a low value. As a result, the base of the second transistor drops toward zero volts and the transistor turns off. This opens the relay used for keying.

If, on the other hand, all nine lights are on, then all of the inputs to the "and" circuit are about 0 volts. Since this takes away the negative bias from the first transistor, the transistor is off. Its collector voltage then becomes negative and provides a negative bias to the second transistor. This closes the relay. In this way we control the relay; if all of the lights are on, the relay closes, but if any one (or all) of the nine lights goes off, the relay opens.

This is all there is to the operation of the circuit. To make sure the circuit works reliably, we add a few more parts. The diode across the relay coil prevents a voltage spike, generated when the relay opens, from burning out the transistor. The 10-microfarad capacitor and two diodes in the emitter circuit provide a steady negative voltage drop of about 1 volt on the emitters of the transistors. This ensures that grounding the base of the transistor is enough to turn it off.

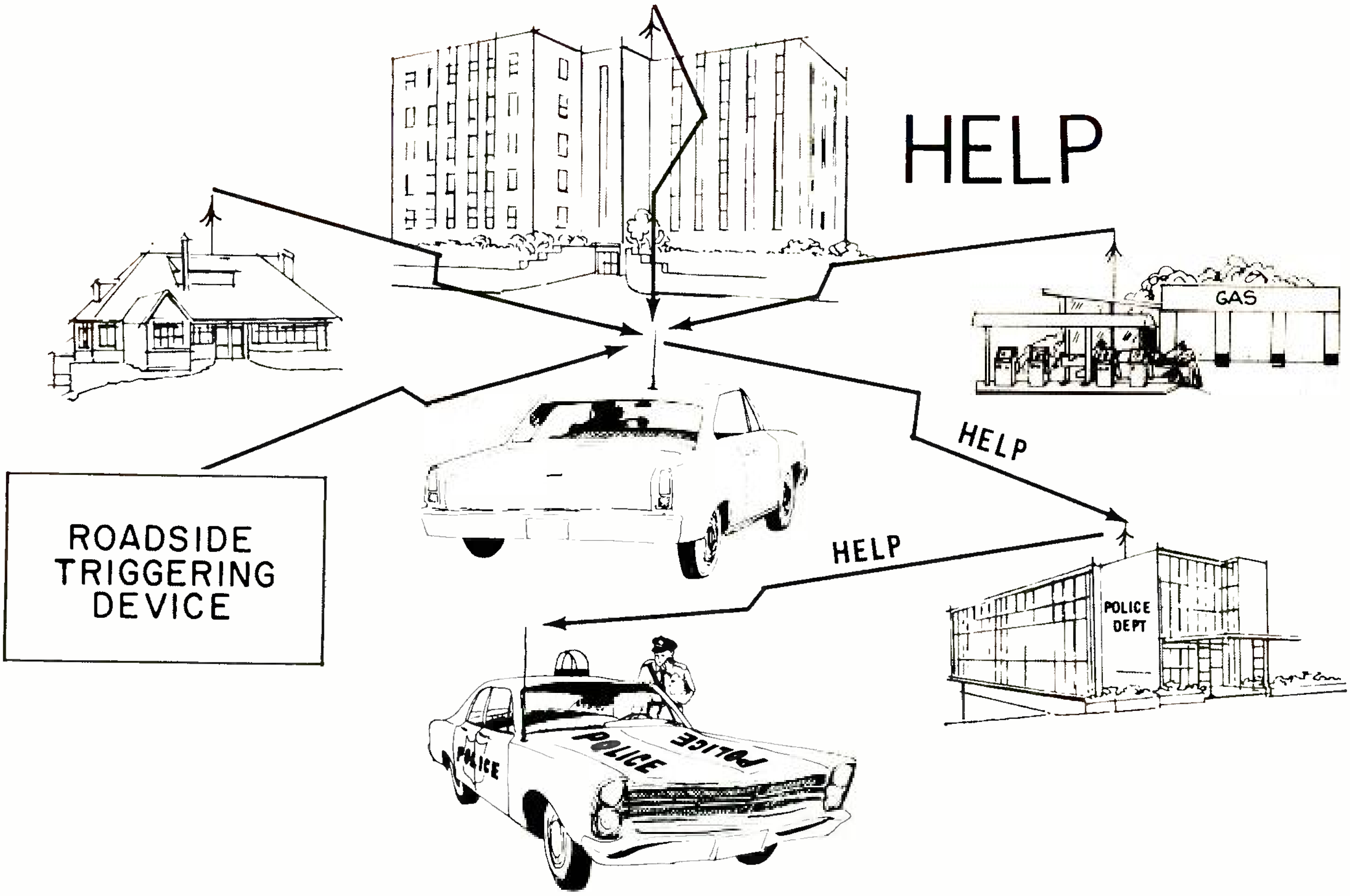
The 2N404 transistors are common medium-speed units used in digital circuits. They can handle relay coils which take up to 100 mA. A relay taking more current will require different transistors. If you plan to use this relay to generate teletypewriter code, a polar relay should be used. This is because a normal relay, while fast enough to produce good Morse code, is not fast enough to produce accurate teletypewriter code.

Operating the Keyer

How well the keyer works depends on the power of the computer and especially on whether the input and output units of the computer can work at the same time as the arithmetic and control units. If they can, then it is possible to sit at the typewriter and have the computer send out every letter as it is typed. If you type slowly, then the computer will have to wait for each letter. If you type quickly, on the other hand, the computer will send at the desired speed and merely store all unsent letters. A moderately fast typist can keep ahead of the computer as much as he wants, since the computer can store quite a backlog of information.

The computer used at WB2KYF, however, is a little more limited. It can either accept text from the typewriter or send out Morse code, but it cannot do both at the same time. For this reason we must first enter the text to be sent into the computer memory, and then send it out. Since we can prestore any number of messages, this is not nearly as bad as it might seem. A good operator can easily copy the other station and, at the same time, type the answers directly into the computer for later transmission. (*Editor's Note: The computer described is used for instruction purposes, while the setup described is actually used for code practice sessions. In order to use the setup for on-the-air contacts, it would be better to have a computer that could key the transmitter at the same time that the message is being typed.*)

The key to the successful use of the unit is in the programming, that is, in the instruc- (*Continued on page 74*)



The Search for a Highway Emergency Radio Program

By ROBERT M. BROWN

The search is on for an electronic system to move automobile traffic with safety and speed. Here is a description of the HELP, REACT, CRW, RRA, and DAIR systems, along with some others that have been tested in the past.

THE concept of a practical device for achieving radio communications between passenger car drivers and local authorities for purposes of routing, information, and road service has long been under study by various groups in the automotive and two-way radio industries. Until recently, the project has lacked the momentum necessary to see it through. In the last few months, however, a combination of factors has resulted in a rebirth of the idea, and the race is now on for an acceptable industry-wide radio system. New ideas are appearing in Society of Automotive Engineers presentations, research and development department conferences, and technical journals, with the more dominant systems now being tested experimentally. At stake are automaker contracts, prestige, and, of course, a great deal of Federal aid.

While the newly formed National Motor Vehicle Safety Council promises to play a major role in the search for the best radio system, right now the FCC is getting most of the attention. This is due largely to its full-scale 1967 inquiry into ". . . how radio might be more effectively and efficiently used in the promotion of highway safety".

Although it isn't known yet just how the final system will be integrated into the passenger car, there is considerable talk in automotive circles that Washington may ultimately legislate the device as standard-equipment to be incorporated into all American production-line cars.

The "Communications Gap"

Part of the motivation for the development of a highway radio system seems to be the necessity for ". . . closing the communications gap on our national highways". What is the "communications gap"? Fred Bauer of *Ford's* Radio Engineering Division describes it as a period in time when communications have progressed "only to the point where the driver must still communicate by horn signals and rely almost entirely upon his eyes for a thousand details of the roadway ahead". Eugene A. Hanysz of *General Motors'* Research Laboratories puts it another way: "As vehicle population and traffic density continue to grow, the motoring public will demand assistance that goes beyond that of present sign techniques." Clearly these manufacturers are planning now for such an eventuality.

The FCC gave interested parties until March 31, 1967 to file comments on which proposed highway emergency system they feel will be most effective. Explaining the Commission's involvement in something as far afield as highway safety, a December, 1966 report stated that the "appalling" death rate on the nation's roadways requires that the agency exercise its "broad authority . . . in the public interest".

Behind this activity is the Highway Safety Act of 1966 which provides 50-50 matching funds for states and local communities "to expand and improve" their road safety programs. In addition, it poses the threat of a 10% loss of Federal highway construction funds for states which fail to comply. Included in the Act are improvements such as "electronic controls that convey regulatory or convenience information to motorists" as well as "statewide emergency medical services programs" that clearly call for mobile radio to do the job. The Department of Commerce's National Highway Safety Agency is supervising the drafting of uniform standards for all the states, and the first suggestions were posted to representatives of the governors of the 50 states on February 16th of this year.

Industry Programs

Meanwhile, several industry-sponsored programs are receiving attention, including the HELP and REACT projects which have been operational for a number of years. These programs have been joined by newcomers CRW, RRA, and DAIR, with more pouring in at the rate of better than one a month. (These highway radio systems will be described in detail further along in the article.) What makes them significant is that they have been developed and financed by some of the country's leading radio and automotive manufacturers: *Hallicrafters, Ford Motor Company, Motorola,* and *General Motors.* In fact, an operational "radio highway" is now functioning with FCC approval between Detroit and Lansing, Michigan along Route I-96 to determine the feasibility of the Automotive Manufacturers Association's CB project.

Basic System Requirements

The diversity of these programs may preclude any all-encompassing description of their capabilities, but it is probably safe to say that each, to some extent, hopes to supply at least a few ingredients needed to effectively "close the gap". All parties concerned are agreed that the required technology is available; but until now necessary public information and promotion have been lacking.

What is needed is a reliable system that possesses several fundamental attributes: (1) it must have the ability to cover as much of the surfaced roadway in America as possible even though it might be initially implemented only in sprawling metropolitan areas; (2) it must be priced low enough to be practical from a long-range point of view; (3) it must furnish the driver with reliable two-way communications at the flick of a switch; (4) it must be capable of providing accurate road information to the motorist in all kinds of weather; and (5) as *Ford* puts it, it must develop a sufficient "initial momentum of sizable proportions" to be put swiftly into operation on a national basis.

It is interesting to note that, almost without exception, the majority of participants so far reporting in with emergency system proposals are starting with 27-MHz Citizens Radio Service equipment. At present, nearly half of all the transmitters in the United States (including TV, broadcast, police, etc.) are crowded into the 11-meter 27-MHz CB band; yet, in spite of this congestion, CB persists as the overwhelming choice. The reason for this is simple. Approximately three million transceivers have been sold to Americans anxious to provide themselves with vehicular communications. And this fact becomes even more important when it is considered that these sales have been made without benefit of massive advertising campaigns. The consensus is that perhaps by sheer acceptance of CB, the public might provide the required "momentum" to put the idea over.

Table 1. REACT statistics based on a recent system survey.

Organization:	
Number of participating teams	1400
Average number of members per team	27
Total of active membership	40,000
Total CB'ers with REACT training	100,000
Messages:	
Percentage of calls for road assistance	52.0%
Percentage of calls on actual accidents	21.4%
Total emergency situations handled monthly	50,238
Total emergency situations yearly	602,856

Present Emergency Programs

REACT. While the *Hallicrafters*-sponsored REACT (for Radio Emergency Associated Citizens Teams) is not the most complex or sophisticated, it is easily the best example of what volunteer channel-monitoring can accomplish. Consisting of about 1400 24-hour stations ready to provide CB channel-9 communications, augmented by a hard-core active membership of 40,000, REACT has handled over one million on-frequency requests for routing assistance, road service, and emergency aid (ambulance, fire, police, etc.). (See Table 1.)

When viewed in terms of a contender for a countrywide motorist emergency service, however, its abilities pale in comparison with total needs. For true participation, the REACT member must be a licensed CB'er familiar with equipment limitations and have the conventional under-the-dash transceiver handy on all occasions. In addition, REACT is relatively unknown outside CB circles and it doesn't pretend to promise direct tie-ins with police, ambulance service, and gas station monitors. Even so, the fact remains that it is the *only* radio-aid system now in operation on a large scale in the United States.

HELP. In early 1965, the Automobile Manufacturers Association announced the formation of project HELP (for Highway Emergency Locating Plan). Initially an extension of the REACT monitoring idea, HELP was promoted in several national magazines, in numerous radio broadcasts, and on more than 400 TV stations (which used an AMA film clip). The idea was simply to equip the *average* motorist with inexpensive CB gear designed for single-frequency (channel 9) operations.

It soon became apparent, however, that reliable, foolproof enactment of the HELP concept required a shift from congested CB frequencies to those outside the service. In this manner, highway authorities and gas stations could monitor the channels without the annoyance of unrelated transmissions. To accomplish this, the AMA petitioned the FCC for use of 27.235 and 27.245 MHz.

Before acting on this petition, however, the Commission in late 1966 requested that a working model highway be set up for scrutiny. On December 1st, the first two-way emergency system along a public highway was established on Michigan's Route I-96. To obtain aid, a motorist simply puts through a call on channel 9; this is answered by any one of several service stations strategically situated along the expressway. The results of this experiment, even though they will be incomplete in terms of the total HELP program, will be crucial to possible FCC endorsement of the AMA proposal.

Two other problems face the HELP proponents. First, the requested frequencies are not under the jurisdiction of the CRS (FCC Rules, Part 95); and secondly, service garages would stand to make a profit on the increased road calls. Both situations pose a serious threat to FCC approval, since enactment would require a major "exception" to normal Commission policy in such rule-makings. The profit factor is particularly controversial, since it has been suggested that a surcharge be placed on all HELP calls to "help pay for the system".

Even more important is the reaction of law-enforcement organizations that would be affected by the proposal. Many groups, including the Associated Police Communications Officers, Inc. (APCO), "aren't sure that HELP is the complete answer". APCO has asked that the Commission hold off a decision on HELP until it can study the matter. Meanwhile, the flood of other proposals has tended to stagnate the early momentum developed by the program. In the interim, the CB industry is stuck with a sizable carload of HELP sets.

CRW. Although *Motorola's* CRW (for Community Radio Watch) was designed primarily as a crime-fighter, it holds considerable potential as a practical highway safety aid. The idea is to have drivers of radio-equipped vehicles report "suspicious and unusual" occurrences to their dispatchers, who, in turn, relay the message to police headquarters where a patrol car is assigned to the vicinity. Rather than confine itself to CB'ers, it is applicable on a local level to all companies who have any form of radio communications equipment in use. This takes into account taxicabs, dry cleaners, and a host of other users where an employer might respond to a civic-pride appeal from City Hall. Indeed, the entire program is administered by the local Chamber of Commerce or Mayor's office.

Since its inception in late December, 1966, over 100 cities have enrolled, each representing a significant number of signed-up vehicles. Pittsburgh, for example, claims 3000, while Detroit has over 6000 participants. Cincinnati's Safety Director Henry J. Sandman has noted that "The . . . Police Division could not duplicate this program with even $100,000 worth of additional radio equipment".

How important a role CRW will play in the highway emergency system race depends solely upon the extent to which traffic accident and medical aid reporting is employed. With any kind of promotion from this angle, CRW may be a major contender for the most practical scheme.

Related Systems

Falling short of being a true two-way communications system, yet still representing a means of furnishing the driver with road and accident information, have been numerous attempts at installing low-power transmitters along the highway. In the early 1950's, for example, the New York Port Authority used a 400-watt AM transmitter feeding into a loop antenna to broadcast to a captive audience of motorists in the New York-bound lane of the Lincoln Tunnel. Every 2½ minutes a tape-recorded message was broadcast on 550 kHz which contained information and instructions; from time to time, authorities broke into the transmission to make emergency announcements. In 1952, however, the system was abandoned because, as one Port Authority official explained, "What can you say that's meaningful?" Apparently the Authority felt it could accomplish what it wanted just as effectively with signs, although a similar system is reported to be in use now in Maryland by the Baltimore Harbor Tunnel Authority. In the 1940's, a concept much the same as the Lincoln Tunnel idea was operated experimentally at New York City's George Washington Bridge. In 1959 a similar attempt was made by *United International, Inc.* to install a system along the New York Thruway.

Other broadcast proposals have included the *General Motors* "HICOM" and "HIGHWAY INFORMER" systems as well as 1966's "INFOMITTER," a highway installation designated for the Smethport, Pennsylvania area.

An insight into the FCC's general objections to methods of AM broadcasting to motorists can be gleaned from the Commission's denial statements in last year's "INFOMITTER" case. "Previous experience has indicated that practical problems . . . arise." These include finding a clear frequency and not causing interference to the broadcasting service. The entire concept, as a matter of fact, has been regarded by the Commission recently as having a "questionable operating status".

Although it is clear that the Commission is opposed to some methods, it is also interesting to note that a unique system not requiring any FCC policymaking and vaguely related to the CRW program has been in use for years in New England. A Boston taxicab association has come up with an unusual customer service. Any cab driver spotting an outpouring of people (from a hotel, movie, etc.) simply picks up his mike and broadcasts the news. Within seconds, dozens of cabs, many from competing taxi organizations, converge to supply the needed transportation.

In addition to alleviating possible inconvenience to customers, it has dramatically demonstrated how successful a central-frequency alerting system can be when intelligently employed to summon assistance. No relay stations are used. All cabs are tuned to the same frequency and simply help each other to cover the town.

Radio Road Alert

The *Ford Motor Company's* Radio Road Alert (RRA) takes a more sophisticated approach to the problem of highway communications. (See Figs. 1, 2, and 3.) Basically, this system consists of a message memory unit (prerecorded tape) that is electrically coupled to the entertainment radio. Action is triggered by a 100-milliwatt (or less) transmitter at the side of the road. Even though the car radio is off, the roadside transmitter automatically injects a message code which sets the memory unit in action to find the correct message on its prerecorded tape. Should a higher priority signal be received (coming from a road crew up ahead, for example), the memory unit interrupts the original message and substitutes the preferred one.

Technically, the *Ford* concept is intriguing. For trig-

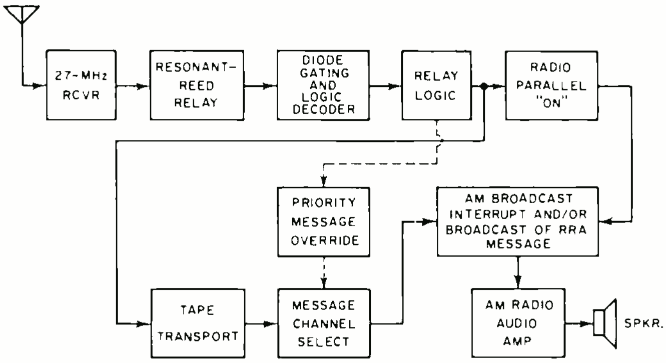
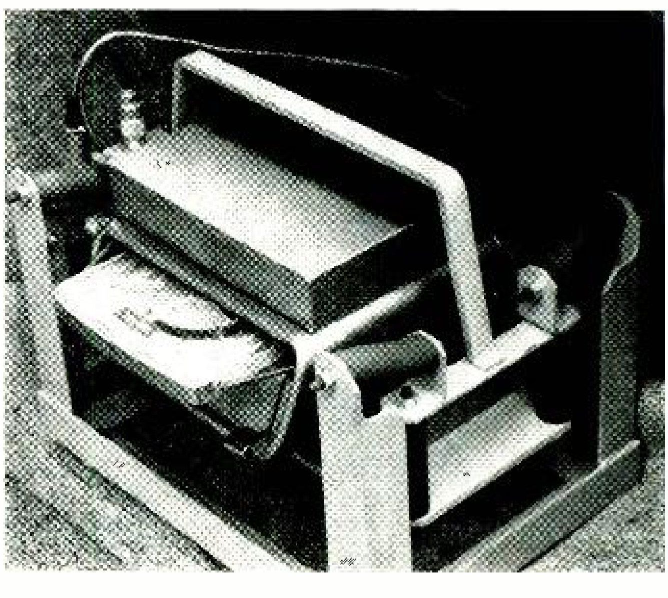


Fig. 1. When the RRA system picks up a tone-coded CB signal, a prerecorded tape takes over the car radio. Should a priority signal come in, it overrides other signals.

Fig. 2. An RRA memory installed in vehicle trunk space.



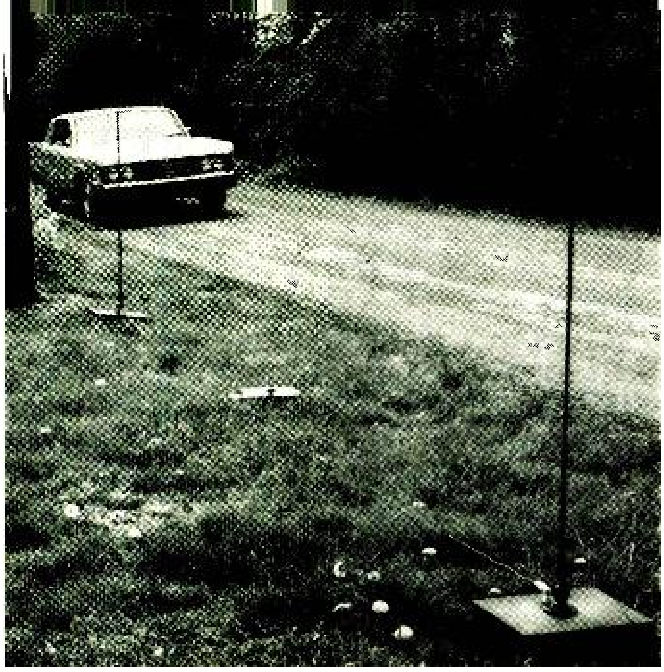


Fig. 3. An experimental RRA roadside transmitter system. Permanent installation would be on high, fixed supports.

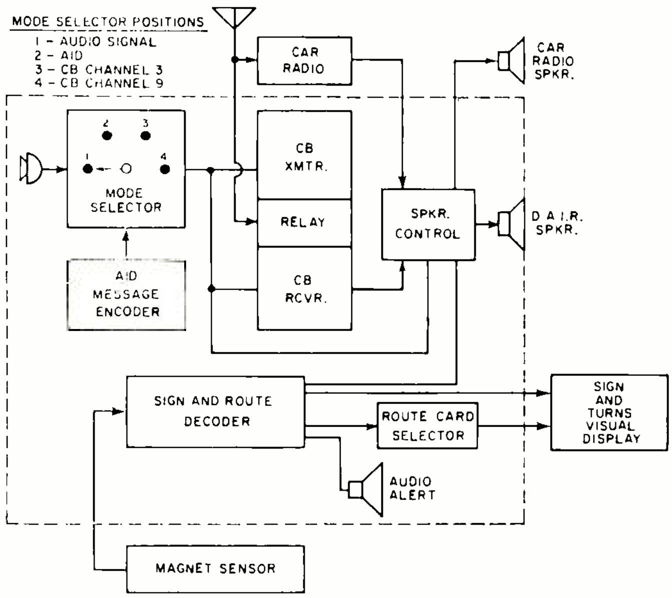
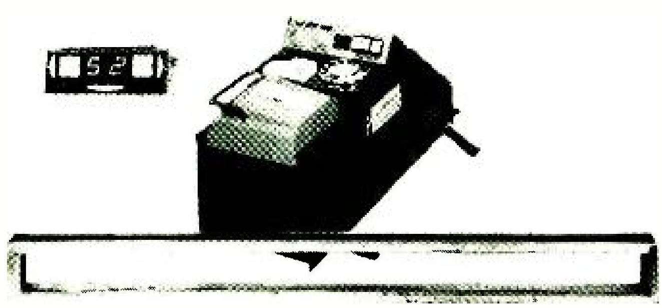


Fig. 4. The DAIR system uses either CB or signals from buried permanent magnets to activate the readout systems.

gering, the transmitted code first enters a resonant reed detector which, together with a diode-gating circuit, decodes the message. A relay IC logic circuit usually blocks incoming codes, permitting the AM radio to operate normally. When the proper code reaches the logic circuit, the tape-transport mechanism selects the correct message (providing priority override if more than one code is received) and injects this into the AM set's audio circuit, turning the

Fig. 5. Essential components of in-car DAIR system. Message readout (left), magnet sensor (bottom), and console. Console houses CB, magnetic logic, and signal processor.



car radio on at the same time (if it happens to be off).

Conventional or standard car radio whips can be used with matching transformers, eliminating the necessity for an additional receiving antenna. Directional transmitting antennas will be used to prevent confusion in cloverleaf areas. *Ford* feels that the tape-recorded message is superior to a direct/receive type in that "there is no possibility of static or other electrical disturbance" and the voice will be familiar to the driver and "well-modulated and properly enunciated".

Under the RRA system, several methods could be used for message storage. Presently in use on an experimental basis are magnetic tapes, although *Ford* states that a possibility exists of utilizing high-resolution photographic film scanned by a light beam to play back the message. A storage tube using a masking technique could also be employed, having the advantage of no moving parts.

If multi-channel operation develops within the framework of RRA, *Ford* envisions the possibility of playing commercials through the system "with a resultant increase in highway beauty", though the company doesn't give any indication of the subsequent cost of the logic or message-storage units required to handle such an increase in "programming".

Should the driver's car be equipped with a conventional CB set, he could tune to the triggering frequency and hear the messages over the air, although they might not be as clear. After sending the beeped code, the roadside transmitter would broadcast the proper voice message which could be periodically interrupted by police officers for direct reports. This law-enforcement break-in is referred to by *Ford* as an "electronic flare", to consist of a remote and portable transmitter "using a high-priority trigger code plus a recording tape". In addition, the police would have facilities for increasing transmitter power beyond Part 15 100-milliwatt limitations.

Finally, RRA would incorporate a timer device in the radio or an extension of the logic circuit which "would eliminate the same code after it had been received, for example, three times in quick succession". This would appear to be a must for someone parked within capture area of a directional RRA transmitting antenna.

GM's Plan: DAIR

General Motor's Driver Aid, Information, and Routing (DAIR) system is even more involved (see Figs. 4, 5, and 6). Basically, it provides four fundamental features: (1) "audio sign", which permits reception of voice messages pertinent to traffic conditions and emergency road situations; (2) "visual sign minder", which reproduces roadside traffic signs on a display panel in the automobile; (3) "code and voice communications", a radio link between the driver and a service garage, permitting direct summoning of aid; and (4) "route minder", which directs the driver along a preselected route without the need to refer to roadmaps or look for route signs. Like the vast majority of other programs, *GM's* system plans to use 27-MHz CB "to take advantage of the . . . great number of mobile transceivers already in use. DAIR can be implemented in a building-block fashion using the CB transceiver as the basic component".

The roadway "communicates with the vehicle" by using permanent magnets buried in the pavement in a binary-coded sequence, setting up flux fields which are sensed and decoded in the vehicle. The pickup sensor is a multi-turn coil mounted laterally beneath the car approximately one foot above the pavement. Because of low sensitivity to electrical noise disturbances, magnetic logic circuits are used to decode the roadway signals as the car passes over the "transmitter". In this manner, the magnets control the in-car configuration.

The "audio sign" system (*Continued on page 67*)

THE LASER INTERFEROMETER

By J. P. ENGEMAN/Airborne Instruments Lab., Div. of Cutler-Hammer

As used in the machine-tool industry, this remarkable device allows distance measurements as great at 60 feet with an accuracy of 10 millionths of an inch.

THE extension of electronics principles into the optical range has resulted in the development of a remarkable new measuring instrument—the laser interferometer. The device discussed in this article uses the wavelength of light generated by a helium-neon gas laser as its unit of measurement. Linear distances as great as 60 feet can now be measured to an accuracy of 10 millionths of an inch ±0.5 part per million. Although it is currently serving industry in a variety of applications, the interferometer is probably best known and most widely used throughout the machine-tool industry.

The trend in manufacturing processes today can best be summarized in two words: automation and precision. Toward these ends, electronics engineers have worked with great success over the past decade. Today's numerically controlled machines, for example, are fast, reliable, and repeatable. The demands upon them for accuracy, however, have in many cases surpassed the capabilities of present inspection techniques.

Consider the relatively simple problem of making an accuracy check every inch over a distance of 150 inches. Add to this the need to closely investigate any increment in minute steps—for example, 0.010 inch—either to satisfy a customer's request or to analyze a particular trouble spot. Multiply this task by a factor of three for a multi-axis machine and the enormity of the job can be appreciated. It is no wonder that the quality-control budget has risen sharply in the past few years.

