Electronics World

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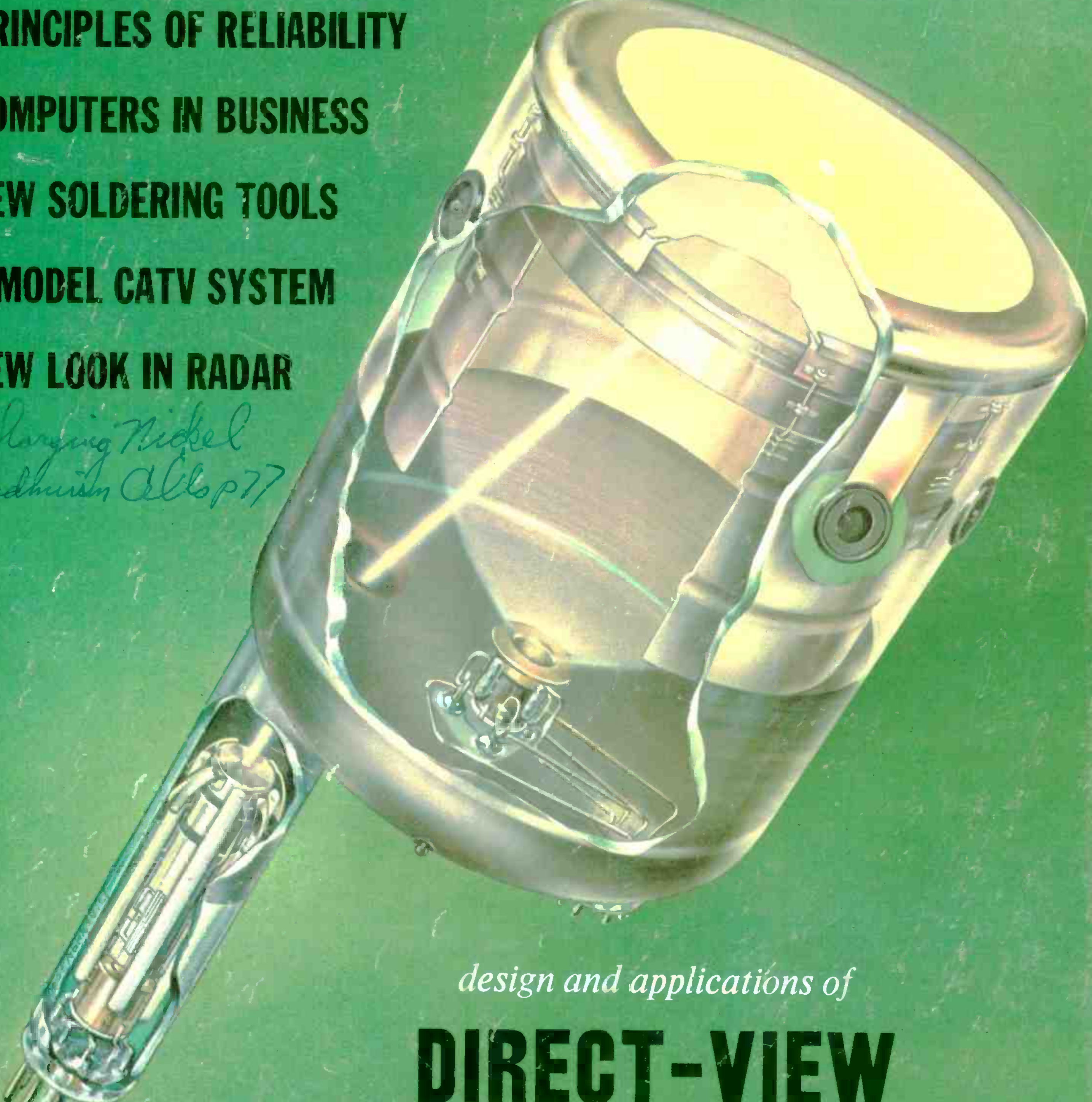
Charging Nickel Cadmium Cells p77



design and applications of

DIRECT-VIEW STORAGE

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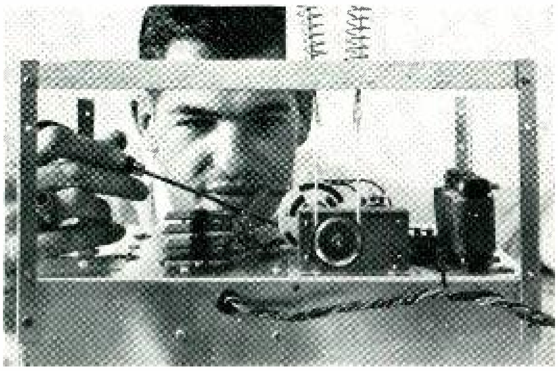

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These Men Trained for Success with NRI—YOU CAN, TOO

"I want to thank NRI for making it all possible," says Robert L. L'Heureux of Needham, Mass., who sought our job consultant's advice in making job applications and is now an Assistant Field Engineer in the DATAmatic Div. of Minneapolis-Honeywell, working on data processing systems.

His own full-time Radio-TV Servicing Shop has brought steadily rising income to Harlin C. Robertson of Oroville, Calif. In addition to employing a full-time technician, two NRI men work for him part-time. He remarks about NRI training, "I think it's tops."

Even before finishing his NRI training, Thomas F. Favaloro, Shelburne, N.Y., obtained a position with Technical Appliance Corp. Now he is foreman in charge of government and communications divisions. He writes, "As far as I am concerned, NRI training is responsible for my whole future."

"I can recommend the NRI course to anyone who has a desire to get ahead," says Gerald L. Roberts, of Champaign, Ill., whose Communications training helped him become an Electronic Technician at the Coordinated Science Laboratory, U. of Illinois, working on Naval research projects.

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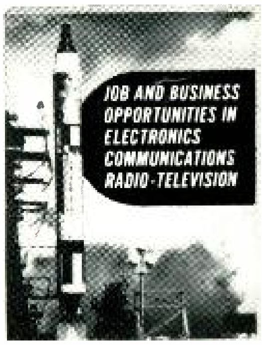

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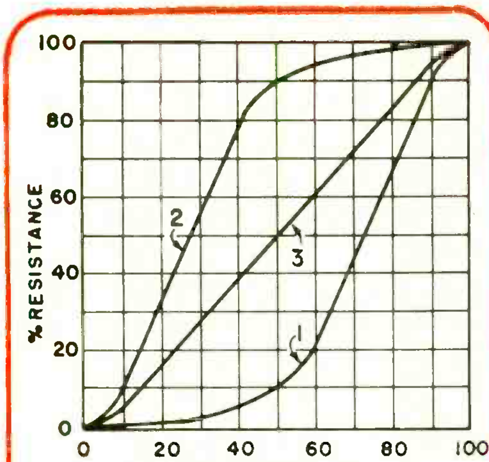
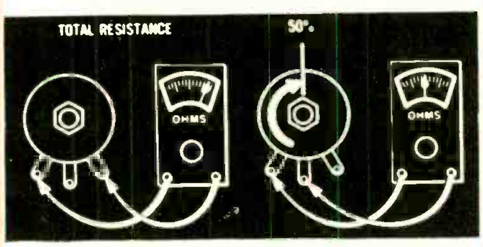
How to choose and use replacement controls



1—Audio taper. 2—Reverse taper. 3—Linear taper.



Using ohmmeter to check control taper


STA-LOC technician kit

There's more to replacing a volume control, "pot", or trimmer than simply selecting the proper value in ohms and watts. Naturally you *need* the proper value, but you also need the correct *taper* or the circuit won't perform properly.

What's taper? Briefly, it's the way resistance changes as you rotate the shaft. There are three basic tapers normally used which match the needs of different kinds of circuits. The chart shows how each of the three works.

Audio taper (often called left hand logarithmic by people who like big words) gives you a small increase in resistance at the beginning of shaft rotation and a faster increase toward the end (clockwise rotation). This matches the response of the human ear and is the reason audio tapers are generally used in volume controls and similar shunt circuits.

Linear taper is just that. Resistance change is exactly proportional to shaft rotation. All standard wire-wound controls have linear tapers. Carbon controls with linear tapers are commonly used in tone controls, sweep controls and other straight voltage-division uses.

Reverse taper (right hand logarithmic) is the opposite of an audio taper. You'll get a big change in resistance in the first half of shaft rotation and very little in the last half. This taper is used with cathode voltage controls such as TV contrast and many bias voltage controls.

In the Mallory STA-LOC® control system, it's easy to remember which taper is which. Linear controls end with "L", and audio with "A", and reverse with "R".

You can check which taper is used in an unknown control by connecting an ohmmeter as shown in the drawing.

First, measure total resistance. Then turn the shaft to 50% of rotation. If resistance is 50% of total, you have a linear taper. If it is 10% to 20% of total you have an audio taper. If it is around 80% of total you have a reverse taper.

To be sure you have the exact control when you need it, ask your Mallory distributor to show you one of the STA-LOC technician kits. With a STA-LOC kit you can make exact on-the-spot replacements of any of literally *thousands* of single, dual, push-pull, tandem, or clutch controls. Pieces snap together and *stay* together. STA-LOC kits are sensibly priced and are real money-makers and time-savers. See your Mallory distributor for everything you need in controls, capacitors, batteries, switches, resistors, and semiconductors.

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Commercial installations have proved that coaxial downlead is *essential* for predictable, consistently good color TV pictures. Coax loss doesn't increase in wet weather, while twinlead loss goes up as much as six times. Coaxial cable can be run anyplace, even next to metal, without mismatch. Coax doesn't deteriorate with age. It won't pick up ignition noises or other interferences. In a word, for satisfactory color reception, even in "ideal" reception areas, your customers need coax.

And now, new Jerrold COLORAXIAL antennas and kits give you a perfect home-installation package for every color-reception need. With COLORAXIAL, you can offer the whole system, from coaxial antenna to indoor matching transformer, or adapt an existing 300-ohm antenna for coax operation. Listed below are all the COLORAXIAL components packaged individually and in kits, for easy, low-cost conversion. Ask your Jerrold distributor for COLORAXIAL brochure, or write *Jerrold Electronics, Distributor Sales Division, Philadelphia, Pa. 19132.*

CAX-16 • COLORAXIAL COLORGUARD

COLORAXIAL Antenna for metropolitan and suburban reception areas. Prematched to 75-ohm coaxial cable; complete with fitting. No outdoor matching transformer required—only an indoor Model T378. List $11.95

K-CAX-16 • COLORAXIAL Antenna Kit. Everything you need for complete installation—a CAX-16 Antenna, antenna tri-mount with 5-ft mast, 50 feet of coax cable with fittings, and T378 indoor matching transformer. List $29.95

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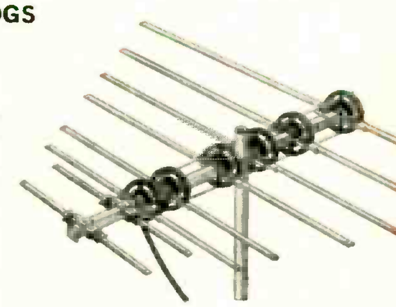
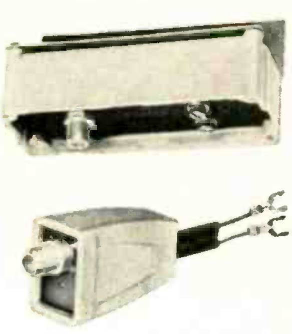
PAX-60 • COLORAXIAL Antenna for suburban to semi-fringe areas. Prematched to 75-ohm coaxial cable; complete with fitting. No outdoor matching transformer required—only an indoor Model T378 needed. List $32.95



CAT-2 • COLORAXIAL MATCHING TRANSFORMER KIT

One TO-374A mast-mounting matching transformer for any 300-ohm antenna, and one T378 set-mounting matching transformer, complete with bracket and mounting strap. List $8.20

COLORAXIAL matching transformers are also available individually: TO-374A, list $4.95; T378, list $3.25



COLORAXIAL CABLE

CAB-50 • 50 feet of sweep-tested RG-59/U 75-ohm coaxial cable complete with F-59A fittings attached, plus weatherboot. List $9.50

CAB-75 • 75 feet of sweep-tested RG-59/U 75-ohm coaxial cable complete with F-59A fittings attached, plus weatherboot. List $11.50

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Electronics World

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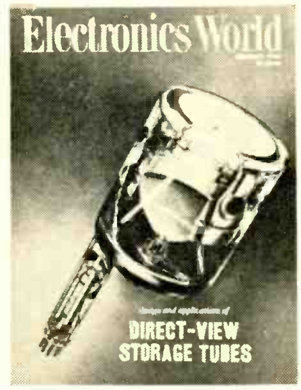
FEBRUARY 1965
VOL. 73, No. 2

MONTHLY FEATURES



THIS MONTH'S COVER shows a cross-section view of a DuMont/Fairchild type K2216 direct-view storage tube, which is currently being employed in airborne radar systems. The tube permits the user to watch the radar display even under conditions of high ambient light. Spot size and beam thickness have been considerably exaggerated by the artist for purposes of improved clarity. For details on the operating principles of this type of display tube and for further applications, refer to the article "Direct-View Storage Tubes" on page 25. ....(Illustration: Otto Markevics.)

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COMING NEXT MONTH

MAGNETIC RECORDING TAPE
Edward Schmidt, vice-president for research and engineering at Reeves Soundcraft Div., discusses magnetic tape applications in computer, audio, instrumentation, and video work. He covers the characteristics of each type of tape and outlines criteria for optimum performance for each of the four categories.

CHOOSING A CCTV CAMERA
Requirements that must be met, rather than manufacturer and/or price, should be the main consideration in selecting a camera. Such features as illumination, resolution, movement, mounting, environment, power, and duty cycle are vital.

THE EVOLVING TRANSISTOR
What are the differences in grown-junction, mesa, epitaxial-planar, and field-effect transistors? Is there any advantage in using one type over another? What determines which is the best transistor for a given circuit? Arthur H. Seidman of Pratt Institute has the answers in this comprehensive article with characteristics table.

"ASTROVISION"
Closed-circuit TV, video tape recording, plus stereo audio tape recording are all included in American Airlines' recently introduced in-flight entertainment system. Two of AA's engineers explain the system's operation.

200-W. SOLID-STATE STEREO AMP
Details on a high-power amplifier, developed by Mattes Electronics, Inc., which provides rated power continuously at less than 0.1% IM distortion. A number of unique circuit features have been incorporated.

SCIENTIFIC COMPUTERS
Beginning where the slide rule leaves off, these computers solve equations, predict performance, and help in the design of various types of equipment. Ed Bukstein explains how these computers operate in this application.

All these and many more interesting and informative articles will be yours in the MARCH issue of ELECTRONICS WORLD . . . ***on sale February 18th.***

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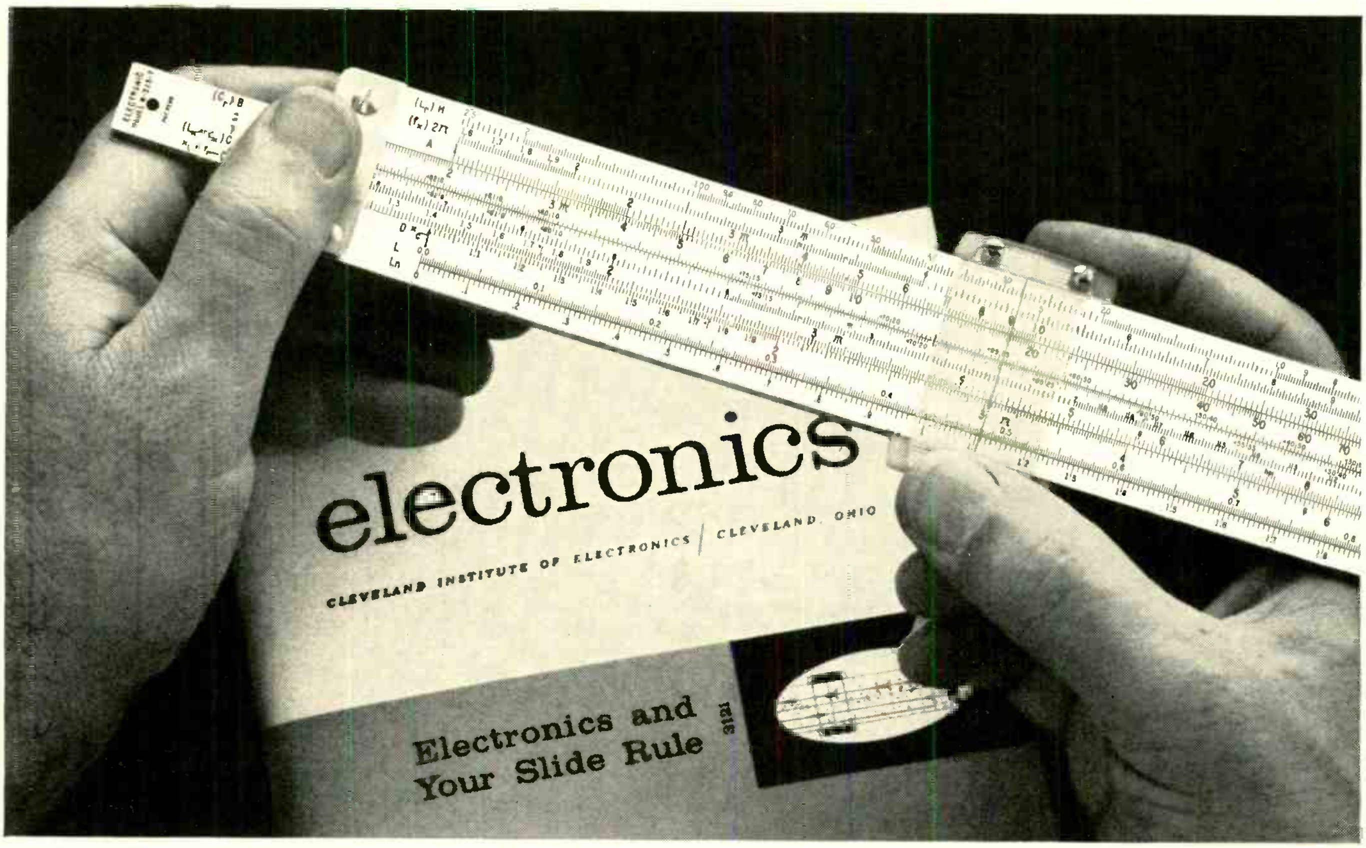

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For the record

WM. A. STOCKLIN, EDITOR

RESEARCH & DEVELOPMENT

WE recently had the opportunity of being a guest at the dedication of *Xerox's* multimillion-dollar research facility in Webster, New York. There were many highlights but, most important in our opinion, was a talk given by Dr. John H. Dessauer, Executive Vice-President, Research & Engineering. We feel his remarks on the philosophy that guides the company's research effort are so important that we would like to quote part of them.

"It is my firm belief that there is no direct relationship between money spent on research and the success of a company. Increased R & D expenditures are not the guarantee of growth that some financiers seem to think. Unless money is directed very skillfully toward carefully chosen and defined targets which can be measured and evaluated, the money can be completely wasted. What counts is not how much you spend, but what you buy with it.

"Our philosophy as it relates to research and engineering is based on three premises.

"First, we believe that invention can be—and often is—the mother of necessity. We don't begin our research by trying to find out what the market is demanding; that is the job of our Market Research people. It has been our experience that, whenever something useful is developed in our field of interest, there will be a market for it.

"Second, we believe in exploring paths that are already somewhat familiar to us—or in following those that open up naturally from the main highway we travel. This, fundamentally, is the technology of image making, particularly xerography. The new phenomena which develop along the way—including our work in such fields as optics and electronics—all result from attending to our own business rather than trying to see profit opportunities in someone else's pasture.

"Third, there is no budget in any of our laboratories for work which doesn't clearly relate to a corporate goal. To this end, we recognize our responsibility to work in careful concurrence with product planning, marketing, and financial people. Research, we feel, can be managed and measured just as effectively as any other division of the company.

"We recognize, of course, that without taking risks, there will be no progress. So we spell out carefully that we will penalize no one who—after careful deliberation and prudent consideration—takes a calculated risk that turns out to be wrong. The crime is sitting on one's chair and failing to act.

"We have divided Research & Engineering into four main laboratories, though in addition we have various planning groups and a new product evaluation activity. In operation, it works as a stepladder.

"Lab I encompasses the area of fundamental research—the closest we come to pure research, which is appropriately called supporting fundamental research. It resembles exploratory university research in the way it is conducted, but differs in that all of the problems examined are related to corporate needs and objectives. A very basic approach to these problems yields publishable research results which will have a significant impact on our technology.

"Lab II is applied research. Here we produce the seeds of practical ideas—and encourage the seeds to flourish. In this area, for instance, we determine whether it is possible to create and erase high-quality images on various materials.

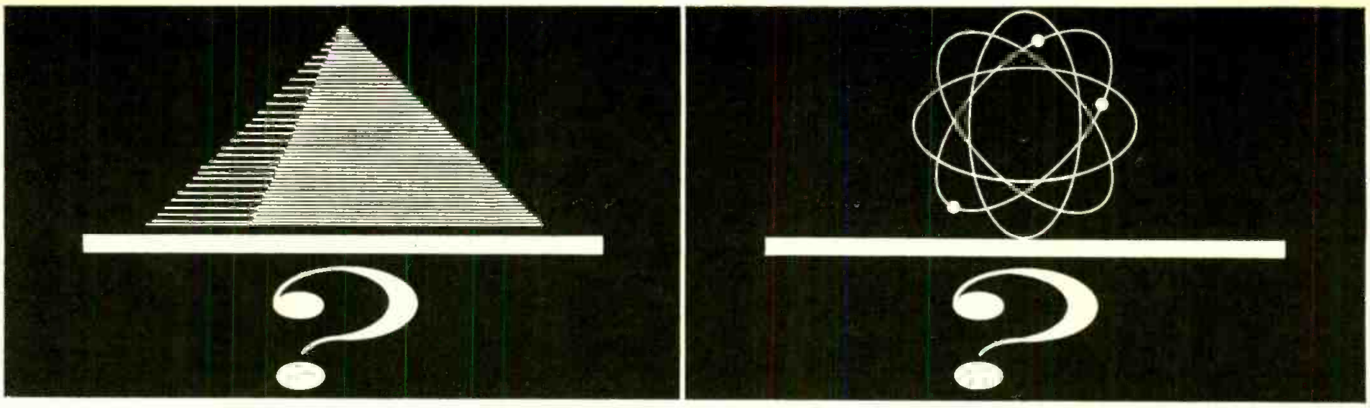
"Lab III is exploratory development engineering. Here we take a concept and carry it through feasibility—or discard it. This is where our new products are conceived.

"Lab IV, which is development and design engineering, is where our products are born and cared for until they reach maturity. Here is where the prototypes of new products are assembled and tested and the specifications made for mass production.

"Now, this is not as compartmentalized as it may seem in this brief description. We have built no walls between one lab and another. If a man in Lab IV needs a specialized skill in Lab I, he is perfectly free to go there and get it. The man in each lab feels as much responsibility for the success of the other labs—and for the company as a whole—as if it were his own assignment."

An interesting sidelight is that an article in one of the early issues of this publication was largely responsible for the birth of the Xerox Corporation. *The article, "Electrophotography" by Nicholas Langer, appeared in the engineering section of our July, 1944 issue. At that time we were called* RADIO NEWS. *The article was a technical analysis of an invention by Chester F. Carlson in which electronic phenomena were substituted for chemical reactions in the reproduction of drawings. When Dr. Dessauer saw the article (reproduced on page 64), he was prompted to get together with the inventor, Mr. Carlson, and with Joseph C. Wilson, President of the* Haloid Co., *forerunner of* Xerox Corporation.

We are extremely proud that our efforts in disseminating such information proved to be of such importance. ▲



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- Nuclear Instrumentation
- Digital Techniques
- TV Servicing
- Color TV Servicing
- Transistors
- Electronics Fundamentals (in English or Spanish)
- Computer Programming
- Drafting

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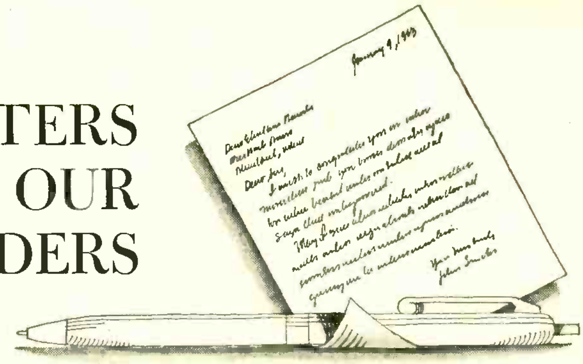


SCR IGNITION SYSTEM

To the Editors:

Your article "SCR Automotive Ignition System" (November, 1964 issue) is just what I have been looking for. However, before proceeding with the ordering of the kit, I would like to have you clear up some discrepancies that may have cropped up in the article.

The ads that I have seen for this kit have indicated a different price than the price quoted in the story. Now, which price is correct?

Also, I have a Volkswagen car which, as you know, employs a 6-volt electrical system. Can I use the SCR ignition system in my car?

JAMES A. CARLSON
Fargo, N. D.

The price given in our article has just recently been reduced by Micro-Kits Co. to $29.95 plus any sales taxes that apply plus postage (for 3 lbs.). In addition, latest catalogues show a price reduction for the SCR used in the circuit to about $6.50.

Although some of our readers have gotten the idea that this system could be used on any automobile, we would like to call Reader Carlson's attention to the Editor's Note that appears at the very end of the story. In summary, the system as described is intended for use only with cars that have the common 12-volt negative-ground electrical system.

Incidentally, we have just learned that some slight changes have been made in a later version of this circuit. These changes involve the use of diode switching rather than transistor switching (Q3) as in the original circuit. Readers who order the kit will receive the later version along with complete construction details. We would like to add, however, that the original circuit as described is perfectly satisfactory. As a matter of fact, one of our editors has had this system in his car for 6 months and has been extremely pleased with its performance.—Editors.

* * *

V.H.F. NOISE FIGURES

To the Editors:

Having received a few squawks from outraged readers myself through the years, I hate to sound one off toward another writer. However, a couple of points in Will Connelly's "Noise Figures of V.H.F. Amateur Converters" in the September issue require additional comment.

First, let me toss the bouquet. This is one of the best articles on noise figure, its meaning, and its measurement that I have yet seen in print. And noise figure has been one of my main specialties for nearly a decade.

Now the small brickbat. I cannot agree with precautions numbered 2 and 8, as they appear on page 35. Nor can I agree with the method of measurement prescribed by W6QID. My objection to precaution number 8 is presented *ad absurdio reductum:* If all stages must be operated in a linear mode, then no superhet's noise figure may be measured, since to obtain mixing action, the stage must be non-linear.

The objection to precaution number 2 is more detailed. *When* the measurement technique shown in Fig. 2 is used, the precaution is valid. However, much more accurate results are obtained by adding a 3-db pad between converter and receiver under test. The initial reading is taken with the pad *out* of the line. The pad is then put in, and the noise generator adjusted for an *identical* output reading.

When this technique is used, any type of output indicator can be used, since we are now comparing rather than using it to measure. Here we have even left a.v.c. on and used the receiver "S" meter with surprisingly good results. Accuracy of the technique is determined by the accuracy of the pad and the lack of leakage around it; this is much less of a problem than that of keeping all stages linear and the output meter in the true-power mode of operation.

JIM KYLE
Oklahoma City, Okla.

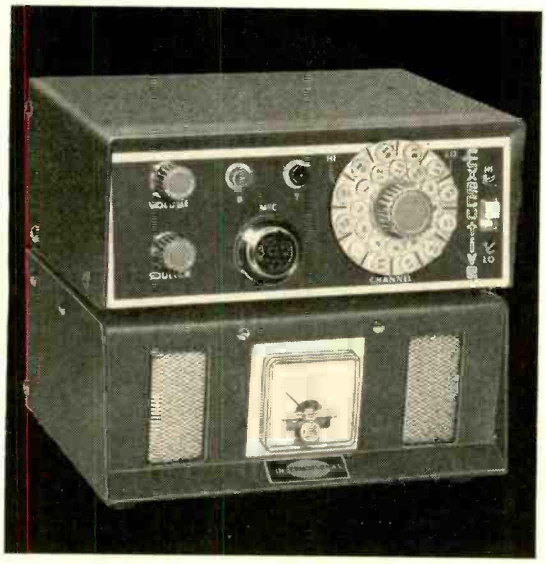
* * *

PIANO TUNING THE ELECTRONIC WAY

To the Editors:

The approach to electronic methods of piano tuning presented in the article entitled "Piano Tuning—The Electronic Way" by Frederick Van Veen in your September, 1964 issue is somewhat different from a method which I myself have developed and used for the same purpose. Your readers may be interested in the latter scheme.

