Electronics World

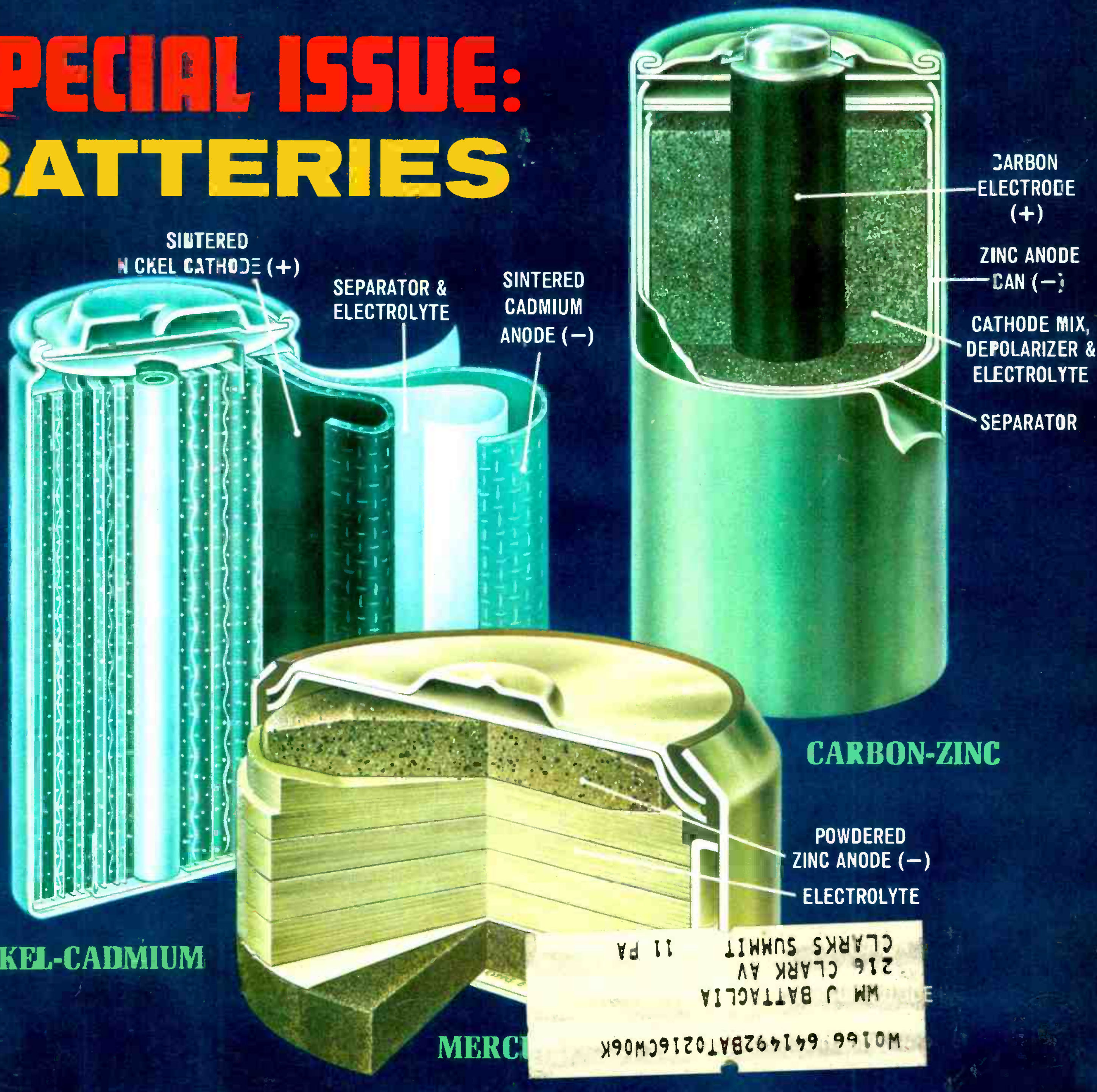
OCTOBER, 1965
50 CENTS

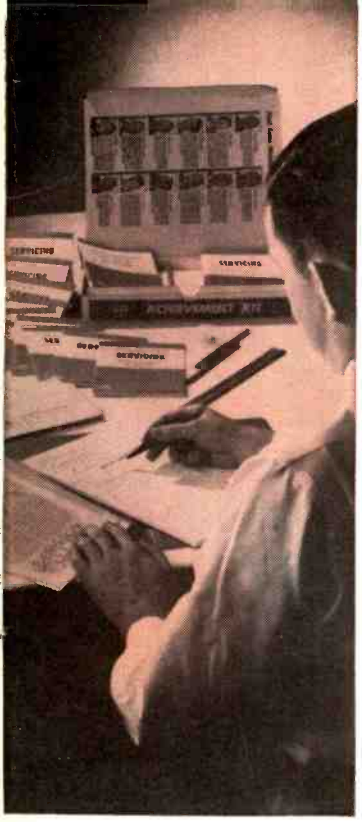
THE ELECTRONICS INDUSTRY: *A SPECIAL EW REPORT*—
on its Products, People, and the employment prospects in the Midwest.

SILICON TRANSISTOR I.F. AMPLIFIER FOR FM TUNER

TRUE 3-D IMAGE FROM LASER PHOTOGRAPHY

SPECIAL ISSUE: BATTERIES





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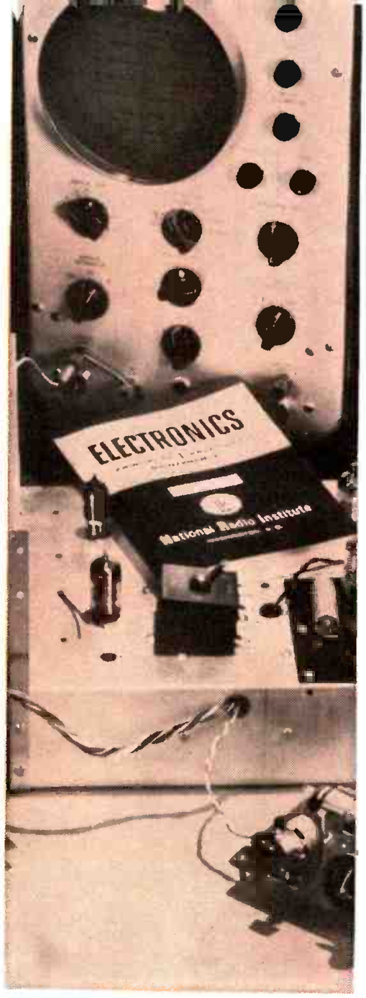

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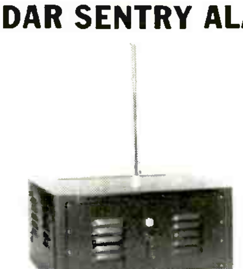

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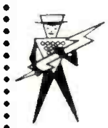

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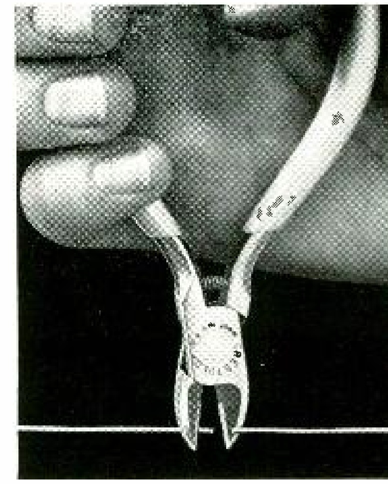
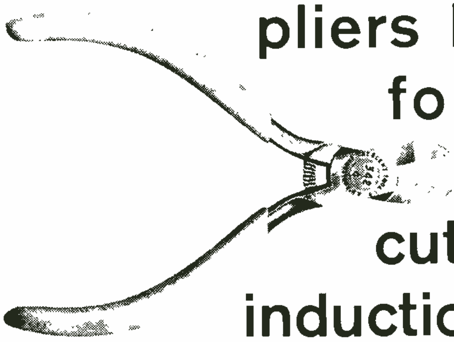


When you've got cutters that snap-cut the toughest nickel ribbon wire as easy as a toothpick, assembly goes faster, costs come down. Our 342 diagonal cutting



pliers have the special cutting edge for it. These Crescent cutters feature a carbide-insert cutting edge, electronically induction hardened and hand

honed for fast, snap-cutting action . . . Lessens operator fatigue with

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the tool to its open position. Ask for Crescent. The name alone is your guarantee of superior quality on any hand tool.

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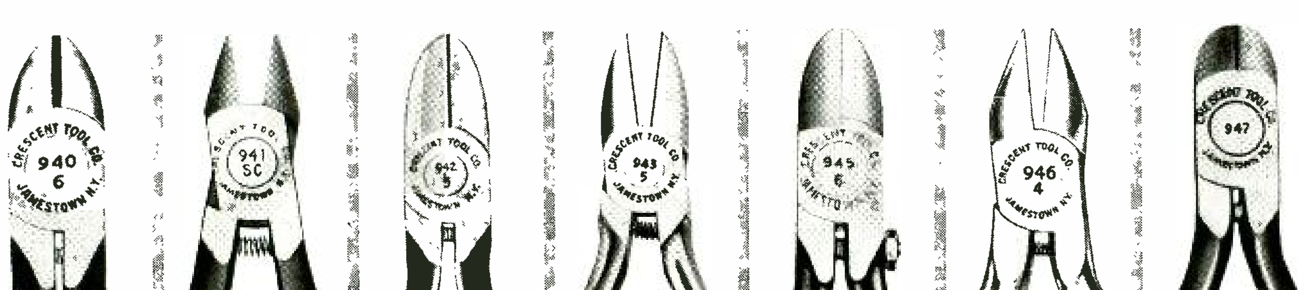

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Electronics World

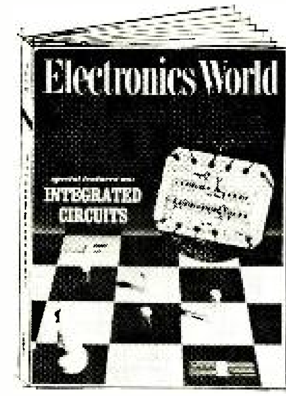
OCTOBER 1965
VOL. 74, No. 4

CONTENTS

MONTHLY FEATURES

OUR COVER shows cross-sections of the three basic types of battery cells: mercury, carbon-zinc, and nickel-cadmium. These have important applications in the electronics field. Although there are actually four basic types, the alkaline-manganese is not shown on the cover since it uses the same active materials as does the carbon-zinc (Leclanché) type except it employs an alkaline rather than an acid electrolyte and the physical arrangement of the active materials is different. The special 16-page section includes four important stories covering each of these four special types of batteries. Cover illustration by Otto E. Markevics.

COMING NEXT MONTH



SPECIAL FEATURE ISSUE

INTEGRATED CIRCUITS—In order to keep our readers abreast of the important developments in the field of integrated circuits, the November issue will carry four special feature articles covering the state-of-the-art. An EW Report on the Integrated Circuit Industry discusses the business and technical aspects, the innovations that can be expected in industrial, military, and consumer products as a result of using integrated circuits, and the changes in job orientations that will occur from their adoption. Donald Lancaster discusses current availability of these circuits in his article "Integrated Circuits: What's Available?" "Integrated Circuit Techniques" by Carl David Todd covers the various types of circuits, their applications, the advantages and disadvantages of the different types for specific circuit requirements. "Linear Integrated Circuits" covers one overlooked area in integrated circuitry. This article includes a brief description of what a linear circuit is and gives examples of its applications.

LINE-OPERATED TRANSISTOR TV: RCA
A brief description of a unique circuit used in RCA's new line-operated transistorized television portable.

GLASS FOR ELECTRONICS
In this comprehensive survey article, John R. Collins discusses the new types of glass that are playing an increasingly important role in electronics. They are finding use in delay lines, precision resistors and capacitors, radomes, and in cathode-ray tubes that are employed for readouts.

LASER MEASUREMENTS
The equipment and procedures for testing laser performance: the measurement of pulse power, laser spectrum, and modulation are all included in this article by Warren Groner of Sperry along with a discussion of laser precautions and standards.

All these and many more interesting and informative articles will be yours in the NOVEMBER issue of ELECTRONICS WORLD . . . ***on sale October 21st.***

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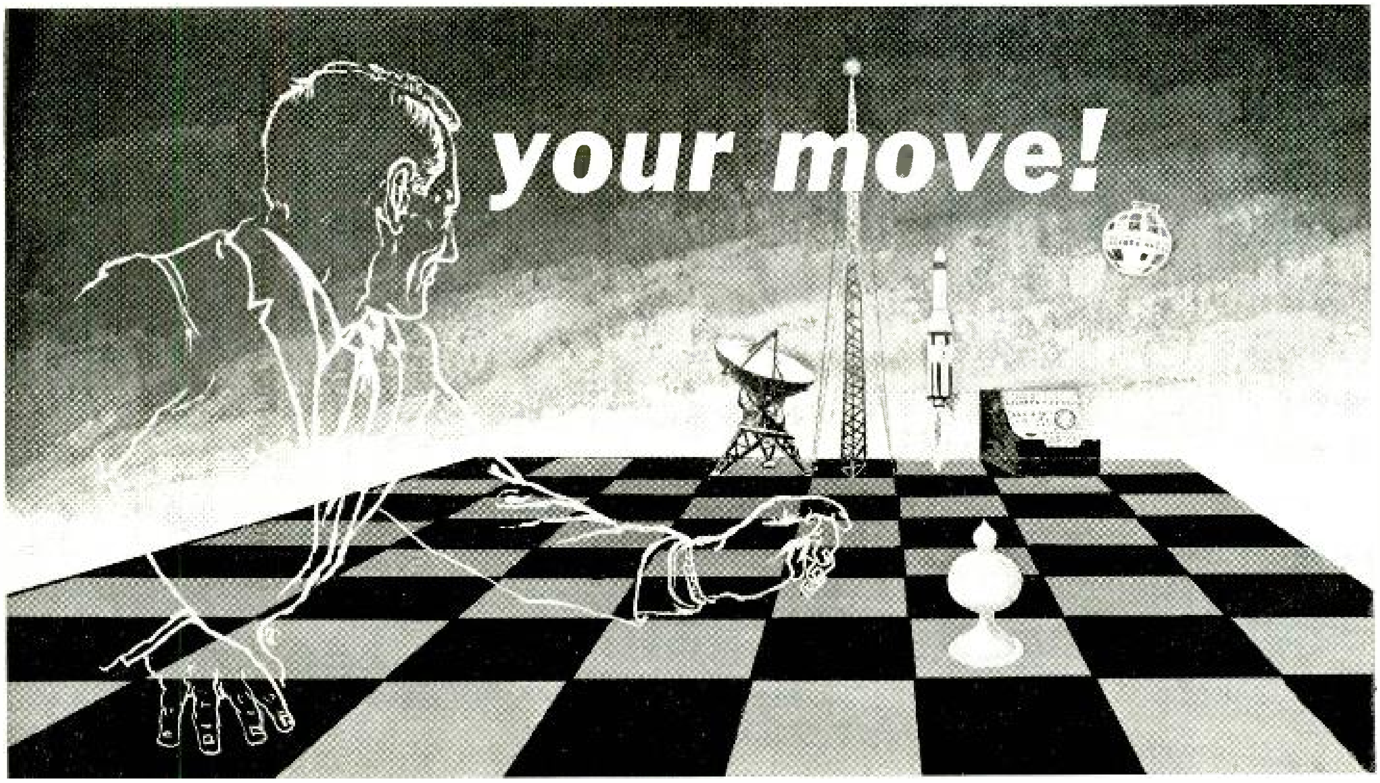

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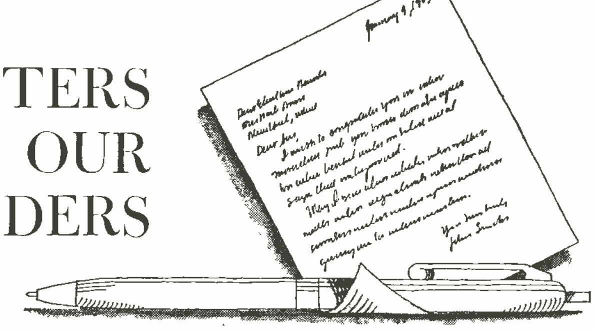
LETTERS FROM OUR READERS



200-WATT STEREO AMPLIFIER

To the Editors:

Being a contrary type, the caption of Fig. 3 in the article "A 200-Watt Solid-State Stereo Amplifier" (March, 1965 issue) was accepted as a challenge, and home construction was attempted. This required hand-winding not only the power transformer but also the trifilar-wound interstage transformers.

Having built all significant versions of the half-bridge or totem-pole type amplifier, it is my opinion that if the commercial unit works as well as my home-built unit (a safe assumption), it is far superior to any amplifier previously designed.

To further document its superiority, my home-built unit used semiconductor rejects, and the following semiconductor substitutions were made: (1) 2N651 for the 2N1307, (2) 2N657 for the 2N696, (3) 2N1015C for the STC1094, and (4) 750-ma., 50-p.i.v. silicon diodes for the 1N4002 and 1N2069. The *RCA* 2N2148 and the *G-E* 7A32 and 1N91 were the only semiconductors *not* substituted.

A few words of caution for anyone desiring to build this amplifier.

1. Seven transistors are used in this power amplifier, five of which require heatsinking; *i.e.*, all but the first two. (These heat sinks must be insulated, as most transistors suitable for use in these locations have an element connected to the case of the transistor.)

2. To prevent low-frequency motorboating, I found it necessary to place a low-value resistor (200 ohms) in series with the primary of the coupling transformer. Note: If the primary leads are phased incorrectly, the results are unmistakable; the motorboating described above sounded more like the speeded-up ticking of a watch.

3. The 15-volt power supplies *must* be well regulated to prevent high-level distortion. (To preclude expensive, large-value capacitive dividers, two independent supplies were used in my unit.)

As described by the authors (Sharma and Berkovitz), the low-level sound was exceptionally clean and brilliant, and maximum power delivered into a dummy load was only 35 watts (50 volts output stage collector supply), as the preamp used could not supply the required input drive. Living in a duplex on a military reservation, using relatively high-efficiency speakers, I could see no requirement for additional drive.

The purpose of this letter is to thank the authors and the editors for providing this article and others like it.

T/Sgt Harold L. Stephens
Shaw AFB, S.C.

* * *

CIRCUIT-COMPONENT NEONS

To the Editors:

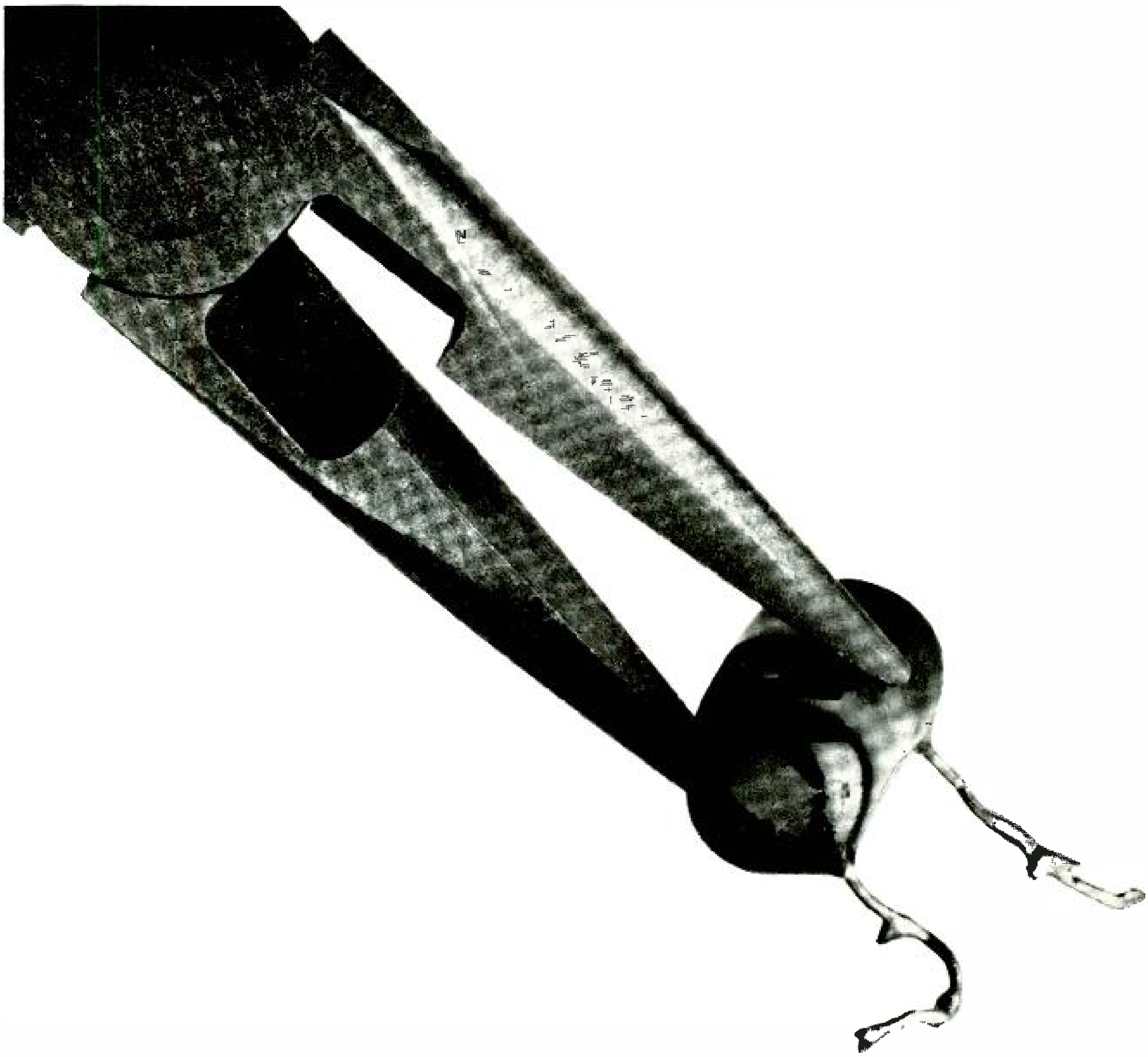
We have just finished reading Part 2 of the article by Donald Lancaster, "Solid-State Dimmers & Power Controls," in your June, 1965 issue. Mr. Lancaster has done an admirable job in pulling together a large amount of valuable information on this subject and is to be commended.

On one point, however, we feel compelled to take issue. On p. 43 he discusses in part "the intrinsic 'orneriness' of neon lamps with regard to their firing levels and pulse capabilities." A few years ago his point would have been well taken. The NE-83 lamp which he uses in a number of circuits certainly does have many shortcomings. As a manufacturer of this lamp, we have not been satisfied with its performance in certain cases.

The problem with the NE-83 and with virtually all neon lamps designed to be used as indicators is just that—they were designed as indicators with rather loose parameters. They were not intended to meet the close tolerances demanded of circuit components in today's electronic devices.

A few years ago, we at *Signalite* decided that something had to be done if the neon lamp were to find its proper place in electronic circuitry. The results of our efforts were announced to the industry well over a year and a half ago. A new method had been devised for the design and production of neon lamps which resulted in a product that maintained its performance and its tolerances to the same critically close level as any other component in an electronic circuit. The first lamp announced in this new series of "circuit-component" glow lamps was our AO59 which held its maintaining voltage at ±1 volt. Since then, many new tubes have been introduced, includ-

(*Continued on page* 12)



This defective capacitor came from a four-month-old TV set. And you want to put in another just like it?

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Elmenco dipped Mylar®-paper (dp) capacitors last longer because they're vacuum-dipped for solid impregnation. They'll hold their rating, even at continuous 125° C operation. Water can't get in to cause leakage or breakdown because the casing's non-porous and moisture-proof.

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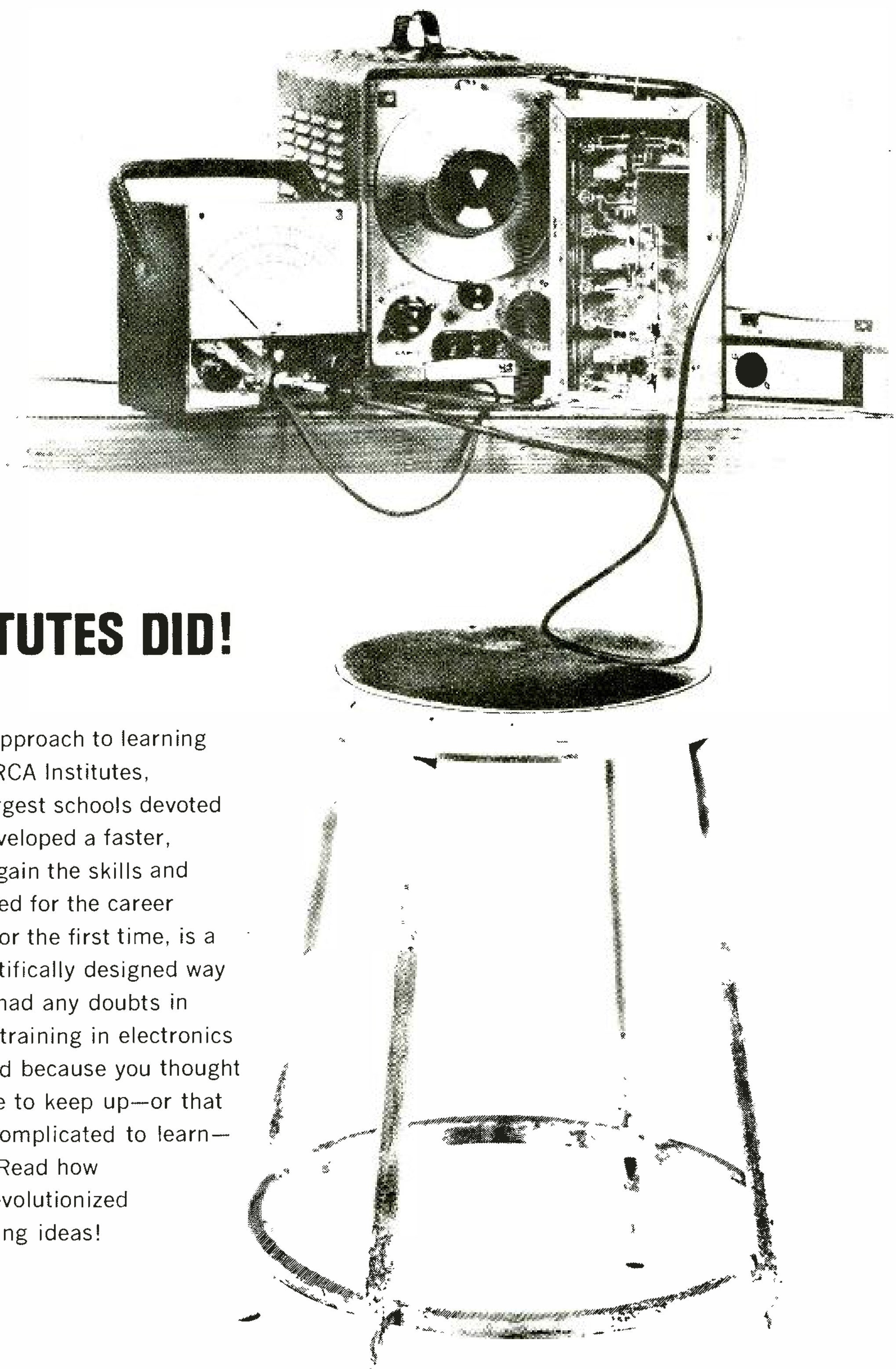
SOMEONE SHOULD DEVELOP AN EASY WAY TO LEARN ELECTRONICS AT HOME



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ing our line of voltage-regulator and voltage-reference tubes, all of which hold their tolerance of ±1 volt or less.

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* * *

SSB FOR MARINE RADIO

To the Editors:

Re Leo Sands' "SSB Comes to Marine Radio" in May, 1965 ELECTRONICS WORLD, I would like to point out an error in this article in the discussion of the percentage divisions of carrier power and intelligence power in an AM waveform. The article states, "When conventional AM is used, only 50% of the radiated power conveys intelligence; the other 50% is wasted in the carrier which conveys no intelligence. Both sidebands convey identical intelligence and represent 50% of the total radiated power, 25% in each sideband."

Actually, when an AM transmitter is 100% modulated, of the *total* radiated power output, 66.6% is in the carrier and 33.3% is in the sidebands. Each sideband contains 16.6% of the *total* radiated power output.

This is easily understood when it is remembered that a 1000-watt AM transmitter is modulated by a 500-watt modulator. The power output of the modulator is added to the carrier power, and the total power output with 100% sine-wave modulation is 1500 watts.

H. LYNN HOPEWELL, JR.
American Embassy (ATO)
APO San Francisco, Calif.

Reader Hopewell's analysis given here is quite correct. The only 50% involved represents the amount of modulating power required compared with the r.f. carrier power. Hence, if the transmitter in the above example is called a "1000-watt transmitter," as it would be, then the modulation power required is 50% of the rated transmitted power.—Editors.

* * *

LIQUID FLOW MEASUREMENT

To the Editors:

I would like to compliment you on your fine article "Liquid Flow Measurement" in the June, 1965 issue of ELECTRONICS WORLD.

In your discussion of the magnetic flow meter, you make mention of the *Foxboro Co.* having furnished a meter with a six-foot pipe diameter for the City of Pittsburgh, Pa. Although it was not stated, it might be inferred that this is the largest meter of its kind in service. For your information, I would like to advise you that the *Fischer & Porter Co.* has manufactured a magnetic flow meter with an internal diameter of 78 inches which is installed at a *Union Carbide* facility in Texas. To our knowledge, this is the largest one in existence. We also have a 72-inch diameter meter in the

10 facts you should know about color-bar generators

If you are going to buy a color-bar generator *—or even if you already own one*—here are several facts you should know.

While other types of test instruments may lack one or more features, they may still be useful in skilled hands—*provided* the user is aware of their shortcomings and *provided* he has other means of determining what he must know.

This is not true of a color-bar generator.

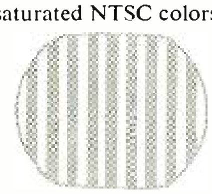
A color-bar generator should allow you to walk away from an adjusted receiver knowing that the owner can turn it on and receive color broadcasts in full-fidelity color and sound.

Not all color-bar generators can give you this assurance.

Let's talk facts.

FACT NO. 1: ***A gated-rainbow type generator is accepted as the standard of the service industry***

You do not need fully saturated NTSC colors to achieve perfect adjustment any more than you need an FCC-type broadcast signal for tuner and if-amplifier alignment. The gated-rainbow type signals are used by virtually all TV manufacturers in establishing service procedures for their sets.



Gated rainbow color-bar pattern

Urgent service needs for a trustworthy color-signal source were met years ago when RCA introduced the *gated-rainbow* system.

Today, this basic system is used in nearly all service-type color-bar generators. The waveforms and procedures in nearly all color-TV service notes are based on this system.

FACT NO. 2: ***All gated-rainbow type generators are not alike***

In spite of their basic circuit similarities, available models differ in their features, accuracy, and ultimate usefulness. Some of these differences are critical.

FACT NO. 3: ***The offset subcarrier oscillator must be controlled within a few cycles of its true frequency***

This oscillator controls the phase angles (hues) of the color-bar pattern. It is the *heart* of the color-bar generator.

The subcarrier oscillator should be within ±20 cps of its fundamental frequency of 3.563795 megacycles. *In the crystal-controlled RCA WR-64B Color-Bar / Dot / Crosshatch Generator, this deviation is kept well within the ±20 cps limit.*

FACT NO. 4: ***Provision must be included to prevent the subcarrier oscillator from drifting off frequency***

The subcarrier oscillator must not only be accurate when the instrument is *new*—it must *stay* accurate. Top-quality components minimize undesirable frequency changes.

Check, for instance, the trimmer capacitor used in the 3.56-Mc subcarrier oscillator. *You'll find a piston-type ceramic capacitor—not a flat mica type—in the RCA WR-64B.*

FACT NO. 5: ***The generator must have an rf-sound carrier to assure proper setting of the fine-tuning control***

Unless your color-bar generator has this essential feature, it may produce a perfect color-bar pattern on the receiver, *but at the wrong setting of the receiver fine-tuning control. In such cases, the receiver may not correctly reproduce a color program.*

The WR-64B has this necessary feature. With it, you can accurately set the fine-tuning control *before* making color adjustments. *In the WR-64B the rf-sound carrier is also crystal-controlled.*

FACT NO. 6: ***The rf picture carrier must be exactly on frequency to assure that the color subcarrier is correctly placed in the receiver bandpass***

Drift, faulty adjustment, or aging of components in the rf oscillator section can move the generator picture carrier off frequency. This shift, in turn, will also move the color subcarrier signal away from its correct position in the receiver bandpass. In some receivers, this shift will affect accuracy of color-circuit adjustments.

A separate crystal-controlled oscillator is used in the WR-64B to keep the picture exactly on frequency.

FACT NO. 7: ***The axes of the output color-bar pulses should lie on the zero axis—and not on elevated brightness pedestals***

Elevated pulses necessitate use of an oscilloscope for accurate setting of receiver phasing. A generator having zero-axis color-bar pulses, such as the WR-64B, does not require use of an oscilloscope for checking phasing in the customer's home.

FACT NO. 8: ***The generator should not require frequent adjustment of internal counter circuits***

All color-bar generators contain circuits which develop vertical and horizontal sync, and dot-and-bar-pattern signals, by dividing or counting down from a higher frequency: usually 189 Kc. If one of these circuits is unstable, the patterns can jitter, ripple, jump sync or contain the wrong number of dots or bars.

Conventional R-C circuits are used in the counters of most generators. *But the RCA WR-64B uses inherently stable iron-core inductors in its counters,* thereby assuring long-term counter-circuit stability.

FACT NO. 9: ***The proper way to check receiver color performance is to feed the generator signal into the antenna terminals***

Color performance depends on overall receiver condition—not on that of a single section alone. A color-test signal fed directly into the video amplifier—rather than through the antenna terminals—will not provide a proper check of the complete receiver. *The only method you should use in adjusting the receiver, therefore, is the rf-signal-input method*—the method provided by the RCA WR-64B.

FACT NO. 10: ***There is no "best" dot size or bar width for convergence adjustments***

Generator dot size or bar width has no significance for convergence adjustments.

Veteran technicians, however, have found that very small dots or thin bars are difficult to use under average lighting conditions. If receiver brightness is turned up to overcome this handicap, blooming will result. Proper convergence cannot be achieved under this abnormal condition.

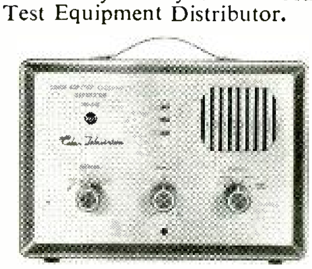
The dot and bar size of the WR-64B is small enough to permit exact, speedy adjustment, and large enough to be useful under average lighting conditions.

These are ten specific facts you should know about color-bar generators. They add up to this

FACT: ***The new RCA WR-64B has all the features you need for complete color-circuit adjustment***

It's the *one* color-bar generator that meets all servicing requirements—from the company that pioneered and developed the color-TV system now in universal use: RCA!

Order it today from your local Authorized RCA Test Equipment Distributor.



$189.50* *Optional distributor resale price. May be slightly higher in Alaska, Hawaii and the West. Prices subject to change without notice.

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CIRCLE NO. 100 ON READER SERVICE CARD

Water Pollution Control Plant at San Jose, Calif.

I would like to make one additional comment in regard to your article, and this has to do with the use of turbine meters for cryogenic fluids. *Fischer & Porter* and other manufacturers of turbine flow meters have many meters in service on cryogenics very successfully. Also, their use in this capacity is on the increase as more is being learned of the properties of cryogenic fluids. Turbine meters as large as 24 inches in diameter have been used in this service.

Richard H. Kutsch
Fischer & Porter Co.
Atlanta, Ga.

* * *

THERMISTOR BRIDGE DESIGN

To the Editors:

There seems to be an error in the article "Thermistor Bridge Design Made Easy" appearing on p. 66 of your July issue. After building the bridge, I found that I had to juggle the value of R_s considerably in order to make the bridge operate correctly. Can you enlighten me?

Richard B. Caldwell
Portland, Ore.

Several equations were omitted from the article because of their complexity. However, it turns out that the combined resistance of $R_s + R_m$ *shown in Fig. 1 should total* 9450 *ohms. When building this bridge, use a variable potentiometer for* R_s *and adjust its resistance to calibrate the bridge as shown in the last paragraph. This will also take into account various values of meter resistance* (R_m) *that might be encountered.—Editors.*

* * *

DESIGN OF TRANSISTOR MV'S

To the Editors:

You should be commended for publishing such an enlightening article as appeared in the February issue, "Design of Transistor Multivibrators" by Louis E. Frenzel, Jr.

This article should appeal to many interested in experiments of this type, as all the basic formulas are clearly described along with their practical use. Few books give such a wealth of information in so few words.

Also, I built the "Triggered Sweep for Improving Scopes" by Merlyn W. Barth in your January issue. It works extremely well, though I use only eleven sweep rates since the unit was contained in a box 6 x 9 x 5 inches.

Philip Brassine
Seattle, Wash.

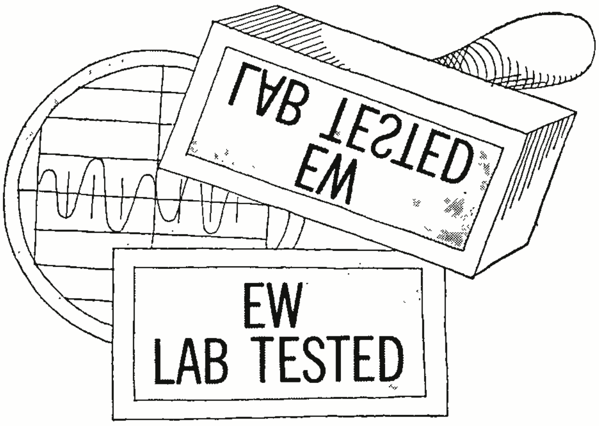
* * *

TRANSISTOR POWER SUPPLY

To the Editors:

In my article "Designing a Transistor Power Supply" (May, 1965 issue), equation (B) on p. 47 is incorrect. The term $V_{1\,min}$ should be $V_{1\,max}$.

Thomas J. Barmore
Seattle, Wash. ▲



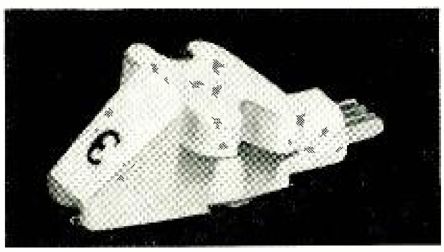
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Euphonics "Miniconic" Cartridge

Euphonics "Miniconic" Cartridge

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



PRACTICALLY all phono cartridges operate by either magnetic or piezoelectric generation of a voltage due to the deflection of a stylus. Other operating principles are possible, such as FM modulation of an r.f. signal or detecting groove modulation by means of a strain-gage element.

The new *Euphonics* "Miniconic" cartridge is a strain-gage pickup of novel construction. It contains two small semiconductor elements whose resistance varies as a function of their deflection by the stylus bar. Strain gages have been employed as phono elements in the past (before stereo), but have not proved notably successful. For one thing, conventional strain gages are not well suited, physically or electrically, to the requirements of playing a stereo record.

The "Miniconic" cartridge uses two silicon elements, each measuring only 0.008" x 0.005". They are sealed in silicon dioxide for protection, and are driven from the stylus through an X-shaped yoke resembling those used on many ceramic cartridges. The elements are housed in a very light plastic case, weighing only 2 grams. A separate power-supply unit is required to operate the cartridge with conventional amplifiers.

In the small power unit, measuring 4"x1⅝"x2½", is a power supply for the elements and two transistor amplifiers. A d.c. current of about 6 ma. is passed through each silicon element, whose resistance is approximately 800 ohms. As the element is deflected by the stylus, its resistance changes slightly, producing a varying drop across its terminals. This voltage is a.c.-coupled to a single-stage amplifier, whose output is nominally 0.4 volt from a typical record. The cartridge is mechanically equalized for the RIAA playback characteristic, which is not far from a constant-amplitude characteristic. An *RC* network in the output circuit converts the normal output to a velocity characteristic and attenuates it to about 8 mv. for connection to the normal magnetic input terminals of an amplifier. A switch on the power unit selects either "H(igh)" or "L(ow)" outputs.

Many arms, designed for conventional cartridges with masses of 5 to 12 grams, cannot be balanced with the 2-gram *Euphonics* cartridge. Weights are provided to be added to the cartridge shell if this should happen. The manufacturer also makes its own arm, whose low mass permits the maximum advantage to be obtained from the cartridge.

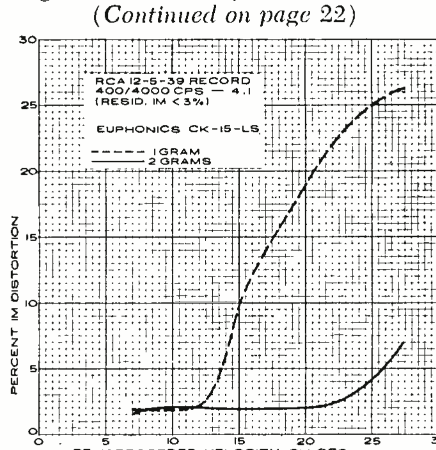
The unit we tested was the CK-15-LS (consisting of U-15-LS cartridge plus matching power source), designed for installation in conventional arms of good quality. It has a bi-radial diamond stylus, easily replaceable by the user, with a rated compliance of 25×10^{-6} cm./dyne. We measured its performance in a high-quality arm of relatively high mass.

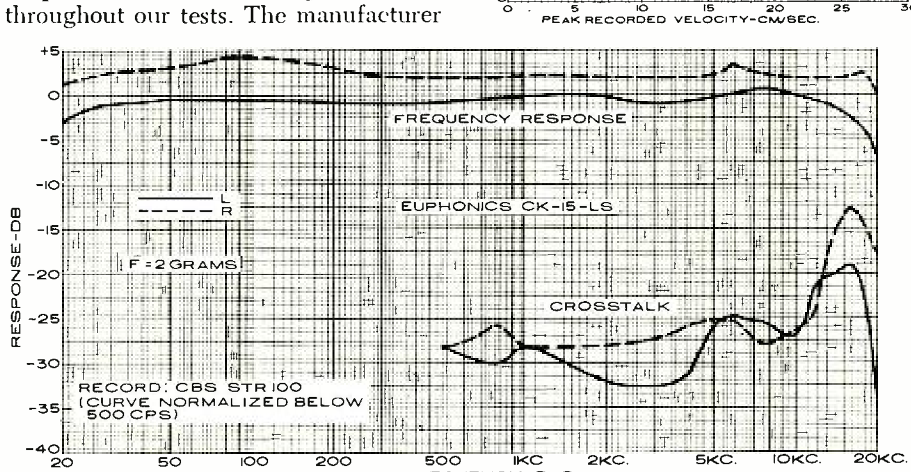
The cartridge tracked our high-level *Cook* and *Fairchild* records at only 1-gram stylus force, matching or surpassing any other cartridge we have tested in this respect. We used a 1-gram force throughout our tests. The manufacturer recommends a range of from ¾ to 1½ grams.

The measured vertical stylus angle was 18 degrees. The output of the cartridge, with a recorded velocity of 3.54 cm./sec. at 1000 cps, was 13 mv. per channel on the "L" outputs and 0.38 volt per channel on the "H" outputs. If the preamplifier to which the cartridge is connected has a setting or an input for high-output magnetic cartridges, this should be used since the cartridge has about twice the output of most magnetic cartridges. In most cases, the manufacturer suggests (and we agree) that it would be preferable to use the "H" outputs connected to the "Aux." or other high-level amplifier inputs.

The cartridge is totally insensitive to magnetic hum fields, of course. Unlike

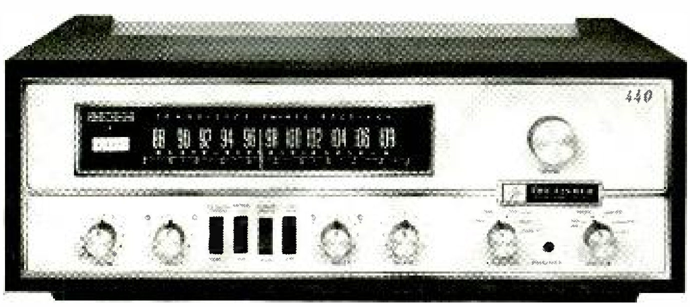
(*Continued on page 22*)





Introducing the first solid-state stereo receiver of Fisher quality under $330.

It is not easy to make an all-in-one receiver that equals or surpasses the performance of comparable separate components. It is even more difficult to adapt the complex new technology of transistor circuits to simple, reliable, integrated stereo receiver design. But to do *both* at a truly moderate price takes almost occult powers. Or Fisher engineering.



It is with exceptional pride and an unprecedented sense of achievement that Fisher introduces the 440-T stereo receiver, a no-compromise, all-transistor instrument suitable for the most advanced audio systems and selling for only $329.50. (Cabinet, $24.95.)

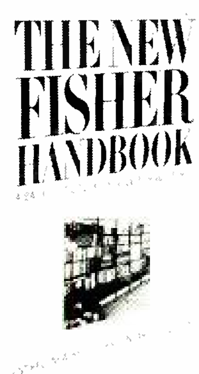
On a single, compact chassis only 11 inches deep and occupying only 16¾ inches of shelf space, the 440-T incorporates a superb, all-solid-state FM-multiplex tuner with automatic mono-stereo switching, an extremely versatile stereo control-preamplifier, and a heavy-duty, silicon-powered stereo amplifier. All the stereo electronics you are ever likely to need, all with Fisher reliability.

The Fisher 440-T fairly bristles with engineering innovations, convenience features and Fisher exclusives. Read the specifications on the right and convince yourself. Then ask your Fisher dealer for a demonstration. We predict you'll walk out with a 21-lb. package under your arm.

Features and Specifications

- *No output transformers—therefore no limitation of bass performance or of transient response because of transformer characteristics.*
- *Silicon output transistors for conservative operation at high power. Massive heat sink. Power output is 70 watts (IHF) at 4 ohms, 50 watts at 8 ohms.*
- *New all-transistor front end with 4-gang tuning condenser for highest sensitivity and lowest noise, plus overload rejection unexcelled by vacuum-tube front ends. Sensitivity is 2.0 μv (IHF); signal-to-noise ratio is 68 db at 100% modulation.*
- *Four wide-band IF stages and three limiters.*
- *Wide-band (one megacycle) ratio detector of highest linearity and lowest distortion, capable of unusually accurate detection of multiplex signals.*
- *Exclusive Fisher* STEREO BEACON* *for automatic switching between FM-mono and FM-stereo modes, and automatic visual indication of stereo broadcasts. No relays, no clicks.*
- *Professional d'Arsonval-type tuning meter.*
- *Highly effective muting between stations.*
- *Convenient speaker selector switch.*
- *Size: 16¾" wide, 5⅛" high, 11" deep (12⅜" overall, with knobs). Weight: 21 lbs.*

*PATENT PENDING



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The Fisher 440-T

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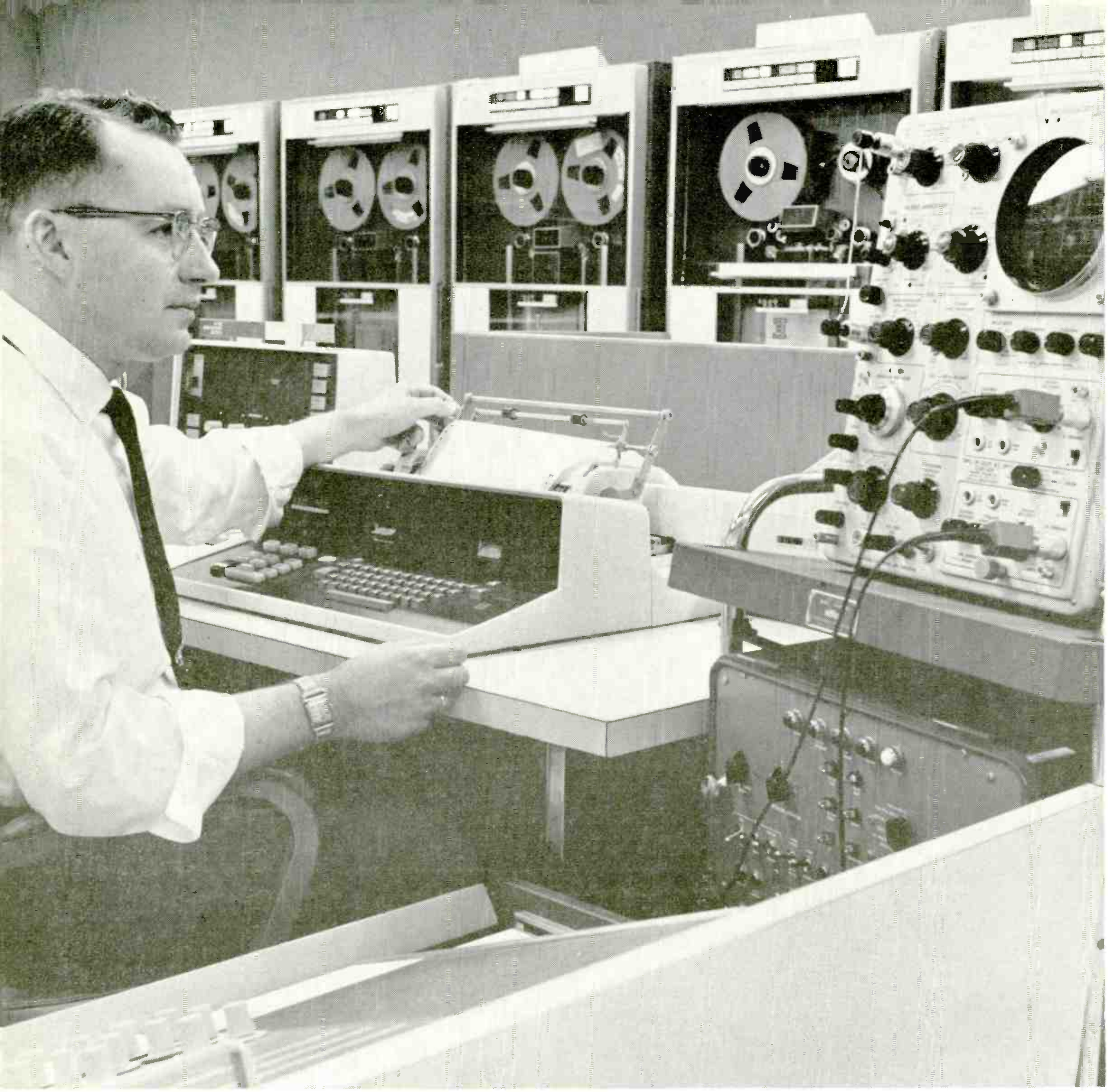

Why Fred got a better job . . .