Let us look for a moment at some of the more conventional measuring devices that the machine-tool builder has at his disposal. For small distances, 0.1 inch or less, the electronic gage is by far the best. Most of these instruments use a linear variable differential transformer (LVDT) as the transducer. By varying the coupling between a primary coil and two series-opposed secondary coils and by synchronously detecting the transformed voltage, a very linear signal is obtained. With suitable amplification, these gages can display increments smaller than 0.000010 inch at a cost of about $500.

To extend its usefulness to longer distances, the electronic gage is often used with a precision gage block. Available in varying lengths up to several feet, these blocks can provide an accuracy of about 2 parts per million at a cost of approximately $3000. Their usefulness is limited, however, because they permit only point-to-point measurement. In addition, long-distance checks require the use of many blocks with a subsequent loss in accuracy.

Other devices that find widespread application in inspection systems use a ruled scale as their basic measuring tool. A distinction is usually made in these systems between the type of scale whose lines are far enough apart to be individually distinguished, therefore requiring interpolation, and a scale whose lines form a continuously repeating pattern. The latter type can be made with a high-density line structure—as many as 5000 lines per inch. When two such scales are superimposed with their structures at a slight angle to each other and proper illumination is provided, a relative motion will cause a moiré fringe pattern to be produced.

In either system, optical detection followed by electronic interpolation or readout is provided. Accuracies of about 0.000010 inch per inch can be obtained over relatively short distances at a cost of about $7000. For measurements of many feet, however, the user must look elsewhere for a satisfactory solution.

One instrument that combines the best features of other gages (precision, ease of use, speed, and continuous long-range capability) is the laser interferometer. Its higher cost of $40,000 can readily be justified by a reduction in the man hours required to check machines and in the ability of a manufacturer to turn out a much better piece of equipment.

Although only machine-tool applications have been mentioned so far, it should be apparent that other industries will also benefit from the laser interferometer. In electronics, for example, the manufacturing techniques used in the production of microcircuits requires a high degree of accuracy. Likewise, the calibration of automatic drafting machines, used by many companies for layout of printed-circuit boards, can be achieved with the interferometer.

Operating Principles

To understand the principles involved in converting a light beam into a yardstick, let us reexamine some fundamental concepts. All light sources are basically a number of electronic oscillators, radiating electromagnetic energy of a very high frequency—about 5×10^{14} Hz. In each elementary beam emitted by a single oscillator, the field vibrations have a definite phase relationship. If the vibrations from two or more oscillators maintain this fixed relationship, the beams are said to be coherent. The light from most sources, however, is the sum of a multitude of independent oscillators, and the resultant vibrations at a point constantly change, depending upon the chance distribution of the fields of the elementary waves. A light source of this nature is unsuitable for interferometry, as will be described.

Certain low-pressure gas discharges exhibit a small degree of coherence and can produce an interference pattern over a path length of several inches. By using the stimulated radiation of a c.w. gas laser, however, the degree of coherence is so great that this length can be increased to thousands of feet. Of course, practical considerations in the fabrication of the optical parts and the fixturing reduce this theoretical limit.

There are many types of interferometers in existence today. We shall concern ourselves only with the type first proposed by the American physicist A. A. Michelson. Fig. 1 shows basic components of this fundamental research tool.

Collimated light is directed onto the partially silvered diagonal beam-splitter mirror. Some of this light is reflected onto mirror *A* and then back through the diagonal to the detector. The remaining light, neglecting losses, is transmitted through the diagonal, strikes mirror *B*, and is reflected back to the detector. If the optical path lengths *L*1 and *L*2 are equal, the fields of the two beams will be in phase when they recombine on the diagonal and will add. This is true regardless of the quality of the light source since each portion of the original beam has traversed the same distance. For unequal distances, however, illumination by an incoherent source does not preserve a consistent phase relationship between the two paths. As a result, the recombined beam, as seen by the detector, is merely the sum of the average intensities of each path.

A coherent source, on the other hand, ensures a phase dependency between each beam. Their relative phase is then a function of the distance the light has traveled. For example, if *L*2 were a quarter of a wavelength longer than *L*1, the light from mirror *B* would return to the diagonal out of phase with the light from mirror *A*. The two beams would cancel and the detector would see no light at all. Another quarter-wavelength movement would bring the beams back in phase and a bright spot would appear. Of course, what is true for the quarter-wavelength points is also true for all intermediate points. Therefore, the continuous signal seen by the detectors is a beam whose intensity varies sinusoidally from zero (darkness) to a maximum.

When the position of reference mirror *A* is fixed, keeping *L*1 constant, a comparatively simple, yet highly accurate, means of determining the linear distance that mirror *B* moves is achieved. By coupling an electronic counter to the optical detector, the number of bright spots (usually called fringes) that occur as mirror *B* moves can be determined. As we have just seen, these fringes are separated by a distance equal to one-half a wavelength, or about 12.5 microinches for the laser interferometer described herein.

Although this system is very accurate, it could not possibly be used as a practical tool outside the laboratory. The angular orientation of a flat mirror, such as mirror *B*, would be difficult to maintain. By inserting a trihedral prism into the system, however, this problem is easily solved. A trihedral prism consists of three mutually perpendicular reflecting surfaces. It has the most useful property that any light ray striking it and being reflected at each surface will return parallel to its original direction regardless of changes in the angular position of the prism (see Fig. 2A). In addition, the path length through the prism remains constant.

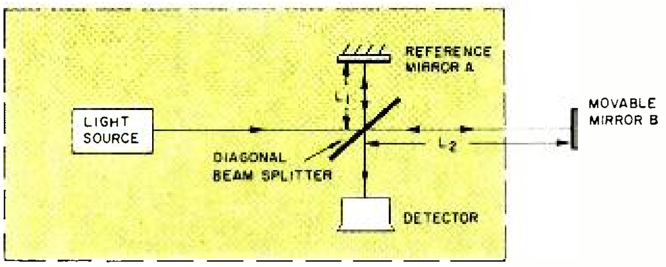


Fig. 1. Operation of the basic Michelson interferometer.

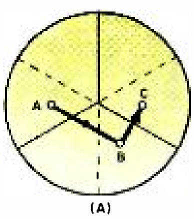
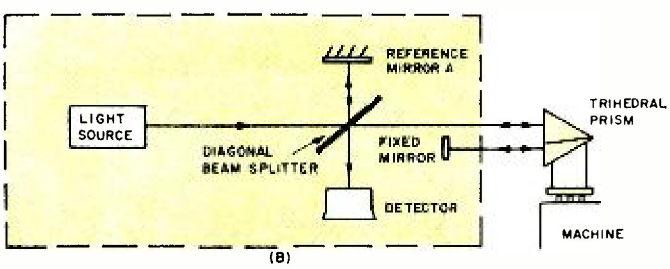


Fig. 2. (A) Top view of trihedral prism. Light striking point A is reflected to B, then to C. It then emanates and goes to detector. Distances AB and BC need not be equal. (B) A basic dual-beam interferometer using a trihedral prism.



A system using this prism is referred to as a dual-beam interferometer and is shown diagrammatically in Fig. 2B. Doubling the variable path length halves the resolution of the device, causing fringes to occur every 6.25 microinches.

Let us take a specific example to better understand how a dual-beam interferometer is used to obtain a linear measurement. Suppose the light source and associated optics are attached to the fixed portion of the machine and the reflecting prism is mounted on the machine's table as shown in Fig. 3, position *A*. We will assume this to be our zero or starting point. When the table is moved to the location shown in position *B*, the motion of the reflector will cause a series of fringes to be seen by the detector. For a total movement of 50 inches, the detector will see $50/(6.24 \times 10^{-6})$ or 8×10^{6} fringes. Using an electro-optical detector such as a photomultiplier tube, the fringes are converted into electrical pulses and can be totaled in an electronic counter. Conversion from a number of pulses to a linear distance can be achieved easily by an electronic circuit.

To make the interferometer a more useful device, two more requirements should be satisfied: (1) machine vibration must not affect the accuracy of the instrument and (2) the trihedral prism should be movable in either direction without interrupting the measurement. Both conditions can be met by the inclusion of a direction-sensing scheme and a bi-directional electronic counter. The usual means of obtaining direction information consists of sharing the light beam in such a way that two interferometers are formed using the same optics. Then, by causing a relative phase difference between the signals from each detector, a simple logic circuit can determine the direction.

Associated Electronics

To complete our discussion of the basic principles involved in interferometry, we should be aware of the effect of certain external parameters on the performance of the device. Since the wavelength of light in a medium is a function of the refractive index of that medium, any change in this index requires compensation. For a desired accuracy of 0.5 part per million, we must allow for a temperature coefficient of about 1 ppm/degree C and a pressure coefficient of approximately ⅓ ppm/mm Hg. Changes in relative humidity can usually be neglected unless they are severe. The detection of these parameters and the subsequent correction for their variations are easily achieved in the electronics associated with the instrument.

Fig. 4 illustrates in block-diagram form the simplicity of the entire electronic support equipment. The sinusoidal detector signals are squared in Schmitt trigger circuits and fed into the direction-sensing logic. At this point, the signals are differentiated to allow pulse techniques to be used. The pulses, representing the forward and backward excursion of the trihedral reflector, are totaled in a bi-directional counter. Particular care has been taken in the design of these circuits to provide high-speed performance. Instantaneous speeds as high as four inches per second can be accurately counted. On a typical machine, this will permit the table to move at a rate of 3 to 3½ inches per second and still allow ample reserve for stick-slip and vibration.

A real-time digital multiplier is included as part of the basic system to eliminate the necessity for making cumbersome calculations from fractions of a wavelength to decimal parts of an inch and/or a meter. The multiplier also offers a convenient means of introducing the correction factors mentioned for atmospheric pressure and ambient temperature changes. These parameters are constantly monitored by suitable transducers to permit continuous compensation.

One of the most serious problems an inspector must face in measurement is the change in dimension that the machine undergoes as a result of temperature. We have corrected our yardstick, the wavelength of light, for temperature variations but have not said anything as yet about the machine itself. We know, however, that steel has a linear expansion coefficient of about 6.5 ppm and aluminum almost twice this amount. In fact, almost all metals exhibit a much greater temperature dependence than does the wavelength of light. Therefore, it seems logical to include additional circuitry to eliminate this source of possible error.

For this reason, a second multiplying circuit has been designed to give the product of the parts expansion coefficient and its temperature deviation from the norm of 68°F. This circuit, together with the atmospheric pressure and ambient-temperature transducers, controls the digital multiplier's scaling factor. The visual readout and the auxiliary printout, therefore, display the distance directly in decimal parts of an inch corrected for any barometric pressure or temperature condition.

Applications

Any device using a laser, state-of-the-art optics, and electronic support equipment gives the impression of being complex and difficult to use; however, such is not the case with the laser interferometer. In fact, one of the original design criteria was that the final instrument be usable by anyone, even personnel completely unfamiliar with optics or electronics.

In making a single-axis measurement, the most difficult task for the operator is the alignment of the laser beam along the measuring path. By trial and error methods alone, this could be done in reasonable time—perhaps 20 minutes or less. However, this straightforward problem has been simplified by including a built-in autocollimator. The operator merely moves the laser until the return beam from an auxiliary mirror is superimposed on a fixed beam originating in the optics, at which point alignment is ensured.

For multi-axis measurements, a separate beam deflector is provided to divert the beam 90° in any direction. The need to relocate the laser for each axis is thereby eliminated.

Despite the obvious advantages that the laser interferometer possesses, the reader may still wonder to what extent industry has accepted the device. Is there such a need that companies will make a substantial capital investment to better their product or performance? The answer is an overwhelming yes. Practically every major machine-tool manufacturer and some of their biggest customers now own at least one interferometer. For example, the *Cincinnati Milling Machine Company* has been using one since late in 1965 to check positioning accuracy on *Cincinnati ATC* machines. The information recorded on the auxiliary printout is used to produce a cam to compensate for lead-screw inaccuracies.

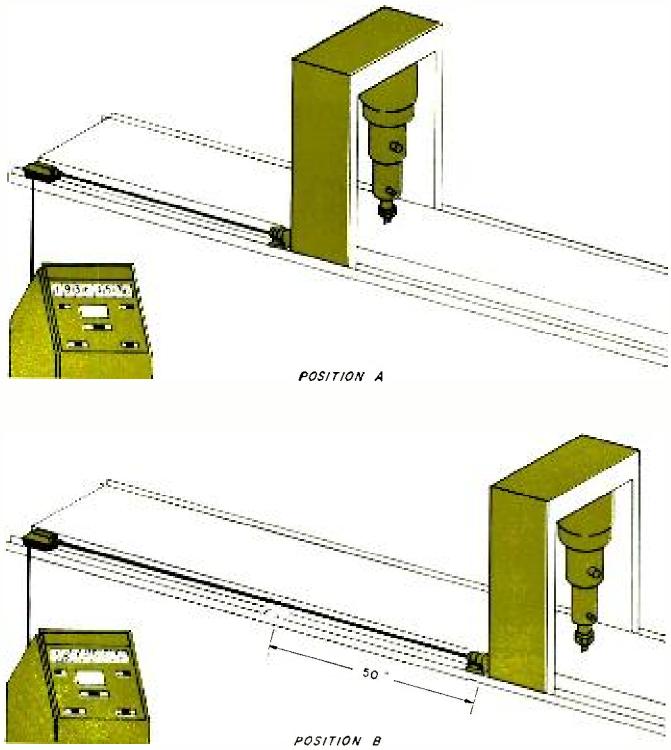


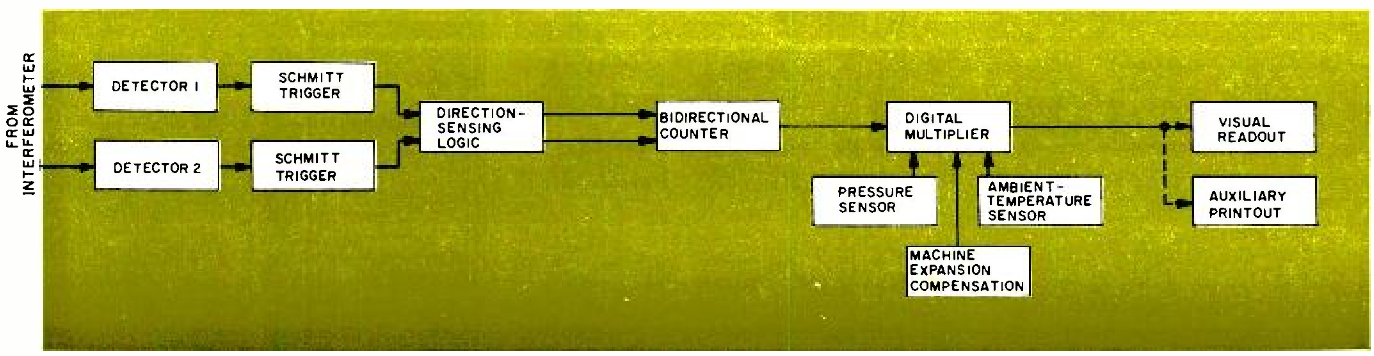
Fig. 3. An example of using a laser interferometer. Position A is the starting or zero point. At position B, the table has been moved 50 inches. Readout is by counter.

The *Giddings and Lewis Company* found that its cost of quality assurance and maintenance per dollar of shipments is 15% to 25% less today than it was only a few years ago due to the effectiveness of new checking devices. Results indicate that incremental checkouts can be made with the interferometer in a fifth to a tenth of the time previously required.

The *Boeing Company* has acquired two laser interferometers, one for use by its shop maintenance personnel and the second for the company's Primary Standards Laboratory. The latter unit has a resolution of 0.000002 inch and is used to calibrate the line standards and tooling tapes that are used.

These examples and many more like them indicate the great impact that the laser interferometer has already made in today's shop. However, its acceptance as a calibration tool is but the first step in realizing the great potential that the laser offers to the automatic factory. The next logical move is to incorporate the interferometer into the control system of the machine and eliminate the need to calibrate a secondary measuring device. Being essentially digital in nature, the problem of compatibility with existing control systems is minimized. (*Continued on page* 79)

Fig. 4. The electronic support system used in conjunction with the laser interferometer. Note that compensation for barometric pressure, ambient temperature, and machine expansion during operation is provided for maximum accuracy.



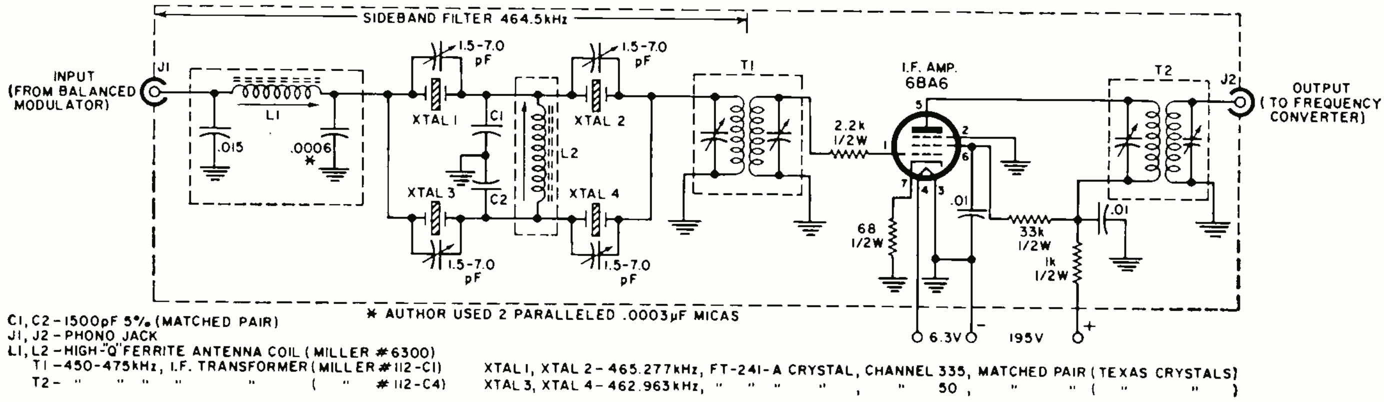


Fig. 1. Filter consists of two cascaded half-lattice crystal-filter sections with low-impedance input and high-impedance output.

Ferrite Coil and Crystal Sideband Filter

By RICHARD A. GENAILLE, K4ZGM

Using readily available ferrite antenna coils in place of the usual i.f. transformers, this filter can be employed as the starting point for the construction of an SSB ham transmitter.

MOST of the single-sideband transmitters in use today employ either the filter method or the phase-shift method of sideband selection. The heart of a transmitter making use of the former method is, of course, the filter which accomplishes frequency discrimination in the low, medium, or high-frequency ranges. Among the various filters which have been widely used are mechanical filters, filters made up of precision high-"Q" toroidal circuits, and quartz crystal filters. This article describes an easily constructed, medium-frequency crystal filter using readily available quartz crystals in unique combination with ordinary ferrite coils and which, in addition, contains a stage of amplification as an integral part of the filter unit. The filter can be used as the starting point for that sideband transmitter that you have always wanted to build.

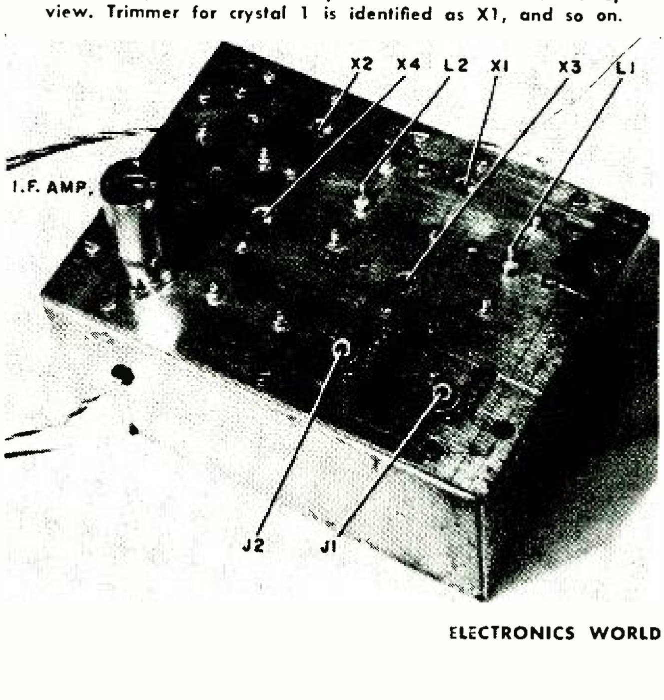
The ferrite coil and crystal sideband filter is shown schematically in Fig. 1. The basic sideband filter circuitry consists of two cascaded half-lattice crystal-filter sections with input and output circuitry arranged for a low-impedance input to the filter proper and a high-impedance output from the filter to the i.f. amplifier stage. The input impedance of the filter was designed to accommodate the output of a low-impedance balanced modulator. A simple, high-"Q" ferrite antenna coil is used in a tuned circuit to provide the transition from low-impedance input to the high impedance of the first half-lattice crystal section.

Ordinarily, one would refer to the crystals used as "surplus" crystals; however, the tremendous popularity which medium-frequency crystals have enjoyed over the years of use in crystal filters such as the one being described, has resulted in suppliers dropping the term "surplus" from their advertisements and making available matched pairs of crystals at a nominal cost.

The exact frequencies or channels shown in Fig. 1 are not rigid but the limit of the lower frequency crystals used should not be below 450 kHz and the higher frequency crystals should not be above 475 kHz. The frequency separation between the crystal pairs determines the bandwidth of the filter and most lattice filters constructed from the type crystals and the standard components specified will have a bandwidth of about one and one-fourth times the frequency difference between the crystal frequencies. A frequency separation of approximately 2.3 kHz is used in this filter which provides a bandwidth of near 2.9 kHz for reasonable voice quality.

The crystal trimmer capacitors provide a means of improving the shape factor of the filter and should be of good quality. The ones used in the author's filter were *Centralab* ceramic-dielectric trimmers #822-EZ. The i.f. transform-

Fig. 2. Capacitor and coil adjustments are shown in this top view. Trimmer for crystal 1 is identified as X1, and so on.



ers as well as the inexpensive ferrite coils were selected to minimize filter losses.

Capacitors C1 and C2 need not be exactly 1500 pF but should be matched as closely as possible. The author bought a half-dozen 5% tolerance capacitors of good quality and, using a "Q" meter, was able to select a pair that was almost perfectly matched. A simple voltage divider test circuit may be used to establish a match of the two capacitors. The capacitors to be checked can be connected in series and across a source of medium-frequency r.f. signal. The voltage measured across each capacitor with a v.t.v.m. should be the same if the capacitance values are alike.

The i.f. amplifier stage is a basic circuit which is used to provide the necessary gain to drive a following converter circuit and to facilitate the testing and alignment of the filter as a separate unit from the rest of the transmitter in which the filter may be used. The filter should be aligned using a low value of input signal to prevent overdriving and subsequent errors in alignment. The combination of low input signal and filter insertion loss results in difficulty in obtaining a suitable output level for driving the average scope or v.t.v.m. The integral i.f. amplifier circuit provides the needed gain and makes possible the testing of the filter as a complete separate sub-unit from the transmitter proper.

Construction Details

Construction of the filter is not difficult; however, considerable effort was expended in shielding the various filter components to insure that the input signal would pass *through* and not *around* the filter. The filter components are housed in a 7″ × 5″ × 3″ chassis box as shown in the photographs of Figs. 2 and 3. Fig. 3 shows the placement of the various components. The shields used for the ferrite coils, the small shield cans for the input and output jacks, the shield partitions separating the filter input and output sections, and the shield partition separating the filter proper from the i.f. amplifier stage are also shown in Fig. 3. Fig. 4 is a view of the filter with the shield cans removed as well as the lids of the input and output jack shield cans. Discarded 35-mm film cans are used as shield cans for the input and output jacks. The removable covers provide excellent access for the mounting as well as for the wiring to the jacks.

The small crystal trimmer capacitors are mounted on phenolic strips and are used as a means of support for the crystals by soldering the crystal holder pins directly to the trimmer capacitor leads. This method of supporting the crystals is shown in Fig. 5. It would be wise to use a heat sink of some sort on the crystal holder pins to avoid damage to the crystals from excessive heat if the builder uses this system of mounting, however. Other satisfactory means of supporting the crystals may be used by the imaginative constructor rather than the means described.

Alignment Techniques

The filter can be aligned by using a signal generator and a v.t.v.m. in the point-by-point system of alignment but this method can be very time consuming. The use of an i.f. sweep generator sweeping the 425 to 475 kHz range and an oscilloscope is recommended and is the method used by the author for aligning the filter. For those who may wish to make an interim alignment with an r.f. signal generator and a v.t.v.m. the following procedure will produce passable results.

As mentioned previously, the inclusion of an i.f. amplifier as an integral part of the filter makes it unnecessary to use a high input voltage to the filter and risk damaging the crystals. In starting the filter alignment all crystal trimmers should be adjusted for minimum capacitance. The output of an accurately calibrated r.f. signal generator should be connected to the input jack on the filter with the output jack

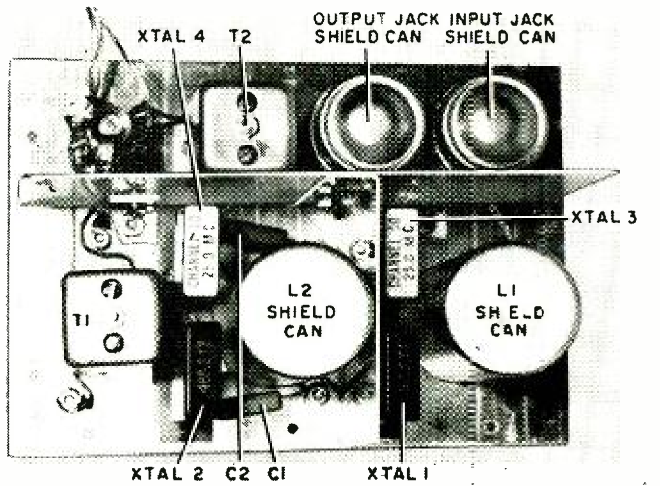


Fig. 3. Inside view showing parts placement and the internal shields. Coil and jack shield cans are in place in this view.

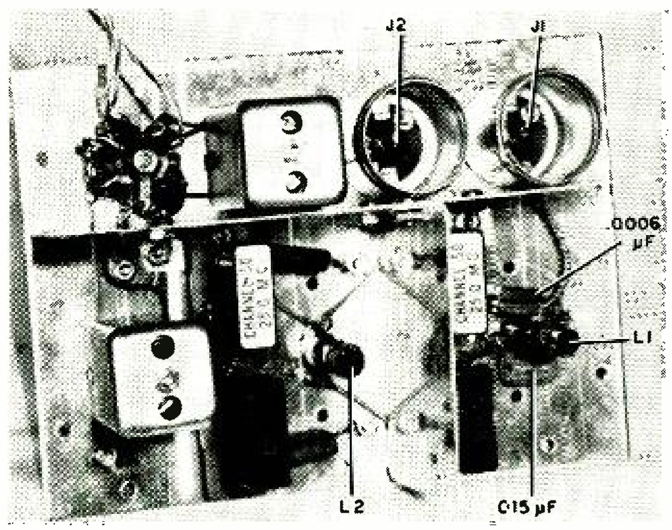


Fig. 4. Inside view with the shields and/or covers removed.

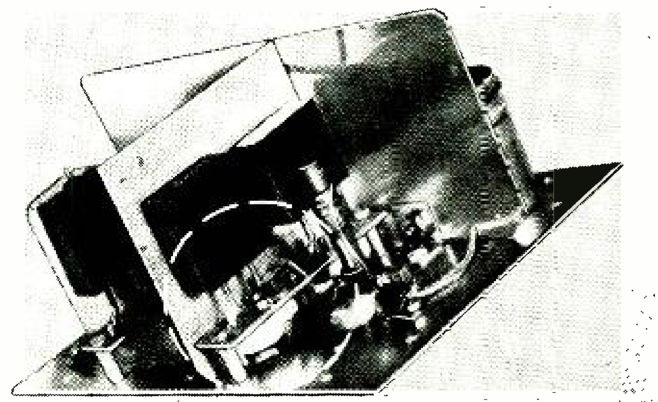


Fig. 5. Method of mounting crystals on the crystal trimmers.

connected to the r.f. probe of a vacuum-tube voltmeter.