My approach utilizes as specialized



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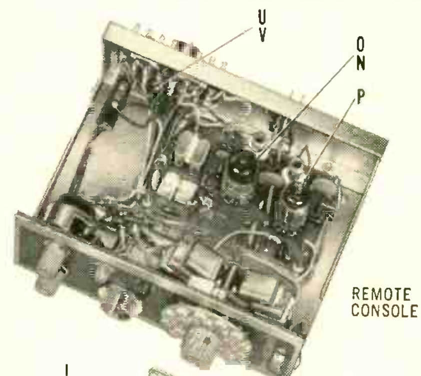

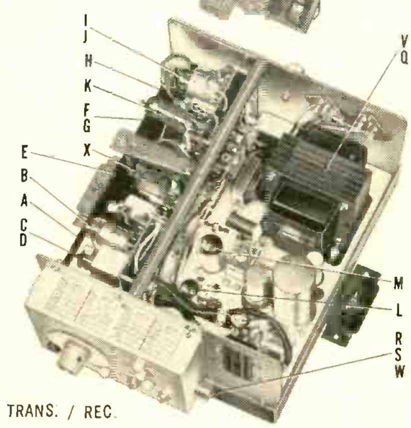

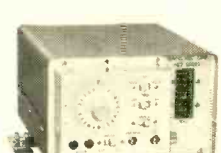

TEST SWITCH POSITION	CHECKS FUNCTION
A	RF Amplifier Cathode
B	1st Converter Screen
C	2nd Converter Screen
D	2nd Rec. Osc. Grid
E	1st IF Amp. Cathode
F	2nd IF Amp. Cathode
G	2nd IF Screen
H	Rec. "S" Meter-Trans. Audio Out
I	1st Audio Plate
J	2nd Audio Cathode
K	Audio P.A. Cathode
L	Buffer Grid
M	Rec. Relay Voltage-Trans. P.A. Bias
N	Trans. Osc. Grid
O	Trans. Adder Grid
P	Channel Osc. Grid
Q	Power Supply B+ Voltage
R	Reflected RF Power
S	RF Power Output
T	Bat. + Volts Neg Gnd.
U	Bat. — Volts Pos Gnd.
V	Fil. Voltage Level
W	Percentage of Mod.
X	Rec. & Trans. Audio Level

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equipment: (1) an octave of thirteen tuning forks, C=261.6 cps to C=523.3 cps, and (2) an electronic drive for the forks.

The audio-frequency signal produced by the tuning-fork drive is used as the horizontal synchronizing frequency for an oscilloscope. There, the fork frequency, or a sub-octave thereof, is compared with the tone of the piano string which is picked up by a microphone and passed through a suitable audio amplifier before being applied to control the vertical deflection of the oscilloscope. If the wave due to the piano string moves to the right, the piano note is below the fork frequency or its sub-octave, while if the wave moves to the left, the note is above the desired frequency.

GLENN H. PALMER
Los Gatos, Calif.

* * *

USING ZENER DIODES

To the Editors:

I would like to comment on Irwin Math's brief article "Using Zener Diodes" (Nov. '64 issue, page 88). The author gives the impression that maximum load current is used to determine power dissipation of the zener diode regulator. This is true only if load current is constant. If there is load current variation, zener current becomes a function of the difference between maximum and minimum load current at any given time. Using the author's figures as an example: $I_{L\,max} = 100$ ma., $I_{zener} = 10\%\ I_{L\,max} = 10$ ma., and $E_{zener} = 10$ v. If load current dropped from $I_{L\,max} = 100$ ma. to $I_{L\,min} = 50$ ma., zener current would increase by 50 ma.; *i.e.*, $I_{zener} = 10$ ma. $+ 50$ ma. $= 60$ ma. Under these conditions, $P_{zener} = E_{OUT} \times I_{zener} = 10 \times .06 = 0.6$ watt. A zener having a one-watt power rating would now be necessary.

The point is this. One must know *maximum* load current to find the correct resistance and wattage values for the zener series resistor R_S, but one must also know the *minimum* load current in order to specify the correct wattage for the zener diode regulator.

RICHARD F. QUICK
Rockaway, N. J.

To the Editors:

The power dissipated by the diode with the 100-ma. load as shown in Fig. 1B of my article is 100 mw. This is only true if the load is constant. Unfortunately, I did not make this point very clear. It would be well to note that in the event that the load is removed altogether, the zener current now becomes approximately 110 ma., and the diode is now dissipating 1.1 watts. Under these conditions a diode with a greater power capability would be required.

IRWIN MATH
Beechhurst, N.Y. ▲

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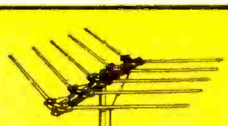

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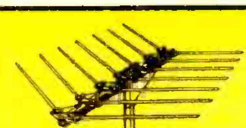

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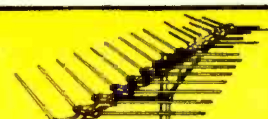

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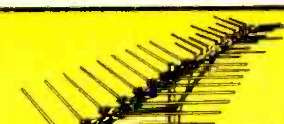

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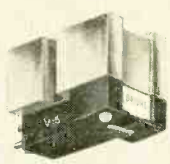
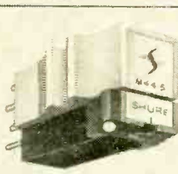
Since then, Shure has developed several models of their Stereo Dynetic cartridges—each designed for optimum performance in specific kinds of systems, each designed for a specific kind of *porte-monnaie*.

We trust this brief recitation of the significant features covering the various members of the Shure cartridge family will help guide you to the best choice for you.

THE CARTRIDGE	ITS FUNCTION, ITS FEATURES . . .	IS YOUR BEST SELECTION
 V-15	The ultimate! 15° tracking and Bi-Radial Elliptical stylus reduces Tracing (pinch effect), IM and Harmonic Distortion to unprecedented lows. Scratch-proof. Extraordinary quality control throughout. Literally handmade and individually tested. In a class by itself for reproducing music from mono as well as stereo discs.	If your tone arm tracks at 1½ grams or less (either with manual or automatic turntable)—and if you want the very best, regardless of price, this is without question *your* cartridge. It is designed for the purist . . . the perfectionist whose entire system *must* be composed of the finest equipment in *every* category. Shure's finest cartridge. $62.50.
 M55E	Designed to give professional performance! Elliptical diamond stylus and new 15° vertical tracking angle provide freedom from distortion. Low Mass. Scratch-proof. Similar to V-15, except that it is made under standard quality control conditions.	If you seek outstanding performance and your tonearm will track at forces of ¾ to 1½ grams, the M55E will satisfy—beautifully. Will actually improve the sound from your high fidelity system! (Unless you're using the V-15, Shure's finest cartridge.) A special value at $35.50.
 M44	A premium quality cartridge at a modest price. 15° tracking angle conforms to the 15° RIAA and EIA proposed standard cutting angle recently adopted by most recording companies. IM and Harmonic distortion are remarkably low . . . cross-talk between channels is negated in critical low and mid-frequency ranges.	If you track between ¾ and 1½ grams, the M44-5 with .0005" stylus represents a best-buy investment. If you track between 1½ and 3 grams, the M44-7 is for you . . . particularly if you have a great number of older records. Both have "scratch-proof" retractile stylus. Either model under $25.00.
 M7/N21D	A top-rated cartridge featuring the highly compliant N21D tubular stylus. Noted for its sweet, "singing" quality throughout the audible spectrum and especially its singular recreation of clean mid-range sounds (where most of the music really "happens".) Budget-priced, too.	For 2 to 2½ gram tracking. Especially fine if your present set-up sounds "muddy." At less than $20.00, it is truly an outstanding buy. (Also, if you own regular M7D, you can upgrade it for higher compliance and lighter tracking by installing an N21D stylus.)
 M99	A unique Stereo-Dynetic cartridge head shell assembly for Garrard and Miracord automatic turntable owners. The cartridge "floats" on counterbalancing springs . . . makes the stylus scratch-proof . . . ends tone arm "bounce."	If floor vibration is a problem. Saves your records. Models for Garrard Laboratory Type "A", AT-6, AT-60 and Model 50 automatic turntables and Miracord Model 10 or 10H turntables. Under $25.00 including head shell, .0007" diamond stylus.
 M3D	A best-seller with extremely musical and transparent sound at rock-bottom price. Tracks at pressures as high as 6 grams, as low as 3 grams. The original famous Shure Dynetic Cartridge.	If cost is the dominant factor. Lowest price of any Shure Stereo Dynetic cartridge (about $16.00) . . . with almost universal application. Can be used with any changer. Very rugged.

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To get more information, promptly, about products and services mentioned in this issue, simply circle the number corresponding to the ad or editorial mention and send the proper coupon to us. Your request will be sent to the manufacturer immediately.

FOR GENERAL USE: In requesting information on products and services listed in the coupon below, you may use your home address.

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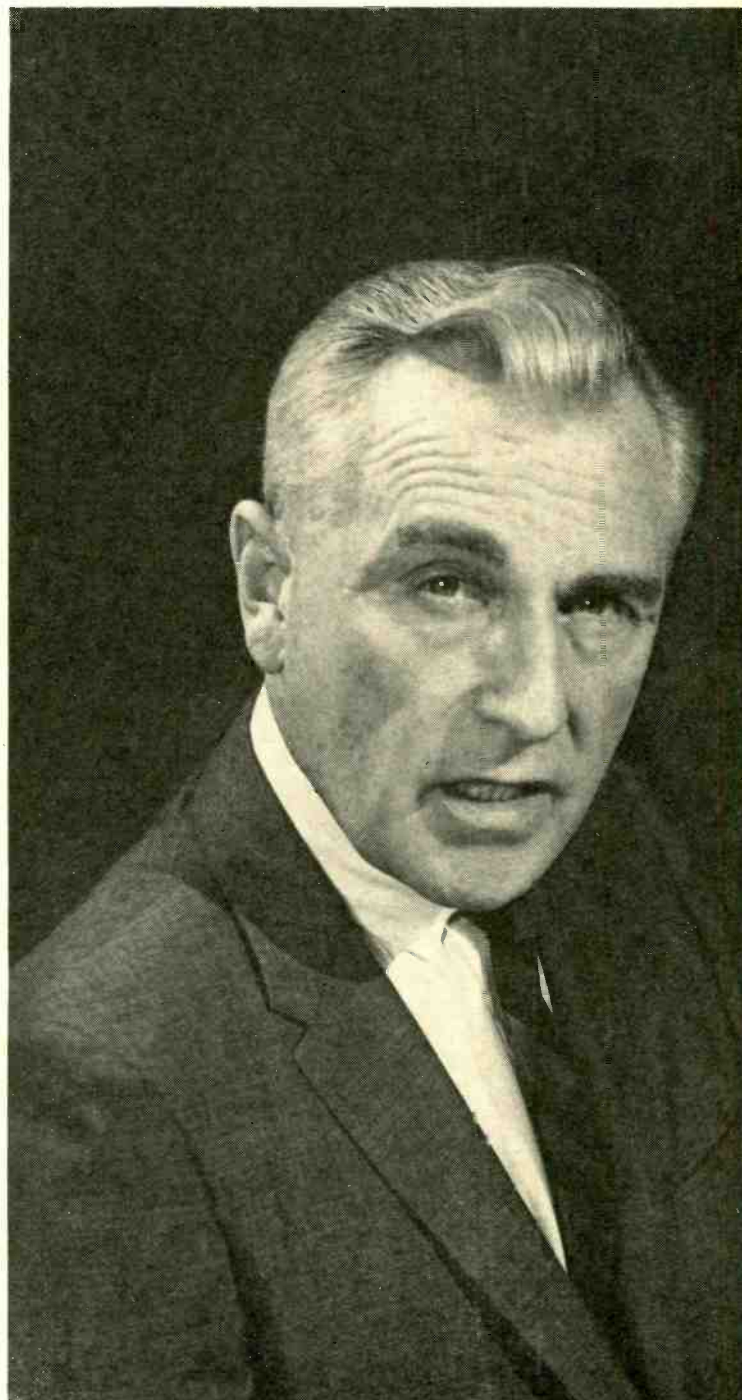

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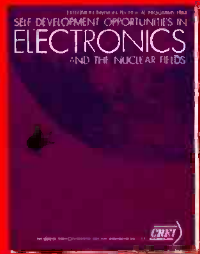

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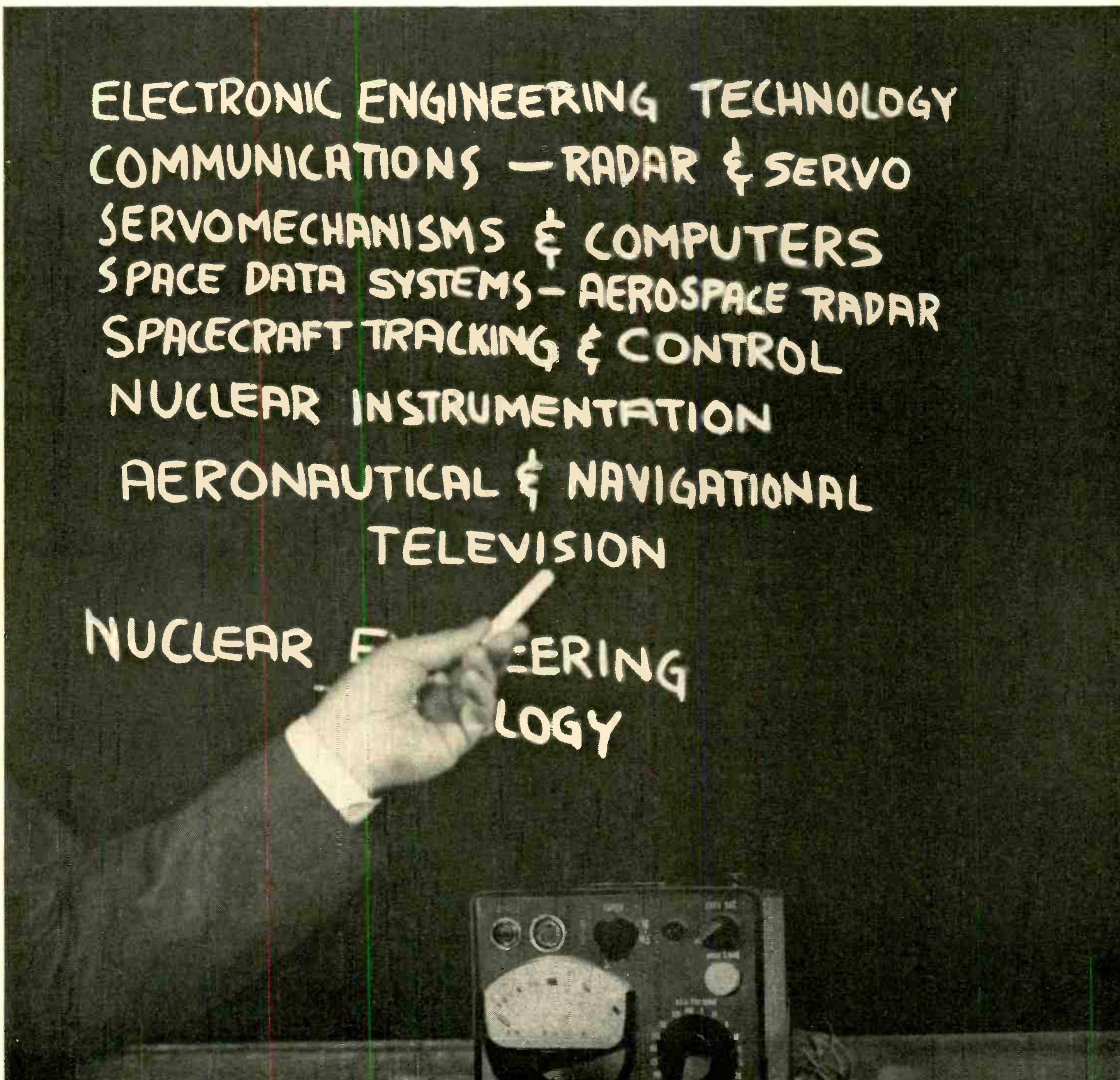
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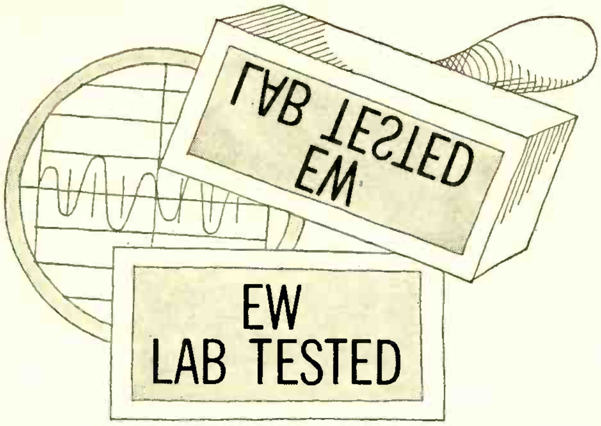
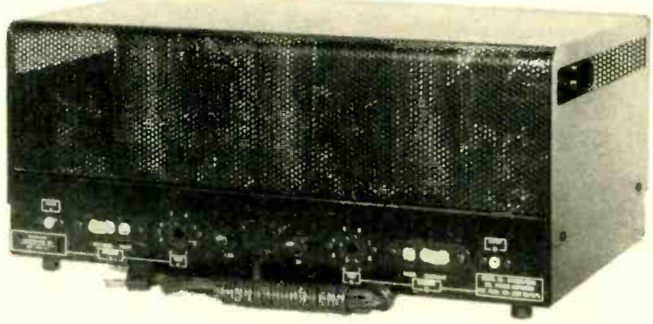


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS
Futterman H-3 Basic Stereo Amplifier

Futterman H-3 Basic Stereo Amplifier
For copy of manufacturer's brochure, circle No. 57 on coupon (page 17).



MANY knowledgeable persons consider that the elimination of the output transformer is a major virtue of transistor amplifiers which may contribute, in a great measure, to their sound quality. Output transformerless (OTL) vacuum-tube amplifiers have also been made, but few have been commercially successful. The new *Futterman* H-3, manufactured by *Harvard Electronics Co.* of New York, N.Y., is a basic vacuum-tube OTL stereo amplifier of unusual design and superior performance.

Unlike most transistor amplifiers, the *Futterman* H-3 uses no driver transformers. In fact, its only iron-cored component is the massive power transformer. Each of its identical channels has a 6EJ7 high-gain pentode amplifier, direct-coupled to a 6SF5 pentode phase splitter. The output stage uses four 6HJ5 beam-power pentodes in a "single-ended push-pull" configuration not unlike that employed in many transistor amplifiers. The speaker terminals are isolated from the output tubes by an 800-μf. capacitor, and heavy over-all negative feedback is employed.

The 6HJ5 is a TV horizontal deflection tube, capable of delivering peak currents of hundreds of milliamperes at very low plate voltage. A group of four tubes provides a low-impedance source, able to drive loads as low as 8 ohms directly. The screens and plates are supplied with regulated voltages, from three separate electronic regulating circuits. Silicon rectifiers are used in plate and bias supplies.

The amplifier has some rather impressive specifications. It is rated at 50 watts steady-state output per channel into 16-ohm loads, with less than 0.2% harmonic or 0.05% IM distortion. Its damping factor is a phenomenal 200. The amplifier is claimed to be unconditionally stable with any type of load, and to have a square-wave rise time of less than 2 μsec., with absolutely no overshoot or ringing.

The H-3 will drive 8-ohm loads with a 50% reduction in power output. The use of 4-ohm loads is not recommended. We tested it with 8-ohm loads, as we do all amplifiers, and spot-checked its performance with 16-ohm loads. Into 8 ohms, it delivered 22 watts per channel at 0.5% distortion, and 24.5 watts at 2% distortion, from 30 to 20,000 cps. The available power fell off less than 20% (1 db) at 20 cps. The frequency response was ±0.2 db from 30 to 20,000 cps, and was down 0.7 db at 20 cps. This was due to the output coupling capacitor, and would be halved if 16-ohm loads were used. The IM distortion was about 0.12% at a few watts output, rising to 0.25% at 30 watts per channel.

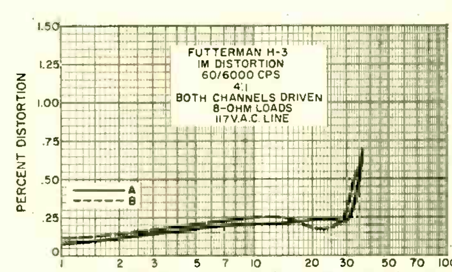
With a 16-ohm load, the amplifier delivered 57 watts per channel at 0.5% distortion, and 62 watts at 2% distortion. As claimed, its distortion was less than 0.2% at 50 watts. The 60-cps square-wave response showed some tilt, due to the output capacitor. A 30-kc. square-wave test confirmed that the rise time was 2 μsec. There was no overshoot or ringing at any time.

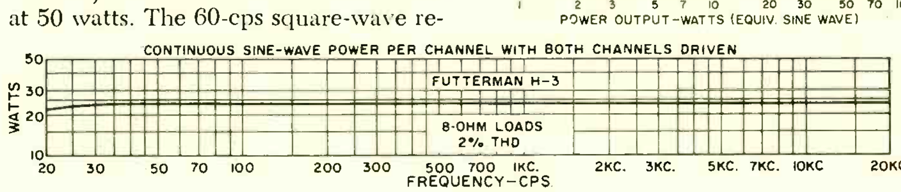
An input signal of 0.6 volt will drive it to 10 watts output. About 1.5 volts is needed to develop the rated 50-watt output. The hum level was about −82 db referred to 10 watts.

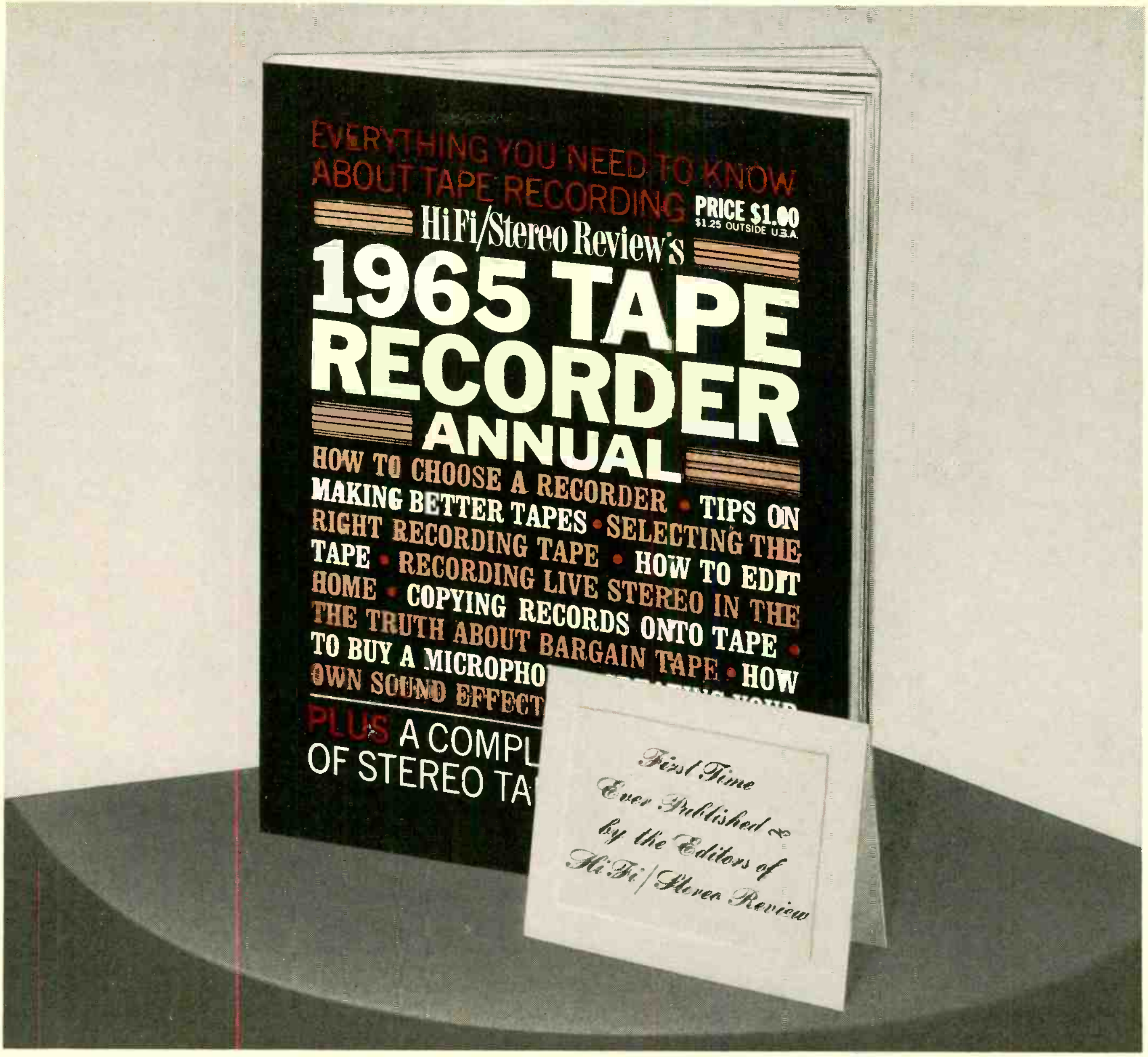
It is obvious that this amplifier meets or exceeds its specifications handily. Its measurements are as nearly perfect as any we have seen. It is perhaps unfortunate that 16-ohm speakers must be used to realize its full potential, but it does a fine job when driving 8-ohm speakers. Like many of the transistorized amplifiers we have tested, this amplifier does not take kindly to sustained full-power operation, blowing its fuses readily when overloaded for more than an instant. However, the output tubes are unharmed by this sort of treatment, which it is unlikely to receive in normal service. The H-3 runs extremely hot and requires thorough ventilation.

It is difficult, and probably meaningless, to attempt to ascribe any sound quality in an amplifier such as this. It is effortless, completely uncolored, and sounds as good as any amplifier we have ever heard. It could hardly be otherwise with the impressive measurement results described above.

The *Futterman* H-3 sells for $288.00, complete with metal protective cover. ▲







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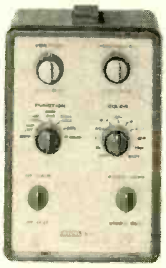

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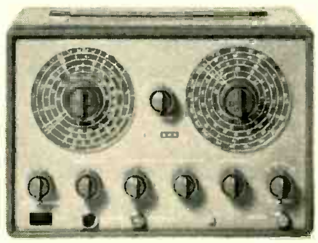

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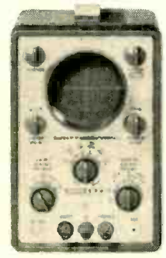

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Design and applications of special types of cathode-ray tubes that permit easy viewing in high ambient light areas.

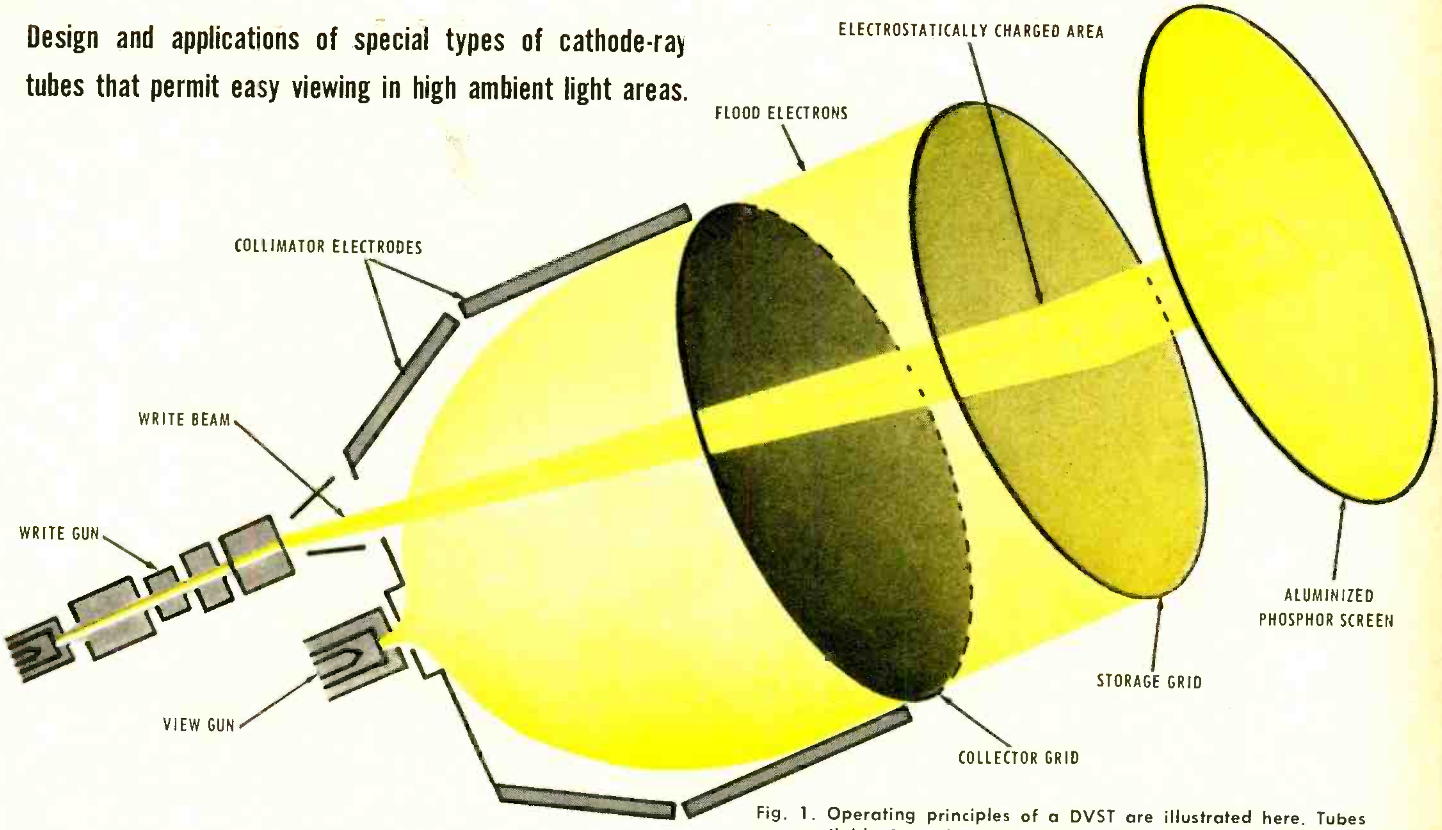


Fig. 1. Operating principles of a DVST are illustrated here. Tubes are available for either electrostatic or electromagnetic deflection.