I laughed when Fred Williams, my old high school buddy and fellow worker, told me he was taking a Cleveland Institute Home Study course in electronics. But when our boss made him Senior Electronic Technician, it made me stop and think. Sure I'm glad Fred got the break . . . but why him . . . and not me? What's he got that I don't. There was only one answer . . . his Cleveland Institute Diploma and his First Class FCC License!

After congratulating Fred on his promotion, I asked him what gives. "I'm going to turn $15 into $15,000," he said. "My tuition at Cleveland Institute was only $15 a month. But, my new job pays me $15 *a week* more . . . that's $780 more a year! In twenty years . . . even if I don't get another penny increase . . . I will have earned $15,600 more! It's that simple. I have a plan . . . and it works!"

What a return on his investment! Fred should have been elected most likely to succeed . . . he's on the right track. So am I *now*. I sent for my three *free* books a couple of months ago, and I'm well on my way to Fred's level. How about you? Will you be ready like Fred was when opportunity knocks? Take my advice and carefully read the important information on the opposite page. Then check your area of most interest on the postage-free reply card and drop it in the mail *today*. Find out how you can move up in electronics too.

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

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

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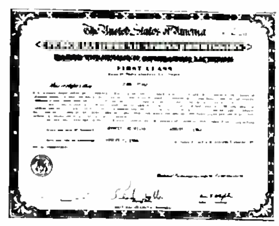

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3. Broadcast Engineering

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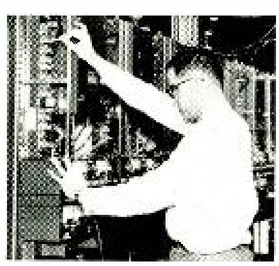

Mobile Radio, Microwave, and 2nd Class FCC preparation are just a few of the topics covered in this "compact" program . . . Carrier Telephony too, if you so desire.

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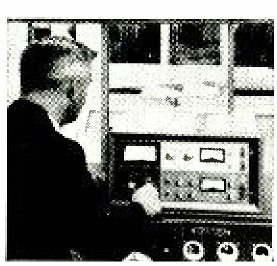

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1776 East 17th Street, Dept. EW-7, Cleveland, Ohio 44114 ceramic cartridges, it is also insensitive to electrostatic hum fields. The silicon elements have such a low impedance that in most cases even lead shielding is unnecessary. Only ground loops remain as a possible source of hum. If it is correctly installed, the "Miniconic" is perhaps the most basically hum-free cartridge on the market.

The IM distortion (measured with the *RCA* 12-5-39 record) was very low over the entire range of velocities likely to be encountered on a stereo record. At 1.5- to 2-grams force, it remained low to nearly the highest velocities on our test records. The frequency response was unusually flat and peak-free over the entire audio range. On one channel it was within ± 1.5 db up to 20,000 cps; on the other it dropped off slightly from 12,000 cps. We would certainly confirm the *Euphonics* claim of ± 2 db response from 20 to 20,000 cps.

Channel separation was better than 25 db up to 11,000 cps, and better than 15 db all the way to 20,000 cps. The square-wave response was one of the best we have observed on a cartridge, with only a single small overshoot on the leading edge of the 1000-cps square wave on the *CBS Labs* STR110 record.

In its sound, the CK-15-LS was as good as its measurements suggest. It is clean, sweet, and uncolored. Its sound is very full, with no portions of the spectrum apparently emphasized or diminished. The total absence of hum makes it especially enjoyable at high listening levels. The "H" outputs sounded almost identical to the "L" outputs, equalized in a good-quality preamplifier. However, the low-frequency response in the "H" position seems to extend an octave or two lower than in the "L" position (where it is limited by the equalization of the preamplifier). As a result, subsonic rumble can cause amplifier overload and speaker cone flutter at high playing levels. Hence, we would recommend this method of operation only with the finest auxiliary equipment, or when the *Euphonics* arm is used (giving a system cut-off of slightly below 12 cps).

The response of the cartridge actually goes to d.c., but because of the matching amplifiers the system is restricted to a lower limit of a few cycles. This is desirable to reduce the effects of record eccentricity and warpage on the output, particularly when a high-mass arm is used. With top-quality auxiliary equipment, the cartridge is capable of a fidelity of response which rivals anything we have heard.

The CK-15-LS sells for $55. For installation in record changers or massive tonearms, the CK-15-P is available, with a 0.5-mil conical stylus of lower compliance, for $39. The TK-15-LS system, with the CK-15-LS cartridge in the low-mass *Euphonics* arm, is $87.50. ▲

Zip through Scott's new solid state FM stereo tuner kit in one afternoon

Four to six hours! That's all you need to zip through Scott's new LT-112 solid state FM stereo tuner kit. All you do is complete five simple wiring groups and breeze through an easy new 10-minute alignment. You can actually start after lunch and enjoy superb FM stereo at dinner.

Scott solid state circuitry is the key to the LT-112's superior performance. Costly silicon transistors, three IF stages, and three limiters give the LT-112 a usable sensitivity of 1.9 uv, selectivity of 45 db . . . performance unapproached by any other kit on the market. The LT-112 is actually the kit version of Scott's best-selling 312 solid state factory-wired stereo tuner, of which AUDIO said, ". . . it is one of the finest tuners Scott makes. And that means it is one of the finest tuners anywhere."

All Critical Circuitry Pre-Wired

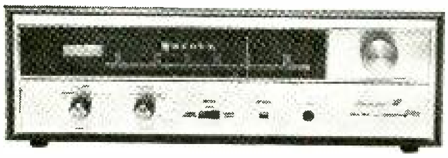
To insure perfect results, your LT-112 arrives with all critical circuitry pre-wired, pre-tested, pre-aligned, and mounted on heavy-duty printed circuit boards. Wires are all color-coded, pre-cut, and pre-stripped to the proper length. Scott's exclusive life-size. full-color construction book fully details every step . . . makes perfect wiring almost automatic.

You'd never believe a kit so easy to build could be so packed with features. Built right into the LT-112 is a brand-new Scott invention . . . the Tri-modulation Meter. A convenient front panel switch lets you use this Scott exclusive as:

1. A signal-Strength Indicator . . . for proper antenna orientation and coarse tuning.
2. A Zero-Center Indicator . . . for extremely accurate fine tuning of very weak or very strong stations. Accurate tuning is essential to minimum distortion and maximum separation.
3. A precision Alignment Meter that enables you to align your tuner, anytime, with absolute accuracy . . . a procedure that previously required the use of a $500 test instrument.

For your further listening enjoyment, the LT-112 is provided with three stereo outlets . . . one of them conveniently located on the front panel (you can connect a portable tape recorder without disturbing the installation of the tuner). Output level controls on the rear of the unit need be set only once, so you don't have to be bothered about duplication of controls.

Stop in at your Scott dealer's today, and pick up an LT-112 tuner kit . . . $179.95 plus one enjoyable afternoon will net you a lifetime of listening pleasure.



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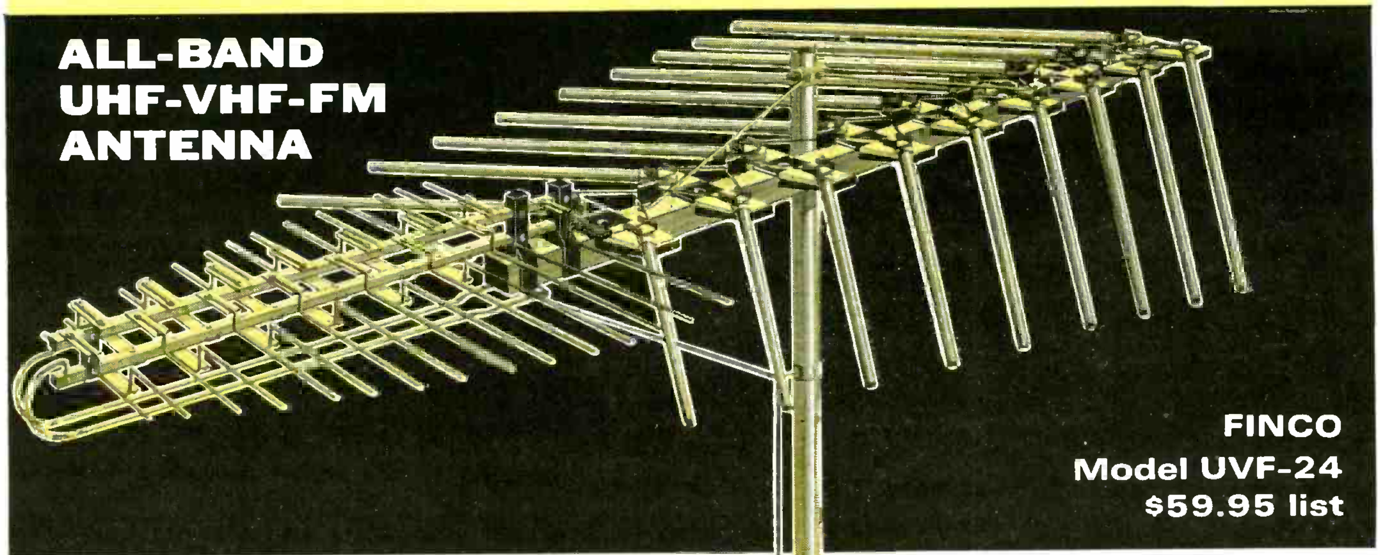
FOR UHF, VHF, FM RECEPTION



The one antenna that does the work of 3! Gives startlingly clear black and white pictures and beautiful color on **both** UHF and VHF television channels — plus the finest in stereophonic and monophonic sound reproduction.

FINCO Model UVF-18—$42.50 list
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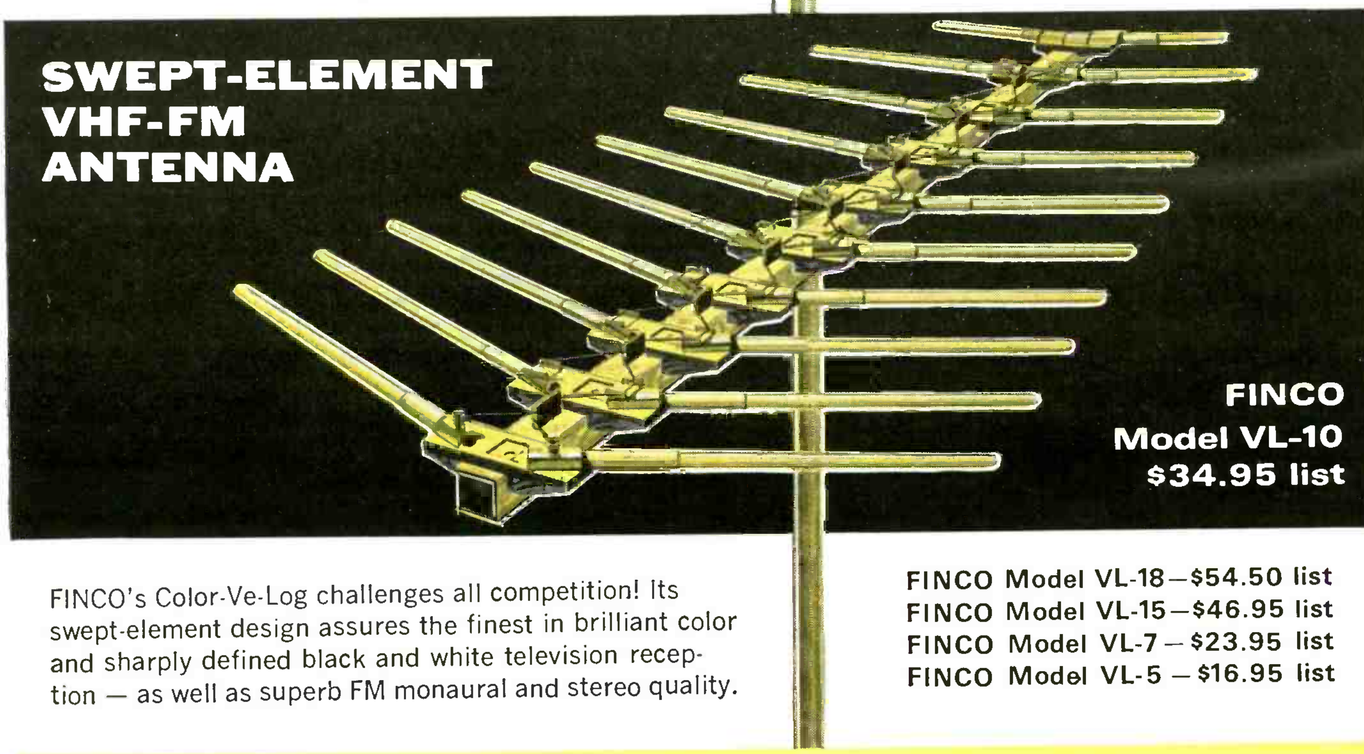

FINCO's Color-Ve-Log challenges all competition! Its swept-element design assures the finest in brilliant color and sharply defined black and white television reception — as well as superb FM monaural and stereo quality.

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ABOUT THE AUTHOR

John A. Kennedy is an electronics engineer, a businessman, a civic leader, and a politician. He is founder and president of James Electronics Inc., a Chicago firm that produces choppers, power vibrators and converters, and miniature transformers for the instrumentation field. He is now chairman of the Council of Economic Advisors to the State of Illinois and is a member of the Governor's Science Advisory Board. Mr. Kennedy is also a Representative in the Illinois General Assembly. One of his aims is to increase the importance of the entire Midwest area especially in the field of electronics.

Midwest Electronics–

A Changing Pattern of Growth

By JOHN A. KENNEDY

A new and stable pattern of growth is emerging in this area as a result of a second post-war boom in consumer products, the industrial controls revolution, and the R & D output of the region's vast university complexes.

MIDWEST electronics was in the depths of an economic, technical, and morale depression in the late fifties—and for good reason. The electronics industry which, nationally, was acclaimed the "growth" industry of the future was—in the Midwest—following the region's dismal industrial and manufacturing pattern of contracted activity, restricted income, an exodus of managerial and technical personnel, and growing unemployment. Opportunities in electronics were few and far apart in the Midwest, as any 1960 survey disclosed.

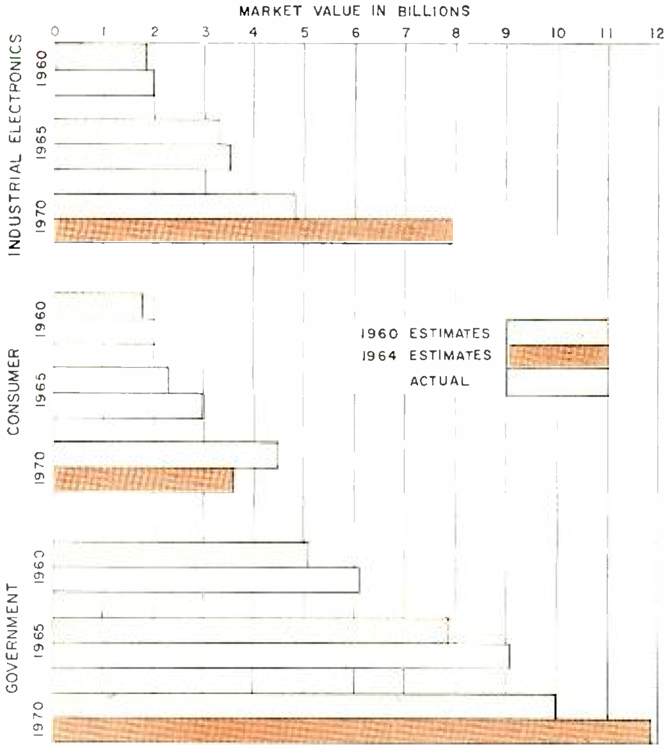
The boom in government electronics and manufacturing, resulting from the demand for missiles and complex defense systems, had reached its maximum growth in the 1960-61 period. The impact of the nation's space program was obviously going to follow the pattern of the defense boom and bypass the Midwest region. The projections in 1960 for the future with continued growth in government electronics, moderate expansion of industrial electronics, and an actual contraction of consumer electronics, painted a depressing picture for the Midwest.

As is sometimes the case, these projections were wrong. Comparison of 1960 estimates with 1965 reality and 1964 projections indicate how the picture has changed (Fig. 1).

Midwest's Role in Electronics

The demand for mass-produced communications and electronics material for World War II sealed the fate of Midwest electronics as the mass-production center for industry. Over 58% of the nation's electronics manufacturing industry was

Fig. 1. Market estimates and annual value of U.S. electronics.



Map of Midwest Region

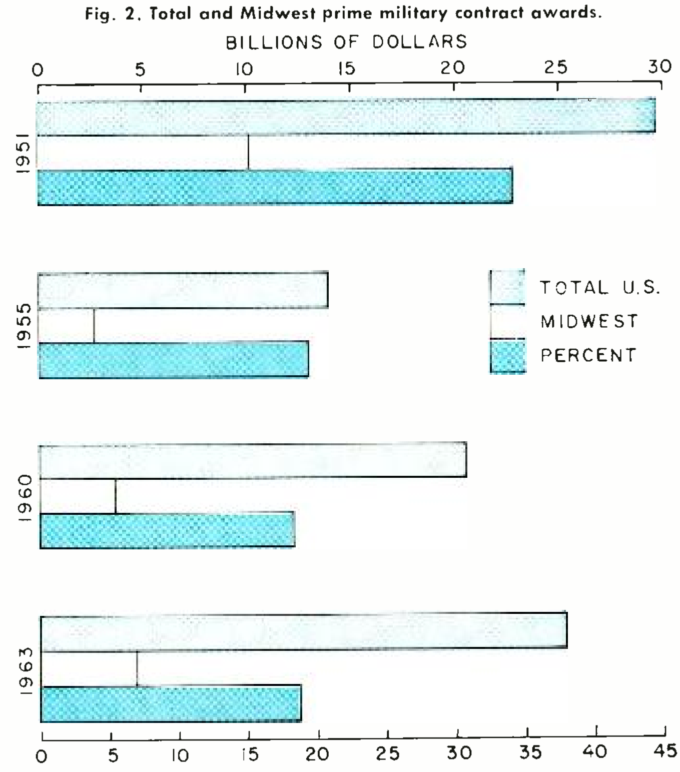
Midwest as % of National Total	
Population	28.8%
Value Added by Mfg.	35.4%
Master's Degrees Conferred	34.4%
Federal Revenue Collections	32.4%

concentrated in the Midwest at the end of the war. The pent-up demand for radios and then television pointed the direction for the region's managers and facilities to go. The *Zeniths*, *Admirals*, *Motorolas*, and others continued their Midwest domination of what was then considered "electronics."

The growth of the electronics industry in the 1946-53 period in the Midwest brought with it a similar growth in employment. Engineers and technicians were in critical demand. The pattern of this early post-war growth was followed by the contraction of the fifties and the brightening future of the sixties for the Midwest electronics industry.

The demand for consumer products, including electronics, leveled off in the period following the Korean War. Since the Great Lakes region was predominately dependent on these markets, there was a period of stagnation in the growth of electronics, manufacturing, employment, and the region's personal income. The area's personal income had traditionally led the nation's average. The post-war industrial expansion for the region carried average personal income from 108% of the national average in 1946 to 115% in 1953, but the slowed

Fig. 2. Total and Midwest prime military contract awards.



economic growth of the region in the late fifties dropped the percentage to 106% in 1961. Since that time, the downward trend has been reversed and is estimated at 108% for 1965.

Military and Space Electronics

A great deal has been written about the failure of the Midwest electronics industry to actively seek a portion of the growing military/space electronics market of the fifties. That it was unable to penetrate this market is another of the remarkable cases of the effect of supply and demand and our democratic economy.

In the 1950-55 period, the facilities, personnel, and management of electronics firms were fully occupied in meeting the continuing demand for its traditional consumer products. The West Coast and, in particular, the aircraft industry had virtually no consumer market so they aggressively solicited and attracted this new military market for complex systems. The same was true of the New England area, suffering from the exodus of the textile industry. By the time the declining consumer market of the late fifties began to worry the Midwest, the new sources for military/space electronics had been established. A chart of federal contracting comparing the Midwest region and the nation is shown in Fig. 2.

Future Growth

There have been three major changes in the growth pattern for the electronics industry in the 1960-65 period. The very concentration of mass production which was the cause for contraction is now healthy and growing and, in turn, providing the real markets for industrial electronics. The consumer market in all electronic products has grown at a faster rate than predicted. The advent of color television, tape and stereo sound, and Citizens Band communications has contributed to the month-in, month-out growth and stability. The periodic rise and fall of radio and TV production in the 1950's has given way to a broader line of products sold throughout the year.

The high personal income rate in the Midwest and its subnational unemployment rate (4% for the region as against 5.1% nationally) have created a large market in itself for consumer electronics. This market also means a larger service industry. The maintenance and installation needs of the entire area are suffering from a lack of qualified technical personnel who are, in addition, good businessmen.

Industrial Electronics

The growth of electronic equipment as a tool of production and service has been more phenomenal than even space and defense efforts. Chicago is now known as the most rapidly automating city in the world. This automation is affecting all industries. This increase in automated production has allowed the Midwest to remain competitive in world markets—while increasing its share of foreign sales.

Automation depends on the marriage of electronics to mechanical and hydraulic systems. The Midwest has created its own need for such systems and its own systems capability. The metal-processing industries, for example, use electronics as the basis of control in planning, controlling, testing, producing, and even selling. This area application has given rise to a growing number of firms which provide the systems fueling this automation explosion. Large firms in the chemical, automotive, and primary metals industries are turning to complete in-house design, construction, and maintenance.

The demand for qualified men in this new application of all forms of electronics is enormous. From technicians to engineers and scientists, there is a growing need for personnel.

Communications

The Midwest has traditionally been the center of telephone equipment manufacturing. The plants of *Western Electric*, *Automatic Electric*, *Teletype*, *Kleinschmidt*, and *ITT-Kellogg*

EMPLOYMENT OPPORTUNITIES

CONSUMER

- Growing production of radio, television, video tape, and sound equipment.
- Installation and maintenance in an area market that has abnormally high personal income and demand for service.

INDUSTRIAL

- Rapid expansion of process-control systems to automate the world's largest concentration of production facilities.
- Continued growth of telephone and radio communications manufacturing industry—the largest in the nation.
- Reorientation and continued growth of the Midwest's component and subsystem industry.
- Design, installation, and operation of automated data-processing systems for manufacturing and service industries.
- Electronic aids to education: visual, aural, and computational.
- Biomedical electronics based on a unique concentration of engineering, medical research and training, pharmaceutical and medical production, and clinical facilities.
- Increasing demand for nuclear application and control in power, industrial, and medical applications.

MILITARY & SPACE

- Expanding university research requiring all levels of technical help.
- Growing private and government research laboratories in basic and applied products and systems.
- A rising demand for mass-produced electronics products for limited warfare.

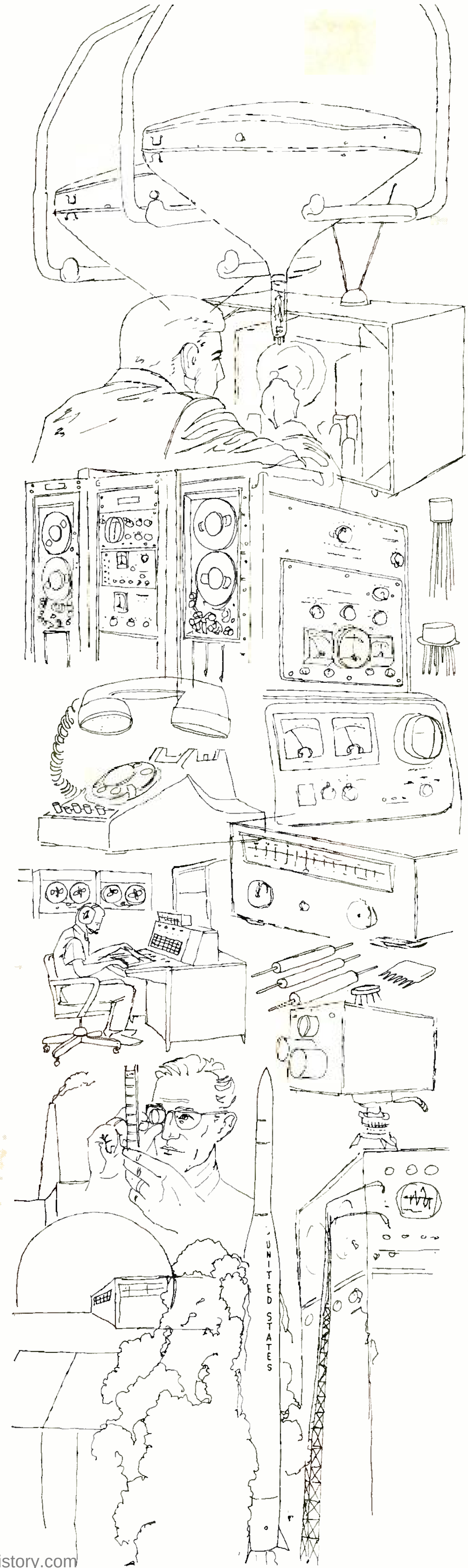
produce the major portion of all land communications equipment. This equipment is undergoing a technical revolution. The totally automated long-distance dialing system, made possible by electronics, is a proven goal. Now the full application of solid-state devices promises new services and even greater reliability.

The *Bell System* is constructing a new research laboratory in Illinois which will be dedicated to the development of new families of transistorized telephone systems. These developments will stimulate the volume production of solid-state systems at various plants in the area.

Components

The Midwest has retained a major part of the electronic component industry. This segment of the industry has prospered with the continuing demand for consumer products. Giants in the field like *Allen-Bradley*, *CTS*, *Mallory*, and many others have exhibited surprising imagination and skill in innovating new components and subsystems, thus retaining their market positions.

There has been little production of solid-state devices in the Midwest area; this must be considered a serious problem for the future. As the use of solid-state devices has grown so will the mass application of complete modular or integrated electronics. Such a development could disrupt and diminish the market for Midwestern component makers. There is considerable research underway in the area dealing with modular



	Prime Contracts $Millions	%	R&D Contracts $Millions	%
U. S. TOTAL	3,787	100	2,667	100
Midwest States				
Ill.	14.3		14.3	
Ind.	4.1		4.0	
Iowa	2.8		2.8	
Kans.	0		0	
Mich.	24.1		24.0	
Minn.	5.9		5.8	
Mo.	264.9		264.9	
Neb.	0		0	
N. Dak.	0		0	
Ohio	163.7		75.5	
S. Dak.	0		0	
Wis.	2.3		2.3	
TOTAL	$482.1	12.7%	$393.6	14.8%

Table 1. NASA contracts in 1963 in millions of dollars.

electronics and, if successful, could result in the application of these makers' mass-production skills to this inevitable new electronic development.

The Midwest has been one of the largest customers for computers for research, industrial, and commercial use. Some 34% of the installations are in the 12 midwestern states to service 28.8% of the nation's population.

Computers are manufactured in the area. *Control Data* of Minneapolis has a major share of the large scientific computer market. *NCR* and *Burroughs* both have wide experience and many computer installations in the commercial field. The Midwest will gain in this market because of the growth in its existing manufacturing plants and from the expansion of the "soft-ware"products required for these systems.

There will be a steadily growing industrial market in educational electronics. Many Midwest manufacturers are already producing audio aids and a large market for video tape systems is projected. Mass-production capability of the area, plus marketing experience will again play a key role in capturing a lion's share of these markets.

The use of electronic systems will also play an important part in medical care during the next decade. The medical instrumentation market already provides an estimated $350-million for this year. This figure is expected to reach $500-million by 1970. A large part of this equipment is electronic.

The large concentration of medical schools, research clinics, and research-oriented hospitals in the 12-state area has already been responsible for the rapid growth of the interdisciplinary programs of electronic engineering and medicine.

The nation's first biomedical school has been operating at Northwestern University since 1962. Such schools create graduated PhD's in a field that intermingles biology, medical practice, and engineering. They will be a key force in this new industrial electronic field.

Biomedical instruments have been developed and will be devised using many new techniques involving ultrasonics, nuclear radiation, and computer analysis, giving the doctor new and rapid information about his patient.

Table 2. Portion of military contracts in electronics field.

Year	Total $Billions	Electronics $Billions	% of Total
1958	39.06	4.38	11.2
1960	41.21	5.67	13.8
1962	46.8	7.07	15.1
1964	49.5	7.82	15.8

These new instruments are generally being developed and marketed by Midwest firms. In some instances, combinations of electronics manufacturers join forces with medical/pharmaceutical suppliers in developing this equipment. Examples of such "marriages" include *Nuclear-Chicago* and *Abbott*, and *Zenith* and *Baxter Laboratories*.

The future of biochemical electronics is a bright one that will generate all levels of technician and engineering employment. This will include those needed for manufacturing the product as well as those needed to install and maintain it.

The 12-state Midwest area is the nation's center for nuclear instrumentation. Major firms are located in the Chicago area, Ohio, and Wisconsin. The broadening application of nuclear energy and radiation techniques has provided firm growth to the industry. This is fed from Argonne National Laboratories, the MURA complex in Madison, Wisconsin, and the medical research programs in the area.

Electronics is the key to nuclear instrumentation and, once again, the field will depend on mass production and on industrial marketing as it grows steadily.

Military procurement fell off as a percentage of the national total from the Korean War peak. The area received 34.3% of prime military contract awards in 1951. This fell to a low of 17.6% of the nation's total in 1961, but has slowly risen to 18.9% in 1963 and is continuing to rise. This will not attain the levels of the early 1950's or World War II unless there is growth in the need for material for traditional land warfare of the Korean and Viet Nam type. This is the sort of electronics gear that the Midwest still supplies in volume.

There have been few "systems" contractors in the Midwest area. This will continue to be a major factor limiting growth in military/space programs. These conditions will not change until major managements with large resources make a decision to enter this complex field. The current prosperity of the consumer and industrial markets makes major change unlikely.

The Midwest has a vast base of scientific education and research in its university complexes. It produces 34.4% of the Masters Degrees conferred and 30.5% of the doctorates. This graduate work has attracted broad support from federal agencies in research. This requires laboratories, technicians, and supporting industry.

The Midwest is gradually overcoming the problem of too little communication among this federally supported research, the area's industry, and its own research and development programs. The value of industry-university cooperation has been demonstrated in other areas of the nation. It is now being recognized as a very important flow pattern for a whole host of new ideas in the Midwest.

A Brightening Future

Midwest electronics has recovered from the stagnation of the 1950's. It is now growing, in total, as fast as the rest of the nation and from a substantial and diversified base.

It is keeping its scientific and engineering graduates. The University of Illinois, which graduates more engineers than any other school in the country, is an example of this new trend. In June of 1963, only 27.78% of its graduates obtained positions in Illinois while 17.23% went to California. By 1964 Illinois retained 45.28% and the Midwest as a whole gave employment to 73.43% while only 8.23% obtained their first jobs in California. This trend continues in 1965.

The region is a natural market for industrial automation and every indication is that it will build its own systems capabilities.

Consumer electronics continues to grow and the region appears to be holding its large share of this market.

The Midwest must move rapidly into the newer fields of electronics. It cannot be complacent over its new vitality. There is a new spirit that gives promise to the future, which can make electronics a vital artery feeding the industrial heartland of our country. ▲

New Shielded Twin-Lead for Color TV & U.H.F.

By ROLAND MIRACLE, Engineer, Electronics Div., Belden Mfg. Co.

Recently introduced TV receiver lead-in has the advantages of coax but has lower losses, is balanced to ground, and does not need special fittings. Here is a report on the performance of this new line.

Editors Note: Our July 1965 issue contained an article on "Coax vs Twinlead" by Lon Cantor of Jerrold Electronics Corp. in which the advantages of a shielded type of lead-in over conventional flat twin-lead were given. Our September issue contained an interesting letter from Ed Finkel, JFD Electronics Corp., commenting on this article and giving some arguments in favor of the use of twin-lead. In our remarks at the end of this letter, we indicated that work was being done on a shielded 300-ohm twin-lead which should possess the advantages of both coax and twin-lead. We promised technical information on this new line, along with results of performance measurements. The following article contains this information.

INDUSTRY spokesmen have predicted that by 1969 American TV viewers will have purchased 15 million color-TV sets along with 50 million sets capable of receiving u.h.f. programs. This means that manufacturers of television receiving equipment must respond by producing

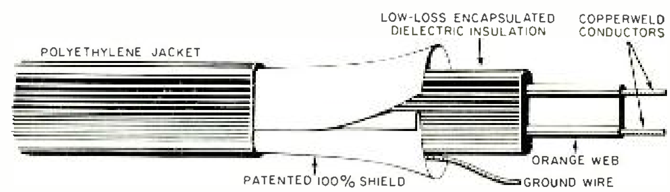


Fig. 1. A stripped-down section of the shielded twin-lead.

not only TV sets incorporating new and advanced circuitry, but must also provide a complete selection of auxiliary components designed specifically for this new market. A new shielded 300-ohm twin-lead TV lead-in, called "Shielded Permohm" by its manufacturer, *Belden Mfg. Co.*, eliminates many of the color and u.h.f. reception problems caused in the past by installing transmission lines which were designed for reception of black-and-white v.h.f signals.

This shielded twin-lead incorporates a total shield—a wrap of thin aluminum foil, and a (*Continued on page 94*)

Fig. 2. Effects of ignition interference using three down-leads. Left, unshielded twin-lead; center, coaxial cable; right, shielded twin-lead.

Fig. 3. Laboratory attenuation data shows that the shielded twin-lead has somewhat greater losses than the unshielded type.

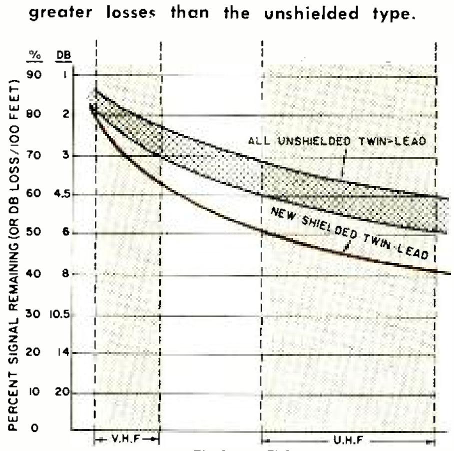


Fig. 4. In a typical installation, however, losses of unshielded twin-lead increase substantially, especially for flat-ribbon.

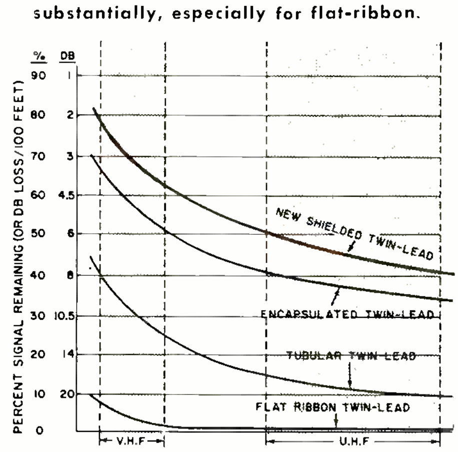
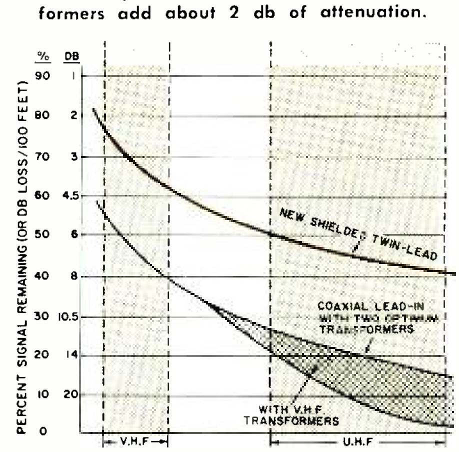
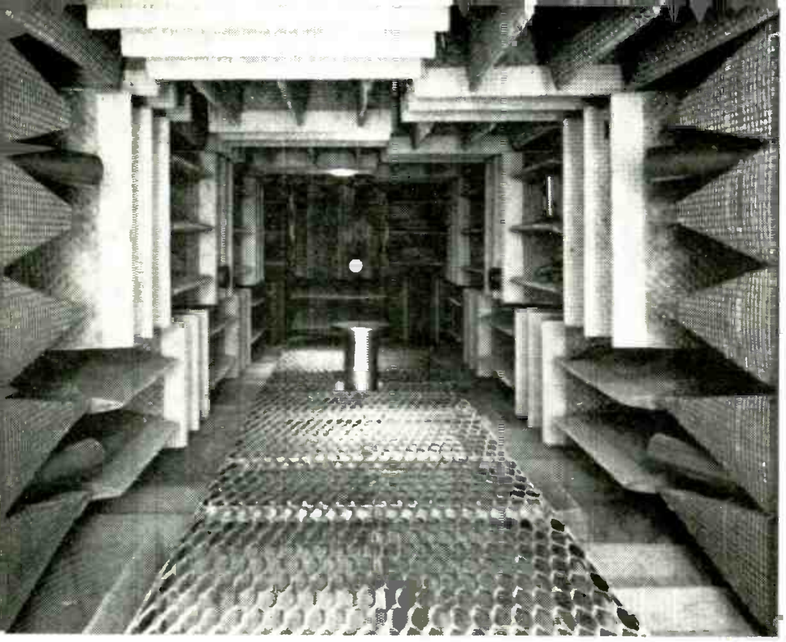


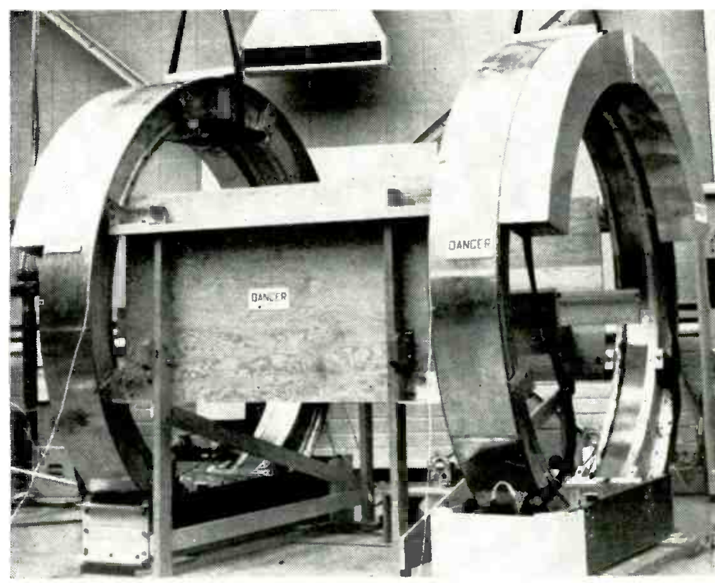
Fig. 5. Attenuation data for shielded twin-lead compared to coaxial line. The transformers add about 2 db of attenuation.



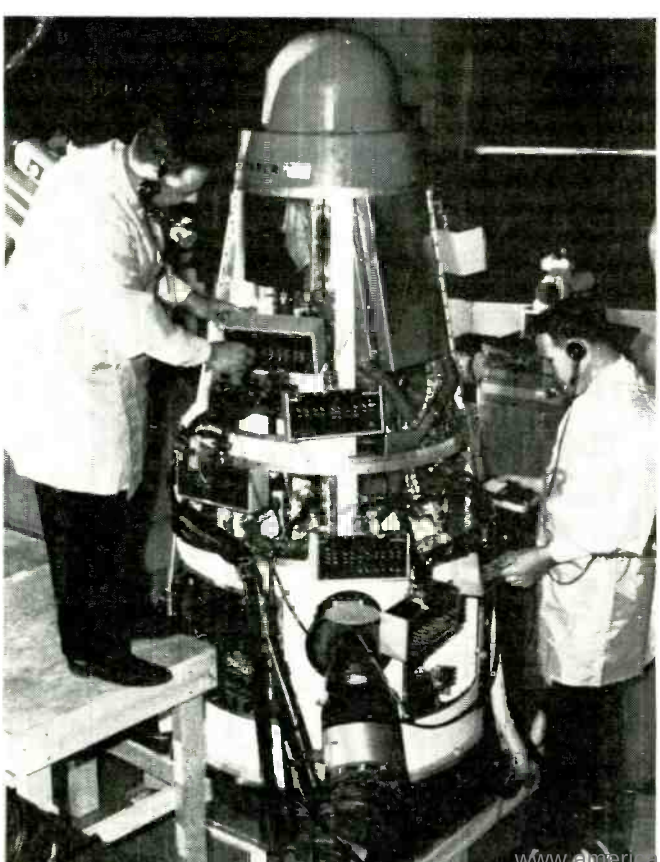


Anechoic Chamber on Wheels. (Left) Sound patterns of small arms and shock-wave intensities from small missiles can be measured in this mobile anechoic chamber that is housed within a 30-ft. trailer truck. In the center of the far wall is the hole through which small arms are discharged. Sleeves on either side wall permit missiles to be fired through the chamber so that shock waves can be measured. Pretested modular wedge units, having a low-frequency cut-off of 140 cps, form the chamber lining. These units are aligned so that when the chamber door is swung through a 180-degree arc, the wedges mounted on the door swing completely clear of the opening. To provide an attenuation of sound from outside to inside the chamber of from 20 db at 125 cps to in excess of 60 db above 1500 cps, the body of the trailer was modified. The mobile lab was built by Eckel Corp.

RECENT DEVELOPMENTS in ELECTRONICS



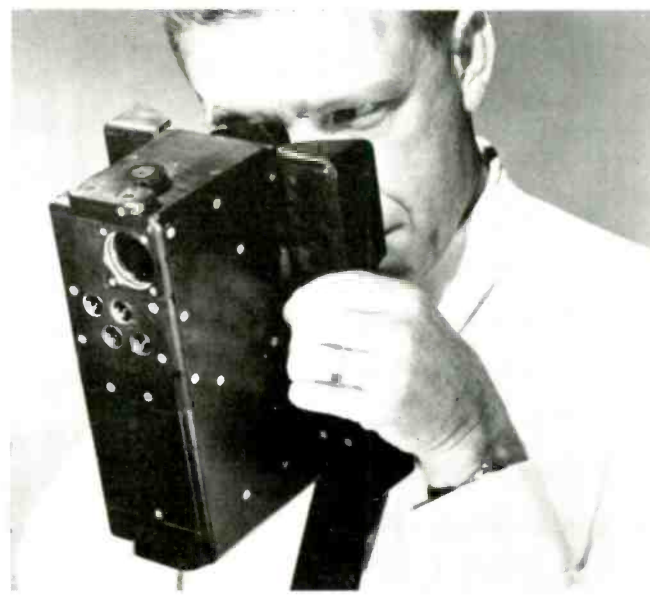
Giant Degaussing Coils. (Above) These two large coils were used to demagnetize the solar panels on the Mariner 4 spacecraft just before the start of its picture-taking and scientific data-gathering trip to Mars. A hoisting gear raises both coils simultaneously to align them with the earth's east-west magnetic direction. The wooden rails on the inside are slides for the solar panels, which are placed between the two coils for demagnetizing. Each coil is about 8 feet in diameter, weighs about 4000 pounds, and is made of 12 externally connected coils. After testing by Westinghouse, coils were shipped to Cape Kennedy.



Stellar Inertial Guidance System. (Left) Technicians are shown making final adjustments on the stellar inertial guidance equipment recently flight-tested by the Air Force. As with the seafaring navigators of old, sights on stars are used to determine position. The present system, designed for ballistic missile use, employs stellar sightings to correct for errors in the missile's guidance platform and helps guide the missile precisely to the target. As in conventional inertial systems, the stellar system operates only until booster cut-off. For prolonged space flights, inertial guidance would be in use throughout the journey. Any errors in the system would then accumulate with time. By tying in a stellar system, periodic in-flight corrections can be made. Equipment was designed by General Precision.

Home Video Tape Recorder. (Left) Still another video tape recorder for home use has been unveiled recently. This one is an Ampex unit selling for $1095 for a one-speed table-top model or for $1295 for a two-speed model. Prices do not include a TV camera. One-inch-wide tape moves past rotary recording and playback heads at 9.6 ips to provide high-frequency performance with relatively low tape consumption. A second speed of 4.8 ips cuts tape consumption in half and provides good quality recordings but not compatible with color. Maximum frequency response is just above 3 mc. at the higher speed, and over 2 mc. at the slower speed. A single reel of 1-in. tape, which will record an hour of TV picture and sound at the higher speed and two hours at the lower speed, will sell for approximately $65.

Space Laser for Astronauts. (Right) This six-pound laser transmitter will be used by one of our astronauts during the 14-day Gemini 7 mission scheduled for early next year. The narrow, intense light beam of the laser will be employed to make contact with the earth. The four small lenses are optics for an array of four room-temperature gallium arsenide laser light sources. The large opening is the telescopic sight used to aim the unit out of a Gemini 7 capsule window at a laser receiver beacon at White Sands Missile Range. The equipment, built by RCA, is completely self-contained. An attempt will be made to contact the ground with the laser pulsing 100 times a second. Then, the pulse rate will be upped to 7000 times a second and voice modulation from the astronaut will be applied.

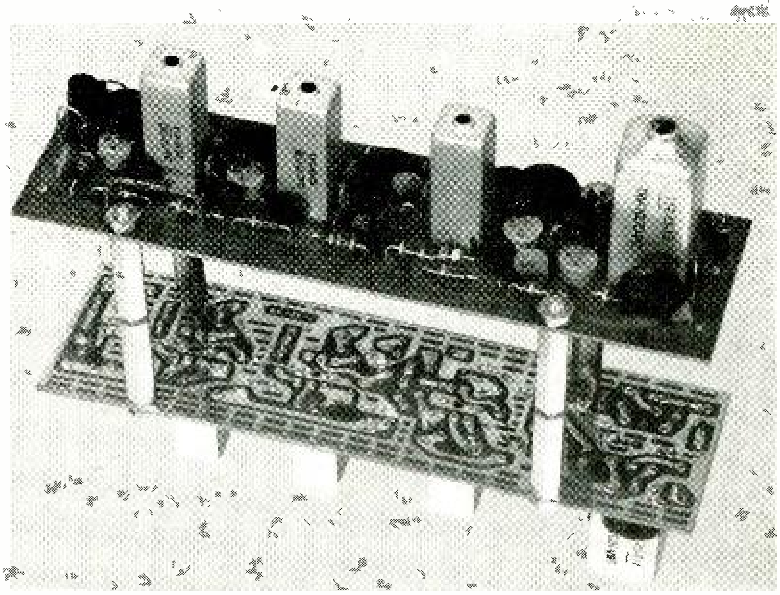


Computer-Assisted Instruction. (Left) The first test of its kind using the computer as an aid to the industrial training of employees at locations thousands of miles apart is now under way. The pilot study, conducted by IBM's Field Engineering Div., is testing the feasibility of using a computer and remote terminals to help train engineers who service the company's information-handling systems. Graphic display of training-course material and telephone communications are utilized. The headquarters computer analyzes the students' responses, checks their accuracy, and retains student performance data. The pace and content of instruction are set by the individual student.

Fault-Detection Tester. (Right) The Air Force is using a device that will forecast the airborne efficiency and accuracy of their weapons control systems while their planes are on the ground. The tester, mounted on a small trailer, is fitted over the nose cone of the aircraft. The device provides a simulated radar/infrared input enclosed in a compact, mobile anechoic chamber which shields the aircraft being tested from outside interference and simulates a target for the fighter's sensing devices. Included is a computer which stores standards and tolerances against which the various systems are tested. The system has been found to be 90 percent correct in locating malfunctions. It will be used both for troubleshooting and as a maintenance tester. The unit will not reduce the number of technicians required to perform the weapon control system checkout, but it will be a reliable, less expensive, and quicker method of testing. It completes a test in about 25 minutes.