Ferrite coils $L1$ and $L2$ and i.f. transformers $T1$ and $T2$ should be adjusted for maximum output at the center of the filter passband. The center of the passband, as shown in the characteristic curve for this filter in Fig. 6 is approximately 464.5 kHz. With the signal generator set to 462.5 kHz, the trimmer capacitors associated with the lower frequency crystals ($X3$, $X4$) should be adjusted for a sharp null on the v.t.v.m. With the signal generator set at 466 kHz, adjust the trimmer capacitors associated with the higher frequency crystals ($X1$, $X2$) for a sharp null also. These adjustments, as previously mentioned, will pro- (*Continued on page* 80)

Common-Sense Design of TRANSISTOR AMPLIFIERS

By DONALD L. CARLSON

Manager of Engineering Services, Hewlett-Packard (Loveland Div.)

Straightforward method of calculating the necessary circuit components for a stage of transistor amplification. Ohm's Law plus some simple formulas are all that are required.

IT is not too difficult to find the information needed to design a tube-type amplifier. Most tube manuals include characteristic curves and other pertinent data, and with a little knowledge of plotting load lines and a few other calculations, the builder may come up with a suitable design. However, working with transistors is a different matter. For the most part, the average technician does not have access to the manufacturer's information and, if he did, would probably throw his hands up in disgust by the time he waded through all the calculations necessary to design a single-stage amplifier. Most manufacturers specify their transistor devices using hybrid parameters. These parameters are not very easily grasped until some of the more basic principles are understood.

The following is a straightforward method—a common-sense approach, using Ohm's Law to calculate the necessary circuit components for a complete amplifier. Although there are hundreds of types of transistors, for simplicity, we will discuss only one type in this article.

Some of the available types fall into the following classifications: small-signal amplifiers, switching transistors, high-frequency transistors, and power transistors, to name a few. There are also voltage ratings, power and current ratings, and leakage currents to consider in selecting the transistor to handle a specific job.

The Transistor Specifications

As an example, let's start with a one-stage amplifier using a 2N2712 and calculate all the necessary circuit components. This is an *n-p-n* silicon transistor capable of performing all functions in an AM radio. This means that not only will it work well at audio frequencies, but it will also amplify well at radio frequencies. Although it is very inexpensive, it does have some very good specifications. Some of the more important specs will be discussed.

V_{CEO} is 18 volts: This is the maximum voltage allowable from collector to emitter and, for all practical purposes, should be the maximum supply voltage since the full voltage would be applied between collector and emitter any time that the transistor is in cut-off condition.

V_{EBO} is 5 volts: This is the maximum voltage from emitter to base with the collector open.

I_C is 100 mA: This is the maximum saturation current or the collector current when the transistor is saturated.

P_T is 200 mW: This is the maximum power dissipation.

I_{CBO} is 1 μA maximum: This is the collector-to-base leakage current with the emitter open, and with $V_{CB} = 18$ V.

h_{FE} is 75 minimum, 225 maximum: This is also known as *beta* or d.c. current gain. The "F" is for forward current transfer ratio, and the "E" indicates a common-emitter configuration.

The static characteristic curve for a 2N2712 is shown in Fig. 1. This type of curve can be plotted by hand on graph paper. All that is needed is a variable power supply (labeled *B1* in Fig. 2A), a milliammeter to monitor the collector current, and a voltmeter to monitor the collector voltage, as shown. *B2* furnishes the base current and R_X may be a number of fixed resistors which will apply the required base current to the transistor. For instance, if $B2 = 1.5$ volts, then R_X would equal 150,000 ohms for 10-μA base drive. As the variable power supply is increased in voltage, the current is monitored at two or three collector voltages and points then marked for these readings. A line is then drawn connecting all points.

This is the same type of curve that is published in a tube manual for electron tubes. The only difference is that the grid of a tube is biased with the voltage where the transistor, because of its forward-biased emitter-base junction, is a current-driven device.

Construction of Load Line

Let's construct a load line and get as much information as possible from this set of curves. As a start, if we draw a 3000-ohm load line, that is, from $I_C = 5$ mA (15/3000 = .005) to $V_C = 15$ volts, we have the basis for a start of an amplifier. Now to get all the information from the curves—note that point "O" which is the intersection of the 30-μA base-current curve and the 3000-ohm load line is directly above $V_C = 7$ volts. This means that for this value of base current and the 3000-ohm load, we could expect +7 volts at the collector (Fig. 2A).

The curve also tells us what the current gain or h_{FE} is. This is the ratio of the collector current change divided by the base current change. We will call it *beta*. From the dotted lines "A" to $I_C = 3.7$ mA and "B" to $I_C = 1.8$ mA, a difference in collector current of 3.7 − 1.8 = 1.9 mA is caused by a change of 40 − 20 μA = 20 μA in base current. Then 1.9 mA is divided by 20 μA = 95, for a current gain of 95.

It should be understood that point "O" is the quiescent operating condition and that if an input signal, let's say a sine wave, were applied to the base of the transistor of such amplitude that it caused, on the positive-going signal, the base current to increase to 40 μA, and on the negative excursion of the signal, to decrease the base current to 20 μA, the collector voltage would then swing from 4.2 volts to 9.8 volts. This would be a useful output signal (E_O) to drive a following stage or transducer of some type.

If we were constructing more than one stage in an amplifier, it might be well to use a larger value resistor in an early stage to get more voltage gain. To see how this works out, let's check E_O for the 3000-ohm load and then draw a 6000-ohm load line and see the difference. From point "A" to $V_C = 4.2$ volts and point "B" to $V_C = 9.8$ volts there is a difference of 5.6 volts or $E_O = 5.6$ volts. This is a peak-to-peak voltage. From point "C" to $V_C = 0.6$ volt and point "D" = 10.5 volts, we have a difference of 9.9 volts, considerably more than was obtainable with the 3000-ohm load.

An even larger value could be used and still maintain a fairly linear output. On the curves of Fig. 1, lay a straight-edge from $I_C = 2$ mA to $V_C = 15$ volts. The intersection at the 1-mA value would equal about 13 μA base current. This would give maximum voltage swing from saturation, which would be 2 mA and 0 volts, to cut-off, which would be 0 mA and 15 volts.

Another thing to keep in mind when working with low-level amplifiers is that it is a good idea to keep the collector voltage and current low. This helps maintain a low noise-to-signal ratio.

To add a little more detail to the circuit, let's draw the amplifier using the 6000-ohm load (see Fig. 2C). At operating point "O_2", we have 20-μA base drive. We could complete the amplifier, except for d.c. bias stability, by connecting a 750,000-ohm resistor between the +15-volt supply and the base to bias the transistor. It is apparent that the base resistor R_B was calculated using Ohm's Law [$R = E/I = 15/(2 \times 10^{-5}) = 750$ kohms]. Also note that as long as the input swing is not too great, this amplifier will work in class-A condition; however, the operating point on the 3000-ohm load line is a better choice, only because the operating point is such that at a quiescent condition approximately one-half of the voltage is dropped across the transistor and the balance across the load resistor.

Fig. 3 shows a characteristic curve with a 3000-ohm load line plotted. Input and output current and output voltage waveforms are also shown. The input voltage waveform would be a function of the voltage across the input impedance of the transistor amplifier.

Fig. 4 shows a characteristic curve with the maximum 200-mW curve drawn in. Any load line drawn tangent to the constant power dissipation line will insure *maximum power gain* of the transistor. The theoretical maximum power gain is the maximum current and voltage gain. However, the condition for maximum current gain is $R_L = 0$ and the condition for maximum voltage is $R_L = \infty$.

Since these conditions are in opposition, the problem of finding the maximum power gain involves matching the input and output resistances of the transistor. The maximum power gain is obtained when the internal resistance of the signal generator is equal to the input resistance of the transistor, and the load resistance is equal to the output resistance of the transistor. When these conditions are simultaneously satisfied, the transistor is image-impedance matched. In practice, it is possible to use transformer coupling and achieve matched impedance conditions, although the majority of designs use *RC*-type circuits where the load resistance and d.c.-bias network will tend to modify the gain of the transistor amplifier whether it be on a current, power, or voltage basis.

Distortion and its Causes

An oscilloscope is a good tool to use when working with amplifiers. If too large an input signal is applied to the amplifier, it may cause clipping which can be observed on the scope. If both the negative and positive portions of the output sine wave are clipped, this simply means the amplifier is overdriven. If, on the other hand, only one-half of the sine wave is clipped, this indicates that either the load or bias resistors are the wrong value. Two extremes, one being the selection of too low a value of collector voltage and the other too high are discussed in the following examples.

Referring to the characteristic curve in Fig. 1 and using operating point "C" on the 6000-ohm load line, if a sine-wave signal is applied to the base of the transistor, it is apparent that as the input signal goes positive, the collector voltage will approach zero and any further increase in sig-

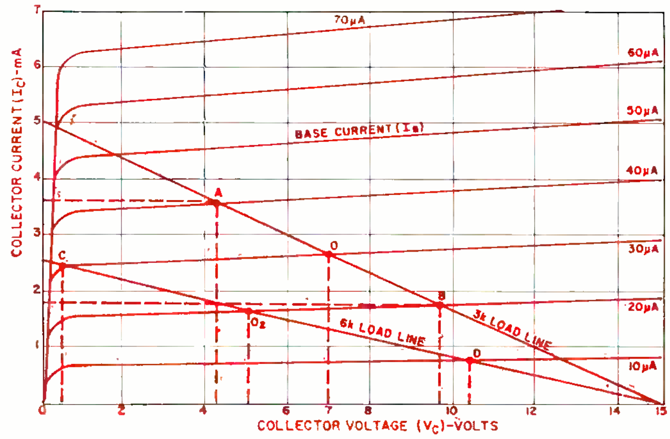


Fig. 1. Characteristic curves for the type 2N2712 transistor.

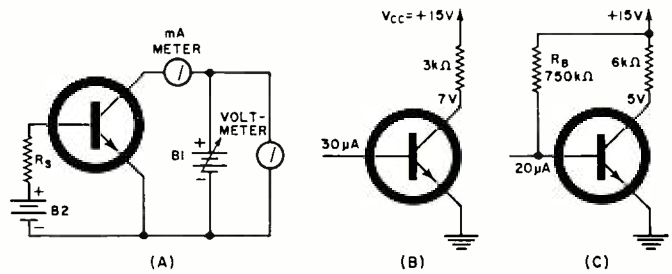


Fig. 2. (A) Setup for obtaining characteristic curves. (B) Operation with 3000-ohm load and (C) with a 6000-ohm load.

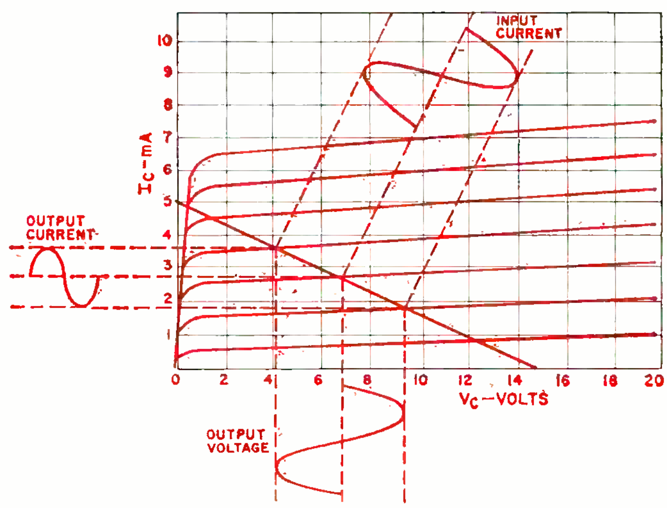
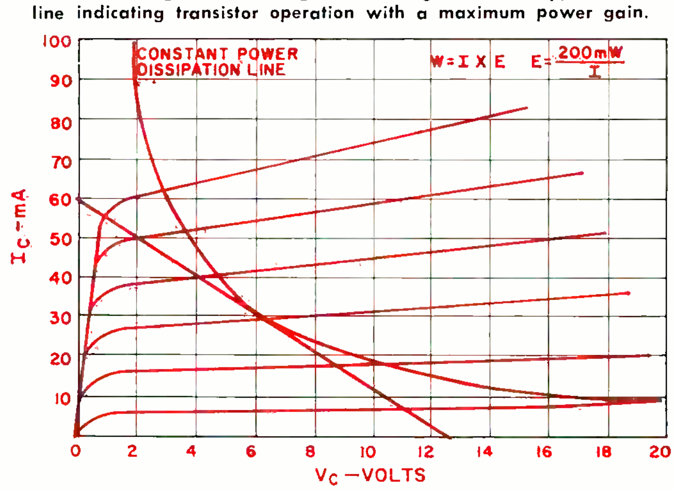


Fig. 3. Use of load line to show input and output currents, voltage.

Fig. 4. Curved line indicates the maximum power dissipation of 200 mW along its entire length. The straight line is a typical load line indicating transistor operation with a maximum power gain.



nal would be shown as a clipped, negative-going output voltage waveform, since the transistor would be saturated at this point. This would indicate that either the load resistor is too high (reducing collector voltage) or the bias resistor is too low (increasing base current).

The other extreme would be if the operating point were chosen at point "D". Using a negative-going input signal, the collector voltage would rise to 15 volts and collector current would be cut off. This would clip the positive portion of the voltage waveform at the output. For maximum swing, the operating point or collector voltage, V_C, should equal one-half the collector-supply voltage, V_{CC}.

Adding Swamping Resistor

If we redesign the circuit we can make some definite improvements and modify the input characteristics. This is shown in Fig. 5A.

The 200-ohm emitter resistor is called a "swamping resistor". Its purpose is as follows: The base-emitter junction of a transistor has a negative temperature coefficient, that is, for a rise in temperature the resistance goes down, allowing more leakage current to flow. If the emitter resistor is large in comparison to the emitter-base junction resistance, the emitter resistor will effectively swamp out the negative resistance. Typically, the V_{EB} will rise about 2.5 mV per degree C. This will tend to forward-bias the transistor, causing increased collector current and making thermal runaway a possibility unless controlled by some bias-compensation technique.

Thus the 200-ohm emitter resistor helps to maintain a proper bias level. This circuit is not unlike the cathode resistor which provides self-bias in a tube circuit. On the other hand, resistor R_B from base to V_{CC}, as shown in Fig. 5A, provides fixed bias.

The circuit without the swamping resistor has a very low input impedance. With the addition of the 200-ohm resistor, the input impedance will equal *base resistance* + (*beta* × 200 *ohms*). In a typical case where the base resistance = 2000 ohms, input R = 2000 + (95 × 200) or 21,000 ohms. Since the input resistance of a transistor is non-linear, the degeneration caused by the emitter resistor will tend to linearize the input resistance. Also, it will reduce the distortion caused by this non-linearity.

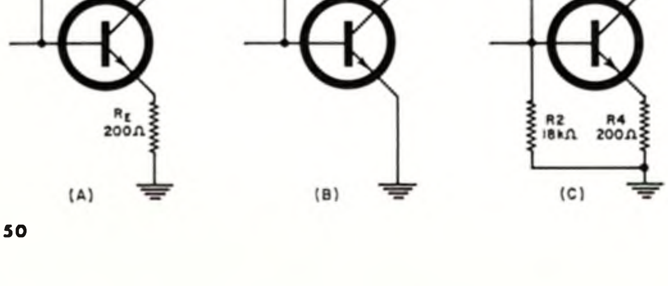
The best temperature compensation exists when R_E approaches the value of R_L. At the same time, gain is reduced to less than unity when $R_E = R_L$. We can figure how much this gain is by the following formula:

$$A = \frac{\beta}{1 + (R_E\beta/R_L)}$$

$$= \frac{95}{1 + (200 \times 95/6000)} = \frac{95}{1 + 3.1} = 23$$

This formula tells us that we now have an amplifier with a gain of 23, with an input impedance of 21,000 ohms. It would also be possible to increase the input impedance by increasing the value R_E. If gain is more important than increased input impedance, the emitter resistor may be bypassed with a capacitor, while maintaining the d.c. bias stability. One means of maintaining a constant d.c. bias stability is to heat-sink the transistor, although this is usually not feasible for small transistors. Another method is to use stabilizing components to avoid runaway.

Fig. 5. (A) Adding a swamping resistor. (B) Changing connection of bias resistor to improve stability. (C) Using voltage divider.



Improving Stability

I_{CO}, known as the reverse saturation current, varies exponentially as temperature increases. Since I_C or collector current causes I_{CO} to rise, a further increase of I_{CO} causes I_C to increase unless stabilized in some manner, if only to the point where the operating point has shifted to saturation. In order to compare different types of biasing, we can assign a stability factor, S, as the rate of change of collector current with respect to the reverse saturation current, or $S = (\Delta I_C)/(\Delta I_{CO})$. The smaller the value, the less likely there will be a change in I_{CO}, thus preventing thermal runaway.

For the simple transistor biasing network of Fig. 2C, $S = 1/(1-\alpha)$, where α = *alpha* the emitter-to-collector current gain of a common-base amplifier. Since we are primarily interested in a common-emitter amplifier, it is well to know that the relationship between *beta* and *alpha* is $\beta = 1/(1-\alpha)$. From this we can determine that a transistor having a *beta* of 100 would also have an S factor of 100 provided it were biased as in Fig. 2C. For a biasing arrangement such as that shown in Fig. 5B, the S factor would equal one-half the S factor of Fig. 2C, provided that one-half of the d.c. voltage were dropped across R_L.

To add a little more d.c. bias stability to the circuit, we could add a resistor from base to ground. This forms a voltage divider and is helpful in maintaining d.c. bias stability. It is also helpful, to some extent, in permitting the interchangeability of transistors of the same type but with different gains. The circuit in Fig. 5C will show a slightly different base bias than was shown on the curves.

If a transistor with a *beta* of 100 and a 6000-ohm load draws a quiescent current of 1.25 mA, then we need a current of 12.5 μA to properly bias the transistor. A biasing resistor of 1.2 megohms from V_{CC} to the base would provide the proper fixed bias.

Let's reduce this fixed resistance by a factor of 4, to a value of 300,000 ohms. Any other factor could have been used rather than 4, keeping in mind that the smaller the value of the total resistance of $R1$ and $R2$, the better the stability. Assuming the total R was divided by a factor of 10, 1/10th of the current will flow to the base and 9/10th will flow to ground. The base will hold a fairly constant voltage—this is the prime purpose of the divider. There is a trade-off, however. More power is consumed in the circuit because of the extra current shunted to ground. Further, the smaller the values of $R1$ and $R2$, the lower the input impedance of the amplifier since $R1$ and $R2$ are effectively in parallel with the input impedance of the transistor.

If we have a total of 1.25 mA flowing in the emitter-to-collector circuit, we should have a 0.25-volt drop across the 200-ohm resistor. The base-emitter junction of the silicon transistor will provide approximately 0.62-volt drop when forward biased (larger values of voltage drops will be experienced for larger values of collector current). This gives a voltage from ground to base of 0.87 volt.

To determine the value of $R2$, we set up a ratio between the total voltage to the total (reduced) resistance and the base-to-ground voltage to the value of $R2$; that is, 15/300,000 = 0.87/$R2$, 300,000 × 0.87 /15 = 17,400. Hence, $R2$ = 17,400 ohms and $R1$ = 300,000 − 17,400 = 282,600 ohms. Standard values are used with $R1$ = 270,000 ohms and $R2$ = 18,000 ohms. For practical purposes, the two resistors are in parallel and become a single source, R_B, which is equal to (270 × 18)/(270 + 18) = 17,000 ohms.

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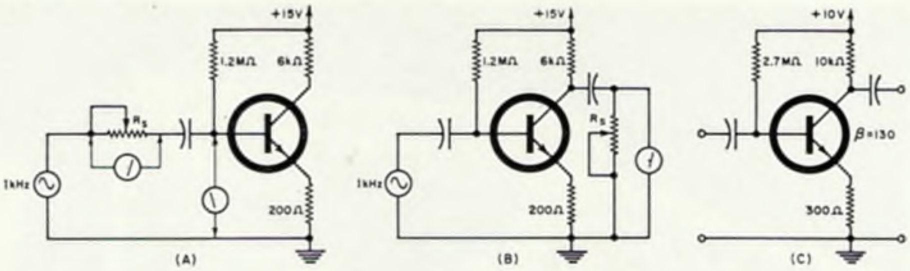


Fig. 6. (A) Measuring input impedance. (B) Measuring output impedance. (C) Amplifier stage used to check the calculations.

The S factor for this circuit can be determined from the following formula:

$$S = \frac{1}{1-\alpha + \alpha\,[R4/(R4 + R_B)]}$$

$$= \frac{1}{1-0.99 + 0.99[200/(200 + 17{,}000)]}$$

$$= \frac{1}{0.01 + 0.0115} = 46.5$$

where *alpha* is 0.99 for a transistor with a *beta* of 100. What all this indicates is that for better stability, the value of $R4$ will have to be increased or the voltage-divider resistance reduced, or both.

Designing without Curves

Let us consider how to design an amplifier without the use of curves and only the manufacturer's ratings as given in a transistor manual. If we have access to a transistor checker, it can be used to give the *beta* of the transistor we wish to use. Let us assume, for the moment, that the transistor we have in mind has a *beta* of 100. We would arbitrarily set some value of voltage for V_{CC}. This might be the voltage of a battery, say, 9 volts, 6 volts, or as in this case, 15 volts.

Since we have arbitrarily set a voltage, we can, by the same method, select a load resistor that will result in less than the maximum wattage dissipation for the transistor and continue with our design. As a start, select 6000 ohms for R_L. (Since this was the same value used on the characteristic curves, we can compare our results.) With the maximum current load of 6000 ohms, the transistor would draw 2.5 mA at saturation and the voltage at cut off would be 15 volts. To select the proper operating point, divide 2.5 mA by 2. This will make our quiescent point at a collector current equal to 1.25 mA, and the d.c. voltage drop across R_L should equal 7.5 volts. An input current to the base of the transistor should swing the operating point along the load line in such a manner that we should have a near linear output for equal positive and minus currents applied. For the bias current, divide 1.25 mA by the *beta*, which gives a 12.5-μA base drive for quiescent condition.

The bias resistors can now be chosen by the method previously shown for d.c. bias stability. One point not yet considered is that I_{CO} doubles for each 10 degrees C rise in temperature. From 25° to 55° C, I_{CO} of the 2N2712, specified as 1 μA, would equal 8 μA leakage current. The 8-μA I_{CO} would be the same as shifting the operating point by 8 μA. If the original operating point on the 6000-ohm load line were chosen (point "O_2" in Fig. 1), the transistor would be close to saturation at 55° C, even without an input signal. On the other hand, if some stabilization were used and the original operating point is chosen for at least half-way between cut-off and saturation, then the operating point won't shift so far that the amplifier is working too close to saturation.

Measuring Impedances

In order to be able to build an amplifier with more than one stage of amplification, it is necessary to be able to measure the input and output impedances of the single-stage amplifier. Fig 6A shows a circuit for measuring input impedance.

A low-impedance signal generator is connected to the input of the amplifier and R_S is adjusted so there is an a.c. voltage drop across R_S equal to the drop measured from base to ground. This is called the equal-voltage method and is quite accurate if the signal generator's output impedance is low in comparison to the input impedance of the amplifier, and the voltmeter used for monitoring the voltages is of a high impedance so as not to load the circuit. The value of R_S is then measured with an ohmmeter. This value is equal to the input impedance of the amplifier.

Fig. 6B shows the method of measuring the output impedance. Here the signal generator is driving the input of the amplifier. A high-impedance a.c. voltmeter is used to measure the open-circuit voltage. R_S is then connected and adjusted for one-half the open-circuit voltage. The output impedance is the measured value of R_S.

Fig. 6C is a circuit using different values of resistance and voltage. Z_{in}, Z_{out}, and gain measurements were taken and the results are as follows: $E_{in} = 0.1$ V; $E_{out} = 2.63$ V; $Z_{in} = 45{,}000$ ohms; and $Z_{out} = 9400$ ohms.

Now, if we use the previous formula $A = \beta/[1 + (R_E\ \beta/R_L)]$, we have $A = 130/[1 + (300 \times 130/10{,}000)] = 26.5$, or for 0.1 volt in, there should be 2.65 volts out.

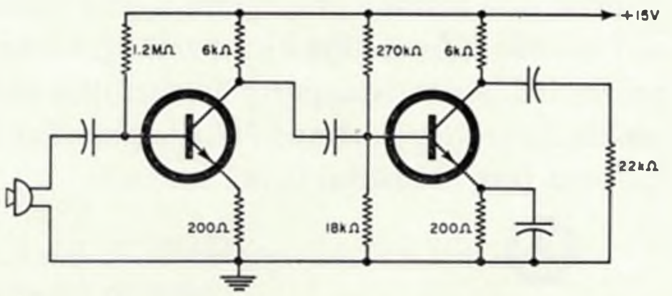
We could also take the measured input Z, calculate the current caused to flow by 0.1 volt, multiply this by *beta*. The product is then multiplied by the output Z to get our voltage gain from input to output. To see how this comes out: 0.1 volt/$(4.5 \times 10^4$ ohms$) = 2.2 \times 10^{-6}$ A. Then $2.2 \times 10^{-6} \times 130 = 2.86 \times 10^{-4}$ A $\times\ 9.4 \times 10^3$ ohms $= 2.68$ volts. This gives us three sets of figures: (1) the measured gain of 26.3; (2) the calculated gain of 26.5; and (3) input current $\times\ Z_{in} \times \beta \times Z_{out} = 26.8$.

It is now evident that we have started out with a device generally considered a current-amplifying device and analyzed it to some extent on a more familiar basis; namely, voltage. Since it is easier to measure voltage than current, this should help in understanding transistor amplifiers.

Designing a Microphone Preamp

To calculate the gain of more than one stage, let's examine the problem of building a microphone preamp to drive a power amplifier. Assume the requirements are for an output voltage of one volt from the preamp. The microphone to be used is a dynamic type designed to work into 20,000 ohms. The output level of the microphone is specified as −54 dB. This means that for a normal speech level, the output voltage across a 20,000-ohm load would be 54 dB

Fig. 7. Two-stage microphone preamplifier discussed in text.



below a one-volt level. This represents a voltage ratio of 500; hence the preamplifier should have a voltage gain of 500 from input to output to drive a power amplifier with one volt r.m.s.

Fig. 7 is the schematic of the preamp. Assuming the *beta* for Q1 and Q2 equals 100, the 200-ohm emitter resistor in the first stage will result in about 22,000 ohms input impedance, which should match the microphone quite well.

To calculate accurately the gain of the amplifier, all impedances must be taken into consideration. For this example, all coupling and bypass capacitors will be assumed to have a reactance low enough not to cause appreciable loss in gain at the lowest frequency to be handled. The second stage will drive an assumed load of 22,000 ohms. This will be in parallel with 6000 ohms and will reduce the gain by $22/(22 + 6) = 0.78 \times 100 = 78$.

The gain of the first stage will be $A = \beta/[1 + (R_E\beta/R_L)]$ where R_L equals 6000 ohms in parallel with the input impedance of the second stage. Since the 200-ohm resistor for Q2 is bypassed with a capacitor for a.c. purposes, there will be no increase in input impedance due to the emitter resistor. This will leave 270,000 ohms and 18,000 ohms in parallel $(270 \times 18)/(270 + 18) = 17{,}000$ ohms. The 17,000 ohms will shunt the input resistance which is probably somewhere between 1500 ohms and 2000 ohms. If we use 2000 ohms, then 2000 in parallel with 17,000 ohms gives us about 1800 ohms. The input impedance of the second stage, 1800 ohms, will shunt the output impedance of the first stage, or $(6 \times 1.8)/(6 + 1.8) = 1400$ ohms. Then for the first stage, $A = 100/(1 + [200 \times 100/1400]) = 100/(1 + 14) = 6.6$. This gives us a gain of 6.6 for the first stage and a gain of 78 for the second stage: $78 \times 6.6 = 515$, which is the gain of both stages together.