DIRECT-VIEW STORAGE TUBES

By JOHN B. PEGRAM
Research Engineer, DuMont Laboratories
Div. of Fairchild Camera & Inst. Corp.

DIRECT-view storage tubes (DVST's) are used in military aircraft, oceanographic-research ships, anti-missile systems, and medical instruments. Commercial passenger airlines now employ weather radar that displays conditions for miles ahead on a direct-view storage tube. In many applications direct-view storage tubes are replacing conventional cathode-ray tubes. In the next few years, designers and equipment manufacturers will utilize DVST's even more extensively.

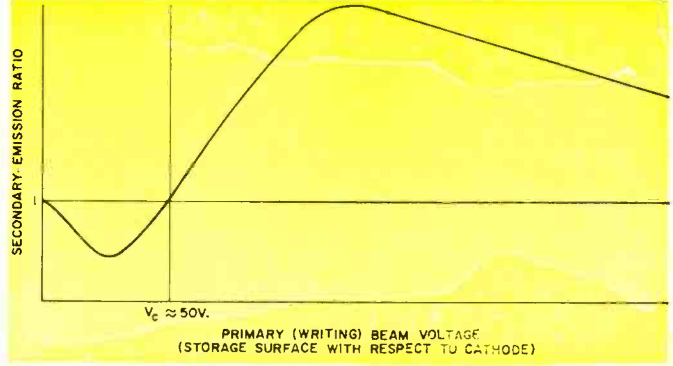
In addition to use in military and commercial ships and planes, DVST's are now being used in military ground systems and will soon appear in consumer and commercial equipment and systems.

Although early designers thought more in terms of projection television, the DVST found its first major application in radar systems, where cathode-ray tube screens had insufficient persistence to give a satisfactory display with slow-scan rates. It was soon discovered that DVST's provide both long controllable periods of display and very high light output, often measured in thousands of foot-lamberts. High light output made DVST's ideal for use in aircraft, where conventional radar cathode-ray tubes required a hood to prevent washout by the sunlight streaming into the cockpit. The few seconds saved by a bright, hoodless radar display are of vital importance in today's sonic and supersonic aircraft.

Secondary-Emission DVST Operation

The most important type of DVST is an electrical-input, visual-output cathode-ray tube which uses secondary emission of electrons to store an image. The major difference between a DVST and an ordinary CRT is the addition of a target and a viewing-gun system to the write gun and phosphor screen of a CRT. The target (storage grid) is a fine mesh screen of up to 250,000 holes per square inch, about ¼-inch away from the phosphor screen. The side of the mesh toward the electron gun is coated with a dielectric material having a high secondary-emission ratio at the voltage of the write-gun electrons (Fig. 2). When the write beam strikes the dielectric storage surface, each electron of the beam removes more than one electron from the surface, leaving a net positive charge

Fig. 2. Typical secondary-emission curve for DVST storage-surface dielectric. At a certain critical voltage (V_c) the number of secondary-emission electrons equals the number of electrons in the primary beam. At higher voltage values there are more secondary electrons emitted than primary ones.



above the cut-off value. A high-transmission mesh (collector grid) at a positive voltage is placed nearby to collect the slow-moving secondary electrons, preventing them from landing again on the storage surface.

The viewing gun of the DVST is usually mounted on the axis, or a ring gun is built concentric with the axis of the tube. It provides a conical "flood" of low-velocity electrons which fills most of the bulb. Metal parts and carbon coating on the glass walls of the tube form large electrostatic lenses which collimate the view electrons toward the target by forcing them to travel parallel to the tube axis (Fig. 1). Pulled forward by the positive voltage on the collector mesh and forced inward by the collimators, each of the electrons reaches the target on a path perpendicular to the mesh. The voltages of the collimators are adjusted in operation for the uniform flood of view electrons over the entire target.

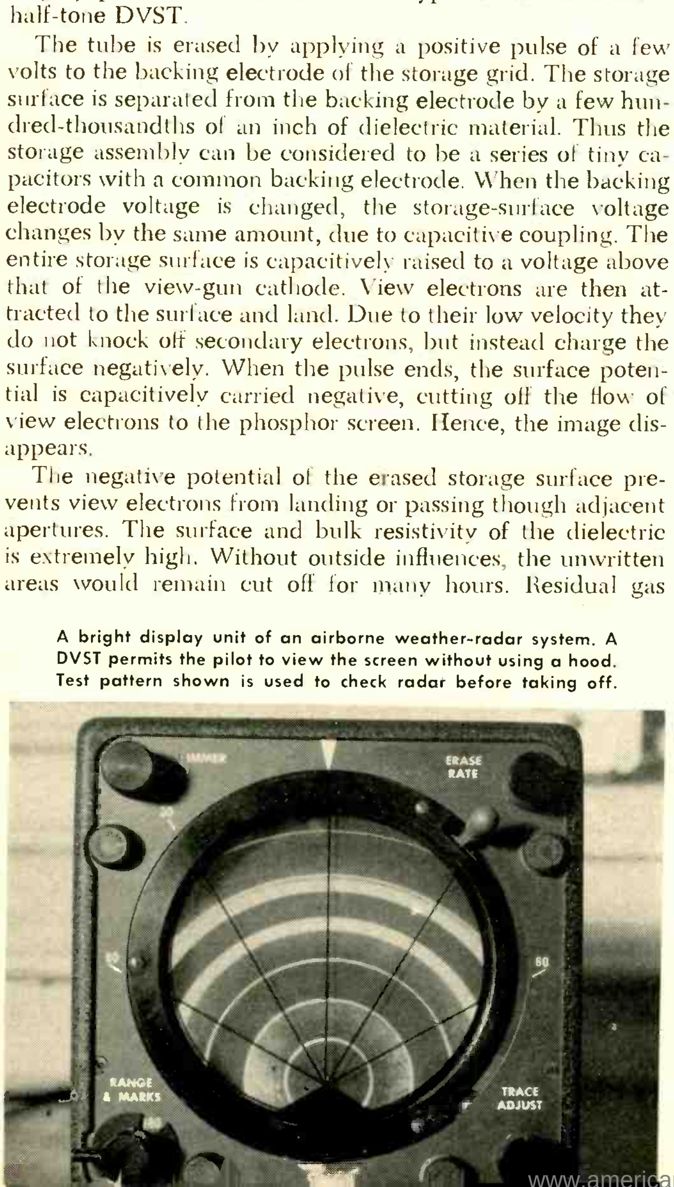
Most of the view electrons then pass through the high-transmission collector mesh and continue toward the storage surface. At points where writing has left a positive charge next to an aperture, the view electrons pass through and are rapidly accelerated to the phosphor by a high voltage. At other points where there is no stored positive charge, the surface of the dielectric is at a lower potential than the view-gun cathode and therefore repels the view electrons. As a result of the action just described, an intense visible pattern appears on the phosphor screen. Note that the pattern is produced by a "flood" of low-velocity electrons rather than by a very rapidly moving beam of high-velocity electrons.

Varying the write-beam current will vary the charge stored on the storage surface; thus the tube can display 4 or 5 shades of grey plus black and white. This type of tube is called a half-tone DVST.

The tube is erased by applying a positive pulse of a few volts to the backing electrode of the storage grid. The storage surface is separated from the backing electrode by a few hundred-thousandths of an inch of dielectric material. Thus the storage assembly can be considered to be a series of tiny capacitors with a common backing electrode. When the backing electrode voltage is changed, the storage-surface voltage changes by the same amount, due to capacitive coupling. The entire storage surface is capacitively raised to a voltage above that of the view-gun cathode. View electrons are then attracted to the surface and land. Due to their low velocity they do not knock off secondary electrons, but instead charge the surface negatively. When the pulse ends, the surface potential is capacitively carried negative, cutting off the flow of view electrons to the phosphor screen. Hence, the image disappears.

The negative potential of the erased storage surface prevents view electrons from landing or passing though adjacent apertures. The surface and bulk resistivity of the dielectric is extremely high. Without outside influences, the unwritten areas would remain cut off for many hours. Residual gas

A bright display unit of an airborne weather-radar system. A DVST permits the pilot to view the screen without using a hood. Test pattern shown is used to check radar before taking off.



molecules in the tube limit this storage time, as the flood of view electrons strikes them, forming positive ions. These ions are attracted to the negatively charged storage surface where they land, gradually charging it in a positive direction. This ion charging causes a decrease in contrast until eventually the maximum brightness of the tube is reached.

Storage time is often defined as the time required for background brightness to increase to a specific percentage (between 20% and 50%) of maximum light output of the particular tube. Storage times for typical tubes range from 15 seconds to 3 minutes.

Most systems using this type of DVST do not use single-pulse erasure, nor do they utilize all of the storage time. These systems use DVST's to achieve a very bright display and controlled persistence. The single erase pulse is divided into a continuous series of pulses at a frequency above the flicker rate which would annoy the viewer. The duty cycle for pulsed erasure is on the order of 1/10 to 1 percent. By varying the duty cycle, the rate of erasure and persistence is controlled. To avoid bright flashes and contrast degradation, caused by the temporary flow of electrons resulting from the positive voltage of the storage surface, the phosphor screen voltage must be reduced to approximately 2000 volts during each erase pulse that is used.

Applications

Half-tone, secondary-emission DVST's have numerous applications. In aircraft they may be used strictly for navigation, location of bombing targets, or in a combined fire-control system which aims the plane directly at the target. In commercial airlines, weather radar is required equipment. The radar unit's ability to display weather conditions enroute not only provides a higher degree of safety, but also permits tighter schedules and improved passenger comfort in flight. Bright display units, such as the one shown in the photo, allow the pilot to check weather up to 180 miles ahead with a single glance at the indicator. Sonar and radar systems are being designed for shipboard use with DVST's to display the returning signals. New anti-missile sites protecting our cities are now using direct-view storage tubes to display the events of missile interceptions in case of enemy attack.

Weather radar and military navigational aids are not the only applications for DVST's. These tubes are being applied to a railroad track inspection device, slow-scan television systems, and various devices for photo-recording of electronic signals.

The slow-scan television systems developed for banks are particularly interesting. Central signature files can be used for numerous branch offices in one such system. A clerk at the control office places a signature card in front of the camera upon request from a branch teller. The camera slowly scans the card, sending the signal to the branch, where it is displayed on a DVST. Only 80 to 100 lines are necessary to provide an accurate picture which the teller may compare with the signature on the check he is about to cash. The low number of lines and slow scanning rate make it possible to use inexpensive phone lines, instead of coaxial cables, to interconnect the bank offices. The slow scanning rate would be impractical without the use of a storage tube.

Bistable DVST's

Two special types of DVST's are related to the half-tone tube already described. They are the *bistable DVST* and the *multimode DVST*. The bistable tube is used for instantaneous oscillographic recording of transients which could otherwise be retained only by photography. The design of this tube takes advantage of the fact that half-tones are not required in an oscilloscope.

The bistable DVST is similar to the half-tone DVST except in three respects. (1) The write gun is designed for oscilloscopes rather than radar-display use; (2) the collector is in contact with the storage surface, and (3) a third mesh electrode is placed between the guns and the target. The collector has an extremely high transmission (80 to 90%), thus leaving most of the apertures and dielectric of the storage surface exposed to the electrons from the write and view guns. When a write beam of sufficient energy strikes the storage surface, the strong field of the adjacent collector causes a local runaway of electrons until the storage surface reaches collector potential. By maintaining the electrodes at the proper potentials, a small amount of energy from a fast-moving beam is sufficient to trigger the bistable action and store the trace. The stored information may be erased by lowering the collector potential. The secondary-emission ratio of the target surface is now less than one, so the flood electrons land, charging the surface to cut off in about 1/10 second.

The third mesh between the electron guns and the collector is operated at a higher voltage than the rest of the target or gun electrodes, thus repelling any positive ions which would otherwise strike the storage surface and degrade the image.

Non-recurring transients may be recorded at speeds up to 1,000,000 inches per second. The ease of visual recording with a bistable DVST makes this type of tube ideal for many measurements in a wide range of studies, from the bottom of the ocean to outer space. A transient may be observed, stored for minutes, and photographed if desired. There is no need to take photographs of every event of possible interest, or keep chart recorders running continuously, when a bistable direct-view storage tube is on duty.

Multimode DVST's

The multimode DVST adds two new elements to direct-view storage tubes—dark-trace writing and non-stored writing. The dielectric used for the storage surface in this tube has the usual secondary-emission characteristics with normal write-beam potentials (approximately 2.5 kv.). If the write-beam potential is approximately 6 kv. however, the dielectric becomes a conductor at the point of electron bombardment. This electron-bombardment-induced conductivity (EBIC) creates a conductive path by which storage surface potential equals that of backing electrode, resulting in a dark trace.

By choosing the proper intermediate write-gun potential, the secondary-emission and EBIC effects may be balanced to accomplish non-stored writing. The EBIC effect is particularly useful for selective erasure of secondary emission written data, and because of increased resolution—approximately double that obtainable with the low write-gun voltage used for secondary-emission writing. To achieve optimum results with the various modes of this tube, two or more write guns are commonly used. This requires the necessary circuitry to compensate for corresponding trace alignment between guns.

A new 11-inch diameter flat-face storage tube. Tubes of this type are ruggedly built for use in mobile ground-radar systems. An integral shield prevents stray fields from affecting operation.

Storage Phosphors

Following World War II there was a great deal of interest in the development of the "dark-trace" tube. German scientists working in this field were brought to this country and almost every major cathode-ray tube manufacturer in the United States had a contract during the 1950's to develop an improved storage tube using a potassium chloride (*KCl*) dark-trace screen. Although not properly described as a phosphor, *KCl* was assigned a phosphor number, P-10, since it was used as a CRT screen material.

When an electron beam or primary x-rays of sufficient energy strike a layer of *KCl* crystals, the crystalline structure is modified and the formerly white crystals darken to a purplish-

Important specifications of various types of direct-view storage tubes discussed in the article.

TYPE	HALF-TONE SECONDARY EMISSION					MULTIMODE	BISTABLE	MESHLESS STORAGE PHOSPHOR	P-10 DARK TRACE
APPLICATION	AIRCRAFT FIRE CONTROL	GROUND RADAR	HIGH BRIGHT-NESS	SLOW SCAN	GROUND RADAR	SELECTIVE ERASURE SLOW SCAN	SCOPE	SCOPE	SCOPE
NOMINAL DIAMETER (INCHES)	5.25	10.5	5	7.5	21	10	5	4 x 6	4.4 x 5.6
USEFUL SCREEN DIAM. (INCHES)	4	8	4	5.7	18	8.5	4	8 x 10 cm.	8 x 12 cm.
VIEWING SCREEN POTENTIAL (KV.)	10	10	8.5	8.5	8	8	3	—	—
MINIMUM BRIGHTNESS (FT. LAMBERTS)	2500	600	4000	600	150	400	40	6	—
RESOLUTION (LINES/IN.)	50	40	25	65	28	55/110*	55	60	60
WRITING SPEED (IN./SEC.)	36,000	200,000	27,000	200	40,000	20,000/50,000*	1,000,000	60,000	50,000
STORAGE TIME (SEC.)	15	180	20	120	120	30/5 to 300*	1 hr.	1 hr.	1 hr.
ERASE TIME (MSEC.)	50	100	20	50	400	300	50 to 150	250	30 to 60 sec.
BRIGHTNESS LEVELS	5	6	4	5	5	—	—	—	—

*write gun/erase gun. Note: The values given are not limits, but are representative of many currently available tubes.

black. When more energy is applied in the form of heat and light, the structure returns to its former appearance.

The advantage of a P-10 display is that it is seen by the difference in reflection of room light from the darkened written areas and the remainder of the screen. Strong incident light cannot "wash-out" a P-10 image as it can a dim picture on a conventional phosphor screen.

However, the P-10 screen has never been particularly successful. A large amount of energy is necessary for writing, making high writing speeds difficult to obtain. Erasure requires even greater energies—perhaps the only successful fast-erasure technique is the use of photoflash bulbs—an expensive and clumsy method. The target mass has been reduced several ways, in attempts to reduce the required erasure energy; but these measures have not been markedly successful and the problems of short life and poor contrast ratio indicate that, until further basic developments are made, P-10 DVST's will find only limited application.

Meshless DVST's

Can a practical meshless storage tube be made? Tube research and development scientists believe it can. A number of methods are now in development and at least one tube is in production.

One method is to form a mixture of phosphor and insulating material for use as the screen. This coating is applied over a transparent conductive coating on the inside of the tube face. Electrons from the write gun leave a positive pattern on the phosphor surface, while the remainder is at a negative potential.

Slow-moving electrons from the view gun are then attracted to the positively charged areas, where they continue to excite the phosphor, while the view electrons are repelled from other areas of the screen.

Another approach to the meshless DVST utilizes a sandwich of electroluminescent phosphor between a thin aluminum coating and an EBIC material on one side, and a transparent conductive coating on the other. The write beam would be used to create electron-bombardment-induced conductivity in the EBIC layer. Current could then flow at that point from the aluminum coating through the EBIC and phosphor layers, exciting the phosphor, and out of the tube through the transparent conductive coating. Conductivity is maintained by photoconductivity, activated by light from the phosphor. Numerous other combinations of phosphors, insulators, bombardment-induced conductivity, and photoconductive materials can be imagined, which might lead to an ideal meshless DVST.

The advantage of the meshless DVST is great, the disadvantages—sometimes serious. The big advantage is greatly reduced cost. The elimination of expensive electroformed mesh, and the extensive target assembly operations make the meshless DVST far less expensive than mesh types. Of course, screen-coating operations will become more involved, but when a phosphor screen is damaged, one need merely wash the glass and start over (with materials worth perhaps 50 cents). When a fine mesh receives the slightest dent, tear, or hole, $20 or more goes down the drain.

The meshless DVST does not require the large accelerating voltage between target and screen, which all mesh types have. Since the operations of the target are incorporated in the screen of a meshless tube, the excitation of the phosphor must be entirely from the low velocity of the view electrons, without the additional energy of the screen-to-target potential as in a conventional DVST. For this reason, present meshless DVST's have a light output of only 2 to 6 foot-lamberts rather than 50 to 5000 foot-lamberts. Effects of the room lighting conditions must be seriously considered when employing a storage tube of this particular type.

Tubes like the KS2455 (left) may replace the present design (right) in airborne radar systems. The newer tube has better resolution and is shorter than the tube that it replaces.

DVST's in the Near Future

What does the future hold for direct-view storage tubes? Events in the past three years may point the way. Quantity prices of several types of half-tone storage tubes have been cut in half. Manufacturers' lines have increased, so that several now have at least a dozen standard catalogue items, along with many special tubes.

Electrical and environmental performance have improved substantially. For example, one tube type must operate after 15-G shock and 5-G vibration tests. In fact, this tube must operate satisfactorily in a vibration test with its face down—a condition which could shake any tiny loose particles down into the target, blocking a hole in the mesh and causing a blemish. It was also during the past three years that meshless and multimode DVST's were introduced.

In the next few years we may expect to see DVST's in many more commercial applications. Meshless storage tubes will open up new areas in which mesh types have proved too expensive. Slow-scan television displays with this tube could be very useful in all types of business. With increasing hazards created by growing traffic, private and company boats and aircraft will increasingly use radar systems with DVST bright display units.

Integral packages will receive more attention from equipment designers. Already, a majority of military storage-tube applications use a DVST sealed into its own magnetic shield. Soon the deflection yoke, for magnetic tube types, and a divider network matched to each tube to provide the proper operating voltage to the various elements, will be supplied as a portion of a direct-view storage-tube package.

Further Improvements

Smaller tubes with the same display area and improved resolution are two areas of current development. An 11-inch diameter tube is now being built, with increased resolution and display area over the 10-inch tube currently used. This fact is not startling, but several improvements in practical electron optics were necessary to build a larger and better display tube to fit into the same length shield and same equipment as its predecessor. A 5-inch diameter DVST with a 4-inch long body may soon replace a tube with a 6-inch long body in new equipment. Here, again, the tube has been improved in display area per unit volume and resolution.

Where current models of 5-inch diameter DVST's feature resolution on the order of 50 lines per inch, 100 lines per inch at 1000 foot-lamberts will regularly appear in military and commercial specifications within the next two years. This improvement, made by optimizing present designs, will place DVST's in the same performance range as many commonly used CRT's. Advanced development of new storage-tube techniques may lead to still better performance in the future. ▲

THE DECIBEL WHEEL

By JIM KYLE

Circular slide-rule technique for reading decibel values of voltage, current, and power directly.

DESPITE the simplicity of the relationship between decibels and power or voltage/current ratios, many persons still seem to have trouble making rapid conversions from ratios to db and *vice versa*.

As a result, any number of tables, charts, and short-cut techniques have been published through the years. All, however, have at least one of two major disadvantages. They are either cumbersome or not fully accurate. For accuracy to 0.1 db or better, detailed tables are required, which in turn are somewhat cumbersome in use. The short-cut techniques yield results which are usually only approximately correct.

The decibel wheel, however, overcomes both of these disadvantages. It is of convenient size, yet is accurate to 0.05 db or better when dealing with power ratios, and to 0.1 db or better with voltage and current ratio conversions.

To use the wheel, either clip or photocopy this page and affix it to firm cardboard, lightweight aluminum, or 1/32" phenolic. White casein waterproof glue is excellent for the purpose. Allow it to dry under pressure, after smoothing out all bumps and wrinkles.

When dry, cut around the heavy lines. Drill or punch the center hole indicated in each disc. The size hole will depend upon the fastener to be used. Cloth eyelets, sold at most sewing counters, are ideal fasteners. They require a 3/16" hole. Machine screws with washers and a lock nut can also be used, but will be bulkier. The old-fashioned brass paper fastener is not recommended. Fasten the two discs together and the wheel is complete.

The outer scale, marked "Ratio," is used for both voltage/current and power-ratio calculations. The 0-9 calibration of the inner scale indicates db for power-ratio calculations, while the 0-19 calibration is used for voltage and current-ratio conversions.

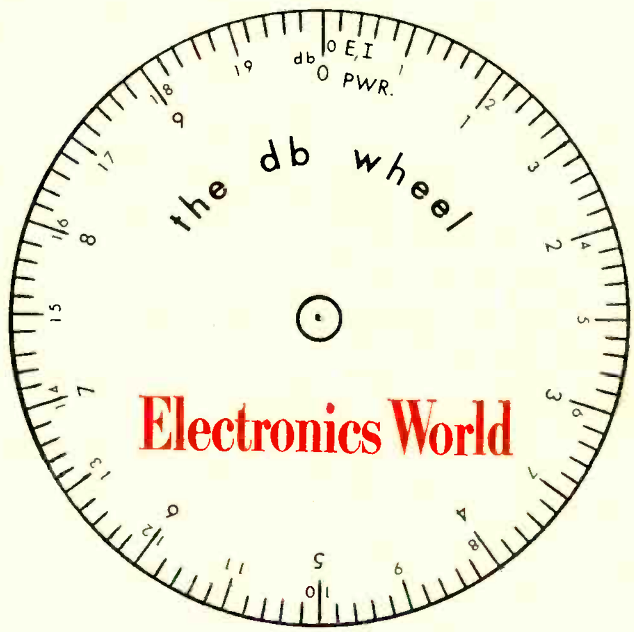
To convert db to a ratio or *vice versa*, set 0 of the inner scale opposite 1 of the outer scale, and read the ratio opposite the desired number of db (being sure to use the proper db scale, depending on whether the ratio is power or voltage/current).

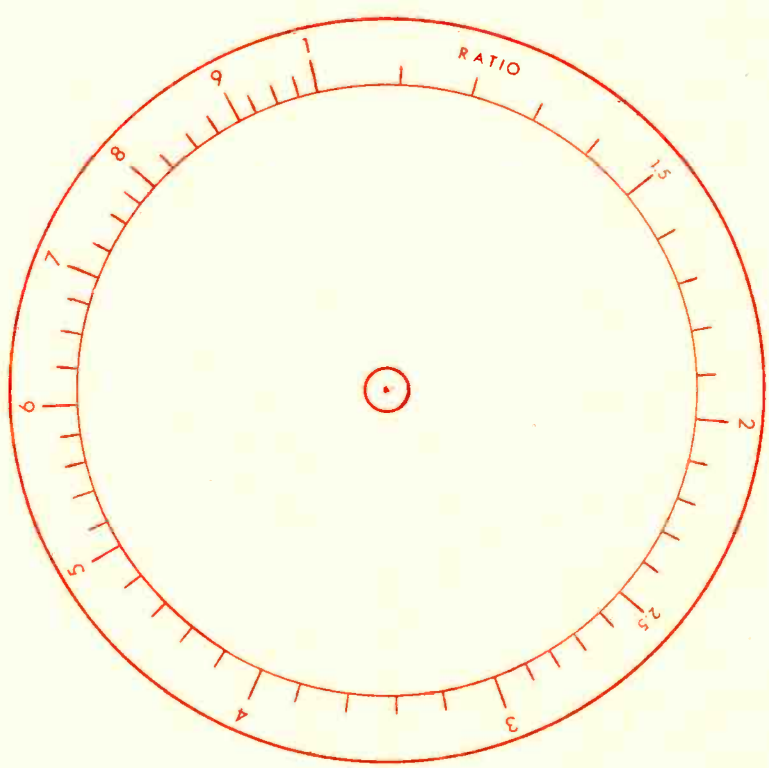
To find the voltage relative to a reference voltage corresponding to a definite number of db, set 0 db opposite the reference voltage (on the "Ratio" scale) and read the unknown voltage opposite the number of db. This procedure can be reversed for making db measurements.

For example, assume the response of an amplifier is being tested, and the reference output level happens to be 2.4 v. Setting 0 db opposite 2.4 volts, we proceed with the measurement. The next reading may be 3 volts which the wheel reveals is +2 db. A reading of 2.2 volts is −0.75 db. (Note that the scales are calibrated in db of gain only; to read db loss, count calibrations backward from 0.)

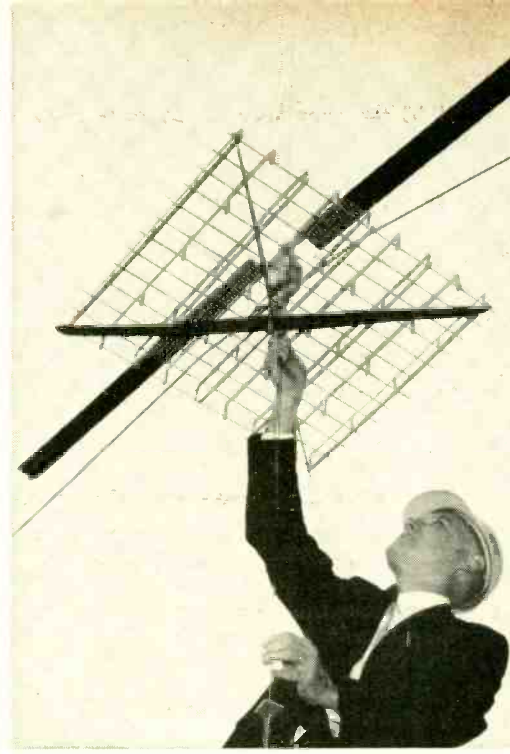
To determine effective radiated power of a transmitter upon change of an antenna, the wheel may be used. Set the 0-db mark of the inner scale opposite the transmitter output power on the outer scale, and read e.r.p. (in the most favored direction) on the outer scale opposite antenna gain in db on the inner scale, using the power calibration.