SILICON TRANSISTOR I.F. AMPLIFIER FOR FM TUNER

By DANIEL R. von RECKLINGHAUSEN
Chief Research Engineer, H.H. Scott, Inc.



Complete i.f. strip is shown here. An additional i.f. transformer which precedes the first transistor is located in the front-end portion of the tuner. The subassembly was photographed over a mirror to show the printed circuit employed.

General requirements for high-fidelity tuner i.f.'s along with the design of a circuit that employs high performance, high-frequency silicon planar transistors.

EVER since the advent of transistors, attempts have been made to use them in almost any application where vacuum tubes had been used. Generally the approach was that with transistors it was merely necessary to eliminate the filament supply, use a lower supply voltage and lower value resistors, and add a bias resistor per stage. This approach works reasonably well when designing some audio circuits as most tube preamplifiers had been designed for triode operation and, after all, transistors behave much like triodes.

The next application for transistors was in AM receivers. Here the low power consumption of transistors is especially attractive. However, when trying to substitute a transistor in a tube circuit, all these transistor stages had a tendency to oscillate. To cope with this, an old circuit design trick of the 1920's was resurrected and neutralization was adopted.

Problem of Oscillation

As every designer knows, the most stable i.f. amplifier circuits can be made with tubes that have the lowest grid-plate capacitances. For this reason, a tube such as the 6AU6 with a grid-to-plate capacitance of 0.0035 pf. became a very popular i.f. amplifier tube. In transistorized circuits, base-to-collector capacitances of several picofarads or more are quite common. If transistors are connected into an i.f. amplifier without further consideration, the circuit will oscillate in the same way a tuned-grid, tuned-plate oscillator will oscillate.

Fig. 1 shows an amplifier which is assumed to have a high output impedance and high gain. Connected to it are an input circuit and an output circuit, both of which are tuned circuits. If the feedback capacitance did not exist, this overall circuit would act as an amplifier for high frequencies and, in particular, as an i.f. amplifier. However, as was mentioned before, there exists a considerable base-to-collector capacitance in every transistor, which acts as a feedback capacitor.

How can such a circuit oscillate? Assume that the signal at the output of the amplifier is out-of-phase with the signal at its input. If the output circuit is tuned to a frequency higher than the desired frequency, 45° phase shift can occur in this circuit at the desired frequency. The input circuit behaves the same way. This adds up to 90° and the additional 90° phase shift of the internal feedback capacitor will then result in a total phase shift of 180°, which is a phase reversal. Therefore, the signal returned to the input of the amplifier through the feedback capacitance is in-phase with the original input signal and thus adds to it. This is positive feedback. If the amplifier gain is high enough, this circuit will oscillate—which an i.f. amplifier should not do.

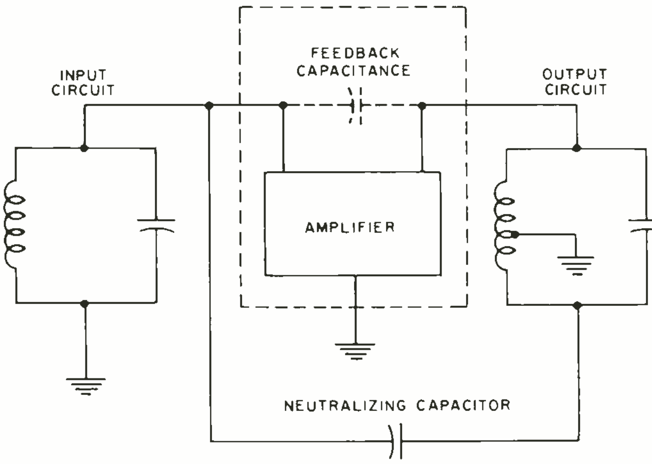
To overcome oscillation, the most common solution has been an old transmitter trick. Here the coil of the output circuit has a tap which is effectively grounded, frequently with a large bypass capacitor. On one end of the coil voltage develops exactly out-of-phase with the voltage at the amplifier output. A neutralizing capacitor is connected between this one end of the coil and the input of the amplifier. A feedback current through this neutralizing capacitor opposes the current from the feedback capacitance of the amplifier. By choosing the right value neutralizing capacitor, the circuit will become stable. This is the basic circuit found in most all-transistor i.f. amplifiers.

Neutralization has a number of advantages, for example, the circuit is capable of very high gain without oscillating. There are, unfortunately, some disadvantages—a major one being that this neutralizing capacitor might have to be adjusted differently for each transistor used if the circuit is to have the highest possible gain.

Selectivity Requirements

There is a further disadvantage, particularly when this transistor is in a circuit where a lot of selectivity and high "Q" are required. The low input impedance and also the low output impedance of the transistor will lower the resonant impedance and the selectivity of both circuits. A change from one transistor to another will change that selectivity drastically.

Fig. 1. Use of neutralizing capacitor prevents oscillation.



In high-fidelity FM tuners it is very necessary that a weak FM station be received without interference from a strong local station which might be 200, 400, or 600 kc. away in frequency. For FM, i.f. amplifiers have an intermediate frequency of 10.7 mc. The "Q's" of these circuits, with the transistor in the circuit, have to be maintained somewhere between 50 and 100. Such "Q's" are difficult enough to get in coils and i.f. transformers, and any substantial reduction in "Q" will reduce selectivity.

It is also important that the alignment of these coils and circuits be stable without being affected by the change in capacitance of a transistor when the operating voltages change or when automatic gain control is used.

Different Design Approach

Fortunately, within recent months, some high-performance, high-frequency transistors have become available which allow a different design approach. These transistors are silicon planar types which have a gain-bandwidth product of 350 mc. and a feedback capacitance of only 2 pf. Calculations and experiments show that maximum gain of 44 db per i.f. stage can be obtained at 10.7 mc. Since an i.f. amplifier may require gain of only 25 db per stage, a considerable loss can be tolerated.

Most i.f. amplifiers are constructed so that the impedance of the input circuit matches the input impedance of the transistor and the impedance of the output circuit matches that of the output impedance of the transistor. This is known as matched operation and results in the highest possible power gain. Furthermore, this matching may also result in the highest output power of the i.f. amplifier.

A discussion of power in an i.f. amplifier, where only a few milliwatts of power exist, may seem odd. In fact, however, only the last i.f. stage has to supply power to drive a limiter and the automatic gain control circuit. Therefore, power handling capability in earlier i.f. stages can be sacrificed.

Referring again to Fig. 1, it seems reasonable that oscillation due to positive feedback cannot occur when the impedance of the input circuit is very low, since insufficient voltage is developed across this circuit from the current through the feedback capacitance. This low-impedance input circuit still has to develop the same input voltage, but requires more input current and, therefore, more power. This, of course, reduces the power gain of the over-all circuit. The same argument can be made for the output circuit wherein the output current of the transistor goes into a low-impedance circuit and develops less voltage across it, effecting a reduction in output power. This again reduces the amount of current which can flow through the internal feedback capacitance.

A further reduction in undesired feedback occurs because the transistor current gain is accompanied by a phase shift at high frequencies amounting to 38° at 10.7 mc. for the particular type used in this i.f. amplifier. This phase shift is in opposition to the phase shift resulting from the feedback capacitance.

Some of the advantages of lowering circuit impedance include the following: First, the operating impedance of the whole circuit is that of the resonant impedance of the coil and capacitor in parallel with the transistor impedance. If the transistor impedance is high compared to the unloaded circuit impedance, any change in transistor impedance will have only a minor effect on circuit impedance. Second, if this circuit is of high selectivity, the addition of the transistor will change that selectivity only slightly. Third, the possible amount of feedback through the feedback capacitance is so low that the circuit with the transistor installed is completely stable and less than a small fraction of a decibel gain change occurs due to the feedback that takes place within the transistor itself.

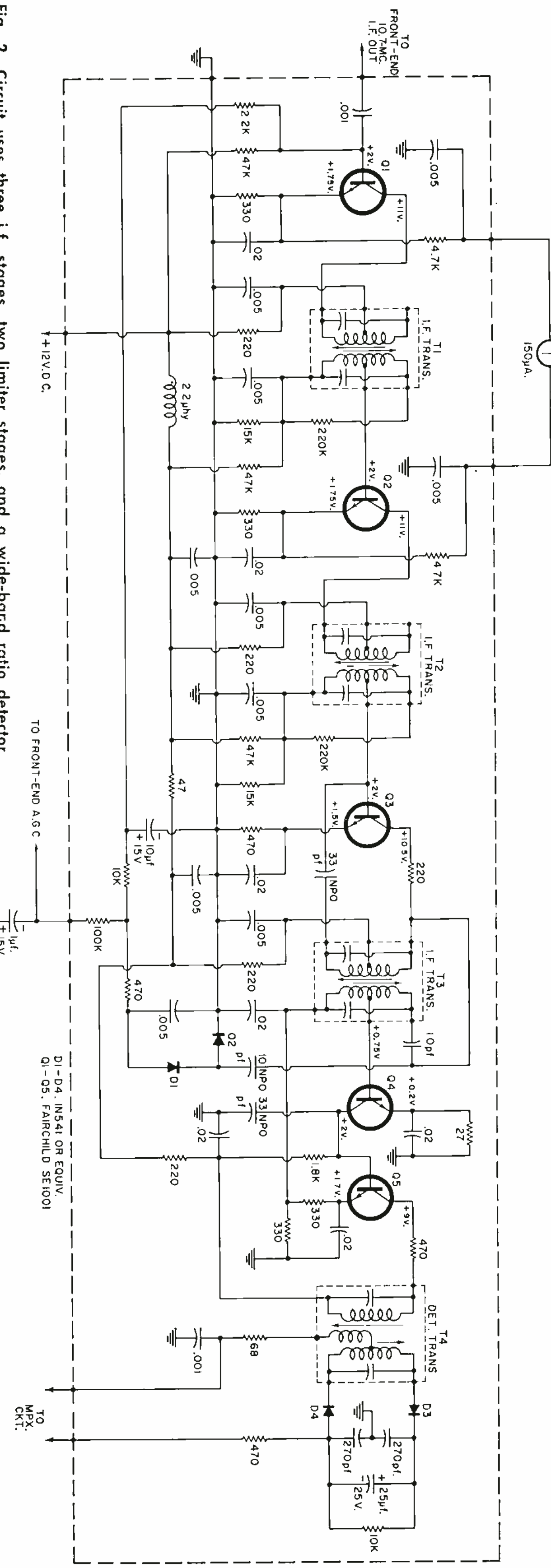


Fig. 2. Circuit uses three i.f. stages, two limiter stages, and a wide-band ratio detector. Note that the dashed line is printed-board outline and does not represent an interconnection.

Fig. 2 shows the circuit of the complete i.f. amplifier. The input signal for the i.f. amplifier comes from the FM front-end which also contains the first i.f. transformer. Its output is coupled through a .001-μf. coupling capacitor directly into the base of the first i.f. transistor (Q1). Bias for this transistor is applied through a (*Continued on page* 78)

TRUE 3-D IMAGE from LASER PHOTOGRAPHY

By E. N. LEITH & J. UPATNIEKS/ Institute of Science and Technology, The University of Michigan

It now becomes possible to create three-dimensional pictures with a lensless camera and projector, and without the use of special optical devices such as tinted glasses or screens.

WITH the introduction of the laser with its monochromatic, coherent light output, researchers have been given an invaluable tool that can be used to open many new areas of scientific investigation. By using the special characteristics of the laser, it is now possible to create a black-and-white, three-dimensional image of an object from a two-dimensional photographic transparency without the use of any special optical viewing devices. With this new photographic system, the viewer sees a three-dimensional image suspended in mid-air. The image is, in fact, more than

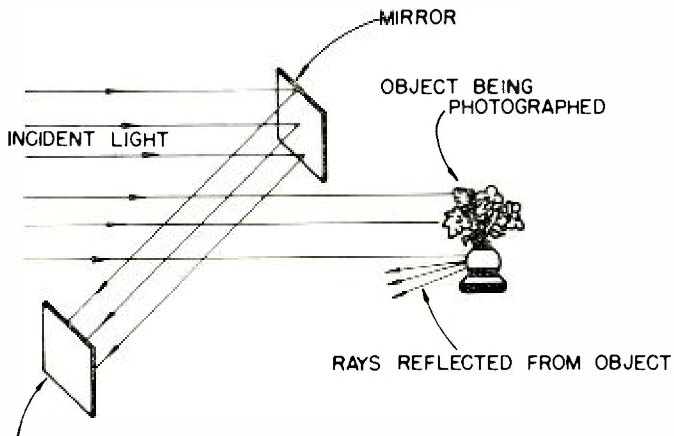


Fig. 1. In creating the hologram, the incident light is from a laser. The system can be likened to an optical superheterodyne with the object-reflected light as the modulated signal and the mirror-reflected light as the local-oscillator signal.

just three dimensional. It has all the visual properties of the original object, including change of perspective with a shift in the observer's viewing position, and parallax between near and far objects in the image. When placed side by side, image and object are indistinguishable to the viewer.

Another amazing by-product is the fact that if the original transparency is divided into many small fragments, each fragment, in itself, is capable of reproducing the original object (with some degradation in resolution).

This approach to laser photography is an adaptation of the wavefront reconstruction process invented by the European scientist Dennis Gabor in 1947. Wavefront reconstruction is an interesting type of photography that bears little resemblance to conventional photography, but can be likened to the carrier modulation methods of the electronics engineer. The light reflected from the object is treated as a modulated carrier wave which, in photographic recording, is mixed with a local oscillator signal (another light beam) in an optical superheterodyne process.

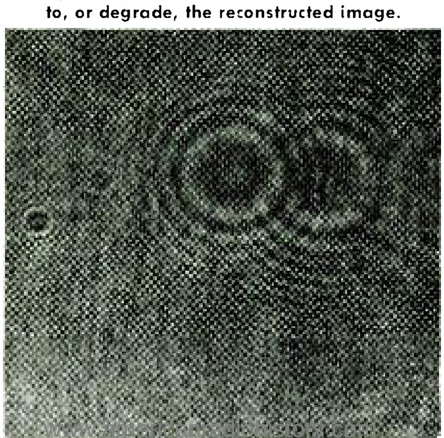
The recent resurgence of interest in wavefront reconstruction is due in part to recent research at the University of Michigan and elsewhere, and certainly in large part to the development of the laser, which permits experiments that heretofore would not have been practicable.

Making the Photograph

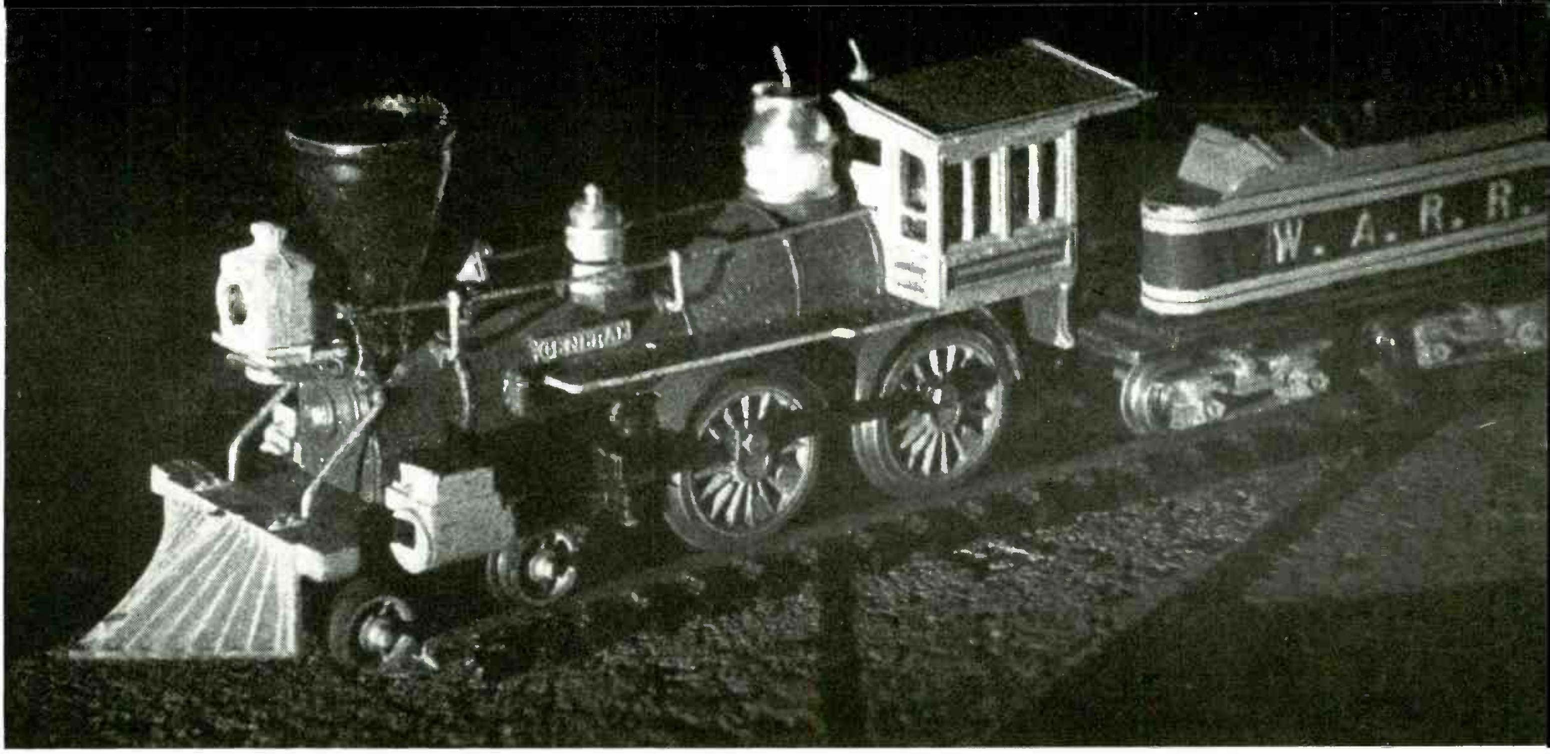
The wavefront reconstruction method for photographing an object is shown in Fig. 1. The procedure is in many ways similar to conventional photography, but differs from it in several significant respects. As in conventional photography, the subject is illuminated and a portion of the reflected light is intercepted by a photographic plate (or equally well, a film).

There are three major departures. First, no lens or other image-forming device is placed between subject and photographic plate; consequently, no image is formed. On the contrary, each point on the plate, instead of receiving light originating from a corresponding single point on the subject, receives light from the entire subject. Or, put otherwise, each point on the subject illuminates the entire plate. Thus, no image, not even a blurred one, forms on the plate. Such a procedure would be expected to produce more or less uniform fogging on the plate. An exposed plate (called a "hologram") is in Fig. 2. The observable rings are caused by dust particles and do not contribute to, or degrade, the reconstructed image.

Fig. 2. Typical hologram appears this way under incoherent light. The observable structures are produced by dust particles and do not contribute to, or degrade, the reconstructed image.



The second departure from conventional photography is that instead of a conventional light source a laser is used for illumination of the subject. And, as the final departure, a small portion of the laser beam is reflected onto the photographic plate by means of a small mirror, which can conveniently be located next to the subject. These two in-



When a camera is substituted for the observer's eye, it becomes possible to photograph a reconstructed three-dimensional image.

novations in part compensate for the absence of the image-forming lens. The resulting photographic plate is now more than merely fogged—but does not contain any sort of a recognizable image.

Interference Modulation

Recorded on the photographic plate is the interference pattern between the light waves scattered from the subject and the auxiliary beam, which we call the reference beam.

If, for the moment, we consider the subject to be replaced by a mirror, then falling on the photographic plate will be two plane waves, one from each of the two mirrors. Also, let the two plane waves be non-parallel so that they impinge on the plate at some angle to each other. Because of the coherence of the light, a set of uniform interference fringes will be formed on the plate, with the fringe spacing being a function of the angle between the two beams.

The fringe pattern has an amplitude distribution which is sinusoidal and is a two-dimensional spatial analog of the temporal sine wave basic to electronic communication systems. And just as the temporal sine wave can be modulated and serve as a carrier wave, so the fringe pattern can be modulated. Let us now remove one of the two mirrors, replacing it with our original subject. The light waves reflected from the subject have an irregularity which is related to the reflecting-surface irregularities of the subject. The fringe pattern, which before was regular, now acquires an irregularity which is manifested in two ways. First, there are variations in the contrast of the fringe pattern. Second, there are variations in the fringe spacing; in some areas the fringes will be more closely spaced, while in others they are more widely separated.

The fringe pattern is thus modulated in accordance with the irregularities produced in the wavefronts by the reflection from the subject. The amplitude distortions of the reflected wave cause a contrast modulation, or amplitude modulation, of the fringes, while the phase perturbations produce a phase modulation of the fringe pattern. Thus, the recorded fringe pattern contains information completely describing the light waves reflected from the subject.

Recording Analysis

The light waves reflected from the subject and impinging on the plate can be compared to radio waves carrying intelligence, except that the frequency of the light wave being used is many orders of magnitude greater than the kilocycles or megacycles of the radio wave. These light waves carry information about the objects from which they were reflected in the form of phase and amplitude modulations. These modulations, however, are spatial rather than temporal. Thus, the amplitude and phase of the light is different at each point on the recording plate. The light wave falling on the photographic plate from the object might be likened to a modulated carrier wave, while the light reflected from the mirror performs the same function as the local oscillator.

The photographic plate serves two purposes. The first is an obvious one: the plate acts as a storage device, storing the recorded waves for later use. The second function, less obvious but nonetheless essential, is that of an optical detector, analogous to the detector in a receiver. The photographic plate, since it responds to intensity, records the square of the sum of the light waves received from the object and the mirror. The plate is thus a square-law device and produces, through detection, a difference-frequency signal. This new signal is analogous to the i.f. in a receiver, except that it is a spatial carrier wave instead of a temporal one. This modulated spatial carrier, or fringe pattern, which contains the intelligence that was on the light wave, is the signal that is stored on the photographic plate.

The process bears a close resemblance to sound recording, where sound waves are converted into modulations of the grooves of a phonographic disc.

Requirement for Coherent Light

To carry out this recording process, the light must have two special properties: spatial coherence and temporal coherence or monochromaticity. If the light is not monochromatic, then the recording will be duplicated for each wavelength component. The fringe pattern on the plate will be washed out, and only a uniform darkening of the plate will result. Similarly, if the light lacks spatial coherence, that is, if the light has not been effectively derived from a point source, then each effective point of the source will similarly duplicate the entire modulation process, and the fringe pattern will be ruined. Thus, the subject to be photographed must be illuminated by a spatially coherent, monochromatic source, and the laser is by far the best of such sources.

Reconstructing the Object

The photographic record produced is called a hologram (Fig. 2). When viewed in ordinary light, it is completely unintelligible, yet it contains, (*Continued on page 58*)

SEA STATIONS FOR AIRCRAFT V.H.F. COVERAGE

By PATRICK HALLIDAY

British feasibility studies are now going on for two to four mid-Atlantic floating platforms. These will provide continuous v.h.f. coverage, radar, beacons, and other aircraft radio aids.

EACH year the Atlantic air routes are filling up with more and more aircraft. In peak periods there may already be some 10,000 people flying across the Atlantic at a time, all dependent upon radio communications and radio navigation aids. Not only are these numbers expected to multiply fivefold in the next few years—but the importance of reliable communications will increase significantly with the coming of supersonic jets.

Tests carried out recently with a U.S. military supersonic jet flying from New York to Paris showed the need for almost continuous voice communications. There were some 100 minutes of conversation during the 200-minute flight. W.L. Polhemus of the University of Michigan has suggested that with supersonic transports there may well be a need to provide significant new capabilities in the communications field with much greater emphasis on unlimited access among the flight crew, air-traffic controller, meteorologist, and dispatcher-performance specialist. Because of the compression of the time scale, any errors could turn an otherwise profitable flight into a profitless and dangerous one.

The V.H.F. Communications Gap

At present there is still a large gap in mid-Atlantic v.h.f. communications. In spite of the current experiments with "extended-range v.h.f.", this gap cannot be bridged by this alone, and the aircraft must fall back on high-frequency operations, with all its problems of fading, interference, and sunspot "black-outs."

Extended-range v.h.f. involves the recent technique of using higher power ground transmitters in conjunction with steerable dish beam antennas providing over 30-db gain. With current airborne equipment, many engineers believe that v.h.f. coverage with high-flying jets can be extended by these techniques to about 400 nautical miles, with current airborne receivers and transmitters, and to about 550 nautical miles if beam antennas with gains of about 12 db were installed in the aircraft.

But this is not enough to close the v.h.f. gap. Now, however, an imaginative scheme is under development which may within about three years enable continuous v.h.f.-u.h.f. communications to be attained and to provide primary or secondary radar coverage, medium-frequency beacons, and other support navigational aids over the entire North Atlantic route without any need to modify the airborne equipment.

Floating Sea Stations

This new scheme, originally devised by the British Ministry of Aviation, is based on the construction of some two to four floating "sea stations" to be permanently moored in mid-Atlantic and linked to the shore by the latest type of lightweight, high-capacity ocean telephone coaxial cables.

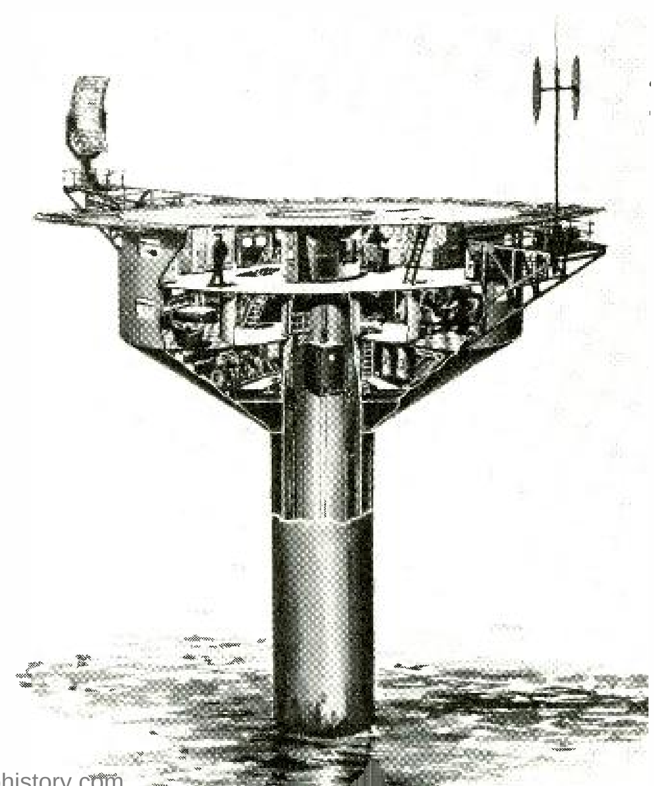
If extended-range v.h.f. systems come up to expectations only two sea stations may be needed: otherwise up to four of these floating electronic bases will be required. The sea stations could be operating within three years.

A design study undertaken by *Seastation Telecommunications Ltd.*, a company specifically set up for this purpose in Britain by a consortium of large electronic and shipbuilding firms, has so far confirmed the practicability of the proposals. Many tests have already been carried out on models of the sea stations in the large tanks of the British National Physical Laboratory.

Each sea station will consist of tubular structures, using double-skin construction akin to submarines, some 400 feet in length and 16 feet in diameter, floating vertically with about 380 feet immersed. The top 20-30 feet of the cylinder is designed to support a platform above the reach of the highest waves and providing accommodation for the electronics equipment, a crew of about 12 including the radio maintenance engineers, the antennas, and a helicopter landing deck. The sea station is thus some 450 feet over-all and would be floated horizontally out into the Atlantic where eventually they would be some 70 feet above the sea level.

The vertical cylinder would be moored in position with three anchors with cables coming into the lower end of the cylinder. The telephone cables would also be brought into the lower end of the cylinder, falling (*Continued on page 59*)

Artist's impression of operational and accommodation decks of sea station showing elevator connecting to engine area below.



Nickel-Cadmium Batteries

By LEWIS HOFSTATTER / Applications Engineer, Battery Div., Sonotone Corp.

This truly rechargeable and compact power source has led to the development of a wide variety of cordless devices in consumer, commercial, industrial, and military areas.

ONE of the most significant developments in portable power during the past 25 years has been the refinement and mass production of nickel-cadmium alkaline batteries. Many millions of sealed and vented rechargeable cells have been used successfully in a wide variety of consumer, commercial, industrial, and military applications. Whole families of new cordless products have come into being, based chiefly on the high performance capabilities of the sealed nickel-cadmium system. The market for the truly rechargeable battery continues to have a brilliant future and, until the fuel cell becomes economically practical, it seems likely that the greatest hope for reliable portable rechargeable power will lie with the nickel-cadmium battery system.

Pocket-Plate Nickel-Cadmium

The first rechargeable alkaline battery was developed by Waldemar Jungner of Sweden in 1899 and employed an open pocket-plate type of cell.

The pocket plate (Fig. 1, left) is a flat nickel-plated steel structure containing parallel rows of small pockets or chambers to hold the active materials. These pockets are very finely perforated to allow electrolyte access without permitting the escape of the material inside. Polystyrene or glass rods are used as separators between plates immersed in aqueous potassium hydroxide electrolyte. The positive plates contain nickel salts and the negative plates contain cadmium salts.

The vented pocket-plate nickel-cadmium battery has proven to be the heavy-duty work horse of the industry. Available in capacities from 10 to about 2000 ampere-hours, the cells may be encased in either plastic or steel. They are assembled in hardwood trays of convenient size and these can then be tiered in steel racks. Each cell delivers 1.2 volts and the most common voltage units are 6, 12, 24, 32, 48, 110, and 220, but any intermediate value can also be obtained.

These batteries have an extremely low internal resistance and can thus deliver very high currents with little loss of voltage. Conversely, they can also be recharged at greatly accelerated rates and, at normal temperatures, will hold their charge for very long periods. When delivering moderate currents, they will perform satisfactorily even at temperatures of −40°C.

Pocket-plate vented cells utilize an excess amount of alkaline electrolyte and contain vents through which evolved gases are released and additional water or electrolyte may be added, if required, for proper maintenance. They are not the lightest batteries in the world, but they probably are the most reliable, often providing as much as 25 years' of useful service. These batteries are thus employed in emergency standby applications with marine, lighting, alarm, control signaling, switchgear, telephone, engine starting, as well as for auxiliary utility power systems.

Sealed Sintered-Plate Nickel-Cadmium

The sintered-plate type of nickel-cadmium cell was developed in Germany during the Second World War and was produced in this country shortly after the war ended. The greatest current activity and volume in nickel-cadmium batteries is with the sealed sintered-plate types. The best testimonial to the efficiency, reliability, and complete lack of maintenance in sealed nickel-cadmium cells is the fact that probably more than half the consumers using cordless appliances with such batteries do not even realize that they contain batteries at all. Many manufacturers have encouraged this tendency by referring to the power source as an "energy cell" or a "powerpack," because they feel that there may otherwise be some sales resistance to a battery-powered device.

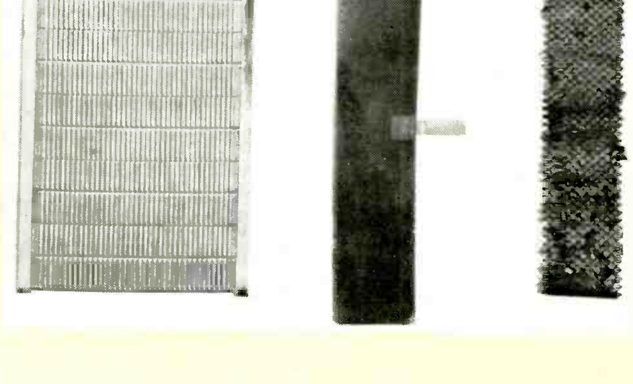
The sealed sintered-plate cell has five main components: a positive plate, a separator or dielectric, a negative plate, electrolyte, and a container. (See cover illustration.) No access vent is provided in a sealed cell and a limited quantity of electrolyte is used, thus reducing maintenance to a minimum and eliminating the need to add either water or electrolyte.

Preparation of positive or negative plates requires the sintering of a fine nickel powder to a woven nickel wire screen. (Sintering involves the conversion of a powdered or earthy substance into a coherent solid mass by heating without thoroughly melting.) This not only acts as a matrix conductor, but also imparts great strength and flexibility to the plate. This results in a thin, highly porous nickel plaque (Fig. 1, center) which is then impregnated with nickel salt solutions for the positive plate and cadmium salt solutions for the negative plate.

The separator, an absorbent dielectric material, mechanically separates the positive plate from the negative while holding electrolyte and permitting ions or electrical current to flow between the plates. The electrolyte used is an aqueous solution of potassium hydroxide.

The usual cell container is a nickel-plated steel can and cover. The cell is assembled by rolling both plates, separated by the dielectric, into a tight roll or core which is then

Fig. 1. Three typical nickel-cadmium battery plates. From left, modern pocket plate, sintered plate, and pasted plate.



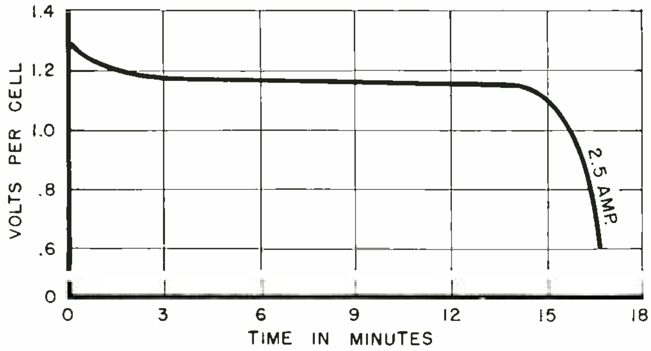


Fig. 2. Cell-discharge voltage vs time for a type S102 cell. This is one-half the size of a standard "C" cell.

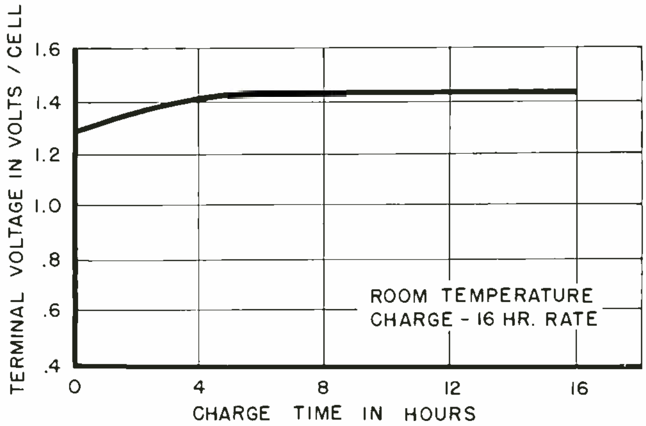


Fig. 3. Terminal voltage measured during a constant charge.

placed into the can with the electrolyte and sealed. The negative plate tab is welded to the bottom of the can, making the entire cell case the negative terminal. The entire cell assembly is then charged, discharged, and completely inspected by the manufacturer of the cell.

Electrical Characteristics

The *closed-circuit voltage* of a single nickel-cadmium cell, irrespective of size or shape, is nominally 1.25 volts but certain other voltage levels may also be encountered.

Open-circuit voltage is the voltage of a cell without a load. At room temperature, this is 1.33 volts. This represents the normal terminal voltage of a nickel-cadmium electrode pair immersed in potassium hydroxide electrolyte.

End-of-discharge voltage is the final voltage to which a cell is discharged. Levels below 1.0 volt per cell should be avoided where possible. Quite often, a higher end point can be used because most of the cell's capacity is exhausted at voltage levels somewhere between 1.10 volts and 1.15 volts (Fig. 2).

End-of-charge voltage is the final voltage across the cell at the end of charge, with charge current still flowing through it. A cell placed on constant charge soon rises to a voltage of 1.40 (Fig. 3) and can climb to 1.47 volts or more. 1.43 volts is an average final voltage and a cell is questionable if it does not reflect voltages reasonably close to these.

Ampere-hour capacity is generally measured to a 1.0-volt per cell end-point and is the product of discharge current and the time under load.

Capacity varies with the discharge rate. Figs. 4 and 5 indicate that at a 1-hour rate the cells will yield about 80% of their 5-hour rate, which is considered the standard capacity of the cell. At lower rates, such as the 10- or 20-hour rate, a somewhat higher capacity than that of the 5-hour rate is obtained. To illustrate, the "AA" size (ordinary penlight) sintered-plate cell has a nominal capacity of 510 ma.hrs. at the 5-hour rate of discharge, 430 ma.hrs. at the 1-hour discharge rate, and 550 ma.hrs. at the 20-hour rate. Fig. 4 also indicates what may be expected in voltage level on any size cell if the discharge rate is changed from the 5-hour to the 10-minute or 1-hour rate.

High-current capability. Sealed sintered-plate cells can deliver high current discharges in the neighborhood of 10 to 15 times their 5-hour rated capacity. For example, a "½C" cell with a capacity of 800 ma.hrs. may be used to deliver 10 amperes for a short time. The same cell will provide a full 16 minutes of operation at a constant discharge of 2.5 amperes (see Fig. 6A). Ordinary batteries are ruined by such treatment. Fig. 4 shows the effect of discharge current upon actual cell capacity obtainable. Note that the total energy available (the area under the curves) is somewhat lower at high current drains, but that the voltage regulation is still excellent.

Table 1 lists representative data on a few of the more popular types of sealed nickel-cadmium cells.

Temperature Effects & Charge Retention

While their discharge performance is affected somewhat at temperature extremes, sealed, sintered-plate nickel-cadmium cells offer some advantages over other battery systems in this respect. At 32°F, the cells will yield approximately 90% of their room temperature capacity, while at 125°F they will produce 70%. The cells can also supply useful but reduced energy over the range of −40° to +165°F. Discharge voltage levels will decrease somewhat from those encountered at room temperatures as the temperature is either increased or decreased.

For best results, cells shoud be charged at ambient temperatures between 60° and100°F. End-of-charge voltages can be expected to be higher (1.55 volts) than those encountered at room temperatures when cells are charged at cold temperatures and can be expected to be lower (1.37 volts) at the upper extreme temperatures. This is why sealed cells should never be charged by constant potential, since the cells tend to warm up during charge and thus de-

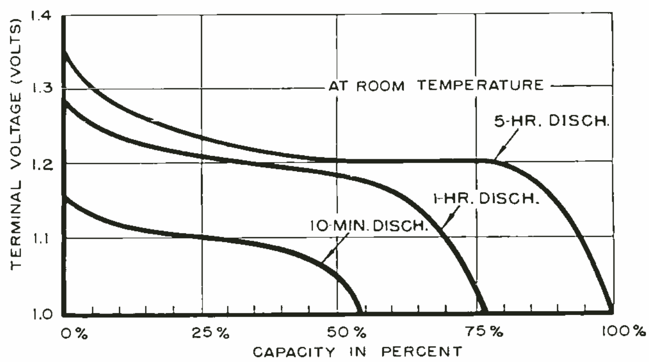
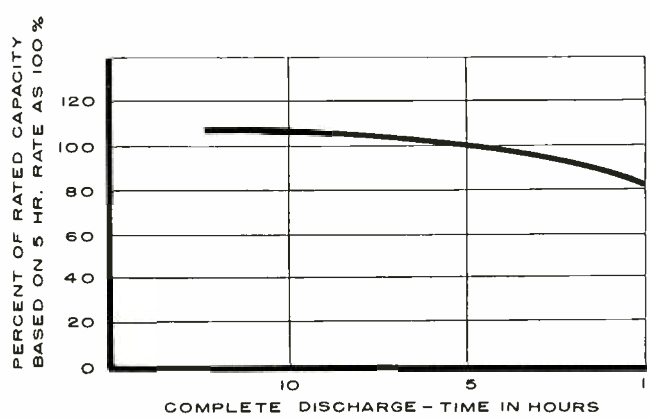
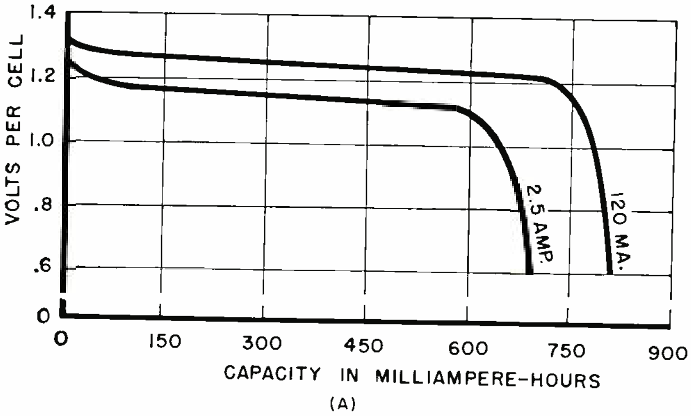


Fig. 4. Discharge voltage characteristics of cylindrical sealed cells for a number of different rates of discharge.

Fig. 5. The variation of cell capacity with discharge rate.





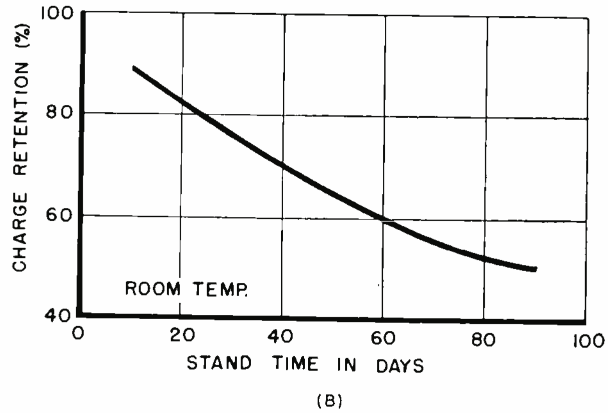


Fig. 6. (A) Comparison between capacities of "½C" size for two discharge rates. Note 600-ma. hr. capacity at 2.5-amp. discharge. (B) Charge-retention characteristics of nickel-cadmium cell.

crease in voltage. The charger will then supply increased currents, causing more heating, and so on, until cell failure results. This condition is call "thermal runaway," and can be prevented only by using constant-current charging.

The sealed nickel-cadmium cell, like all electrochemical storage devices, loses a percentage of its charge while in storage. At room temperature, the cell will retain 75% of its capacity after a 30-day stand, 60% after 60 days, and 50% of its capacity after a 90-day period (Fig. 6B). In any case, the loss of charge is only of a temporary nature and can be regained on subsequent charging. One of the advantages of a rechargeable system is that the loss of shelf life can be prevented by keeping the cells on a trickle charge or simply by recharging them before being placed into service.

Cell Reversal

If a multiple-cell battery is deeply discharged at currents much greater than $C/10$ (C=amp. hr. capacity of cell at 5-hr. rate), there is a possibility that cell reversal will occur. This can happen if one cell is slightly lower in capacity than the others and if, during discharge, its voltage falls near zero while the other cells may be at one volt or more. The battery will continue to discharge through the "dead" cell, charging it in reverse, as it were. If the discharge continues long enough, the cell may reverse its polarity and be damaged.

It occasionally becomes necessary to protect a sealed nickel-cadmium battery from the repetitive deep discharges that might prove injurious. In some cases, the device can be designed to become inoperative when the voltage drops below 1 volt per cell. At other times, the user can be instructed to charge whenever the power appears to weaken. One solution is to use the appropriate zener diode across each cell to prevent it from being driven into reverse polarity. When the weakest cell reaches a reverse 0.1 volt, the diode will pass all the current instead of the cell, thus preventing damage. The correct zener diode must be able to begin conducting current at very low voltages and must possess the required current-handling capability. Such diodes are often quite expensive, so simpler techniques are generally employed. These usually involve the use of a relay across the battery terminals which disconnects the load when terminal voltage drops to a predetermined value.

State of Charge

The state of charge is the amount of energy left in a battery at any given time. There is no simple, practical way of measuring the state of charge in a nickel-cadmium system, since the voltage does not reflect residual capacity and the electrolyte serves chiefly as an ion-carrier, without significant changes in its specific gravity. When dealing with either vented or sealed nickel-cadmium batteries, if in doubt about the state of charge, the best procedure is simply to give a 14-hour freshening charge at the $C/10$ rate or keep on trickle charge permanently at $C/100$.

Charging Techniques

Recharging sealed cells is a simple matter and can be accomplished in several ways. In each case, only constant-current charging should be used due to the possibility of "thermal runaway," described earlier. Because there are some heat losses, gas evolution, and side reactions, recharging is never 100% efficient and it is necessary to replace 140% of what was removed. The standard recharge rate is at a current value of $1/10$ the cell capacity ($C/10$) for from 14 to 16 hours.

Fig. 7A shows a typical half-wave constant-current charger. Note that no filtering is required for nickel-cadmium chargers, since the average cell has an enormous equivalent capacitance. The charger is actually a current-limited device and will not really provide a truly "constant" current, since the counter-e.m.f. of the battery rises during charge and will oppose the transformer e.m.f. The charge currents will be quite constant enough, however, for battery charging and no trouble will be encountered if the current at the end of the charge does not exceed the $C/10$ rate for sintered-plate batteries.

The value of R is chosen as follows:

1. Multiply the number of cells by 1.45 volts to obtain the counter-e.m.f. at end-of-charge.
2. Select transformer with a secondary voltage that is at least twice this voltage.

Table 1. Characteristics of sealed cells. "AA" cells are penlight type while "D" cells are standard flashlight type.

Size	Average Capacity (5-hr. rate)	Average Capacity (1-hr. rate)	Charge for 14-hours (constant current)	Dia. (in.)	Over-all Hgt. (in.)	Weight (oz.)	60-cps Impedance (in milliohms)
AA	.51 amp. hr.	.43 amp. hr.	50 ma.	.580	1.985	0.8	22
C	1.9	1.6	150	1.022	1.925	2.6	15
D	4.0	3.2	400	1.333	2.385	5.5	12
F	6.5	6.0	600	1.333	3.455	8.3	7

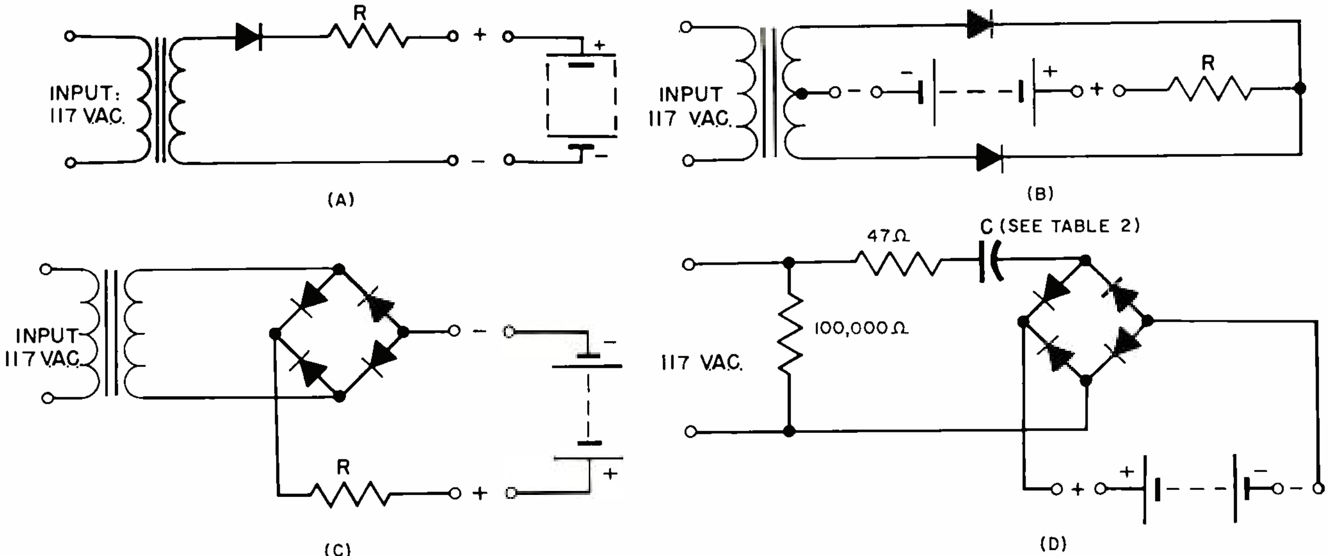


Fig. 7. A grouping of nearly constant current charging circuits recommended for nickel-cadmium cells.

3. Subtract voltage from step (1) from voltage of step (2).

4. Use this value for E in the formula $R=E/I$; use $C/10$ current (or the current desired) for the value of I, and solve for R. The wattage rating of the resistor should be 2.5 to 3 times the product of E and I. Adjustable resistors are handy for prototype use, because exact settings can be made.

The diode should have a conservative peak inverse voltage rating. It will run cool if capable of handling twice the maximum anticipated current. Remember that a heavily discharged battery will draw substantially higher currents until its counter-e.m.f. rises. Some manufacturers incorporate the ballast resistor in the secondary winding of the transformer, others use an incandescent pilot light as a combination resistor, fuse, and charge-rate indicator.

At higher currents and for greater efficiency, full-wave charging can be used. If the transformer secondary is center-tapped, the double-diode circuit of Fig. 7B can be used. The value for R is calculated as above, but the secondary voltage of the transformer is just twice that required for half-wave rectification.