In choosing coupling capacitors for transistor amplifiers, electrolytics are generally used. This is so because the input impedance of the transistor is low. To predict the low-frequency response, the output impedance in series with the input impedance of the following stage is compared with the X_c of the coupling capacitor. When X_c of the capacitor equals the impedance at the lowest frequency to be passed by the amplifier, the response will be 3 dB down from the mid-band gain. A rule of thumb is to choose the capacitor's reactance to equal 1/10th the impedance for negligible loss of gain. The emitter bypass capacitor would be chosen by the same method, comparing the values of X_c and R_E at the lowest frequency of interest. ▲

JOHN FRYE

Many factors enter into the design of an effective shield for protecting sensitive devices against magnetic fields.

MAGNETIC SHIELDING

BARNEY strode into the service shop and tossed three large booklets on the bench in front of Mac, his employer. "Boss," he announced, "I'm just bubbling over with information about magnetic shielding absorbed from those books and a raft of other leaflets and article-reprints sent me by various manufacturers of such shielding. I've simply got to tell someone what I've learned or explode."

"Well now, we can't have that, can we?" Mac drawled as he picked up the booklets and read the titles: " 'The When Why and How of Magnetic Shielding, A Designer's Handbook,' by the *Westinghouse* Metals Division, Blairsville, Penna. 15717; and 'The Netic and Co-Netic Magnetic Shielding Manual' and 'Do-It-Yourself Magnetic/Electrostatic Shields Using Netic and Co-Netic Foils Manual,' both issued by the Magnetic Shield Division of the *Perfection Mica Co.*, 1322 N. Elston Ave., Chicago, Illinois 60622. Knowing you seldom bone up on anything for which you don't have an immediate use, I presume something inspired this sudden thirst for knowledge."

"You might say that—if you insist on being nasty," Barney admitted. "In building a compact monitor scope to keep a continuous check on the operation of my SSB linear amplifier, I found I had to use shielding to prevent the field of the power transformer from deflecting the beam and making my signal look worse than it is. Suddenly I realized I knew very little about magnetic shielding, so I sent for information. The more I read, the more fascinating the subject became."

"The knowledge certainly won't hurt you," Mac said. "The present trend in miniaturization and compactness is putting renewed emphasis on shielding. When magnetic-field generating equipment and devices sensitive to such a field are jammed closer and closer together, something must provide the isolation formerly furnished by mechanical separation."

"Good," Barney agreed, "but let's start at the beginning by deciding why shielding is necessary. There are many devices besides scopes that must be shielded from magnetic fields to prevent a degradation of performance. These include such things as color-TV tubes, tape recording heads, photomultiplier tubes, and audio transformers in high-gain circuits. Sources of strong magnetic fields include permanent magnets or electromagnets, cables carrying heavy currents, electric motors, and power transformers. What we want to do is attenuate the effect of the field on the device. As you just suggested, separation of the two is a legitimate way to do this, for the intensity of a magnetic field at any point is inversely proportional to the cube of the distance between that point and the source of the field.

"However, sufficient separation is often impracticable, and we must use magnetic shielding. Such a shield can be defined as a ferromagnetic metal enclosure that surrounds the device as completely as possible. Keep in mind that it may be used to confine a field near the source or to protect a distant device from that field. In other words, sometimes the shield is trying to keep the field inside itself and at other times it may be used to keep the field outside an enclosure. These two approaches become important later when we talk about multiple shields.

"Right here I'd better confess my former ignorance. I had a foggy notion a magnetic shield did its job by *repelling* the field the way a windshield repels a rush of air. Actually, this isn't true. A magnetic shield *diverts* the field around the object it is trying to protect by offering an easier, though longer, path for the magnetic lines of force to follow. It cons those lines of force into taking a detour the way a smooth, wide bypass around a city beckons a motorist.

"The ability of a shield material to provide an easier path for magnetic lines of force is called its *permeability*. Suppose we have a field whose *strength* (H) measured in oersteds can produce a certain *flux density* (B) measured in gauss in our shield material when the shield and magnetic source are in a certain position. Flux density, don't forget, represents lines of force per cm^2. Now, if we divide the flux density in the shield material by the field strength at the shield, B/H in other words, we get (μ), the permeability of the shield. If a weak field produces a high flux density, we have a very permeable material."

"I suppose the higher the permeability the better the shield."

"It's not that simple. It depends on the strength of the field you're trying to attenuate. Permeability is not a constant. It's comparatively low for weak fields, increases rapidly with growing field strength until the material *saturates* and can't accommodate any more lines of force, and then falls off in effectiveness as the field strength continues to increase. The joker is that increasing permeability is accompanied by decreasing saturation level. A low μ material actually affords better shielding against a strong field that would saturate a more permeable material. As the field strength decreases, however—as it does rhythmically with an a.c. field—the low μ shield loses much of its effectiveness. In many cases, the best job of shielding is done by nesting one shield inside another of different μ so that the magnetic field strikes the low μ field first. It knocks down the field strength until the higher μ shield can handle the remainder of the field strength without saturating.

"An alternative would be to use a single thicker shield since increasing the thickness increases the attenuating ability. Then the trick becomes one of selecting a shield material of high enough permeability and adequate saturation characteristics for the field in which it is to be used to provide the required attenuation without the shield's becoming too thick. Since shielding calculations are seldom exact, this becomes a good trick indeed.

"While I'm thinking about it, I'd better mention another drawback of extremely high permeability shields. They are usually accompanied by increased *shock sensitivity*. That means their effectiveness may be degraded by any strain placed on them, say by being struck or dropped or flexed. If a shield is likely to be subjected to any of these stresses, it would be better to use a multiple shield of less sensitivity. *Perfection Mica*, however, claims its Netic® and Co-Netic® shields are non-shock-sensitive. The company says its shields can be sheared, sawed, drilled, or dropped for appreciable distances without destroying their shielding qualities."

"What determines the permeability of a shield?"

"The alloy from which it is made and the heat treatment given it. You'll find lots of tables and graphs outlining different characteristics of different materials in those books. I remember an 80% nickel/20% iron alloy that *Westinghouse* calls Hiperon® that has a saturation of 8000 gauss and a maximum μ of 400,000, while the company's Hipernick® alloy with only 50% nickel saturates at 15,000 gauss and has a maximum μ of 75,000. By way of contrast, 1010 carbon steel saturates at 22,000 gauss and has a maximum μ of 3000. These figures are all for material 0.020" thick.

"*Perfection Mica* presents attenuation and saturation information on its shielding material in graph form and employs a different thickness, so a direct comparison is not too easy. Its Co-Netic® alloy is designed for low-intensity, low-frequency problems and its Netic® alloy is designed for attenuating high-intensity fields. The company also has shielding coatings that increase the effectiveness of shields when properly applied for particular applications.

"Both companies produce thin, flexible shielding foils that can be cut and wrapped around objects to be shielded. These foils are simple and easy to apply and are particularly appealing to the do-it-yourself experimenter and to the engineer who wants to know in a hurry what sort of results he can expect from shielding."

"But how do you design a shield to do a certain job?"

"First you measure the strength of the interfering field at the device to be protected, a fascinating subject in itself! The books describe how a multi-turn sensing coil and a sensitive a.c. v.t.v.m. can be used to translate intercepted lines of force from an a.c. field into millivolt readings. For d.c. fields, the coil is rotated by a shielded synchronous motor so that the coil windings cut the static lines of force and generate an a.c. voltage for the v.t.v.m. But I soon gathered that a Hall-effect gauss meter was rapidly replacing this type of instrument, so I got a wealth of information from a large manufacturer of Hall-effect probes and other flux-sensing equipment based on this effect, the *F. W. Bell Company*, 1356 Norton Avenue, Columbus, Ohio.

"The Hall-effect is the potential difference observed between the edges of a strip of conductor carrying a longitudinal current when the strip is placed in a magnetic field perpendicular to the plane of the strip. The strip can be made of various semiconductor materials, but indium arsenide is one of the most popular. If current through the strip is a.c., the Hall voltage output is a.c.; if the current is d.c., the output voltage is d.c. for a d.c. field and a.c. for an a.c. field. This voltage can be amplified before being applied to an a.c. or d.c. meter, as the case may be. The *Bell Company* markets a low-cost '*Bell* Hall-Pak Kit' that contains a probe, a transistorized differential amplifier, and calibrating magnets for carrying out experiments and actually making flux-density measurements.

"Once you know the strength of the field and the amount of magnetic flux interference the sensitive device can tolerate, you figure the required attenuation (g). It is given by the formula, g equals the ratio of the field intensity outside to the intensity inside, both intensities measured in oersteds. Multiplying this ratio by $20 \log_{10}$ reduces the attenuation to dB.

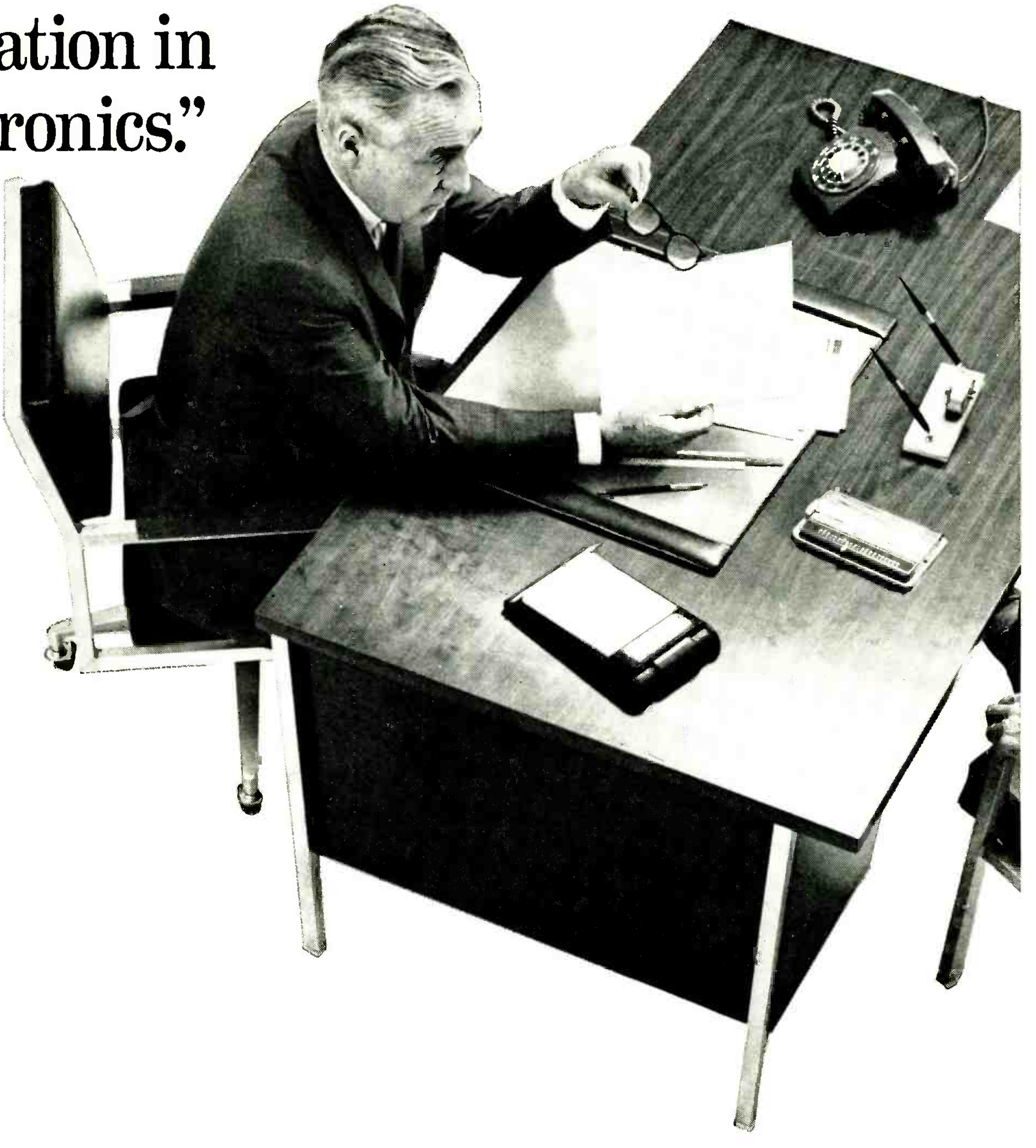
"Then you select a shield material that can provide that attenuation. Hipernom 0.020" thick has a maximum attenuation of 100 dB; 1010 carbon steel, 58 dB. Increased thickness or nested shields can provide more attenuation. But those books explain that the nature of the field, the direction from which it impinges on the shield, the physical dimensions of the shield—especially when both ends must be open as in a scope shield—the nature of the joints, etc., must all be taken into account in designing a shield. Still, the reader is repeatedly reminded that dealing with a three-dimensional shifting magnetic field is quite different from working with an accurately measured current or voltage in a conductor. Shield design is not an exact science. It is always wise to build and test a prototype before freezing any particular shield design.

"There are many other alloys, including those using molybdenum and cobalt; and several other companies, such as *Allegheny Ludlum* and *Carpenter Steel*, manufacture shields. Magnetometers, too, come in a wide variety, including the saturated core, the flux gate, and the nuclear resonance types. In fact, about the most important thing I learned from my reading was how little I really knew about the subject of magnetic shielding.

"Still and all, I now know how a shield does its job, the important properties of a shield alloy, parameters to be considered in designing a shield, properties of some available shielding materials, the methods of measuring a magnetic field—including a much better understanding of the Hall-effect than I ever had before—" Barney stopped talking for a moment and got a glazed look in his eyes.

"I just realized that I became so interested in reading about shielding I never did a thing to that scope monitor!" he confessed sheepishly. "Guess I'm becoming a pure scientist!" ▲

"He's a good worker. I'd promote him right now if he had more education in electronics."



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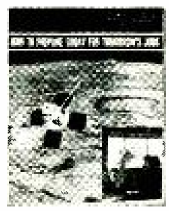

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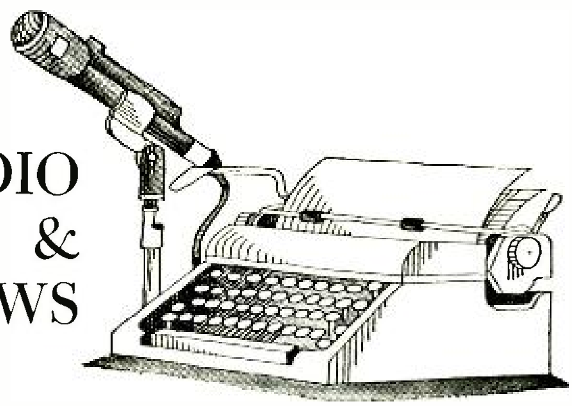

THE classic theory that the eye sees color because of red, green, and blue cones in the retina has been challenged by George Biernson of the *Sylvania Applied Research Lab.* At the last meeting of the IEEE, Mr. Biernson discussed the probability that the eye may perceive color by detecting rhythmic optical modes or patterns in the cones.

Mr. Biernson likened these optical patterns to vibrations of a drum. "When a drum is struck, complicated vibration patterns are excited over the drum head. Similarly, colors generate patterns of light energy over the cone, the patterns varying with the wavelength of the light.

"Although the retina of the eye superficially may appear similar to the photosensitive surface of a three-color TV camera, the two are radically different from a feedback point of view. The photosensitive surface of a TV camera is a static device with fixed characteristics, whereas the retina of the eye is a dynamic device employing complex feedback control processes," he explained.

Mr. Biernson went on, "The eye, which can discriminate among 10 million colors, is superior in color detection to TV or photography, which can distinguish only a few hundred colors. The greater color fidelity of the eye may be better explained by optical modes or patterns than by the three-cone theory."

The chief difficulty in resolving the mystery of color, according to Mr. Biernson, is a mistaken conviction that the three-color calculations of colorimetry characterize human vision. "What is not generally understood is that colorimetry is merely a collection of standards indirectly related to psychological reality. In fact, the standards were derived by extensive averaging of very crude experimental data."

Digital Policeman

Through a technique known as "digital overlay", direct digital communications between cruising police patrol cars and a central computer for on-the-spot checking of police records may soon be used by the nation's police in its fight against the rising crime rate.

Recent tests by both police and *G-E* engineers indicate that small-size, two-way Teletype machines installed in squad cars permit faster, more accurate "talk" between a central computer and the police officers. Both voice and Teletype messages can be sent simultaneously over the same voice channel with no mutual interference between the two channels.

Tests show that this new method of communications produces clear Teletype copy even when conditions are such that voice communications are particularly bad.

Tape Recorder Help

If you own one of the expensive ($700 to $1000) Japanese tape recorders having the names of Freeman, Neat, Frontier, Camena Voice, Stereocraft, or Vansonic, you should know that the company (*Tsbusa Sanyo*) is no longer in business. For parts and other information, contact Mr. Emory R. Howell, 3917 N. 31st St., Waco, Texas 76708.

FM Spurts

In the past five years, the number of FM stations in the U.S. has increased by more than 70%, from 889 stations in 1961 to 1521 stations in 1966. Also, the number of stations broadcasting FM-stereo has skyrocketed 780%, from 50 to more than 440 stations at present.

Along with this expansion in broadcasting, sales of FM radios have zoomed more than 500%, with last year's total reaching a record high of nearly 10 million units.

One major contribution is the fact that the FCC now prohibits duplication of more than 50% of programming heard on commonly owned AM-FM facilities in the larger cities.

Laser Drill

If you have ever had to drill fine holes using a #54 drill bit (0.0055"), you will appreciate the new instrument developed at *RCA* Aerospace Systems. In this new look in drills, a ruby laser is aimed through a series of special optical lenses; when the button is pressed, lo and behold, the laser drills perfectly round holes only 0.00048" in diameter through a human hair of 0.0042" diameter. ▲

Measuring Tracking Ability

(*Continued from page 28*)

At present, we know of no suitable tone burst record, but expect that it is only a matter of time until one is available so that this method can be thoroughly investigated.

Subjective Evaluation

The ultimate aim in making tracking-ability measurements is to correlate these measurements with subjective listening. We have made an extensive evaluation of phonograph cartridges from the standpoint of tracking ability, primarily through use of the variable-speed turntable technique. Cartridges so measured have been compared using a record entitled "An Audio Obstacle Course" designed specifically for subjective evaluation of tracking ability. (Available from *Shure Brothers, Inc.*, 222 Hartrey Ave., Evanston, Illinois 60204 at $3.95 each.) This record contains a series of bands using different musical instruments. Each band is subdivided into four sub-bands containing the identical musical selection with each successive band cut at a level 4-dB higher than the previous one. In playing this record, one notes the modulation level for each instrument at which the cartridge ceases to track. A chart like that shown in Fig. 7 can then be obtained. This provides a subjective evaluation of the cartridge tracking ability.

We have found good correlation between the tracking-ability measurements made on the variable-speed turntable and those made with "An Audio Obstacle Course". For example, cartridges which have poor tracking ability at low frequencies are found to be very poor on the band containing a bass drum beat. Cartridges which track poorly at high frequencies are also found to be poor on such instruments as orchestral bells and cymbals. After many such comparisons, we have found that by making an analysis of the tracking-ability measurements, we can predict with good accuracy the subjective characteristics which will be obtained with the record.

Conclusion

The tracking ability of a phono cartridge is analogous to clipping level in amplifiers. In both cases large peak input signals which drive the device into saturation cause intolerable distortion.

While there are many characteristics of a phonograph cartridge that contribute to the quality of reproduction, tracking ability is one of the major characteristics which affect the ultimate sound. Measurement of this characteristic is an extremely important factor in any evaluation. For this reason we believe that a means for making such a measurement should be standardized and that tracking ability should be among the specifications listed for phono cartridges. ▲

Fig. 7. Chart of tracking ability using test record described.

	MONO			LEFT CHANNEL				RIGHT CHANNEL			
LEVEL	OB	D&C	BD	O	P	A	H	O	P	A	H
1											
2	θ	θ		TRA	CKS						
3			θ			θ	θ			θ	θ
4				θ	θ			θ	θ		
				MISTRACKS							

	FREQUENCY RANGE
OB–ORCHESTRAL BELLS	HIGH
D&C–DRUM & CYMBALS	HIGH
BD–BASS DRUM	LOW
O–ELECTRONIC ORGAN	MID
P–PIANO	MID
A–ACCORDION	MID
H–HARPSICHORD	HIGH
θ–INDICATES CARTRIDGE TRACKS	

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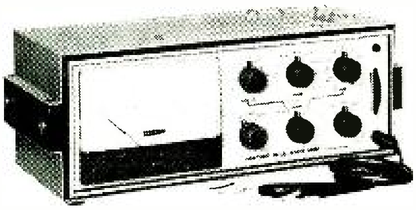

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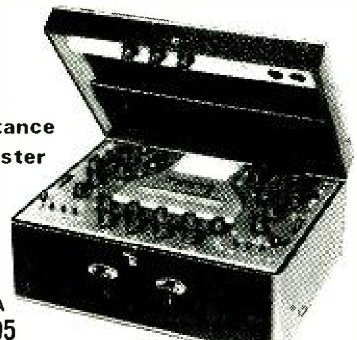

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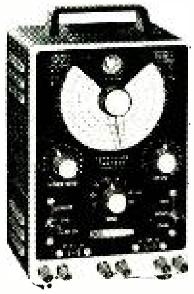

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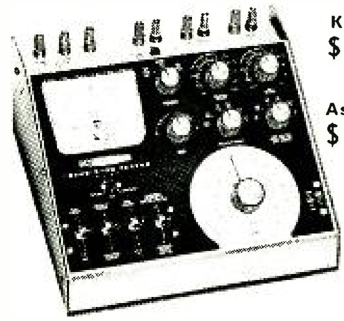

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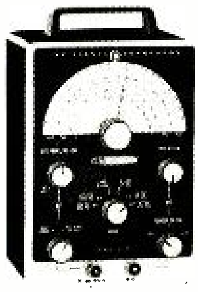

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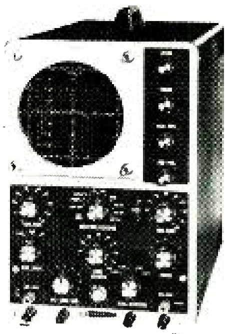

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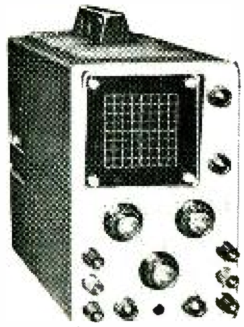

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• Identical vertical & horizontal DC or AC coupled amplifiers • DC to 200 kHz bandwidth — less than 5° phase shift • Recurrent sweep generator, 5 Hz to 50 kHz in four ranges • External capacitor binding posts for slower sweep rates • Small, compact, easy to carry from job to job • All critical voltages regulated for high stability • Transformer operated power supply. 16 lbs.

PKW-2
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NEW Low Capacitance Scope Probe

• Completely assembled, ready to use • Essential for high frequency wave-form analysis • Minimizes loss of gain, circuit loading or distortion • Designed for scopes with 1 megohm input, such as Heathkit IO-14 (above) • Switch for X1 direct or X10 attenuated operation • DC response to 25 MHz; max. DC voltage is 600 v. • Sliding, spring-loaded tip is notched for hooking to wires or terminals for hands-free use. 1 lb.

Kit ID-22
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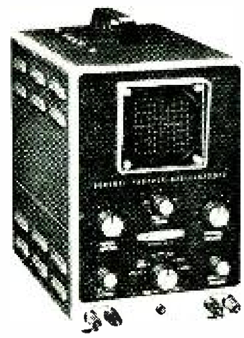
• Permits display of two separate signals on CRT screen • Displays signal levels as low as 0.1 volt • ±1 db, 0-100 kHz response • Separate gain controls for each channel • All-electronic switching • Four switching rates — 150, 500, 1500 and 5000 Hz • Sync output to control scope sweep • Simple to use — just connect signal sources to "A" and "B" inputs & output to scope vertical input. 7 lbs.



Kit IO-21
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• Push-pull vertical and horizontal amplifiers for minimum trace distortion • Wide-range sweep — 20 to 100,000 Hz • Automatic sync • Retrace blanking • Compact, lightweight, versatile • Dependable, well-rated oscilloscope for general purpose requirements • Professional-quality components used throughout • Clean, open circuit layout for easy assembly, 12 lbs.

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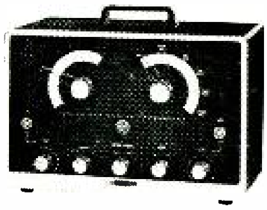

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OCCUPATIONAL OUTLOOK FOR ELECTRONICS TECHNICIANS*

Engineering and science technicians are the fastest growing occupational groups in the United States—demand will exceed supply for next decade.

IN recent years, the needs of an expanding and increasingly technical economy have greatly intensified the demand not only for engineers and scientists but also for the technical workers who assist them.

Unfortunately, the terms "technical worker" and "technician" have no generally accepted definition. They are used by different employers to refer to workers in a great variety of jobs, requiring a wide range of education and training. They are applied to employees doing relatively routine work, to persons performing work requiring skills within a limited sphere, and to persons doing highly technical work, among them assistants to engineers and scientists. The workers' job titles may be descriptive of their technical level (for example, junior engineer or engineering technician) or their work activity (for example, quality control, production analyst, or materials tester). Some employers use the word "technician" preceded by adjectives descriptive of areas of technology in which their personnel are employed.

The government, on the other hand, refers to technical workers whose jobs require both a knowledge and use of scientific and mathematical theory; specialized education or training in some aspect of technology or science; or those who, as a rule, work directly with scientists and engineers as "technicians".

In general, the jobs of engineering and science technicians are more limited than those of the engineer or scientist and have greater practical orientation. Many of these jobs require the ability to analyze and solve engineering and science problems and prepare formal reports on experiments, tests, or other projects. Some require considerable aptitude in mathematics: others, the ability to visualize objects and to make sketches and drawings. Design jobs often require creative ability. Many technician jobs require some familiarity with one or more of the skilled trades, although not the ability to perform as a craftsman. Still others demand extensive knowledge of industrial machinery, tools, and processes. Some jobs are supervisory and require both technical knowledge and ability to deal with people.

In carrying out their assignments, engineering and science technicians frequently use complex electronic and mechanical instruments and experimental lab apparatus. Almost all technicians must be able to use engineering handbooks and standard computing devices.

They engage in virtually every aspect of engineering and scientific work. In research, development, and design work (one of the largest areas of employment), they conduct experiments or tests: set up, calibrate, and operate instruments; and make calculations. They also assist scientists and engineers in developing experimental equipment and models by making drawings and sketches and, under the engineer's direction, frequently do some design work.

Technicians also work in jobs related to production, usually following a course laid out by the engineer or scientist, but often without close supervision. They may aid in the various phases of production operations, such as working out specifications for materials and methods of manufacture or devising tests to insure quality control of products. They may also perform liaison work between engineering and production or other departments.

Technicians often do work that might otherwise have to be done by engineers. They may serve as technical sales or field representatives of manufacturers; advise on installation and maintenance problems: and write specs and manuals.

Technicians are not confined just to the electronics field but perform similar roles in chemical, mechanical, metallurgical, and industrial technologies—to cite a few.

The Electronics Industry

The electronics industry is extremely broad in nature. It includes, for example, radio, radar, sonar, telemetering, television, telephony, and other forms of communications; industrial and medical measuring, recording, indicating, and controlling devices; navigational equipment; missile and spacecraft guidance and control instruments; electronic computers; and many other types of equipment using vacuum-tube and semiconductor circuits. Because the field is so broad, technicians generally become specialists in one area, for example, induction or dielectric heating, servomechanisms, automation controls, ultrasonics, etc.

Where Employed

It is estimated that there are some 620,000 engineering and science technicians in all categories but not including draftsmen. Of this number about 12 percent are women. Nearly 475,000 of these technicians (about three-fourths of the total) were employed by private industry. The industries employing the largest numbers of engineering and science technicians were electrical equipment, machinery, chemicals, and aerospace.

In mid-1964, the Federal Government employed approximately 75,000 engineering and science technicians: chiefly as engineering aids and technicians, electronics technicians, equipment specialists, cartographic aids, meteorological technicians, and physical science technicians. Of these engineering and science technicians, the largest number worked for the Department of Defense. Most of the others worked for the Depts. of Agriculture, Commerce, and Interior.

State government agencies employed over 40,000 engineering and science technicians in mid-1964 and local governments about 15,000. The remainder were employed by colleges and universities, mostly in university-operated research institutes, and by non-profit organizations.