For instance, a CB transmitter having an r.f. output power of 3.5 watts is to be connected to a beam antenna with 9.1 db gain. What is the e.r.p.? Setting 0 db opposite 3.5 (interpolating between the 3.4 and 3.6 calibrations) on the outer scale, a reading of 2.84 is found on the outer scale opposite 9.1 db power. Since the reading required that the "1" ratio be passed, the actual e.r.p. is 10 times this, or 28.4 watts. ▲

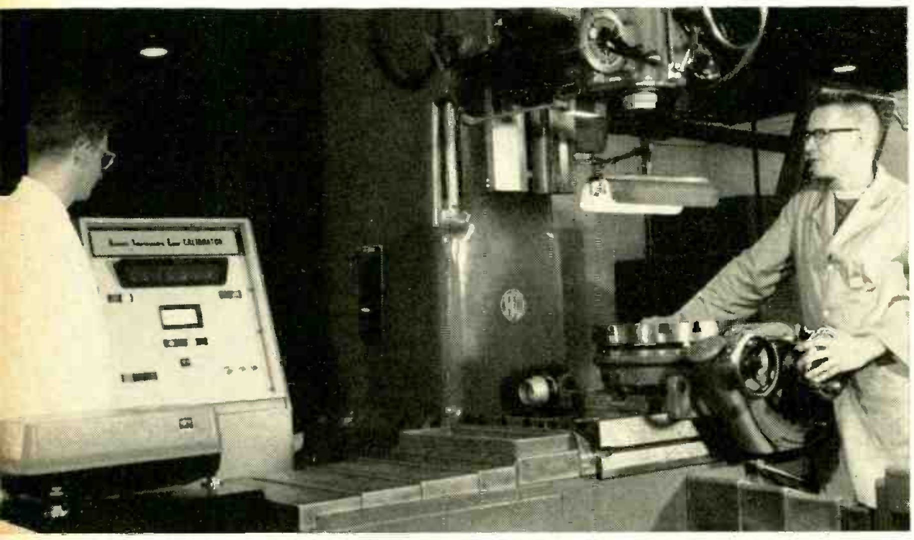




RECENT DEVELOPMENTS in ELECTRONICS

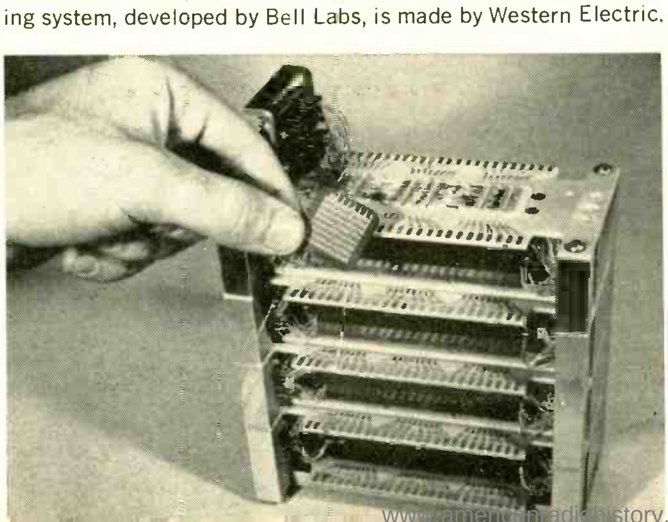


Microwave-Powered Helicopter. (Above) In a demonstration for the Air Force, Raytheon scientists beamed microwave power at an array of diodes beneath the 6-foot rotor of the small helicopter shown. The diodes converted the microwave energy into d.c. power which operated the rotor motor. The helicopter rose 50 feet above the ground in its flight. The company is conducting a development program on the feasibility of this method of power transmission for hovering aircraft or platforms.

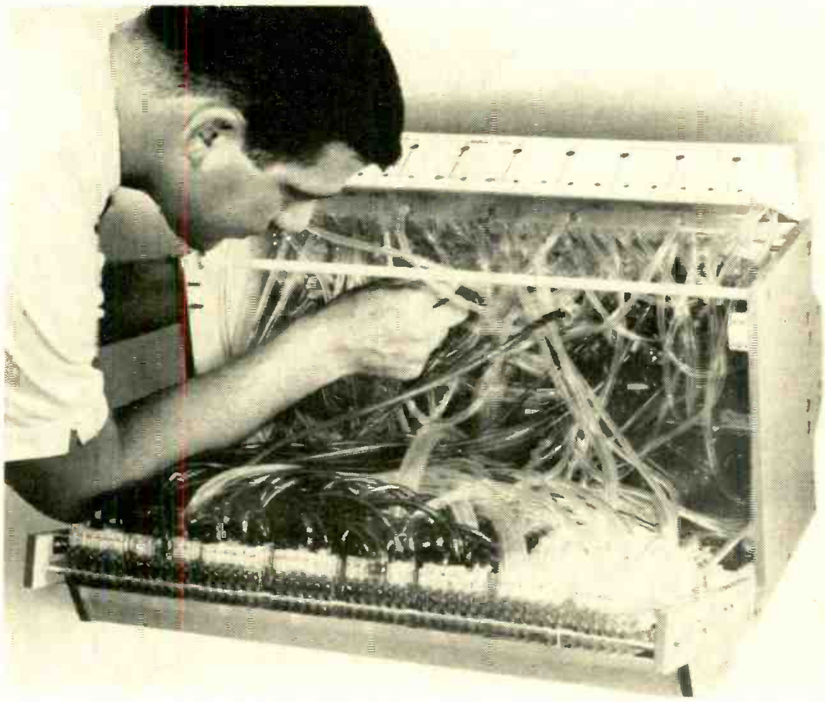


Laser Calibrator. (Above) Mounted on a precision jig borer, a new laser interferometric calibrator is shown performing measurements with accuracies previously unheard of in machine-shop environment. It is particularly suited for calibration and checkout of numerically controlled machine tools and measuring machines. Measurements up to 100 inches with accuracies to within 10 millionths of an inch are possible. The calibrator, produced by Airborne Instruments Laboratory, consists of a sensor, light reflector, and electronics cabinet. The sensor (laser, optics, photoelectric detector) is on the fixed portion of the machine. The reflector is on the moving portion. The cabinet houses a computer and readout and operator controls.

Telephone Switcher Memory. (Below) This one-inch square ferrite sheet, perforated with 256 tiny holes, is part of the temporary memory unit used in a new telephone electronic switching system. The ferrite around each hole acts as a "core" and stores one bit of information. Three wires threaded through the holes and a conductor plated onto the sheet are used to write information into and read out of the memory. Sheets are stacked in a module and four modules make up a "call-store" assembly which holds almost 200,000 bits of erasable information. The switching system, developed by Bell Labs, is made by Western Electric.

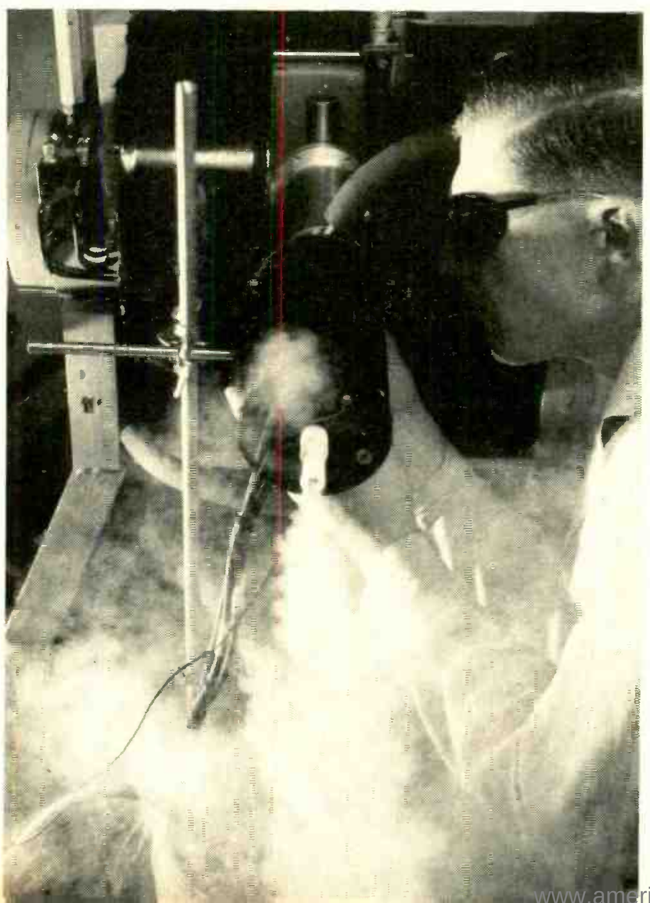


Semiconductor Plastic Film. (Above) A new plastic film, irradiated polyolefin, with a resistivity of 10,000 ohms/sq. in., is expected to find uses in the manufacture of electronic and electrical products. This film, developed by G-E, conducts electricity as shown by the lighted lamp at the right. It also retains its form stability at temperatures up to 325 degrees C and can be self-sealed when tightly wrapped on itself and heated to about 200 degrees C. The film has already been employed as a corona-shielding layer in special, high-voltage cables that will carry 125,000 to 150,000 volts.



Air-Operated Computer. (Left) Plastic tubing is being attached to one of the switching elements in the Univac fluid computer shown here. This experimental, general-purpose digital computer operates entirely by air flowing through plastic channels and elements. It has no moving mechanical parts. The experimental system has four instructions and four words of memory, each word being four bits long. Fluid systems cannot compete with electronic computers because of their relatively slow operating speeds. However, such computers should have a lower failure rate than their more complex electronic counterparts. Also, fluid circuits should be able to withstand the rigors of environments in which electronic equipment cannot operate. A fluid computer can be constructed to be extremely rugged, and it is immune to the effects of radiation and electromagnetic interference.

Magnetic Field Controlled Laser. (Below) A new way to control the intensity of a ruby laser beam at extremely high frequencies—by applying a magnetic field—has been developed at the Honeywell Research Center. A research technician, partially obscured by nitrogen vapor cooling the laboratory apparatus, aligns light source before firing a light burst at a resonance absorber (silver cylinder) where the magnetic field can change the beam's intensity. This technique is one of several that are being worked on in laboratories throughout the world to develop an effective modulation system for the laser. Such a system is needed before lasers can be used for communications.



Man-Machine Communication. (Above) Experiments in the communication of automotive design information between man and computer are being conducted at the General Motors Research Laboratories. Here at the graphic console of the device being used, a research engineer checks out a computer program that allows him to modify a design "drawing." A touch of the electric "pencil" to the tube face signals the computer to begin an assigned task. In this case, a line deletion is to be made where indicated. The man may also instruct the computer using the keyboard at the right, the card reader below the keyboard, or the program-control buttons below the screen. Hundreds of special computer programs will be needed to carry out these studies.

NEW LOOK IN RADAR

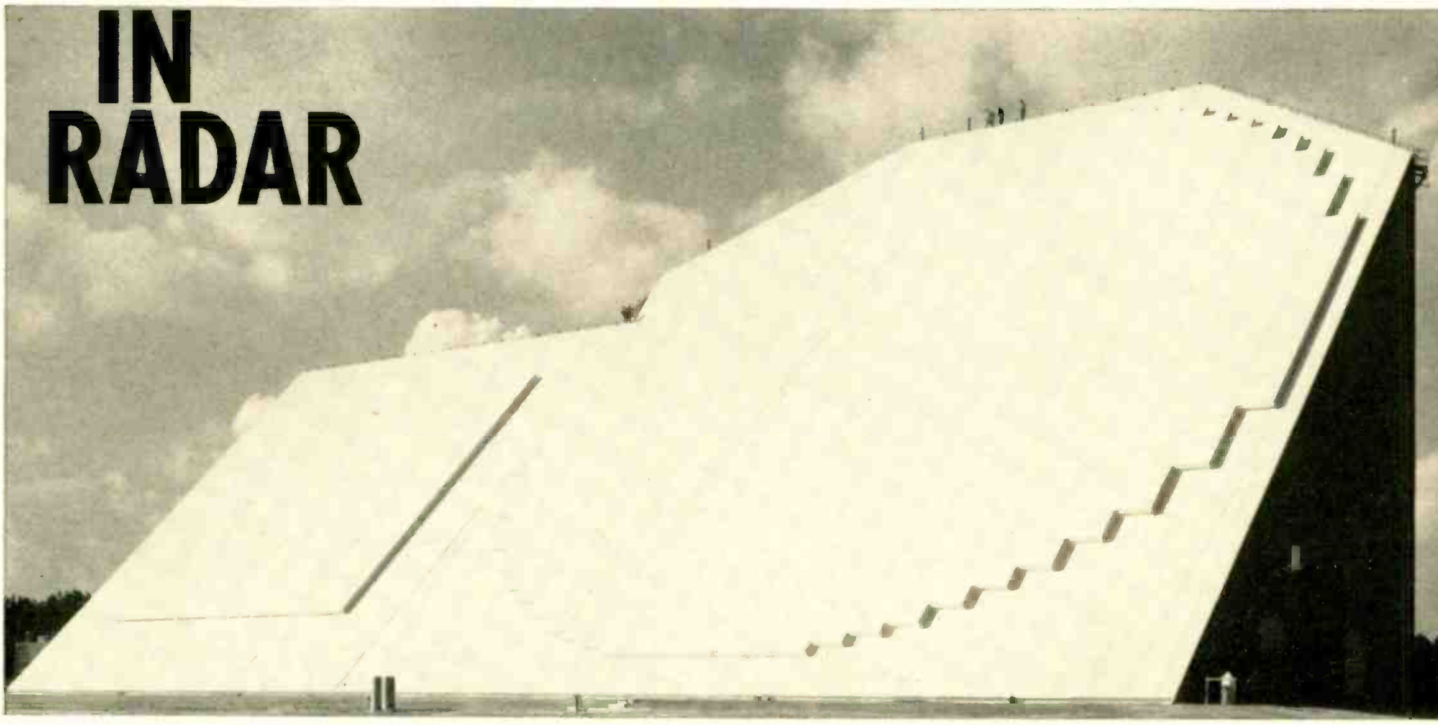


Fig. 1. The newest and largest of the phased-array radars. The array is 327 feet long, 145 feet high, and 145 feet wide.

ALMOST everyone can recognize a conventional radar installation. However, a new generation of radars is coming of age and from their outward appearance few will recognize them as such. These new sets are phased-array radars, generally known as electronically steerable array radars (ESAR)), and they are introducing a new look in both a physical and electronic sense.

Although the phased-array radars may eventually take over many of the functions performed by existing equipment, this is not their present mission. Their immediate and primary function will be to search for, track, catalogue, and store in computer memories information on satellites, missiles, or other space objects. The number of such objects, known and unknown, friendly and otherwise, that are circling the earth is rapidly increasing and it is important that we keep our files on these objects complete and up-to-date. As will be seen, this function cannot be easily performed by our existing conventional radars.

In a physical sense there is nothing about the appearance of an ESAR to tie it to the commonly accepted picture of a radar installation. Gone are the radomes, gone are the pedestals and towers with their reflectors of various sizes and shapes whose rotating, nodding, and oscillating motions serve to mark an active radar site. Neither does an ESAR resemble the huge fence-like structure whose multiple horns mark the site of early warning systems of the BMEWS types.

Instead, at a phased-array site you will find a single windowless building, five or more stories high and perhaps over 300 feet long, an odd building to be sure, with one wall tilted at an angle so as to face the sky. The only indications of any electronic activity may be a few communications antennas mounted atop the building. Yes, physically, the ESAR's have brought a new look to radars.

Examples of this new generation of radars, the electronically steerable array radars, are shown in Figs. 1 and 2. Fig. 2 is the AN/FPS-46 (XW-1) ESAR built by the *Bendix Radio Division* of the *Bendix Corporation* for the Advanced Research Projects Agency of the Department of Defense. The AN/FPS-46 (XW-1) was one of the first full-scale models of a phased-array radar to be built and one that provides the capabilities of this new type of set.

Fig. 1 shows the newest and largest of the phased-array radars, the AN/FPS-85 Space Track. This set is being built for the Air Force by the *Bendix Radio Division* of the *Bendix Corporation* at Eglin Air Force Base in Florida. The approximate over-all dimensions of the AN/FPS-85 are 327 feet long by 145 feet high by 145 feet wide. Both of these particular systems were constructed under the direction of the Rome Air Development Center, Air Force Systems Command.

Basic Concepts

In the electronic sense, the new look is even more impressive than the physical new look. Basically the concept of phased arrays is not new. In fact, the first radio broadcast station that directed its programs in a selected direction by using two antennas driven by signals of different phase, made use

A new type of radar, with an electronically steerable antenna array, is being used to search for, track, catalogue, and store in computer memories information on satellites, missiles, and other objects in space.

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Senior Engineer, Bendix Radio Div.
Bendix Corporation

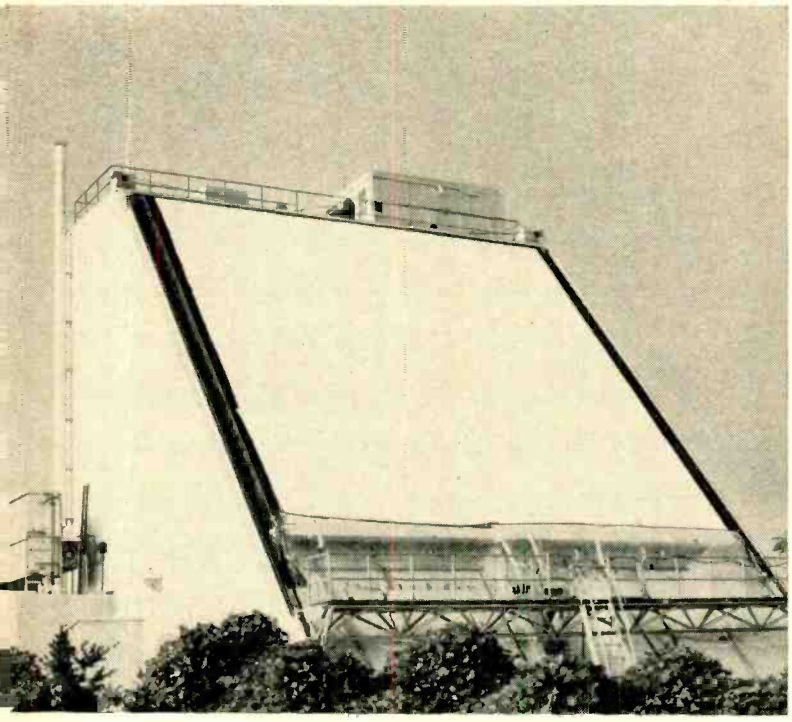


Fig. 2. One of the first full-scale models of a phased-array radar.

of a phased array, elemental to be sure, but still a phased array.

A linear antenna array using more than two antennas is shown in Fig. 3. The elements of a phased array may be directly driven as shown or parasitically driven. Multi-element arrays are widely used by radio amateurs, for TV transmission and reception, by some broadcasting stations, by long-distance commercial communications systems, and many others. This type of phased array, in general, uses manual phase adjustments; however, in some cases a series of manually tuned adjustments selected by relay circuits may be used to obtain a limited degree of flexibility.

Figs. 4, 5, and 6 illustrate in a simple manner one way in which the modern phased array may be developed. Fig. 4 shows nine antennas and three phasers connected to make three identical *columns*, each column being a linear array similar to Fig. 3. In the same manner, Fig. 5 shows nine antennas and three phasers connected to make three identical *rows*, each row being a linear array similar to Fig. 3.

Fig. 6 is a two-dimensional phased array obtained by superimposing Figs. 4 and 5. Notice particularly that the row and column driving signals are combined by mixing (crossed circles) before feeding the antennas. Fig. 6 shows:

1. The phase relationship between *antennas* in any given *column* is the same as for the *antennas* in the *columns* of Fig. 4. However, whereas the phase relationship between *columns* in Fig. 4 is zero (assuming no phase shifts in the connecting lines), the phase relationship between *columns* in Fig. 6 is

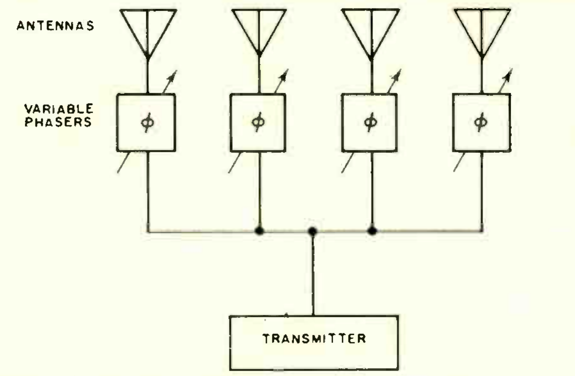


Fig. 3. An elementary linear antenna array with 4 elements.

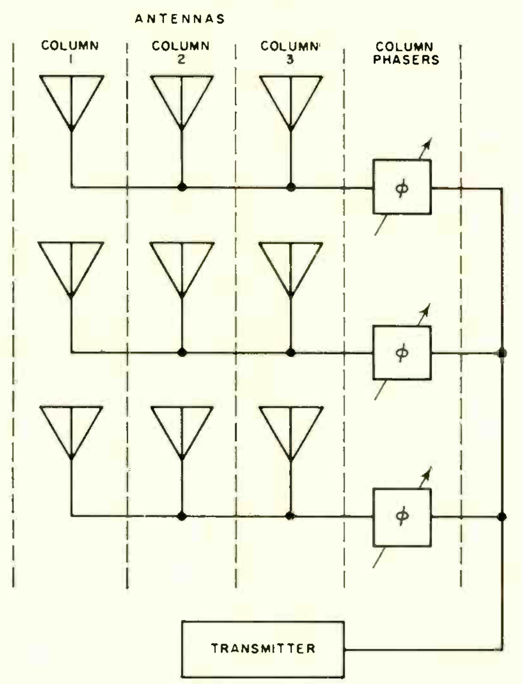


Fig. 4. Column excitation of a group of 9 elements is shown.

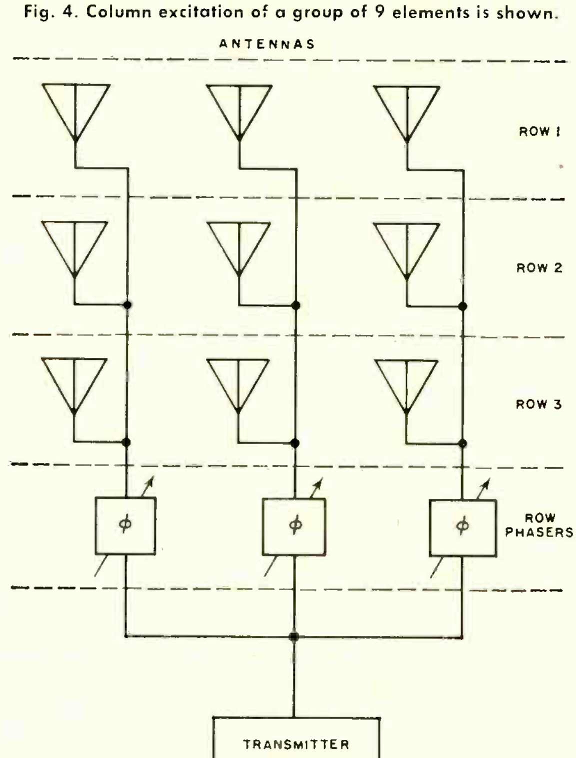


Fig. 5. Excitation of the 9 elements into a row grouping.

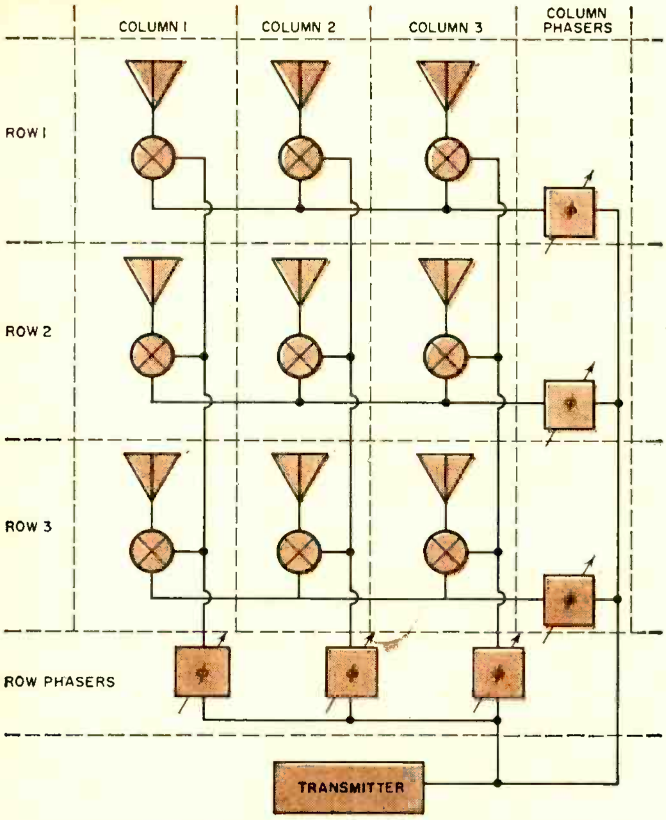


Fig. 6. Two-dimensional phased array produced by combining the techniques shown in previous two figures. Mixers combine signals.

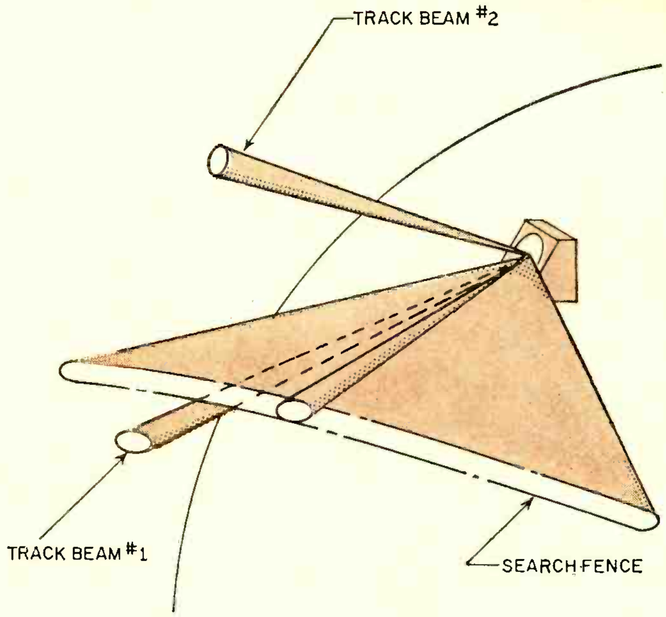


Fig. 7. Typical search pattern consisting of overlapping beams.

controlled in a definite manner by the *row* phasers employed.

2. In the same way, the phase relationship between *antennas* in any given *row* is the same as for the *antennas* of Fig. 5. However, whereas the phase relationship between *rows* in Fig. 5 is zero (assuming no phase shifts in connecting lines), the phase relationship between *rows* in Fig. 6 is controlled by the *column* phasers.

3. The phase of each antenna is dependent on the setting of two phasers, a column phaser and a row phaser, and no two antennas are fed by the same two phasers.

The net result obtained by driving antennas as shown in Fig. 6 is a pencil beam whose direction with respect to the plane of the antennas can be controlled by controlling the phase of the row and column drive signals.

Comparison with the elemental phased array used by broadcasting stations shows that the modern radar phased-array frequency is hundreds of megacycles instead of kilocycles; there are hundreds or even thousands of antennas instead of two or three, or nine; there is a programmed computer-controlled method for changing the relative phase between antennas in microseconds instead of manual-semi-fixed tuning; the beam is narrow (1.5 degrees or less) instead of wide; and it is pencil-shaped and can be steered in both azimuth and elevation.

The AN/FPS-46 (XW-1) of Fig. 2 has less than 1000 antennas mounted in the face of the array. The same antennas are used for both transmission and reception.

The AN/FPS-85 Space Track of Fig. 1 uses separate antennas for transmission and reception. The square face contains many thousands of transmitter antennas and the circular face contains many thousands of receiver antennas.

Power Capability

Additionally, phased-array radars have the capabilities for peak powers undreamed of and unattainable in conventional radars. Conventional radars are power limited in two ways: (1) they are limited by the amount of power that can be generated in a single output tube and (2) they are limited by the breakdown of antennas, waveguides, cables, and other components under high power stresses. While the peak power generation and handling capabilities of a conventional radar varies with frequency, a peak power on the order of 10 megawatts (10,000,000 watts) is pushing the state-of-the-art. Even this value is still at the lower limit as far as power requirements for space tracking are concerned.

In a phased-array radar each antenna element is fed by a relatively low-power amplifier using conventional components. These amplifiers would be between the mixers and the antennas of Fig. 6 and high peak powers will exist only in space at those points where the low power outputs of the individual antennas add in the proper phase. With the beam peak power equal to $N \times P$, where N equals the number of antenna elements and P equals the peak power of an individual transmitter, it is apparent that peak powers on the order of tens of megawatts are easily obtained. It is high peak powers of this magnitude plus the ability to steer the radar beam in microseconds that enables a single phased-array radar to combine the search function with ability to track multiple targets.

Comparison with Conventional Radars

Aside from the power requirements, consider also the equipment that is needed and the procedure that must be followed at a conventional radar site in order to find and track a target. First a search set must sweep its vertical fan-shaped beam around the horizon to find and determine the azimuth angle and range of a target. Second, a height finder, looking in the azimuth as determined by the search set, must sweep its horizontally fan-shaped beam up and down to determine the target elevation angle. Finally, a tracker, using the azimuth, range, and evaluation information supplied by the search set and the height finder, rotates and tilts its circular dish antenna so that its pencil beam can take over the tracking function. The same procedure must be followed for each new target acquisition.

Although one search set and one height finder may be used to supply acquisition information for a number of targets, each target requires the exclusive use of a tracker because the inertia of the mechanical systems prevents their use in tracking multiple targets on a time-sharing basis. In those areas of great expected activity where multiple installations of search sets and height finders may be necessary to handle the load, the system rapidly becomes so complex that computer control centers must be installed to keep track of operations and to prevent duplication of effort. A large part of this complexity would be due to the effort required to correlate information

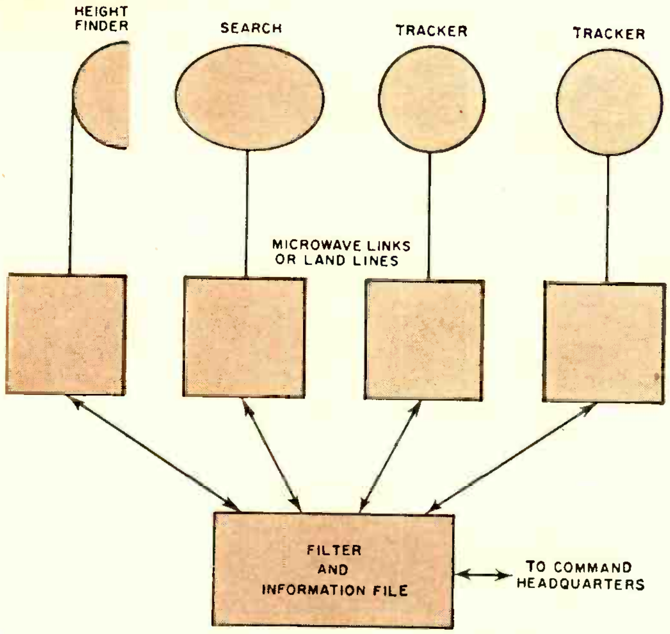


Fig. 8. An elementary control system for typical radar site.