A common full-wave charger using an untapped secondary and a bridge rectifier is shown in Fig. 7C. The bridge rectifier requires four diodes and must not be operated without the battery connected, because the resulting current imbalance could damage the diodes. The same bridge can be used with a capacitor replacing the transformer, as in Fig. 7D. Due to the size of the capacitor, it is feasible only for small or moderate currents. Table 2 shows some typical values for C at various charge rates.

Table 2. Values for series capacitor C in Fig. 7D. This particular circuit has a potential shock hazard as it is connected directly to the power line, hence it should be built into end device with suitable personnel protection.

Cell Capacity (ma.hr.)	Number of Cells in Series	Value of C (in μf.)	Nominal Charging Current (ma.)
50	1 to 5	0.12	5
100	1 to 5	0.25	10
150	1 to 5	0.40	15
250	1 to 5	0.65	25
500	1 to 5	1.40	50
1000	1 to 5	3.25	100

Smaller cells can sometimes be conveniently recharged from a larger primary battery—the relative voltages often work out perfectly. For example, a pair of 20 ma.hr. hearing-aid cells can be recharged in parallel from a single #6 Leclanché cell. These cells may be kept on charge while another pair of cells is used in the hearing aid. At least two years of use can be obtained in this manner.

Most sintered-plate sealed cells made today have some sort of safety venting device to prevent seal failure in the event of cell abuse. A puncturable diaphragm composes the top cell seal and a piercing point impinges upon the center of the diaphragm. Any gas accumulation due to excessive discharging or charging rates will cause the diaphragm to be distended upward and the point will make a small puncture. When the gas pressure is relieved by venting to the external atmosphere through the hole in the top cover, the diaphragm is elastically restored to its original plane, almost closing the pierced opening. The cell will continue to function for a number of cycles but it will naturally age somewhat faster than would an unpunctured cell.

Cycle Life & Packaging

Cycle life refers to the number of charge-discharge cycles of operation possible before capacity drops to a predetermined level. Cycle life is at an optimum when over-discharge is avoided, recharging is performed regularly, and depth-of-discharge is kept as shallow as possible. When the charge-discharge cycles are nearly full, life is measurable in hundreds of such cycles; when partial discharges are used, cycle life may be in the thousands.

Sealed cells are available in capacities from 20 ma.hrs. to 25 ampere-hours and they can all be assembled to form a variety of finished battery packs. Small disc cells are stacked to make compact cylindrical batteries. The popular cylindrical cells may be packaged either in long end-to-end cylinders or side-by-side in convenient modular configuration; larger rectangular cells are assembled side-by-side in battery trays or enclosures.

Pasted or Pressed Plate

For many years, nickel-cadmium cells have been made by simply pressing, under pressure, a paste of active materials into a supporting matrix (Fig. 1, right) rather than by sintering. This type of cell is less expensive to produce, has excellent charge retention, and gives good capacity-volume efficiency. However, it has a higher internal resistance and is thus limited to low and moderate current-drain applications. Pasted-plate cells are available in both cylindrical and disc-shaped configurations; the latter can be assembled in stacks to give any desired voltage. These cells are relatively inexpensive compared to the sintered-plate type and have a minimum average life of from one to three years.

Vented Sintered-Plate Batteries

Vented cells are produced from standard sintered plates which are made in parallel assemblies to give a rectangular configuration (Fig. 8). Batteries of these cells can safely deliver enormous currents with good voltage regulation. They may be fully charged in times as short as ½ hour over temperatures from −65° to +165°F. The cell containers are polystyrene or nylon and are housed in stainless steel or fiberglass battery cases. No acids, noxious gases, or corrosive fumes are evolved during normal use. Because of the type of one-way vent employed, these cells can be discharged in any position, although they should be kept vertical during fast discharge to prevent loss of electrolyte. Vented sintered-plate batteries can be stored for long periods in any state of charge and will retain a charge for at least a year.

The extremely long life and corrosion-resistant construction virtually eliminates the need for inspection or maintenance. An occasional electrolyte check and the addition of a little distilled water a couple of times a year is all that may be required. If it ever becomes necessary to change a vented cell in a battery, the cell is simply removed and replaced by a new one. This feature enables every battery cell to be used to exhaustion. Because all the internal connections are welded and the plates have very low resistance, pulse discharges up to 40 times the cell capacity are possible.

The vented sintered-plate nickel-cadmium batteries are extensively used in military and industrial applications, including engine starting, switchgear operation, and emergency standby service. Available in low-, medium-, and high-current rate versions, they are more expensive than their sealed counterparts but have a normal life expectancy of from 5 to 10 years. Vented cells may be charged with either constant voltage or constant current, whichever seems more suitable. Combination circuits can be designed to charge initially at constant voltage and high current, then taper automatically to constant trickle current.

At times it may be necessary to charge two or more cells in parallel. This can be accomplished by inserting a resistor in series with each of the cells being charged from a single source. The value of the resistor chosen must be at least 100 times the magnitude of the internal resistance of each cell. Slight differences in cell internal resistance thus exert a negligible effect. ▲

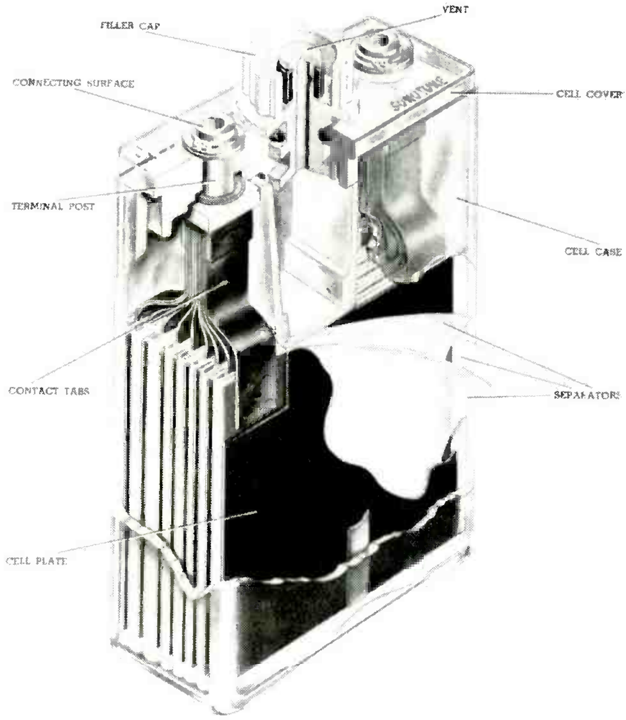


Fig. 8. Cutaway view of vented sintered-plate battery cell.

Battery Sources

Source	MERCURY	SILVER-ZINC	CARBON-ZINC	SILVER-CADMIUM	NICKEL-CADMIUM	ALKALINE-MANGANESE
Acme Battery Corp., 200 Henry St., Stamford, Conn.			●			
Alkaline Batteries Co., 2278 Mora Dr., Mountain View, Cal.					●	
Bright Star Industries, 600 Getty Ave., Clifton, N. J.			●		●	
Burgess Battery Co., Freeport, Illinois	●	●	●		●	●
Carbone Corp., 400 Myrtle Ave., Boonton, N. J.			●			
Catalyst Research Corp., 6101 Falls Road, Baltimore 9, Md.		●	●		●	
Cook Batteries Co., Denver, Colorado		●				
Delco-Remy Div., General Motors Corp., Anderson, Indiana		●				
Eagle-Picher Co. Chemicals Div., P.O.B. 290, Joplin, Mo.		●		●	●	
Electric Storage Battery Co., 2 Penn Center Plaza, Philadelphia, Pa.	●	●	●	●	●	●
Electrochimica Corp., 1140 O'Brien Dr., Melno Park, Cal.		●		●	●	
General Electric Co., Battery Prod. Sect., P.O.B. 114, Gainesville, Florida		●		●	●	
General Electric Co., Ordnance Dept., 100 Plastics Ave., Pittsfield, Mass.		●				
Gould-National Batteries Inc., Alkaline Battery Div., 1st Nat. Bank Bldg., St. Paul, Minn.		●		●	●	
Gulton Industries Inc., 212 Durham Ave., Metuchen, N. J.				●	●	
Mallory Battery Co., Broadway & Sunnyside Lane, Tarrytown, N.Y.	●	●	●			●
Marathon Battery Co., Box 298, Wausau, Wisconsin			●			
Nife Inc., Copiague, Long Island, N. Y.					●	
RCA, Electronics Components and Devices, 415 S. Fifth St., Harrison, N. J.	●		●			●
Sonotone Corp., Battery Div., Saw Mill River Rd., Elmsford, N. Y.					●	
Telecomputing Corp., Power Sources Div., 3850 Olive St., Denver, Colorado		●		●		
Union Carbide Corp., Eveready, 270 Park Ave., New York 17, N. Y.*	●		●		●	●
Yardney Electric Co., 40 Leonard St., New York 13, N. Y.		●		●		

*Also makes air-depolarized types.

Carbon-Zinc Batteries

By FRANK B. PIPAL / Manager, Battery Engineering Dept., Union Carbide Corp.

The most widely used primary battery system because of its low cost, reliable performance, ready availability.

THE standard carbon-zinc Leclanché type battery dominates the primary battery market. It is expected to still be the most widely used system in the future because of its low cost and reliable performance.

As uses widened in scope and character, the battery industry developed cells of various sizes and grades to meet new requirements. For example, the "Eveready" line includes 159 types of carbon-zinc batteries. They come in 23 different voltages, ranging from 1.5 to 510, with many different shapes and sizes and terminal arrangements. There are ten basic round and twenty-two flat cells used to build the 159 different batteries. Round cells are available as unit cells or in assembled batteries. Flat cells are used in multi-cell batteries only. In any one specific size the cell ingredients and formulas may be varied to give certain performance qualities for different applications.

Service capacity of individual carbon-zinc cells ranges from several hundred milliampere-hours to about 30 ampere-hours. When assembled into batteries in various cell arrangements, the battery capacities of currently available types range to over 100 ampere-hours.

Chemical Composition & Construction

The anode or negative electrode in a carbon-zinc cell is zinc. It easily gives up electrons to an external circuit and thus becomes a source of positively charged ions.

The cathode or positive electrode is manganese dioxide in the form of a bobbin consisting of a mixture of manganese dioxide, acetylene black, and solid ammonium chloride wet with a zinc chloride-ammonium chloride electrolyte. The manganese dioxide serves both as a depolarizer and as a source of about one-half of the energy output of the cell. As a dry cell delivers current, the manganese dioxide loses oxygen while the zinc is oxidized. As the available oxygen from the manganese dioxide becomes depleted, the manganese dioxide becomes less and less active as the cell cathode.

To get a mechanically suitable termination in the usual cylindrical cell, a carbon rod is inserted into the bobbin. The carbon rod with a metal cap is a good electrical conductor which serves as a current collector to conduct electron current from the outside circuit. It is chemically inert. It is also porous enough to permit the escape of gases accumulating in the cell while, at the same time, not permitting the leakage of electrolyte.

The separator is an inert insulating medium, such as cereal paste or plastic film, that physically separates the positive and negative electrodes but permits ion transfer between electrodes through the electrolyte.

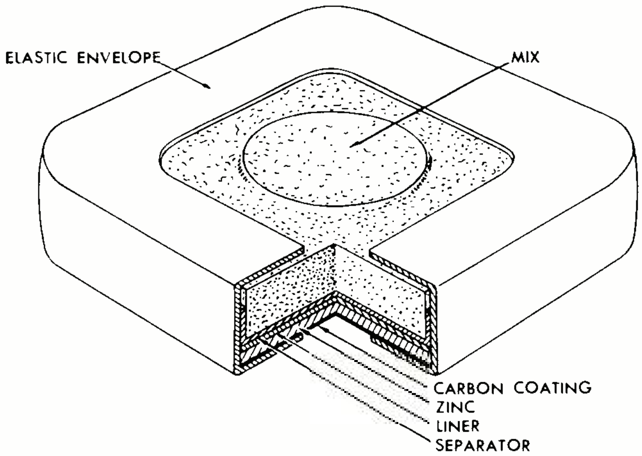
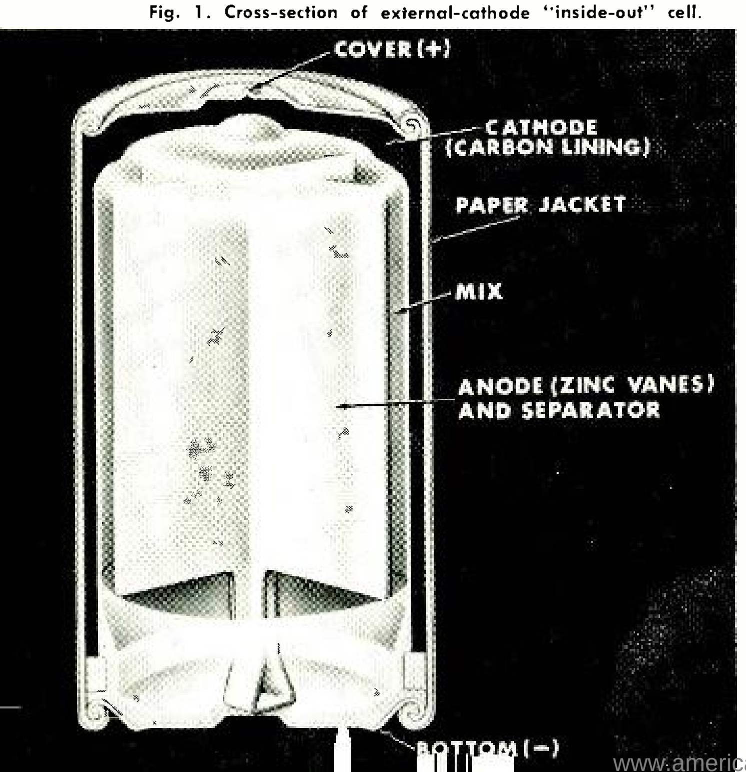


Fig. 2. Cross-section of the "Mini-Max" flat cell.

Fig. 1. Cross-section of external-cathode "inside-out" cell.



The carbon-zinc cell cannot be hermetically sealed and must have vents for gases generated within the cell during reactions and while idle. Pitch, wax, rosin, water-proofed cardboard, plastic, and insulated metal covers are types of seals used which minimize air access and moisture loss by evaporation and thereby contribute to service maintenance. Air spaces are left between the depolarizing mix and the seal to provide for expansion of the cell contents as the cell is used.

The basic carbon-zinc cell is made in many shapes and sizes but two general categories exist, round and flat cells. The chemical ingredients are the same for both, the difference is mostly physical.

In addition to the standard round cell (shown in cross-section on the cover), a unique patented external cathode or "inside-out" round cell construction is shown in Fig. 1. (Patent No. 2605299) In this cell an injection-molded, impervious, inert carbon wall is the container and also functions as the current collector. Zinc vanes are inside the cell, surrounded by the cathode mix. This insures efficient zinc consumption and, since zinc is not used as a container, a high degree of leakage resistance.

The "Mini-Max" flat cell utilizes cell materials in a laminated structure. In these flat cells, carbon is coated on a zinc plate to form a duplex electrode—a combination of the zinc of one cell and the carbon of the adjacent one. The "Mini-Max" cell, shown in Fig. 2, contains no expansion chambers or carbon rod.

This construction increases the amount of depolarizing mix available per unit cell volume and, therefore, the energy content. In addition, the flat cell, because of its rectangular form, reduces waste space in assembled batteries. Since zinc is not used as a container in the "Mini-Max" flat cell, leakage is, for practical purposes, eliminated.

Voltages

The open-circuit voltage of carbon-zinc dry cells manufactured of the same materials is the same irrespective of cell size. Voltmeter readings, because of meter load, will show slightly higher values as cell size increases because of the difference in impedance between the cells.

With an electrolyte of ammonium chloride, a manganese dioxide positive electrode, and a zinc negative electrode, the initial open-circuit voltage is referred to as a nominal 1.5 volts. However, the actual initial voltage may vary from about 1.5 to over 1.6 volts depending on the type and the amount of manganese dioxide and on slight differences in electrolyte formulation. A higher-voltage battery is not necessarily better than one of lower voltage. (*Editor's Note: According to tests made some years ago by the National Bureau of Standards of a number of brands of batteries containing "D"-size cells stored at 70°F, the average open-circuit voltage per cell measured: initial, 1.576 v.; 1 yr, 1.526 v.; 2 yrs, 1.506 v.; 3 yrs, 1.500 v.*)

The open-circuit voltage of dry cells on shelf declines only a few hundredths of a volt per year until the battery reaches a condition of final exhaustion, at which time the voltage begins to drop very rapidly. The open-circuit voltage also decreases about 0.0004 volt per °C when temperature decreases from 25°C (77°F) to −20°C (−4°F).

The terminal voltage of the cell while under discharge is called the working voltage or voltage under load. It is more important than the open-circuit voltage. It is lower than the open-circuit voltage by an amount dependent upon the current passing through the cell and the internal resistance of the cell. The working voltage of a carbon-zinc cell falls gradually as it is discharged, as shown in Fig. 3. The service hours delivered are greater as the cut-off or end-point voltage is lower.

Internal Resistance

The internal resistance of a carbon-zinc dry cell is a combination of the cell's solid conductor, electrochemical, and contact resistance. The internal resistance of unused dry cells is very low and is quite negligible in most applications.

Internal resistance may be defined in terms of flash current or short-circuit amperage. It has often been assumed, incorrectly, that the amperage reading is indicative of service capacity.

Amperage is usually higher in larger cells, but in cells of any size amperage may vary widely with different grades and different makes. Sometimes a cell with lower amperage has the better service capacity, but this is not necessarily true in all cases.

The internal resistance increases with use, storage time, and decreasing temperature. With age, the cell dries out and, with use, some of the MnO_2 is converted to Mn_2O_3, which has higher resistance. Coatings over the reactants also reduce currents.

Table 1 indicates the approximate internal resistance, as determined by the flash current, of several representative round cells. The cells are all of a general-purpose grade. Flash current varies with different formulations of materials in the same cell size.

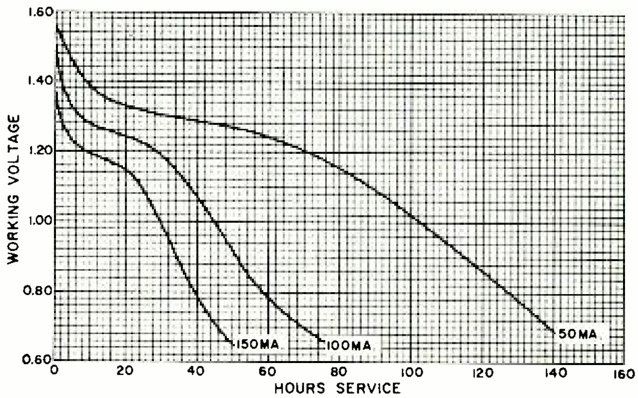


Fig. 3. Voltage-discharge characteristics of fresh carbon-zinc "D"-size cell discharged 2 hours per day at 70°F.

A.S.A. Cell-Size Designation	Average Flash Current (amps.)	Approx. Internal Resistance (ohms)
N	2.4	0.69
AAA	3.5	0.44
AA	5.4	0.29
C	3.3	0.47
D	5.8	0.27
F	9.0	0.17
G	11.0	0.11
6	38.0	0.03

Table 1. Internal resistance of fresh round cells.

Service Capacity

The service capacity of a carbon-zinc dry cell cannot be stated as a single value. The amount of electrical energy which can be withdrawn varies under different conditions. This is because the cell functions at different degrees of efficiency depending upon the load.

If the load is too heavy and energy is withdrawn too rapidly from the cell, the reaction rate of both electrodes can be exceeded. Reaction products which are generated in the cell cannot diffuse away fast enough, thus the working voltage drops off and the cell does not function efficiently. If energy is withdrawn more slowly, the depolarizer functions more effectively and diffusion can take place so that the cell maintains its current and working voltage holds up well.

If the withdrawal of energy is too slow, the time required to exhaust the cell is so extended that shelf deterioration is sufficient to detract from the cell's available energy and so reduces its electrical output.

Between these two conditions of service, heavy and light, there is a point where depolarization is at its best and shelf deterioration is still negligible and here the most efficient service is obtained.

The three conditions described result in differences in energy output and also in the shape of the discharge curve. The conditions are shown in the curves of Fig. 4.

Severe service conditions may be due to either heavy current drains or continuous or long discharge periods. Continuous use is not necessarily inefficient if the drain is very light.

A relatively heavy drain may be permissible if the discharge periods are very short and the rest periods constitute a very large proportion of the time.

Carbon-zinc dry batteries are intended primarily for intermittent service. The total service life obtained is normally greater for a discharge schedule of 2 hours per day, for example, than for continuous discharge. Intermittency allows sufficient time for the back diffusion of reaction

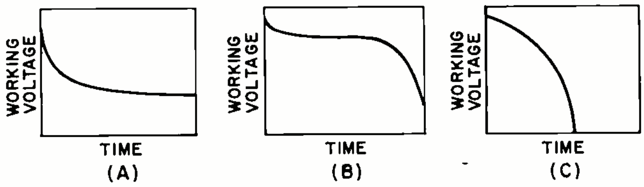


Fig. 4. Performance of No. 6 general-purpose cells. (A) Heavy withdrawal of energy, incomplete depolarization (elapsed time of few hours). (B) Highly efficient performance (elapsed time 6-12 months). (C) Light service shows reduction in the energy output due to shelf depreciation (elapsed time 2 to 3 years).

products and other reactions in the recuperation process.

Service life at low temperatures is reduced because of retarded chemical action in the cell. High temperatures increase cell output at the expense of shelf life.

Cut-Off Voltage

The cut-off or end-point voltage is the closed-circuit voltage at the end of a useful discharge. It is the cell voltage below which the battery-powered equipment will not operate satisfactorily or below which operation is not recommended.

Typical cut-off voltages for carbon-zinc cells range from 0.6 to 1.2 volts per 1.5-volt cell, depending upon the application. The cut-off voltage should be made as low as possible so as to use the available energy in the battery. This is sometimes done, if the equipment can tolerate it without causing failure, by using a slightly higher voltage battery than the application normally requires. The cut-off voltage per cell is then lower and insures efficient use of the battery. The curves of Fig. 5 show the advantage of a low cut-off voltage for moderate or heavy use.

Effect of Temperature

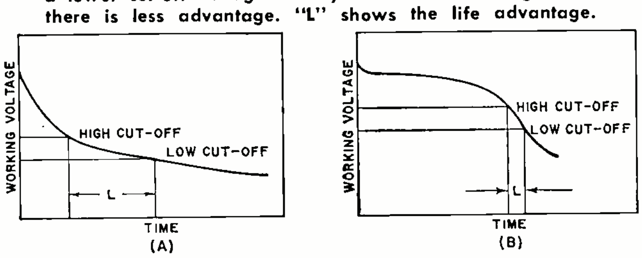
Continued high temperature, either operating or storage, is an abusive condition for dry cells. Most carbon-zinc cells are designed to operate at normal room temperature. Voltage and depolarization are increased by high temperature, but this is offset by more rapid shelf deterioration. Shelf deterioration is greatly hastened due to greater loss of moisture and accelerated chemical action. The higher the discharge temperature, the greater the energy output of the cell. However, high temperature may cause early complete breakdown of a cell. Prolonged exposure to temperatures above 125°F, for example, may cause erratic operation and sudden failure. Any temperature above 70°F reduces the normal shelf life of a cell.

The service capacity of carbon-zinc cells at low temperatures is sharply curtailed because of increased resistivity and viscosity of the electrolyte, the decreased rate at which chemical reactions occur, and freezing. Cells provide very little service at sub-zero temperatures. With special low-temperature electrolytes, however, service can be obtained at a temperature of −40°F.

Shelf Life & Storage

Shelf life is a measure of the lasting quality of dry cells prior to the time of their being put in service. The most valuable measure of shelf life is the useful electrical output

Fig. 5. (A) For moderate or heavy use, the advantage of a lower cut-off voltage is very marked. (B) For light use, there is less advantage. "L" shows the life advantage.



of the cells after some specified period of storage time.

As dry cells become older, they gradually deteriorate either in use or idle. This deterioration is the result of very slow chemical reactions and moisture changes which take place in the cell. These changes can be minimized but not avoided. They gradually reduce the service output. During idleness, there is slight deterioration with time. The rate of deterioration is increased with higher temperatures. It can be retarded by storage at low temperatures. The rate of deterioration is greater for partially discharged than for unused cells.

A storage temperature of 40° to 50°F is very effective and the major benefit is derived by avoiding exposure to temperatures in excess of 70°F.

In connection with cold storage of dry batteries, it is important to observe certain precautions:

1. Unnecessary handling should be minimized after batteries are chilled.

2. Batteries for cold storaging should be packed in suitable containers and left in such containers after being withdrawn from the lower temperature until the batteries reach normal outside temperature.

Standard Methods of Testing

The variety of uses for dry cells and batteries has led to the adoption of a considerable number of tests, each intended to simulate some kind of service as, for example, flashlight, radio, or hearing aid. In the early days of the dry battery industry, important uses were studied and tests devised which duplicated these uses as to current drain, periods of discharge and recuperation, and cut-off voltage. Such tests duplicated usage conditions approximately as to over-all period of time, which is a very essential feature. Tests, to be of value, must approximately duplicate the conditions of use. Quick continuous tests are not related to longer intermittent uses and are not indicative of cell behavior in actual service.

Service tests have been developed by a sectional committee of the American Standards Association acting under the sponsorship of the National Bureau of Standards. These tests are described in the National Bureau of Standards Handbook 71 entitled "Specification for Dry Cells and Batteries." New tests are devised from time to time as new uses develop. These standard tests have been universally adopted by the battery industry and have been very useful in developing the high-quality dry cells which are available today.

There is no simple or rapid method of determining the service capacity of a dry battery. Tests must be run which closely duplicate the class of service for which the battery is intended. The schedule of operation is very important. The service capacity of a battery used two hours per day will be considerably different from that of the same battery used 12 hours per day.

There is no relation between continuous-duty service and intermittent service. It is, therefore, impossible to rate the merits of different batteries on intermittent service by comparing the results of continuous-duty tests.

Another fallacy concerning dry batteries is that relative "quality" or service capacity of a battery can be determined by amperage readings. This is not true and in most instances gives results which are totally misleading. The size "D" photoflash round cell and the flashlight cell are identical in size and shape. However, the photoflash cell, which will show more than twice the amperage of the flashlight cell, runs a poor second to it in service capacity in typical flashlight uses.

The short-circuit amperage of a cell may be adjusted over a wide range by varying the carbon content of the depolarizing mix. Carbon contributes nothing to the cell energy and is used primarily to control cell impedance.

It is apparent that as carbon is added to a cell, depolarizer must be removed. This means that the energy content is reduced.

Dry batteries can be meter-tested to check present condition. A meter test, however, will give no indication of remaining service capacity unless the exact history of the battery is known and can be compared on a service *vs* meter reading basis with other batteries tested in similar service.

A loaded voltmeter is considered the best spot-check device, since open-circuit voltmeter readings give no indication of internal impedance and a short-circuit amperage reading is damaging, especially to "B" batteries that are employed for radio receivers.

Rechargeability of Carbon-Zinc Cells

It has been known for years that the Leclanché type carbon-zinc cell is rechargeable to some degree if the discharge and charge cycles are controlled with precision. On this matter the National Bureau of Standards (Letter Circular LC 965) makes the following comments:

> From time to time attention has been turned to the problem of recharging dry cells. Although the dry cell is nominally considered a primary battery it may be recharged for a limited number of cycles under certain conditions. Briefly these are:
> 1. The operating voltage on discharge should not be below 1.0 volt per cell when battery is removed from service for charging.
> 2. The battery should be placed on charge very soon after removal from service.
> 3. The ampere-hours of recharge should be 120%-180% of the discharge.
> 4. Charging rate should be low enough to distribute recharge over 12-16 hours.
> 5. Cells must be put into service soon after charging as the recharged cells have poor shelf life.
>
> Recharging of dry cells may be economically feasible only when quantities of dry cells are used under controlled conditions with a system of exchange of used cells for new ones already in practice, and with equipment available to provide direct current for charging. Such a system would not be practical for home use.

By reversing the flow of current through the battery, both the anode and the cathode can be restored to a near-original condition through the process of electroplating. The efficiency of these replating operations determines how useful the system is for rechargeable batteries. This efficiency is affected by: 1. electrolyte conductivity, 2. the nature of the reaction products, and 3. the type of battery separator that is used.

In the carbon-zinc system, zinc dissolves in the electrolyte during use and often forms reaction products in combination with the manganese dioxide. Upon recharging, the zinc ion must travel from the electrolyte and redeposit on the anode. To produce a smooth plating operation, it is necessary that a good portion of the original zinc remain intact and that current distribution within the cell be very uniform. Conditions existing in the ordinary dry cell quickly lead to unevenness in the plating after successive charge and discharge cycles.

Zinc depositing more heavily in certain areas of the anode causes the formation of dendrites or tree-like growths which penetrate the separator, touch the cathode and cause internal short-circuiting of the battery.

During discharge of the cathode, the manganese dioxide is reduced to one of the lower valent oxides. The re-oxidation or reforming of the manganese dioxide during recharge proceeds smoothly unless substantial insoluble reaction products prevent even distribution of the current within the cell.

Deep discharge uses battery materials non-uniformly. The low conductivity of the electrolyte used in carbon-zinc batteries, when compared to those used in rechargeable systems, also limits the rate of discharge and the rate of charge acceptance to values that are lower than normally useful in rechargeable systems.

Recharging cells which are not specifically designed for charging can be dangerous. Excessive amounts of gassing which may result from too high a value of charging current may cause a tightly sealed cell to explode, resulting in personal injury or damage to equipment.

How to Select a Battery

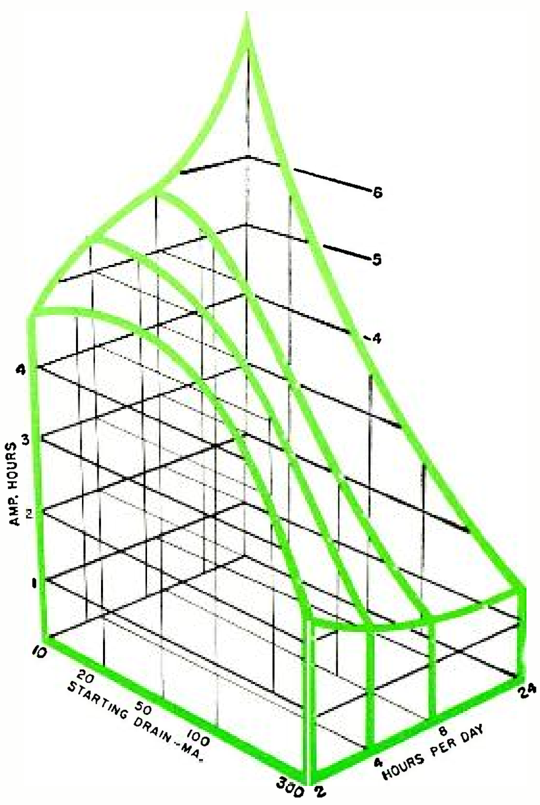
In order to specify a battery, at least the following minimum information must be known about the applications: maximum permissible starting voltage; initial current drain to which the battery is subjected at full battery voltage; voltage below which the device will not operate properly; periods of time battery must furnish current; and service life required. Other factors to be considered are operating temperature of the battery, size and weight, environment, and type of terminals.

Information on batteries of a given voltage is normally arranged in the manufacturer's literature in the order of increasing service life. If the service hours of the first battery examined are not sufficient for the application, continue to larger sizes with greater service capacity. The efficiency of carbon-zinc batteries improves as the current density decreases. For this reason, use as large a battery as possible for the application. This will give a lower cost-per-hour of operation and longer shelf life. Over a certain range of current density, service life may be tripled by halving the current drain. This is equivalent to using a larger battery for a given application and so reducing the current density within the cells. This is true down to a certain point beyond which shelf deterioration becomes important.

Service capacity for carbon-zinc batteries depends on the relative time of discharge and recuperation periods. Fig. 6 shows the service advantage to be obtained by proper selection of a battery for a specific application.

When a battery is chosen that will give adequate service life, it should be determined if it will meet the requirements of size and weight. If not, compromises must be made in either service or size and weight, or batteries with other chemical systems should be examined. A final selection is based on a balance of size, weight, and operating cost. The choice should also consider availability. ▲

Fig. 6. Battery service life as a function of the initial current drain and duty cycle for "D" size carbon-zinc cell.



Mercury Batteries

By GORDON E. KAYE / Applications Engineer, Mallory Battery Co.

These cells are widely used because of their voltage accuracy, extended shelf life, high energy density, low noise, along with good temperature stability.

THE unique physical and chemical characteristics of the mercury primary battery provide designers of portable electronic equipment with a versatile, maintenance-free power source. Mercury-battery applications are widespread and many newly developed products would not be feasible or economical without the serviceability implicit in its design.

A brief survey of its structural and functional capabilities is useful, since this power source must be considered not only as a component, but as part of an over-all system. This involves an analysis of the structure of the product in which the battery is to be used, the imposed environmental conditions, and the desired performance.

Cell Structure

The basic chemistry of the mercury battery system incorporates as a negative terminal an amalgamated zinc anode, usually made from highly purified compressed zinc powder. (See cover illustration.) The positive cathode terminal, or depolarizer, is a densely pressed structure of mercuric oxide and a nominal percentage of conductive graphite.

The electrolyte is typically a 40% solution of potassium hydroxide (KOH) saturated with the zincate ion. This saturation is required to prevent premature dissolution of the zinc anode during stand time. This, in turn, suppresses unwanted hydrogen gas. The electrolyte is structurally immobilized in either a gel or an absorbent of cellulosic material.

The cathode and the anode are separated by a microporous barrier material, which is permeable to the flow of ions, but will not permit the migration of structural or waste product particles between the electrodes that are employed.

Chemically speaking, the basic cell is a reactor in which the controlled corrosion of zinc takes place under electrical loads by oxygen released from the mercuric oxide. A by-product of this corrosion is the availability of free electrons at an initial nominal potential of about 1.3 volts under rated load conditions.

The external cell package is designed to perform several functions. It holds the active components in place and provides electrical contact to the load. It seals the electrolyte within the cell by means of a molded polyethylene or neoprene grommet, or seal, which is crimped in place upon final assembly. This seal also acts as an insulator between the negative anode or cell top, and the positive cathode, or container.

The dual-container structure of steel is part of a venting structure. If excessive hydrogen gas should evolve under certain conditions, the pressure lifts the top slightly and gas bleeds out of the seal interface near the inner container lip.

The cell top consists of two separate parts welded together. The peripheral flanges provide double sealing points. The anode-to-top contact is a mercury wetted interface with the tin-plated inner top and the zinc anode. The outer, nickel-plated cell top provides a clean electrical contact for external loads.

The cells can be welded in series or parallel to provide a wide variety of voltages and capacities. Hundreds of thousands of variations in form factors, packaging methods, and electrical outputs may be attained with standard cell modules. Since complete encapsulation in epoxy resins is feasible with the mercury system, it can meet severe environmental specifications.

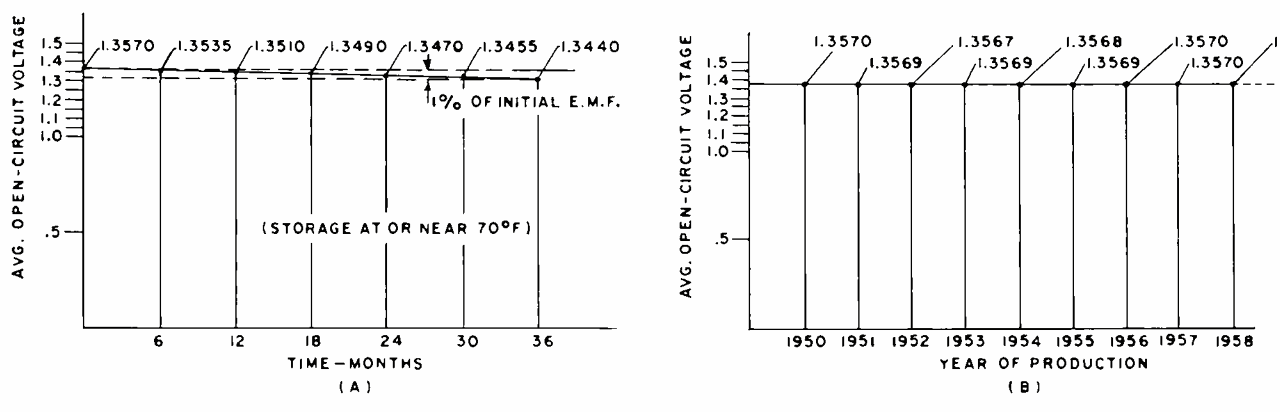
Electrical Performance

The performance of a battery package must be considered from both electrical and environmental standpoints.

Available Energy: The mercury battery system is capable of packaging 45 watt-hours per pound, and 6 watt-hours per cubic inch. These figures are for basic cells. The packaging efficiency will lower these values, but over 35 watt-hours per pound, and 5 watt-hours per cubic inch can be achieved with optimum packaging.

Voltage: The basic e.m.f. of the pure mercuric oxide-zinc alkaline system is 1.350 v. ±½%. This value is repeatable and reliable and is, in fact, a secondary voltage standard over a wide variety of temperature and environ-

Fig. 1. (A) Open-circuit voltage of mercury cell is within ± ½ percent of 1.350 volts over a three-year period of time. (B) Stability of open-circuit voltage of mercury cells over nine years of production.



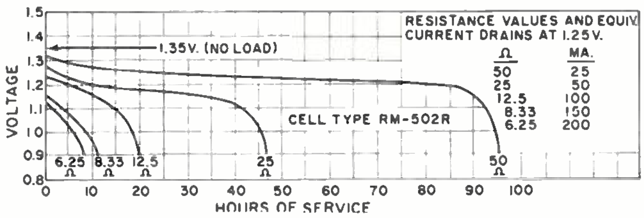


Fig. 2. Voltage-discharge curves for "AA" penlight mercury cell.

mental conditions (Fig. 1A). To stay within these tolerances, the current drain should be kept low, under a milliampere, for cells over one ampere-hour and, preferably, the drains should be intermittent. The low internal resistance of these cells is responsible for their ability to deliver closely regulated voltages under useful loads. The larger capacity cells are more widely used in realizing this capability.

These reference voltage values are reliable within the shelf life of the cell and, in effect, have been measured on cells fourteen years old. It is not generally related to the milliampere capacity of the cell or its expenditure. The repeatability of individual pure mercury cells is within millivolts, over many years of production (Fig. 1B). The reference capability diminishes with increasing load conditions. The terminal or load voltage will drop due to the internal resistance of the cell. This value varies from ¼ ohm to 5 ohms per cell and is a function of cell size and capacity.

Some mercury batteries utilize a depolarizer with a small percentage of manganese dioxide. The initial voltage of these cells is 1.45 volts. This higher value "burns off" during the early stages of cell utilization when the mercury potential is reached. The higher initial voltage is not seen after this point. Pure mercury cells are distinguished from blended cells by the designation "R" after the type number for the 1.35-volt cell.

Cell Capacity and Current Delivery Rate: The cell capacity is the installed, rated, milliampere-hour capability of the unit cell or battery. As an example, ten cells in series, each having a capacity of 1000 milliampere-hours, will usually deliver 1000 ma. hrs. at an average load voltage of 12.5 volts. The rate of current delivery is defined as the cell capacity divided by the drain rate (the 20-hour rate on a 1000-ma. hr. cell would be 50 ma.). However, at the ten-hour rate (100 ma. on a 1000-ma. hr. cell) the cell efficiency will drop and the actual hours delivered will be 6 hours to .9 volt (representing a 60% efficiency, or 600 ma. hr.).

Run-out data is usually specified at a load resistance in ohms at a certain temperature. Typical performance curves are illustrated in Fig. 2 for an "AA" size penlight mercury cell.

In general, a mercury cell will provide a nominal voltage regulation of 30% of its cut-off voltage, which will account for 90% of battery capacity at the twenty-hour rate. If cell current rates are reduced, a 10% voltage regulation can be achieved.

Temperature Effects: Battery performance is affected by temperature. To improve the efficiency of mercury cells at low temperature, a ribbon-wound zinc anode is used instead of the pressed powdered structure (Fig. 3). This effectively increases the relative active anode surface area in each cell volume.

Further advances in low-temperature performance are possible with increases in the permeability of the anode to

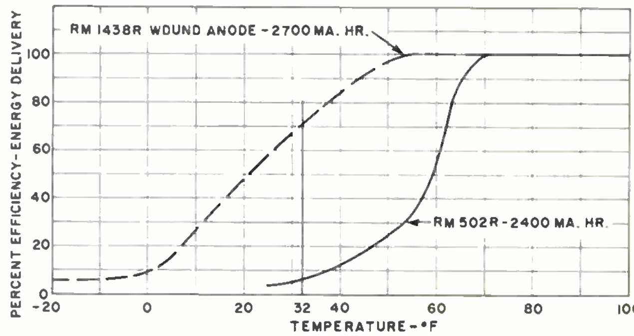


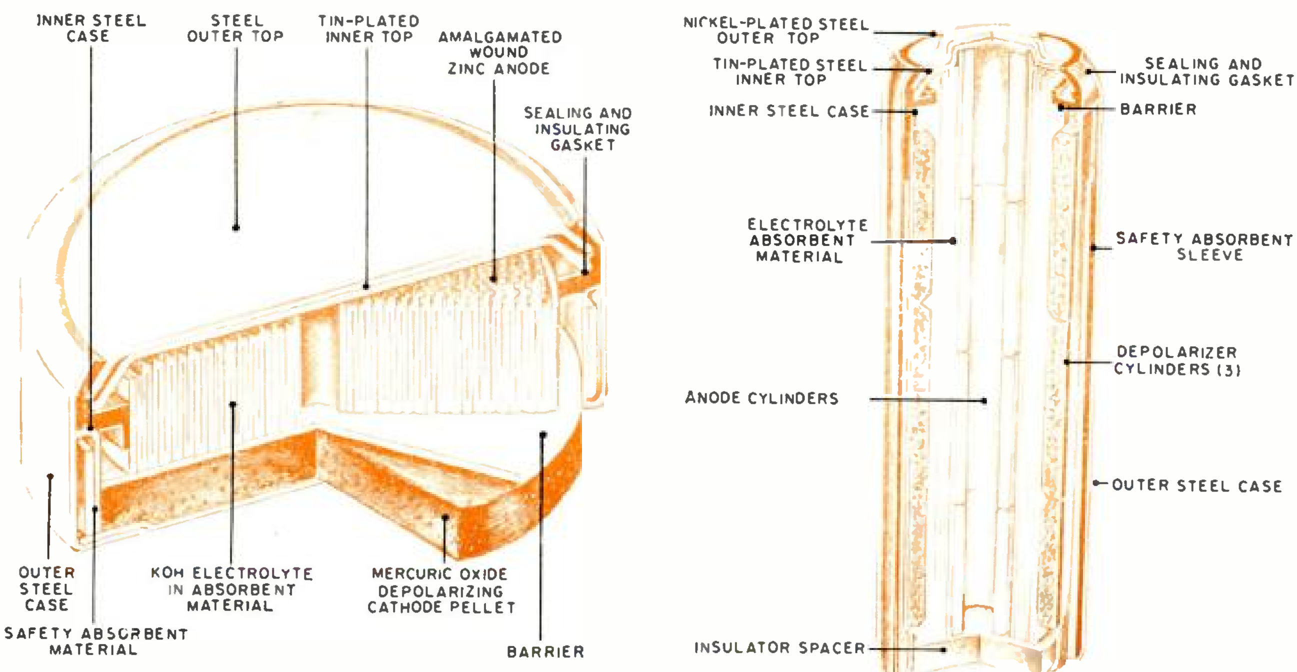
Fig. 4. Comparison of wound-anode vs pressed-pellet anodes in cells of similar capacity. Ten-ohm (125 ma.) continuous load.

ionic transfers. In general, the current density (milliamperes per square inch) must be kept low and all sources of internal resistance must be reduced.

The relative efficiencies of cells that have been constructed with pressed powder and wound zinc anodes are shown in Fig. 4.

Shelf Life: The shelf life of a primary battery is the

Fig. 3. (A) The wound-anode flat mercury cell construction. This type of cell is designed specifically for low-temperature use. (B) The cylindrical structure is used for tall, thin battery cells.



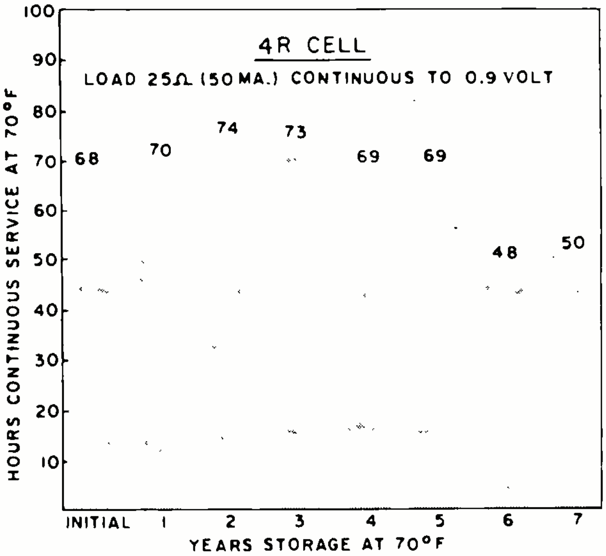


Fig. 5. Hours of service versus years of storage at 70°F.

length of time it takes for the unit to decay 50% of its initial rated capacity in milliampere-hours. This decay is due to the slow internal chemical reaction which affects the quantity of available oxygen or the amount of zinc anode remaining. Loss of oxygen occurs during the oxidation of the organic compounds in the cell. It can be caused by electrical leakage across the cell internally due to oxide or waste products bridging the active terminals. Chemical impurities can also cause losses through unwanted side reactions. The mercury battery is so constructed to avoid or reduce these possibilities. (Refer to Fig. 5.)

Paramount in attaining a long shelf life is excellence in design and manufacture of the cells. Tight control of all the physical and chemical parameters is, of course, mandatory to achieve this important characteristic.

Applications

The mercury battery has been available for 20 years and has perhaps been applied to a greater diversity of electronic and electrical devices than any other battery system. The choice of battery system is a function of battery characteristics and their relationships to product design requirements.

The extended shelf life and high energy density of mercury batteries are employed to provide greater reliability in emergency devices such as air-sea rescue radios. Since these are carried aboard aircraft, the use of mercury batteries effects economies in equipment, size, and weight with attendant reduction in aircraft fuel expenditure during the operating life of the craft. Three to five years standby service is generally obtained from battery packs built for this application.

The reference capability of the cell is widely used to provide accuracy in electrical measuring circuits. Instruments based on this parameter can supply measurement accuracies within 1% over several years of battery service, since both duty and drain rates are light.

The low noise factor, less than 10 μv. on a good-size battery, is indicated where delicate signal detection is required. This is economical when filters and other regulators can be eliminated in product circuitry. The biasing of various types of analog computer circuits, another example of this particular capability, can be maintained readily over a five-year service period.

The high energy density of the system allows the construction of miniature cells. Capacities ranging from 16 ma. hr. to 500 ma. hr. are widely used in hearing aids which will provide 3 to 10 days service.

This battery system exhibits greater stability under a high temperature delayed storage than most available battery systems. As a result, the use of mercury cells in implanted cardiac pacemakers is indicated. These batteries usually consist of 5 to 6 cells in the 1000-ma. hr. range and are wired into a timing circuit which is encapsulated both in epoxy and silicone rubber. Circuits have operated for over four years at 20 microamperes in the very constant 98°F of the human body.

Cell structure and chemistry, while generally reliable, are even more so when built to very tight manufacturing standards in facilities set up for the purpose. Under these conditions, a general manufacturing failure rate of less than 1 part in 25,000 is attainable.

It is interesting to note that the internal structure of batteries for service requirements of over 5000 hours must be designed especially to avoid internal loads resulting from internal migration of the converted expended electrode material during operation. These special low-drain types will not function well at less than the 100 hour rate. Low-drain mercury cells are also used in electric wristwatches and will operate for a year or more.

The mercury battery can be used at low temperatures when built in a wound-anode structure. Other performance factors at higher temperatures are not degraded with this construction. A low-temperature capability also means that higher current drains are possible at normal operating temperatures.

Another advance will take place in low-temperature performance of mercury cells. Recent advances in zinc anode structure will provide −40°F performance with efficiencies at least 20% of room temperature performance. The other favorable high-temperature characteristics will not be materially affected.

The reliability of mercury cells for special purposes can be materially increased. A zero-defects program now underway is pointing the way to further attainments in reliability of all mercury cells and batteries.

The designers of tomorrow's portable electronic equipment will continue the trend toward battery miniaturization. This, in turn, will raise the requirements for cell efficiency both in packaging and performance.