Training

Young men and women who wish to prepare for careers as engineering or science technicians can obtain the necessary training from a number of sources, including specialized formal training programs offered in post-secondary schools—technical institutes, junior and community colleges, area vocational technical institutes, and extension divisions of colleges and universities—and technical and technical-vocational high schools. Persons can also qualify for technician jobs by completing an on-the-job training program, through work experience and formal courses taken on a part-time

*Reprinted in part from the revised edition of the "Occupational Outlook Handbook," prepared by the Bureau of Labor Statistics, U.S. Department of Labor.

basis in post-secondary or correspondence schools, or through training and experience obtained while serving on active duty in the Armed Forces. In addition, many engineering and science students who have not completed all requirements for a bachelor's degree, as well as some other persons with college education in mathematics and science, are able to qualify for technician jobs after they obtain some additional technical training and experience. In general, post-secondary school technical training is required for high-level engineering and science technician jobs.

Engineering and science technicians usually begin work as trainees or in the more routine positions under the direct supervision of an experienced technician, scientist, or engineer. As they gain experience they are given more responsibility, often carrying out a particular assignment under only general supervision. Technicians may move into supervisory positions. Those with exceptional ability sometimes obtain additional formal training and are promoted to professional engineering positions.

For admittance to most schools offering post-secondary technician training, a high school diploma is usually required. Some schools, however, admit students without a high school diploma if they are able to pass special examinations and otherwise demonstrate their ability to perform work above the high school level.

Programs offered by schools specializing in post-high school technical training require one, two, or three years of full-time study. The majority are two-year programs, leading to an associate of arts or science degree.

Because of the variety of educational institutions offering training and the differences in the kind and level of training, persons seeking a technical education should use more than ordinary care in selecting a school.

Technical institutes offer training designed to qualify the graduate for a specific job or cluster of jobs immediately upon graduation and with a minimum of on-the-job training. In general, the student receives intensive technical training but less theoretical and general education than is provided in curricula leading to a bachelor's degree in engineering and liberal arts colleges. Emphasis is placed on lab and practical work in order to familiarize students with industrial techniques and instruments.

Some technical institutes offer cooperative programs under which a student spends part of his time in school and part in employment related to the occupation for which he is preparing himself. It may take more than two years to complete the curriculum at a school with a cooperative plan, but this type of program gives students valuable work experience, which often outweighs the disadvantages of a longer training period. In addition, students participating in cooperative programs frequently earn enough to pay for at least a part of their educational expenses and, on their first job, often obtain higher starting salaries than those with no experience.

Many junior and community colleges offer the necessary training to prepare students for technician occupations. Some of these schools offer curricula which are equivalent to those given in freshman and sophomore years of 4-year colleges. Graduates can transfer as a junior in a 4-year college or qualify for technician jobs. Other schools offer 2-year programs of the technical-institute type.

Junior college courses in technical fields are often planned around the employment needs of the industries in their localities. Therefore, the training programs for prospective technicians vary and may include highly specialized preparation in addition to general courses. In some cases, the courses are designed to meet the specifications of one or two industries or even of a single plant.

Area vocational-technical schools are post-secondary public institutions that are established in central locations to serve students from several surrounding areas. In the early 1960's, the number of such schools increased rapidly due primarily to the stimulus provided by Title VIII of the National Defense Education Act of 1958. In some states, many established public junior and community colleges have been designated as area schools and have received Title VIII funds in order to extend their training facilities.

Total electronic/electrical technicians' employment increased 24.9% from 1964 to 1965 and another 24.8% in 1966. Another interesting statistic, taken under a slightly different set of conditions by the Engineering Manpower Commission, predicts that by 1976 total technician employment will have increased 80% over that of 1965.

In general, the admission requirements of vocational-technical schools are less rigid than those of other schools offering post-secondary technician training. Area school curricula are usually designed to train the types of technicians most needed in that area.

Some large corporations conduct programs to meet their needs for trained personnel. This type of training is primarily technical and rarely includes any general studies.

Although most engineering and science technician jobs require post-high school education or the equivalent in experience, a few technical and technical-vocational high schools, principally in large cities, offer programs which qualify their graduates for some technician entry jobs. However, graduates of this type of school often need supplementary training before they can move up to higher level positions. In recent years, public high schools of this type in some states have been designated as area schools to serve several school districts and have received funds provided by Title VIII to increase their training capacity.

Many technical high schools have high admission requirements and offer more thorough and advanced courses in mathematics, science, drafting, and laboratory work than are usually available in academic high schools. They sometimes offer a year of schooling beyond the 12th grade. Some have evening courses.

Correspondence schools provide technician training for those who wish to learn more about their jobs or who wish to advance in the same field by increasing their theoretical and mathematical knowledge.

Employment Outlook

Employment opportunities for engineering and science technicians are expected to be very good through the mid-1970's. In recent years, technicians have been one of the fastest growing occupational groups and it is estimated that this rapid growth will continue. In general, the demand will be strong for graduates of post-secondary school programs to fill high-level engineering and science technician jobs.

Among the factors underlying the increase in demand for technicians are the anticipated expansion of industry and the increasing complexity of modern technology. As prod-

Note: General information on careers for engineering and science technicians may be obtained from American Society for Engineering Education, Technical Institute Council, Dupont Circle Bldg., 1346 Connecticut Ave., N.W., Washington, D.C. 20036; Engineers' Council for Professional Development, 345 East 47th Street, New York, N.Y. 10017; and National Council of Technical Schools, 1507 M Street, N.W., Washington, D.C. 20005.

Information on training opportunities may also be obtained from Engineers' Council for Professional Development, a nationally recognized accrediting agency for engineering technology programs; the National Council of Technical Schools; and the U.S. Department of Health, Education, and Welfare, Office of Education, Division of Higher Education and/or Division of Vocational and Technical Education, Washington, D.C. 20202.

State departments of education at each state capital also have information about approved technical institutes, junior colleges, and other educational institutions within the state offering post-high school training for specific technical occupations.

Other sources include: American Association of Junior Colleges, 1315 16th St., N.W., Washington, D.C. 20036 and National Home Study Council, 1601 18th St., N.W. Washington 20009.

ucts and the methods by which they are manufactured become more complex, increasing numbers of technicians will probably be required to assist engineers in such activities as production planning, maintaining liaison between production and engineering departments, and technical sales work. Furthermore, as the employment of scientists and engineers continues to grow, increasing numbers of technicians will be needed to assist them. The trend toward automation of industrial processes and the growth of new areas of work, such as that related to atomic energy, will increase demand for technical personnel. In addition to technicians needed to fill new positions, more than 25,000 will be needed each year to replace those who retire, die, or change jobs.

Another factor supporting the expected increase in demand for engineering and science technicians is the growth in research and development expenditures. Such expenditures have increased very rapidly in recent years and are expected to continue to rise through the mid-1970's, although somewhat more slowly than in the past. Expenditures for the defense and space programs also greatly affect the demand for technical personnel. The level of such expenditures is not expected to change substantially in the years ahead.

Earnings

In general, a technician's earnings depend upon his education and technical specialty, as well as his ability and work experience. Other important factors which influence his earnings are the type of firm for which he works, his specific duties, and the geographic location of his job.

Annual starting salaries for graduates of post-high school technical schools averaged about $5000 in private industry in 1964. Young persons entering engineering and science technician jobs with less formal training generally earned less.

In Federal Government agencies in early 1965, beginning engineering and science technicians were offered $4005, $4480, or $5000, depending upon the type of job vacancy and the applicant's education and other qualifications. Some Federal Government agencies hire high school graduates and train them for technician jobs. Beginning salaries for these jobs ranged from $3680 to $4005 a year, depending on high school courses and experience.

Most technicians can look forward to an increase in earnings as they move to higher positions. In 1964, annual salaries of workers in high level technical positions in private industry averaged $8500 and approximately one-fourth of the workers had salaries above $9200 a year, according to a Bureau of Labor Statistics survey. ▲

Highway Emergency Radio

(*Continued from page 42*)

incorporates a triggering concept that works as follows. As the car hits a "magnetic transmitter", logic circuits open the speaker of the CB rig for 8 to 10 seconds, just long enough for an upstream transmitter to broadcast a message concerning road conditions or accommodations ahead. Simultaneously, the AM radio is muted. Cars traveling in the other direction are not triggered and hence do not receive this message. The transmitter need only be about 20 to 50 milliwatts and this neatly confines the range to a 500-foot area, sufficient for adequate reception of two 4-second prerecorded messages to cars traveling at 75 mi/h. A remote cable-connected control would permit appropriate selection of the tape track at various times.

The "visual sign minder" is a combination light and alpha-numeric readout-tube panel device which mounts on the dashboard and provides a "sign" corresponding to one posted on the roadway. An audio tone is sounded to gain the driver's attention. Passing over a magnetic code in the pavement triggers the display on the dash; the "sign" will light up with "25" for 25 mi/h, for example, in addition to conventional lights illuminating such messages as "STOP," "YIELD," and "RR".

The "route minder" operates on the IC memory unit principle, responding to unique identification of all intersections. When the proper code is received from the buried magnets (as the driver approaches the intersection), the memory unit activates the sign minder panel device which then lights up "STRAIGHT," "LEFT," or "RIGHT" to alert the driver for proper turning. Again, an audible signal calls the driver's attention to the readout. Obviously, the magnetic coding here must be different from that employed for other functions, so *GM* suggests using six magnets. The first three are for sign purposes; the remaining three are for intersection identification.

The "code and voice communications" function uses 27-MHz CB in a unique configuration. Utilizing a telephone-type dial encoder installed in the console, the driver dials the service needed: "1" for police, "2" for ambulance, "3" for fire truck, and "4" for tow truck. Then he dials the last three digits of his license-plate number and finally his location. This coded transmission is received at a relay station and passed on to the Aid and Information Center (AIC) by wire for added security. At the Center (Fig. 7), the signal is decoded, indicated on alpha-numeric readout tubes, and printed for permanent record. The dispatcher sends for the

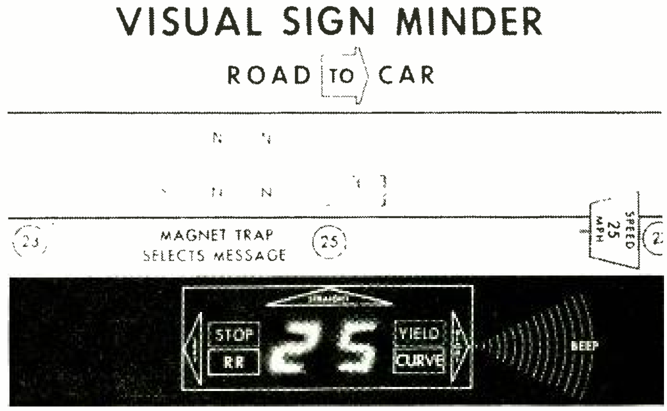


Fig. 6. In the DAIR system, passing over magnetic traps produces a driver alert tone and indicates the message.

assistance and assures the driver by one-way CB transmission that help is coming. For information, the motorist dials "0" followed by his license number. The Center dispatcher acknowledges the call and directs the driver to an appropriate CB channel where he can call in for direct contact. This leaves the coded aid channel open for priority calls. To check on channel availability, the driver pushes a "monitor" button to prevent interfering with another driver who is requesting aid at that moment.

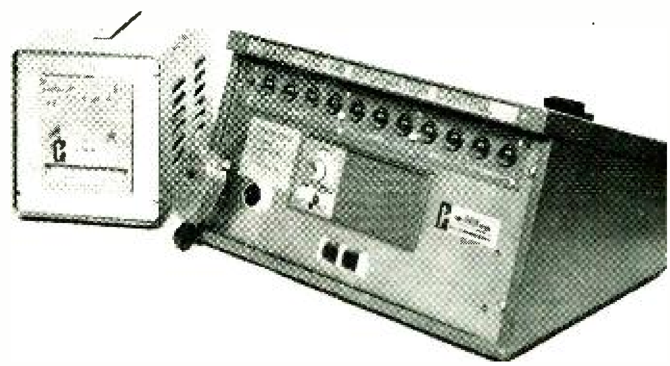
GM feels that nationwide coding of intersections on a single magnetic tape might be impractical, although it would certainly be feasible to furnish the driver with several cartridges which he could then insert into the DAIR unit as he passed from his local area into another section of the country. Over 500 thirty-bit binary intersection codes and routing instructions could be stored on a single tape less than one foot long. A search of the entire tape loop would take about one second.

General Motors now has several vehicles set up with DAIR equipment at the company's Technical Center for experimental tests and demonstration purposes. Needless to say, considerable interest has been stimulated by the demonstrations.

Radio Helicopters

While most of the controversy over which system is best revolves around those programs just described, the independent radio helicopters now hovering over several large metropolitan areas should not be overlooked. In the New York City area, for example, two AM broadcast stations (WOR and WCBS) maintain three helicopters solely for the purpose of providing the rush-hour motorist with accurate traffic information and suggestions for alternate routes. What makes these efforts significant is that these same "flying reporters" often spot accidents long before the police are alerted to them, and although the average listener is frequently unaware of it, the helicopters are

Fig. 7. A DAIR central control center showing readouts.



responsible for obtaining a considerable amount of road assistance that otherwise would have necessitated the driver leaving his car, walking along a busy freeway, and telephoning for help. (One station now issues "HELP!" banners to drivers for placing on car roofs when the vehicle conks out. Helicopters spot the signs and quickly radio for assistance. There is no charge for the service or the banners.)

But perhaps most important is the fact that at present helicopter reports are the only real source of up-to-date traffic news. If nothing else, they at least keep the motorist informed, which is more than anyone else is doing.

Central Traffic Control Centers

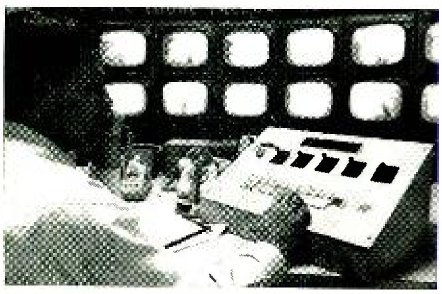
The reader will note that most of the two-way communications systems being proposed rely to some extent on a central control center. This center could be fed information from smaller monitoring stations, change transmitter codes, alter speed limits, and generally coordinate vehicular flow in high-density traffic areas. While many cities are currently working on small versions of this concept, the installation at the Detroit National Proving Ground for Freeway Surveillance is perhaps the most advanced. It serves as a headquarters during peak traffic hours for all kinds of information relating to vehicular flow and, using lane lights, can to some degree control sections of Detroit expressways.

The control center (Fig. 8) is provided with CB equipment for taking calls from volunteer traffic reporters, a battery of telephones, and an impressive array of CCTV units for accurate surveillance of major arteries and trouble-spots. In addition, traffic counters and police reports help to round out the incoming information.

What has been learned even with existing equipment is that if traffic flow can be maintained at a uniform pace, safety can be significantly improved.

Whatever form the control centers take, however, one thing is certain: they will ultimately have the responsibility for servicing any vehicular highway radio system that is expected to be used effectively for improving safety ▲

Fig. 8. In this typical freeway control center, extensive use is made of both Citizens Band and closed-circuit television systems. Locale is in Detroit.



Currently, Mr. Frost reports, he's an inspector of major electronic systems, checking the work of as many as 18 men. "I don't lift anything heavier than a pencil," he says. "It's pleasant work and work that I feel is important."

Changes Standard of Living

Gene Frost's wife shares his enthusiasm. "CIE training has changed our standard of living completely," she says.

"Our new house is just one example," chimes in Mr. Frost. "We also have a color TV and two good cars instead of one old one. Now we can get out and enjoy life. Last summer we took a 5,000 mile trip through the West in our new air-conditioned Pontiac."

"No doubt about it," Gene Frost concludes. "My CIE electronics course has really paid off. Every minute and every dollar I spent on it was worth it."

Why Training is Important

Gene Frost has discovered what many others never learn until it is too late: that to get ahead in electronics today, you need to know more than soldering connections, testing circuits, and replacing components. You need to really know the fundamentals.

Without such knowledge, you're limited to "thinking with your hands" ...learning by taking things apart and putting them back together. You can never hope to be anything more than a serviceman. And in this kind of work, your pay will stay low because you're competing with every home handyman and part-time basement tinkerer.

But for men with training in the fundamentals of electronics, there are no such limitations. They think with their heads, not their hands. They're qualified for assignments that are far beyond the capacity of the "screw-driver and pliers" repairman.

The future for trained technicians is bright indeed. Thousands of men are desperately needed in virtually every field of electronics, from 2-way mobile radio to computer testing and troubleshooting. And with demands like this, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

How can you get the training you need to cash in on this booming demand? Gene Frost found the answer in CIE. And so can you.

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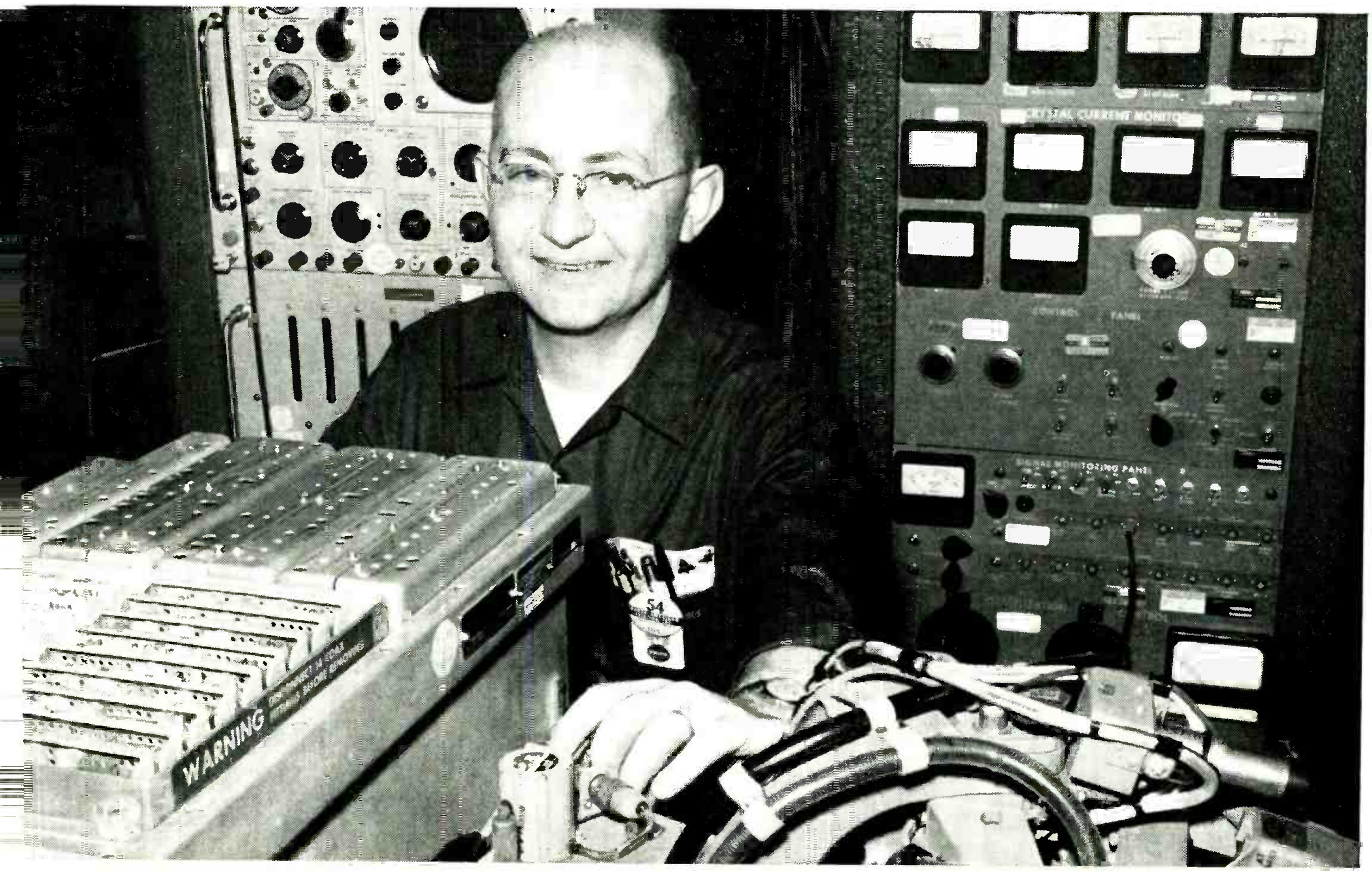

CIRCLE NO. 120 ON READER SERVICE CARD

Penultimate Automatic Keyer

(Continued from page 38)

tions which tell the computer what to do. Since the exact instructions depend on the particular computer used, we will not describe the exact program. Instead, we will describe what it does.

The computer program permits the operator to sit at the typewriter and "converse" with the computer. By typing in the correct symbols, the operator tells the computer what to do. If the computer needs to tell the operator something, it merely types back on the same typewriter. In this way the operator and the computer "converse" with each other.

To control the computer, there are five so-called *control words* which have a special meaning to the program running the computer. These words start with a slash to tell the computer that the following word is a control word.

The five words are /REC, which tells the computer to receive a message from the keyboard and store it in the memory for future sending. /ERS tells the computer to erase a previous message from its memory and /KEY tells the computer to send a message in code. To help the operator, /PRT tells the computer to print out on the typewriter all the messages stored in the computer, and/PUN tells the computer to prepare a tape of all messages inside the memory. This tape is useful if we want to save the messages while we use the computer for something else.

To identify what is sent, received, or erased, each of the messages in the memory has a name of up to four letters. For example, a message calling "CQ" would be called "CQ"; a message with the operator's name would be called "NAME"; a description of the station equipment might be called "EQPT"; the station address might be called "ADDR."

Fig. 5 shows the actual typewriter printout during a typical operation of the keyer. At the beginning, we store several messages in the computer with the /REC code. Just to make sure that they are in correctly, we "play them back" with the /PRT code. Finally, we use the /KEY code to actually send them over the air. To make it more obvious which of the typing is the operator's and which is the computer's, we have underlined everything put in by the operator.

Any new invention, especially one which uses automation to replace a human, is scorned and decried. We are sure that the same fate will befall our penultimate automatic keyer.

No doubt many amateurs will feel that they have been replaced by a machine and that they are being forced out of a hobby rightfully theirs. They will claim that the computer, being but a machine, has no right to a hobby, especially *their* hobby.

To these foolish souls we would like to point out that the computer program which makes the computer work is hardly designed to make the computer enjoy itself. After all, how would *you* like it if you had to blink your eyes in time to Morse code for hours on end? ▲

Fig. 5. Example of the conversation between the keyer and the operator during typical operation. (Operator answers to computer are underlined in this reduced actual printout.)

```
WHAT SPEED? 0005

/REC,    /ERS,    /KEY,    /PRT,    /PUN?    /REC

WHAT NAME?       CQ

 GO AHEAD.

CQ CQ CQ CQ CQ CQ DE WB2KYF WB2KYF WB2KYF SK

/REC,    /ERS,    /KEY,    /PRT,    /PUN?    /REC

WHAT NAME?       QTH

 GO AHEAD.

OUR QTH IS IN BAYSIDE, NEW YORK.

/REC,    /ERS,    /KEY,    /PRT,    /PUN?    /PRT

CQ

CQ CQ CQ CQ CQ CQ DE WB2KYF WB2KYF WB2KYF SK

QTH

OUR QTH IS IN BAYSIDE, NEW YORK.

/REC,    /ERS,    /KEY,    /PRT,    /PUN?    /KEY

WHAT? CQ

/REC,    /ERS,    /KEY,    /PRT,    /PUN?    /KEY

WHAT? CQ
```

This *Remington* PREMIER PORTABLE TYPEWRITER

WHEN YOU BUY THIS RCA WR-64B COLOR BAR/DOT/CROSSHATCH GENERATOR...THE ESSENTIAL COLOR TV TEST INSTRUMENT

Here's a deal you can't afford to miss! A FREE Remington portable typewriter—yours when you purchase the most essential color-TV test instrument—the RCA WR-64B!

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The standard of the Color-TV Servicing Industry. Generates all necessary test patterns—color bars, crosshatch, dots plus sound-carrier. *Only* **$189.50***

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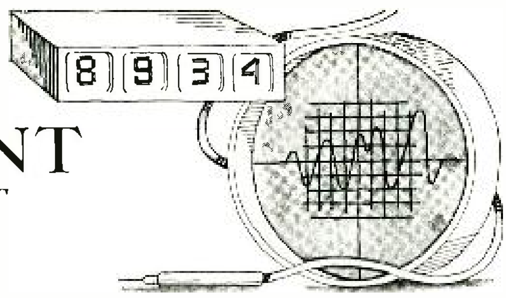
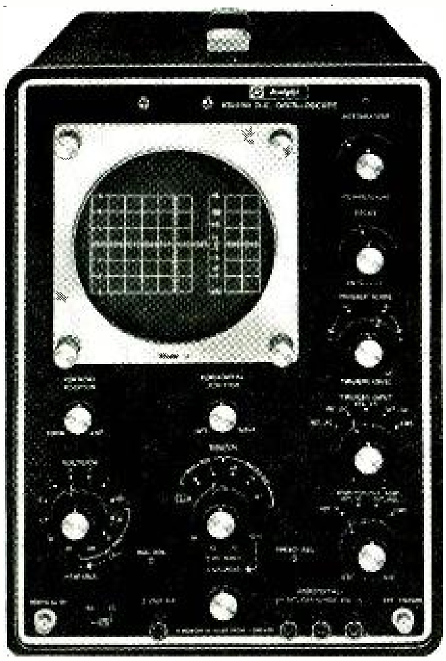
TEST EQUIPMENT
PRODUCT REPORT



"Knight-Kit" KG-2100 Laboratory Oscilloscope

For copy of manufacturer's brochure, circle No. 27 on Reader Service Card.

THE *Allied Radio Corp.* is no newcomer to lab scopes in kit form. We remember writing up a report on the big brother of the present Model KG-2100 just about five years ago for our April, 1962 issue. This previous model was a large professional-type instrument that used plug-in preamps



and needed two carrying handles to tote it around. The price of that model was about $400 for the kit main frame without the required preamp, which added another $80 to the cost.

The new "Knight-Kit" KG-2100 is no less a professional instrument, although some of the fancier frills, such as the crystal-controlled marker generator and the 24-step voltage calibrator, have been trimmed off. Also, the preamp is built into the scope rather than being a plug-in unit. Both size and weight have been reduced to more convenient values. For example, the scope's dimensions of 14½" × 10⅛" × 15½" make it only slightly larger than some service-type instruments that we have seen. The price of the new scope is down, too; it runs $249.95 for the kit or $349.95 for the factory-assembled unit.

The scope has a vertical bandwidth from d.c. to 5 MHz. An additional preamp is switched in to boost the sensitivity to as much as 5 mV/cm for weak a.c. signals. The sweep is triggered and calibrated from 0.05 sec/cm up to 200 nsec/cm. Triggering can be made to occur at any point on the waveform being observed or preset triggering is available. The two little neon lamps that show where the trace is located are very useful when the operator is trying to find a waveform that has disappeared off-screen. The scope uses 22 vacuum tubes, excluding the five-inch flat-face CRT, plus seven diodes.

Extensive use is made of voltage regulation in order to keep the pattern steady and to maintain the adjustments and calibration accuracy. The three low-voltage power supplies as well as the high-voltage supply are highly regulated. Even during the 40-hour aging period recommended for a newly constructed kit, the pattern on the screen remained rock-steady at all times. Also, we observed that the instrument's very quiet ventilating fan seemed to be exhausting fairly cool air even after prolonged use. Evidently, the scope does not run hot and the little heat that is produced is readily removed by the fan.

The best tribute we can pay the instrument is to say that its performance is everything that it should be; we were particularly pleased that all the internal adjustments occurred just about at the middle of their ranges, indicating good, optimum circuit design.

Construction of the oscilloscope is not complex although it is time-consuming due to the absence of printed boards. Our actual construction time was 49 hours, plus another several hours for calibration and final checks. For those who want an excellent, hand-wired instrument at a reasonable price, the "Knight-Kit" KG-2100 should certainly be considered. ▲

Hickok Model GC-660 Color-Bar Generator

For copy of manufacturer's brochure, circle No. 28 on Reader Service Card.