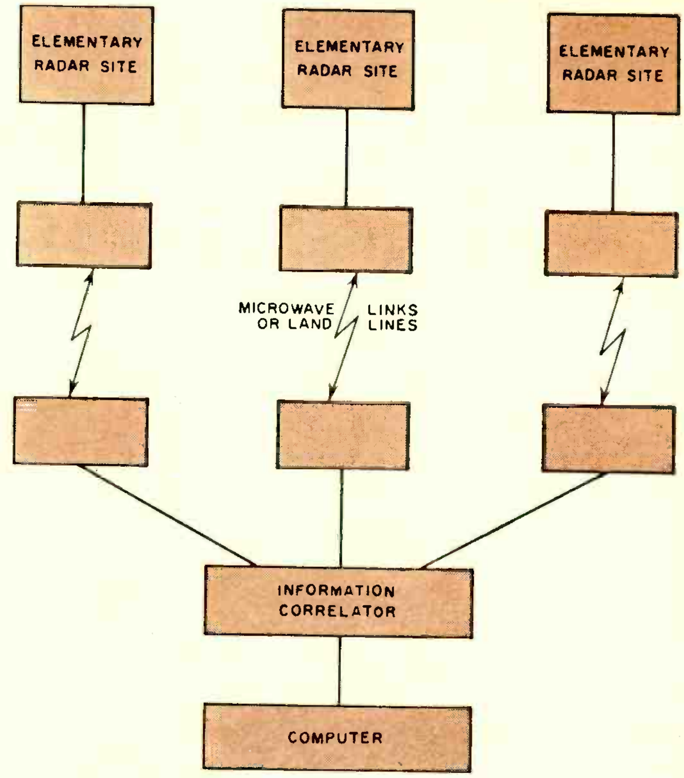


Fig. 9. Block arrangement showing control of several sites.

from each radar and its control equipment that has been designed to operate independently.

In contrast, a phased-array radar combines the functions of search set, height finder, and more than one hundred precision trackers. This type of operation is possible because:

1. A phased-array radar is not hampered by mechanical inertia. The radar beam is electronically formed and can be steered in microseconds instead of seconds or minutes.

2. A phased-array radar generates track beams, as needed, independently of the search beam. The search function is not interrupted by the track function.

3. A phased-array radar is designed to operate under integrated, program-directed, computer control.

4. In the phased-array radar the beam shape is flexible. Although nominally a pencil beam, it can, as an instantaneous occasion demands, be broad or narrow, round or oval, high-powered or low-powered, a single beam or a cluster of beams.

5. A built-in memory containing information on thousands of targets is constantly being updated and expanded and all search and/or track returns are constantly checked against this store of important information.

Performing the Search Function

In its search function, a space-track radar will be programmed to sweep a pattern or fence that will intercept all targets of current interest. Fig. 7 illustrates such a typical search pattern which actually consists of a series of overlapping pencil beams. This diagram also illustrates how track beams are not confined to the space enclosed by the search beam. Track 1 shows a track beam that originated in the search fence when the search beam detected an unknown object. Track 2 shows a track beam that was originated on command by the computer to check an object whose initial location was obtained from the catalogue of known objects. An ESAR can be located and its search fence so shaped that very few objects in orbit around the earth will not be intercepted at least once every 24 hours. Two ESAR's can be sited so that no earth-orbiting object can escape detection.

Whenever a target penetrates this search fence, the search equipment notes the azimuth angle, elevation angle, range, and time at which penetration occurred, and sends this information to the computer where it is checked against information on file in the computer memory. In the meantime, the search function continues without interruption. Information on file may indicate that:

1. This is a target whose mission is known and no further information is required. No tracking action is called for.

2. This may be a known target but one whose ephemerides or other characteristics are not exactly known and additional information is desired. In this case, a track program tailored to obtain the desired information is initiated.

3. This is a new and unknown target. This answer initiates a track program that will obtain the maximum amount of information on the object detected.

4. This is a target already under surveillance, no additional action is required.

As indicated previously, as many as 100 tracking programs can be carried on simultaneously without interfering with the search function. This ability of the AN/FPS-85 Space Track to simultaneously carry on a search program and 100 track programs is due to:

1. The development of phased-array techniques whereby beams can be formed and steered electronically in microseconds.

2. The use of high-speed computers and large memories that can carry out, process, and store complex programs involving thousands of bits of information.

3. The development of programming techniques whereby all returns, search, and track, are evaluated and weighed against information in the memory file before further action takes place.

4. The fact that all equipment and techniques are designed from their very inception to operate entirely under integrated programmed computer control.

Control of the System

On the basis of past experience in tying together individual search radars, height finders, and trackers, it would seem that the control of the AN/FPS-85 would be inordinately complex. This is not necessarily so.

Fig. 8 shows how an elementary system of one each search and height finder plus two trackers might be controlled. In a simple installation such as this, the filter would normally be a human operator. It would be the operator's job to determine which of the many targets located by the search set should be tracked. The azimuth angle and range of the selected target would then be passed on to the (Continued on page 62)

MULTISET COUPLERS:

OPERATION AND PROBLEMS

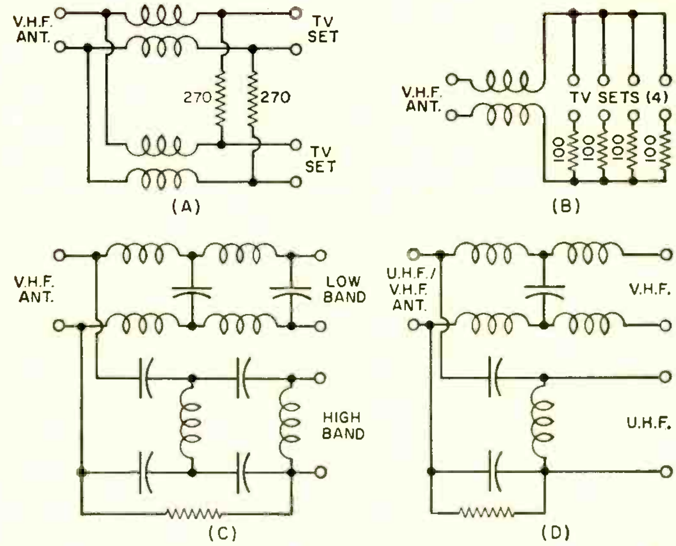


Fig. 1. Circuits of four types of couplers. (A) Two-set coupler. (B) Four-set coupler. (C) High-band/low-band (v.h.f.) coupler. (C) A coupler used to separate u.h.f. from v.h.f.

Besides covering the theory of operation of these devices, this article also points out a problem that can occur when two or more TV sets are coupled to a common antenna. One may be severely degraded.

MULTISET couplers are used when it is desired to connect more than one TV set to a common antenna. There are several types of multiset couplers presently being used: those having built-in amplification, those using resistive splitting for strong-signal areas, and those with a relatively low-loss impedance-matching network. This article will cover the most common types, *i.e.*, the passive, relatively low-loss multiset units, and will attempt to show why certain types of problems exist in installations using them.

The typical two-set coupler shown in Fig. 1A consists of two impedance-matching, coiled transmission-line transformers having a characteristic impedance of about 420 ohms. When a 300-ohm TV set is connected to one of the coupler output terminals, it will appear as a 600-ohm reactance at the coupler antenna terminals. When the two outputs are connected to a pair of 300-ohm input TV sets, the two 600-ohm reactances are connected in parallel at the coupler antenna input, thus producing a 300-ohm load for the 300-ohm antenna. Coupling loss for this type of device is about 3 db.

If both TV sets hooked to the coupler outputs have approximately 300-ohm input impedance, and if the antenna has a 300-ohm impedance, then the two 270-ohm resistors will have no effect on the circuit as they are connected across circuit points having the same potential.

Mutual interference between the two sets will be reduced because there are two paths that an interfering signal can take to get from one set to the other. One path is through the 270-ohm resistors, and the other path takes the signal through one impedance transformer, where it is then shunted by the antenna impedance and passed through the other impedance transformer. As each of these transformers is approximately ¼-wave long, the signal following this path will be reversed 180° to cancel out the signal arriving through the resistors.

However, the usual case is that the antenna is not a pure 300-ohm source and the impedance transformers are only ¼-wave long at one frequency. A balance is struck by having the transformers ¼-wave long at the center of the low v.h.f. band and ¾-wave long at the center of the high v.h.f. band.

Isolation between the two sets is about 12 db at channels 2, 6, 7, and 13, reaching about 25 or more db on channels 4 and 10.

A typical four-set coupler is shown in Fig. 1B. Here, a transmission-line system converts the 300-ohm antenna impedance into approximately 173 ohms. Like the two-set coupler, this impedance transformer is ¼-wave long at the center of the low v.h.f. band and ¾-wave long at the center of the high v.h.f. band.

Each TV set has a resistor of 100 ohms connected in series with it, making a total of about 400 ohms per set. When the four terminals are connected in parallel (a TV set hooked to each pair of terminals), the resulting impedance is about 100 ohms, thus making up the load for the impedance transformer. These 100-ohm resistors produce about 1½-db loss and also provide some resistive isolation among the four sets. The net result is a device that produces nearly 8-db signal loss to each set. If the resistors are not used, then this would be a true impedance coupler. In this case, there would be only 6-db loss if each set had a 300-ohm input impedance. However, the impedance at the antenna of a TV set varies greatly depending on which channel it is tuned to and the condition of the fine tuning control. Therefore, it is very possible that one operating set can have a sufficiently low antenna impedance to effectively short out the signal at the other three. Hence the resistors.

The coupler shown in Fig. 1C can be used when it is desired to separate the v.h.f. high band from the v.h.f. low band for some particular installation. Operation is similar to an audio crossover system (except for frequency). The low band has an upper frequency cut off of about 125 mc., while the high-band network has a low-frequency cut off which is also about 125 mc. The filters are connected in parallel at the antenna terminals so that the input impedance of one filter acts as the terminating reactance for the other.

In the case where it is desired to connect a u.h.f. set and a v.h.f. set to a combined u.h.f./v.h.f. antenna, the coupler shown in Fig. 1D is often used. Here, as in the high-band/low-band coupler, a pair of filters is used to separate the two frequencies. The upper cut-off frequency of the v.h.f. filter is about 300 mc., while the u.h.f. filter operates between 300 and 1000 mc. (*Continued on page* 76)

A MODERN BROADBAND CATV SYSTEM

By JOHN FRYE

A study in depth of a model broadband cable TV system, from the time signals are picked up until they arrive at customer's TV set.

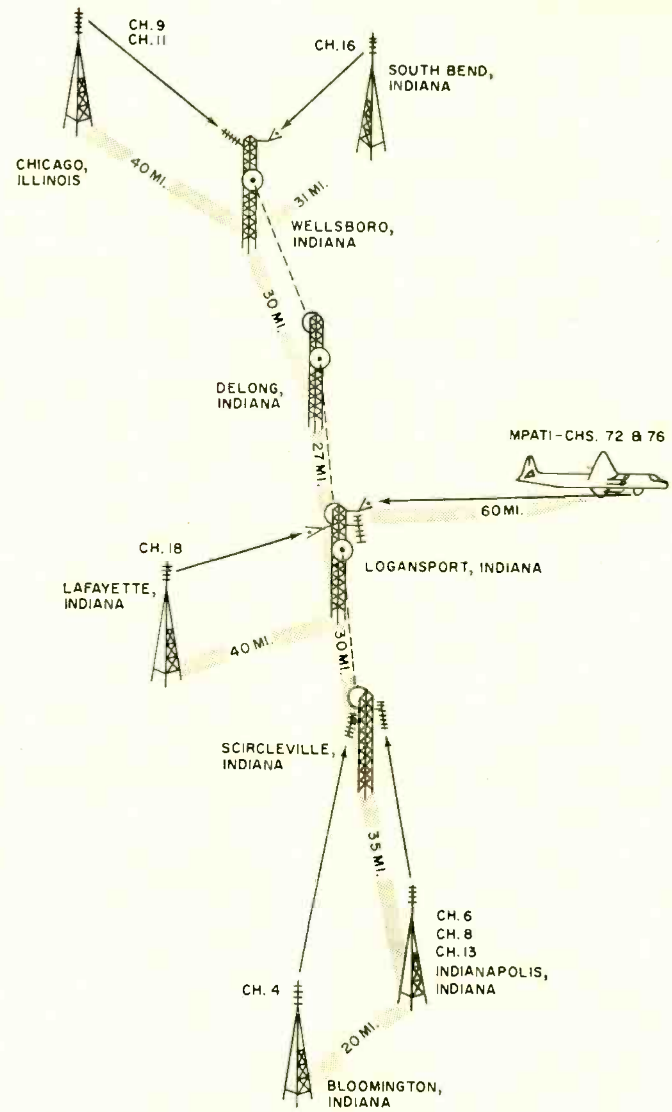


Fig. 1. The network of pickup points and microwave relay stations used to provide Logansport with multichannel TV.

LAST year an average TV viewer in Logansport, Indiana needed a high-gain antenna atop at least a 50-foot tower to get barely tolerable reception from the three closest v.h.f. stations at Indianapolis, about 70 miles to the south. Distance alone did not account for the poor reception. Logansport lies in a deep valley cut into limestone by the Eel and Wabash Rivers that flow together in the center of town. Much of the city lies 100 feet below the surrounding terrain. Moreover, B-58's taking off and landing around the clock at Bunker Hill AFB, eight miles south-southeast and squarely in the reception path, created terrific airplane flutter.

If the viewer's set was equipped for u.h.f., he could put up a u.h.f. antenna and rotator and get good signal strength on channel 18 from Lafayette, 40 miles southwest, or on channels 72 and 76 telecast from the Midwest Program on Airborne Television Instruction (MPATI) plane flying at 23,000 feet, 60 miles to the east; but many viewers felt the programming and limited telecasting schedules of these stations did not warrant the expense. Occasionally a thermal inversion permitted channel 4, Bloomington, or some of the Chicago stations to be watched for a few minutes or even hours, but 90% of the viewing was on channel 6 (NBC), channel 8 (CBS), and channel 13 (ABC) from Indianapolis.

Deep variations in received signal strength of these stations created a major problem. Table 1 lists maximum and minimum readings measured over a 24-hour period at the author's home with a *Jerrold* 704B signal-strength meter. Signals were received on an all-band yagi 55 feet in the air and a bowtie-and-corner reflector u.h.f. antenna 50 feet high. Both antennas were on a rotating mast, and separate 75-foot lengths of foam-filled, low-loss lead-in came directly from the antennas to the meter. Actually, over a period of days, minimum levels often fell below those logged in this short period. Pictures from even the strongest v.h.f. stations on channels 6 and 13 occasionally disappeared completely in the snow, and rarely was there enough signal strength to overcome strong ignition noise.

Today a Logansport viewer can receive the ten stations shown on the map of Fig. 1 with only his v.h.f. receiver. In addition, he can receive six FM stations over the same cable that brings him the TV signals. As a bonus, one of the two remaining blank channels will occasionally light up with a local-interest program televised by a camera feeding directly into the cable. Table 2 gives signal strengths measured across the cable input to the author's receiver during the same 24-hour period. A step-by-step analysis of how the *Logansport Cable TV Company*, jointly owned by *Jerrold* and the *Alliance Amusement Company*, was able to effect this startling change

Table 1. Microvolts across TV receiver input terminals delivered by 50-foot-high antennas.

Channel	Maximum	Minimum
4	80	10
6	500	140
8	100	20
13	400	80
18*	2000	1400

MPATI not available at time of tests but roughly equal to channel 18.
*Converted to channel 5.

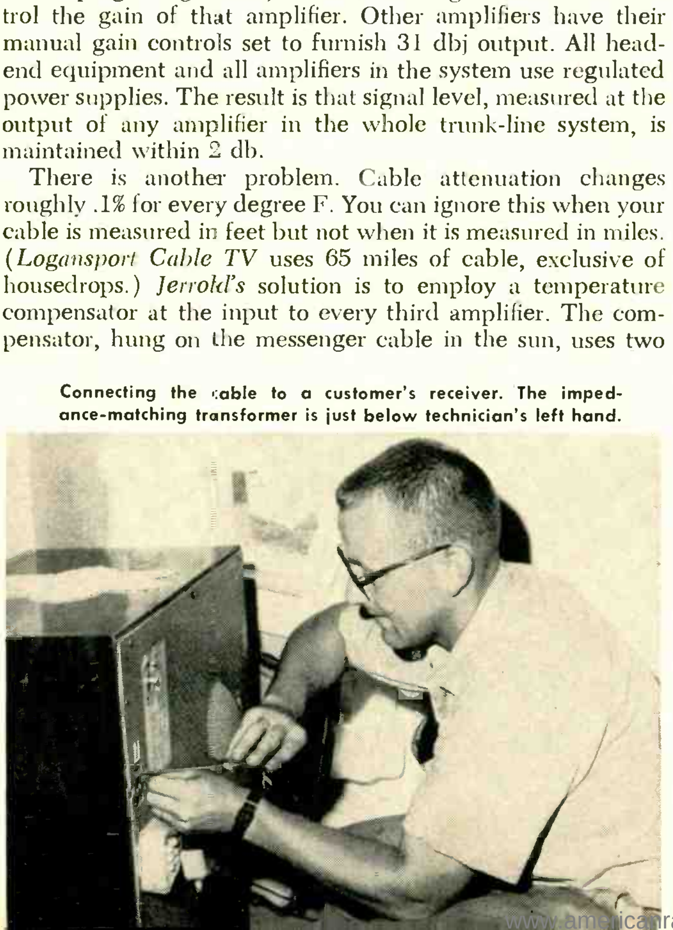
Technician installing pressure tap on distribution line for housedrop. Note strain-relief arrangement used here.

15 to 24 db of attenuation at channel 13. Since mechanical considerations often make it necessary to mount amplifiers closer together than the optimum spacing, it is necessary to have equalizers for shorter lengths of cable.

Head-end receiver a.g.c. circuits maintain the individual levels of signals entering the cable, but how about the composite level after that? Weakening tubes, changes in cable attenuation, etc., can cause unwanted variations in the signal level in the trunk line. Trunk-line a.g.c. is needed to keep this level constant. One of the TV signals can be used to produce amplifier a.g.c., but this would tie the gain of the whole system to that one signal, and if it were lost, the a.g.c. would be lost. Instead, a crystal-controlled carrier on 73.5 mc. (the 18th signal) is placed between channels 5 and 6 and is put on the cable at a level 15 db below the video signals. At every third line amplifier, this signal is picked off, amplified, and rectified with a plug-in a.g.c. unit, and the resulting d.c. is used to control the gain of that amplifier. Other amplifiers have their manual gain controls set to furnish 31 dbj output. All head-end equipment and all amplifiers in the system use regulated power supplies. The result is that signal level, measured at the output of any amplifier in the whole trunk-line system, is maintained within 2 db.

There is another problem. Cable attenuation changes roughly .1% for every degree F. You can ignore this when your cable is measured in feet but not when it is measured in miles. (*Logansport Cable TV* uses 65 miles of cable, exclusive of housedrops.) *Jerrold's* solution is to employ a temperature compensator at the input to every third amplifier. The compensator, hung on the messenger cable in the sun, uses two thermistors to compensate for the tilt in the preceding 21 db of cable—it replaces the equalizer unit for that amplifier—and it compensates for temperature variations in the preceding 64 db of cable. (*Jerrold* measures cable in db of attenuation at channel 13 instead of in feet.) When it is necessary to divide the trunk line, a passive line splitter is used that gives 3 db attenuation in the forward direction and at least 15 db of isolation so that a failure in one branch will not materially affect the other.

Connecting the cable to a customer's receiver. The impedance-matching transformer is just below technician's left hand.



The only way signals are taken off the trunk line is by means of one of two different types of bridging amplifiers. One is always used with a line amplifier and is housed in the same cabinet. With 31-dbj input, it provides 40 dbj at each of four 75-ohm outputs. It has a frequency response within ±½ db between 54-108 mc. and 174-216 mc., and features individual gain controls for the high and low bands.

The other unit is designed to connect in the main trunk line and covers the same frequencies. Since signals in the cable will have acquired a tilt at the point where this latter amplifier is inserted, equalizing pads are used in the input to correct for this, and controls in the amplifier furnish some additional tilt correction. With 8 dbj minimum signal input, the amplifier will deliver 40 dbj to each of two 75-ohm outputs.

Type 408D double-shielded 75-ohm cable, .460″ in diameter and having 1.6 db attenuation per 100 feet at channel 13, is used for all distribution lines coming out of these two amplifiers. Two types of line-extender amplifiers are used to keep the signal level up in long runs of distribution cable. These are all-band extenders covering the high and low v.h.f. TV and FM bands with minimum gains of 40 db on the high band, 39 db on the low band and at 98 mc., but only 25-db gain at 108 mc. Now you see why FM stations are placed on the low end of the band. This amplifier can produce 40-dbj output with 1-dbj input and features amplifier-tilt controls, separate high- and low-band gain controls, and plug-in tilt equalizers for the low band only.

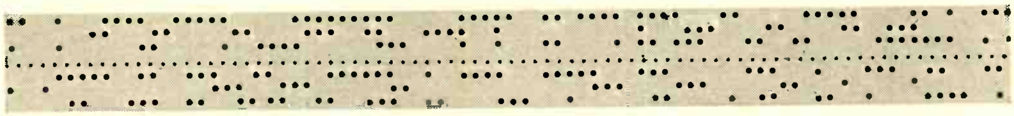
The high-band extender is used to prop up drooping high-band signals at the end of the line. Low-band signals are bypassed around the amplifier while the high band is boosted 20 db.

Housedrop cables can be connected anywhere along a distribution line. RG-59/U, JEL-105, or JT-205 cable is used for housedrops. All are 75-ohm cables, .242″ in diameter: RG-59/U has 6-db loss per 100 feet at channel 13; JEL-105, 5-db; and JT-205, 3.75-db. Connection to the distribution cable is made by means of a pressure tap containing an isolation insert. If the connection is made near an amplifier where there is little tilt, a resistive insert is used. These come in 40-, 35-, and 30-db ranges. If the tap is some distance from an amplifier, a capacitive insert is used to correct the tilt. Various types are available, covering 34-db attenuation at channel 2 and 22-db at channel 13; and 16-db attenuation at channel 2 and 6-db at channel 13. The aim is to come as close as possible to providing 0 dbj on all channels to the house. This is true for both monochrome and color sets. With a good flat-response system, there is no necessity to brute-force the color signal through with excessive signal strength.

The housedrop terminates in a baseboard-mounted junction with an FM tap. This tuned tap provides 8- to 17-db isolation of the FM band. Coax leads for both the TV set and the FM receiver come from the junction box and terminate in impedance-matching transformers, each of which employs a bifilar transformer, capacitors, and a tuning coil to transform the 75-ohm single-ended cable to 300-ohm balanced twin-lead. About six inches of twin-lead goes to the TV- or FM-set terminals. Voltage is doubled in the transformation, so that 1000 microvolts across the coax becomes 2000 microvolts across the TV-set terminals. Cable splitters can be provided to furnish signals to more than one television receiver within a single household. (*Continued on page* 66)

COMPUTERS IN BUSINESS

By ED BUKSTEIN
Northwestern TV and Electronics Institute



Applications for electronic data processing include payroll calculations, inventory recording and control, accounts payable and receivable. Here are techniques used in the computer to handle these basic operations.

ALTHOUGH the digital computer has been much publicized for its ability to solve complex mathematical formulas, it is more often used for simple arithmetic operations. In a payroll application, for example, the computer multiplies the number of hours each employee worked by his hourly pay rate. It then performs the necessary subtractions for withholding tax, Social Security, insurance premiums, etc. It also keeps track of each employee's year-to-date withholding tax and Social Security payments.

Why use a computer for this simple fifth-grade arithmetic? Because it is *fast* and *accurate*. In a few hours the computer can complete the payroll calculations for a large firm with thousands of employees—a task that might otherwise require the full-time efforts of a staff of payroll clerks. Furthermore, the computer is much less likely to make an error because it does not try to anticipate a forthcoming coffee break, it does not pause to admire a passing secretary, and it is not interested in the progress of a baseball game.

A further advantage of the computer is its ability to prepare management reports that might not be economically feasible to prepare if the work had to be done by humans. As a by-product of its regular calculations relating to payroll, inventory, and sales statistics, the computer accumulates much information of value to managers and executives in making decisions, formulating policy, and establishing procedures.

Certain basic data-processing procedures occur in practically all businesses: payroll calculations, inventory recording and control, accounts payable for services and goods received from suppliers, and accounts receivable for services and goods furnished to customers. In addition, *special* data-processing problems arise in certain businesses. Airlines and railroads, for example, must keep track of seat reservations on a minute-by-minute basis to avoid the embarrassment of two offices selling the same seat to two different passengers. In the publishing field, magazines having subscription lists of several million accounts employ computers to control the printing of address labels and to process subscription data so that renewal literature will go out to about-to-expire accounts. The computer also compiles subscription data in terms of geographical area, expiration dates, and other factors required for management decisions. In banking, checks are read quickly and accurately by means of magnetic ink and computers up-date accounts according to the deposits, the interest, and the withdrawals that are made.

File Processing

The *file* concept is basic to business data processing. A file is a collection of information about employees or customers' accounts or whatever other type of data is to be processed. In a payroll application, for example, the file contains the name of each employee, his Social Security number, hourly pay rate, and deductions. In an inventory control application, the file contains the stock number of each item, the quantity of that item remaining in stock, and the re-order level (at which the stock must be replenished). In physical form, the file may be a deck of punched cards, a reel of magnetic tape, a magnetic drum, or a stack of magnetic discs.

The examples just given refer to *master* files. These contain permanent or semi-permanent information which is up-dated periodically. By contrast, a *detail* file, also known as a *transaction* file, contains relatively transient information. An example is a file containing information about items sold during a particular day or week. This detail file is then used to modify the master file of customers' accounts, increasing the balance due according to the purchases of each customer. The detail file may also be used to up-date a master *inventory* file.

Data-processing procedures are determined, to some extent, by the characteristics of the file, that is, whether the file provides *sequential* or *random* access to the records. A sequential access file is one in which a given record can be reached only by passing through all of the intervening records. A reel of magnetic tape is representative of this type of file. In an inventory-control application, for example, the magnetic tape may contain the part numbers and other pertinent data about items stored in a warehouse. This master file is processed in accordance with a transaction file containing details of orders received for various items. For each such item the tape file must be read to determine if the quantity remaining in stock is sufficient to fill the order, to prepare shipping instructions, to subtract the quantity ordered from the remaining quantity, and to issue re-order instructions if the remaining stock has dropped below a predetermined level.

Typically, the records on the master file are in ascending order according to part number. If the records are to be processed for part number 150, for example, and then for part number 600, the tape must be searched through 450 records before it arrives at the record for part number 600. This is a characteristic disadvantage of the sequential access file. To avoid numerous back-and-forth searches through the tape file, the transaction file should also be in ascending order according to part number.

Typically, the transaction file is a deck of punched cards prepared from sales slips and order books. These cards are then read one at a time, and for each card the tape is searched to find the record for the corresponding part number. Since

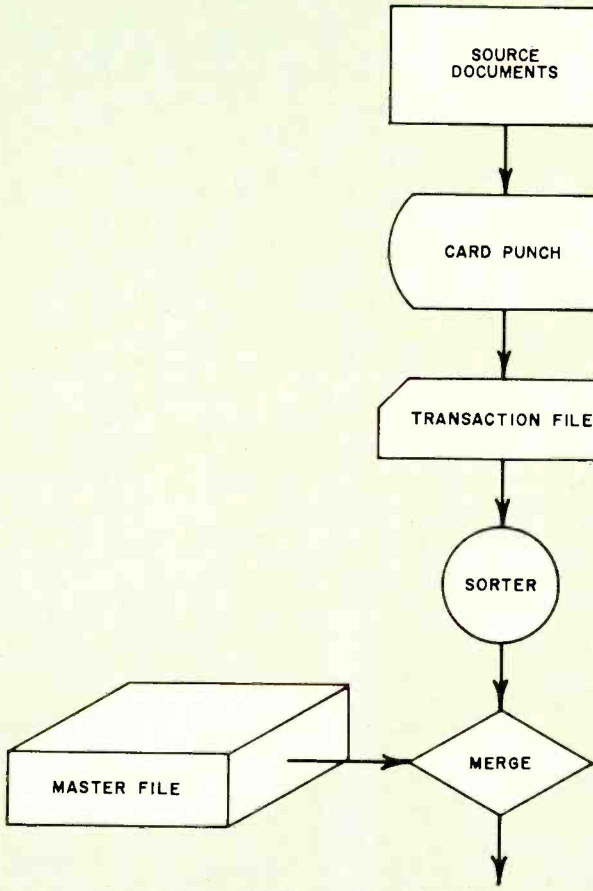


Fig. 1. Flow chart shows operations sequence for data processing.