There will be a trend away from larger cell sizes in electronic applications as production designs adapt to the new integrated circuitry. It seems likely that mercury cells will continue to provide answers to designers' portable power-supply problems for some time to come. ▲

ABOUT RECHARGING MERCURY CELLS

Mercury primary cells and batteries are designed to provide electrical energy, within their rated capacity, efficiently. They are *not* specifically designed for recharging, although it is claimed that a limited number of charging cycles can be obtained. It is hazardous to recharge these batteries, even though claims of success have been made. Statistically, a defect in the charging system or production variation can exist in the cell. This could cause a cell explosion which could scatter caustic electrolyte and cell parts on a person or his property. The responsibility for the potential damage must be assumed by the user, since system rechargeability is outside the performance claims made for this product.

If rechargeability is required, then cell systems specifically designed for this purpose should be employed.

Alkaline Batteries

By HOWARD J. STRAUSS / Director of Research & Development, Burgess Battery Company

Operation and characteristics of alkaline-manganese, silver oxide-zinc, silver oxide-cadmium, and air-depolarized types.

IN other articles in this issue, nickel-cadmium and mercury batteries are being covered separately. While these batteries are classified as alkaline batteries since they use caustic electrolytes, there are many other alkaline batteries that are of considerable importance. These include the alkaline-manganese, silver oxide-zinc, silver oxide-cadmium, and air-depolarized types.

Alkaline-Manganese

Of these, perhaps the most important to the electronics industry is the alkaline-manganese system. While this system has been known for many years, the availability of new materials and new assembly techniques have combined to project this system into commercial importance during recent years.

Although developed essentially as a primary battery, the alkaline-manganese system has been found to be rechargeable to a commercially useful degree. At the present time, the alkaline-manganese system is undergoing intensive further development by many producers, particularly as regards its rechargeability. In this regard, it is quite likely that the alkaline-manganese system will, within the next few years, fill the important gap between the inexpensive one-shot primary carbon-zinc (Leclanché) system at one end of the scale, and the extended cycle life rechargeable nickel-cadmium system at the other end of the scale.

The fundamental energy-producing reaction in alkaline-manganese cells is the same as for carbon-zinc cells:

$$(2A + B)\, MnO_2 + (A + B)\, Zn \longrightarrow A\, Mn_2O_3 + B\, MnO + (A + B)\, ZnO$$

However, the different environment (alkaline *vs* acid) results in significantly different cell properties, and perhaps one of the potential difficulties in using the alkaline-manganese cells is to regard them as direct substitutes for carbon-zinc cells.

In actual construction the two types are quite different. As shown in Fig. 1, a typical alkaline-manganese cell uses a cylindrical depolarizer in contact with the cell container of (usually nickel-plated) steel. Because of the passivity of steel in alkaline electrolytes, there is no chemical reaction between the MnO_2 depolarizer and the steel, permitting the latter to be a current collector as well as a strong cell container. The depolarizer surrounds a cylindrical granular zinc anode, the two electrochemical components being separated by porous sheet materials. When the zinc is amalgamated to discourage gas generation on open-circuit stand, copper-coated steel or brass current collectors are generally used, and the cell may be hermetically sealed. However, some manufacturers provide rupturable closures or relief valves to avoid violent gas relief in the event of a faulty or misused cell.

It should be noted that the polarity is reversed from that of conventional carbon-zinc cells (in which the can is the negative), but through external jacketing and terminal pieces, alkaline-manganese cells have been made to appear conventionally polarized (that is, with the center-button terminal positive and the opposite terminal negative).

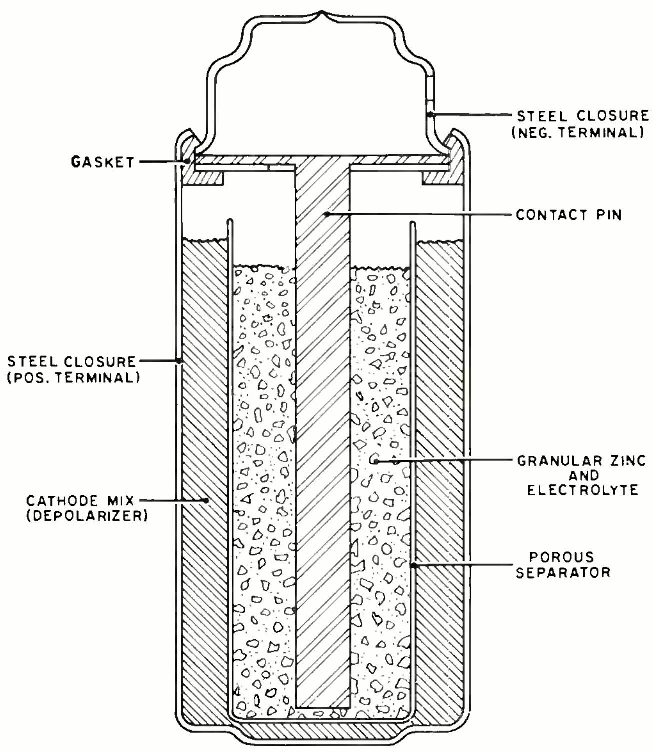
Electrical Properties

Electrically, the properties of alkaline-manganese cells can best be reviewed in relation to carbon-zinc cells. Although the two systems have about the same open-circuit voltage (approximately 1.5 v.), the alkaline-manganese system discharges at lower voltages than carbon-zinc cells. Also, as indicated in Fig. 2 (using a generalized time scale), the discharge voltage decreases steadily, but more slowly.

On the other hand, alkaline-manganese cells have 50-100% more capacity (depending on discharge rates) than their carbon-zinc counterparts. However, while carbon-zinc cells will yield most of their available energy above 1.25 v. and will be virtually exhausted at 1 v., alkaline-manganese cells yield most of their energy below 1.25 v., and with a considerable portion of the energy released at less than 1 v. As a matter of fact, for best capacity, alkaline-manganese cells should be run to a cut-off of 0.9 v., or even to 0.8 v., where possible. This is further indicated in Fig. 3 which shows the capacity of alkaline-manganese cells as a function of initial drain rate and cut-off voltage.

Fig. 3 also indicates that alkaline-manganese cells are capable of very high discharge rates; in fact, much higher

Fig. 1. Cross-section of alkaline-manganese cell. Through external jacketing and terminal connections, cells can be made to appear conventionally polarized (center button +).



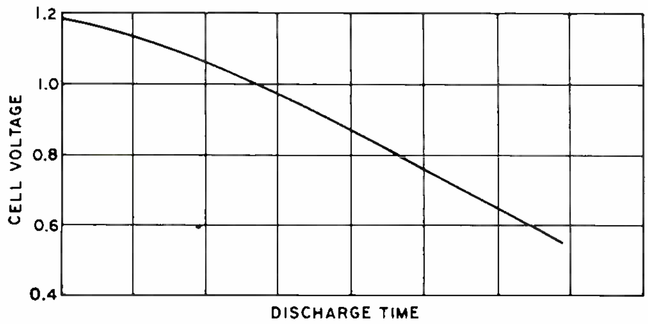


Fig. 2. Discharge characteristics of alkaline-manganese cells shown on arbitrary linear time scale. Note that cell discharges at lower voltages than does the carbon-zinc cell.

than comparable carbon-zinc types. Furthermore, they do not polarize readily, meaning that high drain rates can be sustained over extended periods. Furthermore, alkaline-manganese cells can be continuously discharged without sacrificing capacity. In addition, it is not necessary to provide rest or recovery periods to develop maximum capacity.

The alkaline-manganese system, in common with other alkaline cells, has fairly good low-temperature characteristics. Generally speaking, alkaline-manganese can be used effectively down to about −10°F, although they can yield some useful energy down to as low as −40°F.

Table 1 gives generalized data showing temperature characteristics of alkaline-manganese cells. It should be noted that elevated temperatures have no adverse effects on capacity, but long exposures to high temperatures, *i.e.*, above 130°F, may result in excessive self-discharge losses, and attendant generation of disruptive gases. Normally, with properly compounded anodes, the shelf life of alkaline-manganese cells is considered to be excellent and, in fact, may be better than carbon-zinc cells.

Rechargeability

The rechargeability of the alkaline-manganese system is of considerable interest to the electronics industry. At its present state of development, the conditions for rechargeability are fairly restrictive. Essentially, these conditions require strict limitation of the discharge, recharge rate, and overcharge. As indicated by the energy-producing reaction, more than one oxide can form during discharge, and these in various proportions depending on the discharge conditions and depth of discharge.

If the discharge is limited to 40% of the nominal capacity of the cell, and recharge is carried out at low rates (over a period of 10-20 hours) with little or no overcharge, alkaline-manganese cells can yield 50 to 150 cycles. Because of the limited depth of discharge, there is a very large reserve of power during early cycles. During these cycles, the discharge will terminate at a 1.1-1.2 v., whereas in the later cycles, with the reserve power having been expended, the discharge will terminate at lower voltages, *i.e.*, about 0.8 v. (See Fig. 4.)

As either primary or secondary batteries, the alkaline-manganese system is finding widespread applications in portable radios, portable television receivers, tape recorders, shavers, photoflash units, lighting systems, hobby craft, toys, cameras, and other devices.

Table 1. Temperature characteristics of alkaline cells.

	Percent Capacity (to 0.8 v. cut-off)		
Temp.(°F)	Light Drain	Medium Drain	Heavy Drain
113	100	100	100
70	100	100	100
30	70	40	25
−10	15	10	3

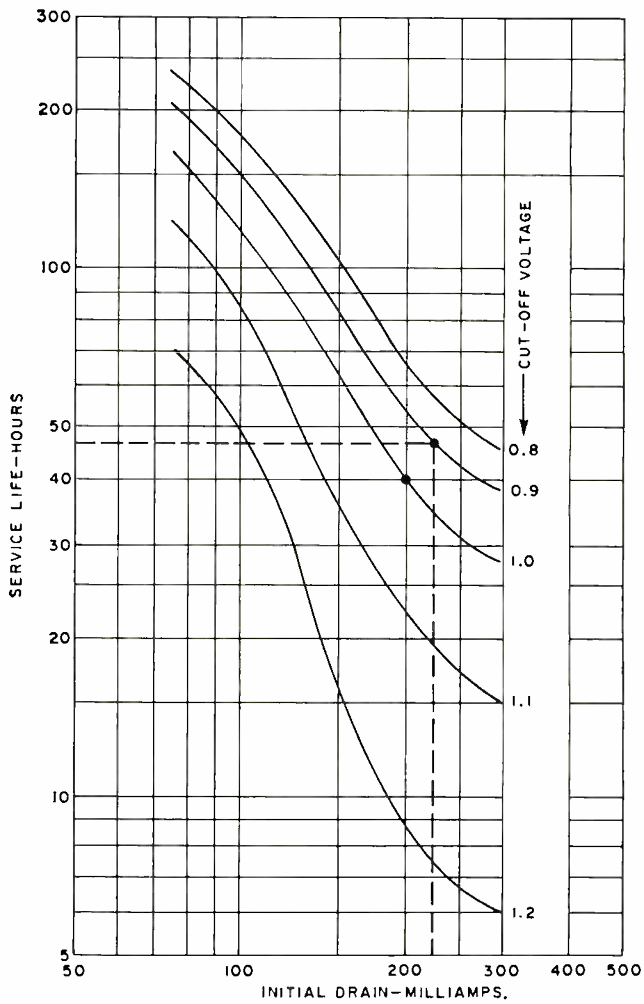
Silver Oxide-Zinc

The silver oxide-zinc system is also important to the electronics industry, particularly those branches dealing with military communications, missile guidance, and underwater surveillance. Of all electrochemical power sources, none surpasses the silver oxide-zinc system in its ability to yield power (watts) from a given weight or volume, and few surpass it in energy (watt-hrs.). See Table 2. This system generates energy through the reduction of silver oxides by zinc:

$$(2A + B)\ AgO + (A + B)\ Zn \longrightarrow$$
$$A\ Ag_2O + B\ Ag + (A + B)\ ZnO$$
$$Ag_2O + Zn \longrightarrow 2\ Ag + ZnO$$

Electrically, the outstanding features of the silver oxide-zinc system are illustrated in Fig. 5. A substantial part of the energy of a silver oxide-zinc cell can be extracted within 15 minutes or (by special cell design) less. At the one-hour rate (*i.e.*, that current drain which will exhaust

Fig. 3. Capacity of alkaline-manganese cells as a function of initial drain rate and cut-off voltage. The curves are for a D-size cell with rated capacity of 10,000 ma. hr. Service life for other cell sizes can be obtained from the curves by using an initial drain rate in proportion to rate capacity of cell. For example, for a 10,000-ma. hr. cell with an initial drain rate of 200 ma. and a cut-off voltage of 1.0v., the service life will be 40 hrs. For an AA-size cell rated at 1800 ma. hr., with an initial drain rate of 40 ma. and a cut-off of 0.9 v., the service life can be obtained from the intersection of the vertical coordinate 10,000/1800 × 40 or 222, with the 0.9-v. cut-off curve. This is found to be 48 hrs. as shown. These curves are generalized for estimation.



the battery in one hour) and lower drains, the available capacity is virtually constant. At these rates, the discharge characteristics are such as to exhibit long periods at virtually constant voltage. Frequently, for electronic purposes, by sacrificing a relatively small fraction of the cell capacity, it is possible to get almost entirely constant voltage discharges.

Although some silver oxide-zinc batteries are designed as primaries, these must be stored dry with electrolyte added just before use. Consequently, silver oxide-zinc primary cells have found only limited, specialized application such as for torpedo propulsion, missile guidance power, and the like. Of greater and more general interest are rechargeable (secondary) types.

Conventional, vented silver oxide-zinc secondaries can be successfully operated over a wide range of charge and discharge conditions. The newer, sealed type must be charged and discharged at (reasonable but) low rates to avoid gassing, and overcharge must be kept to a minimum. The cycle life of vented cells depends very strongly on the use conditions. At one end of the scale, silver oxide-zinc cells discharged completely at high rates and then recharged promptly at moderate rates, with severe overcharge, will yield only 15-20 cycles. At the other end, cells subject to shallow discharges (*i.e.*, up to about 40%) at low-to-moderate rates, with slow recharge and limited overcharge, can yield 100-200 cycles. For electronic work, 5-10 hr. discharges to 60% depth, followed by 10-16 hr. recharge with 10% overcharge is a common routine which should yield 50-100 cycles.

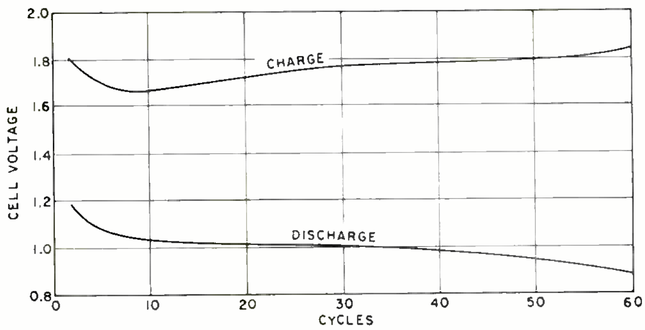


Fig. 4. Cell voltage at end of charge and discharge for alkaline-manganese secondary cells related to cycle history.

Silver oxide-zinc batteries perform well at low temperatures yielding usable energy down to $-40°F$ (*i.e.*, about 5-10% of its normal temperature capacity at low drain rates). Where permissible, a silver oxide-zinc cell can be short-circuited at low temperatures ($-40°$, down to even $-60°F$) in which case the internal heat generated can warm the cell sufficiently to yield acceptable discharges. By this and similar techniques, it is possible to get up to perhaps 30% of the normal temperature capacity at low-to-moderate rates starting at an ambient temperature of $-40°F$.

The shelf life of charged silver oxide-zinc cells is also variable, depending on design and use. Capacity losses of less than 20% per month are now common even for high-rate designs. For low-to-moderate rate cells, shelf losses are on the order of 5-10% per month.

Silver Oxide-Cadmium

In general construction and characteristics, silver oxide-cadmium cells are very closely related to silver oxide-zinc cells. The differences stem from the substitution of cadmium for zinc as the negative electrode material:

$$(2A + B)\ AgO + (A+B)\ Cd \rightarrow$$
$$A\ Ag_2O + B\ Ag + (A + B)\ CdO$$
$$Ag_2O + Cd \rightarrow 2\ Ag + CdO$$

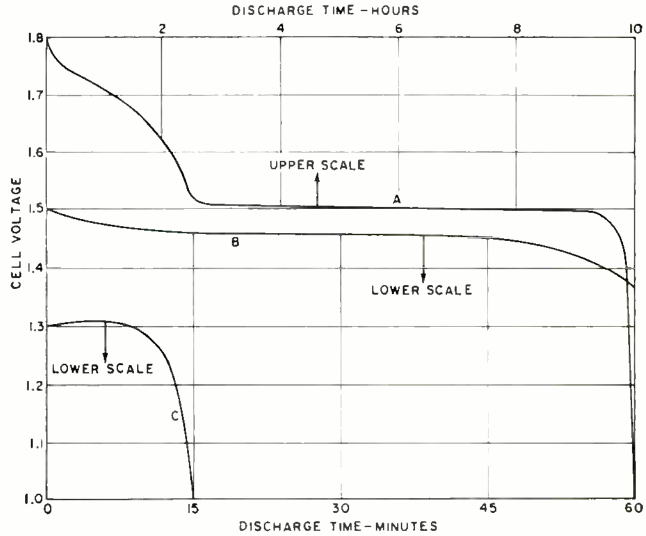


Fig. 5. Discharge characteristics of silver oxide-zinc secondary (rechargeable) cells. Curve A is at the 10-hr. rate, or that current drain which will yield useful energy for 10 hrs. Curve B is at the 1-hr. rate and Curve C is at the 15-min. rate. As the current drain increases, resistive losses within the cell result in lower voltages and considerable heating.

These differences, however, bring about some important practical changes in certain cell characteristics. For one thing, cadmium being less electronegative than zinc, a silver oxide-cadmium cell releases its energy at lower voltages than its silver oxide-zinc counterpart (see Fig. 6). However, the lower activity of the cadmium is such that a spontaneous reaction with caustic electrolytes does not occur (as is the case with zinc) so that shelf life is considerably better. As a matter of fact, silver oxide-cadmium cells are currently available with shelf losses of only 1 or 2% a month. The absence of reaction with the electrolyte also avoids the spontaneous generation of hydrogen gas on open circuit so that silver oxide-cadmium cells can be more readily designed as hermetically sealed units.

Perhaps the most important difference, however, lies in the fact that cadmium oxide (*i.e.*, the discharged form) is virtually insoluble in caustic solutions, whereas zinc dissolves to an appreciable degree. In the case of the latter, this results in plate washing and penetration of the separators (shorting) by zinc dendrites which form from soluble zinc during recharge. As a result, these life-limiting factors are not operative in silver oxide-cadmium cells which therefore have a cycle life expectancy of 10 to 25 times that of comparable silver oxide-zinc cells.

Air-Depolarized

A fourth type of alkaline system, air-depolarized cells, has been important to the electronics industry since the early days of radio when such cells were widely used. Air-depolarized cells utilize oxygen directly from the atmosphere as one of the electrochemically active materials:

$$O_2 + 2\ Zn \rightarrow 2\ ZnO$$

Thus the ingredients are inexpensive and large capacities can be had since only one electrochemically active com-

Table 2. Comparative characteristics of alkaline cells.

	Open-Circuit Volts	Average Operating Volts	Watt/hrs. per pound	Watt/hrs. per cu. inch	Amp/hrs. per pound
Alkaline-manganese	1.46	1.15	50	23	43
Silver oxide-zinc	1.86	1.5	26-60	1.4-4.0	18-40
Silver oxide-cadmium	1.4	1.1	12-40	0.7-3.0	10-38
Air-depolarized	1.4	1.2	53	2.2	40-45

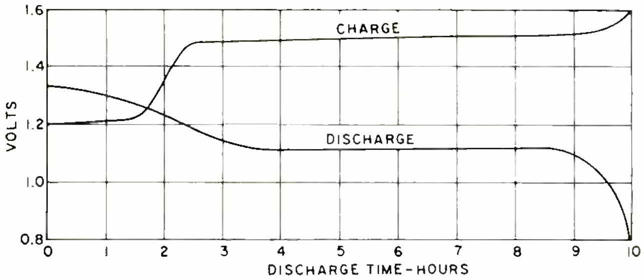


Fig. 6. Low-rate charge and discharge characteristics of silver oxide-cadmium cell. The discharge characteristics will be about the same for discharge currents up to 3-hr. rate. Recharging should be done at the 10 to 20 hour rate.

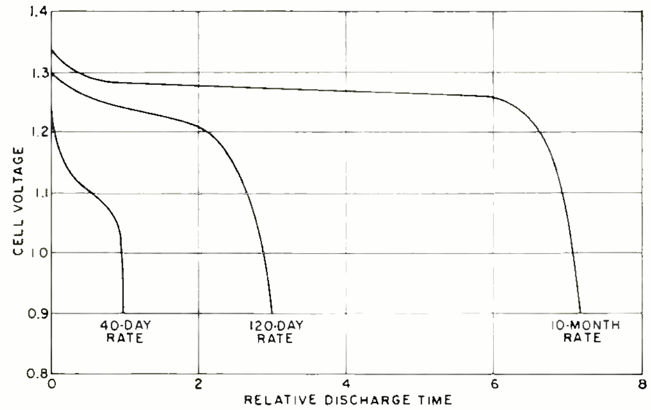


Fig. 7. Discharge characteristics of air-depolarized cells show excellent voltage stability and long, continuous service life capability although at low rates of discharge.

ponent need be stored within the cell itself. However, air-depolarized cells are limited to low current drains (Fig. 7). This limitation of power capability has retarded the commercial importance of this system. But recent developments in gas-electrode engineering (stemming from the development of fuel-cell systems in recent years) and the development of porous (active) zinc electrodes as a replacement for the solid zinc electrodes used in conventional air-depolarized cells, can greatly extend the power capability of this system and reactivate its growth.

One of the inherent difficulties of air-depolarized cells is that the alkaline electrolyte readily absorbs carbon dioxide from the air. Unlike other types of alkaline cells, this is unavoidable in air-depolarized cells, since air must have free access to the inside of the cell if the atmospheric oxygen is to be the depolarizer. As the carbonate content of the electrolyte increases, so does its resistance, still further reducing the cell's power capability, and it may be necessary to replace the electrolyte from time to time or use special carbon dioxide absorption systems. However, in spite of these difficulties, air-depolarized cells continue to be an excellent source of low-voltage, high-capacity battery energy.

Including the nickel-cadmium and mercury cell systems, which also use alkaline electrolytes and are discussed separately in other articles, the electronics designer has a choice of at least six alkaline cell systems. As indicated, these differ very widely as regards their capacity and power capabilities per unit space and weight. In addition, they differ markedly in discharge characteristics, rechargeability or non-rechargeability, high and low temperature performance, shelf life, and charge retention. In addition, some types may be hermetically sealed, or may be encased in steel containers (to obtain high levels of mechanical integrity). With this variety, the electronics designer can select a battery system which will provide economical, dependable, noise-free direct-current power having electrical characteristics closely aligned to the requirements of the particular application involved. ▲

NEW POCKET-PLATE NICKEL-CADMIUM BATTERY

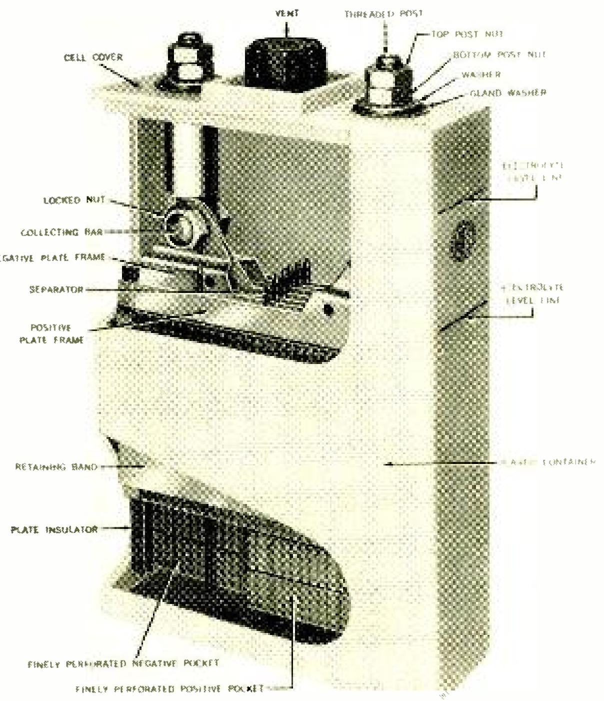
A SIGNIFICANT and new development in nickel-cadmium pocket-plate battery technology has been announced recently. For the past 20 years, pocket-plate (the active materials are enclosed in perforated steel "pockets") battery performance has become stabilized in two distinct categories, with virtually no major changes during that period. Batteries were offered either for high-rate applications, such as engine starting and switch tripping, or for low-rate applications, where the discharge was uniform over a fairly long period of time. While the batteries were exceptionally reliable, they were also quite bulky and expensive. These last two limitations have been essentially eliminated with the introduction of three completely new cell types by the *Nife Corporation*. These serve practically any application requiring high current or high capacity, or both together.

Available in capacities ranging from about 10 to 200 ampere-hours, the new cells feature a unique method of plate separation, shown in the photo. The separators are a number of vertical rods rather than solid sheets of plastic. The cells have an extremely low internal resistance, accomplished by the use of a large number of very thin plates with minimum separation. In addition, more capacity is achieved by use of more active materials in the plates themselves. The type HI cells are for very high discharge rates, type MD for moderate discharges, and the type KA for low rates at maximum capacity.

To illustrate the relative significance of the new cell technology, consider the following comparison.

	Capacity in amp.hrs. @ 8-hr. rate to 1.14 v./cell	5-sec. current in amps to 0.65 v./cell	30-sec. current in amps to 0.85 v./cell	Weight (in lbs.)
Old type KBI-16	165	1056	640	27.4
New type HI-8	80	1060	620	14.2

For a given ampere-hour capacity twice the starting performance is possible or, more important, for comparable starting requirements, a battery is now available for the same job with half the former capacity and weight. The smaller cell is also much less expensive and in battery economics the total of all the improvements becomes meaningful.



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The ability to make neat, clean solder joints is as much a part of good servicing as locating faulty components.

THE ART OF SOLDERING

BARNEY'S face wore a puzzled frown as he looked up from the TV chassis on the bench in front of him. "Hey, Mac," he said to his employer, "how can Oscar over on Maple Street be such a fine diagnostician and trouble-shooter and make such lousy solder joints? The ones he left in this set look as though they were made with a dirty, luke-warm poker. See how the gobs of solder look grainy and frosted, indicating the solder was never heated enough really to flow? And notice how careless handling of the soldering gun or iron has charred and melted the insulation on wires surrounding the joints. I just don't get it."

"That's because you expect a man who does one thing well to do all things well. It's not logical, but we all do it. That's why we elect successful generals to the presidency, let star athletes tell us how to shave, and accept as Gospel a pronouncement on any subject from a man who has made a lot of money.

"I agree with you that Oscar is a real whiz at pinpointing trouble in any sort of electronic device. Time and again I've seen him pore over a diagram for a few minutes, make a couple of tests, and then unerringly point out the defective component. But when he has done this, he loses all interest in the job. The intellectual part of servicing is what intrigues him. Making a neat replacement of the bad part is a necessary bore, and he rushes through it as quickly as possible.

"Quite a few of the newer service technicians are of this type. They consider effort to make a neat-appearing part replacement a waste of time. They argue that a good solder joint does not have to be a 'pretty' solder joint."

"From your tone I take it that you don't agree."

"You take it right. I'm of the old school that believes there's a right and a wrong way of doing everything, and I think it's worth the effort to learn the right way. I *know* this applies to making a solder joint. Good soldering is an art, and like any art it takes practice and patience to learn; but the ability to produce clean, strong, low-resistance solder joints is as important to the service technician as skill in making neat, strong sutures is to a surgeon. In both instances, the mastery of the technical art is necessary to bring an 'operation' to a successful conclusion."

"Don't you think you're laying it on a little thick to call good soldering an art?"

"Nope. The wedding of strength and beauty is what makes architecture an art, and the same goes for soldering. A good solder joint is both strong and aesthetically pleasing. The solder is not grainy or fudge-like in texture; there are no sharp points where molten solder has tried to follow with withdrawal of a cooling iron; and, above all, the solder is not piled on in shapeless blobs. Instead, the entire joint is enclosed in a smooth, tight-fitting skin of solder that covers every bit of the joint but still reveals the contours beneath exactly the way stretch pants do."

"Hey, you've been noticing!" Barney accused with a grin.

"I assumed I was supposed to," Mac retorted. "Anyway, the solder feathers off gradually along the wires leading to the joint so there is an almost imperceptible change from wire to solder. And the joint's appearance is not marred by the presence of unvaporized resin or melted insulation on its surface."

"Why do you think new technicians are more likely to produce poor joints than the old timers?"

"For one thing, the old timer, unless he is pretty stupid, has learned the importance of good soldering the hard way by having sets bounce back on him because of cold solder joints. That teaches you in a hurry. For another thing, many old timers have done quite a bit of construction. Many built some of their first broadcast receivers, as I did. On those early breadboard jobs, all the wiring was right out in plain view; and we were as concerned as much about the appearance of the wiring as we were about the performance of the receiver. I still can remember using rectangular bus bar or round bus bar with spaghetti and making only precise 90-degree bends in the wiring to make it look beautiful. Naturally, we took infinite pains to insure the soldering would not detract from the appearance of the rest of the wiring.

"Finally, the old timer had to learn to make a good solder joint with a clumsy, heavy iron without any heat regulation. His solder, which came in the form of a long bar, was not really designed for electrical work and was not uniform in quality. Flux was not integrated into the solder but had to be added separately and judiciously. And most of the wires he soldered were not pre-tinned or even free of oxidation. Having learned to make a good joint with this crude equipment, the old timer finds using convenient flux-cored wire solder scientifically designed for electronic work to solder pre-tinned wires with modern solder guns or heat-regulated irons a real breeze."

"I'd think so!" Barney exclaimed; "but I can tell you one good way a fellow can teach himself to do a good job of soldering in a hurry, even today.'

"What's that?"

"Let him put together a couple of kits, especially ones that involve high-frequency circuits. If he wants these kits to work the first time he throws the switch, he must follow instructions and learn how to do a decent job of soldering."

"You're so right. A friend of mine works in the repair department of a large kit manufacturer, and he tells me a very high percentage of all kits returned to be straightened out have nothing wrong with them but poor solder joints. As you know, every now and then someone brings a kit job in here for us to check, and it always amazes the owner that I am often able to spot a defective connection simply by inspection, which brings us back to my contention that a good solder joint has to *look* good. If anyone doesn't know how a good soldering connection ought to look, let him carefully examine the connections in a commercially produced hand-wired radio or TV receiver. Better still, let him examine with a magnifying lens the joints in surplus military electronic equipment. Some of these contain the most beautiful examples of artistic soldering I've ever seen."

"You're waxing downright lyrical," Barney teased. "After all, there are only a few basic requirements for good solder-

ing. (1) The soldering tip should be clean and well-tinned, and the connection should be free of grease, corrosion, insulation, or other contaminating material. (2) Enough heat should be applied to the joint so that solder touched to it melts quickly and spreads almost immediately to every part of the connection, flowing as freely as water into all the crevices. (3) Heat should be applied long enough to cook out any surplus flux and avoid a 'resin joint,' but not so long as to burn the 'life' out of the solder. (4) Enough solder should be applied to encase the joint completely with a thin layer, but no more. (5) All wires leading to the joint should be held immobile until the solder has hardened."

"A couple of those requirements should be qualified in applying them to printed-circuit-board soldering," Mac suggested. "When soldering a lead to a printed circuit, I do not apply the soldering tip to the juncture of the lead and the foil. Instead, I heat the short lead while holding the board so that the molten solder runs down the lead to the foil. The thin foil absorbs much less heat from the solder than the comparatively heavy lead. This technique permits heating the lead enough to melt the solder and to make a good bond to the lead. The solder still has plenty of temperature left to bond with the foil when it reaches it, but there is no excess of heat to cause the foil to lose its bond with the board—something that often happens when you try to heat foil and lead simultaneously. By the same token, it's much easier to err on the side of 'too much heat' in soldering to a printed-circuit board than it is when soldering hand-wired connections."

"None of these requirements sound very tough to me," Barney mused. "I still don't see why otherwise good technicians often make bad solder joints."

"As I mentioned, many technicians do not look upon soldering as an art to be mastered through striving for perfection. To them, it's only a necessary nuisance. They simply place wire, solder, and the gun tip in the vicinity of the joint and pull the trigger of the solder gun and keep it pulled until they feel the solder melt. Then they yank on the lead of the component they have been soldering. If it doesn't pull loose, they figure the joint is 'good enough.' After all, they think, who's going to see it?"

"Yeah, I've often thought that if radio and TV sets came in transparent cabinets, we'd see much neater component replacements than we do now. Anyway," Barney continued, picking up the solder gun and waving it about with graceful flourishes, "you've given me a new ambition. I intend to become known as 'The Michaelangelo of the Solder Gun'!"

"You could do lots worse," Mac growled. ▲

PRINTED-CIRCUIT REPAIR

By LOUIS E. FRENZEL, Jr.

THE repair of electronic equipment using printed-circuit boards is difficult in that it requires special care and patience to remove a defective component without damaging the board. Damage is usually caused by excessive soldering-iron heat or mechanical strain produced while removing parts from the board. This trouble is due to the inability to remove all of the solder holding the component to the copper pads on the board.

This is doubly the case when a multi-connection component like an i.f. transformer, tube socket, or transistor must be removed. The technician often holds the iron on the connection to keep the solder melted while he pries at the leads with the point of a knife or pulls heavily at the component on the other side of the board. With techniques like this, the board is sure to be damaged.

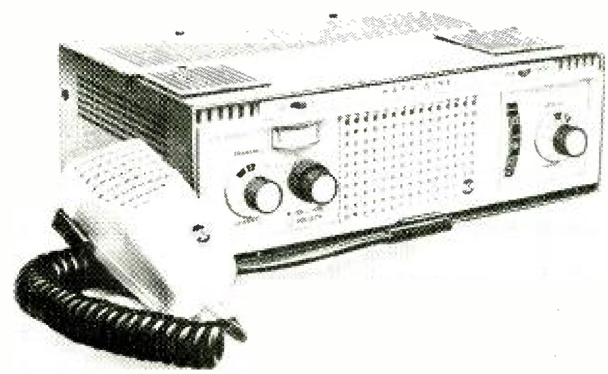
This frustrating job can be eliminated by first removing all of the solder holding the part. Then the part can simply be lifted from the board without damage to either. All that you need to do this is some small, tinned braided wire like *Belden* No. 8674-50, some *Kester* solder paste, and a low-wattage (less than 50 watts) soldering iron. To remove the solder from a portion of the board, dip about two inches of the braided wire into the paste and lay it on the connection. Place the iron on the braid with a slight bit of pressure so that the heat through the braid melts the solder.

Because of the action of the solder paste, melted solder will be drawn into the braid, leaving a perfectly clean but tinned pad on the board. The leads can now be straightened with a small long-nose pliers and the component removed. Repeat this "wick-action" enough times so that all the solder is removed. Use as little heat as possible and work quickly to prevent heat damage.

The solder-filled braid should be cut off and discarded and a fresh piece used each time. The braid and the paste are both needed for proper results.

After the new component has been installed and the connection resoldered, be sure to clean the excessive solder paste and flux from the board.

With practice, this technique can be perfected so that damage due to printed-circuit repair can be reduced to zero. The technique can also be adapted to remove the solder holding a larger number of leads on tube socket pins or terminal-strip connections. With all the solder removed, the wires can be unwrapped and removed without damage. ▲



Laser Photography

(*Continued from page* 35)

in a peculiar way, all the information necessary to recreate the original subject.

The recreation, or reconstruction process, is carried out by placing the hologram in a laser beam. As the light waves pass through the plate, they interact with the recorded fringe pattern. Emerging from the plate are three sets of waves, as shown in Fig. 3. One of these sets, the one which is undeviated, is of no interest. The other two wave sets, which are analogous to the sum and difference frequencies that are generated in an electronic mixer, are spatially modulated in accordance with the modulations on the fringe pattern. These waves thus resemble the original waves which were recorded by the plate. One of the wave sets is in fact identical to the original waves and can be focused by a lens to form an image of the original subject, even though the original subject is no longer present.

If the wave set is intercepted by an observer, he will interpret it as coming from a subject located on the other, or source, side of the plate, at the same position relative to the plate as was occupied by the original subject. Thus, the observer looks through the hologram plate as if it were a window, and through it he sees what may be called a "ghost subject."

The identity between the original waves and the reconstructed waves implies that the reconstructed image will be identical in all its visual properties to the original subject. The image will be completely three-dimensional, without the need for any of the usual stereo devices, such as stereo pairs, Polaroid glasses, etc. The perspective of the picture will change as the viewer moves his head. The parallax effects which occur in real life will be present here. In particular, if an observer were to find one object hidden behind another, he could move his head and look around the near object, thereby seeing the hidden object. All of these properties are indeed realized in wavefront reconstruction photography.

The other set of waves, which is deviated in the other direction, is similar to those waves which exposed the plate, but differ in having a complementary or conjugate property, which results in the formation of an image on the side of the plate away from the source. This is called a real image and appears to be suspended in space between the hologram plate and the observer. Although the observer often has difficulty focusing on this image, it can, under the proper conditions, appear even more dramatic than the other, or virtual image.

Such a photograph is shown at the beginning of this article.

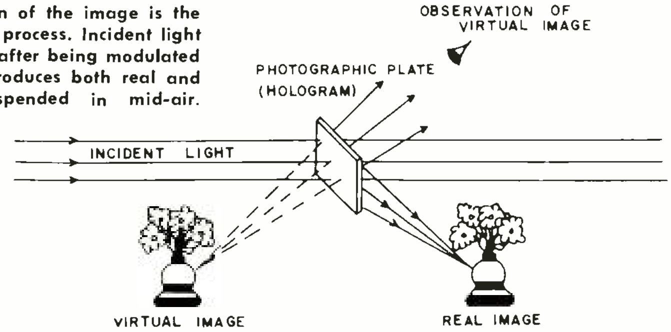
Other Image Properties

The reconstructed images have several interesting properties other than those pertaining to their three-dimensional nature. First, each part of the hologram, no matter how small, reproduces the entire image. Thus, it may be broken into small fragments, with each fragment producing the entire picture. However, as the pieces become small, resolution is reduced since resolution is related to aperture and the fragment size is the aperture of the imaging process.

This curious property can be understood by recalling the statement made earlier—that each point on the subject illuminates the entire plate. Thus, every point on the subject is contained in every part of the plate, and each part thus reproduces the complete subject.

Another curious property is that the process does not produce a negative. The hologram, as made in the above-described manner, would ordinarily be regarded as a negative, but the image that it produces is a positive. If the plate were copied, for example, by contact printing, the image reconstructed from the copy would also be a positive. Negatives just do not occur. This phenomenon, upon further examination, becomes less strange. The image is recorded on the plate in the form of a modulated wave. Contact printing, for example, causes only a reversal of the polarity of the wave, just as does a vacuum-tube amplifier in typical circuit arrangements. However, polarity reversal of a waveform does not alter the detected signal, whether it be a sound wave or a television display. Similarly,

Fig. 3. Reconstruction of the image is the reverse of recording process. Incident light is from a laser and after being modulated by the hologram, produces both real and virtual images suspended in mid-air.



the reconstructed image from a hologram is insensitive to polarity changes in the carrier wave.

Finally, the contrast rendition or gray scale of the reconstructed image is always very nearly that of the original subject. This is true regardless of the *gamma*, or contrastiness, of the photographic emulsion. In particular, the hologram can be recorded on an emulsion which does not produce gray scales, such as the high-contrast emulsion for photography of line drawings. The resulting hologram will then have only two levels of photographic density—transparent and opaque—but the reconstructed image will have a complete gray scale which essentially matches that of the original object.

Because no viewing optics are used, the usual optical limits and distortions do not apply in this method of photography, where hologram microphotos having resolutions of only one angstrom have been produced.

Applications

With the demonstration of high-quality, three-dimensional imagery, we have turned our attention to possible applications. Certainly, simulation and training devices and general three-dimensional display systems are natural areas of application. Three-dimensional motion pictures and television seem obvious and exciting possibilities. It must be recognized, however, that application in these areas, while possible, is technically difficult. For example, bandwidth demands of a hologram television system would be enormous, possibly 100 times that of conventional television, unless one were willing to compromise in attaining the dramatic effects inherent in the wavefront reconstruction method.

Applications in microscopy have been proposed and demonstrated. Gabor, many years ago, proposed to improve electron microscopy by making a hologram with electron waves and reconstructing it in the visible region, where one has better control of system aberrations. Several years ago, El-Sum and Baez, formerly of Stanford University, demonstrated wavefront reconstruction at x-ray lengths, with the reconstructions being made in the visible region. By this technique, it is possible to produce sharply focused images of objects illuminated with x-rays, even though it is in general not possible to focus x-rays. The difficulty in achieving coherence in x-ray sources has been an obstacle, but this difficulty may in time be overcome.

Other applications can be expected to develop, particularly as a result of advances in laser technology. ▲

Sea Stations
(*Continued from page* 36)

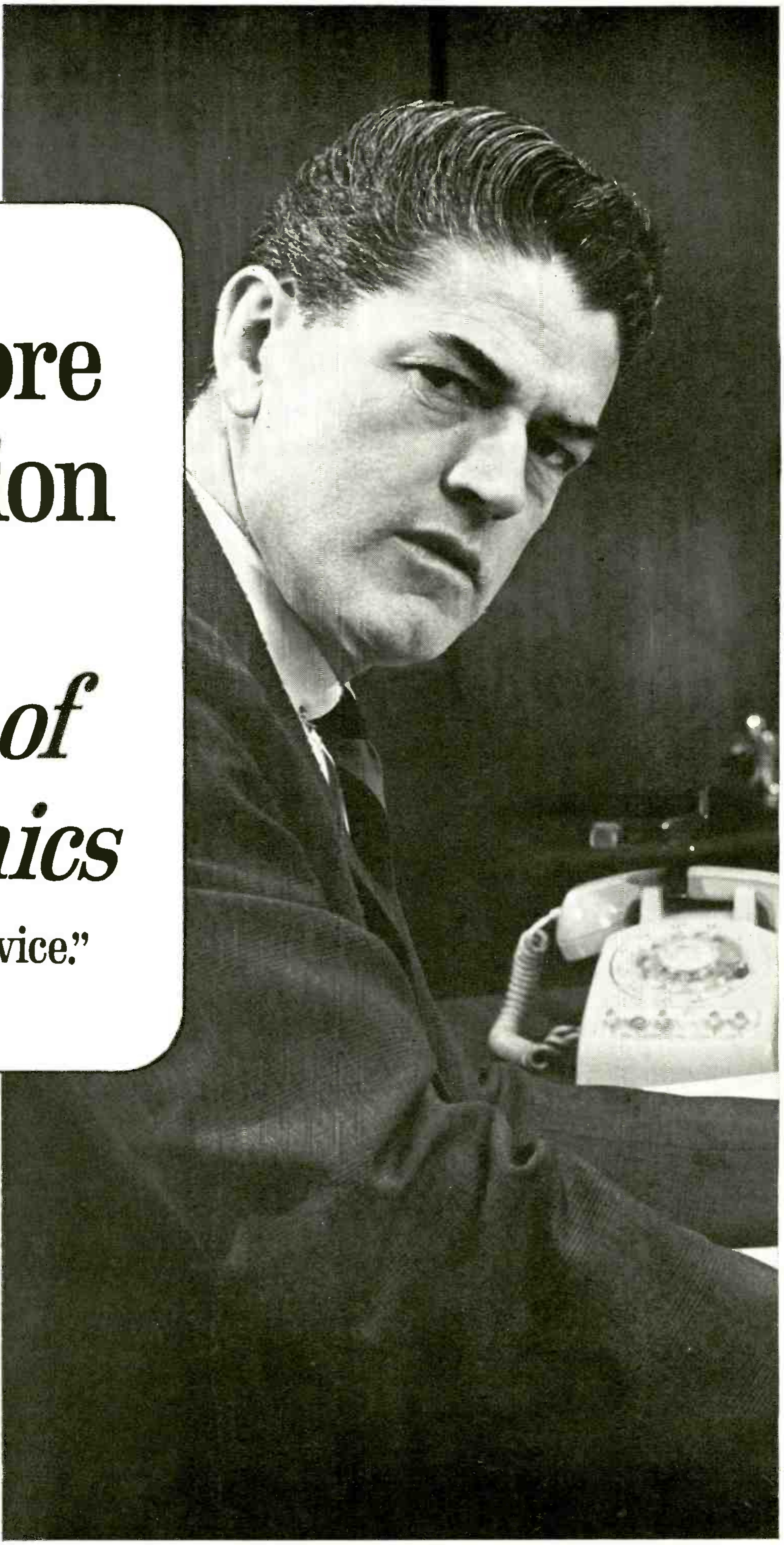
in catenaries to the sea bed. The object of the unusual shape is to achieve stability even in the roughest seas. Calculations indicate that for 95 percent of the time the roll would not exceed 0.5 degree and the vertical motion 0.5 foot. Even in storms the movement of the antenna platform would be insufficient to affect its use for air traffic control and possibly for passenger-to-shore telephone circuits.

With secondary surveillance radar, which would offer substantial benefits, data could be transmitted along the ocean cables to shore-based air-traffic-control stations.

The cost of the entire system is not more than about $40 million, with an annual operating cost of about $1 million. Provision of Atlantic radio services is the prime responsibility of the United Kingdom, Eire, and Canada. Other countries, including the United States, would be involved mainly as users.

When recently we took off from Kennedy International Airport to return to Europe, we relied on the skill of the flight crew to see us safely across that v.h.f. gap. Perhaps by the next time we make the trip, radio communications will be so good that not only the crew but also the passengers will be able to keep in touch with their offices. ▲

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



Hybrid Computers

A new type of computer combines digital and analog techniques to solve a variety of complex problems.

By LOUIS E. FRENZEL, Jr.

COMPUTERS are man's link between the formulation of a problem and the solution. They were developed to relieve man of the tedious task of computation, and this they have done admirably, with improvements not only in speed and accuracy but in versatility. Today it is possible to solve almost any problem that can be conceived by man, even those that previously were impossible because of their complexity or tremendous size.

There are two basic kinds of computers—the analog and the digital. Both solve mathematical problems, but this is where the similarity ends. Each type is unique and has its own advantages and disadvantages. Both types have specific uses and in many areas their coverage overlaps.

Now there is a new kind of computer—the hybrid, which promises to revolutionize the computer field and permit the solution of an even greater variety of complex mathematical problems. The hybrid uses essentially a combination of analog and digital techniques for solving problems that cannot be handled satisfactorily on the analog or digital computer alone. It is one of the most interesting and exciting developments in the computer field to date.

Analog Computers

Before we can understand the operation of the hybrid and fully appreciate its advantages, we must know something about analog and digital computers and their relative merits. Let's take a look at the analog computer first.

An electronic analog computer solves problems by letting d.c. voltages represent the problem variables and parameters. It takes these voltages and manipulates them with electronic devices so that the necessary mathematics required by the problem is performed.

The basic component of the analog computer is the operational amplifier. This is a d.c. amplifier with an extremely high gain—usually several million. By adding feedback to the amplifier it is possible to use it to provide accurate addition, subtraction, inversion, multiplication by a constant, integration, and differentiation.

Fig. 1. Analog computer operational amplifiers connected as (A) a constant multiplier and inverter, (B) a summer, (C) an integrator, (E) track-store amplifier. (D) is a potentiometer.

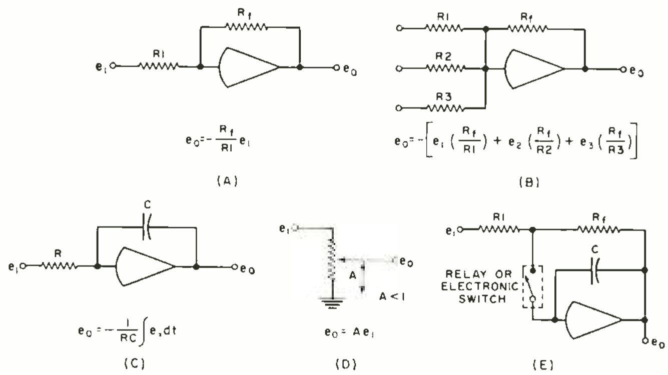


Fig. 1 shows several typical operational amplifier connections. In Fig. 1A, the feedback and input impedances are resistors. The feedback connection causes the gain of the circuit to be dependent upon external impedances rather than the amplifier itself. In fact, the gain of the circuit is the ratio of the feedback resistance to the input resistance (R_f/R_1). If R_f is 100,000 ohms and R_1 is 10,000 ohms, the circuit gain is 10. The input voltage e_1 will be amplified 10 times by this circuit. The amplifier also introduces a 180° phase shift which means that it inverts any input signal. The minus sign in the expression of Fig. 1A shows this. This circuit is used for multiplying by a constant and introducing inversion.

By adding more input resistors to the basic circuit of Fig. 1A, the circuit can be used for summation. This is shown in Fig. 1B. Here three input voltages can be added together. If all resistors are equal, the output will simply be the inverted sum of the inputs. If desired, each input can be multiplied by a different constant by properly proportioning the values of the input and feedback resistors.