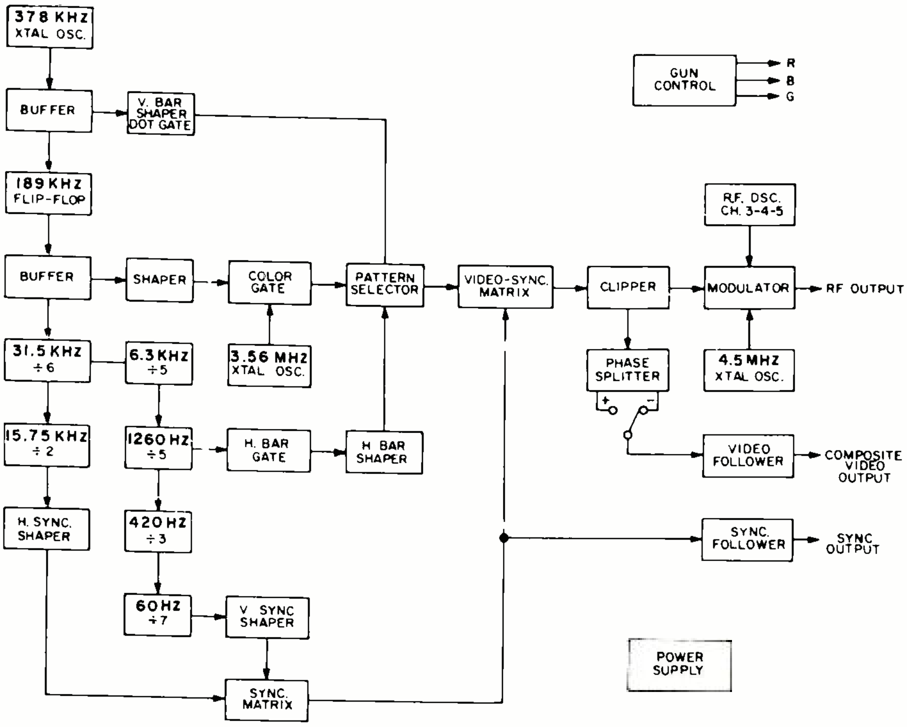
THE recent introduction of a new color-bar generator by *Hickok* adds to the company's line a dependable, all-solid-state device designed to answer the needs of today's technician in color-television receiver servicing.

The Model GC-660 instantly provides the required signals for testing alignment and convergence, as well as those necessary for checking and repairing video and color circuits. The unit is entirely transistorized, requiring no warm-up of tubes, and is therefore less susceptible to the aging characteristics associated with tube-type equipment.

Video patterns supplied by the instrument include a gated-rainbow color pattern consisting of ten crystal-controlled keyed bars with a 30° change between each, a dot pattern supplying 324 dots of 0.1 microsecond duration, eighteen horizontal bars, eighteen vertical bars, and a low-flicker cross-hatch pattern. All chroma signals are maintained at zero reference to insure correct receiver phase adjustment.

Additional signals available consist of a ±2 volt peak-to-peak composite video, a −2 volt peak-to-peak sync signal, and a 4.5 MHz sound carrier that is crystal-controlled to assure proper setting of receiver fine tuning.

Operation of the Model GC-660 is straightforward. The five display patterns are available at the r.f. output cable and are coupled to the receiver through the antenna terminals. A single control selects the pattern to be viewed and the "Chroma Signal" control varies the level of the color signal supplied to



the receiver. The "Color Gun" control provides a means of making fast purity checks without disturbing the color screen controls of the receiver. Use of the gun control will also allow individual $R-Y$, $B-Y$, and $G-Y$ displays to be viewed, thereby utilizing the picture tube to check color demodulation outputs and eliminating the need for an oscilloscope.

One of the Model GC-660's unique features is its ability to maintain good timer stability over a wide range of operating and temperature conditions. Stability in any color generator is directly related to the number of timer stages and the divisions per stage in its design. Many generators use only six with as many as fifteen divisions in each. The eight timer stages used in the GC-660 have no more than seven divisions in any one stage and provide a high degree of accuracy. Model GC-660's have maintained their timer stability in Military Standard environmental test chambers at temperatures from −5°F to +120°F.

All display signals from the generator are locked to the crystal-controlled master oscillator at 378 kHz. (See diagram.) The output of this oscillator is coupled to the buffer shaper, and pulses from the buffer shaper are used to trigger the 189-kHz flip-flop circuit. The 189-kHz pulses are applied to the buffer inverter, producing square-topped pulses which are fed to a shaping circuit and converted into sharp spikes. These spikes are then used to trigger the 31.5-kHz countdown circuit. A unijunction transistor is employed as a 31.5-kHz relaxation oscillator and functions as a locked frequency divider, dividing the 189 kHz from the buffer inverter by six and providing an output frequency of 31.5 kHz as shown in the diagram.

Positive-going spikes from the 31.5-kHz oscillator are coupled to a frequency divider and cut in half, producing a frequency of 15,750 Hz. Negative pulses from the 31.5-kHz oscillator are coupled to a buffer inverter. The output pulses are divided by five, producing 6300 Hz. In a like manner divisions of five, three, and seven, respectively, are made. The final result is the 60-Hz frequency for vertical sync.

The instrument operates from the a.c. power line and is therefore not subject to the fall-off in battery voltage which would detract from its over-all stability and performance. Each unit is provided with a visual color-bar standard which displays the rainbow pattern exactly as it should appear on the screen of a properly operating color-television receiver. The Model GC-660 is lightweight (6¼ pounds) and is supplied in a rugged, wooden, leatherette-covered portable case. The price is $159.50. ▲

Sensi-Tronics Model 200 Electronic Circuit Breaker

For copy of manufacturer's brochure, circle No. 159 on Reader Service Card.

WHEN engaged in the development of equipment using expensive, high-power transistors with their short burn-out time, an engineer sometimes inadvertently overloads and burns out a transistor or other sensitive component. The *Sensi-Tronics* Model 200 electronic circuit breaker offers a solution to this problem by providing a very rapid (1 microsecond) circuit interruption that protects the transistor. A current-break range from 10 to 1000 mA is available, the exact value being set by the calibrated dial. Supply voltages of up to 60 volts may be used.

An indicator lamp above the dial goes on when the breaker trips. Reset is automatic, as the breaker attempts to reset itself every two seconds, succeeding only when the overload is removed. The instantaneous current during these reset attempts is of very short duration (about 1 millisecond) and does not exceed the break-current setting. Manual reset can also be used.

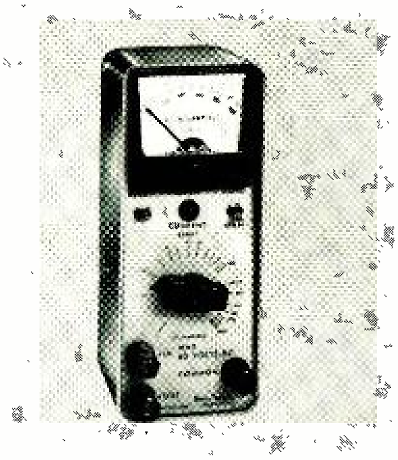
The breaker circuit consists of a series transistor with a controlled base current. When the current through the load exceeds the breaker setting, the voltage drop across this transistor increases. This voltage drop is fed back through four other transistors which act to immediately decrease the base current of the series transistor, causing the load current to drop to zero. This condition is stable so that the breaker remains open until it is reset (after two seconds) by an astable multivibrator using another pair of transistors. A built-in current meter indicates the current to the load.

To prevent damage to the breaker in the event that the power source is connected with reverse polarity, a diode is used to stop reverse current through the breaker circuitry.

This circuit breaker operates entirely on power obtained from the input power supply. When the breaker is closed, this current drain is about 20 mA for a supply voltage of 60 V and decreases proportionally as the voltage is reduced. Similarly, the drain is about 100 mA with the breaker open at 60 volts, falling to 64 mA for a 6-volt supply.

When the input is between 6 and 60 V, the breaker acts normally. Below 6 volts, the indicator lamp becomes dimmer, there is a loss of calibration accuracy, and the reset MV speeds up.

The breaker measures 3" × 7" × 3" and can be used in single, multiple, or rack-mounted configurations. The price is $185. ▲



Fluidic Systems

(Continued from page 25)

devices are readily available from a number of different manufacturers.

Analog Devices

Digital devices perform "on-off" functions because of the wall-attachment principle. But to construct an analog or proportional fluidic device—one that allows some output through each leg—the output legs are not connected by a common wall (Fig. 6).

The amount of air flow exiting each leg is determined by the difference in pressure being introduced through the two control ports. For example, if a stronger signal is applied through control port 2, a greater proportion of the port air will be diverted to output leg 2 rather than output leg 1. Typical gain of these analog devices is from 5 to 7, although they can be cascaded or staged for higher gains.

If a stream is conditioned to be laminar (streamlined flow rather than turbulent) and the pressure low enough to maintain it in this condition, the stream can be transmitted from one tube to another across an air gap (Fig. 7). When a signal is introduced to impinge on the laminar stream, the stream will become turbulent and not reach the receiver tube. This is a *nor* device and by adding a second amplifier an *or/nor* gate can be constructed.

Other digital and analog devices such as impact modulators, double-leg elbow amplifiers, air foils, and vortex amplifiers have been constructed and are just about ready for the market.

Sensors & Output Devices

A number of fluidic sensors are commercially available now. Frequently the best such devices are designed and built by the user—most commonly back-pressure sensors and interruptible jets (Fig. 8).

Ten-percent supply pressure is needed to switch the back-pressure devices, consequently, a dropping resistor (actually a constriction in the channel) and an air-bleed vent are used to keep pressure below 10 percent. When the object being sensed nears the bleeding tee, back pressure builds up to 10 percent and causes the device to switch.

The interruptible-jet device is also known as a "fluidic eye". Air is transmitted from the sending to receiving portion of the circuit, keeping the device switched on until an object interrupts the signal. When the signal is cut off, it exits through the *nor* leg.

Other sensors are available which perform pressure, temperature, rate, and position operations.

When fluidic devices with high outputs are needed, interface equipment must be used. Fluidic devices normally operate with supply pressures up to 20 psi/g. Some combined fluidic and interface devices will switch 3000 psi/g hydraulic pressure.

Fluidic systems can control appliances, flight guidance autopilots, marine guidance equipment, machine tools, heating and air-conditioning units and can be used in computers, process instrumentation, liquid-level controls, air gaging, simulation, and a variety of other applications. As more and more is learned about the capabilities of these useful devices, we can expect to find fluidic systems being used in more and more equipment.

Fluidic technology has come a long way since some of the early devices were worked on around 1959. Today, newly available fluidic components are of high quality and great versatility. ▲

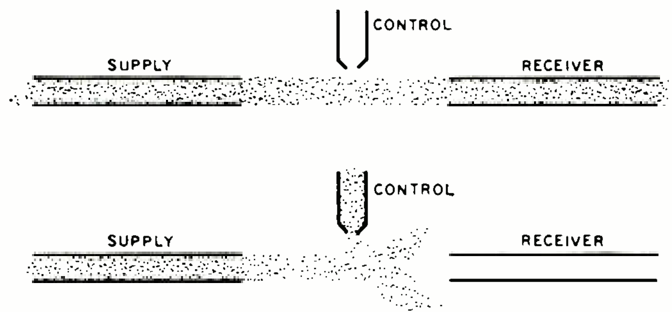


Fig. 7. Illustrating the principle of the turbulence amplifier.

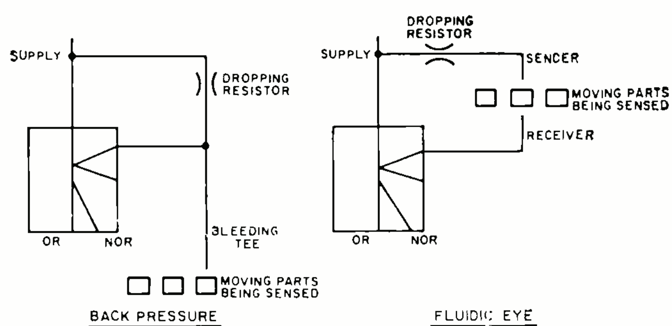


Fig. 8. Commonly used back-pressure and fluidic-eye type of sensors.

Laser Interferometer

(*Continued from page* 45)

On an experimental basis, laser-controlled machines have already been in operation. Commercial units are not yet available, however, because the cost per axis for such a machine is prohibitive. To overcome this problem, engineers are currently investigating the possibility of sharing a single unit between axes. The addition of a separate optical beam splitter, for example, could make the laser beam usable in both X and Y directions. Similar sharing techniques might be used in the electronics to further reduce costs. It is the author's opinion that a practical solution will soon be found and machine-tool controls will take another great step forward.

Their application as interferometric light sources is only one way in which lasers contribute to precise measuring techniques. Another distance-measuring instrument using a laser is the "Mach III Geodolite" made by *Spectra Physics, Inc.* This device functions both as a geodetic surveying instrument with a 20-mile range in daylight (50 miles at night) and as an airborne profile recorder at altitudes up to 35,000 feet in sunlight. Accuracies of 1 ppm are attainable assuming that corrections for barometric temperature and pressure are made. A distance of 15 miles, for example, can be measured with an accuracy of less than one inch.

Unlike the interferometer, this instrument's laser is modulated at radio frequencies. In operation, the modulated beam is directed at a target and reflected back into the instrument. The phase of the impressed modulation of the reflected beam is then compared with a reference phase, the difference being a measure of the distance. Five modulating frequencies are available, from 50 MHz to 5 kHz, in multiples of ten. The 50-MHz frequency is used for the precision range; the other frequencies remove ambiguity and provide a choice of recorder sensitivity.

Aside from their use in measuring instruments, lasers are also serving industry in many other ways. Their high intensity and ease of collimation make them ideally suited for alignment or guidance purposes. A 1000-foot tunnel in New Mexico, for example, is being drilled by a machine guided by a laser beam. A bank of photocells mounted on the machine serves as the laser's target. Any wandering off the intended course is detected by the photocells and a signal is transmitted to the operator who makes the necessary corrections.

Satellite tracking is another area in which lasers are finding useful applications. In the particular field of space rendezvous, where the atmospheric problems of attenuation, bending, and scattering are absent, the characteristics of coherent radiation have particular advantage as their extremely high frequency allows broadband communications while also permitting a small-size optical system to be used as a high-gain "antenna".

In the near future, a non-contact gage for use in steel, textile, and paper mills will no doubt be available. The machine-tool industry can expect the difficult problems of angular measurement to be by interferometric means. Chemical and other processing plants will find the laser a valuable tool in analyzing the properties of fluids, particularly where the immersion of a probe would be harmful. Interesting possibilities in data storage, information processing, and display systems are opened up through the creation of holograms. Improved fabrication of semiconductor devices will almost certainly result from more accurate photographic techniques. Medical and biological applications will increase. In fact, it is difficult to think of any industry that will not benefit from the laser. Fulfillment of its great promise has just begun. ▲

Crystal Sideband Filter

(Continued from page 47)

duce a passable characteristic curve but this will by no means be the most desirable one.

Sweep-Generator Method

The use of a sweep generator, in conjunction with a scope, is perhaps the simplest and most effective way of aligning a filter of the type described. The circuit of a simple sweep generator used by the author for alignment work is shown in Fig. 7. The arrangement works admirably and gives the builder a visual check as to the effects of the various adjustments on the filter characteristic curve. At this point it may be worthwhile to digress briefly and present a few pertinent details regarding the generator.

The sweep generator circuit is one adapted from a circuit which appeared in the May, 1965 issue of "Wireless World." The circuit parameters have been selected for a sweep voltage input of approximately 8 volts peak which is obtainable from a number of widely used measuring scopes. A sweep range of about 25 kHz is obtainable.

To set the sweep generator up, first adjust coil *L1* with the trimmer capacitor set to maximum, for oscillations at 450 kHz. A broadcast receiver can be used for listening to the second harmonic on 900 kHz. With the minimum frequency set, apply a direct voltage, equal to the peak sweep input voltage that will be used, to the sweep input connection and set the deviation control pot to give a deviation of 25 kHz. The 475-kHz signal can be checked on the broadcast receiver at its second harmonic of 950 kHz.

The low cost and few minutes required to assemble the simple i.f. sweep generator will more than compensate the builder in the time saved in aligning the sideband filter. It will also provide the experimenter with a useful piece of test equipment for receiver i.f. alignment as well, especially if a crystal filter is incorporated in the receiver that is used.

In using the sweep generator and scope to align the filter, the interim adjustments described previously can be made to establish a convenient starting point. With the sweep generator and scope connected to the filter one need only make the necessary adjustments and watch the scope. The trimmers

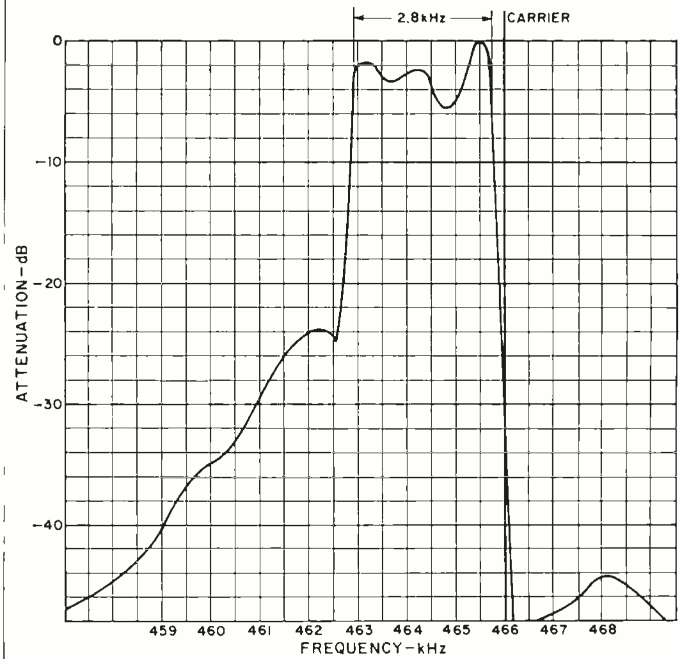


Fig. 6. The passband characteristics of the ferrite coil and crystal sideband filter are shown here after all the adjustments have been correctly made. Note the position of the carrier along the steep h.f. skirt.

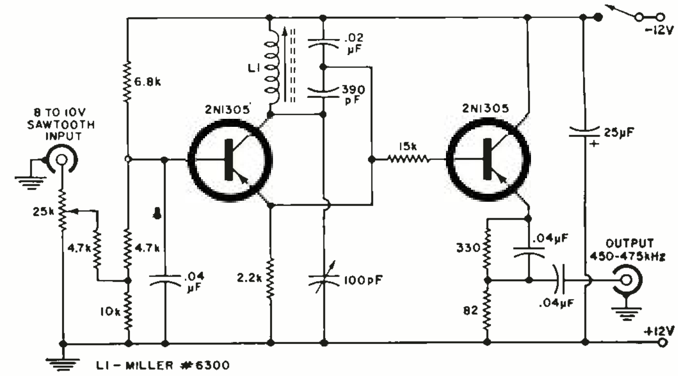


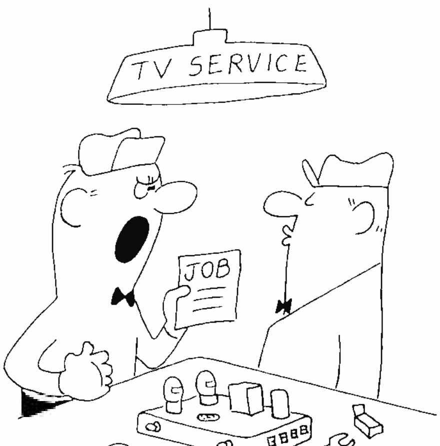
Fig. 7. Complete circuit diagram of the test sweep generator used by the author to develop the response curve of the filter.

and coils should be adjusted until a characteristic curve that is similar to the one that is illustrated in Fig. 6 is obtained.

It may be of interest to know that the trimmer adjustment of the secondary of the i.f. transformer *T1* has more effect on the filter output amplitude than on the characteristic curve. The adjustments made to i.f. transformer *T2* affect the output level of the amplifier stage only. The seven adjustments which are the most critical in shaping of the characteristic curve are the adjustments to *L1* and *L2*, the crystal trimmer capacitors, and the trimmer adjustment of the primary of the i.f. transformer *T1*. The crystal trimmers across the high-frequency crystal will have a pronounced effect on the high-frequency side slope of the filter curve and *vice versa* for the low-frequency crystal trimmers. The basic filter adjustments may require repetitive adjustment because they interlock slightly.

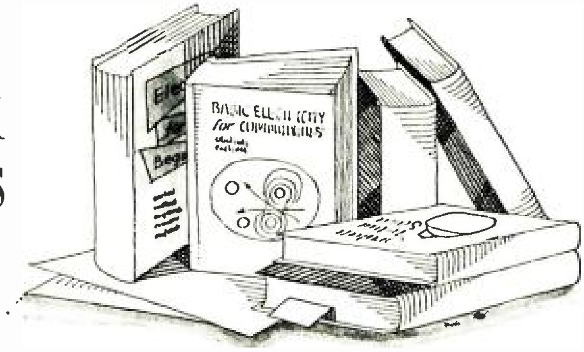
As can be noted from the filter curve, there is approximately a 6-dB sag or difference in the peaks of the filter passband. This sag causes no impairment of the voice quality, however. Needless to say, the visual display of the filter characteristic curve will also provide information relative to the amount of sideband rejection obtainable. By checking the passband one can readily determine the relative position for the carrier oscillator frequency. For the crystals used this frequency should be approximately 466 kHz.

Initial operational tests of the ferrite coil and crystal sideband filter have been made in an experimental 160-meter sideband transmitter. The results of the test have proven the effectiveness of the filter. Construction of the described filter will provide you with an excellent starting point as well as the heart of your new "home-brew" sideband transmitter. ▲



"Forget the Supreme Court ruling! Around here you have to admit when you're wrong!"

BOOK REVIEWS



"THE RADIO AMATEUR'S HANDBOOK" complied and published by the *American Radio Relay League*, Newington, Conn. 05111. 602 pages plus tube and semiconductor section and catalogue. Price $4.00 in U.S.

This is the 44th edition of the standard manual of ham radio communications, construction, and design. It covers all phases of the hobby including radio communications theory, equipment construction, communications methods, and mobile radio theory and practice.

Like the earlier Handbooks, this volume contains something for everyone—from the novice to the Old Timer. The section on vacuum-tube and semiconductor characteristics is, as always, one of the most complete and convenient sources of such data. There are 500 tube base diagrams providing a "plus" in this section.

The text itself contains over 800 illustrations including photos of equipment and components, schematics, graphs, line drawings, and tables. Because of the wealth of material gathered together in one spot, this book should be on the reference shelf of all who work in electronics and/or communications whether interested in ham operation or not.

* * *

"BASIC CARRIER TELEPHONY" by David Talley. Published by *John F. Rider Publisher, Inc.*, New York. 189 pages. Price $4.95. Soft cover.

This is a revised second edition of a handbook which originally appeared in 1960. It is addressed to engineers, technicians, and students and is written at a basic level with only occasional resort to mathematics. This revision reflects the many state-of-the-art advances which have taken place in the past six years and covers the telephone system, telephone carrier definitions, wire transmission principles, transmission practices, carrier system fundamentals, modulation and demodulation, electrical filters, carrier system operations, transmission and signaling features, cable carrier systems, carrier applications in radio systems, and PCM carrier systems.

The text is lavishly illustrated and since questions and problems are appended to each chapter, the book can be used as a classroom text or for home study by those who wish to upgrade themselves in their chosen field.

* * *

"ELECTRICITY" edited by Harry Mileaf. Published by *Hayden Book Company, Inc.*, New York. Available in 7 paper-bound volumes @ $16.95 or single cloth-bound volume @ $12.76.

This "course" has been prepared especially for technical and vocational schools and provides a comprehensive grounding in the fundamentals of electricity. Students are required to have little more background than a smattering of math since the presentation is progressive and the student picks up the requisite skills as he goes along.

Volume I covers producing electricity, atomic theory, electrical charges, electron theory, current, voltage, magnetism, and electromagnetism. The course then proceeds to coverage of d.c. circuits, a.c. circuits, *LCR* circuits, test equipment, power sources, and electric motors.

Each volume is elaborately illustrated by two-color diagrams showing the circuit function or the operation under discussion. There are review questions for each chapter and a summary of the material discussed, making these volumes suitable for both classroom and home-study applications.

* * *

"ELECTRONICS" edited by Harry Mileaf. Published by *Hayden Book Company, Inc.*, New York. Available in 7 paper-bound volumes @ $20.95 or single cloth-bound volume @ $14.96.

These volumes (or volume) are designed to provide the student with a basic understanding of electronics, its circuitry and components. Volume 1 treats electronics signals, Volume 2 electronic building blocks, Volume 3 electron tubes, Volume 4 semiconductor devices, Volume 5 power supplies and amplifiers, Volume 6 oscillators, modulators, demodulators, and discriminators, and Volume 7 auxiliary circuits and antennas.

In order to provide the clearest exposition possible, the editors have used two-color diagrams and pictorials with a lavish hand. Because of this feature and the clear-cut technical explanations, this book is entirely suited for those who wish to study the subject on their own as well as for students enrolled in technical or vocational school courses in electronics.

Although anyone with pretentions to a high-level career in electronics will need advanced math, this introductory course has virtually eliminated mathematical treatment so as not to alienate students at the very start. The explanations of circuits and principles which take the place of the formulas usually encountered in textbooks are excellent and most students won't regret the omission of math.

* * *

"INTERPRETING FCC BROADCAST RULES & REGULATIONS" edited by Verne M. Ray. Published by *TAB Books*, Thurmont, Maryland 21788. 152 pages. Price $5.95. Soft cover.

This book represents a compilation of material which originally appeared in "BM/E" magazine as articles addressed to broadcast station executives, legal and engineering consultants, and others concerned with station management and operation.

By presenting the information in compact, easy-to-find form, the editor has performed a service to the broadcasting industry by condensing and extracting pertinent information from the often voluminous FCC Rules & Regulations.

* * *

"DICTIONARY OF ELECTROTECHNOLOGY" compiled by Eduard Hohn. Published by *Barnes & Noble, Inc.*, New York. 705 pages. Price $22.50.

This German/English technical dictionary includes atomic energy, automatic control, etc. terminology in addition to those words usually associated with electronics. In addition, commercial, financial, and legal terminology as it applies to the electronics field has been included.

Although the compiler insists that the dictionary can be used by those "without full command of the German language", the fact that the listings are given according to the German word and that there is no parallel English/German section may possibly be over optimistic since it would depend on what "full command" of the language means to the various users. Where American and British usage differ, the compiler has indicated (A) or (B) in the translations.

* * *

"TV TROUBLESHOOTER'S HANDBOOK" by the Editors of "Electronic Technician". Published by *TAB Books*, Thurmont, Maryland 21788. 189 pages. Price $6.95.

This is a compilation of various service hints, circuit descriptions, production changes, and field service notes for a number of black-and-white and color receivers as originally published in "Electronic Technician" magazine. ▲

Now—it's easy to make recordings of children

WITH POPULAR PHOTOGRAPHY'S UNIQUE NEW RECORD ALBUM

"TONY SCHWARTZ ON HOW TO RECORD—THE SOUND OF CHILDREN"

To instruct you in the techniques of recording children's voices, the editors of Popular Photography asked famed sound authority Tony Schwartz to prepare this special record, available exclusively and by mail only through Popular Photography magazine and other Ziff-Davis publications. By listening to it you can quickly acquire the skills needed to make top-quality recordings of youngsters—thus preserving permanently the sound of their voices.

YOUR TEACHER: AN EXPERT'S EXPERT

You couldn't have a better instructor than Tony Schwartz. A pioneer in the use of portable tape recorders, he has been capturing the sounds of actuality for 23 years. You've read his monthly column in Popular Photography. Now **hear** him explain and illustrate in provocative recorded demonstrations the working methods that have helped him to become the world's No. 1 sound collector.

SIMPLE, COMPLETE INSTRUCTIONS

HEAR ACTUAL DEMONSTRATIONS OF

- A tape recording before and after editing.
- The sound of a battery-operated recorder at three tape speeds: 1⅞, 3¾, and 7½ inches per second.
- The improvement in fidelity when a quality microphone replaces the mike supplied as a recorder's standard equipment.
- How to reduce unwanted noise while recording.
- Acoustics: the sound of sound in the living room, kitchen, hallway, and street.
- Improving sound quality by re-recording a tape.