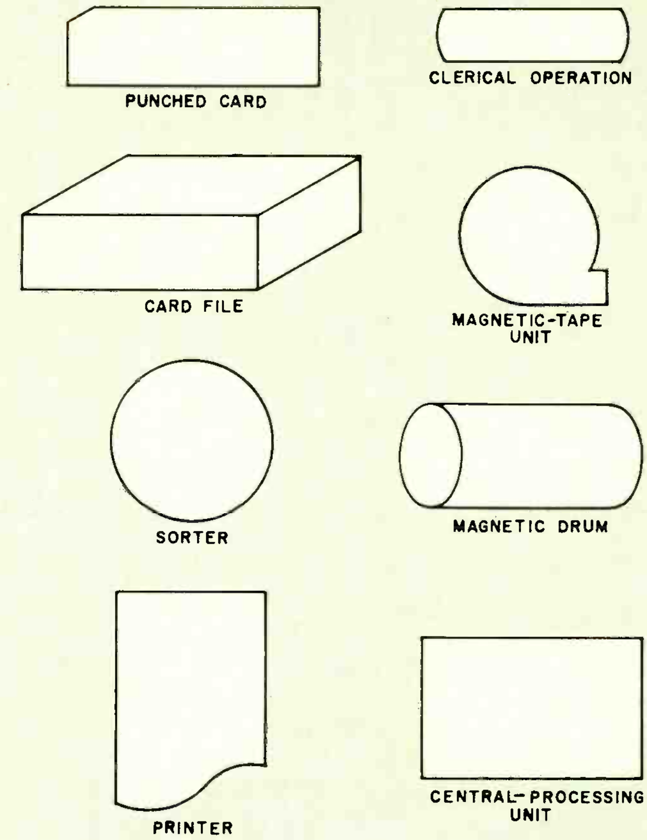


Fig. 2. Some symbols that are commonly employed on flow charts.

the cards and the tape are both arranged and recorded in ascending order according to part number, the master file can be up-dated in one "pass" through the tape.

Random-Access Files

In contrast to the sequential-access file, the *random-access* file permits reading of the records in any order. Since it is not necessary to pass through all intervening records in going from one to another, it is not necessary to sort the transaction file into the same order as the master file. Magnetic discs and magnetic core devices are examples of random-access files. These generally are more costly than sequential-access devices, but they simplify the data processing by eliminating the need to sort the transaction file.

In general, *batch processing* is employed with sequential-access files. The details of the individual transactions are accumulated over a period of time, and the whole group (batch) is then processed. In processing sales data, for example, it is usually sufficient to accumulate the sales slips and then process the data once a day or even once a week. In other applications, however, it is necessary to process each transaction as it occurs. In an airlines reservation system, for example, each transaction must be immediately processed. To wait until the end of the day to up-date the file may result in multiple sales of the same seat on the same flight. In such applications, random-access files are preferable because the desired record can be reached directly and quickly without passing through all intervening records.

Flow Charts

People responsible for planning data-processing jobs use *flow charts* extensively. An example of a flow chart is shown in Fig. 1. The source documents (sales slips, for example) are converted, by an operator, to punched cards. This collection of cards is the transaction file and is then sorted into the same order as the cards in the master file. The master file and the transaction file are then merged so that each master card is followed by the transaction card or cards relating to the same item, part number, product, etc. With the files merged in this manner, the processing can then continue through additional steps that remain.

Flow chart symbols have not yet reached the status of industry-wide standardization. Some frequently used symbols are shown in Fig. 2. The terms "flow chart" and "block diagram" are sometimes used interchangeably, but the distinction is often made that the block diagram is a more detailed representation than a flow chart. Some equipment manufacturers and programmers use different sets of symbols for flow charts and for block diagrams.

Fig. 3 shows a portion of a block diagram for processing payroll data. Each card contains the name of an employee, his payroll number, and the number of hours he worked. The hourly payrate, deductions, and other pertinent data regarding the employee are contained in his record in the master file. It is therefore necessary to locate the master record corresponding to each card. As indicated in Fig. 3, each card is read and the next master record is then read. If the card and the master record are not for the same employee, the next master record is read. In this manner, the master file is searched until the correct record is found. The payroll computation for that employee then proceeds. Normally, the cards and the master records are in the same order and the next card in the deck will match the next record in the master file. However, variations in this one-to-one correspondence of cards and records sometime occur and must be planned for in advance. It may happen, for example, that there is no card

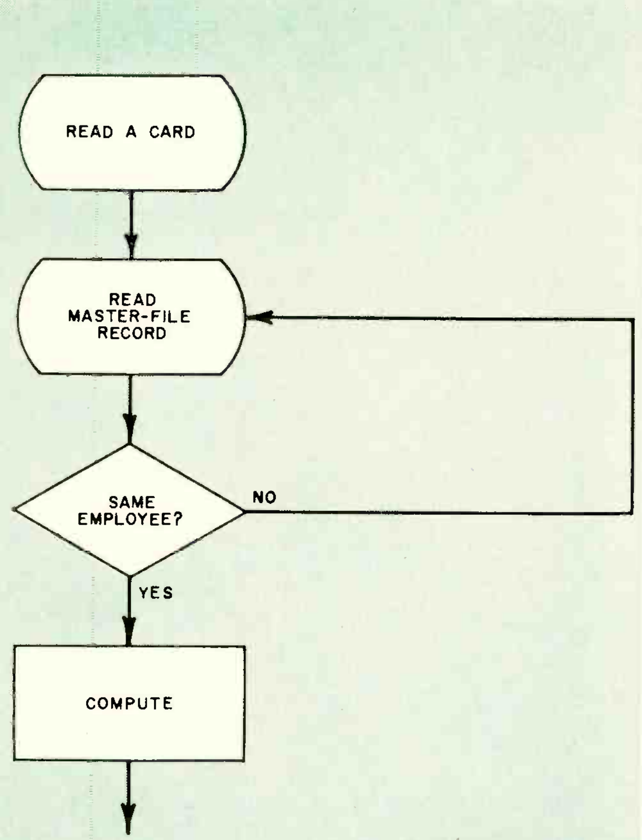


Fig. 3. Some of the steps that are required in payroll processing.

for one of the employees, because the employee did not work that week. This is handled, as indicated in Fig. 3, by advancing to the next master record until the correct one is found.

Fig. 4 shows a block diagram of some of the steps in processing inventory data. Each card corresponds to an order received for a particular product. After each card is read, the master file is searched to find the record for the same product. The master file record contains, among other information, the number of units remaining in stock. If the remaining stock is insufficient to fill the order, an *out-of-stock* notice is printed and processing continues by reading the next card. If the remaining stock is sufficient to fill the order, the number of units ordered is subtracted from the inventory. The new remainder is then tested to determine if it has dropped to the re-order level. If so, a re-order instruction is printed. The new remainder is then written into the master record to replace the old remainder, and processing continues by reading the next card.

When a card file is involved in processing, it is necessary to include a "last-card test." Otherwise, the equipment will "hang up" as it attempts unsuccessfully to process the next card after there are no cards left. A block diagram of a last-card check is given in Fig. 5. After each card is read and the necessary processing steps are performed, the last-card test takes place. If the card just processed is not the last one, the next card is read and processing continues. If it was the last card, printing or other output operations are performed and the machine then halts.

Ultimately, each step represented in the block diagram must be converted to a series of machine-language instructions. These instructions are then stored in the memory of the computer so that processing can proceed automatically. ▲

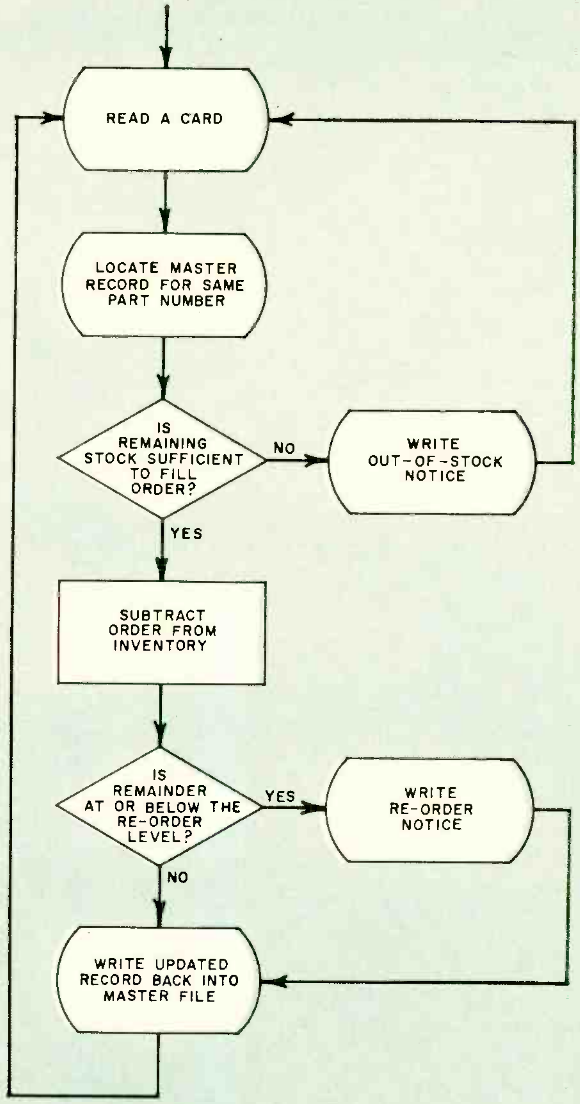


Fig. 4. Steps required in an inventory-control application.

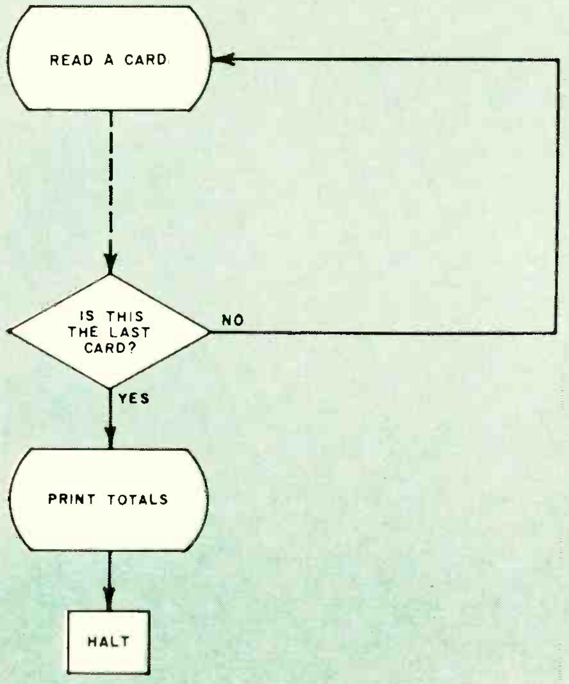
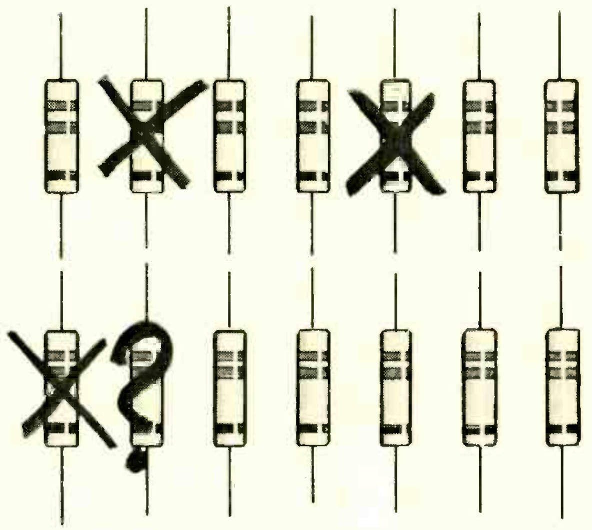


Fig. 5. "Last-card check" halts computer after processing.

Electronic systems must operate properly for extended periods of time. Here is a summary of the basic concepts of how component and system reliability are determined.



BASIC PRINCIPLES of RELIABILITY

By JOSEPH H. WUJEK, JR.

As electronic systems grow in size and complexity, reliability becomes increasingly important. Reliable systems safeguard lives and property and reduce operating costs. Our nation's security depends upon many electronic systems functioning properly for extended time periods.

Reliability

"Reliability is the probability that an element performs its mission for a given period of time." Other definitions exist, but they all boil down to the same thing. Now let us examine our definition in detail.

Probability is nothing more than the "chance" that some event will happen. Intuition tells us that if we flip a coin, the chance of a "heads" is one out of two. If we draw a card from an ordinary pack of playing cards, the chances of drawing the ace of spades (or any other *particular* card) are one in 52, assuming the jokers are removed from the pack. If we ask what the chances are of drawing a particular suit, say diamonds, the answer is one in four. But talking about "chance" in this manner would prove to be cumbersome, so let us introduce some simple mathematics to give us a shorthand method of discussing chance.

If we agree to call probability ("p") the number of ways the desired event can happen divided by the total number of possible events, we have a more compact way of talking about chance. Since we see that a "heads" can occur only one way, and since two events are possible (heads *or* tails), the probability of a heads showing up is just $\frac{1}{2}$ or 0.5. The probability of drawing a diamond from the pack of cards is 13 diamonds divided by 52 cards $= \frac{1}{4}$ or 0.25. As for drawing the ace of spades, one ace of spades divided by 52 cards $= \frac{1}{52} = 0.019$ (to three decimal places). Calculating probabilities is done the same way for any situation but is not always so straightforward. Notice that probability is always a positive number between zero and one, or else zero *or* one. A probability of zero just means that the event is impossible, such as the probability that out of a bag of pennies you will draw a dime. The probability of one is just the certainty of an event. The probability of drawing a penny from a bag of pennies is of course one.

Now that we have an idea of what we mean by probability, let us go back and look at our definition of reliability once again. An *element* can be almost anything, but for our purposes let us confine ourselves to electronics. Then an *element* is a resistor, a vacuum tube or transistor, a TV set, a radio, or an electronic computer, or anything we wish to discuss.

"Mission" means that an element performs the function for which it was designed. The *mission* of a soldering iron is to melt solder. The *mission* of a broadcast receiver is to convert electrical signals to the signal as originally transmitted. Now we might revise our definition to read: "Reliability is the chance that something performs properly over the time period that we want it to work."

Time-Dependence

There is another important idea in reliability that we need to understand. This idea is the time-dependence of reliability. Suppose we had just constructed a TV set from a do-it-yourself kit. Even though we had some experience in assembling electronic equipment, we would still be surprised if the set worked perfectly the first time we plugged it in. We might have miswired a circuit, reversed a semiconductor diode, or the like. So we plug it in. Suppose after a few cycles of "off and on" operation it fails to work properly. Then, we go to work with our equipment and tools to diagnose the trouble. The process we are describing is the familiar "debugging" process that is required in all electronic equipment. We can appreciate that for the TV set we have discussed, "debugging" will probably last only a few hours. For a radar system "debugging" may take several weeks. For an electronic computer of 100,000 transistors the process may take several months. We find a problem, correct it, and perhaps another problem arises. This kind of process is characterized by many failures, spaced at short time intervals.

Instead of an electronic system, we might be placing vacuum tubes under power and leaving them on test, or burn-in. Soon after the test starts we expect to see some failures. Even with good quality-control practices, a few defective units will pass inspection. Because these units tend to fail early in the test, this is called "infant mortality." (See Fig. 1.) After a short time, say 100 to 200 hours, failures become less and less frequent. Similarly with our TV set. It is bound to fail every now and then, but not as often as during the "debug" stage.

Let us suppose that we have operated our TV set or test group of vacuum tubes for four or five years. Now we notice that failures occur more and more often. This is not surprising, for "time has caught up" with us. We are now in the "wear-out" region of Fig. 1. In the case of our TV set, we can extend the time it takes to get to "wear-out" by routine maintenance, but sooner or later we will get to a point where the set is on the bench most of the time. We say it is "worn out" and buy another, as it is not worth repairing any more.

There are a few things we can do to extend tube life, but the point is that, unlike our coin-flipping or card-drawing, the probability of the TV set or tubes working properly depends upon *when* we expect to look at the results. If we average the time between failures, we get a quantity known as the *Mean* (average) *Time Between Failures*, or MTBF. The MTBF is low during "debugging" and "wear-out"; it is higher during the useful life of the element. Bear in mind that this is an average, no more nor no less. If a TV set proves to have an MTBF of, say, seven months, that does not mean that it will fail at *exactly* seven-month intervals. It just says that on the *average* it will fail every seven months. This is like a .300 hitter in baseball. Over the season he averages three hits in every ten official at-bats, but he may go hitless in 30 at-bats one week and get 15 out of 25 the next, and so on.

Failure Rate

People who work with reliability also talk about *failure rate*. Failure rate is the reciprocal of MTBF, or failure rate equals 1/MTBF. If we average one failure in six months, the MTBF is six months and the failure rate is 0.167 per month. Failure rate is usually expressed as "percent per thousand hours." If we assume 30-day months, six months is 180 days or 4320 hours. Then the MTBF is 4320 hours and the failure rate is 0.00023 per hour, or 0.23 per thousand hours, or 23% per thousand hours. Fig. 1 shows a typical failure-rate curve for an electronic part. The time scale for different parts will be variable, but the shape of the curve is essentially the same for different parts. From the start (zero time) to about 150 hours, the failure rate is high (MTBF low) due to "debugging" or "infant mortality." The curve is constant, or flat, out to about 20,000 hours, and then the failure rate increases (MTBF decreases) when "wear-out" starts. In passing, we should mention that some parts and/or systems behave differently with time, but the behavior we have described is most typical and is most commonly used by those attempting to predict reliability. There are some methods available using that branch of mathematics known as statistics which give a more detailed picture of what is happening, but a discussion of these techniques is beyond the scope of this article.

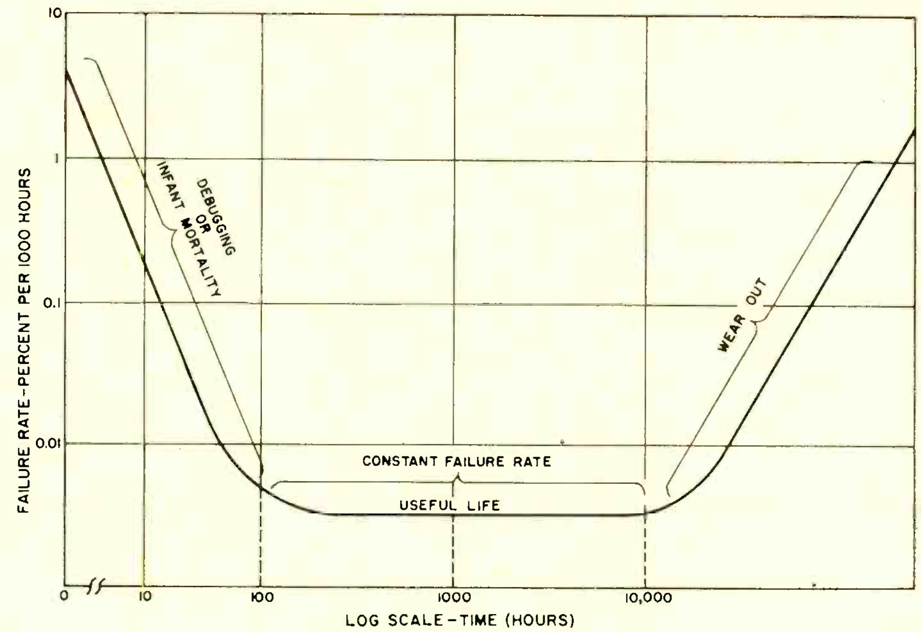


Fig. 1. Failure rate curve showing use-time relationship.

We have said a great deal about failure rate and MTBF, but we still have not discussed getting at the probability that something will work. From the branch of mathematics called differential equations we can show the following. If we are operating in that region of the curve of Fig. 1 where failure rate is constant (flat), then the reliability R of an element is $R = e^{-t/MTBF}$ where t is time. This equation looks familiar because it is similar to the voltage discharge of an RC circuit if the capacitor were charged to one volt initially, and if the MTBF were the "RC time constant." So with *any* MTBF the reliability is one when we first start out at "zero time." We must recognize that "zero time" in the reliability equation refers to the start of the mission *after* "debugging" and *before* "wear-out," and hence is *not* the "zero time" of Fig. 1. "Zero time" for the mission (using the part described by Fig. 1) would be found after 150 hours and before 20,000 hours, where the curve is flat. If our mission extends into the "wear-out region" then the reliability equation we have given no longer applies.

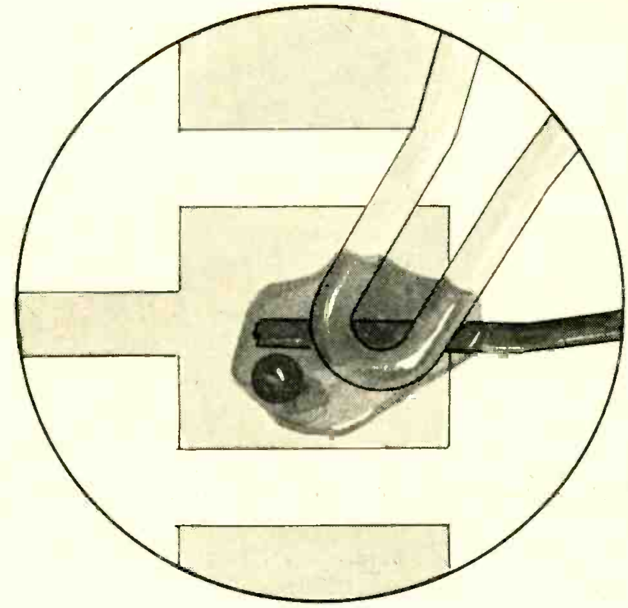
If the MTBF is 10,000 hours, then at 1000 hours the probability of proper function is about 0.9, or nine chances out of ten. When we have had the system operating for 10,000 hours, reliability is one "time constant down," so reliability is only 0.37, or 37 chances out of 100 that we will still be "on the air." Notice that if we want to have a nine-out-of-ten chance of being operational at some time τ, then our MTBF should be 10τ. It should be clear that our equation requires t and MTBF to be in the same units. The chances are about even, or approximately one out of two for being operational when $t = 0.69 \times$ MTBF. See Table 1.

For many years, few people worried about reliability. A manufacturer built parts or systems using a reasonable amount of care, and his job was finished. But as systems grow bigger, maintenance costs become higher, so more reliable equipment is now needed. Meanwhile we are learning how to estimate the reliability of a system by the use of careful design techniques and the proper choice of components. ▲

Table 1. Reliability (success probability) as a time function.

Time (t)	0	MTBF/20	MTBF/10	MTBF/5	MTBF/2	.69 MTBF	MTBF	2 MTBF	3 MTBF
Reliability Or Probability Of Success At Time (t)	1 (certainty)	.951	.905	.819	.607	.502 (1 chance in 2)	.368	.135	.05 (1 chance in 20)

NEW SOLDERING TOOLS AND TECHNIQUES



By WALTER H. BUCHSBAUM

New approaches to soldering methods now permit close control of soldering material and temperature besides allowing high-speed automated techniques.

THREE developments have been primarily responsible for the creation of new soldering techniques. These are the introduction of printed wiring; the expanding use of transistors; and, most recently, microminiature circuits. As components and circuits have become smaller, soldering-tip size has also shrunk while the temperature sensitivity of semiconductor materials has made it necessary to limit the applied heat. Printed wiring has made it possible to use machines to solder many connections simultaneously by dipping the entire assembly in molten solder.

In computers and other large systems, where millions of solder connections affect the reliability of electronic equipment, it is essential that each connection be perfect for the life of the equipment. Cold solder joints and corrosion cannot be tolerated, and for that reason new techniques and materials were developed to assure perfect soldered connections. Soldering has become a specialized branch of production engineering, resulting in precise specifications for the various chemicals, carefully controlled temperatures, and a well-defined system of inspection and test. This field is now so exact that the angle made by the solder and the conductor serves as numerical measure of the solder joint quality. For our purpose, the practical aspects of the new soldering techniques, such as automatic-wave soldering, ultrasonic, and microcircuit assembly are of interest.

In order to illustrate what these techniques are and how they are used, typical examples are presented.

Table 1. Soldering iron power for various types of joints.

POWER (WATTS)	TIP SIZES (INCHES)	APPLICATION
12-18	1/32-1/16	.020 inch thick P/C boards, integrated circuits, 30 or smaller gauge wire and lugs for that size.
20-30	1/16-3/16	.030 inch thick P/C boards, miniature components (diodes, transistors), 24 gauge wire and lugs for that size.
40-50	3/16-1/4	.060 inch thick P/C boards, miniature tube sockets, connectors, 20 gauge wire, turrets and terminals for that size.
50-100	1/4-3/8	Standard components, connectors, 16-18 gauge wire, cables and terminals.
100-150	1/4-3/8	High-speed production on standard components, etc. Ground lugs and joints on chassis.
200-300	1/2-5/8	Thin sheet-metal work, heavy shielding braid, ground straps.

Miniature Hand Soldering

Every manufacturer of soldering irons now offers low-power, small-size soldering pencils especially designed for miniature and semiconductor work, but space does not permit us to show and describe them all. Tips are available as fine as 1/16" in diameter and, in addition, many special shapes of tips both for soldering and unsoldering are on the market. One of the latest versions is the pistol-grip (Fig. 1). The pistol-grip, it is felt, has some advantage in light production work since the whole hand rather than only three fingers is used to hold the iron. Like most low-power soldering irons, it usually operates from a low-voltage transformer and is suitable for use on transistors and other semiconductors.

The problem of solder temperature and its effect on the size of soldering-iron tip is quite complex. For one thing, the soldering iron temperature itself depends not on the wattage rating but rather on its construction and on the thermal dissipation rate. A 100-watt iron, once it has reached its equilibrium temperature, will radiate 100 watts into its surroundings. If this iron rests on a large metal plate, an equilibrium will soon be established, with the iron temperature relatively high while the temperature of the metal plate decreases as we get farther away from the iron itself. If the metal plate can radiate much more than 100 watts into its surrounding air, the heat drain on the iron will be greater than the 100-watt supply, causing the tip temperature to be low. If the same 100-watt iron is placed in a well-insulated box, it will be unable to dissipate 100 watts into the surrounding air without substantially raising the temperature in the box. The tip temperature itself will rise beyond what it would be in free air until another equilibrium is established. We see from these two examples that, regardless of actual soldering temperature, the power rating of the soldering iron itself must be compatible with the size of the soldered connection. In Table 1, a rough guide of soldering-iron power *vs* the type of solder connection is given. The thickness given for printed circuit boards refers to the copper path only and not to the insulating material.

The temperature of the soldering-iron tip must be higher than the solder melting point in order to heat up the wire and terminal lug or other parts that must be soldered. Only when these parts are at a temperature higher than the solder melting point can a good solder connection be made. All the solder used in electrical work is a tin-lead alloy, but for such special applications as tinning ceramics or glass, indium alloys must be used. For sealing canned foods, a lead-free tin alloy is used. In electronics, practically all solder will be ASTM-60-A, an alloy of 60% tin and 40% lead. For pre-tinning, a 70-30 and for plumbing a 50-50 tin-lead alloy is used. The melting point of these solders ranges from 367°F for the 70-30 to 417°F for the 50-50 alloy. In general, an increase of 60° to 150°F above the melting point of the solder is considered necessary for a good solder joint. For standard 60-40 electrical solder and its 370°F melting point, the iron-tip temperature should be 430°F for very small solder joints and 520°F for heavier wire and larger terminals.

The question is often asked why most soldering is done only to copper with occasional use of silver or gold plating. Anyone who has tried to solder to a chrome-plated, or to an aluminum chassis, will know that this does not work. Very special techniques are required for this. Aluminum soldering in particular has been the subject of considerable research and a number of special methods have been developed. The main problem is that aluminum oxidizes very rapidly as the temperature goes up and special fluxes, ultrasonic cleaning, and even soldering in a controlled atmosphere have had only limited success. The only approved method of joining aluminum is the welding technique in which a helium atmosphere covers the welded area.

The *Circon* Pulse-Dot Micro-Soldering System combines the quick heat characteristic of the soldering gun with the small size of a soldering pencil and provides the added features of foot-switch control and carefully measured solder. The circuit of this system is shown in Fig. 2 and consists of a variable autotransformer followed by a step-down transformer connected to the soldering loop. Temperature control is obtained by an approximate setting of the autotransformer and by the length of the time during which the foot switch is kept depressed as shown by the neon indicator light. The small soldering loop is mounted in a pencil-type handle and, in practice, the operator dips the loop into the flux and then, with the sticky loop, picks up a solder ball. *Circon* furnishes solder balls in 12 graded sizes from .005 to .06″ in diameter and each solder ball is gold-plated to prevent oxidation during storage. Solder ball and flux are deposited at the point to be soldered, the loop is held against the joint, and the foot switch is depressed and released when the solder joint is complete. Standard soldering loops are available from one to three watts and are made of .015″ to .025″ diameter nichrome wire. Because of the small size, this soldering system is normally used together with a binocular microscope and is an ideal and inexpensive method for hand soldering small quantities of microelectronic circuitry.

Automatic Temperature Control

As we have mentioned, the soldering temperature has a vital influence on soldering reliability, and therefore many soldering systems, from the hand-held pencil iron to automatic-wave soldering, use some type of automatic temperature control. Like any automatic control scheme, there is a sensing device, either a thermocouple, thermistor, or thermostat, which controls the heating current. Of the many different systems now becoming available, we have chosen two as illustrative examples which we will discuss at some length.