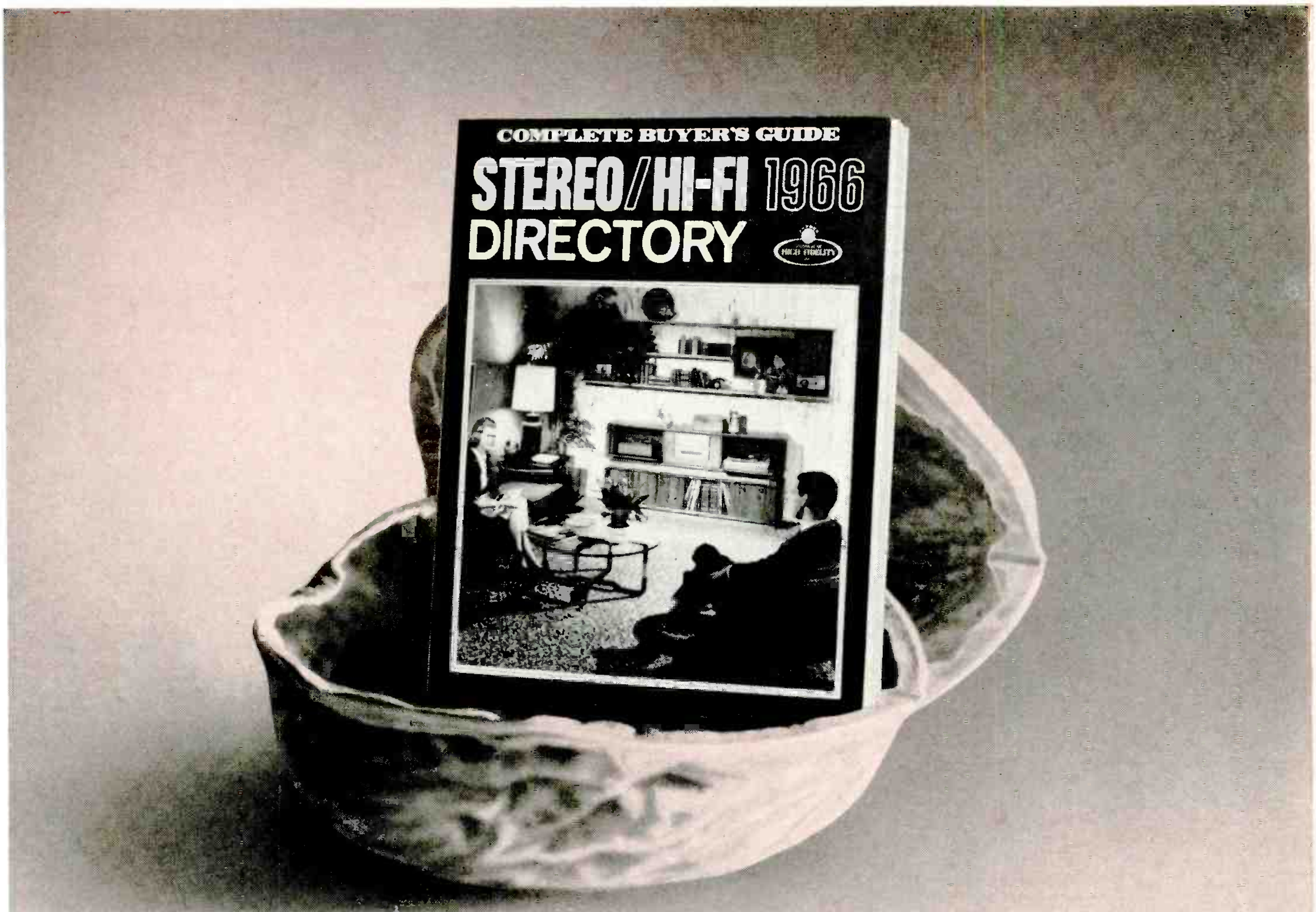
The circuit of Fig. 1C is an integrator. It produces an output voltage that is the integral of the input voltage. A capacitor is used as the feedback impedance. A differentiator can be formed by using a feedback resistor and an input capacitor. Differentiators are not normally used since they are unstable and tend to produce more noise than integrators. Since integration is the inverse operation of differentiation, it is usually possible to arrange a problem so that only integration is required to find the solution.

Another useful component in the analog computer is the potentiometer of Fig. 1D. It is used to multiply a constant less than one. When used before or after an operational amplifier it can give continuous control of the amplifier gain.

There are other electronic devices in the analog computer that perform multiplication, division, roots, powers, logarithms, and generate special or unusual signals. By combining these components with the operational amplifier circuits, it is possible to solve a wide variety of problems.

Analog computers find their greatest use in solving calculus problems, especially differential equations. Algebraic and trigonometric problems are also readily solved. An accuracy of from 1% to 3% is usually obtainable, but accuracies greater than 1% can be obtained at greater expense. The accuracy obtained depends on the problem being solved and the type and quantity of equipment used.

Many of the problems arising in science and engineering involve differential equations. These equations are used to describe a physical system mathematically. Such equations may describe a mechanical device, an electrical circuit, a hydraulic system, or a chemical process. The simpler problems encountered in an engineering design can usually be solved by hand, but the larger, more complex problems are usually



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Inverter circuit using unijunction transistor along with inexpensive SCR supplies the operating power.

THERE are a number of occasions when a battery-operated fluorescent lamp would be a real convenience. The advantages of fluorescents over incandescent lamps are: higher efficiency (you will get about four times the light from the same battery current), better distribution of light, and less heat dissipation.

The high-frequency inverter to be described will find applications in lighting for automobiles, trucks, yachts, houseboats, buses, mobile homes, etc.

The schematic diagram is shown below. Operation is as follows. When switch S1 is closed, a pulse of current flows through *T*1, *D*1, *L*1, charging up *C*2, *C*3, and *C*4. This charge is kept from discharging by *D*1. The pulse of current in the primary winding of *T*1 induces a high voltage across the secondary winding which is applied to the fluorescent lamp *via C*6. The lamp lights.

Meanwhile the voltage across *C*2 is applied to the emitter of the unijunction transistor *Q*1 *via R*3 and *R*4, charging up the capacitor *C*1. When the voltage across *C*1 reaches approximately 5 volts, *Q*1 breaks over and dumps the charge of *C*1 into the gate of *SCR*1. *SCR*1 turns on and rapidly discharges *C*2, *C*3, and *C*4, *via* the small reactor *L*1.

More current is now demanded from the battery to charge the capacitors and so another pulse of current flows through the transformer primary. The current pulses are only about 200 μsec. apart, so there is no flicker from the lamp.

Fuse *F*1 is included in case of component failure which would otherwise discharge the battery at a high rate.

Capacitor *C*5 and resistor *R*5 bypass the high-frequency transients which would otherwise cause uncontrollable triggering of *SCR*1. *C*7 allows the use of long (100-foot) battery leads by bypassing the lead inductance.

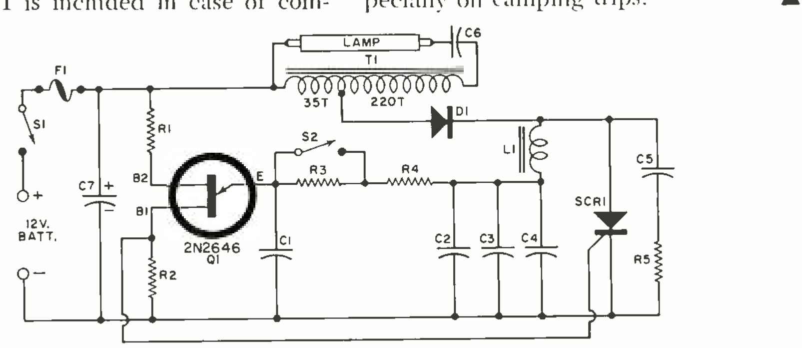
Resistor *R*3 may be switched out by S2 to give a high frequency of operation and so a brighter light, but at the cost of higher battery current. With S2 open, battery current drain is about ½ ampere; with S2 closed, 1 ampere.

Precautions

The inverter will draw about 5 amperes with the lamp out of the circuit. Do not run it for long periods in this mode as the fuse will blow after a few minutes.

Connect both pins together at each end of the lamp. In cold weather the lamp may be difficult to start with S2 open. Start with S2 closed. A good heat sink must be used, otherwise the fuse may blow repeatedly. Attach *SCR*1 and *D*1 directly to a metal block. Electrically insulate the block from the ground, not the semiconductors from the block. The two cores of *T*1 and *L*1 emit a certain amount of high-pitched noise. This may be made inaudible if the cores are imbedded in some non-hardening substance such as silicone rubber (*G-E* RTV), "Playdoh®," etc.

Make provision for a spare fuse, especially on camping trips. ▲



R1—220 ohm, ½ w. res.
R2—47 ohm, ½ w. res.
R3—150,000 ohm, ½ w. res.
R4—100,000 ohm, ½ w. res.
R5—68 ohm, ½ w. res.
C1, C5—.01 μf., 100 v. capacitor
C2, C3, C4—1 μf., 200 v. capacitor
C6—0.04 μf., 600 v. capacitor
C7—60 μf., 15 v. tantalytic capacitor
S1, S2—S.p.s.t. switch
F1—5 amp fuse (Type AGX2)
L1—11 t. #22 insulated wire wound on Arnold core #930157-2. (Arnold Eng. Co., Marengo, Ill.)
T1—Autotransformer, 35 t. #22 wire & 220 t. #28 wire wound in same direction on Arnold #930157-2 core.)
Lamp—8 watt fluorescent lamp (G-E F8)
D1—20 amp. 200 p.i.v. rectifier diode (G-E A40B)
SCR1—7.4 amp. 200 p.i.v. silicon controlled rectifier (G-E C20B)
Q1—2N2646 unijunction transistor (G-E)

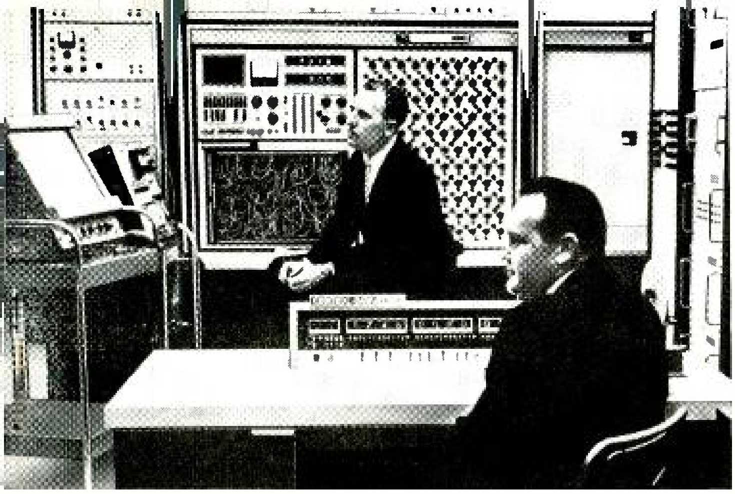


Fig. 2. Hybrid computer installation which employs Computer Systems 5800 analog and Control Data 160A digital computers.

handled by the computer to save time and money. The engineer can actually see his system in action on the computer. He can change the problem variables and evaluate the results. Thus he can predict with good accuracy what his actual system will do under different conditions.

The process of writing the mathematical equations of a physical system and solving them on a computer to predict results and determine design values is called "simulation." This particular technique represents one of the more popular applications of analog computers.

Digital Computers

Digital computers are vastly different from the analog type. Instead of working with varying voltage levels, the digital computer works with numbers that represent the problem variables. These numbers are part of a special system known as the binary number system. In this system, any quantity or variable can be represented by a combination of two symbols, usually "1's" and "0's." For example, the decimal number 22 is represented by 10110 in the binary system. The digital computer works with these binary numbers by allowing electronic pulse and switching circuitry to represent the 1's and 0's. A closed switch may represent a "1" while an open switch may represent a "0." Another way to do it is to let the absence of a voltage be a "0" and the presence of a designated voltage be a "1."

The digital computer is a counter and it operates by adding or subtracting binary numbers. Since almost any mathematical operation can be simulated by successive additions or subtractions, the digital computer can, theoretically, solve any problem. Multiplication is simulated by successive additions while division is a repetitive subtraction process. Other mathematical operations, such as integration, differentiation, and square roots, are performed in a similar manner. This means of solving problems is practical only when the additions and subtractions are performed at high speed, as they are in digital computers.

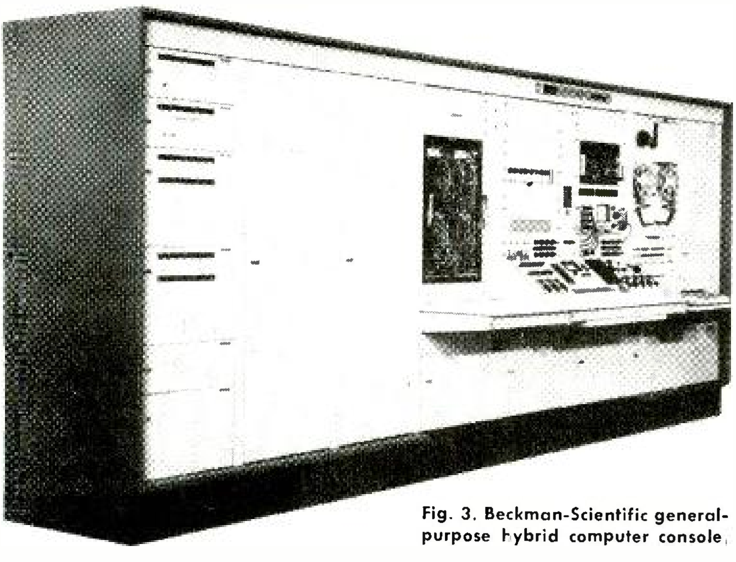


Fig. 3. Beckman-Scientific general-purpose hybrid computer console.

Typical of the electronics circuits used in digital computers are binary multivibrators used in counters and registers, astable and monostable multivibrators used as clocks and delays, diode logic gates used for the *and* and *or* logic functions, and magnetic cores and tapes and delay lines used as memory or storage units.

The biggest advantages of the digital computer over the analog computer are: versatility, wide dynamic range, and accuracy. Its disadvantages are: high cost, more complex programming, and its inherent lack of ease and speed in solving differential equations.

The digital computer is truly a versatile machine and it can solve almost any mathematical problem. Of course it may be slower than the analog computer in the solution of differential equations, for instance, but it can solve them. Accuracy

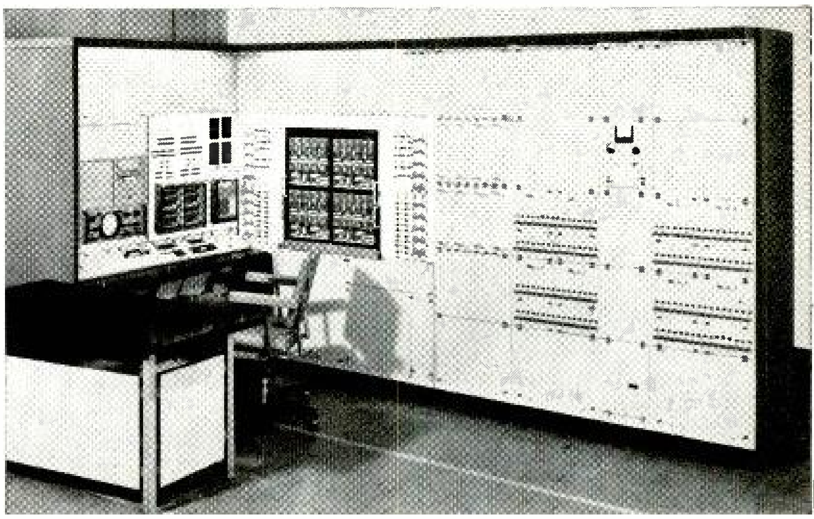


Fig. 4. Applied Dynamics AD256 analog unit with digital controls.

of the digital computer is limited only by the computer design and is easily several orders of magnitude better than that of the analog computer. As for high cost and complexity, these factors are outweighed, in many cases, where flexibility and accuracy are important.

Like the analog, the digital computer is also used for simulation. In addition, one of its prime functions in business and industry is data processing. The computer is used to process payrolls, keep inventory records, and do other repetitive, routine bookkeeping-type jobs.

The Hybrid

The hybrid computer was developed to solve problems that could not be handled by either an analog or a digital computer alone. The hybrid is formed by combining analog and digital computer elements and by taking advantage of the most desirable features of the two computers. The result is a computing system with tremendous capabilities.

The problems that can be solved by hybrid systems are those that are either beyond the accuracy or dynamic range of the analog computer or require a computation speed faster than that available from a digital computer. The digital computer is very accurate and can be programmed to have a wide dynamic range, overcoming the limitations of the analog computer. The analog is extremely fast and can solve complex, multi-variable problems instantly. This feature compensates for the slower, serially performed calculations of the digital computer.

Some of the areas in which the hybrid has been found

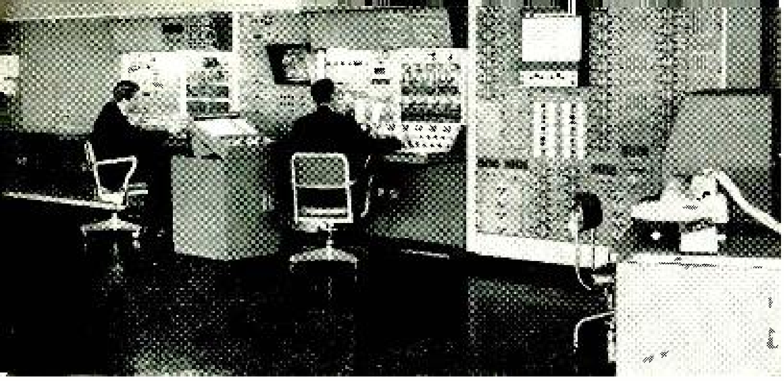


Fig. 5. Model 2400 hybrid computer made by Electronic Associates.

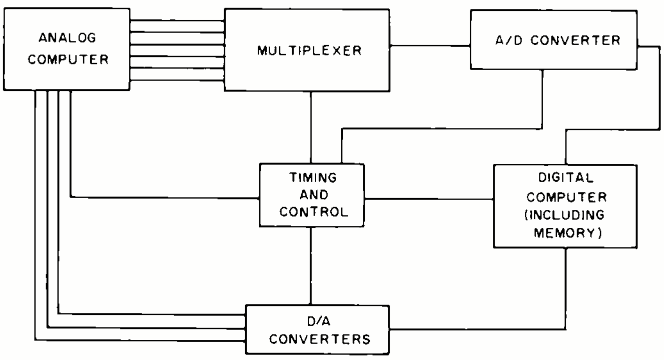


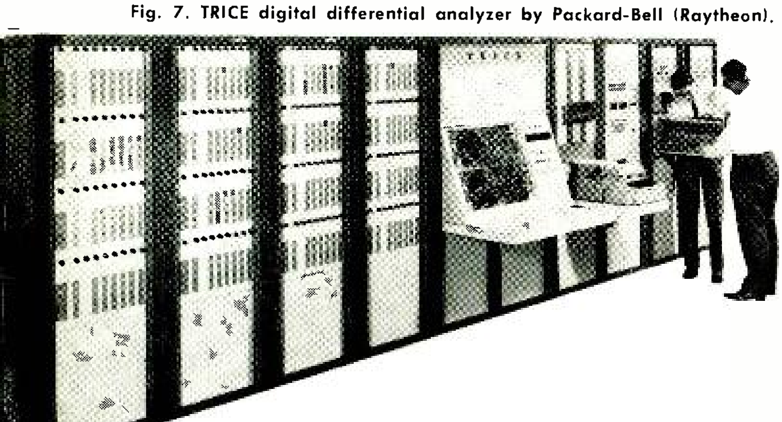
Fig. 6. Block diagram of general-purpose hybrid computer showing the analog, the digital, and interface sections.

useful include the following: 1. simulation of space vehicle guidance and control; 2. simulation of complex chemical processes; 3. study of biological systems; and 4. optimization of multi-variable systems.

All of these examples involve the solution to complex mathematical problems. The hybrid is useful because it can handle such operations as the solution to simultaneous differential equations with both low- and high-frequency characteristics, ordinary differential equations with transport delays, partial differential equations, statistical analysis problems, and any problems involving a combination of both continuous (analog) and discrete (digital) variables.

Hybrid computers exist in a number of different forms. For example, the accepted definition of a hybrid computer is a general-purpose analog computer combined with a general-purpose digital computer with some form of conversion between them. Fig. 6 is a block diagram of such a computer. Part of the problem being solved is programmed on the analog computer and some of the answers derived from the analog section are fed to the digital computer *via* a multiplexer and an A/D converter. The multiplexer repetitively and sequentially samples the analog voltages that represent answers or partial solutions and feeds them to the analog-to-digital (A/D) converter where they are changed to digital numbers capable of being handled by the digital computer.

Fig. 7. TRICE digital differential analyzer by Packard-Bell (Raytheon).



The digital computer processes the information it receives and, in turn, sends data back to the analog. The digital-to-analog (D/A) converters between the two computers convert the digital information into analog data compatible with the analog computer. A central timing and control section produces signals that keep all the units in the hybrid in synchronism.

Fig. 2 shows a commercial hybrid computer installation similar to the one just described. The three units in the background make up the general-purpose analog computer, while in the foreground is the control console for the general-purpose digital computer. The two large racks at the far right contain the A/D and D/A converters and the multiplexing equipment. This portion of the hybrid is generally known as the interface.

Another hybrid computer of this type is shown in Fig. 3. In this installation both general-purpose analog and general-purpose digital computers are housed in a common enclosure with the interface equipment.

A general-purpose analog computer with digital programming and controls is also referred to by many as a hybrid computer. Such a hybrid is essentially an analog computer that is controlled digitally while operating in either its repetitive or iterative modes and that uses digital techniques in programming, such as automatic pot set and check out.

An important part of the analog computer when it operates in these modes is the track/store amplifier circuit of Fig. 1E. The circuit contains a conventional operational amplifier with input and feedback resistors that provide a gain of one. A capacitor is connected across the feedback resistor. A relay or electronic switch controls the operation of the circuit. When the switch is closed and an analog signal is applied to the input, the circuit produces an output that is simply an inverted version of the input. At the same time, the charge on the capacitor follows the input analog signal. If the switch should suddenly open, the output no longer follows the input. Instead, the output is the voltage that was on the capacitor at the instant the switch opened. The circuit stores analog voltage levels on command from the switching system. Specially programmed pulse or digital signals usually control the switching. This is one of the most important circuits in a hybrid computer.

Figs. 4 and 5 show two hybrid computers that are considered to be digitally controlled analogs. In Fig. 5, the unit in front of the operator on the right is a general-purpose analog computer, while the unit in front of the other operator is the companion digital operations system. This particular installation is capable of being used in conjunction with the general-purpose digital computer shown at the far left in the photograph.

Another form of hybrid computer is the digital differential (DDA) analyzer. This is an all-digital machine that is built in such a form that it is operated and programmed the same as an analog computer. It offers the capability of solving complex differential equations with ease of programming and speed of the analog computer and with an accuracy far greater than that of a conventional analog computer. A commercial version of the DDA is the "TRICE" computer shown in Fig. 7.

Of course, many other forms of hybrid are possible but those shown and described here are the most representative of those hybrids in use today.

It now appears that many future computer installations will be hybrids simply because of the tremendous, general-purpose problem-solving capability they have. Today, scientists and engineers are thinking in terms of hybrid solutions to their problems. By carefully considering all three forms of computation, the scientist or engineer can find the best type of solution to his problem and thus obtain the quickest and most accurate answer for the available computational time and money. ▲

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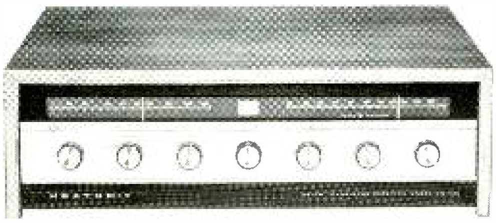

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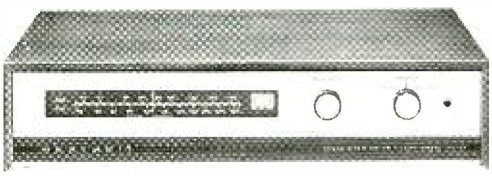

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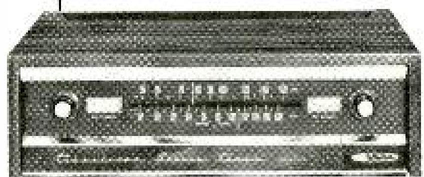

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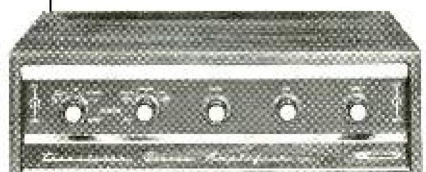

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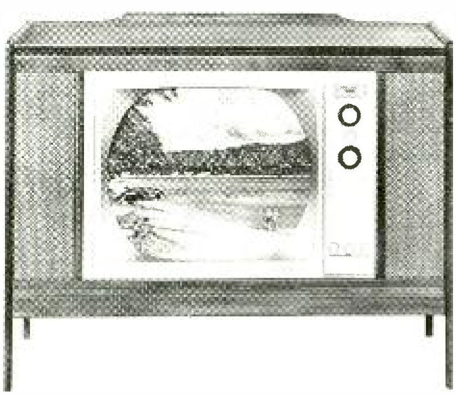

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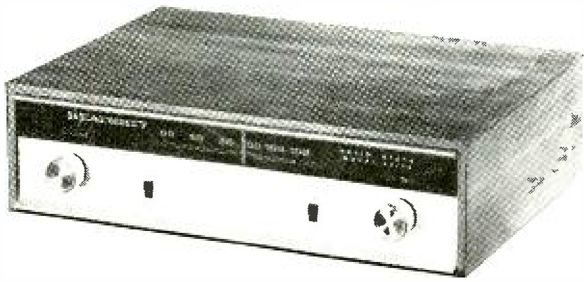

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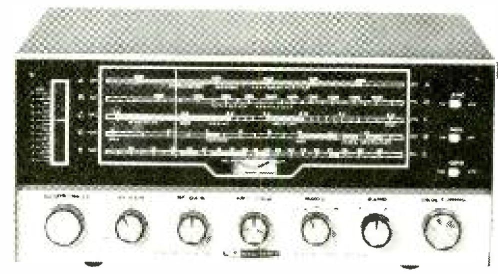

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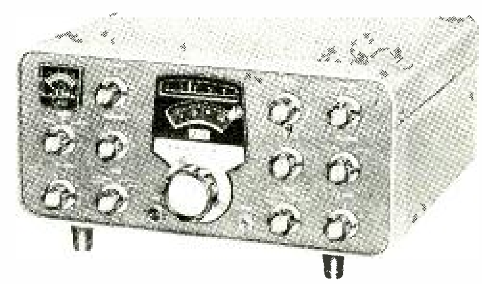

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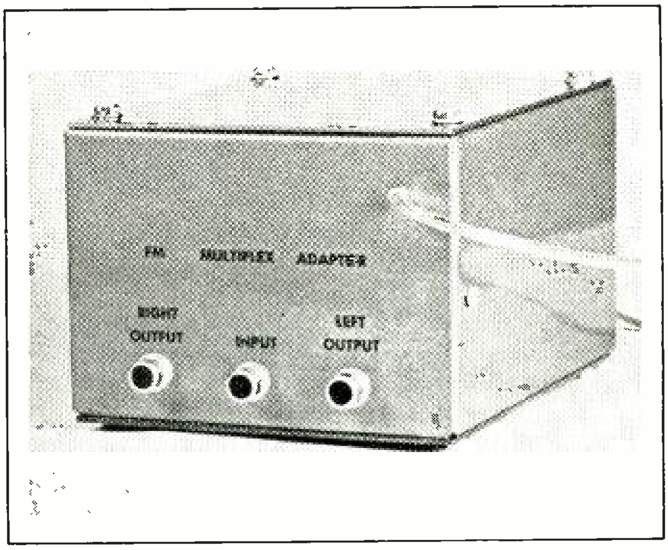
A MULTIPLEX ADAPTER FOR FM STEREO

By DAVID A. WILLIAMS

A solid-state design using new inexpensive silicon transistors. Method of subcarrier generation used results in high stability and ease of adjustment.



The entire adapter is contained in a small aluminum box.

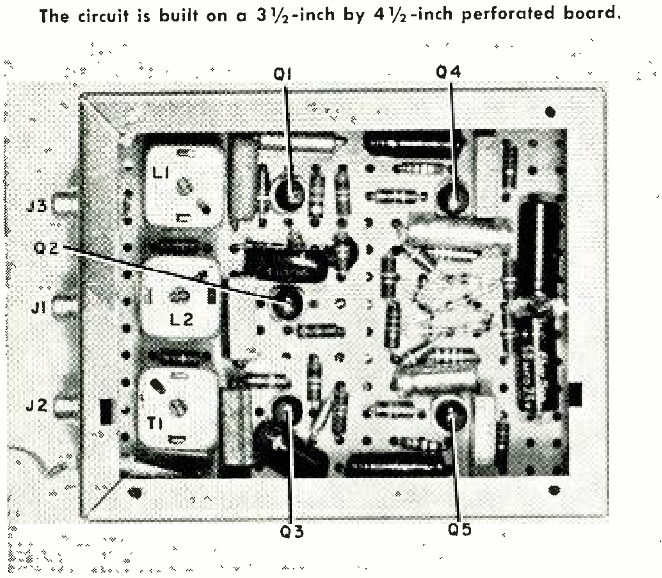
THIS multiplex adapter is a simple, solid-state design that uses silicon transistors for stability and a method of subcarrier generation that is easily adjusted and very stable. The result is a unit which gives excellent stereo quality over a wide range of operating conditions.

The 2N3638 transistors used are from a line of economical, but high quality, silicon transistors made by *Fairchild Semiconductor* of Mountain View, California. They are available from many local distributors or can be ordered direct from the manufacturer. The advantages of silicon transistors are greater temperature stability and more reliable operation. Silicon transistors have been around for some time, but it is only recently that the price has become competitive with germanium types. The 2N3638 is 46 cents in small quantities.

Subcarrier Generation

There are several ways of generating the 38-kc. subcarrier required to demodulate the stereo signal. Most manufacturers employ circuits which amplify the 19-kc. pilot carrier and use it to sync either a 19-kc. or 38-kc. oscillator. If a 19-kc. oscillator is used, the output is fed through a frequency doubler to obtain a 38-kc. carrier. A major difficulty with these circuits is the stability of the oscillator. It is important not only that the oscillator be synced, but that a definite phase relationship be maintained between the pilot carrier and the subcarrier. It is difficult to maintain this phase relationship in the presence of temperature changes, voltage changes, and changes in the amplitude of the pilot carrier.

The circuit is built on a 3½-inch by 4½-inch perforated board.



One circuit which has been largely ignored in the past nullifies these disadvantages. This technique does not require an oscillator. The pilot carrier is simply amplified and put through a frequency doubler to obtain the subcarrier. This method of subcarrier generation, as embodied in the adapter, results in a unit which is very stable with respect to temperature, voltage, and input amplitude. In addition, it eliminates the need for switching when changing from mono to stereo reception. There is no audible interference or "birdies" when tuned to a mono station transmitting SCA programming since there is no subcarrier present. To the best of the author's knowledge, there are not enough stations broadcasting both stereo and SCA that they need be considered in a design intended for home construction. If SCA interference should become a problem, the circuit of Fig. 2B can be incorporated in the design to take care of it.

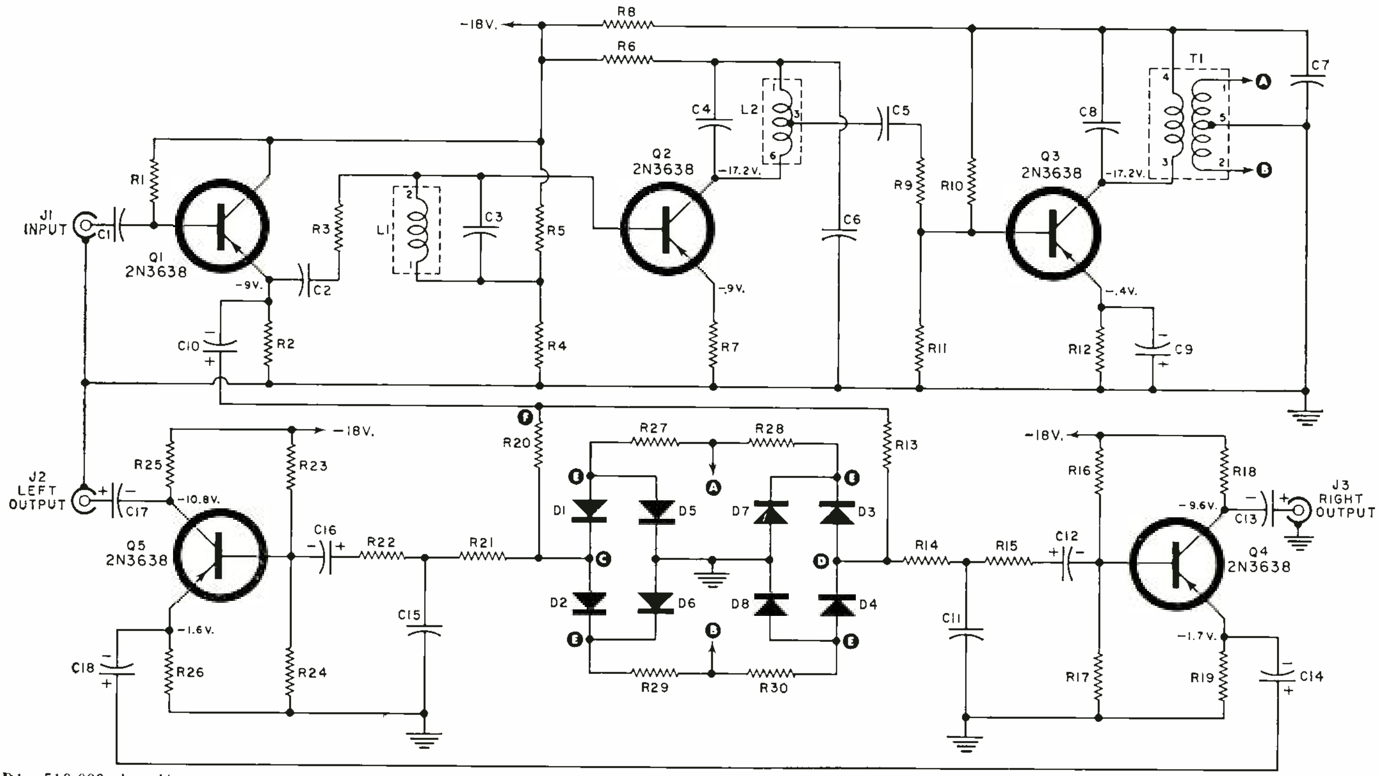
A possible disadvantage of this method is that the subcarrier amplitude is subject to variation since it depends on the amplitude of the pilot carrier. With some detectors this would be critical, but the switching scheme used in this particular adapter is not affected by the subcarrier amplitude as long as the input to the doubler stage is large enough for the frequency doubling action to take place.

Circuit Description

Fig. 1 is the circuit diagram and parts list for the adapter. Q1 is an emitter-follower used to avoid loading the FM tuner. Its input impedance is a function of the current gain of the transistor and will generally be greater than 200,000 ohms. Even with a transistor on the manufacturer's lower tolerance limit with respect to gain, the input impedance will be greater than 100,000 ohms. The bias circuit for this stage is not the most stable configuration, but is adequate here because of the inherent stability of the silicon transistor and the fact that the supply voltage is large compared to the signal amplitude at this point.

Q2 is a 19-kc. amplifier with a tuned circuit in both the base and collector circuits. The use of two 19-kc. tank circuits gives a high degree of selectivity and assures a clean subcarrier. Q3 is a doubler circuit which provides d.c. isolation and a push-pull output. *R6-C6* and *R8-C7* are decoupling circuits.

Several other detector circuits were tried, but none achieved the performance of the diode circuit used. Briefly, the purpose of this circuit is to ground points C and D during alternate half-cycles of the subcarrier. The relative size of



R1—510,000 ohm, ½ w. res.
R2—6800 ohm, ½ w. res.
R3—68,000 ohm, ½ w. res.
R4,R7,R8,R9—1000 ohm, ½ w. res.
R5,R11—10,000 ohm, ½ w. res.
R6—680 ohm, ½ w. res.
R10—150,000 ohm, ½ w. res.
R12—820 ohm, ½ w. res.
R13,R18,R20,R25—10,000 ohm, ½ w. res. ±5%
R14,R21—56,000 ohm, ½ w. res. ±5%
R15,R22—33,000 ohm, ½ w. res. ±5%
R16,R23—18,000 ohm, ½ w. res. ±5%
R17,R24—39,000 ohm, ½ w. res. ±5%
R19,R26—2200 ohm, ½ w. res. ±5%
R27,R28,R29,R30—22,000 ohm, ½ w. res. ±5%
C1—.5 µf. capacitor
C2—.01 µf. capacitor
C3—.0015 µf. silver mica capacitor
C4—.01 µf. silver mica capacitor
C5—.047 µf. capacitor
C6,C7—.1 µf. capacitor
C8—.005 µf. silver mica capacitor
C9—1 µf., 6 v. elec. capacitor
C10—4.7 µf., 15 v. elec. capacitor
C11,C15—.003 µf. silver mica capacitor
C12,C16—2 µf., 6 v. elec. capacitor
C13,C17—50 µf., 25 v. elec. capacitor
C14,C18—50 µf., 6 v. elec. capacitor
D1,D2,D3,D4,D5,D6,D7,D8—1N34
L1—Bandpass filter, shunt element (J.W. Miller 1353)
L2—19-kc. locked osc. coil (J.W. Miller 1354)
T1—38-kc. output trans. (J.W. Miller 1355)
J1,J2,J3—Phono jack
Q1,Q2,Q3,Q4,Q5—2N3638 silicon trans. (Fairchild Semiconductor)

Fig. 1. Circuit diagram and parts listing for adapter which employs five inexpensive silicon transistors.

the associated resistors (22,000 and 10,000 ohms) and the amplitude of the signal relative to that of the subcarrier assures that the voltage at points E is solely dependent upon the subcarrier and is independent of the signal. Thus, whether the diodes conduct or not depends upon the subcarrier. One of the advantages of this circuit is that the magnitude of the subcarrier passed to the output is very small and therefore little filtering is required.

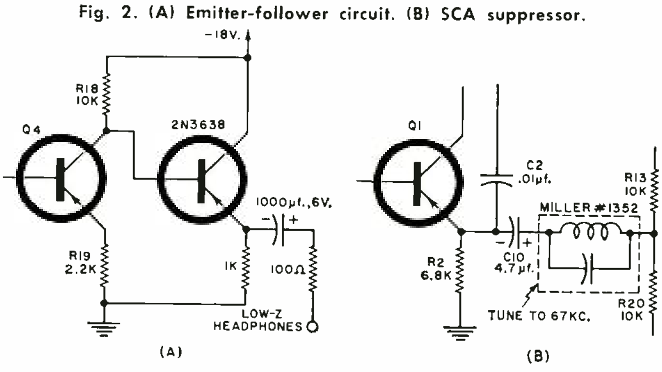
The degree of subcarrier suppression depends partly on how well the diodes are matched. A bad match can be remedied somewhat by placing large (330,000 ohm) resistors in parallel with diodes *D*1 through *D*4 while watching points C and D with an oscilloscope. An audio oscillator set to 19 kc. can be used for an input. Point F should be grounded during this operation to keep the 19-kc. signal out of the switching circuit. You probably won't need to bother with this adjustment unless you get interference with the bias oscillator of your tape recorder.

The switching circuit is followed by a de-emphasis filter and an output amplifier in each channel. The amplifier recovers most of the amplitude lost in the switching circuit and the filter and limits the insertion loss to about 3 db. *R*15 and *R*22 are used to isolate the filters from the amplifiers. The output impedance is about 10,000 ohms. This is low enough to drive several feet of shielded wire, but the amplifier should be followed by an emitter-follower stage as shown in Fig. 2A if longer cable runs are required or if you want to drive a set of stereo headphones.

The coupling between the emitters of *Q*4 and *Q*5 compensates for the mixing of left and right signals that is inherent in the demodulation process. When both channels contain identical information there is no current flow between the emitters, but when they differ, a portion of the signal present in one channel is introduced 180° out of phase into the opposite channel to cancel the unwanted component. The capacitors (*C*14 and *C*18) could be eliminated and a single emitter resistor used in the interest of economy, but the stability of the operating point would suffer since any d.c. unbalance which occurs in one channel will be amplified in the other. For the same reason *Q*4 and *Q*5 should be the best matched pair of transistors available to achieve the best possible a.c. balance. This also accounts for the tight tolerance on the resistors in the switching and de-emphasis circuits. A separation control can be added to the circuit by placing a 5000-ohm pot in series with *C*14 and *C*18.

A stereo indicator circuit was not provided because, in the author's opinion, it is unnecessary. If one cannot tell the difference between stereo and mono broadcasts by listening, why bother with a stereo receiver in the first place? Secondly, most people who are interested know which stations in their

Fig. 2. (A) Emitter-follower circuit. (B) SCA suppressor.



area broadcast in stereo and the stations themselves are not reticent about mentioning the fact. When a stereo station does broadcast a mono program, the pilot carrier usually stays on anyway so that a stereo indicator circuit would be none the wiser.

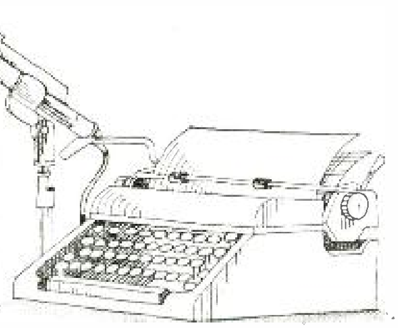
The unit was built on a 3½"x 4½" piece of perforated circuit board and mounted in an aluminum box as shown in the photos. Parts placement is not critical and other layouts should work as well. Some parts substitutions can probably be made to take advantage of junk-box items on hand, but there are certain critical points that should be observed. The over-all stability will suffer if the silver mica capacitors are replaced by other types. The components which are duplicated in each channel should be closely matched to preserve balance between channels. All of the non-mica capacitors can be replaced by larger values if they are available. The usual care must be exercised to protect the components from heat during soldering operations.

Adjustment

After the adapter is assembled, check the wiring carefully for errors. Transistors are very reliable when used within the limits of their ratings, but they are most intolerant of overloads even for short periods. Next, check the voltages shown on the circuit diagram with a v.t.v.m. if one is available. A v.o.m. may also be used, but will give inaccurate readings at some points in the circuit. The readings shown were taken with a supply voltage of 18 volts, but any value between 15 and 20 volts will work as well. The voltages are dependent on the individual transistors used. If a voltage is considerably different from that shown on the diagram try switching transistors. The voltages at the collectors of Q4 and Q5 should be equal to about half the supply voltage to avoid clipping large signals. Other voltages are not critical as long as the adapter is working. If it is not, they may indicate trouble.

Next, connect the adapter to the multiplex output of an FM tuner and tune in a stereo station. Tune *L1*, *L2*, and *T1* for maximum subcarrier. An oscilloscope is best for this, but a meter may be used. After the maximum subcarrier is obtained, *L1* should be tuned for best separation.

This adapter should work with any vacuum-tube tuner that has a multiplex output taken directly from the detector. Transistor tuners will require a stage of amplification between the detector and the adapter. Some older tuners not specifically designed for multiplex may give satisfactory performance if the de-emphasis circuit is disconnected. The lead length between the tuner and the adapter should be as short as possible or three feet long at the very most. ▲



RADIO & TV NEWS

PRODUCTION of color-TV receivers in April, 1965 was nearly double that of April, 1964, while the output of black-and-white sets remained just about at last April's level, according to a report from the EIA.

The report also showed April production and distributor sales of radios up by a substantial margin and distributor sales of monochrome TV sets just above those of April of last year.

Producers turned out 179,321 color sets in April, an increase of 94% over the 92,318 produced in April, 1964.

April production of monochrome TV sets fell off 7% to 577,450 from the 620,351 recorded in April of last year and dropped a sharp 27% under the March figure of 790,379, this year's best month for black-and-white output.

Combined total for color and monochrome production was 756,771 in April, compared with 712,669 in April, 1964. Total output during this year's January-April period was 3,348,669, up 9% from the 3,073,068 registered for the first four months of 1964.

Infrared Circuit Tester

One of the major problems with microcircuits is that if one component heats up due to a malfunction, it can easily destroy other components located in close thermal proximity.

Researchers at the Naval Electronics Lab in San Diego have developed a high-speed infrared mapper consisting of a cryogenically cooled infrared detector, a mechanical scanning mechanism, electronic circuitry, and a modified facsimile machine. At present, the equipment uses 600 scanned lines, each .0014 inch wide per inch of surface scanned. The scientists claim that a thermal map of a one-inch square circuit surface can be made in 30 minutes with mapping resolution down to a .001-inch square circuit area. Infrared energy change would disclose the presence of a faulty component and indicate it on the thermal map.

Japanese Transistors

The other day we came across a brief description of Japanese transistor types that we would like to pass along.

Those transistors prefixed 2SA are *p-n-p* types for high-frequency (above audio) use; 2SB indicates a *p-n-p* transistor for low-frequency (audio) use; 2SC indicates an *n-p-n* transistor for high-frequency use; while 2SD indicates an *n-p-n* transistor for low-frequency use. The number following the prefix has no special significance, while any suffix letters indicate an improved version of the original unit.

Our thanks to the Kings County TV Service Association and their "TV Service Association News" from which this information was extracted.

Industry News

The EIA recently took steps to increase its participation in international standardization activities and to implement its cooperation with other industry associations.

During their recent meeting, members of EIA heard its president Harper Q. North forecast a year of increased business activities that are expected to move the value of electronic production upward to $16.9 billion, a 4.7% increase. ▲

Transistor I.F. Amplifier

(*Continued from page* 33)

47,000-ohm resistor, and automatic gain control through a 2200-ohm resistor. The collector supply for the transistor is connected directly to a tap on the primary of i.f. transformer *T*1 and no neutralization is used. The second i.f. stage (*Q*2) is connected in exactly the same manner as the first i.f. stage, except that it receives no automatic gain control voltage.

The third i.f. stage (*Q*3) has to deliver power. It is connected directly across the major portion of the complete primary of *T*3 and a 33-pf. capacitor is used for neutralization. A 1-pf. capacitor is used to provide a small amount of additional coupling between the windings. This stage delivers power to drive both the automatic gain control diodes and the limiter. The limiter is a two-stage cascaded circuit (*Q*4 and *Q*5). It has a large amount of d.c. feedback from the junction of the two 330-ohm emitter resistors of the second limiter stage back into the base of the first limiter stage. Therefore, any variations in gain of these two transistors with signal is compensated for and the two transistors are always operated with their best limiting characteristics. The last limiter stage drives a ratio detector (*D*3 and *D*4). This is a conventional circuit with a 2-mc. bandwidth except that both outputs of the detector are available or either of the two may be grounded.

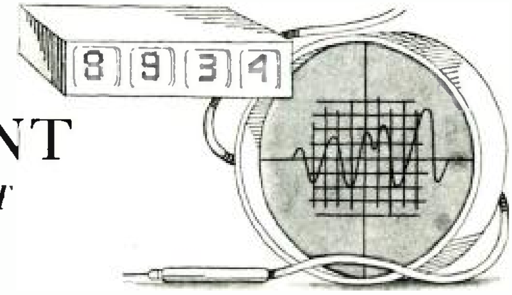
All transistors in this circuit, including i.f. amplifiers and limiter stages, are of the same type (*Fairchild* SE 1001's). These transistors can be interchanged or replaced without affecting their performance in this circuit.

The automatic gain control circuit operates as follows: The output voltage of the third i.f. amplifier is rectified by a peak-to-peak detector (*D*1 and *D*2) and provides reverse bias for the first i.f. amplifier, thereby reducing its gain. This negative voltage is also available for automatic gain control of the FM front-end. The negative voltage applied to the base of the first i.f. transistor will, of course, lower its emitter voltage. The tuning meter is connected through 4700-ohm resistors between this first emitter and the emitter of the second i.f. stage in a bridge circuit. The result is a zero current meter indication for very low i.f. input signals, where no a.g.c. voltage is developed, to full-scale indication for very strong signals.

The over-all i.f. selectivity is 45 db or more on the adjacent channel, with a fully modulated FM signal, when tested according to the IHF-T-100 standard on tuners. An i.f. circuit of this type is used in all current tuners made by *H.H. Scott, Inc.* ▲

TEST EQUIPMENT

PRODUCT REPORT



THE gated-rainbow type of color-bar generator has been universally accepted by the servicing fraternity for general shop and outside use. Generators designed around this system can be as accurate and stable as their manufacturers wish to make them. The technician likes them because they are small, lightweight, and portable. In addition, TV manufacturers use them to establish reference color-bar patterns and waveshapes for their published service notes.