In addition to the tips on selecting and using equipment, you learn how to create complete sound stories with children—even recreate a situation that has already taken place! Actual sound demonstrations enable you to hear the effects of various tape speeds, microphones, and acoustical conditions. You also learn how to eliminate unwanted noise and to improve your tapes by re-recording them. In less than one hour, you get the benefit of years of experience and recording know-how!

EXTRA!

You'll be intrigued and thoroughly entertained by Side II of this superb new album. It's devoted entirely to three of Tony Schwartz's most famous sound essays, all acclaimed as "works of great artistry that will surely be enjoyed by anyone who enjoys and appreciates the sounds of children."

"CHILDREN AND GOD"—a fascinating composite of thoughts expressed by youngsters of various religious faiths. Their naively reverent concepts of God, heaven, good and bad, and prayer will be a revelation to you. This unique presentation is unlike anything you have ever heard before!

"NANCY GROWS UP"—a remarkable sound portrait of a girl's developing personality. In just two minutes, you hear her voice from 20 minutes after her birth, through the years until she's 13—when she reveals: "I've discovered boys!"

"SOUND SNAPSHOTS"—a potpourri of chuckles . . . once-in-a-lifetime sayings that could come only from the mouths of babes. These uproarious remarks, all said in the innocence of childhood, include delightfully ingenuous observations like these:

"I'm so hot I'd like to take my skin off!"

"I had growing pains yesterday."

"You go up in heaven when you die. You don't have to pay taxes, or anything—I'm positive."

A high-fidelity 12-inch, 33⅓ RPM long-playing vinyl album manufactured by the Custom Services Division of Capitol Records.

. . . plus many more that will make you howl with laughter! You and your friends will enjoy listening to all of these entertaining essays in sound again and again.

Free INSTRUCTION BOOKLET WITH EACH RECORD ALBUM

Packed with valuable facts, it contains scores of helpful tips you can use to make better, more interesting recordings—information that supplements the instructions in the record. And it's yours if you place your order now for "Tony Schwartz on How To Record—The Sound Of Children."

Get the most out of your recording equipment by discovering the easy way to make tapes that you'll always treasure. This instructive and entertaining album should be owned by everyone within the sound of a child's voice and laughter. The special low price is:

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Please send ________ "Sound of Children" albums at $4.98 each, postpaid.

My check (or money order) for $________ is enclosed.

(Outside U.S.A. please send $7.00 per record ordered.)
N.Y. State residents please add local sales tax.

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EW Lab Tested

(*Continued from page* 16)

numbers of listeners whose spacial or financial resources were limited.

Despite their relative compactness, most "bookshelf" speakers were too large and heavy for mounting on real bookshelves. Over the years, many manufacturers have attacked the problem of creating a small, light, and inexpensive speaker system with wide-range, low-distortion response. There have been a few successful designs, and many more which are best forgotten.

The new *Jensen* X-40 and X-45 speaker systems are recent additions to what might be called *true* bookshelf systems—and they deliver a caliber of sound which belies their size and price. Their oiled walnut enclosures measure 10½" x 19½" x 9" or slightly over one cubic foot, and their weight of about 20 pounds will not overtax any shelf capable of supporting books. The X-40 and X-45 are identical except for their high-frequency drivers.

Frequencies from 30 to 2000 Hz are radiated by an 8-inch long-travel cone woofer with a resonant frequency of 35 Hz. Above 2000 Hz, the X-40 has a 3-inch direct-radiator speaker, while the X-45 uses a horn-loaded compression-type driver. Both systems are rated at 8 ohms, with a power handling capacity of 25 watts and a useful frequency range of 30 to 16,000 Hz. On the rear of the enclosure is a level adjustment for the high-frequency speaker.

We tested the X-40 and X-45 under identical conditions, simulating bookshelf mounting. The microphone response at eight points in the room were averaged to obtain a composite response curve. Although the two speakers have identical woofers, we found the X-40 to have somewhat more response below 100 Hz. Ignoring the small peaks at 40 and 60 Hz, which are properties of the test room, both speakers have an over-all response of ±5 dB from 30 to over 13,000 Hz, and are down only slightly at 15,000 Hz, which is the upper limit of our mike's calibration.

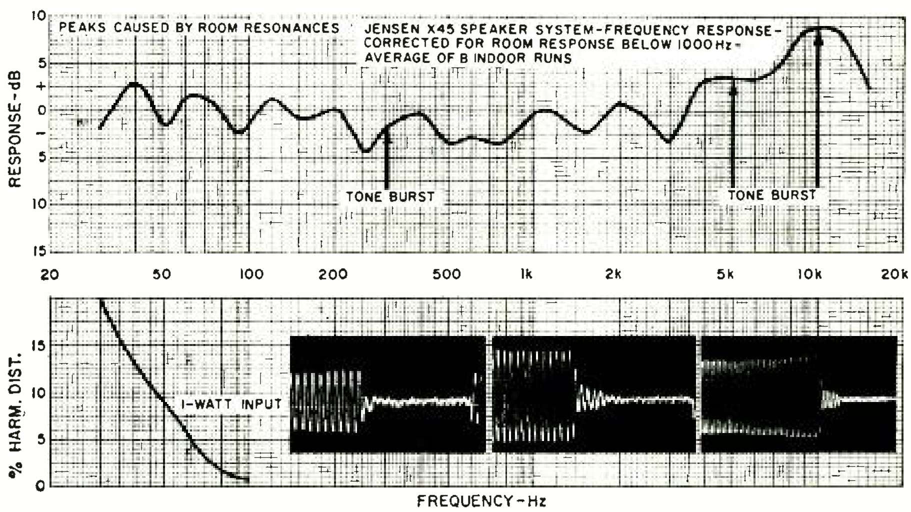
The X-40 has its most uniform response with the tweeter level at maximum, while the more efficient high-frequency speaker of the X-45 shows a rise of about 8 dB at 10,000 Hz under these conditions. Both speakers had low distortion at low frequencies. The X-40 had about half as much distortion below 60 Hz as the X-45, which is probably due to normal production tolerances. It also had somewhat less efficiency than the X-45.

Both speakers have excellent tone-burst response over their entire frequency range. Over-all, we would rate their transient response as good as that of any dynamic speaker we have tested, including some costing several times the price of the *Jensen* speakers. At no time did we find any evidence of prolonged ringing, breakup, or spurious outputs.

In listening tests, we found that the X-40 sounded most pleasing with maximum tweeter level, which corresponds to the flattest measured response. It was necessary to turn down the tweeter level of the more efficient X-45 horn driver considerably to match the sound of the X-40, after which they were indistinguishable from each other. The cone radiator of the X-40, however, has a distinctly better high-frequency dispersion than the X-45's horn, with virtually no audible beaming of highs.

Both speakers have an effortless, natural sound which one rarely finds in speakers of much greater size and price. Although their bass output does not match that of some larger and costlier systems, the listener is never aware he is listening to a one-cubic-foot enclosure. Either speaker can radiate a solid, relatively undistorted 30-Hz fundamental.

The *Jensen* X-40 sells for $57 and the X-45 for $63. Anyone who doubts that speakers in that price and size bracket can produce true high-fidelity sound owes it to himself to hear one of these speakers and be convinced. ▲



NEW PRODUCTS & 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, fill in coupon on the Reader Service Card.

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

DUAL-PURPOSE PENCIL IRON

The dual-purpose pencil soldering iron being marketed as the "Uniline Mark VII" consists of three basic components: a combined handle with a three-conductor flexible cord set, NEMA plug, and pneumatic section; a long-life heat cartridge (available in 20, 30, 40, and 50 watt

sizes); and a ruggedized tip (in 33 configurations in six styles of 0.062 o.d. x 0.023 i.d. tip) specifically designed for matrix soldering and micromodule assembly. Also included are eight styles of the 0.125 o.d. x 0.035 i.d. tips as well as seven variations of the 0.187 o.d. x 0.055 i.d. All of the tips are available in chisel, point, spade, pyramid, flat-faced, and general-purpose shapes.

The unit comes with a white porcelain "Brazier Consolette" which incorporates two waste solder depositories which also serve the purpose of keeping the iron tip tinned.

Since all components in the iron are interchangeable, users can select and combine features as required for a specific soldering job. Details on the full line and the various components will be supplied on request. Vanguard

Circle No. 1 on Reader Service Card

PLASTIC-PACKAGED IC'S

Two new integrated circuits, designed for use in telemetry, data-processing, instrumentation, and communications equipment, have just been introduced as the CA3029 and CA3030.

These monolithic silicon operational amplifiers are housed in a 14-lead dual in-line plastic package, permitting simpler insertion, higher packaging densities, and reduced cost. They offer open-loop voltage gains of 60 dB and 70 dB typical, common-mode rejection ratios of 94 dB and 103 dB typical, and have maximum output-voltage swings of 6.75 volts peak-to-peak and 14 volts peak-to-peak typical. RCA Electronic Components

Circle No. 126 on Reader Service Card

CURRENT-LIMITER DIODES

A series of nine current-limiter field-effect diodes for constant current biasing of transistors, FET's, differential amplifiers, and zener reference diodes has just been announced. These new units are useful in place of the logic pull-up resistor for high-speed switching, as a high-impedance load with low supply voltage, and as a current-limiting protecting device. Other applications include linear time-base circuits and d.c. current supplies.

The CL2010 series offers standard EIA current values from 220 μA to 4.7 mA. The first three digits of the number indicate rated current in microamperes while the fourth digit indicates tolerance; e.g., CL1520 is a 1500-μA, 20%-tolerance diode. The units are housed in a miniaturized plastic package. Siliconix

Circle No. 127 on Reader Service Card

VIBRATING MEMBRANE CAPACITOR

The Type XL7900 vibrating membrane capacitor is designed as a transducer for extra-sensitive current measurements. When employed in an electrometer, the XL7900 has measured currents as weak as 500 electrons per second (8×10^{-17} ampere). The unit can be used in such instruments as dosimeters, gas chromatography current detectors, picoammeters, pH meters, and transducer monitors.

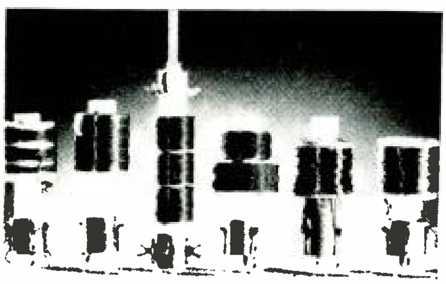
Driven by a high-frequency electric field and housed in an evacuated glass envelope, the new sensor offers input impedance greater than 10^{15} ohms and temperature dependence of only 15 μV/°C. The high-frequency, electric-field drive effectively isolates the drive frequency from the signal output and greatly simplifies design of the drive oscillator, according to the company. Amperex

Circle No. 128 on Reader Service Card

COLOR-TV SWEEP-CIRCUIT COILS

Exact replacement sweep-circuit coils for the color-TV sets produced by more than 25 manufacturers are now available.

The focus, convergence, and sweep-circuit coils are directly interchangeable with original coils in sets manufactured by such firms as



RCA, Philco, Westinghouse, Motorola, and Muntz. Full details on the entire line will be supplied on request. J.W. Miller

Circle No. 2 on Reader Service Card

MINIATURE COMPONENTS

Two new miniature electronic components, the Model 4211 microtransformer and the Model 4221 microinductor have just been introduced, both designed for welded module and hybrid circuit applications.

The new models measure only 1/8" x 1/8" x 1/8" and weigh a maximum of 0.15 gram. Frequency range is 2000 to 500,000 Hz while the operating temperature range is $-55°C$ to $+105°C$. Both models meet or exceed environmental requirements of MIL-T-27, grade 5.

The microtransformer has a primary and secondary impedance range of 10 to 10,000 ohms while the inductance range of the Model 4221 is from 0.1 to 3.5 henry at 1 kHz, 0.1 volt r.m.s. Bourns Trimpot

Circle No. 129 on Reader Service Card

TRANSISTOR TRANSFORMERS

A new series of ultraminiature transistor transformers is now on the market and available for immediate delivery. The DO-T200 series features straight pin terminals, making them suitable for printed-circuit applications. They are metal encased and ruggedized. Maximum diameter is 0.350" and maximum height is 9/16". The mounting base has a key-bearing moisture-barrier offset of 0.035". Leads are 7/8" long and of 0.016" Dumet wire, gold plated. The leads are weldable or solderable.

Units in the series have primary impedances from 1000 to 200,000 ohms, d.c. in the primary from 0 to 3 mA, secondary impedances of 50 to 12,000 ohms, and operating levels of 25 to 100 milliwatts. Details on the full line are available on request. UTC

Circle No. 130 on Reader Service Card

PUSH-BUTTONS FOR COMPUTERS

The 913 series of momentary contact push-button switches has been designed for use in dry circuits or with low currents at higher voltages. The switches mount in a 3/8" clearance hole on 19/32" centers. Available for s.p.s.t. double-break, normally open or normally closed; s.p.d.t., double-break, two-circuit (one n.o., one n.c.) operation, this series can be obtained illuminated or non-illuminated. Lighted switches use permanently mounted T-2 neon lamps with or without the necessary current-limiting resistor.

Switch ratings are 0.1 amp, 125 V a.c.; 0.1 amp, 30 V d.c. (non-inductive); operating force is 10 ounces (approximately) and button travel is 5/64". Life rating is 1,000,000 operations. Dialight

Circle No. 131 on Reader Service Card

NICKEL-CADMIUM BATTERIES

A new line of sealed, rechargeable nickel-cadmium batteries and power packs has just been announced. The batteries, available in a variety of sizes, shapes, and capacities, will be built to customers' specifications to provide high cell-to-cell uniformity.

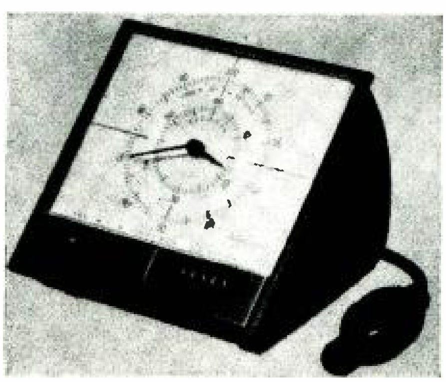
Applications of these new power sources include aircraft emergency power, military and industrial instruments and systems, telecommunications equipment, and cordless power tools and appliances. Texas Instruments

Circle No. 132 on Reader Service Card

LABORATORY STOP CLOCKS

Two new compact, portable laboratory stop clocks specifically designed for maximum versatility have been introduced as the K15140 and the K15150.

The K15140 is calibrated in seconds and hundreds, with a totalizer scale of 0-60 seconds



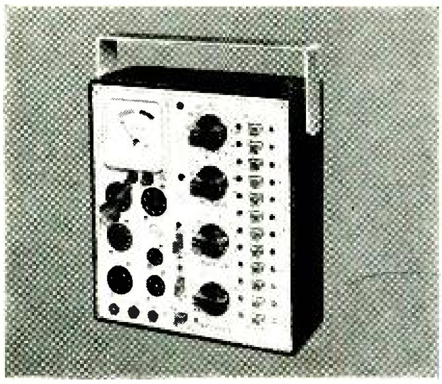
and a sweep scale of 0-1 second. Accuracy is ±20 ms per operation. The K15150 is calibrated in minutes and hundredths. The totalizer scale registers 0-60 minutes and the sweep scale 0-1 minute. Accuracy is ±0.005 minute per operation.

The instruments can be started, stopped, or reset by the front-panel-mounted 3-position rocker switch or by a six-foot remote-control cable. A 3-ampere, timed convenience outlet permits outside circuits to be controlled and timed simultaneously. Electrical requirements are 115 volts a.c., 60 Hz nominal. Both clocks can be furnished for bench use or with hardware for panel mounting. A.W. Haydon

Circle No. 133 on Reader Service Card

PORTABLE TUBE TESTER

The Model 636 tube tester is designed for the quick-testing of 800 types of radio-TV vacuum tubes, load-testing of commonly used



batteries, and the "go/no-go" testing of continuity.

The Model 636, which comes completely wired, features transformer isolation, a three-color meter, and a neon-lamp indicator. It is housed in a Bakelite case with carrying handle, measures 8⅝" h. x 7½" w. x 3⅛" d., and weighs 4 pounds. It is designed for 117-V a.c., 60-Hz operation. Eico

Circle No. 3 on Reader Service Card

PROFESSIONAL PLIER SET

A three-piece matched set of professional, precision pliers designed especially for all phases of electronics work is now available as No. 23091. The set includes a diagonal cutting plier, a chain nose plier, and a flat nose plier. Each tool is 4½ inches long and has vinyl cushion-grip handles. It is forged from fine-grain tool steel, individually fitted, tempered, adjusted, and tested. Kraeuter Tools

Circle No. 4 on Reader Service Card

PLASTIC-PACKAGED SCR'S

A new series of low-cost, plastic-encapsulated SCR's has just been introduced as the types 2N4441 through 2N4444. The new devices can control high electric power (e.g., 2600 watts, 240 volts, full wave). Typically 10 mA d.c. gate current is required to cause switching from the "off" stage to the "on" stage.

These new "Thermopad" SCR's have a rated blocking voltage range from 50 to 600 volts and are designed for consumer products requiring reliable phase control. Typical examples of such applications are motor speed, temperature and light controls for household appliances, and for portable power tools. They are also expected to find use in ignition systems, voltage regulator and starting systems for cars, outboard motors, chain saws, etc. and for automated machinery such as vending machines.

Complete technical specifications on this new series are available on request. Motorola

Circle No. 134 on Reader Service Card

ULTRA-COMPACT POWER SUPPLY

The new "Micropak II" ultra-compact power supply is being offered in three basic models, 200, 250, and 400.

Featuring greatly reduced size, the line offers a wide range of voltage and power output ratings. The Model 400 consists of four switching-type regulator supply models which operate from 3 to 30 volts d.c. at power ratings up to 120 watts. Model 400 consists of three dual-output models available at only a slight increase in price over single-output units. Output voltages for the three models in this series range from 3 to 40 volts d.c. at a maximum of 2 amperes per output with total output ratings of 35, 70, and 100 watts. Model 250 has been designed for a single voltage, low-power output requirements and consists of one model. Typically it has a 3 to 30 volt d.c. output range and maximum power output of 24 watts. Litton Industries

Circle No. 135 on Reader Service Card

PROFESSIONAL VTR

A new one-inch, helical-scan professional video tape recorder specifically designed for educational and business training has been introduced as the Model 2-30.

The new unit features slow motion and stop action, tape interchangeability, and two separate audio channels to allow delayed sound dubbing. It can be operated in either horizontal or vertical position. It will record and play back any TV signal with a 60-Hz field frequency at a tape speed of 7.8 inches per second in the normal record/playback mode. This provides 63 minutes of continuous recording on a single 8-inch reel of one-inch tape.

The recorder weighs 88 pounds, measures 26" x 18" and is equipped with a detachable lid and handle for portability. It comes with a power cord, reel of tape, pickup reel, a use and care kit, carrying bag, and a user manual. General Electric

Circle No. 136 on Reader Service Card

SUBMINIATURE TOGGLE SWITCH

The new Model 7213 subminiature d.p.d.t. toggle switch offers a minimum electric life of 40,000 make-break cycles, terminals and contacts of solid coin silver, and a capacity of 5 amperes at 115 volts a.c. The switch incorporates a threaded ¼" bushing for fast and easy mounting. The case is of general-purpose phenolic and the operating lever is the standard bat handle. Colored plastic caps will be supplied on request at no additional charge. C&K Components

Circle No. 137 on Reader Service Card

SOLID-STATE INDUSTRIAL VTR

The new Panasonic NV-204 solid-state industrial video tape recorder features five motors,

records on one-inch tape, provides for complete interchangeability of tape with any other NV-204, and offers 67 minutes of recording time.

A slow motion feature permits reduction of tape speed to two frames per second in addition to "stop frame", forward, or reverse. A special "pause" lever permits instant "stop action". Picture resolution is 350 lines, the recorder is color compatible, and fast forward or rewind can be accomplished in 2¾ minutes. Matsushita

Circle No. 138 on Reader Service Card

NICKEL-CADMIUM BATTERY CHARGERS

Twenty-four models are included in the new Series C battery charger line to handle virtually all requirements for recharging nickel-cadmium cells.

Designed for the OEM market, the units operate from an input of 117 volts, 60 Hz with a single output for charging batteries having nominal voltages of 1.2, 2.4, 3.6, 4.8, 6.0, 12.0, 24.0, or 36 volts. Units of 1.2, 2.3, and 4.0 ampere-hour ratings are available for each of the 8 output voltages.

Each unit charges at its rated current into a fully discharged battery, tapering to a safe charge rate when the battery is fully charged. The Series C units are potted in a cylindrical enameled steel cup with bottom mount inserts and 12" leads for both the input and output circuits. Specifications and price data are available on request. Berkleonics

Circle No. 139 on Reader Service Card

REPLACEMENT COLOR-TV RECTIFIERS

A full line of "direct replacement" rectifiers for color-TV receivers is now available in individual packages. Eleven different rectifiers are included in the line. Silicon units are the CTV-650 focus rectifier, 80C and F8 voltage boost rectifiers, and 60C and F6 "B+" rectifiers. Also included are the S-880 selenium focus rectifier, the S-879 selenium voltage boost rectifier, and four selenium convergence rectifiers—S-855, S-420, S-798, and S-781. A complete listing of the units in the line, along with replacement information, will be supplied on request. Sarkes Tarzian

Circle No. 5 on Reader Service Card

HI-FI—AUDIO PRODUCTS

A.F. POWER AMP IC'S

A multi-purpose a.f. power amplifier which combines the functions of preamp, phase inverter, driver and power output on a single monolithic silicon chip has just been introduced as the CA3020.

Designed especially for use in portable or fixed audio communications systems, the circuit is designed to operate from a single power supply between +3 and +9 volts—the power output capability being a direct function of the supply voltage used. At a supply voltage of +9 volts, the CA3020 delivers a typical power output of over a half watt with an idling current of 22 mA; at +3 volts, it delivers 65 mW with an idling current of 7 mA.

The CA3020 is mounted in a 12-lead TO-5 package and will operate over the temperature range of −55°C to +125°C. RCA Electronic Components

Circle No. 140 on Reader Service Card

"THEATER ORGAN" IN KIT FORM

A do-it-yourself kit version of the professional Thomas horseshoe theater organ is now available as the Model TO-67.

The organ features 15 manual voices and 4 pedal voices which can be selected by simply flipping the multi-color stop tablets. The kit also incorporates "Color-Glo" key lights to make it easy for beginners to play complete songs immediately. There are two separate speaker systems and two separate solid-state amplifiers capable of providing 200 watts of peak power.

There are two 44-note keyboards, 28 notes

of electronic chimes, selective repeat percussion to produce xylophone, mandolin, marimba, and other special-effect sounds; 13-note bass pedals, selected attack percussion, manual balance control, and a hardwood cabinet and bench. Assembly time is estimated to be between 80 and 100 hours. Heath

Circle No. 6 on Reader Service Card

MUSICAL INSTRUMENT SPEAKERS

Two new musical instrument loudspeakers have just been introduced as the 417A and 418A.

The 12-inch 417A and the 15-inch 418A will each handle 100 watts of music power. Both speakers feature 3-inch voice coils made of edgewound aluminum ribbon and a rugged diaphragm with a lightweight aluminum dome. A heavy-cast aluminum frame is used and the massive magnet structure houses an Alnico V magnet. Altec Lansing

Circle No. 7 on Reader Service Card

CARTRIDGE TAPE PLAYERS

A new line of stereo cartridge tape players for cars including a four-track player, a compact eight-track player, and a combination stereo tape player/FM radio will soon be on the market. Later in the year the firm expects to offer a furniture model cartridge tape player for home use.

Details and complete specifications on this new line will be provided by the manufacturer. Tenna Corporation

Circle No. 8 on Reader Service Card

CAR-DOOR SPEAKER

A large magnet and a thin profile are the special features of the new C5FC speaker designed for upgrading automotive stereo installations. Although this 5" round speaker has a 5.5 ounce, barium-ferrite magnet, total depth is less than 2 inches.

The speaker will handle 10 watts of program material. A moisture-resistant cone prolongs speaker life. Impedance is 8 ohms. Utah

Circle No. 9 on Reader Service Card

FOUR NEW AMPLIFIERS

A new series of audio amplifiers in 10, 20, 35, and 75 watt models has recently been added to the "Carillon" line.

Featuring operational flexibility in all models, these amplifiers offer optional plug-in transformers to change microphone channels from high to balanced-low impedance and the program channel from high impedance to balanced

600-ohm line for receiving wired background music.

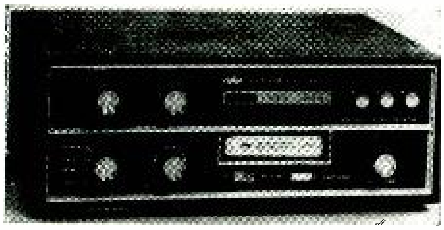
A continuous audio-taper gain control provides precise level adjustment of input channels while a master gain with separate full bass and treble controls permits simultaneous adjustment of all input signals in the 35 and 75 watt models. All units have 4, 8, or 16 ohm outputs and a 70-V line, with the addition of a 25-V line on the 35 and 75 watt models. Bell P/A Products

Circle No. 10 on Reader Service Card

8-TRACK CARTRIDGE PLAYERS

Two new 8-track stereo tape-cartridge players have just been introduced as the "Apollo" (HP895) and the "Satellite" (CD885). The former is a self-contained system while the latter is a playback deck.

Both models feature fast-forward selectivity which incorporates a silence-sensing device that automatically locates the beginning of the next selection, an "Eject-A-Matic" feature which automatically pushes the cartridge away from the tape playing heads when the machine is shut-off, vertical tracking which virtually elim-



inates crosstalk, and automatic "off" and "replay" buttons providing a choice of continuous play or automatic shut-off after the last selection has been played. Capitol Records

Circle No. 11 on Reader Service Card

VOICE-ACTUATED MICROPHONE

A voice-actuated microphone, designed for use with a battery-operated transistorized tape recorder equipped with a jack for remote mike control, is now available as the No. 99-4604.

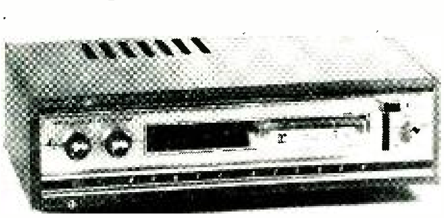
An electronically controlled relay in the mike automatically starts the recorder when sound is picked up and automatically stops the recorder when the sound stops. The unit is equipped with a 3-position switch for "voice-control/off/remote" functions. In "voice-control" position the six-transistor circuitry operates the amplifier and electronic relay in the mike. In the "remote" position, the microphone operates as a dynamic mike with remote "on-off" switching. There is an additional control for adjusting sensitivity of the microphone above the ambient noise levels.

The mike comes complete with cord, plugs, and instructions. It requires a 9-volt battery for operation. Lafayette

Circle No. 12 on Reader Service Card

HOME CARTRIDGE TAPE SYSTEM

The Model HW-12 is a cartridge stereo tape system designed for use in the home. The new



unit will play both 4-track and 8-track stereo cartridges and will accommodate all cartridge sizes from single "Mini-Paks" to full-size quads, the latter featuring up to 2½ hours of stereo entertainment.

The system is housed in a walnut finished enclosure with optional matching walnut speaker enclosures. The enclosurers have a low silhouette and are designed to accommodate twin 3" x 5" full-range speakers. Muntz Stereo-Pak

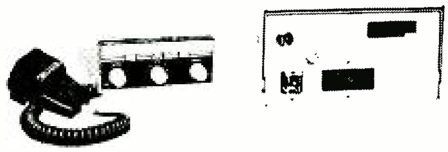
Circle No. 13 on Reader Service Card

CB-HAM-COMMUNICATIONS

FM MOBILE RADIO

A compact, 120-watt FM two-way radio which can be operated on from one to six channels in the 148-174 MHz band has just been introduced as the Model DT76.

Battery drain is extremely low and the radio



employs solid-state circuitry throughout except in the final r.f. power amplifier stage of the transmitter in which an instant-heat tube is used.