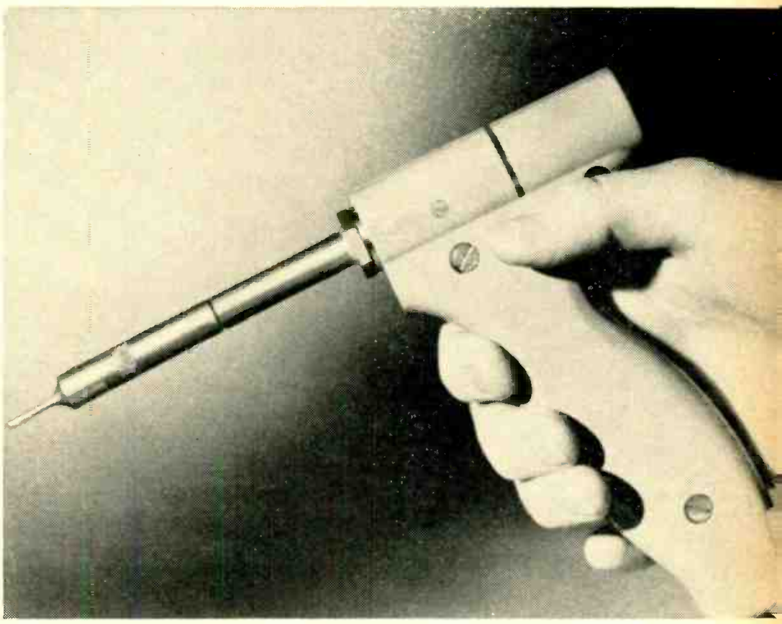


Fig. 1. A pistol-grip soldering iron designed for light to medium production jobs in electronics and communications work.

The first is unique because of its simplicity and because it uses a rarely applied physical property. When a ferromagnetic material, such as an iron alloy, is heated, it loses its magnetic property at a certain temperature. This temperature is called the "Curie point" of the particular material. In the *Weller Electric Corp.* soldering pencil shown in Fig. 3, the Curie-point effect is used in a novel and ingenious way.

As illustrated in Fig. 3, the soldering-iron tip contains a temperature-sensing element made as a disc of nickel-iron alloy to which a permanent magnet is attracted. At a given temperature, the Curie point of this particular alloy loses its magnetic properties and the magnet is then retracted by a spring to open the power switch and thus disconnect the heating current. As soon as the temperature drops, the magnetic properties of the nickel-iron disc are restored, the permanent magnet pulls up again, and the power switch is closed.

The actual temperature is therefore controlled by the magnetic and temperature characteristic of the nickel-iron temperature-sensing disc. By using different mixtures of this alloy, tips with temperatures of 500°, 600°, and 700°F are available as standard values. Other temperatures can be furnished on special order. For temperatures between 200° and 450°F, this company offers a soldering pencil whose temperature is controlled by a thermistor which, in turn, controls a silicon controlled rectifier circuit.

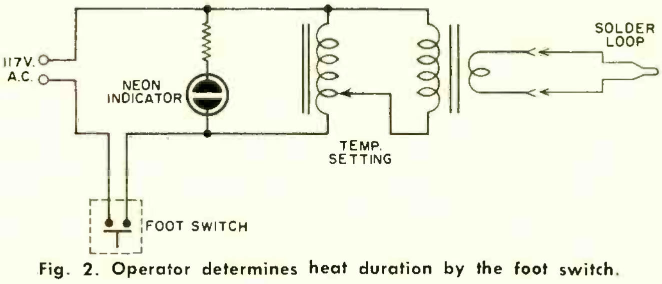
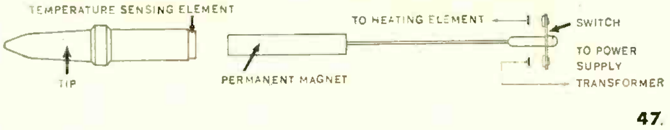


Fig. 2. Operator determines heat duration by the foot switch.

Fig. 3. Curie-point magnetic temperature control. When the temperature-sensing element reaches a certain temperature, it loses its magnetic property, allowing switch to snap open.



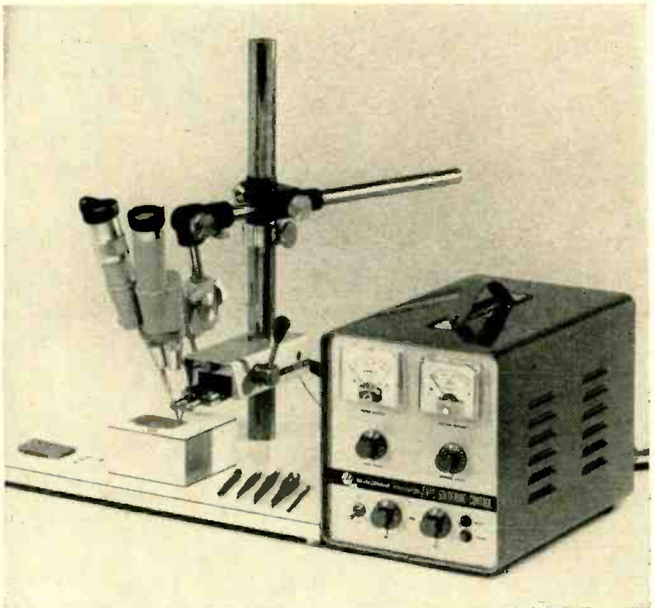
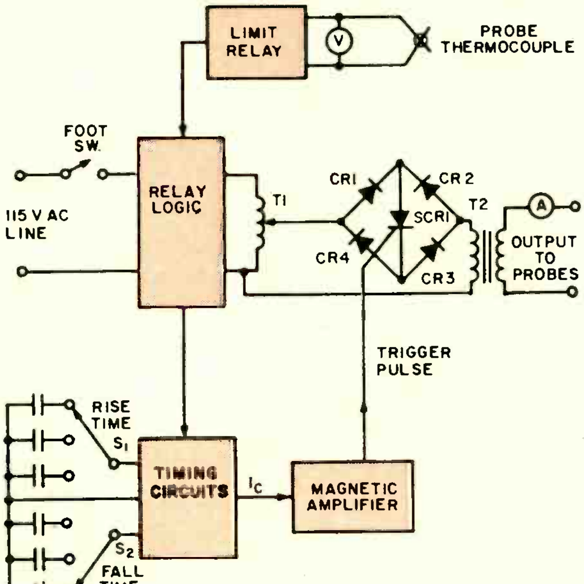


Fig. 4. Resistance soldering fixture allows control of both heating and cooling times. The microscope aids in positioning.

The second example of automatic temperature control is a sophisticated system of precision soldering, designed especially for soldering microelectronic circuits. Shown in Fig. 4, the *Development Associates* system consists of a resistance soldering fixture and control unit. A binocular microscope is used to observe the positioning of the soldering fixture and the formation of the solder joint. Not shown is a foot switch which starts the soldering cycle. Until the foot switch is depressed, the fixture is cold and the two soldering probes are positioned (through the microscope) on the joint to be soldered. Usually, the printed wiring board to which the microelectronic circuits are to be soldered is pre-tinned so that sufficient solder is deposited on the pad, but it is also possible to apply solder during the soldering cycle. Once the soldering probes are positioned, they are lowered down onto the lead ribbon and held against the pad with a preset pressure. When the foot switch is depressed, a.c. is applied across the two soldering probes, heating up the ribbon and melting the solder. The heating cycle can be carefully adjusted for the particular type of solder joint, and once this adjustment is made, the cycle will then be automatically repeated for every subsequent soldering operation that may be required.

Fig. 5. In resistance soldering unit, the timing circuit determines how long an SCR passes current to the solder probes.



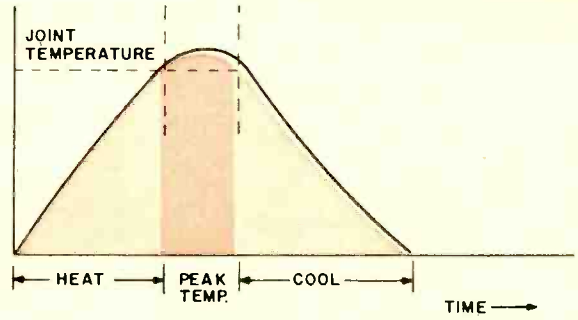


Fig. 6. In resistance soldering unit, heat and cool cycles can be individually controlled to suit the particular need.

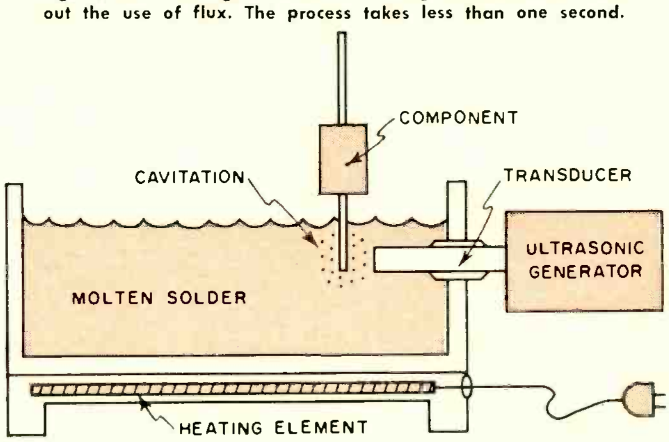
The diagram of Fig. 5 shows the electronics used to control the heating cycle. One of the two soldering probes contains a thermocouple, the output of which can be adjusted for the maximum desired temperature. Two switches control the heating (rise) time and cooling (fall) time. A magnetic amplifier is driven by the timing circuit and controls the SCR which, in turn, controls the current to the output transformer *T2*. When the foot switch is depressed, the relay logic connects *T1* to furnish power to the SCR and its diode bridge and also starts the rise- or heating-time timing circuit. The SCR, controlled by the magnetic amplifier, allows more and more current to reach *T2* and the solder probes. When the limit relay is tripped by the thermocouple, the relay logic stops the rise-timing and starts the fall- or cooling-timing circuit. The result can be plotted as a graph and is shown in Fig. 6 which illustrates that the heating and cooling cycles can be individually controlled. While not suitable for automatic production, this soldering fixture is very valuable for breadboard and prototype equipment assembly of microelectronic circuits onto printed wiring boards or other fine soldering.

Ultrasonic Soldering

Practically all soldering depends on the chemical cleaning action of the flux. This chemical action invariably produces corrosion and all fluxes leave a residue which is also corrosive to some extent. When a claim is made that a particular flux leaves a non-corrosive residue, this merely means that the corrosion will take a longer time. For this reason, some cleaning after soldering is always necessary if high reliability of solder joints is required. The solder used for hand soldering in the electronics industry usually contains a flux, either as a single core or as several thin strands within the solder itself. The most widely used fluxes are activated resin compounds which can easily be cleaned off with alcohol or any of the chlorinated flux removers.

To eliminate the requirement for a flux of any kind, ultrasonics can be used. For this process, pre-tinning and solder-dipping rather than hand (*Continued on page 86*)

Fig. 7. Ultrasonic agitation allows tinning of components without the use of flux. The process takes less than one second.



A basic explanation of laser action which results in the production of an intense coherent beam of light.

THE LASER-
A THREE-STEP DEVICE

By WILLIAM H. MURRAY
Physics Department
Temple University Technical Institute

THE need for a laser-type device (which produces *l*ight *a*mplification by *s*timulated *e*mission of *r*adiation) has only recently been recognized—within the past decade. The present communications spectrum, including all frequencies and microwaves, has a total bandwidth of about 30,000 megacycles. On the other hand, the visible part of the spectrum is about 300,000,000 mc. wide. It is obvious that the development of coherent-light (same phase) devices, such as lasers, for the optical frequencies would have a significant impact on communications.

As the volume of information increases, for example, on coast-to-coast television and telephone hookups, more and wider channels are needed. With the large bandwidths that will be available with a laser communications system, infinitely greater amounts of information can be transmitted. Point-to-point communications in space is another application of the laser. The laser will be able to boast better transmission per pound equipment weight than other types of communications gear that is in current use.

How it Works

A laser is a device which converts energy of one form or another into an intense and narrow beam of optical electromagnetic radiation. There are three essential requirements which must be met in order to produce a working laser system. The light amplifier must contain an active laser material, an optically resonant cavity, and a very intense energy source. In the pulsed ruby laser system, a ruby rod serves as the active material—its silvered ends in conjunction with the active material act as the optically resonant cavity, and an intense white light is used as the external energy source.

The process of fluorescence, much like that found in an ordinary fluorescent lamp, must be understood before one can venture into the realm of stimulated emission.

A fluorescent material when exposed to a specific frequency or band of frequencies will emit light, usually at a lower frequency than that of the stimulator. In the case of a fluorescent lamp, ultraviolet light stimulates the fluorescent coating on the inside of the tube which gives out a visible white light.

In the ruby rod of the pulsed laser, green light is absorbed as the exciter. When the rod is exposed to a "quantum" of green light, it emits red light of a defined lower frequency. To obtain the red fluorescence, an impurity consisting of chromium replaces a small amount of the ruby material. As in the transistor, this impurity is used in a carefully controlled proportion.

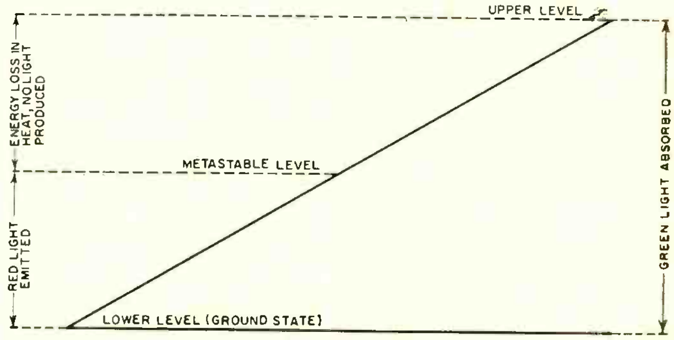
Atoms cannot store energy in different amounts when they are at rest. It is, therefore, necessary to talk of "energy levels" when referring to the amounts of energy an atom can store. In the pulsed ruby laser there are three major energy levels. Atoms usually tend to remain in the lowest of the energy levels. They can be moved to a higher energy state by absorbing energy (in our case, visible light), and from the higher state back to a lower state by emitting energy. While we are here concerned with a "white-light" source as the exciter, the energy may be in the form of heat, ultraviolet, or other types of radiation. Just as these atoms exist in defined energy levels, they can be stimulated by light only of a specific frequency. The difference in energy between any two of the energy levels is proportional to the critical output frequency.

The green portion of the white light flooding the ruby crystal is absorbed by the rod, exciting some of the chromium atoms to higher energy levels or excited states. This "pumping action" actually transfers the atoms from the ground state (the lowest level) into a broad excited level. The time the chromium atoms spend in the upper energy level is approximately 10^{-7} second. Then in a radiationless transition, involving an interaction with the crystal lattice, the atoms "relax" to an intermediate or metastable level. The atoms then "relax" at a much slower rate (approximately 10^{-3} second) from the metastable level to the ground state. During this last transition, energy is given off in the form of a "quantum" amount of red light with a wavelength of 6943 angstroms. The three-level system is shown in Fig. 1.

The laser system uses the process of stimulation to force the atoms from the metastable level to the ground state more readily. Stimulated emission of light, in contrast to spontaneous emission, distinguishes the laser from the ordinary fluorescent lamp.

Let us suppose the red light produced by the fluorescent process travels from the left to the right (Fig. 2). We can assume the ruby rod to be an active medium since most of the chromium atoms are in the upper energy level (shaded). When a light wave of the proper frequency (red light) strikes one of these excited chromium atoms, the atom is forced to emit energy of the same frequency, thus increasing the original light wave. Since the (*Continued on page* 64)

Fig. 1. With a drop in energy level, light is emitted.



A high-fidelity stereo phono cartridge using a new operating principle, with a response from d.c. to over 30 kc. Unit has low impedance and high output permitting its use with transistor audio circuits.

A NEW SEMICONDUCTOR PHONO TRANSDUCER

By JOHN F. WOOD
President, Euphonics Corp.

A NEW hi-fi stereo phono cartridge has been developed that has an RIAA flat response, that operates down to d.c. and up beyond 30 kc., and that delivers increased power to low-impedance amplifiers. It is a semiconductor transducer that does *not* obtain all its energy from the record grooves. The cartridge, Model U-15 manufactured by the *Euphonics Corp.*, is essentially a modulating and amplifying device—not a reciprocal generator as is a ceramic or magnetic type. At low impedance it can supply more than 100 times the electrical power of ceramic cartridges and 10,000 times the electrical power obtainable from magnetic cartridges—making it ideal for use with transistor circuits. All the usual requirements for the highest level of transducer performance are met and exceeded.

Velocity and Amplitude Devices

All magnetic phono cartridges generate voltage as a result of a relative motion of a magnetic field and a coil. The faster the conductors are cut by a field, the higher the voltage. Thus, the magnetic cartridge has an output that rises with frequency, assuming a constant-amplitude recording. Obviously, this generated voltage is related *not* to the amplitude of stylus motion but to stylus *velocity*.

In order to reproduce the standard RIAA response, which is fairly close to constant amplitude, about 40 db of equalization (bass boost and treble roll-off) must be provided from one end of the spectrum to the other. This is the function of the preamplifier-equalizer circuit in an amplifier's magnetic input circuit. In a practical magnetic cartridge, output voltage may be listed as 5 millivolts at 1 kc. However, by extending this down in frequency as required by the RIAA characteristic, one arrives at the 30-cycle output voltage of only about .5 millivolt. Not only is this a rather weak signal voltage to amplify readily, but the frequency is in the range of induced hum from nearby power equipment.

Cartridge types that produce a voltage proportional to stylus excursion (amplitude) include crystals and ceramics. Both use piezoelectric elements, which produce an electrical charge when stressed. Since they are high-impedance capacitive elements, they are best suited for vacuum-tube circuits.

Wide-range RIAA response can be obtained from ceramics, if properly designed and provided with high-impedance loads. The ceramic elements are not affected by heat or moisture, and low mass permits good high-frequency response. However, it is not practical to obtain capacitance values that are optimum for conventional transistor circuitry. The highest value of capacitance it is economical to obtain is less than 10,000 pf., which is a reactance of 500,000 ohms at 30 cps.

A Semiconductor Cartridge

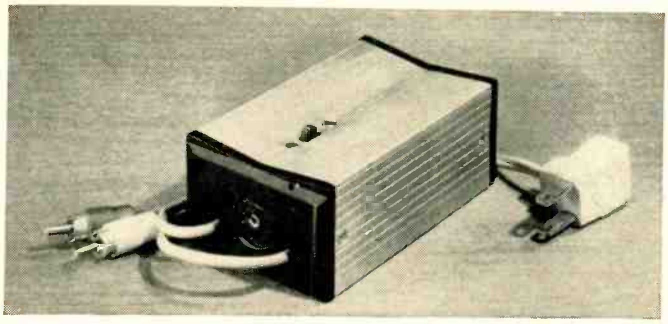
Several novel systems have been investigated by our laboratory over the last five years in an effort to find the ideal cartridge. It became evident that the most promising avenue was related to the transistor.

The new U-15 transducer employs a pair of specially doped silicon semiconductor elements. Each element, measuring about 1/16" square by .005" thick, is mechanically coupled to the stylus through a force-resolver yoke. Vibrations in the record grooves cause minute compressions of the silicon elements. When this occurs, the resistance of the elements varies in accordance with the modulation of the grooves. If a low current, on the order of 10 ma., is passed through the elements, this current is modulated by the changing resistance. The principle is similar to that of a strain gage except that here the conversion efficiency is much greater.

By properly coupling the generating element to the stylus, very high compliances can be achieved. Since the generating element is inherently low impedance (around 1200 ohms), it is suitable for transistor circuitry.

Because it is basically an *ohmic* device, this semiconductor transducer will respond to steady-state signals. Also, its low mass and inherent damping permit smooth, amplitude-type

The semiconductor phono cartridge is shown here mounted in the manufacturer's matching tonearm.



Power source for the new semiconductor phono cartridge. Silicon diode supplies the low d.c. voltage that is required.

response to well beyond the normal audio-frequency range.

The low mass is achieved by mounting a very small bi-radial diamond stylus on a thin-wall aluminum tube. The reflected mass from the internal assembly is decoupled by the lever system and a resilient force resolver, allowing an effective stylus-point mass of less than one milligram. Control of damping within the assembly provides for the minor RIAA crossover adjustments in the mechanical system.

Response of a typical unit is plotted in Fig. 1. Since record response extends only from 30 cps to 12 kc. in this case, the extended range was obtained by speeding up and slowing down the record. Thus, at 78 rpm, this test record provides 78/33 × 12 kc., or 28 kc.

The silicon elements with their mountings have an inherent cosine or figure-eight polar response pattern. In other words, they produce maximum output when compression occurs along one axis and no output for compression at right angles to this axis. The nulls on this pattern for one of the elements are oriented 90° from the opposite-channel element for maximum cross-channel rejection.

In addition, a proven force-resolver coupling device between the stylus shank and the two independent elements insures good separation. The legs of the resolver are only .020" long but contribute both compliance and damping to the system. Further distributed damping is provided by an inert and stable silicone compound which also dissipates the small amount of heat developed in the elements.

The lower curve in Fig. 1 indicates typical separation throughout the range. Due to the extended low-frequency response and the very low crosstalk signal, a rumble filter is necessary for accurate separation measurements.

Transient Tests

Extension of the system response beyond the range of hearing has been discussed in many technical papers, and the importance of smooth, wide-range response to the reproduction of transient signals is well established. The square-wave test demonstrates this and reveals any resonance that may cause ringing or spurious response.

We should at this point take note of certain facts about square-wave tests. Obviously, it is impossible to trace or reproduce an actual square wave from a phonograph record. Therefore, what is really recorded is an *integrated* square wave—which is triangular. (You can verify this by taking a record labeled "square wave" and examining the grooves with a magnifying glass.) A velocity-sensitive device such as a magnetic cartridge will differentiate this triangular wave into the familiar square wave shown in various articles and reports. However, if we then feed this square wave into the magnetic preamp-equalizer circuit, we once again get the original triangular wave, or what's left of it.

It should be emphasized that these triangular-wave tests are very useful, as long as they are interpreted properly. Good high-frequency response is indicated by clean, sharp corners (on either the triangular or square waves). Rounded, blunt corners indicate poor high-frequency response. Extra

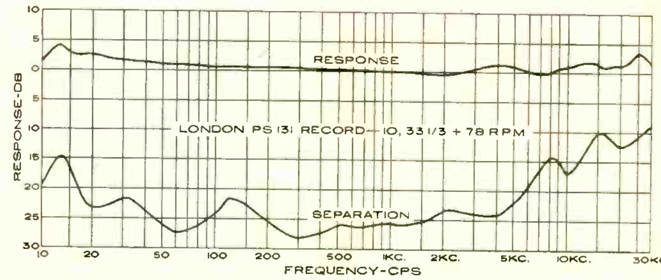
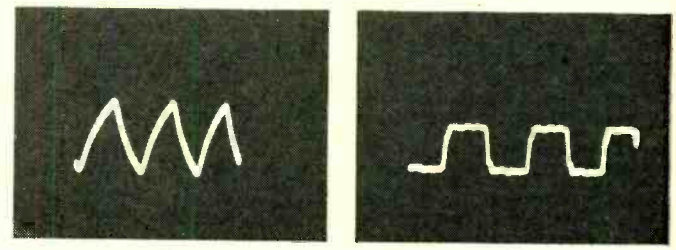


Fig. 1. Response and separation curves measured by the manufacturer.



A B

Fig. 2. Triangular and square-wave response of the cartridge.

waveforms superimposed on the basic shape are evidence of spurious resonance or "ringing." Both good high-frequency response and lack of ringing combine to produce good transient response—the ability to reproduce with accuracy complex or rapid changes in waveform. Low-frequency response is indicated by the direction of curvature of either waveform.

Waveforms of the new semiconductor transducer are shown in Figs. 2A and 2B. Fig. 2A shows the triangular output waveform. When this waveform is differentiated, the result is the more familiar form shown in Fig. 2B. Note that in both cases very little ringing is evident and corners are sharp. The slight curvature of the triangular wave is due to the RIAA equalization, which is not an exact constant-amplitude curve.

Circuit Considerations

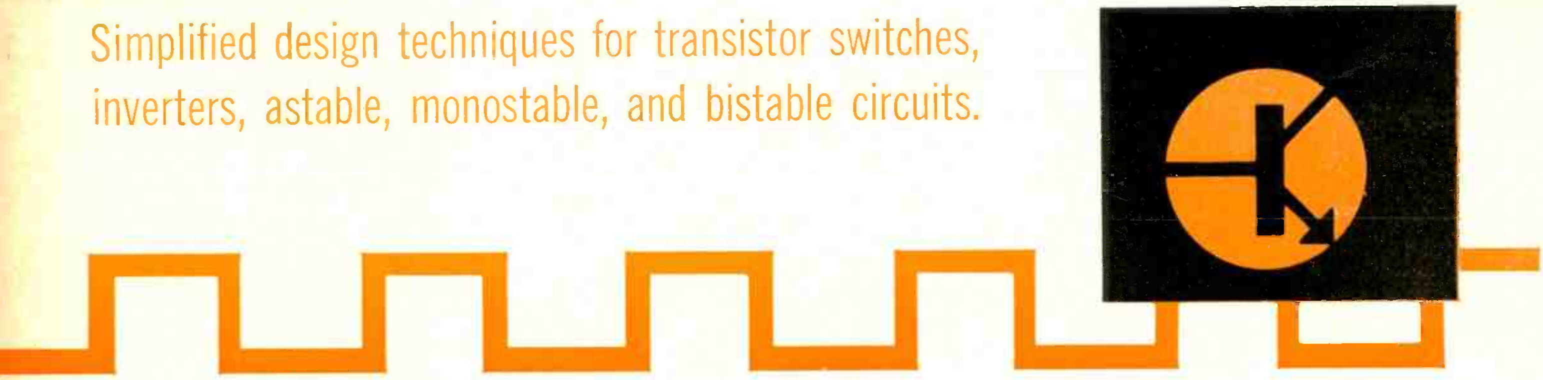
Since the U-15 is a modulating device requiring external power, associated circuits consist only of load resistors and a power source. Each of the silicon elements employed is capable of dissipating .2 watt maximum. However, a current of 10 ma. or less in each stereo element is recommended to keep the power down to .1 watt. A 2000-ohm external series load resistor may be used if source voltage is 20 volts or less. Under these conditions, output voltage is approximately 25 mv. r.m.s., with a source impedance of 750 ohms. If supply voltage can be increased along with load resistance, constant-current conditions can be approached to obtain several db more output. Thus, under maximum ratings and constant-current conditions, about 80 mv. can be obtained.

A typical circuit with load resistors is shown in Fig. 3. Note the stereo balance pot (*Continued on page* 97)

Table 1. Preliminary specification of the U-15 cartridge.

ELEMENTS	Silicon semiconductor (unaffected by heat or moisture)
RESPONSE	D.c. to beyond 30,000 cps
SEPARATION	Better than 25 db
COMPLIANCE	20×10^{-6} cm./dyne
TRACKING FORCE	.75 to 3 grams
WEIGHT	2 grams
STYLUS	.0009 × .0002" bi-radial low-mass diamond (easily replaceable)
OUTPUTS	RIAA flat, for ceramic/auxiliary inputs (high level) Velocity-equalized, for magnetic inputs (low level)
OUTPUT IMPEDANCE	Matches all high- and low-level inputs
MOUNTING	½ × 7/16" centers (standard)

Simplified design techniques for transistor switches, inverters, astable, monostable, and bistable circuits.



DESIGN OF TRANSISTOR MULTIVIBRATORS

By LOUIS E. FRENZEL, JR.
Gulf Aerospace Corporation

MOST electronic technicians are familiar with the operation and application of multivibrators, but the design of such circuits is not as well known. In view of the versatility and wide use of multivibrators, design procedures for such circuits should be understood. The information given in this article will help any technician to design simple, usable transistorized multivibrator circuits for a variety of control operations.

By way of review, there are three basic multivibrator types—the astable, the monostable, and the bistable. The astable or free-running multivibrator is an oscillator whose output waveform is approximately rectangular, and whose frequency, duty cycle, and amplitude are easily controlled.

The monostable multivibrator produces a single rectangular-shaped output pulse every time it receives a trigger pulse at its input. The duration of the output pulse is a function of the circuit components. This circuit is also known as a single-shot multivibrator.

A bistable multivibrator is a circuit that has two outputs, either of which can assume one of two different states. While one output is on, the other is off. When an external trigger pulse is applied, this condition reverses, and the circuit will remain in this state until another trigger pulse is applied. Because of this circuit action, the bistable multivibrator is commonly called a flip-flop.

The applications of multivibrator circuits are almost limitless, and while it would be virtually impossible to list all of them, following are several of their many uses.

The astable multivibrator will make a good code-practice oscillator. Connect a set of earphones between one of the collectors and ground through a 1-μf. capacitor and put a key in series with one of the emitter leads. This same oscillator will also make a good signal generator for troubleshooting audio, video, and pulse amplifiers.

By replacing the collector load of the output transistor in the monostable circuit with a relay of equivalent resistance, a time delay will result. The closing of the relay will be delayed after the application of a trigger pulse for a time equal to the pulse width W. This circuit is very useful where the timing or sequencing of operations is essential.

The bistable multivibrator is an excellent two-to-one frequency divider. Driving a flip-flop with an astable multivibrator will produce a bistable output whose frequency is exactly one-half of the astable frequency. Cascading flip-flops produces a series of harmonically related signals.

Transistor Switches

Multivibrator circuits are nothing more than automatic switches that turn the supply voltage off and on in accordance with internal circuit components, external triggers, or both. Transistors are excellent switches and for this reason are nearly perfect for multivibrator circuits. When the transistor is in a cut-off state, it acts as a very high resistance or an open switch. If the transistor is made to conduct heavily, it acts as a very low resistance or a closed switch. Fig. 1 shows operation of such a transistor switch.