RCA's WR-64B color-bar dot/crosshatch generator is the latest version of the gated-rainbow system introduced by this company in the 1950's. The WR-64B provides ten vertical bars of different colors simultaneously on the picture tube. Colors cover the spectrum at 30-degree intervals from yellow-orange through green and can be used to align any NTSC-type color set, regardless of the demodulation system. Close control of the carrier signals and bar phase angles make the generator a reference source for checking phasing and matrixing, and aligning color a.f.c. circuits.

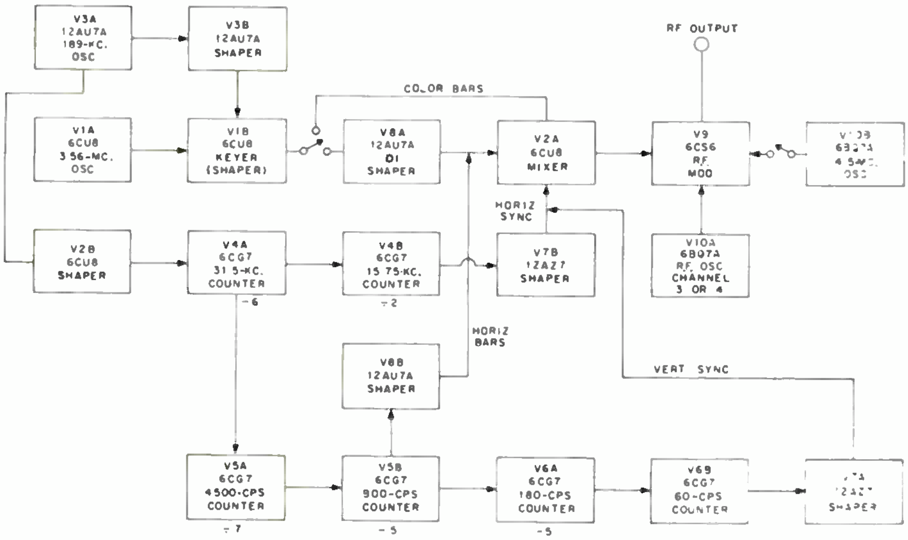
General output—which is fed into the receiver antenna terminals—can be switched to provide the ten simultaneous color bars or a dot or crosshatch pattern for convergence and linearity adjustments. A chroma control provides continuous adjustment of color-bar pulse amplitude for checking color lock-in performance. Three front-panel switches are included for shorting color-tube guns to ground during purity and convergence adjustments.

Stability and long-term accuracy are enhanced by crystal control of four critical circuits and by use of iron-core inductors in frequency-divider circuits. Crystals are used to control the r.f. picture-carrier circuit, the offset color subcarrier (3563.795 kc.), the gating frequency (189 kc.), and the r.f. sound carrier, which is spaced 4.5 mc. from the picture carrier. The color subcarrier frequency is held within ±20 cps.

RCA WR-64B Color-Bar Generator

For copy of manufacturer's brochure, circle No. 29 on Reader Service Card.

Like its predecessors, the WR-64B provides an r.f. sound carrier in addition to the picture carrier. The unmodulated sound carrier can be switched on and off and produces a beat pattern which is minimized when the receiver fine-tuning control is set correctly. Availability of both carrier signals provides the service technician with the means of verifying, in the customer's home, that tuner alignment is correct. If the tuner is misaligned, and only a picture-carrier signal is available, it is possible for the technician to align color circuits to produce a perfect color-bar pattern, but at the wrong setting of the fine-tuning control. In such cases, the receiver will not correctly reproduce a color program.



The WR-64B has been designed to withstand the rigors of daily color servicing and to meet the needs of the service technician who must make color-set adjustments in the customer's home. The generator is supplied with attached leads for connecting output to the receiver antenna terminals and for shorting color-tube guns during purity and convergence adjustments. The gun-shorting leads have insulation-piercing clips for easy connection to picture-tube leads.

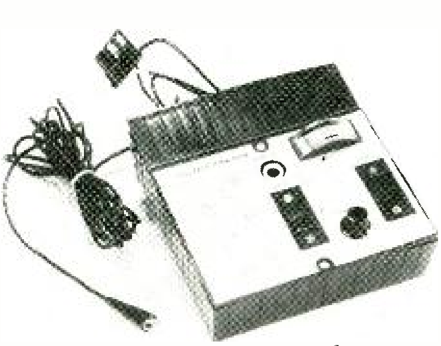
Other features include a "standby" switch position for removing all r.f. output, and attached cable-holding brackets. The WR-64B is housed in a steel case and measures 8" x 10" x 13½". Price of factory-wired unit is $189.50. ▲

Delco Radio Auto Radio System Tester

For copy of manufacturer's brochure, circle No. 30 on Reader Service Card.

THE *Delco Radio* auto radio system tester is a new tool designed for use by car dealers, mechanics, and technicians. This new tester eliminates guesswork in diagnosing auto-radio complaints by narrowing down the defect to a faulty antenna mast, antenna lead-in cable, speaker, or to the radio itself.

The antenna test is a test of the leakage resistance between the antenna mast and ground. This resistance measure-



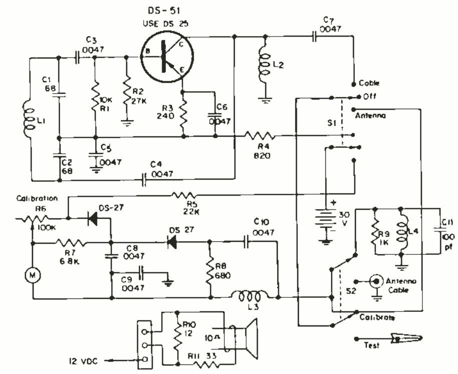
ment will reveal the presence of rust, corrosion, or water inside the antenna which may be shorting a large portion of the incoming radio signals to ground. The meter scale indicates "Good" for those antennas having a leakage resistance of greater than 500,000 ohms. For those antennas having from 100,000 ohms to 500,000 ohms leakage resistance, the meter indicates "Poor," and for all antennas measuring below 100,000 ohms, the meter indicates "Replace."

The cable test is a measure of the antenna lead-in continuity. This is a measure of the r.f. continuity of the cable rather than d.c. leakage. An r.f. oscillator sends a 3.5-mc. signal through the cable. This is rectified and the d.c. meter in the tester will then indicate "Good" or "Open." In this way, all antenna lead-in cables may be tested, including those used in some rear-antenna installations in which a small series capacitor is used.

The speaker test is merely a substitution test, wherein a small, quality speaker is substituted for the front speaker to check for an open or for distortion.

If the above tests do not disclose any trouble, it is assumed that the radio itself is at fault. Then the radio must be removed and serviced on the bench in the usual manner.

The circuitry for performing these tests is shown here and includes a radio-frequency oscillator, a half-wave rectifier, and a d.c. ohmmeter. The tester also has external provisions for calibrating the meter and checking the condition of the tester batteries. The tester is available from *Kent-Moore Organization, Inc.*, 28635 Mount Road, Warren, Michigan 48092 at a cost of $23. ▲



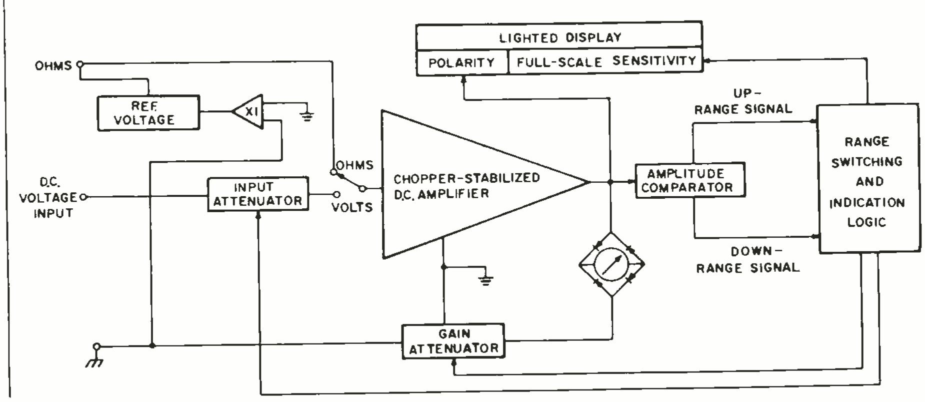
Hewlett-Packard Model 414A Automatic Volt-Ohmmeter

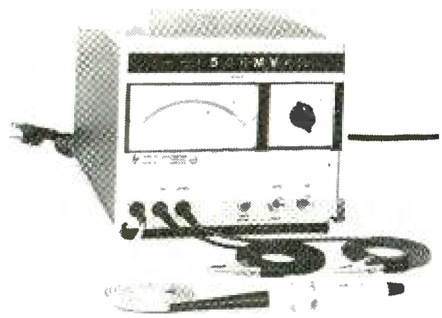
For copy of manufacturer's brochure, circle No. 162 on Reader Service Card.

UNIQUE among analog meters (*i.e.*, meters which present readings by means of a pointer on a scale) is a new, all-solid-state d.c. volt-ohmmeter from *Hewlett-Packard* which "autoranges." Responding silently and swiftly—ranging takes less than 300 milliseconds—it automatically displays range and polarity with illuminated characters and gives the reading on a mirror-backed, individually calibrated taut-band meter.

There are twelve voltage ranges, from 5 millivolts to 1.5 kilovolts full-scale. The device will also measure resistance, automatically selecting and displaying the range and presenting the measured value on linear scales with full-scale ranges from 5 ohms to 1.5 megohms. More accurate than conventional 1% meters, it will make measurements on the bench or on the production line as rapidly as the operator can probe from point to point and read the meter.

For voltage measurements, the unknown voltage is applied to a chopper-stabilized d.c. amplifier through an input attenuator. The attenuator has two states, either straight through (0 db) or 60-db attenuation. The amplifier, which has a forward gain of more than 10^6, provides an output through the meter by means of a diode bridge to the gain attenuator. This attenuator is switchable from 0 to 50 db in 10-db steps. The combination of the input attenuator and gain attenuator provides the full 110-db





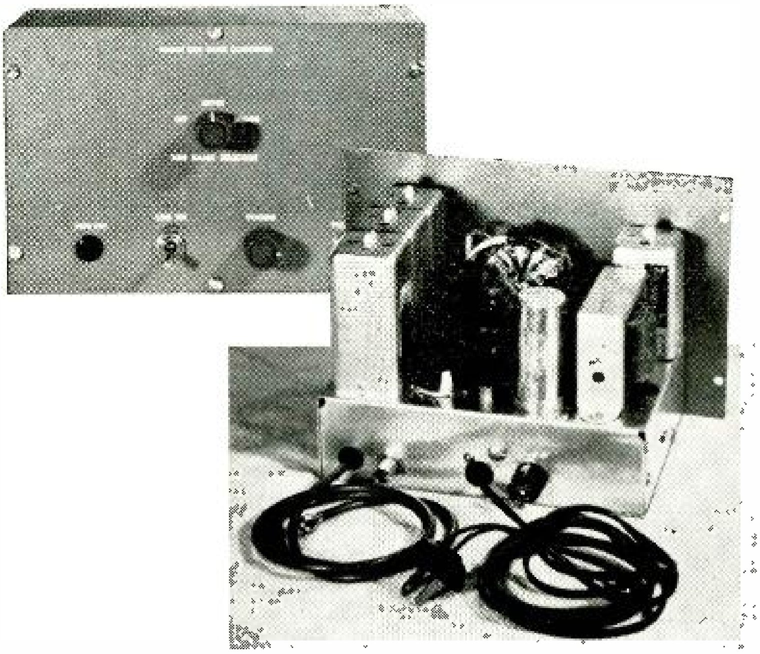
attenuation which is necessary for the twelve ranges from 5 mv. to 1500 volts.

The second output of the amplifier is fed to two transistors which sense the polarity of the output voltage and correspondingly light the plus or minus sign on the display unit.

A third output of the amplifier goes to the amplitude comparator, which consists of three sections: a converter, an isolator and comparator, and a multivibrator and Schmitt trigger.

The converter circuit provides a response that is proportional to the magnitude of the amplifier output voltage. This unipolar voltage is then applied to the isolator and comparator circuits, which in turn sense the coincidence of the voltmeter's input voltage with the up- and down-ranging points. When the up-ranging point is exceeded, one comparator activates the Schmitt trigger, which in turn switches the instrument to its highest range (least sensitivity). When the input voltage lies below the the down-ranging point, the other comparator circuit allows the free-running multivibrator to fire and subsequently to step the voltmeter toward more sensitive ranges until the meter reads upscale sufficiently to stop the ranging, or until the most sensitive range is reached. Both the Schmitt trigger and the multivibrator modify the state of a four-stage binary counter, which with the appropriate decoding networks "defines" the twelve ranges of the instrument.

Model 414A adds speed and convenience to operations where a large number of analog readings of widely different values are wanted. Price of the instrument is $650. ▲



Cabinet and panel were made from 9" x 6" x 5" aluminum utility box. For compact construction, author used three small circuit boards. Conventional wiring techniques may be employed but most leads should be kept as short as possible.

UNIVERSAL SSB CONVERTER

By J. P. NEIL

Designed especially for amateur and commercial communications receivers, circuit permits stable single-sideband reception.

THERE are many commercial and amateur communications receivers which are intended for AM and c.w. reception only. With the increasing trend toward SSSC (single-sideband suppressed carrier), more commonly known as SSB transmission, there is a need for a universal SSB converter for those receivers which do not have the SSB detection feature.

Although one can, by careful manipulation, use the b.f.o. in a standard receiver for i.f. carrier re-insertion, this is a laborious, time-consuming, and often impossible procedure. Primarily this is due to the instability of the receiver's b.f.o. The time required to extract a clear conversation from an incoming SSB transmission frequently exceeds the duration of the transmission. The net result is that, generally speaking, this process leaves a great deal to be desired.

Many circuits have been devised in the form of "product demodulators" which as a whole are no better than the b.f.o. insertion method, simply because they necessitate application of the drifting b.f.o. output. This article will describe a universal SSB converter which eliminates the problems normally associated with run-of-the-mill product demodulators. It is so designed that it can be adapted quite easily to almost any standard communications receiver.

Converter Requirements

The prime criteria for an SSB converter are: 1. upper and lower sideband selection; 2. a sharp receiver i.f. carrier "notch" filter; 3. a highly stable, separate i.f. re-insertion oscillator; 4. separate converter a.g.c.; 5. no more than two connections to the receiver (*i.e.*, i.f. and a.f.); and 6. small physical size and low cost.

These conditions are all met in the unit under discussion.

Circuit Description

Referring to the block diagram of Fig. 1 and the schematic of Fig. 2, the i.f. output signal (6 volts max., 1 volt average) is fed into the SSB converter *via* *J*1. Here the i.f. signal divides between *V1A*, the input i.f. amplifier, and *V1B*, the a.g.c. input cathode follower.

V1A is a broadband i.f. amplifier. It is followed by the (switched) upper and lower sideband filters, *T*1 and *T*2. These, in turn, drive the intermediate i.f. amplifier, *V*3. The crystal-capacitor combination, *Xtal.* 1 and *C*21 from the *V*3 grid to ground, constitute the receiver i.f. carrier notch filter (trap). This filter, together with the converter's b.f.o., provide the key to successful operation of the converter.

*V*3 has as its plate load, *T*3, a broadbanded i.f. transformer. The output of *T*3 connects to a balanced-ring type detector (demodulator), followed by audio preamplifier, *V2B*.

*V*4 is a crystal-controlled b.f.o. which supplies the i.f. re-insertion carrier. Its output is fed into the detector *via* the junction of capacitors *C*25 and *C*26.

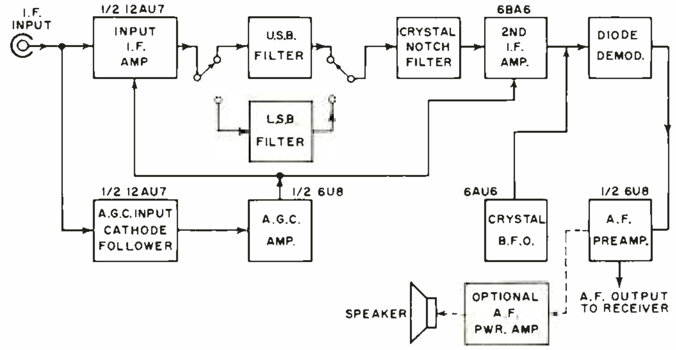
Theory of Operation

The i.f. amplifier, *V1A*, is choke-capacitance coupled by *L*1-*C*4 to selector switch *S1A*. U.S.B. and L.S.B. filters *T*1 and *T*2, respectively, are high-"Q" (iron-core) i.f. transformers. They are tuned to peak at approximately 4 kc. above and below the i.f. carrier value, respectively. Switch section *S1B* connects the output of *T*1 or *T*2 to the notch filter and grid of *V*3. The crystal *Xtal.* 1 should be ordered with a frequency high by about 25 to 50 cps from the i.f. carrier point. A 4 to 30 pf. capacitor, *C*21, permits tuning the crystal frequency downward.

The i.f. amplifier *V*3 is transformer-coupled to the demodulator consisting of diodes *D*2,*D*3,*D*4, and *D*5. Transformer *T*3 is of the capacitively tuned variety. The inductance of its secondary must be such that it may still be peaked even with the shunting effect of capacitors *C*25 and *C*26 in series.

The only purpose of these two capacitors is to provide a balanced input connecting point for the carrier re-insertion

Fig. 1. Functional block diagram of the SSB converter unit.



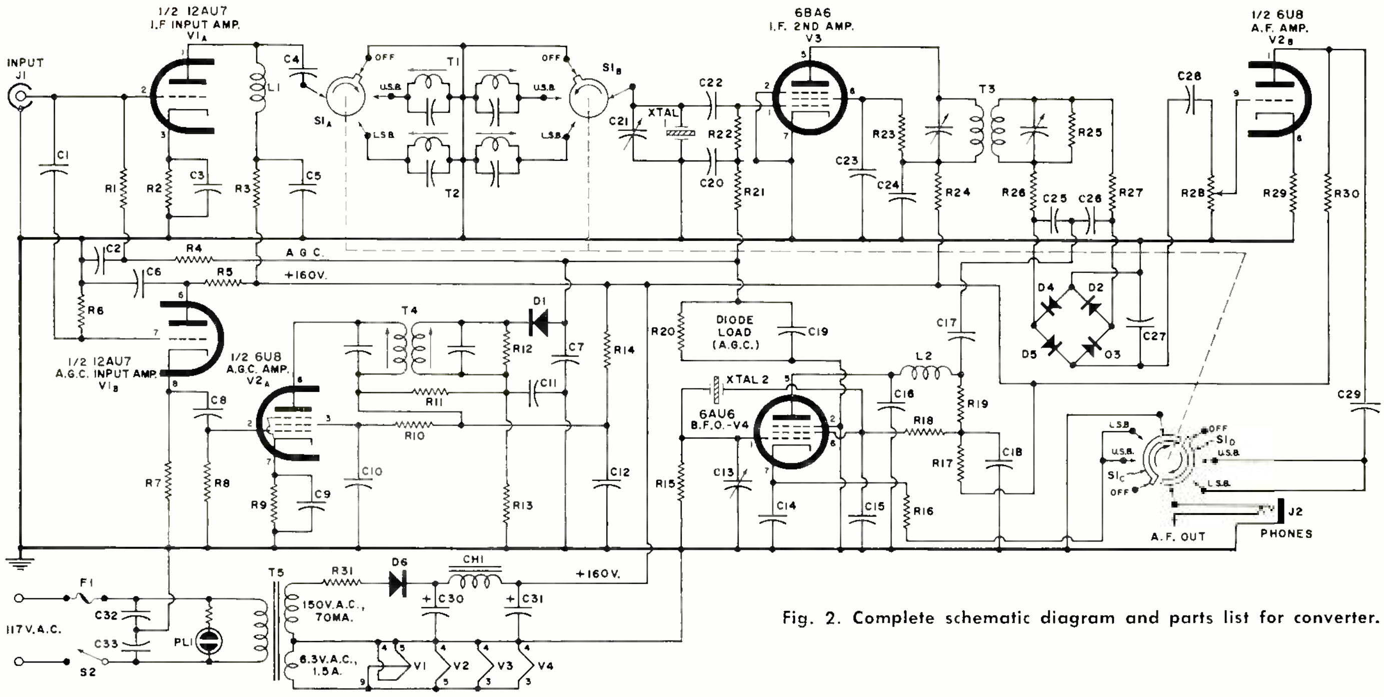


Fig. 2. Complete schematic diagram and parts list for converter.

R1,R6,R8,R15,R18,R22—100,000 ohm, ½ w. res.
R2,R7,R14,R17,R24—1000 ohm, ½ w. res.
R3,R5—2200 ohm, ½ w. res.
R4,R12,R21—47,000 ohm, ½ w. res.
R9—150 ohm, ½ w. res.
R10—12,000 ohm, ½ w. res.
R11—39,000 ohm, 2 w. res.
R13—410 ohm, ½ w. res. (range 390-470, see text)
R16—56 ohm, ½ w. res.
R19—6800 ohm, ½ w. res.
R20—470,000 ohm, ½ w. res.
R23—33,000 ohm, ½ w. res.
R25—4300 ohm, ½ w. res.
R26,R27—1200 ohm, ½ w. matched pair
R28—500,000 ohm audio-taper pot
R29—3300 ohm, ½ w. res.
R30—220,000 ohm, ½ w. res.
R31—20 ohm, 5 w. wirewound res.
C1, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C14, C17, C18, C22, C23, C24, C28, C29—0.01 µf. disc capacitor
C2,C20—470 pf. mica capacitor
C13,C21—4 to 30 pf. adj. ceramic capacitor (Centralab No. 822EN)
C15,C25,C26—100 pf. mica cap. (C25, C26-matched)
C16—360 pf. mica capacitor
C19—0.22 µf. capacitor
C27—0.005 µf. capacitor
C30,C31—16/16 µf., 250 v. elec. capacitor
C32,C33—0.02 µf. disc capacitor
J1—Female panel-mount coax jack
J2—Closed-circuit phone jack
F1—¼ amp "Slo Blo" 3AG fuse
PL1—Neon panel lamp assembly
S1—4 p. 3-pos. ceramic wafer switch
S2—S.p.s.t. toggle switch
L1—10 mhy. choke (J.W. Miller No. 9350-42, molded)
L2—270 µhy. choke (J.W. Miller No. 9350-18, molded)
CH1—4.5 hy., 50 ma. choke
D1—1N482B, 1N483B, or 1N456A (Raytheon)
D2,D3,D4,D5—1N128 (G-E)
D6—1N1694 (G-E)
Xtal. 1, Xtal. 2—Texas Crystals TX—H (dash indictates i.f. value from 455 to 500 kc.)
T1,T2,T4—455 kc. i.f. trans. (J.W. Miller No. 012-C2 or No. 12-C9. No. 612-Q1 for 500-kc. i.f.)
T3—455 kc. i.f. trans. (J.W. Miller No. 412-C2. No. 612-Q2 for 500-kc. i.f.)
T5—Power trans. 150 v. a.c. @ 70 ma.; 6.3 v. a.c. @ 1.5 amp.
V1—12AU7 tube
V2—6U8 tube
V3—6BA6 tube
V4—6AU6 tube

oscillator signal. This signal is actually balanced out in the demodulator, leaving only audio output at the grid of *V2B*. Resistors *R25*,*R26*, and *R27* provide damping and broadbanding of the detector input voltages.

V2B, the triode half of a 6U8, serves as a conventional *RC*-coupled a.f. amplifier. Its output, also connected to a phone jack, *J2*, is switched by *S1D*. This audio output connects to the receiver a.f. power-amplifier grid through a shielded lead, utilizing a phono plug-jack combination. In lieu of using the receiver's a.f. power stage, one could incorporate an audio power stage and output transformer in the converter itself. This, however, would also require an extra speaker.

The amplified output of *V2A* is transformer-coupled to a.g.c. rectifier *D1*. This transformer, *T4*, has its secondary shunted by *R12* to broaden the tuning characteristics. Resistors *R11* and *R13* form a voltage divider which provides a reverse (+) bias of about 1.75 volts on diode *D1*. *R13* should be adjusted to give approximately this voltage, and should be between 390 and 470 ohms, depending upon the actual plate-supply voltage. This reverse voltage serves as a gate, below which the a.g.c output is ineffective.

The a.g.c. rectifier will develop a negative bias of up to 20 volts d.c. This converter a.g.c. bias operates into the grid returns of *V1A* and *V3*. The receiver a.g.c. should be turned off for SSB reception since in most sets it is too slow. SSB requires a fast attack and slower release time-constant. The attack time is governed by the a.g.c. amplifier components and the i.f. amplifier grid networks. It is approximately 1 msec. The release time is a function of the diode load *RC* values, consisting of *R20*-*C19* and is about 100 msec.

The beat frequency re-insertion oscillator is a conventional crystal-controlled type. This crystal, *Xtal.* 2, and also *Xtal.* 1 are inexpensive stock items with a normal tolerance of ± 25 cps. A small amount of crystal tuning for *Xtal.* 2 is obtained with *C13*. *L2*-*C16* in the plate circuit of the b.f.o. tube V4 create a low-pass filter with a cut-off value of around 500 kc. The actual value of *C16* can be adjusted if necessary if its commercial tolerance is such that the knee of the low-pass filter curve is below the i.f. carrier value.

The built-in power supply is also conventional. It utilizes half-wave diode rectification and *LC* output filtering, with an output voltage under load of about +160 volts d.c. The total plate load is less than 20 ma. However, a higher current-rated transformer (*T5*) high-voltage secondary and choke *CH1* are used to insure good regulation.

Mechanical Considerations

Photos illustrate the outward physical layout. Three small circuit boards were made up and mounted in a vertical position using angle brackets. Boards 1 and 3 were phenolic sheet with copper backing on one side only. Holes were drilled with a #50 drill for all components. Connections were then marked out on the copper side with a grease pencil. The copper between connections is removed using a small electric drill and a fine routing bit. Blank boards and tinned wire connections will work just as well. The latter method was followed on circuit board 2.

Except where leads are very short (less than 1"), i.f. and a.f. leads should be shielded. The following wires use 3/16" o.d. plastic-covered shielded instrument coax: (a) *V1A*, *V2B*, and *V3* input and output leads; (b) all *S1A*, *S1B*, and *S1D* leads; (c) the lead from $C17$ ($V4$) to the junction of $C25$-$C26$; and (d) the plate lead from $V2A$ to the primary winding of $T4$.

The panel and cabinet consists of a 9" x 6" x 5" hammer-tone-finished aluminum utility box The aluminum chassis is 7" x 5" x 2". Since the chassis protrudes at the rear about ⅛", the rear box cover was cut off 2⅞" up from the bottom to clear the chassis top. Ventilation holes were drilled near the top edge of this rear cover plate. Both back and front bottom (½" wide) cabinet lips were cut off to permit the chassis to slide in and out of the cabinet. The front panel is attached to the chassis by means of the various front-panel chassis components and by means of a single self-tapping screw.

Converter and Receiver Alignment

The first step is the matter of the two electrical connections between receiver and converter, *i.e.*, i.f. and a.f.

If there is no i.f output jack (or set of terminals) on the rear of the receiver, this should be added. The receiver's final output i.f. secondary voltage should be measured with a v.t.v.m. A shunt voltage divider of several hundred thousand ohms should be added across the last i.f. transformer secondary and tapped up from the ground end such that the maximum output at the tap will be no more than 6 or 7 volts signal level. A capacitor of 0.01 μf. should be placed in series with the tap and the output jack.

With respect to the audio output from the converter, unless a power output stage is added to the converter, a phono jack should be added to the receiver. This jack, in turn, should be wired, using shielded lead, to the grid of the receiver's a.f. output stage.

The next step is rough alignment of the converter. First, the filters $T1$ and $T2$ plus transformers $T3$ and $T4$ should be peaked at the receiver's rated i.f., utilizing an r.f. signal generator with a range capable of covering between 450 and 550 kc. This process should be done with crystals *Xtal.* 1 and *Xtal.* 2 removed from their sockets. The signal-generator output should be applied to $J1$ of the converter, using the lowest possible signal level. An a.c. v.t.v.m. (set for 1.5-2 volts full-scale) or an oscilloscope should be connected across the input to the detector (across $C25$-$C26$), making sure that the meter leads are floating, *i.e.*, ungrounded. Generator input level should be increased until a meter reading of ½ to ¾ volt is obtained.

Crystal *Xtal.* 1 should now be installed. The generator should be very carefully tuned until the meter or CRO indicates a sharp downward dip. The generator dial should now be marked with a fine line at this point. This indicates generator resonance with the crystal *Xtal.* 1, at the "notch" point.

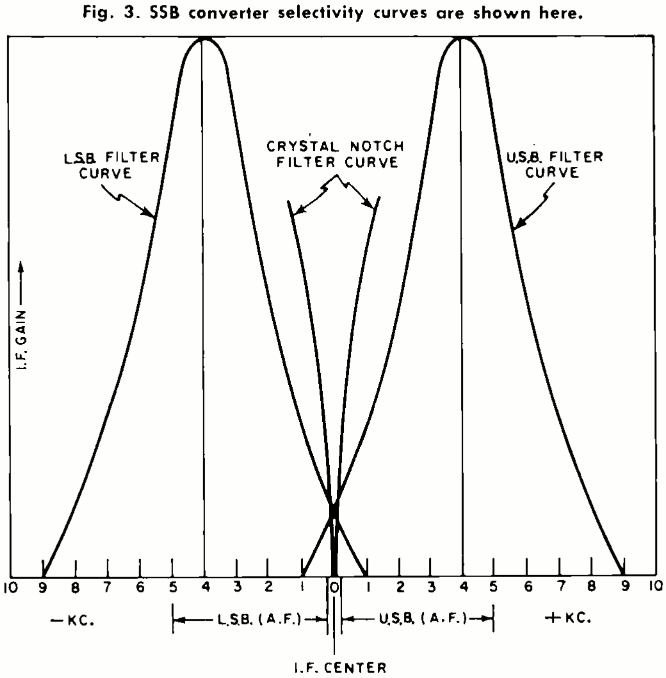
Leaving the generator set at the above mark, the receiver's oscillator and i.f. stages should be adjusted to this frequency. This may require complete re-alignment of the receiver if it was much out of alignment at the start.

The converter's U.S.B. and L.S.B. filters should now be peaked in that order by the same amount (about 4 kc.) above and below the marked i.f. point.

Again, using the signal generator set at the point calibrated against crystal *Xtal.* 1 (*Xtal.* 2 still removed), transformers $T3$ and $T4$ should be re-peaked to exact resonance with the generator.

This completes the alignment procedure. Crystal *Xtal.* 2 can now be permanently installed and trimmer $C13$ adjusted for the best over-all operation.

Fig. 3. SSB converter selectivity curves are shown here.



SSB Reception

Step 1. Connect the converter i.f. input to the receiver i.f. output using a previously prepared coax connector cable; plug the converter's a.f. output plug into the receiver's a.f. input jack.

Step 2. Switch off the receiver a.v.c.

Step 3. Turn the receiver a.f. gain control to minimum.

Step 4. Be sure the receiver b.f.o. is turned off.

Step 5. Set the receiver r.f. sensitivity control about 90% full on.

Step 6. Set the converter band selector initially to the U.S.B. position, and the gain control at about ¾ full on.

Step 7. Switch on both receiver and converter and allow them to warm up for at least 10 minutes or more.

Note: At all times during SSB reception, the receiver's r.f. sensitivity (gain) control should be kept at its lowest possible setting consistent with sufficient a.f. volume level.

Now, tune across an SSB signal. When the lowest a.f. level point is reached, note whether this (distorted) signal increases in level towards a higher or lower frequency dial setting. If it is louder on the high side, this is an upper sideband signal. Conversely, if level increases toward the lower frequency side, this is an L.S.B. signal. The converter band selector switch $S1$ can be set accordingly, and the receiver tuned (carefully) until a clear voice is heard. Desired level can be set by using the receiver r.f. gain control in conjunction with the converter a.f. gain control.

An alternative and the quickest tuning method is to tune the SSB signal until clear reception is heard, then to switch between U.S.B. and L.S.B. for loudest reception. Normally it will be unnecessary to touch the converter a.f. gain control if it is left nearly full on. Best reception of SSB signals will be found in conjunction with the receiver's crystal or regenerative selectivity controls and phasing capacitor under conditions of QRM.

Fig. 3 shows the SSB selectivity curves of the i.f. filters $T1$ and $T2$, plus that of the crystal notch filter. It can be seen that the inner skirts of the U.S.B. and L.S.B. filter curves overlap the i.f. center point. However, the very sharp skirts of the crystal filter cut into the inner filter slopes. This notch filter therefore serves not only as a trap for the receiver's actual i.f. carrier, but to give separation between the U.S.B. and L.S.B. filters as well.

Like fringe FM broadcasts or u.h.f. TV tuning, SSB voice reception is somewhat sharper and more critical than conventional AM tuning. Nevertheless, it is not at all difficult. A little experience will make the process quite easy. All SSB reception is accomplished by adjusting the receiver tuning dial alone, due to the fixed crystal b.f.o. carrier re-insertion signal within the converter itself. The vagaries of normal receiver b.f.o. carrier injection and the associated instability are thus eliminated by the unit described. ▲

CURRENT-LIMITING POWER SUPPLY

By HUGH L. MOORE
Electronics Education,
Los Angeles City School Districts

Details on a circuit design that is safe for use in schools or small laboratories while performing transistor circuit experiments or breadboarding.

WHEN transistors are operated near their limits, there is the constant danger of overheating or thermal runaway. This can happen so fast that the technician has no opportunity to disconnect the circuit. Fuses are of little help because the same action that melts the fuse also melts the semiconductor and changes its structure so that it no longer functions as originally intended. This problem can be overcome by using a current-limiting power supply, such as the one to be described.

The power supply initially generates around 150 volts of d.c. This voltage is first filtered and then dropped through resistors of sufficient value to allow the supply to act as a constant-current source. A zener diode then terminates this voltage and will consume energy at a constant voltage reference. The current needed for operation of laboratory experiments is then robbed from the zener at this fixed voltage. When the external circuit current equals the current limitations of the power supply, then the voltage falls below the zener voltage and the supply acts as a constant-current source under these conditions.

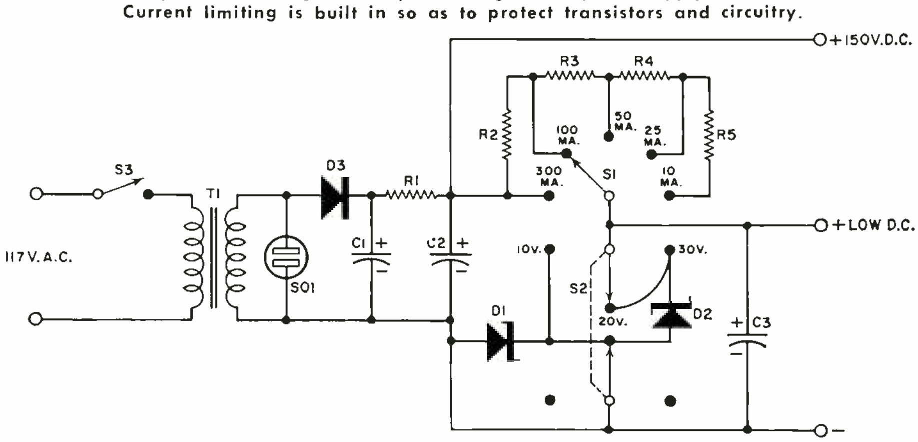
Since the transformer used in this device puts out approximately 117 volts r.m.s., this winding may be used as an isolation transformer at 35 watts.

The unregulated 150 volts d.c. may be taken off for vacuum-tube experiments. If regulation is needed, a voltage regulator tube may be used at somewhat lower voltage than 150. It is recommended that only one of these features be used at one time. A 6.3-volt filament transformer may be added to make the supply more suitable for use with tubes.

Due to the extreme simplicity of this unit, construction problems should be at a minimum. Care must be taken to provide proper heat sinks for the zener diodes. Two-inch square or larger piece of aluminum is drilled and bolted directly to each of the zeners, provided that the aluminum is mounted on insulated standoffs.

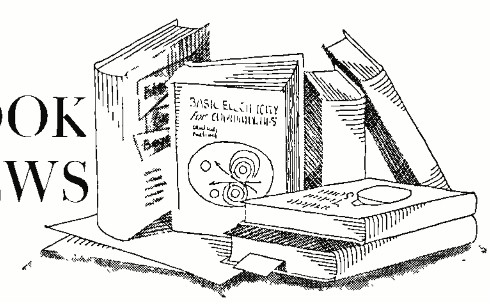
If all new parts are purchased, this unit can be built for under $25.00. This cost can be reduced by purchasing surplus transformers, diodes, resistors, etc. There are quite a few transformers on the surplus market that will meet or exceed the requirements specified. ▲

Complete circuit diagram and parts listing for the power supply described. Current limiting is built in so as to protect transistors and circuitry.



R1—400 ohm, 50 w. wirewound res.
R2—1000 ohm, 25 w. wirewound res.
R3—2000 ohm, 10 w. wirewound res.
R4—2500 ohm, 5 w. res.
R5—10,000 ohm, 2 w. res.
C1,C2—100 μf., 150 v. elec. capacitor
C3—1000 μf., 50 v. elec. capacitor
S1—S.p. 5-pos. rotary sw.
S2—D.p. 3-pos. rotary sw.
S3—S.p.s.t. toggle sw.
SO1—117 v. female socket
D1—1N1593 zener diode, 10 v. @ 3.5 w.
D2—1N1358 zener diode, 20 v. @ 10 w.
D3—1N539 diode, 750 ma., 300 p.i.v.
T1—Trans. 117 v. pri., 117 v. sec. @ 35 va. (Triad N-51X)

BOOK REVIEWS



"SOURCEBOOK ON THE SPACE SCIENCES" by Samuel Glasstone. Published by *D. Van Nostrand Company, Inc.*, Princeton N.J. 908 pages. Price $7.95.

This is another of the NASA-sponsored texts published by *Van Nostrand* and, like the volume "Space Probes and Planetary Exploration" reviewed in the September issue, is of interest to a large segment of the technical community. By definition, the author categorizes "space sciences" as those areas of science which can be expanded by means of space vehicles of various types. These include the fields of astronomy, biology, geodesy, physics and chemistry of the earth and its environment, and of the celestial bodies.

The text is divided into 13 chapters. Of particular interest to our readers will be chapters 4 and 5 on guidance, tracking, and information systems and applications in meteorology, communications, and navigation.

The treatment is lucid and scholarly and since mathematics has been kept to a minimum, readers with only an elementary knowledge of the basic sciences will have no difficulty in understanding the material.

* * *

"EVEREADY BATTERY APPLICATIONS AND ENGINEERING DATA" compiled and published by *Union Carbide Corporation*. 720 pages. Price $4.95. Soft cover.

This is a revised and expanded edition of a useful battery reference handbook which contains descriptions, specification listings, terminal sketches, and service life tables on all available battery systems, with all types arranged in ascending order of service capacity within the voltage category.

Separate sections are devoted to carbon-zinc batteries, primary and rechargeable alkaline-manganese batteries, rechargeable nickel-cadmium types, and mercury and silver batteries. A cross-reference of comparative and interchangeable battery numbers is included in the appendix—an especially useful section for all those who design and/or service battery-operated equipment. There is also a valuable section on chargers and the recharging of batteries.

Copies of the handbook are available from the Battery Engineering Department of the company at 270 Park Avenue, New York, New York 10017.

* * *

"ELECTRONIC INSTRUMENTS AND MEASUREMENTS" by Paul B. Zbar. Published by *McGraw-Hill Book Company*, New York, New York. 106 pages. Price $3.95. Soft cover.

This volume is subtitled "Laboratory Manual for Electronics Technician" and is another of the series of manuals sponsored jointly by the Electronic Industries Association and the *Voorhees Technical Institute*.

The manual is divided into 15 "experiments," each involving a specific piece of test equipment. Each experiment includes a statement of the objectives; lists the materials, test equipment, and components required to perform the experiment; the basic principles and theory back of each experiment; a detailed step-by-step procedure; and a series of questions to check the student's grasp of the work.

Both laboratory and service-type test equipment are covered and include v.o.m.'s, v.t.v.m.'s, capacitance and resistance bridges, impedance bridge, scopes, sine- and square-wave generators, r.f. sine-wave generators, sweep-frequency generators, linearity and color-bar generators; tube, transistor and solid-state diode testers; plus other test instruments.

Even the experienced technician could find much of value in this manual.

* * *

"FUNDAMENTALS OF ELECTRONICS" by Matthew Mandl. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, New Jersey. 664 pages. Price $14.60. Second Edition.

This is a revised and updated edition of a popular textbook written for those planning a career in any of the various branches of electronics, including industrial control, automation, radar, microwave electronics, computer systems, communications, or allied fields.

The material is presented in three major sections covering a review of electric fundamentals, the principles of electronics, and applications and components. Each chapter carries a list of review questions and a representative selection of practical problems on the material discussed. Answers to the problems are given in the appendix.

* * *

"INTRODUCTION TO ELECTRON TUBES AND SEMICONDUCTORS" by C. Alvarez & D.E. Fleckles. Published by *McGraw-Hill Book Company,* New York, N.Y. 285 pages. Price $6.95.

This volume is still another in this publisher's "Technical Education Series" and, like the earlier books in the series, designed as a classroom text. Written for the technical institute or the pre-engineering student, the only prerequisites are high school mathematics and a background in a.c.-d.c. theory.

There are 14 chapters dealing with the various types of tubes (including CRT's, special-purpose, and gas-filled) and transistors and other semiconductors. There is a chapter devoted to the use of tube and transistor manuals, for which the authors deserve a medal, a periodic chart of the elements, and characteristic curves for selected tubes and transistors.

* * *

"THE RADIO AMATEUR'S V.H.F. MANUAL" by Edward P. Tilton, W1HDQ. Published by *The American Radio Relay League, Inc.*, Newington, Conn. 314 pages, plus catalogue section. Price $2.00. Soft cover.

This is another of the ARRL's excellent specialized handbooks—this one covering ham communications on the frequencies above 50 mc. Like the "ARRL Handbook," this volume combines theory and practice. Written at the beginner's level, there is still much material that may surprise the experienced v.h.f. operator.

Thirteen chapters cover the history of v.h.f. amateur radio; allocations and their extent; reception above 50 mc.; v.h.f. receivers, converters, and preamplifiers; v.h.f. transmitter design; transmitters and exciters; the complete station; antennas and feed systems; building and using antennas; u.h.f. and microwaves; test equipment; interference causes and cures; then finally a chapter entitled "Bits and Pieces" which contains all sorts of handy hints for the v.h.f./u.h.f. experimenter.

Since the book is so fully packed with essential information—some of it unavailable elsewhere—it would be considered as a "must" book for all those operating above 50 mc.

* * *

"FUNDAMENTALS OF DIGITAL COMPUTERS" by S.M. Weinstein & A. Keim. Published by *Holt, Rinehart and Winston, Inc.*, New York. 153 pages. Price $4.95.

This is sort of a "do-it-yourself" course in digital computers with the presentation geared for those with no more than a nodding acquaintance with algebra.

There are seven main sections to the presentation covering the history and philosophy of computers, number systems, basic computer operation, programming, computer logic, arithmetic and control units, and computer usage.

The text is lavishly illustrated with photographs, line drawings, block diagrams, tables, and charts. For students whose appetite is whetted for further forays into the computer field, the authors have appended a "suggested reading" list. ▲

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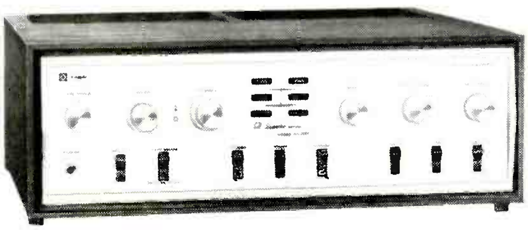

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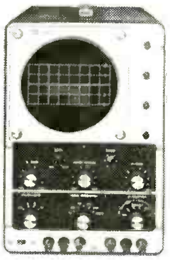

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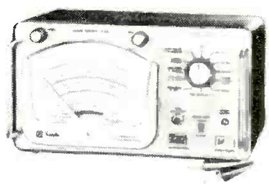

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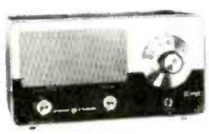

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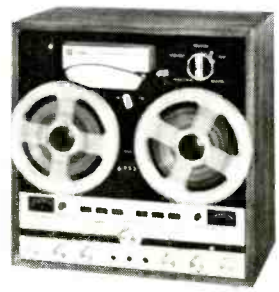

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REMOTE CONTROL SYSTEM

By DONALD H. ROGERS / Mgr., Distributor Products Engr., Jerrold Electronics Corp.

An interlocking relay arrangement permits switching ten circuits over a twisted pair up to ten miles in length.

THE equipment to be described in this article was designed to provide multiple switching facilities over a single pair of lines connecting the remote antenna site of a CATV system to the town-based office. The system is simple, maintenance-free, and will operate through ten miles of surplus field telephone wire or through the coaxial cable if bypass filters are provided at any repeater amplifiers.

The principle involved is that relays requiring a.c., positive d. c., and negative d.c. may be operated independently over the same line by proper selection of the applied voltage at the control point. Simultaneous operation by a.c. and either positive or negative d. c. is possible if the two voltages are superimposed and applied simultaneously at the control point.

The receiver, shown in Fig. 1, accepts voltages from the line and sender to directly operate relays *RL6*, *RL7*, and *RL8*. The contacts of these three relays are interconnected so that ratchet relay *RL1* operates when the transmitter "Minus" push-button is depressed, *RL2* when the "Plus" push-button is depressed, *RL3* when the "A. C." push-button is depressed, *RL4* when the "Minus A.C." push-button is depressed, and *RL5* when the "Plus A.C." push-button is depressed.

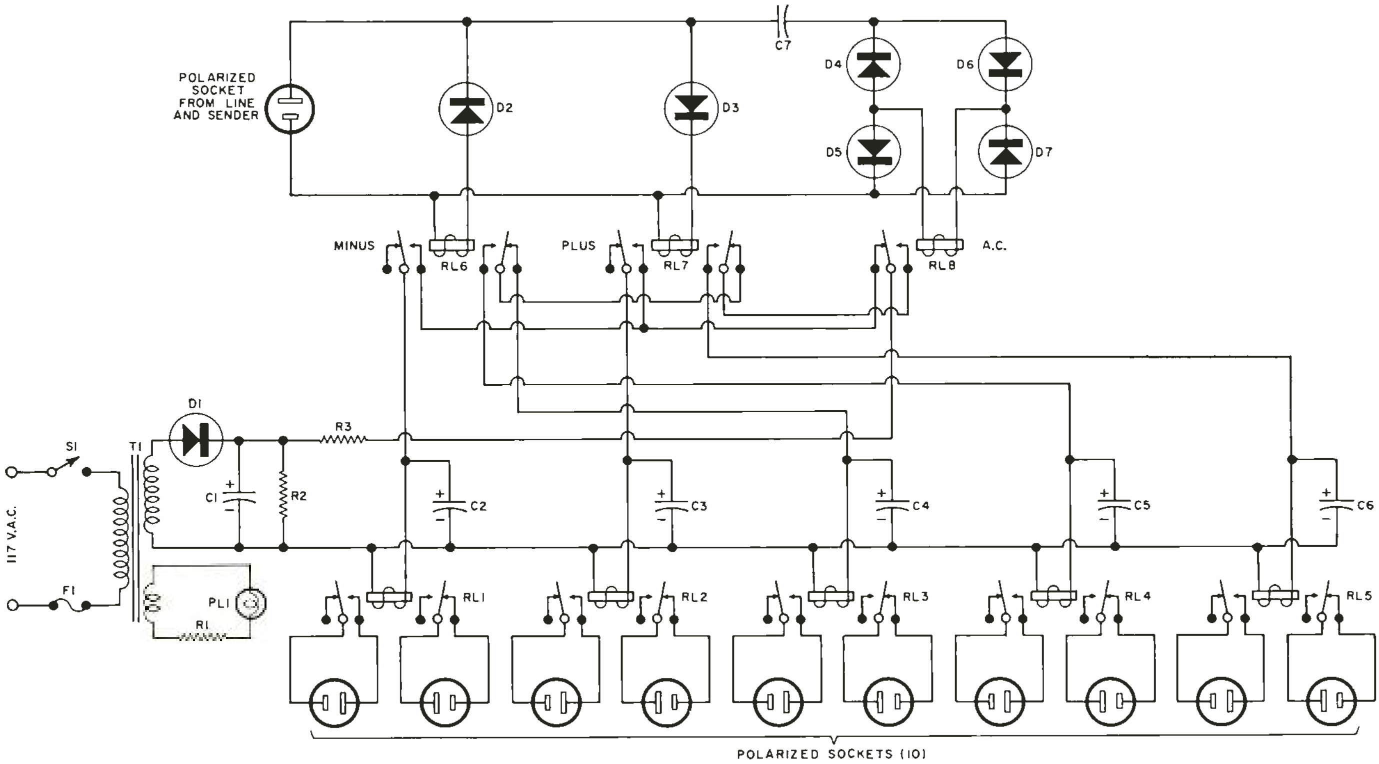
Relays *RL1* through *RL5* are ratchet relays used because they draw power only during the moment of switching and cannot produce false transfer due to power-line failure. D.c. relays are used with their coils bypassed to introduce a time delay that prevents false operation by switching transients or line surges. A series resistor (*R3*) is used to reduce sparking and arcing and to increase the life of the line relay contacts.