Automatic frequency control in the receiver locks it to the incoming signal, minimizing clipping distortion and electrical noise interference. A current-saver circuit limits standby current from a 12-volt battery system to only 0.11 ampere. Transmission at full power is achieved in a fraction of a second.

The transmitter r.f. output is 120 watts between 148 and 162 MHz and 110 watts between 162 and 174 MHz. Spurious emissions are down more than −85 dB and distortion is less than 4%, according to the company.

The transmitter-receiver unit is designed for trunk mounting and is only 15" long x 9⅛" wide x 4½" high. Weight is 15 pounds. The remote-control unit is provided with volume, channel selection, and squelch controls. Kaar

Circle No. 141 on Reader Service Card

OVERLAY TRANSISTOR FOR MARINE RADIO

A new high-power r.f. amplifier for use in marine communications equipment operating in the 2 to 3 MHz frequency band has been introduced as the 40444.

This new 20-watt overlay transistor, operating from a 13-volt power supply, is primarily intended for marine communications equipment as a class B and C r.f. amplifier for use in medium-frequency service with amplitude modulation.

The 40444 exhibits a typical gain-bandwidth product of 100 MHz at 3 amperes and produces an output of 20 watts minimum with a 1-watt r.f. power input at 2.5 MHz. It is an epitaxial silicon "n-p-n" transistor with the overlay emitter electrode construction and is packaged in a JEDEC-type TO-3 case.

Full technical data and operating parameters will be supplied upon request. RCA Electronic Components

Circle No. 142 on Reader Service Card

SPLIT-CHANNEL RADIOS

Announcement has been made of the availability of new 450-470 MHz radio equipment which meets the split-channel requirements recently announced by the FCC. These new rulings, built around 25-kHz channel spacing rather than 50-kHz spacing, will make operational changes necessary for present owners of u.h.f. radio equipment and will eventually make additional channels available for more users. Use of full split-channel equipment is authorized by November of this year and mandatory by November 1, 1971.

Model prices and installation cost data on the firm's line of radio equipment meeting these new specifications will be forwarded on request. Motorola Communications

Circle No. 143 on Reader Service Card

SOLID-STATE CB RIG

A new 23-channel, solid-state CB rig has just been introduced as the TR-23S. The new unit features transmitter silicon transistors manufactured to a higher peak voltage than previous-

ly available, plus new zener diode protection. The unit measures 5¾" w. x 6¼" d. x 1⅞" h. It comes complete with microphone, illuminated "S" meter, illuminated channel selector, and d.c. cord. Crystals are supplied for all 23 channels. Courier

Circle No. 14 on Reader Service Card

COAXIAL SWITCH FOR HAM/CB

A new single-pole, two-position coaxial switch designed for either ham or CB applications is now available as the Model 2 P. The switch has a current-carrying capacity of 9 amperes and a power-carrying capacity of 1000 watts. It may be inserted into the system without measurable insertion loss or impedance problems, according to the manufacturer.

The switch can be installed in line and is designed for panel mounting, if desired. The average initial contact resistance on the switch is 5 milliohms. It has a power rating of 1 kW AM or 2 kW p.e.p. for SSB. Clips and rotor contacts are silver-plated brass and the switch is insulated with electrical-grade laminated phenolic which provides protection against voltage breakdown of critical parts to 1000 volts r.m.s. Gold Line Connector

Circle No. 15 on Reader Service Card

COMMUNICATIONS RECEIVER

The SB-301 ham-band communications receiver is an improved version of the firm's SB-300 kit receiver. It offers increased sensitivity, full RTTY provisions with an RTTY position on the mode switch, 15 to 15.5 MHz coverage for WWV reception, built-in switch-

selected automatic noise limiter, and front-panel switching for control of the optional 6- and 2-meter converters.

The receiver provides 80 through 10 meter ham-band coverage for receiving AM, c.w., upper and lower sideband SSB, and RTTY. It has a crystal-controlled front-end and a pre-assembled and calibrated linear master oscillator for linear tuning and maximum stability. It is capable of transceiver operation when used as a companion to the SB-401 transmitter. There is a matching speaker kit. SB-600, available for use with the receiver. Heath

Circle No. 16 on Reader Service Card

CB TRANSCEIVER FOR MARINE USE

The new "Ranger" transceiver has been especially designed to provide CB communications between boats or between a boat and shore.

The 11-channel, all-transistor model features heavy welded steel chassis, spray-coated for protection from moisture and salt elements, and a splash-proof speaker. The circuit board is constructed of epoxy glass for long life while the circuitry includes a Collins mechanical filter for maximum selectivity. A TO-3 power transistor provides 100% duty-cycle capability.

The operator can use plug-in type crystals for any 11 of the 23 CB channels. For mobile operation, 12 volts d.c. is required or the unit may be operated as a base station with the optional 120-volt, 60-Hz power supply. There is provision for an external speaker or hailer facility.

The transceiver measures 2⅞" x 6⅜" x $7\frac{13}{16}$". Regency

Circle No. 17 on Reader Service Card

PRIVATE TONE CALLER

The "Priva-Com III" transistorized private tone caller features ceramic and resonant tuning fork circuitry instead of conventional reed relays. It is designed to be used with 12-volt solid-state CB transceivers. It features 9-transistor, 2-diode circuitry with simple-to-operate

push button switches for standby, normal, call, and reset. There is a volume control and indicator light.

The unit, which measures $1\frac{7}{16}$" h. x 4" w. x 5¾" d. is supplied with a mounting bracket, two plug-in tuning fork filters, and connecting cable with plug for the firm's HB-500A, HB-555, HB-525A, HB-600, and HE-20T CB transceivers. A model for use with tube-type transceivers is also available. Lafayette

Circle No. 18 on Reader Service Card

CB TRANSCEIVER/P.A. SYSTEM

A new five-watt, solid-state CB transceiver/p.a. system with the accent on mobile operating convenience and safety has been introduced as the Model CB-21.

The new unit contains a 17-transistor, 8-channel transceiver with a dual-conversion receiver. Features which provide increased convenience and safety include concentric volume and squelch controls, illuminated channel selector, and an easily operated rocker switch which converts the CB-21 into a p.a. system with 4 watts of low-distortion audio output.

The CB-21 measures $2\frac{3}{16}$" high x 6" wide x 8" deep and weighs approximately 5½ pounds. It comes complete with channel-11 crystals for transmit and receive. An optional power supply for 110-125 volt a.c. operation is available. Hallicrafters

Circle No. 19 on Reader Service Card

SHORT-WAVE PORTABLE

The new "Globepacer" short-wave portable receiver is all-solid-state and features coverage of 11 bands, including AM and FM broadcast bands as well as long-wave and short-wave services.

The receiver has a horizontal slide-rule dial with rotating cylindrical dial scale for precise and accurate tuning. It features tone control and a.f.c. to eliminate drift on FM. A large ferrite bar antenna is used for the long- and

medium-wave bands while a multi-section whip is provided for short-wave and FM reception. The two-way speaker system consists of a 4" woofer and a 1½" tweeter. There are separate jacks for external antenna, earphone, a.c. (with optional adapter), speaker, and phono. The unit measures 13" x 8" x 5" and requires six "C" cells for operation. Lafayette

Circle No. 20 on Reader Service Card

MARINE RADIOTELEPHONE

A new generation marine radiotelephone operates in the v.h.f. band with the static-free clarity of FM radio, according to the manufacturer. The new set is designed to transmit at full power with an antenna as short as 20 inches and needs no ground plate attached to the boat's hull.

The new 12-channel two-way radio can be used to talk with other boats, call the Coast Guard for assistance, or talk to anyone ashore through the marine operator. Range of the new radiotelephone is up to 40-50 miles. Raytheon

Circle No. 21 on Reader Service Card

MANUFACTURERS' LITERATURE

VOLTAGE REGULATORS

A new 12-page illustrated brochure describing the "Solatron" line of line-voltage regulators is now available. Complete electrical and mechanical specifications for single-phase, three-phase delta, and three-phase wye regulators are outlined in the booklet.

In addition, the publication (VR-201) describes a number of housings for the instruments as well as auxiliary harmonic filters. Sola

Circle No. 144 on Reader Service Card

TEST EQUIPMENT

A new 16-page 1967 test equipment brochure covering a complete line of v.o.m.'s and adapters, v.t.v.m.'s, general-purpose microtesters, oscilloscopes, temperature-measuring instruments, and accessories has been published. Featured in the booklet is the company's newest addition, the Model 160 palm-sized v.o.m. Simpson

Circle No. 22 on Reader Service Card

SPEAKER CATALOGUE

A new 24-page illustrated booklet covering a full line of high-fidelity sound products has been issued. Described in the brochure are full-size and bookshelf loudspeaker systems; unitary, dual-cone, and coaxial loudspeakers; speaker system components including woofers, tweeters, crossover networks, and balance controls; and three-way loudspeaker systems kits.

Featured in the catalogue (No. 165-M) are sections on designing speaker enclosures and choosing loudspeakers. Jensen

Circle No. 23 on Reader Service Card

ELECTRONIC COMPONENTS

A full line of composition- and wirewound-element potentiometers, field-assembled controls, power rheostats, resistors, and miscellaneous components is described and illustrated in a new 32-page 1967 catalogue. Complete technical specifications and dimensional drawings are provided for all devices listed. Clarostat

Circle No. 145 on Reader Service Card

MAGNETIC SHIELDING

A new 36-page illustrated design handbook (No. B-9236) covering all aspects of magnetic shielding in low-frequency applications is now available. Topics discussed include design parameters; choice and comparison of materials; cylindrical, conical, multiple (nested), and wrap-around shields; heat treatment; and shield evaluation. Westinghouse

Circle No. 146 on Reader Service Card

NICKEL-CADMIUM BATTERIES

Introduced in 10-page illustrated brochure is the company's new line of sealed, rechargeable nickel-cadmium batteries and power packs. The booklet outlines the firm's automated production progress and describes in detail various performance characteristics of the new batteries. Texas Instruments

Circle No. 147 on Reader Service Card

THERMOCOUPLE CALIBRATION

Of special interest to those involved in temperature measurement studies is a new 24-page booklet containing a number of thermocouple calibration tables and alloy data charts.

The information offered in Bulletin CT-2 includes useful ranges for all types of thermocouples; sheathed material temperature characteristics; melting temperatures of important materials; and suggested extension wire selection. Omega Engineering

Circle No. 148 on Reader Service Card

SOLDER ALLOYS

More than 150 different solder alloys are described in a new 4-page technical bulletin (No. SA-64). Data is arranged in convenient chart form and includes percentage compositions of solder alloys as well as their melting points in both liquid and solid states in centigrade and Fahrenheit. Semi-Alloys

Circle No. 149 on Reader Service Card

PLASTIC FOAMS

A new illustrated wall chart on "Eccofoam" plastic and ceramic foams is now available. Eighteen different materials are covered, including rigid and flexible foam-in-place liquids, rigid and flexible plastic sheets, and powders. Temperature, density, compressive strength, thermal conductivity, water absorption, and dielectric constant are given for each material listed. Emerson & Cuming

Circle No. 150 on Reader Service Card

TEFLON TUBING

A new specification chart giving wall dimensions and tolerances of extruded Teflon tubing is now available. Listed on the chart are inside diameter dimensions as well as wall dimensions of standard wall, thin wall, and lightweight in AWG sizes from 30 to 0 plus fractional sizes. Zeus

Circle No. 151 on Reader Service Card

PREFABRICATED CHASSIS

A new 12-page catalogue describing the "Omniclosure" line of prefabricated chassis kits and parts for EIA rack mounting, including chassis drawers and card drawers, has been issued. Basic kits consist of the front panel, side frames, cross plates, sliding top and bottom perforated covers, handles, and screw package. Techmar

Circle No. 152 on Reader Service Card

CONTROL KNOBS

A 4-page illustrated product bulletin on the company's new line of "DR Series" control knobs has been issued. The devices are available in a number of finishes and sizes in round, pointer, and concentric styles. Complete specifications are provided in the booklet. National Radio

Circle No. 153 on Reader Service Card

CABLE-SPLICING KITS

Cable-splicing and cable-terminating kits for a variety of shielded and unshielded installations, both indoor and outdoor, are described in a new 24-page catalogue (No. 400). The booklet supplies illustrations, material lists, cross-section drawings, and ordering information for AWG/MCM cable sizes through 15 kV ungrounded for a number of splices and terminations. Crescon

Circle No. 154 on Reader Service Card

POWER TUBES

More than 740 industrial and power tubes are described in a new 32-page technical guide (No. B-9234). Included are radio-frequency oscillators and amplifiers, audio-frequency amplifiers, gas and vacuum rectifiers, ignitrons, thyratrons, and special-purpose sensing and control tubes. Specifications, base diagrams, and electrical characteristics are provided for all devices covered.

Featured in the booklet is an 8-page direct interchangeability listing that covers major American electronic tube manufacturers. Westinghouse

Circle No. 155 on Reader Service Card

SOLDERING GUNS

A new 4-page illustrated catalogue featuring the company's complete line of single-post-type soldering guns and kits for the hobbyist, home craftsman, and industrial user has been released. All units are complete with built-in working spotlight, trigger switch, and comfortable pistol-grip design.

Also listed in the booklet are a number of extra tips and accessory items. Wen

Circle No. 24 on Reader Service Card

PUSH-BUTTON SWITCHES

Described and illustrated in a 22-page catalogue (No. PBS-1) is an extensive new line of push-button switches. The booklet emphasizes the modular design of the new switches and shows how the modules can be used in a great variety of combinations to solve a wide range of switching problems.

Complete mechanical, electrical, and environmental specifications are included in the catalogue, along with dimensional drawings and a glossary of engineering nomenclature. Centralab

Circle No. 156 on Reader Service Card

FOUR-INPUT FLUIDIC DEVICE

A new data sheet which describes a four-input bistable device that provides flip-flop logic with double the sensing capability of a two-input bistable device is available.

The publication explains applications in switching, pneumatic pulse detection, volatile memories, pulse amplification, and shaping. Detailed information is provided on installation, performance characteristics and curves, and dimensions. Corning

Circle No. 157 on Reader Service Card

SOLID-STATE COUNTERS

A new six-page catalogue which lists a complete line of electronic solid-state counters and frequency instruments has just been issued.

Complete specifications and prices are given on counter-timers, bi-directional counters, variable time-base counters, and preset counters. Over 40 standard and special application units are included.

In the section devoted to frequency instruments are descriptions and prices on d.c.-to-frequency converters, frequency-to-d.c. units, frequency detecting switches, frequency meters, and frequency deviation meters. Anadex

Circle No. 158 on Reader Service Card

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Letters from Our Readers

(*Continued from page 12*)

riods of time (I recently checked a *Weston* galvanometer built in 1895 which is still within 1% accuracy), while v.o.m.'s, v.t.v.m.'s, and other bench-type equipment subjected to hard usage sometimes do require remagnetization.

HAROLD E. KNIPPENBERG
Augusta, Ga.

* * *

COMMUNICATING WITH COMPUTERS

To the Editors:

This is in reference to the article by Jim Kyle "Communicating with Computers" which was published in the February, 1967 issue of ELECTRONICS WORLD.

This article was extremely well done; however, we did detect one minor error in Table 1. The Baudot code for the character "H" should be 24 and not 21 as indicated. The number 21 indicates the character "Z".

CAPT. ROBERT T. KUNTZ, USAF
Chief, Q Analysis Section
AF Tech. Applications Ctr.
Washington, D. C.

* * *

SHURE V-15/II CARTRIDGE

To the Editors:

I believe the "EW Lab Tested" review of the *Shure* V-15/II cartridge in the April issue contains some errors. The IM distortion graph percent distortion scale descends from 1% to .07% and .05%. This should descend from 1% to .7% and .5%. Also, in the text (p. 92): ". . . but below these levels it is an insignificant .05%." This certainly would be phenomenal! I believe this should have been "insignificant .5%."

The "EW Lab Tested" reports are among the select few which we believe are honest and accurate. Many of our customers discuss these reports with us, so I am sure the above noted misprints will be thoroughly discussed in the weeks and months that lie ahead! Our own laboratory measurements indicate that IM distortion should be the .5% figure, not the .05%.

ELECTRONICS WORLD continues to improve its coverage of stereo. You certainly have upgraded the magazine over the past several years. Although many of us never take the time to write you, we certainly do appreciate the good work you are doing.

DAVID CRAIG
Craig Audio Laboratory
Rochester, N.Y.

Reader Craig is, of course, correct. The cartridge is a good one but not quite that good. We have misplaced the decimal points on the graph as well as in the text reference, as mentioned in the above letter.—Editors

ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 70¢ per word (including name and address). Minimum order $7.00. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.

READER RATE: For individuals with a personal item to buy or sell. 40¢ per word (including name and address). No Minimum! Payment must accompany copy.

GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd preceding month (for example, March issue closes January 1st). **Send order and remittance to:** Hal Cymes, **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016

FOR SALE

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 6556 W. Higgins Rd. Chicago, Ill. 60656.

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

METERS—Surplus, new, used, panel and portable. Send for list. Hanchett, Box 5577, Riverside, Calif. 92507.

INVESTIGATORS, FREE BROCHURE, LATEST SUBMINIATURE ELECTRONIC SURVEILLANCE EQUIPMENT. ACE ELECTRONICS, 11500-J NW 7TH AVE., MIAMI, FLA. 33168.

R.F. CONVERTERS World's largest selection. Also CCTV cameras, etc. Lowest factory prices. Catalog 10¢. Vanguard, 196-23 Jamaica Ave., Hollis, N.Y. 11423.

CONVERT any television to sensitive big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco-A22, Box 10563, Houston, Texas 77018.

RECTIFIERS, TRANSISTORS & COMPONENTS

6 tube Amplifier, New 4 lbs. 2 @	$1.98
¼ Watt Resistors, asstd. 50 @	1.00
½ Watt Resistors, asstd. 60 @	1.00
Ceramic Disc Capacitors, asstd. 75 @	1.00
Precision Resistors, asstd. 50 @	1.00
Pots. 2-4 Watt, asstd. 15 @	1.00
R. F. Coils, asstd. 25 @	1.00
Axial Lead mica. asstd.	30/1.00
Tantalum Capacitors, asstd. 10 @	1.00
Mercury Battery 5.4V	4/1.00
2N2944 Sil. Chopper To-46	1.00
50W. Zeners 10 to 19 Volts	1.00
Thermistor bead, 900 or 1200 ohm. 2 @	1.00
2N1021, Ger. Power, 7amp, 100V., To —3	.60
2N456A, 7A. 40V. Ger. Power To —3	.45
2N1718, Sil. Power, 10W., 60V., Heatsink, 3 @	1.00
70 amp Stud, 50PIV—$2.50; 100PIV	$3.50

SILICON CONTROLLED RECTIFIERS

AMPS.	300PRV	400PRV	500PRV
7A.	1.50	2.05	2.75
16A.	2.15	2.65	3.25

Pots, 1W. 100K, or ½W. 500K, 5 @	1.00
Surprise Kit, 10 lbs. components	2.50
Epoxy Hi-Vol diode, 200ma, 3000PIV	.98
Computer Board, TO-3 Power, Heat Sink	1.50
I.C., TO-5, untested, 5 @	1.00
I.C., Dual-inline, untested 10 @	1.00
2N389,85W 60 V. TO53	.79
2N3707-11 Asstd. Plastic Silicon Xisters 20 @	1.00
2N3704-3706, Asstd. Plastic Sil. Xisters 10@	1.00
2N2151, Sil. Power Xister	.65
2N1009 Ger. Min. Xister untested 30 @	1.00
3N35 Tetrode, NPN, untested 5 @	1.00
Ger. Diodes, Asstd. 15 @	1.00
2N458A, 7A. 80V. Ger. Power, TO —3	.55
Sil. Diodes, Switching, Signal, Asst. 15 @	1.00
2N118, Silicon, NPN	10/1.00
2N1149, Silicon, NPN untested	20/1.00
2N1300, Untest. PNP & NPN. ¼" leads @	25/1.00
2N1714, Silicon Power 10W 60V.	4/1.00
Computer Boards, Parts Free, per transistor	.05
Germanium Power, 2N457A, 7A; 60V	.50
Silicon Power 40 W, 2N1047,TO-57 2 @	1.00
Tophats 750 ma., 200PIV-8¢, 400. 12¢ 600PIV	.18
1N34A. untested	100/2.98
Varicaps, 27, 47, or 100 pf	1.25
2N1038, Germanium 20 W. 40 V	4/1.00

With any $10.00 Order any $1.00 item **Free.** On $25.00 order any (3) $1.00 items **Free. Catalog.**

Minimum order $3.00 plus postage, C.O.D.'s 25%

ELECTRONIC COMPONENTS

Post Office Box 2902 Baton Rouge, Louisiana 70821

CIRCLE NO. 113 ON READER SERVICE CARD

METAL-TREASURE Detectors, transistorized. lightweight. $39.95 to $89.95. Free Catalog. **JETCO INSTRUMENTS,** Box 2880-E, Huntsville, Texas 77340.

INTEGRATED CIRCUIT Experiment Kit. $6.95. Others. Catalogue 25¢. Kaye Engineering, Box 3932, Long Beach, Calif. 90803.

NEED RESISTORS? All standard values—only 5¢ each (½ watt). **FREE** bargain sheet. Crown TV Service. 175 Davey Street, Bloomfield, New Jersey 07003.

MARCONI test equipment—brand new TF-2002 AM generator, TF-2701 bridge, TF-1041C voltmeter, Eddystone EC-10 comm. receiver, TF-1060/3 UHF generator. 15% off, one each, only offer. J. Perez, Box 1268, Mayaguez, Puerto Rico 00708.

JAPAN & Hong Kong Electronics Directory. Products, components, supplies. 50 firms—just $1.00. Ippano Kaisha Ltd., Box 6266, Spokane, Washington 99207.

FREE ELECTRONICS (new and surplus) parts catalog. We repair multimeters. Bigelow Electronics, Bluffton, Ohio 45817.

DETECTIVES! Free brochures! Electronic Surveillance devices. **SILMAR ELECTRONICS,** 3476 N.W. 7th Street, Miami, Florida 33125.

SUDYMONT acoustic baffles. Plans $5.95; Baffle $26.95; with cabinet from $39.95. Send speaker size. **SUDYMONT,** 120 Liberty Str., NYC. 10006.

MUSIC LOVERS, CONTINUOUS, UNINTERRUPTED BACKGROUND MUSIC FROM YOUR FM RADIO, USING NEW INEXPENSIVE ADAPTOR. FREE LITERATURE. ELECTRONICS, 11500-Z NW 7th AVE. MIAMI, FLORIDA 33168.

MESHNA'S Transistorized Converter Kit $5.00. Two models converts car radio to receive 30-50mhz or 100-200mhz (one mhz tuning) Meshna, No. Reading, Mass. 01864.

FREE CATALOG—Loads of Electronic Bargains. R.W. Electronics, Inc. 2244 South Michigan Ave., Chicago, Illinois 60616.

NEW supersensitive transistor locators detect buried gold, silver, coins. Kits, assembled models. $19.95 up. Free catalog. Relco-A22, Box 10563, Houston, Texas 77018.

ANY RADIO - TV RECEIVING TUBE
32¢ EACH! $29.00 PER 100!

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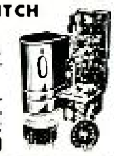

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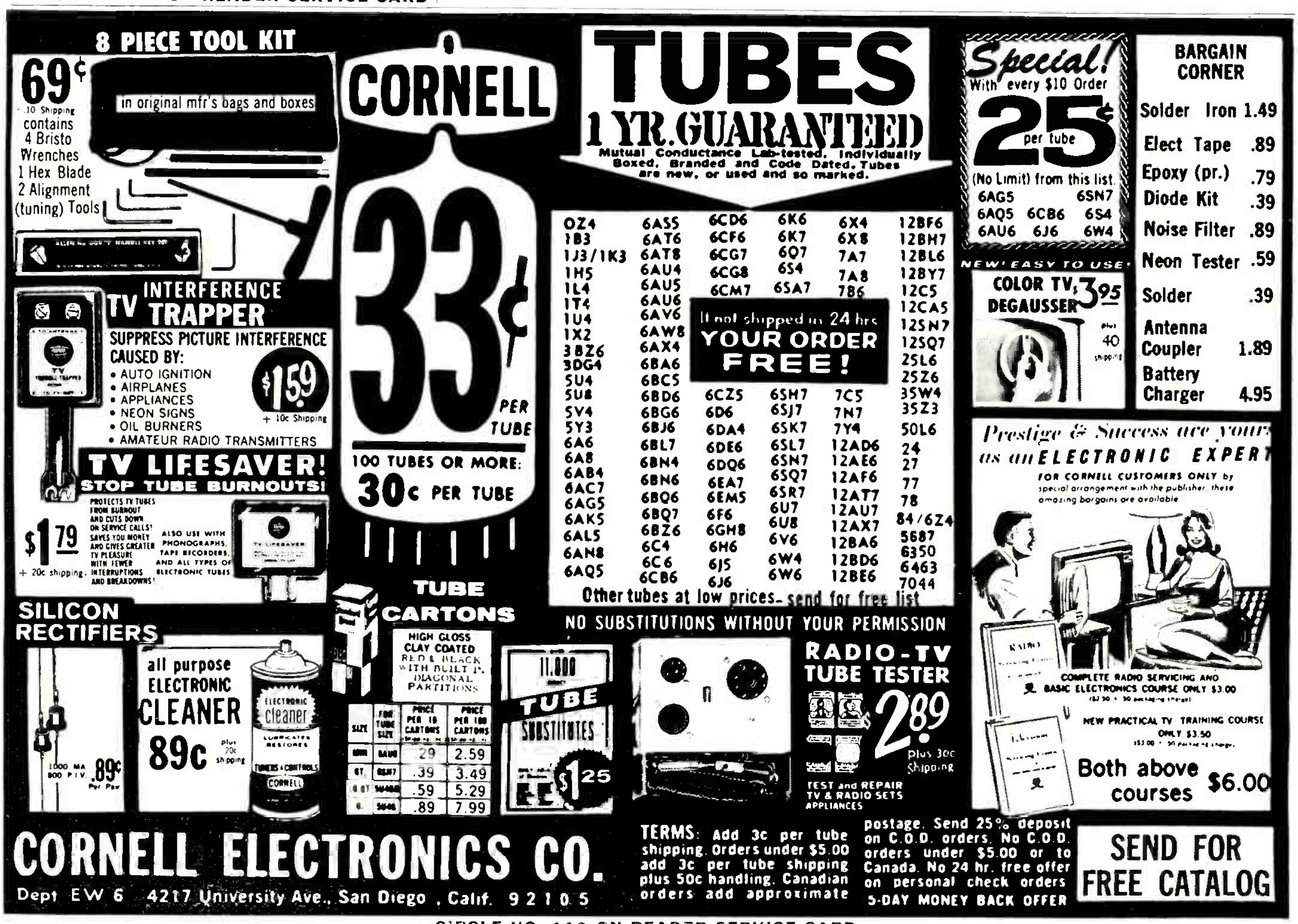

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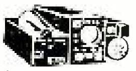

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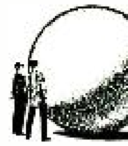

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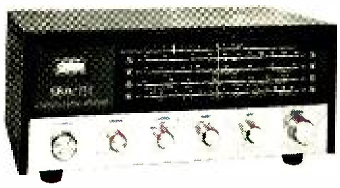

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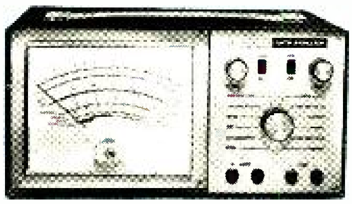

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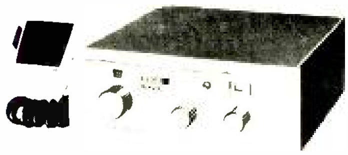

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EXCLUSIVE dual-crystal lattice filter for advanced razor-sharp selectivity of reception.

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EXCLUSIVE use of precision series-mode fundamental crystals for superior transmit and receive stability. **Wired only, $189.95**

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EW-6

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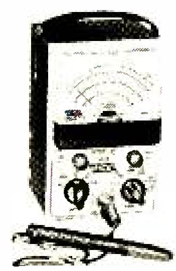

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