The transmitter is shown in Fig. 2. Push-button switches S2 through S6 are used to place the desired voltages on the transmission line. Because the receiver uses latching relays, the transmitter need not be left on if only occasionally used. Bleeder resistors drain the filter capacitors to prevent accidental operation when the transmitter is supposedly off.

Since the receiver requires 4.5 ma. into 10,000 ohms, and the transmitter delivers approximately 100 volts, the com-

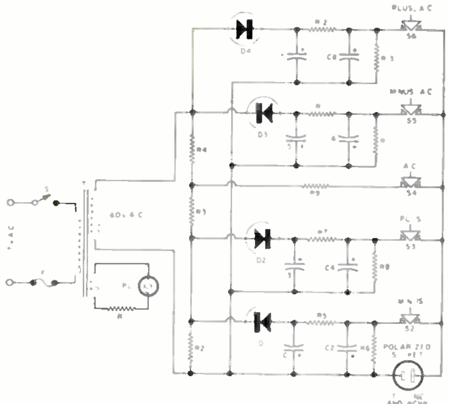
Fig. 1. Schematic and parts list for the receiving unit. The three upper relays control the operation of the five lower relays. These five relays, in turn, can be used to control the power being applied to operate ten external circuits.

R1—18 ohm, ½ w. res.
R2—7500 ohm, 10 w. res.
R3—400 ohm, 5 w. res.
C1, C2, C3—80/80/60 µf., 250 v. elec. capacitor (Aerovox AFH-3-21 or equiv.)
C4, C5, C6—40/40/40 µf., 150 v. elec. capacitor (Aerovox AFH-3-10 or equiv.)
C7—.05 µf., 600 v. capacitor
F1—1 amp "Slo-Blo" fuse (3AG)
S1—S.p.s.t. toggle switch
RL1-RL5—Ratchet impulse relay. 110 v., 1350 ohm coil res. (Potter & Brumfield AP-11D-110 v. or equiv.)
RL6, RL7, RL8—Plate circuit relay, 10,000 ohm coil res. (Potter & Brumfield LM-11-10K or equiv.)
PL1—No. 47 pilot bulb
D1-D7—Rect. diode, 600 p.i.v., 750 ma. (1N2071 or equiv.)
T1—Power trans. 160 v. @ 75 ma., 6.3 v. 1.2 amps.



plete control system will operate satisfactorily through transmission paths as high as 10,000 ohms resistance. Since line current flows only during actual signaling, the danger of false operation due to line intermittents is very slight.

Shock hazard does exist but only during actual signaling, and then the current is limited by the relatively high source impedance. It can be minimized at the time of installation by building the line out to the maximum permissible value (10,000 ohms) by inserting resistors at the sending end. In many cases, it will be possible to add enough series resistance to reduce the shock hazard to that comparable with telephone-ringing current or coin-return pulses. ▲



R1—18 ohm, 1/2 w. res.
R2, R4—1500 ohm, 10 w. res.
R3—400 ohm, 5 w. res.
R5, R7, R9, R10, R12—1000 ohm, 5 w. res.
R6, R8, R11, R13—100,000 ohm, 1/2 w. res.
C1-C8—30 μf., 150 v. elec. capacitor (CD BR3015 or equiv.)
F1—1/4 amp "Slo-Blo" fuse (3AG)
S1—S.p.s.t. switch
S2-S6—Snap-action push-button switch (Grayhill 2201 or equiv.)
D1-D4—Rect. diode, 400 p.i.v., 500 ma. (1N2070 or equiv.)
PL1—No. 47 pilot bulb
T1—Power trans. 160 v. @ 75 ma. 6.3 v. @ 1.2 amps

Fig. 2. Schematic and parts list for the transmitter unit described by the author.

"I could get it repaired cheaper than that across the street, except they went bankrupt!"

New, Shielded Twin-Lead

(*Continued from page 29*)

jacket of weatherproof polyethylene. (See Fig. 1.) No longer must a TV technician concern himself with the time-consuming installation of standoffs or the careful twisting and routing of lead-in to minimize reflections. This shielded lead-in is designed to be taped directly to the mast or tower, to be routed through metal conduit, or to be buried underground. It can even be installed in rain-filled gutters, if need be.

Unlike coaxial cable, this shielded twin-lead does not require a copper wire braided shield for current-carrying purposes. A full-coverage aluminum shield may be used to enclose this twin conductor lead-in, because the shield of a *balanced*, two-conductor cable is *not* in the circuit which is carrying signal current. The excellent shielding characteristics of this new lead-in are illustrated in Fig. 2. While exposed to automobile ignition noise, the three lead-in types were alternately connected to a TV set where the effects were photographed.

The very severe noise evidenced on the unshielded twin-lead is reduced to a minimum by switching to coaxial cable and is eliminated altogether when shielded twin-lead is substituted in the TV receiving system. Although the photographs indicate that coax can be used to decrease down-lead pickup of man-made electrical noise, it is significant that the shielded twin-lead delivers a bonus feature—a stronger signal.

A review of the attenuation characteristics of popular TV transmission line emphasizes the transmission efficiency of the shielded twin-lead. Note in Figs. 3 and 4 that all unshielded lead-in types require *two* curves of attenuation *versus* frequency. The first represents laboratory data, or performance when a lead-in is new and clean, while the second represents typical operation in a residential installation after encountering surface deposits, signal disturbances due to metal objects, and perhaps a coating of moisture. It is apparent that the actual performance of unshielded TV lead-in varies widely from the laboratory data supplied by the manufacturer. However, the performance curve for the shielded twin-lead is exactly the same when installed as it was in the laboratory. The total shield completely isolates the TV signal from outside disturbances.

The search for the best lead-in type for color-TV recently caused a brief revival of interest in the familiar coaxial lead-in, RG-59/U. This was, more accurately, a search for a shielded TV transmission line. Although the photographs of Fig. 2 indicate that coax has shielding characteristics which approach the effectiveness of the shielded twin-lead, this advantage is offset by losses which may be intolerable in some v.h.f. and in many u.h.f. TV receiving systems.

The signal losses in a coaxial lead-in (Fig. 5) are increased by additional losses of the two matching transformers required to convert the unbalanced 75-ohm cable to a balanced 300-ohm impedance. Laboratory tests indicate that a pair of these components typically adds 2 db attenuation loss over the band of frequencies for which they are designed to operate. Also, the vast majority of matching transformers are designed for v.h.f. only, seriously limiting their use in today's over-all TV market.

Shielded twin-lead delivers the same general range of signal levels on u.h.f. channels as a coaxial system delivers on v.h.f. channels. This shielded twin-lead delivers approximately 40% to 50% of the antenna signal through 100 feet of transmission line at u.h.f., while coax can deliver only about 15 to 25% of u.h.f. signal with the best matching transformers. Of course, matching transformers designed for v.h.f. only would make u.h.f. reception practically impossible because of their high losses at u.h.f.

When we review the shortcomings of the conventional flat-ribbon twin-leads, and note performance variation with weather and, also, a tendency to pick up man-made electrical noise ranging from ignition noise to out-of-phase TV signals, we realize these are not the transmission lines for the growing new color and u.h.f. TV market. By the same token, coaxial cable may not be the answer, due to attenuation losses and the necessity of introducing matching transformers into the TV receiving system.

Installation Notes

Shielded twin-lead differs from conventional encapsulated lead-in only in that it incorporates a shield, a ground wire, and a jacket. The installation instructions are few and simple. It is not necessary to use special fittings of any type. At the antenna end, clip off the jacket, shield, and ground wire and connect the two conductors to the antenna terminals. A similar procedure is followed at the TV set terminals although here the ground wire may be connected to a convenient point on the TV chassis. In most cases, connecting the ground wire to the TV chassis is not essential. However, additional shielding may be accomplished in some installations by making this connection, since the signals intercepted by the shield will be routed to an r.f. ground. ▲

(*On the matter of cost, the new shielded twin-lead line is expected to be priced above that of encapsulated twin-lead or coaxial line. When the cost of one or two matching transformers required for coax is added, then the total cost for a typical shielded twin-lead installation may be somewhat less.—Editor*)

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

"N"-CHANNEL FET'S

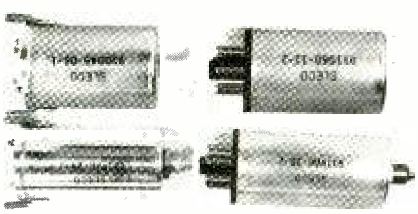
A new "n"-channel FET providing low-noise capability extending from 10 cycles to more than 500 mc. has been developed and is now in volume production. The new FET is available in a four-lead TO-18 package, designated 2N3823, and a dual matched-pair in a TO-5 type configuration, as the TIS25-27.

Advantages include low noise, superior cross modulation, low leakage, and high breakdown voltage. The 500-mc. capability of the new unit opens many high-frequency communications applications formerly restricted to conventional bipolar transistors. The device features symmetrical geometry which means that the drain and source leads are interchangeable. This permits use in high-speed multiplex and sample-hold circuits and allows both mechanical and electrical replacement of older devices with non-standard lead configurations. Texas Instruments

Circle No. 126 on Reader Service Card

MAGNETIC REED RELAYS

A new series of variable and fixed time-delay relays is now available in a variety of configurations and operating features. Contacts on the new relays are of rhodium, rated at 1/2 amp; contact arrangements up to 3 poles n.o., 2 poles n.c.,



or a combination of 1 pole n.o. and 1 pole n.c. Fixed or variable delays from 1 to 60 seconds on either opening or closing are available. Coil voltage is from 2 to 50 volts. Other voltage and time delays are available on special order. Stearns-Lyman

Circle No. 127 on Reader Service Card

MATCHING-TRANSFORMER KITS

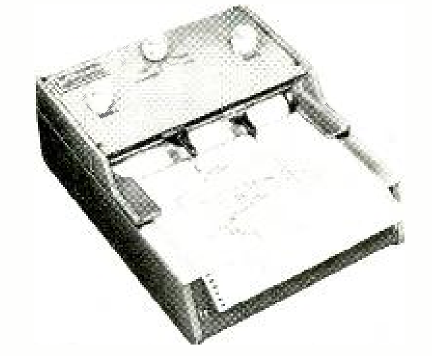
Two matching-transformer kits, MT51 and MT55, are designed to provide improved performance, especially in color-TV installations. Each "Color-Match" kit includes an antenna transformer, an indoor transformer for the set, and all necessary hardware. The MT51 kit uses the outdoor-indoor MT52 antenna transformer, no-strip terminals for easy connection to any 300-ohm antenna, and an integral "U" bolt for mounting to any antenna mast. 72-ohm output fittings include a coax connector and matching plug. The MT54 indoor transformer has a 72-ohm coaxial input connector and matching plug for the cable.

The MT55 has an MT53 outdoor antenna transformer, and MT54 indoor transformer. There are two pair of built-on aluminum bus-bars for direct, low-loss connection to the antenna take-off terminals. JFD

Circle No. 1 on Reader Service Card

POTENTIOMETRIC RECORDER

A portable chart recorder in single- and dual-channel versions is available as the 850 Series. Both versions have multiple input range of 1 mv. to 100 v. in 10 ranges; 1, 5, 10, 50, 100 mv. potentiometric; and 1, 5, 10, 50, 100 volts, 1 megohm. Accuracy is .3% on all ranges.



Features include "flip-top" chart loading, 8 1/2" wide charts, disposable ink cartridges, and solid-state circuitry. The recorders are 10" wide x 12" deep and produce a full 7 1/2" record. A complete spec sheet is available on request. CP Instruments

Circle No. 128 on Reader Service Card

SUBMINIATURE TIME-DELAY RELAY

A low-cost static time delay, Model RST-2, measures only 1 15/16" x 1 5/16" x 1 7/32" and weighs approximately 1 ounce. It is capable of delaying d.c. voltages powering loads to 3 amps. such as converters, display tubes, machine-tool controls, photographic and other processing equipment.

Life expectancy is 2 million cycles at full load. Delay time is continuously adjustable from 1 to 120 seconds by the addition of an external 1/2-watt resistor. It is hermetically sealed and designed for high reliability, utilizing silicon semiconductors to operate over temperatures ranging from −20° to +71 C. Arnold Magnetics

Circle No. 129 on Reader Service Card

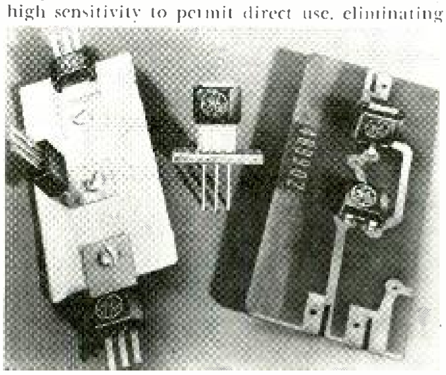
PILOT LAMPS

The West-German-made "Liliput" pilot lamps are now available at OEM prices in the U. S. Developed for use in computers and other electronic and telecommunications devices, the T5.5, T6.8, and B7 types with voltages from 6 to 60 volts and currents from 20 to 200 ma. are available from stock. International Electro Exchange

Circle No. 130 on Reader Service Card

LOW-COST SCR'S

The development of a unique SCR which will be priced as low as 35 cents in high-volume production has been announced. This all-planar SCR is plastic encapsulated, is in a rectangular flat pack designed for high packaging density on printed-circuit boards, and is of sufficiently high sensitivity to permit direct use, eliminating



intermediate amplifying stages, with very low-signal, low-cost sensors.

The C106 has applications in motor speed control, lighting, temperature control, pressure applications, as a timer, in liquid-level measuring devices, remote switching, as a dryness sensor, and as a proximity switch. General Electric

Circle No. 131 on Reader Service Card

FUSES FOR ZERO-DEFECTS PROGRAMS

High-reliability versions of Picofuses and Micro-fuses have been introduced to meet the requirements of military and industrial zero-defects programs. The new fuses are hermetically sealed and have gold-plated terminals for soldered or plug-in applications. Resistance values are closely controlled and time/current characteristics are certified to 1% AQL per MIL-Std-105, Inspection level II. Identifications, test data, and traceability records are maintained and supplied to the user. Littelfuse

Circle No. 132 on Reader Service Card

TRANSISTORIZED FREQUENCY COUNTER

Nominally 10 to 100,000 cps, the FLF-1 transistorized frequency counter provides sensitivity of better than 0.5 v. r.m.s. with an input impedance in excess of 150,000 ohms. No sensitivity adjustment is required in the input range of 0.5 to 250 v. r.m.s. A double-shielded case and floating input provide d.c. isolation in excess of ±500 v.

The unit features simplicity of operation for convenient use by both technical and non-techni-

cal personnel. Standard line or an optional internal clock is provided for measuring accuracy in excess of 0.01%. A resolution of 0.1 cycle is provided over the full 7 to 120,000-cycle measuring range. A register overload indicator provides unambiguous 6-digit resolution over 10 kc.

The unit measures 10" x 6" x 6" and weighs less than 7 pounds. Power consumption is less than 8 watts. W. H. Clark

Circle No. 133 on Reader Service Card

WIRING HARNESS ACCESSORY

Strap tying time on wiring harness can be reduced by means of a new accessory called "Pan-Ring," a simple plastic device that ties "Sta-Straps" quickly and with little effort. The new accessory can be used on both point-to-point and harness board tying. They are available to tie bundles up to 1 1/4" in diameter and are offered for both miniature and standard "Sta-Straps." Panduit Corp.

Circle No. 134 on Reader Service Card

CAPACITIVE IGNITION SYSTEM

A new capacitive ignition system for all gasoline, propane, or natural-gas-fueled engines is now available as the "Mark 10 Thunderbolt." The unit features an SCR system which stores voltage in a capacitor until needed rather than being built up by an induction coil. Applied battery voltage is converted from 12 volts to 400 volts by converter circuitry. The power supply will deliver full energy to the capacitor at engine speeds over 8000 rpm. The unit is being offered in both kit and factory-assembled versions. Delta Products

Circle No. 2 on Reader Service Card

BATTERY CHARGER SOURCE

A wide range of different types and ratings of battery chargers for makers of portable appliances using NiCd and other rechargeable batteries is available without price, performance, or delivery premiums.

Typical of the units available is the BC series designed to handle up to 150 ma. and up to five NiCd batteries in series. In addition to a wide range of electrical performance specifications available to the designer, the new line is available in a variety of open-frame and potted physical configurations and with UL cords and plugs. A custom line is also available to customer's specifications. Jerome Electric

Circle No. 3 on Reader Service Card

SOLID-STATE PULSE TIMER

The Series C2252 solid-state pulse timer can be programmed locally or remotely by resistances for time sequences or by limit switches for mechanical control. Internal solid-state logic provides a fixed, minimum 100 msec. pulse. The

pulse rate (from 0.2 to 60 seconds) is controlled by either the timer's contained potentiometer or by using provided remote-control facilities. The pulse created is used to energize the coil of the timer's relay for 100 msec. minimum. This electrical event causes closure of the timer relay's 10-amp d.p.d.t. contacts for 100 msec., providing ample time to operate solenoids or to electrically lock control circuits. Electro-Seal

Circle No. 135 on Reader Service Card

REGULATED POWER SUPPLY

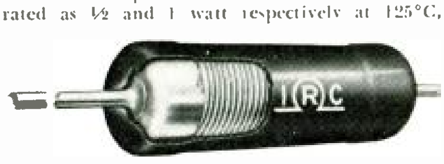
Designed for use in the engineering lab and production test equipment, the Model 370 regulated power supply features continuously variable output voltage of 0-32 volts d.c. @ 300 ma., line regulation of 10 mv. maximum for line changes of 108-132 volts a.c., load regulation of 10 mv. maximum for 300 ma. load change, 50 μsec. response time to input and load changes, ripple and noise 300 μv. typical and 3 mv. maximum, and automatic current limit and short-circuit protection set at 350 ma.

The supply is housed in a 4" x 1⅜" x 7½" aluminum case and weighs 3 pounds. Semiconductor Circuits

Circle No. 4 on Reader Service Card

PRECISION WIREWOUND RESISTORS

Precision power wirewound resistors, which are 20 to 30 times smaller than equivalent metal film units, are available as the AS-½ and AS-1. Designed especially for miniaturizing transistor circuitry due to their small size, high power density, and precise tolerances, the units are rated as ½ and 1 watt respectively at 125°C,

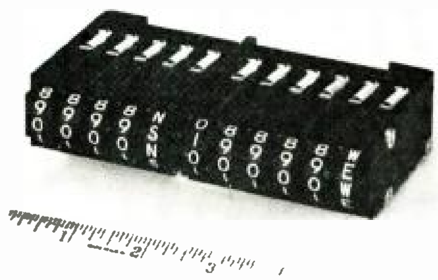


power ratings double at 25°C. These types are available with resistances of 0.1 ohm through 7500 ohms; initial tolerance ±0.1% to ±5% (±0.05% available on special order). International Resistance

Circle No. 136 on Reader Service Card

SINGLE-WHEEL COUNTER

A binary decade counter, developed for use in solid-state systems where digital readout is required, has recently been introduced. The new unit measures 0.4 inch wide, 1.2 inches high, and



2.5 inches deep and weighs only 1.3 ounces per decade. Single decade modules may be custom-mounted in modular packages to achieve desired capacities and combinations.

Each wheel is independently driven by its own self-contained solenoid, and a binary-coded switch indicates the position of the corresponding wheel for monitoring by the actuating computer. Each pulse on the solenoid adds one count, with a maximum speed of 25 counts per second. Power consumption is 3 watts maximum at 28 volts d.c. Veeder-Root

Circle No. 137 on Reader Service Card

HIGH-VOLTAGE RECTIFIERS

A new series of diffused silicon high-voltage and high-voltage/high-frequency rectifiers, designed for commercial and industrial applications, is now available at prices competitive with selenium rectifiers.

Termed the Series 7715 and 7715X, the new series is available with p.r.v. ratings from 3 kv. to 50 kv. and average d.c. forward current from 75 ma. to 15 ma. The 7715X series has a reverse recovery time of 300 nanosec. max. at $I_F=2$ ma. and $I_R=2$ ma. Ambient operating and storage temperature is −55° to +125°C. Varo

Circle No. 138 on Reader Service Card

INTERCHANGEABLE LABELER DIALS

Three separate snap-in dial packs, to make embossed-letter labels in different sizes, can now be used with the new Rotex Compact Labeler. Dials are available for use with ¼", ⅜", and ½" tapes. Avery Products

Circle No. 5 on Reader Service Card

HI-FI AUDIO PRODUCTS

SPEAKER SYSTEM KIT

A low-cost kit version of the Model RM-1 speaker system has been put on the market for hi-fi enthusiasts and hobbyists. The 16-page construction booklet accompanying the kit includes the "whys" as well as the "hows" of assembling the system. Frequency response is 15 to 20,000 cps and the system will handle 40 watts of average program material and 80 watts peak.

The system includes one 6" linear high-compliance woofer and one high-frequency tweeter, crossover is at 5000 cps and impedance is 8 ohms. The cabinet, which is supplied in unfinished birch veneer, measures 11½" x 10½" x 7¼" and weighs 12 pounds. Sonotone

Circle No. 6 on Reader Service Card

40-WATT FM-STEREO RECEIVER

The Model RT4000 solid-state FM-stereo receiver features flywheel tuning, 40-db stereo separation, and is rated at 40 watts. Its FM section has a sensitivity of 2.5 μv. IHF; distortion is less than 0.5% at full output. Hum and noise are 60 db below 100% modulation. Frequency response is 15-30,000 cps ±1 db. Another feature of this 14" x 16" x 4⅝" receiver is a stereo minder indicator which automatically switches from mono to stereo when the station broadcasts in stereo and indicates the change visually. Bogen Communications

Circle No. 7 on Reader Service Card

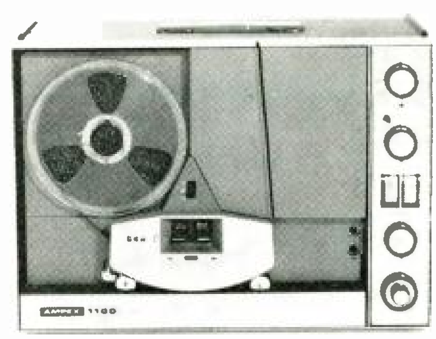
CONTACT MICROPHONE

A small-size, electro-magnetic contact microphone that can be hidden under the user's collar, is now available as the "Larynx AC-77". The unit is energized directly through the vibrations of the vocal cords and will not pick up sound waves from the outside. The unit is available from 50 ohms to 5000 ohms and comes equipped with a lightweight plug-in cord. Frequency response is 200 to 3000 cps. Telephone Dynamics

Circle No. 8 on Reader Service Card

STEREO RECORDER LINE

The new 1100 series of medium-priced stereo tape recorders for home use includes three models: 1165 a walnut encased recorder, 1160 in a tan vinyl case, and the 1150 tape deck. All models offer four-track stereo and mono record; four-track stereo and mono, half-track and full-track mono playback. Speeds are 7½, 3¾, and 1⅞ ips. They also feature all-solid-state electronics including silicon transistors in the preamps;



three heads; twin vu meters; automatic threading and reversing; automatic digital counter; and dual capstan drive. Ampex

Circle No. 9 on Reader Service Card

80-WATT SOLID-STATE RECEIVER

An 80-watt silicon power transistor FM-stereo receiver, the Model TK-80, is now available. Special features include speaker output terminals and power for two sets of stereo speakers plus stereo headset jack; front-panel switching for selection of either set of speakers, both sets, or earphones; a special power transistor protection

circuit; automatic mode switching; output selector switch; interstation muting circuit; illuminated pinpoint tuning meter; illuminated program source indicator; and tape recorder output.

Frequency response is 20-60,000 cps ±1 db and 15-120,000 cps ±3 db. FM usable sensitivity (IHF) is 1.8 μv. and signal-to-noise ratio is 60 db at 100% modulation 1 mv. input. The unit which measures 17¾" x 5¹³⁄₁₆" x 14" is designed either for free-standing or cabinet mounting applications. Kenwood

Circle No. 10 on Reader Service Card

CUSTOM SOLID-STATE AUDIO AMPS

A new series of 20- to 800-watt solid-state amplifiers, custom designed for the OEM market, is now available. There are five models available: AA-1000 (20 watts), AA-2000 (100 watts), AA-3000 (200 watts), AA-4000 (400 watts), and AA-5000 (800 watts). All units operate from a signal input level of 1 volt r.m.s. and have full-power frequency response from 20 to 20,000 cps. These completely transistorized units are lightweight, small sized, and cool operating. No venting of cabinets is required. Power output transistors drive the speakers and operation is free from distortion and microphonics. Jordan Electronics

Circle No. 139 on Reader Service Card

SOLID-STATE STEREO TAPE RECORDER

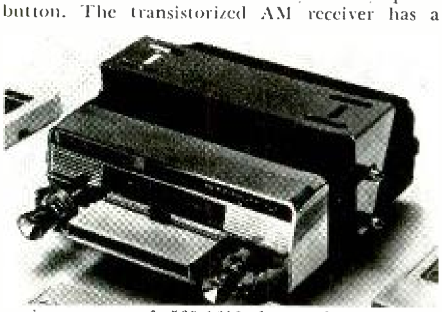
The Model 300 solid-state 4-track stereo tape recorder has been added to the "Oki" line and features 4-track mono/stereo record/playback, sound-on-sound, sound-with-sound, 4-track stereo head, lever operation, instant pause control, automatic shut-off switch, two record buttons with safety lock, 3-digit index counter, two record-

level meters, detachable speaker systems, and a fully transistorized OTL amplifier. The unit operates at 7½ and 3¾ ips and will handle reels up to 7". Response is 40-15,000 cps at 7½ ips. The recorder measures 12" x 8¼" x 11½" including the speakers. Chancellor Electronics

Circle No. 11 on Reader Service Card

MOBILE STEREO UNIT

A cartridge stereo tape player and an AM radio have been combined in a single unit designed for installation in any car, boat, or airplane. The "Stereo 8" tape playback unit has 8 tracks and plays at 3¾ ips. The program can be selected either automatically or by pushbutton. The transistorized AM receiver has a



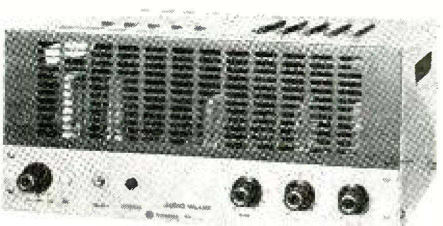
tuning range of 535-1610 kc. and features 7 tuned circuits, double-tuned i.f. coils, and r.f. stage.

Three models are being offered: the ASR-830P (panel installation with radio), ASR-830H (add-on accessory with radio), and AS-830H (add-on accessory without radio). An extensive line of recorded tapes from major record companies' libraries is available. Lear Jet

Circle No. 12 on Reader Service Card

AUDIO AMPLIFIER LINE

First units in a new line of audio amplifiers are the Model MA-325 (25-watt) and Model MA-216 (16-watt) units. Both units feature THD of better than 1% at 1000 cps; output hum and noise better than 70 db below rated output; solid-



state full-wave power supply for operating voltages; three-position switch with standby position; visual indicators; inputs wired for choice of hi-Z plug or low-Z transformer; and seven-terminal barrier strip for all output choices: 4, 8 ohms and 25-volt and 70.7 volt systems. Both units are designed for use with background music systems and in commercial sound applications. Browning Laboratories

Circle No. 13 on Reader Service Card

REMOTE-CONTROL EQUIPMENT

A new remote-control station and relay-control electronics designed to be used with the Models 1021, 1022, and 1024 tape recorders have been made available. The relay-control transport converts the standard electro-mechanical button control to touch-button control while the remote control station allows the remote control of all modes: rewind, record, stop, cue, play, and fast forward. Both of these new items are available as options on new equipment or can be purchased separately for use with the above model tape recorders already in the hands of the public. Magnecord

Circle No. 14 on Reader Service Card

AUTOMATIC/MANUAL TURNTABLES

A new line of British-made automatic/manual 4-speed stereo turntables is now available in the U.S. The three models on the market are the RCD-4 "Princess" deluxe which accepts any standard flip-under stereo/mono cartridge and

has a 4-pole motor; the RC-2 model which comes complete with diamond stylus; and the RC-1. Each unit features removable center spindles for manual use, a patented built-in stylus cleaning brush, self-locking tonearm, and dynamically balanced heavy-duty motors. The units come complete with a.c. line cords and audio cables and will take a 10-record intermix for standard size records of the same speed. RFS Industries

Circle No. 15 on Reader Service Card

SOLID-STATE P.A. AMPLIFIER

Both size and weight have been drastically reduced in a new line of p.a. amplifiers currently available. Offered in models with outputs of 16, 34, or 50 watts, they may be operated from 6 or

12 volt batteries or 117-volt a.c. lines with an adapter. Separate volume controls are provided for microphone, phono, or tape. They have dual microphone inputs. American Geloso

Circle No. 16 on Reader Service Card

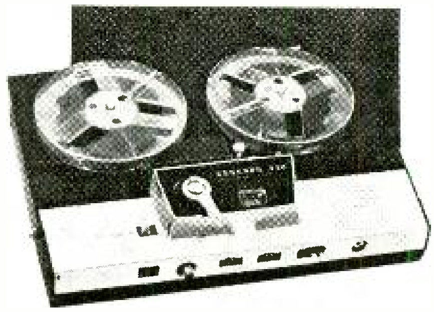
ELECTRONIC MEGAPHONE/SIREN

A siren feature has been added to the high-powered, battery-driven electronic megaphone, MV-16S. The high-powered siren is activated by a slide switch which closes the circuit, converting the transistorized amplifier into an electrical oscillator. Rated at 16 watts, the megaphone is said to have a range of over 800 yards under normal wind conditions. The amplifier is powered by 5 transistors in a class B push-pull circuit and normally operates on 8 "C" cells. It can be operated from 12-volt power sources by means of an optional adapter cord which plugs into a car, boat, or truck cigaret lighter socket. The unit weighs 5 pounds and measures 9" x 11" over-all. Fanon

Circle No. 17 on Reader Service Card

PORTABLE TAPE RECORDER

A portable dual-power tape recorder that operates on both a.c. and flashlight batteries has been introduced as the Model 320. A key feature



of the solid-state unit is the remote-control microphone which permits start/stop operation from a distance.

The six-pound unit provides 3¾ and 1⅞ ips speeds, will handle standard 5" reels, will record up to 6 hours at 1⅞ ips, has a frequency range of 50-10,000 cps; and is powered by six "D" cells or external a.c. sources. The circuit uses 9 transistors and 1 diode. The recorder measures 12" x 8¾" x 3¾". Concord Electronics

Circle No. 18 on Reader Service Card

MIXER/PREAMP

A new solid-state mixer/preamp is now available for p.a. applications. The LX-40 has an output level of +10 dbm at 600 ohms unbalanced. It has four microphone inputs and a separate program input which are individually controlled. Such features as master gain and tone control and a cueing switch are provided. A phone jack has been incorporated for monitoring program material.

Optional accessories include three-conductor mic connectors (male or female); phono, program, and tape-head preamps; universal microphone-line input transformer; vu meter; and a 19" rack-panel mounting. McMartin Industries

Circle No. 19 on Reader Service Card

CB-HAM-COMMUNICATIONS

INDUSTRIAL/BUSINESS RADIO

A 30-watt AM Industrial/Business Band two-way radio, the IBC 301, features an all-transistor receiver for low power drain, a solid-state power supply, illuminated function indicators, adjustable squelch and pre-set noise limiter, muting switch, and a corrosion-resistant housing which measures 11" wide x 3½" high x 8½" deep.

This new single-frequency radio can be installed as a complete unit or the self-contained remote-control head may be slipped out of the main unit and installed independently with its own mounting cradle. The remote-control head weighs less than 2½ pounds and is only 6½" w. x 2½" h. x 7½" d. Pearce-Simpson

Circle No. 140 on Reader Service Card

PANORAMIC ADAPTER

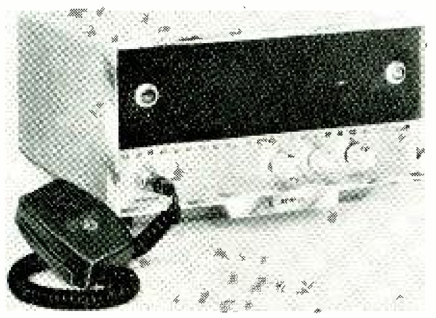
An improved model "Panadaptor", the Model PR-1, is now available for immediate delivery. It is designed for use with receiver i.f.'s from 450 to 500 kc. and presents a graphical display of signal level versus frequency on a 3" CRT. The PR-1 permits instantaneous observation of the activity in the band, assists location of "CQ" replies and QRM-free regions, as well as analysis of signal quality by detailed narrow-band sweeps.

The unit displays signals up to 100-kc. on either side of the frequency to which the receiver is tuned. Operating off the i.f. of the receiver, connection is made to the converter tube by a resistor with spring loop to fit pins of octal tubes or a capacitive pickup through a clip fitting over miniature tubes. Singer Company

Circle No. 20 on Reader Service Card

INDUSTRIAL TRANSCEIVER

A new 85-watt AM radio transceiver, designed to provide low-cost, two-way communications in the Business/Industrial band, is the "Messenger 600". Interchangeable for base station or mobile use, the unit measures 5 3/16" x 11" x 10" and weighs 19 pounds. With the base station antenna



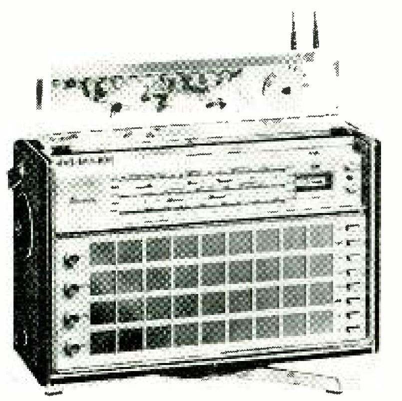
mounted well above surrounding obstructions, the "600" will maintain reliable base-mobile communications over distances up to 35 miles or more. The transceiver is FCC-type accepted for use in Public Safety, Industrial, and Land Transportation Services in the 25-50 mc. range. E. F. Johnson

Circle No. 21 on Reader Service Card

AM-FM-S.W.-MARINE PORTABLE

The Model L638 portable radio incorporates AM, FM, marine, and short-wave coverage in a unit which measures 15 9/16" x 10 1/16" x 4 3/4" and weighs only 13 3/4 pounds.

Coverage includes the 150-415 kc. aircraft band, 517-1622 kc. AM band, 1.6-4.2 mc. marine band, three short-wave bands (including the 11, 13, 16, 20, 25, 30, 40, 50, and 60 meter bands), and 87.5-108 mc. FM band. The portable contains a 5" x 7" speaker and output is 1000 mw. The



unit is powered by 9-volt, six dry cells, or Type R-20 cells. Output connections for tape recorder, record player, and outdoor AM and FM antennas are included. Norelco

Circle No. 22 on Reader Service Card

MANUFACTURERS' LITERATURE

RESISTORS & TRIMMERS

A new, expanded "Quick Reference Guide" listing 144 different resistors and trimmer pots has been published, and covers military, commercial, and general-purpose grades.

The listing includes wirewounds and film resistors in various categories. Dale Electronics

Circle No. 141 on Reader Service Card

ELECTRONIC COMPONENTS

A 32-page product catalogue (No. 765) has been issued covering a wide variety of electronic components and test instruments. The listing ranges from accelerometers to variable transformers and covers products for commercial applications as well as military requirements. American Relays

Circle No. 23 on Reader Service Card

TRANSISTOR SELECTOR GUIDE

A uniquely designed silicon transistor selection guide which permits the user to choose the high-frequency amplifier or switching device which most closely fits his exact performance requirements has been published.

The new guide covers over 100 different high-frequency silicon annular transistor types for both amplifier and switching service. Motorola Semiconductor

Circle No. 142 on Reader Service Card

SWITCH CATALOGUE

A 10-page Engineering Specification Catalogue No. S-323 covering Series 35000, 36000, 37000, and 38000 "Multi-Switches" is now available.

Complete engineering specification information is provided about such items as illumination, styles and shapes of push-buttons, stack module design, and many other "Multi-Switch" design requirements. Switchcraft

Circle No. 143 on Reader Service Card

MOLDED PLASTIC PARTS

A catalogue and price list covering molded plastic parts for electronic packaging includes encapsulation shells, headers, covers, module packages, and sheet stock—all off-the-shelf items.

A comparative chart describes the electrical and mechanical properties of epoxy, phenolic, alkyd, and diallyl-phthlate to assist the designer in selecting the proper material for his requirements. Epoxy Products

Circle No. 144 on Reader Service Card

STOCK PANEL-METER SELECTOR

A 20-page quick-reference catalogue (#Z-100) for panel meters and accessories has just been published. This detailed catalogue features a size-index tab guide which permits rapid selection of the desired meter size. All types of panel meters are included in the catalogue which also carries a glossary of terms, conversion factors, and ordering information. Weston.

Circle No. 145 on Reader Service Card

PRECISION SWITCHES

A comprehensive 12-page catalogue/brochure covering the company's basic lines of sensitive precision subminiature switches is now available. The fully illustrated catalogue contains electrical and mechanical specifications and case and terminal diagrams on all models in the line. Milli-Switch

Circle No. 146 on Reader Service Card

REED SWITCHES

An engineering design kit for custom building and breadboarding prototype circuit applications is described in a new six-page folder entitled "Reed Switches." The kit contains an assortment of reed switches, magnets, and coils. Instructions for designing 10 devices are included in the kit. In addition to the kit, the folder covers the firm's complete line of reed switches, with specifications, actuating power sources, test circuits, and ordering information. New Product Engineering

Circle No. 147 on Reader Service Card

IGNITION-SYSTEM BROCHURE

A 4-page illustrated brochure giving complete details on the "Super 7" noise-free and waterproof ignition system for land and marine vehicles is now available. Mercury Enterprises

Circle No. 24 on Reader Service Card

BUSINESS COMMUNICATIONS

A pocket-sized, 20-page booklet entitled "The Modern Approach to Business Communications —Two-Way Radio" is now available on request. It answers in brief, non-technical terms most of the questions businessmen are likely to ask regarding the feasibility of two-way radio for their particular operations. In addition, the booklet carries brief catalogue data on a line of two-way radio equipment available from the manufacturer. Pearce-Simpson

Circle No. 25 on Reader Service Card

MICROCIRCUIT MOUNTING BOARDS

Literature covering its new ADC 13-8 series of mounting boards, which are designed to simplify breadboarding and small production run problems associated with microcircuits, has been announced. The literature describes the over-all line, its applications, and information on individual boards and patterns. Applied Development

Circle No. 148 on Reader Service Card

ELECTRONIC PARTS & HARDWARE

A 48-page catalogue covering electronic parts and hardware is now being offered. It covers binding posts, contact and terminal strips, interlocks, fuse and diode holders, lugs and terminals, anode connectors, tip jacks and plugs, alligator clips, phone and phono plugs and jacks, and many other items. National Tel-Tronics

Circle No. 149 on Reader Service Card

PRECISION WIREWOUNDS

A 16-page catalogue which provides detailed specifications on a complete line of precision wirewound resistors is now available. It includes full information on high-reliability units; epoxy cast resistors for military, commercial, and industrial applications; printed-wiring resistors; ceramic resistors for commercial computers, industrial instrumentation, and laboratory experimentation; and molded resistors and custom networks. Hi-Q Div., Aerovox

Circle No. 150 on Reader Service Card

OSCILLOGRAPH PAPERS

Bulletin 1639-6 describes three oscillograph recording papers which cover virtually all modes of recording that utilize direct print or print-out techniques.

Dataflash 54 is a high-writing speed paper designed for ultraviolet light-source instruments, Dataflash 55 features writing speeds in excess of 75,000 ips and an extremely high latensification rate, while Dataflash 56 is formulated with a wide spectral response and is used in instruments utilizing xenon light sources. Consolidated Electrodynamics

Circle No. 151 on Reader Service Card

TUBE & SEMICONDUCTOR CATALOGUE

An 8-page, two-color catalogue listing over 2500 tubes by type with their prices is available as the "1965 Wholesale Electronic Tube Price Catalogue." Included are radio, TV, photomultiplier, magnetron, ignitron, klystron, microwave, photo, trigger, ballast, subminiature, tungar bulb, nuvistor, thyratron, voltage regulator, planar triode, vidicon, iconoscope, ATR, TR, traveling wave, backwave, storage, transmitting, and cathode-ray tubes and semiconductors. Thor Electronics

Circle No. 152 on Reader Service Card

SHIELDED TAPE, FOIL & TUBING

Electromagnetically shielded tape, foil, and tubing are described in an 8-page, two-color catalogue. The publication includes diagrams, alloy content tables, applications, available quantities, price lists, and ordering information. Russell Industries

Circle No. 153 on Reader Service Card

FLAT WIRE HARNESSES

A four-page, illustrated brochure covering "Plycon" flat flexible wire harnesses is now available on request. The catalogue gives electrical and physical data, as well as ordering information on straight and retractable harnesses in single- and multiple-layer configurations.

The harnesses are designed for use in drawer or rack-mounted electronic equipment, and as jumpers between points on a chassis. Methode

Circle No. 154 on Reader Service Card

SWITCH TIPS FOR PRODUCTION

Six prize-winning "tips" on using the proper switch to solve plant production problems are included in a four-page illustrated brochure, No. 39. Since the ideas cover a variety of problems, the publication should have wide appeal. Micro Switch

Circle No. 155 on Reader Service Card

STEREO BROCHURE

An 8-page, full-color catalogue covering an entire line of hi-fi components—speakers, playback systems, and cartridges—and ideas on "decorating with sound," is now available. Each component listed carries a complete specification breakdown and price structure. Empire Scientific

Circle No. 26 on Reader Service Card

GRAPHIC PRESENTATION MATERIALS

A comprehensive 100-page catalogue covering a complete line of time-saving tapes and components will be of interest to engineers, draftsmen, cartographers, architects, teachers, technical illustrators, and printers working in the drafting, art, and visual communications fields.

The catalogue includes "how to" sections, product sections, and specifications on a wide range of supplies. Chart-Pak

Circle No. 27 on Reader Service Card

PRESSURE-SENSITIVE TAPES

A "Select-A-Tape" pocket catalogue describing a complete line of pressure-sensitive adhesive tapes has just been published. The 24-page guide covers masking, packaging, printable, protective, electrical, and special-purpose tapes for high and low temperatures, chemical resistance, and other critical applications. More than 80 tapes are included with full information on physical characteristics, typical applications, sizes, and government specs on each. Mystik Tape

Circle No. 156 on Reader Service Card

TRANSISTOR HARDWARE

Now available is a six-page illustrated data sheet detailing a full line of sockets, holders, bushings and pads for transistors and semiconductor special devices. Bulletin 82B contains descriptive engineering drawings of 16 types of transistor holders, 14 types of transistor sockets, and 10 grommet-type chassis mounting transistor bushings. Sealectro

Circle No. 157 on Reader Service Card

SHORT-FORM POT CATALOGUE

A short-form catalogue (No. 11) covering a complete line of military, industrial, and commercial adjustment potentiometers is offered without charge. The 8-page brochure also lists brief specs on precision pots, time delays, relays, microcomponents, and exponential resistors. Bourns Trimpot

Circle No. 158 on Reader Service Card

CONNECTORS FOR COAX CABLE

A complete line of connectors and adapters for use with shielded and coaxial cables is described in a new 12-page illustrated brochure now available. A complete description, including a step-by-step installation guide, is featured in the T-60 catalogue. New tools for extracting leads and for compressing the connectors are also covered. Thomas & Betts

Circle No. 159 on Reader Service Card

TRANSFORMERS & COILS

A 150-page catalogue covering over 1100 stock items which will replace in excess of 30,000 original manufacturers' parts has just come off the press. Coils and transformers for both the service and industrial markets are included. A 60-page section is devoted to direct replacement listings on a wide range of inductive components. Merit

Circle No. 160 on Reader Service Card

REAR-PROJECTION READOUTS

A two-page engineering data sheet covering the new Series 340 microminiature rear-projection readouts is now available.

Each unit will display up to 11 different messages including numbers, letters, words, symbols, and colors. The data sheet provides engineering details, mounting dimensions, lamp specifications, and a chart of the standard displays that are available, and a price schedule. Industrial Electronic Engineers

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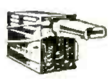

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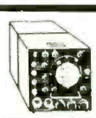

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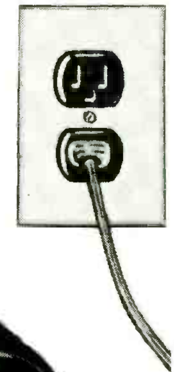

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CIRCLE NO. 101 ON READER SERVICE CARD

ELECTRONICS WORLD OCTOBER 1965
ADVERTISERS INDEX

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Some plain talk from Kodak about tape:

Noisemanship...modulation noise... and how to get extra dbs. of silence

Noisemanship is a very hip subject. The more noise your sound system has, the muddier your reproduced signal. Which brings up the subject of defining tape noises, how they occur, how they are measured, and what can be done to reduce them. Like at the start of Salome's dance, there's a lot to uncover.

Starting at the beginning

Kodak tape is mighty quiet when it leaves the factory. Because of special milling techniques and our now-famous "R-type" binder, the gamma ferric oxide particles are more uniform in size and shape and more uniformly dispersed than was ever before possible. Result: a superior degree of magnetic randomness, and thus, built-in quietness. To make sure that the roll of Kodak tape you purchase is as "quiet" as possible, we also bulk erase each roll. By "randomizing" the particles' polarity in *all* dimensions, foreign signals picked up during manufacture are eliminated.

This fairly pristine state doesn't last long. Once the tape has been subjected to the erase field and record bias from your recorder, a certain degree of randomness is lost. So-called zero-signal noise results because a recorder's erase system is not as efficient as a bulk eraser. Whereas bulk erasers cause 3-dimensional decay of the remnant signal, an erase head causes decay in one dimension only—along the length of the tape. This explains why zero-signal noise is always higher than bulk-erase noise.

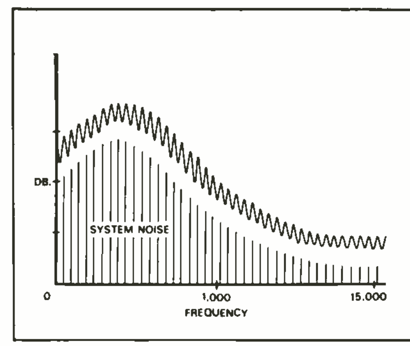
Blue plate special—noisewise

Noise in the presence of a recorded signal—modulation noise—is the real meat and potatoes of tape performance. Testing for modulation noise is a bit tricky, however, because both ac program and noise get mixed up in the amplifier. And if we are to determine the amount of noise in a system, it's imperative that we distinguish between one and the other. One way to do this is to use what our scientists refer to as a dc equivalent in r.m.s. milliamps of an ac signal.

Simply explained, we select the ac signal level that represents the practical limit for linear recording—2% third harmonic distortion. Then we apply a dc signal to the record head and increase the record current until it reaches the same level as that of the above ac signal. On the tape we have recorded a "zero frequency" program plus the modulation noise contributed by both equipment and tape. Since the reproduce amplifier filters out dc signals, only the modulation noise comes through, and this can be measured by an output meter.

Strike up the band pass

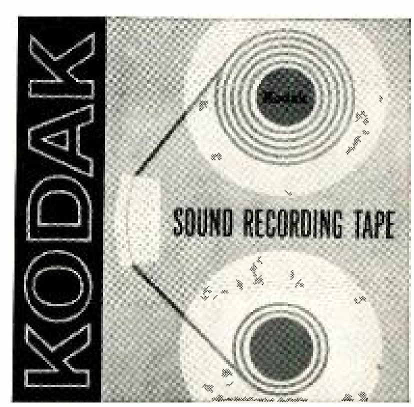
Final proof-of-the-pudding is to examine the total noise spectrum through band pass filters. Fun! One could, for example, measure the noise that comes through a 1-cycle band pass filter—even get a signal-to-noise ratio of about 115 db. But this really tells nothing about the tape's practical performance. For as the graph shows, there is much more noise in the lower frequencies than in the higher. For more meaningful evaluation, we specify two signal-to-noise ratios . . . one for the average low frequencies (20-1000 cycles at 15 ips) and one for the high frequencies (1000-15,000 cycles at 15 ips). We are happy to report that Type 31A (Kodak's general-purpose/low-print tape) rates as much as 6.5 dbs better in the low frequencies and 1.5 dbs better in the high frequencies. At Kodak, "shhh" is the word.



TOTAL NOISE SPECTRUM

KODAK Sound Recording Tapes are available at most electronic, camera, and department stores.

FREE. New, 24-page, comprehensive "Plain Talk" booklet covers all the important aspects of tape performance, and is free on request. Write: Department 8, Eastman Kodak Company, Rochester, N. Y. 14650.



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