It will be recalled from basic transistor theory that for a transistor to conduct, its emitter-base junction must be forward biased. The transistor in Fig. 1 is cut off if the base voltage is zero and the collector supply voltage is V_{cc}. At this time, no current flows through the transistor or collector resistor R_c, and the output voltage is equal to V_{cc}. When a positive voltage is applied to the base, the emitter-base junction becomes forward biased and the transistor conducts. If the voltage applied to the base is great enough, sufficient base current will flow and cause the transistor to saturate. A transistor is saturated when both emitter-base and collector-base junctions are forward biased. At this time the transistor's resistance becomes very low—less than one ohm in many cases. Because of the extremely low value of transistor resistance, the current flowing through the transistor and R_c is very nearly equal to V_{cc}/R_c. The transistor is acting as a closed switch connecting the bottom of R_c to ground. The output signal at this time is essentially zero. (It is actually some small value since the transistor has a finite resistance.)

The transistor switching circuit of Fig. 1 is commonly known as an inverter. If a pulse is applied to the input through base resistor R_b, the output will be a pulse of the same duration with an amplitude V_{cc} and 180° out-of-phase with the input pulse. This action is shown by the waveforms of Fig. 1B.

To insure a low "on" resistance for the transistor, the base current must be large enough to drive the transistor into saturation. The value of this base current I_b depends on two main factors, the collector current I_c and β. The term β (*beta*) is defined as I_c/I_b. It is easy to see that if β and I_c are known, the base current I_b can be found from the expression I_c/β.

The design procedure for transistor switches involves the selection of a suitable transistor and supply voltage and the calculation of the proper base and collector resistors. To illustrate a basic design procedure, let's design an inverter circuit like that of Fig. 1A using the expressions just covered.

Suppose that we have a transistor with a β of 50 that will stand a maximum collector voltage of 25 volts and a maximum collector current of 100 ma. (.1 ampere). This information is found in any transistor data sheet. First select a supply voltage V_{cc}. Naturally it must be below the maximum rating, so let's choose 10 volts. Next pick a value of collector resistor R_c. A value of 1000 ohms is reasonable. Now calculate I_c when the transistor is on. Remembering that when the transistor is on, the collector current is V_{cc}/R_c, I_c is found to be $I_c = V_{cc}/R_c = 10/1000 = .01$ ampere or 10 ma. This is well below the maximum rating of 100 ma. From the above expression it can be seen that any value of resistance giving an I_c less than 100 ma. could be used. In this case any value more than 100 ohms ($R_c = V_{cc}/I_c = 10/.1 = 100$ ohms) would work. This value of collector resistor does not consider external loads or base drive needs.

We can now calculate the value of R_b. First assume that the base is to be driven from a 10-volt source which we can call V_s. The value of the base resistor R_b is equal to the voltage across R_b divided by the base current I_b. The voltage across the base resistor is equal to $(V_s - V_{be})$ where V_{be} is the emitter-base junction voltage when I_b is flowing. Normally this is only a few tenths of a volt for good switching transistors, so that V_{be} can be considered negligible compared to V_s. For all practical purposes then, the voltage across R_b is V_s (10 volts). To find R_b, simply solve equation $R_b = V_s/I_b$. The base current I_b is found from the previously given expression $I_b = I_c/\beta$. Since $\beta = 50$ and $I_c = .01$ ampere, $I_b = .01/50 = .02 \times 10^{-2} = 200$ microamperes, therefore $R_b = V_s/I_b = 10/.0002 = 50{,}000$ ohms.

Having chosen V_{cc} and R_c and calculated R_b, the design is complete. The multivibrator design procedures to be described use basically the same technique.

Astable Design

The three formulas used in designing an astable multivibrator are: $R_c = V_{cc}/I_c$, $R_b = \beta R_c/S$, and $C = 1/1.39R_bf$.

Choosing a transistor with known characteristics, selecting a suitable supply voltage, and using the previous formulas are all that is necessary to produce a suitable design.

Fig. 2A shows the astable multivibrator circuit. Essentially it consists of two transistor inverters connected to one another by capacitors. In this circuit, the transistors receive their base current from the main collector supply V_{cc} rather than an external source like V_s in the inverter example given earlier.

The entire design procedure is as follows:

1. Specify circuit characteristics. Before we can design the circuit we must know what we want. For the astable multivibrator, the frequency and output voltage are the characteristics we must know. In all of these circuits, the output voltage will be equal to the supply voltage V_{cc}. The frequency must also be chosen, so for this example let's use 800 cps.

2. Choose a transistor. There are many types of transistors to choose from and the final choice is largely individual preference. From a transistor manufacturer's catalogue, select a switching transistor that meets your cost, size, and frequency requirements. For our example we will choose the 2N1304. This is a good, inexpensive switching transistor that is made by several manufacturers. After you choose the transistor, be sure to obtain a data sheet on it. This sheet will give you information on the transistor that will be used in the design. If no data sheet is available, most of the necessary specifications can be obtained from the manufacturer's catalogue.

3. Select a supply voltage V_{cc}. This d.c. supply voltage is selected now that the output voltage and transistor voltage ratings are known. The supply voltage V_{cc} will be equal to the desired output voltage and should be less than the maximum emitter-base and emitter-collector ratings given in the data sheet. Assume a 12-volt V_{cc} for this problem. This is well within the 25-volt rating of the 2N1304.

4. Calculate R_c. The collector resistors R_c are calculated by using the formula V_{cc}/I_c. We know V_{cc} but not I_c. The collector current I_c should be less than the maximum rating of the transistor, which here is 300 ma. The choice of I_c is rather arbitrary, but a value of 10 ma. is satisfactory. The transistor data sheet will sometimes give a clue to a practical I_c value. Most manufacturers give the transistor specifications for one value of I_c. Design is simplified if this value is used since the other specifications can be taken directly from the data sheet. Using I_c as 10 ma., R_c is found to be $V_{cc}/I_c = 12/.01 = 1200$ ohms. A standard 1200-ohm, ½-watt resistor can be used.

5. Calculate R_b. As shown earlier, $R_b = \beta R_c/S$. This formula was derived from the expressions given in the inverter design. *Beta* (β) is taken from the data sheet, and it may be found listed as h_{fe} instead of β. Always use the minimum value given. This is 40 for the 2N1304. *Beta* is difficult for transistor manufacturers to control economically, so they usually rate the transistor over a wide range and only ensure the *beta* to be greater than some minimum value. *Beta* also changes with age and temperature, so it is nearly impossible

Fig. 1. (A) Simple transistor switch. (B) Switching waveforms.

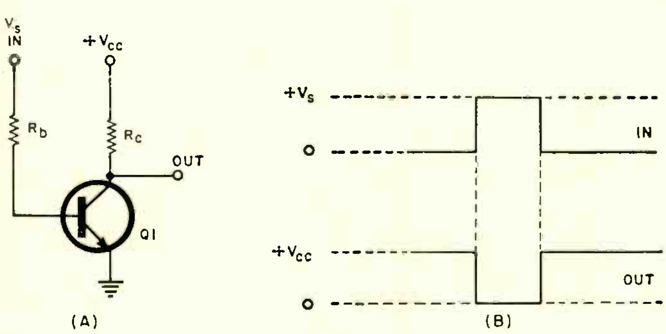
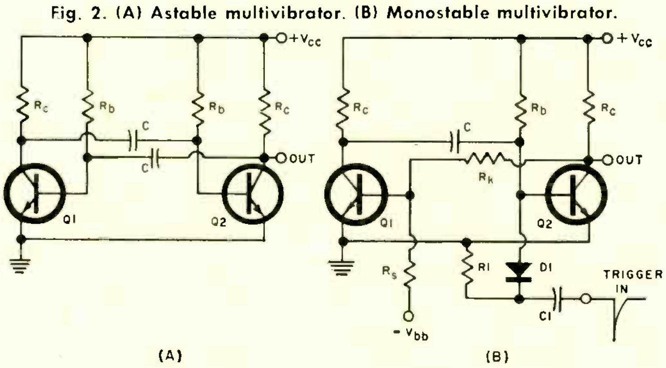


Fig. 2. (A) Astable multivibrator. (B) Monostable multivibrator.



to predict the *beta* of the transistors you buy. To overcome this difficulty and to ensure transistor saturation during switching, we use the minimum β value given by the manufacturer and a safety factor S. The safety factor is not critical and can be anything between 2 and 10. Three is a reasonable value. Knowing β, S and R_c; R_b can now be found as $R_b = (40 \times 1200)/3 = 40\ (400) = 16{,}000$ ohms. A conventional 16,000-ohm, 5% resistor could be used, but the less expensive 15,000-ohm, 10% unit would work satisfactorily.

6. Calculate C. The last step is to solve for the value of C that will make the circuit oscillate at 800 cps. Using the formula $C = 1/1.39R_bf$, C is easily found to be:

$$C = 1/(1.39 \times 15{,}000 \times 800) = 1/(1.67 \times 10^7) = .06 \times 10^{-6} = .06\ \mu f.$$

Monostable Design

The design procedure for monostable multivibrators is basically the same as that for the astable circuit. All of the previously given formulas are used with the following exceptions and additions: (*a*) in step 1, specify an output pulse width instead of an operating frequency, remembering that this width must be less than the time between input trigger pulses; (*b*) $R_k = R_b$; (*c*) $R_s = 5\ R_b$; (*d*) C now equals $W/.69R_b$, where W is the specified pulse width in seconds; and (*e*) $V_{bb} = V_{cc}$.

The monostable circuit is shown in Fig. 2B. The additional supply voltage V_{bb} and resistor R_s have been added to ensure the cut off of transistor Q1 at high operating temperatures where the transistor leakage current (I_{co}) becomes excessive. V_{bb} reverse biases the emitter-base junction of Q1 through R_s to do this. The value of V_{bb}/R_s should be greater than the maximum value of I_{co} given in the transistor data sheet. If a good, low-leakage transistor is used and no high-temperature operation is anticipated, then V_{bb} and R_s can usually be eliminated.

As before, a design example best illustrates the procedure.

1. Let the pulse width W be specified at 50 milliseconds (.05 second).

2. Again choose a transistor with a β minimum of 40. In this example, we will again use the 2N1304.

3. Let the output voltage, V_{cc} and V_{bb} equal 22.5 volts.

4. $R_c = V_{cc}/I_c$. Again letting $I_c = 10$ ma., $R_c = 22.5/.01 = 2250$ ohms. A standard 2200-ohm, ½-watt unit will suffice.

5. $R_b = \beta R_c/S$. Using $B = 40$ and $S = 3$, $R_b = (40 \times 2200)/3 = 29{,}300$ ohms. Use a standard 27,000-ohm resistor.

6. $R_k = R_b = 27{,}000$ ohms.

7. $R_s = 5\ R_b = 5(27{,}000) = 135{,}000$ ohms. Since this value is not too critical, a standard size 120,000- or 150,000-ohm unit would work. Use 150,000 ohms.

8. $V_{bb}/R_s > I_{co}$ maximum. The maximum value of I_{co} for the 2N1304 is given as 6 microamperes. $V_{bb}/R_s = 22.5/150{,}000 = 1.5 \times 10^{-4} = 150\ \mu a$. Cut-off of Q1 is guaranteed since V_{bb}/R_s is much greater than 6 μa.

9 .$C = W/.69R_b = .05/69 \times 27{,}000)$. $C = 2.68 \times 10^{-6} = 2.68\ \mu f$.

The design is complete except for components D1, C1, and R1. Diode D1 can be any good germanium or silicon diode. R1 and C1 are chosen to have a short time constant so that they differentiate the trigger pulse. Operation will be satisfactory if $R1 = 10{,}000$ ohms and $C1 = 100$ pf. A negative trigger pulse amplitude of approximately 6 volts or more is needed to operate the circuit in a reliable fashion.

Bistable Design

A conventional bistable multivibrator circuit is shown in Fig. 3. The design technique is exactly the same as that for the monostable multivibrator. In fact, the values of R_c, R_k, R_s, V_{cc}, and V_{bb} obtained for the monostable circuit can be used in the circuit of Fig. 3 to form a workable flip-flop. Only values for R_t, C_t, and C_k are needed.

Capacitor C_k is called a speed-up capacitor because it decreases the switching time it takes for one transistor to turn off and the other to turn on. It is not really needed for operation below about 10 kc., but it is essential for higher frequencies and it is a good idea to include it. The value of C_k can be found with the formula $C_k = t/100R_k$ where t is the time between trigger pulses. If the trigger pulse frequency (f) is known, $t = 1/f$. The formula above gives only an approximate value for C_k, and for critical applications C_k should be found experimentally (usually between 50 and 200 pf.).

Resistor R_t and capacitor C_t along with D1 and D2 make up the triggering network. R_t is usually made equal to ten times R_c, and C_t is found from the expression $C_t = t/100R_t$ with t being the trigger pulse interval. Like the value of C_k, C_t given by this formula is only approximate and the best value should be found experimentally (usually 100 to 500 pf.).

To complete the design of a typical flip-flop, use all of the pertinent values from the monostable design and calculate C_k, C_t, and R_t with the above formulas.

Assume a trigger pulse frequency of 1000 cps. The trigger pulse interval is $t = 1/f = 1/1000 = .001$ second. Therefore,

$C_k = t/100R_k = .001/100 \times 27{,}000) = 1 \times 10^{-3}/2.7 \times 10^6 = .37 \times 10^{-9} = 370$ pf.

$R_t = 10R_c = 10(2200) = 22{,}000$ ohms

$C_t = t/100R_t = .001/(100 \times 22{,}000) = 1 \times 10^{-3}/2.2 \times 10^6 = .455 \times 10^{-9} = 455$ pf.

A negative trigger pulse several volts in amplitude is needed to reliably trigger the bistable circuit.

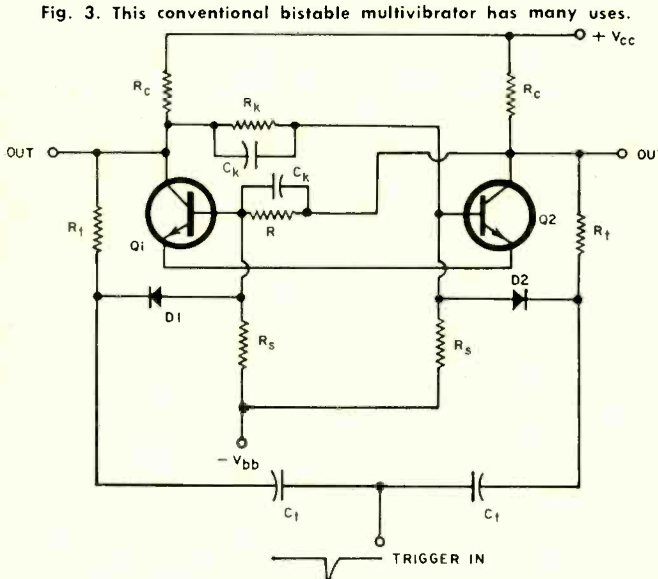
Design Philosophy and Applications

There are several things that should be remembered when designing multivibrators by the procedures outlined.

First, no consideration was given to the loads that might be fed with these circuits. If a high-impedance load (greater than $10R_c$) is used, the formulas will hold true. But if heavier loads (less than $10R_c$) are used, the output will not equal the supply voltage. Instead, it will equal $V_{cc}R_L/(R_c + R_L)$ where R_L is the value of the load resistance. In addition, placing a load on the astable will change its frequency of oscillation.

Second, the formulas used in the designs have been simplified as much as possible. In doing this, some assumptions were made that are not exactly true. Nevertheless, the circuits that will result from these designs are quite satisfactory for all but the most critical applications. Third, *p-n-p* transistors may be used as well as the *n-p-n* units shown here. Reverse all polarities shown or mentioned. ▲

Fig. 3. This conventional bistable multivibrator has many uses.



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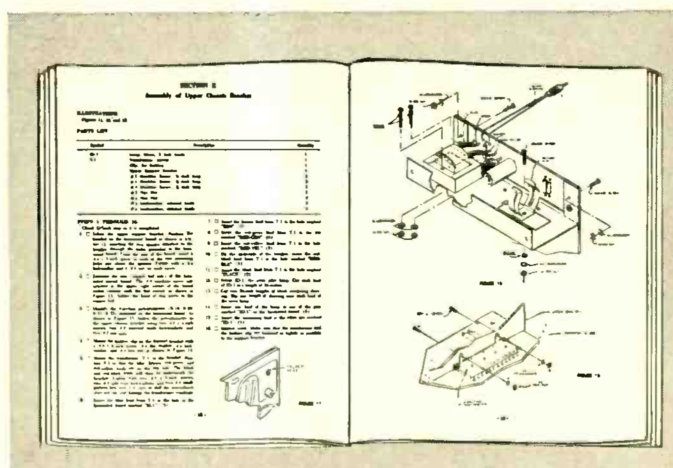

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A NEW GARAGE-DOOR OPENER

A FEBRUARY thaw had finally broken a bone-chilling succession of sub-zero days. When Barney prepared to leave the service shop for lunch, Mac, his employer, suggested:

"You'd better take that new garage-door opener receiver of Mr. Willibanks over to his house and install it on your way back. He phoned while you were out and said he'd chipped the ice away from the bottom of the door so it will operate. He wanted to know if you'd checked out the receiver thoroughly as you promised you would."

"Okay," Barney agreed a little reluctantly, "but I've been having so much fun with the thing I hate to let it go. Really, there's not a thing the matter with the receiver Mr. Willibanks is using now, but he got all worked up because a CB station opened the door a time or so."

"It's something to get worked up about," Mac offered. "An automatic garage door not under the owner's complete control is more worry than it's worth. Not only is it an invitation to theft and vandalism, but it's dangerous. A stray signal may bring it down on a child or your own car while you're driving in or out. Practically all actuating mechanisms have automatic features that stop or reverse the door when it encounters enough resistance, but a door could still injure a small child or damage a moving car. And there's another thing: the instructions warn that Mr. Willibanks' receiver must not receive a signal during the last six inches of door travel. If it does, the door keeps right on going in the same direction and breaks the chain and may damage other parts of the opening-and-closing machinery. Random signals could easily wreck the mechanism of an unattended door."

"No wonder Mr. Willibanks wants a new control!" Barney exclaimed. "The present one uses a 5-watt crystal-controlled transmitter on channel 23 of the Citizens Band. It requires a class C license costing eight bucks, is mounted in the engine compartment, is powered from the car battery, and uses an antenna strung under the front bumper. The r.f. carrier is modulated with an audio tone of 2000, 2900, or 3700 cps.

"In the t.r.f. receiver, the detected audio tone passes through a filter and operates a relay control tube. Actually, receiver selectivity is not good enough to reject strong nearby signals, but the audio filter is quite sharp, and a signal modulated with near the proper tone must be received for an appreciable length of time—say a second—for the door to be actuated.

"Unfortunately, channel 23 is becoming increasingly busy with class D Citizens Band traffic; and if the FCC proposal to concentrate all interstation traffic on this and six other channels goes into effect, that traffic will increase enormously, and so will the chance of the door's being opened accidentally. Any class D mobile station operating near the garage can input a strong r.f. signal to the receiver, even from an adjacent channel, and voice tones or a heterodyne with another carrier can supply the audio signal needed for tripping the actuating relay. Worse yet, some bird-brained CB operators deliberately try to open these garage doors by parking in front of them and switching from channel to channel while whistling rising notes into the microphone."

"What's different about the new control?"

"It's the new *Heath* GDA-20-4 designed to correct the shortcomings of the original model Mr. Willibanks is using now. It's interesting because it's characteristic of the new breed of garage-door transmitters and receivers appearing lately. The transmitter is only about the size of a couple of packages of cigarettes and is self-powered with two flashlight batteries. It can be carried in the purse or glove compartment, or it can be clipped to the sun visor or dash. It requires no external antenna and no operating license.

"The transmitter operates on any one of seven frequencies lying between 230 and 290 mc. Modulation is by any one of six ultrasonic frequencies lying between 16 and 26 kc. The high-frequency and ultrasonic modulation make it most unlikely the receiver will ever respond to the fundamental or harmonic of a voice or music amplitude-modulated transmitter."

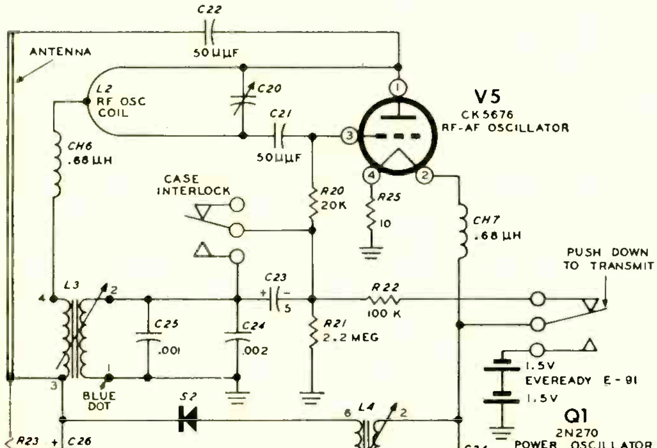
"Why don't you need a license?"

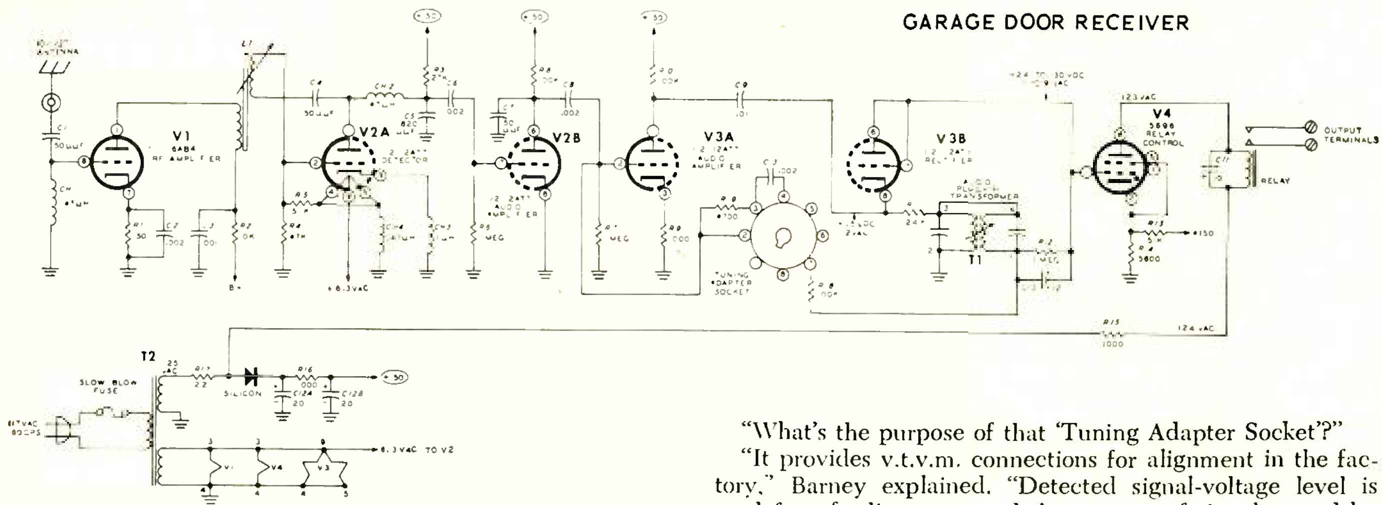
"The transmitter operates under Part 15.211 of the FCC regulations. An unlicensed communications system operating in this band must meet three requirements: (a) field strength at 100 feet must be limited to 150 microvolts per meter, (b) a timing circuit must limit the transmitter duty cycle to one second on followed by 30 seconds off, and (c) no transmitter adjustments must be accessible on the outside of the case. Here, take a look at this transmitter diagram I copied out of the manual. The CK5676 hearing-aid tube operates as a Colpitts oscillator whose frequency is determined by $C20$. The antenna is just a length of heavy wire inside the case."

"I suppose the transistor oscillator supplies the modulation."

"I'm glad you made the same mistake I did. Actually it's the heart of a miniature transistorized power supply that steps

GARAGE DOOR TRANSMITTER





GARAGE DOOR RECEIVER

up the 3 volts available from the flashlight batteries to more than 50 volts for the plate of *V5*. Oscillations of *Q1* are stepped up in the secondary of *L4*, rectified by *S2*, and filtered by *C26*."

"Then where's the audio modulation?"

"Forget about *V5* being an r.f. oscillator and think of it as an audio oscillator with *L3* furnishing the feedback between the plate and grid circuits. The grid winding is tuned by *C24*, *C25*, and the movable slug."

"Hm-m-m-m, so *V5* is oscillating at both a v.h.f. and an ultrasonic frequency at the same time so that the v.h.f. carrier is modulated with the ultrasonic signal!"

"There's more," Barney continued. "When *V5* starts to oscillate, negative voltage developed on the grid starts charging *C23*. After about a second, this voltage rises high enough to cut off the plate current and stop the oscillations. Then *C23* begins slowly discharging through *R21*. After slightly more than 30 seconds, the grid voltage falls low enough for the tube to start oscillating again. This grid-block oscillator action satisfies requirement (b) of the regulations. But isn't *V5* a busy little rascal? It's oscillating three different ways simultaneously!"

"Busier than a one-man band!" Mac agreed. "I see the transmit switch in the 'Off' position bleeds the charge on *C23* off through *R22* to permit sending reasonably close-spaced pulses when needed, say to stop a partially open door."

"Right, and you notice the case interlock switch shorts out *C23* and stops the blocking oscillator action when the case is opened so that the transmitter can be kept on continuously to provide an alignment signal."

"What's the receiver like?"

"I 'just happen' to have a diagram of that, too," Barney confessed, fishing it from his pocket. "*V1* is an untuned r.f. amplifier. *V2A* is a self-quenched super-regenerative detector. While a superregenerative receiver has drawbacks in that it radiates a signal and is not too selective, it provides, *in a single tube*, sensitivity on the order of a couple of microvolts. We need this sensitivity with our limited transmitter power, and the r.f. stage prevents much signal from being radiated by the antenna.

"Detected ultrasonic audio is amplified by *V2B* and *V3A* and presented to the cathode of *V3B*. Negative-going half cycles are rectified here and appear as additional negative bias on the grid of *V4*, a miniature thyratron already biased to nonconduction by the drop across *R14*. If the audio signal is not the one for which the receiver is designed, nothing happens except that the bias on *V4* becames increasingly negative. But if the signal is one that will pass through the tuned windings of the audio plug-in transformer *T1*, the audio signal is delivered to the grid of *V4* through *C10*, and the peaks of the positive half cycles overcome the bias and fire the thyratron, closing the relay and actuating the door."

"What's the purpose of that 'Tuning Adapter Socket'?"

"It provides v.t.v.m. connections for alignment in the factory," Barney explained. "Detected signal-voltage level is used for r.f. alignment, and the amount of signal passed by *T1* is used for audio alignment."

"What sort of tests have you been making?"

"For one thing, I've found the transmitter will operate the receiver from a distance of 300 feet—about four times as far as Mr. Willibanks' present control. But mostly I've been testing to see if anything *except* the control transmitter will close the receiver relay. I connected another relay through the receiver's output contacts and arranged it so that if the contacts closed, even for a second, a light would come on and stay on. Then I exposed the receiver to the strong field of my ham rig operating on all bands from 75 meters through 10. I had a friend park his CB rig nearby and transmit on all 23 channels, one at a time. I kept the receiver running continuously for two days and three nights when I knew hams were operating. I swished my grid-dip oscillator back and forth across the receiver frequency. Nothing caused the light to come on."

"That will make Mr. Willibanks happy," Mac observed.

"I'm thinking it ought to give us an idea," Barney said. "It seems to me we could make some money and create a lot of customer satisfaction by selling and installing these new-type controls on existing garage-door installations. People would be delighted with the flexibility, convenience, and reliability of these new controls. Here's a list I've jotted down of a few companies who make garage-door openers. Why don't you have Matilda drop them a line and ask for promotional and service literature on their new models?"

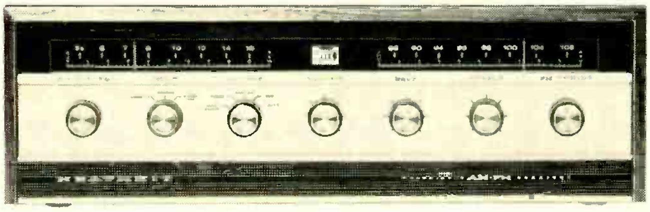
Advance Industries, Inc., Appleton, Wis.
Alliance Mfg. Co., Alliance, Ohio
Delco Radio Div., GM, Kokomo, Ind.
Heath Co., Benton Harbor, Mich.
Multi-Products Co., 21470 Coolidge Hwy., Oak Park, Mich.
Perma-Power Co., 3102 N. Elston Ave., Chicago 18, Ill.

"I'll do it," Mac promised. "Servicing these units could become quite an item, too. Personally, I've always thought garage-door openers have never been pushed enough. They are a near-necessity for the cardiac sufferer, the elderly, and the handicapped; but they are also a wonderful convenience for women who dislike getting out of the car to open the door of an unlighted garage at night when they are alone."

"Yeah, and don't forget that if an impulse relay is connected to those receiver contacts, one pulse from the transmitter will turn something on and another pulse will turn it off," Barney suggested. "Those units will do a lot more than open garage doors. You could turn off the house lights after you were in your car and turn them back on before you left the car. An elderly person could turn on the bathroom light before leaving his bed and turn it off after he was back in bed. A TV set, a ventilation fan, or an air conditioner could be turned on or off from the bed of an invalid or a guy who's just plain lazy."

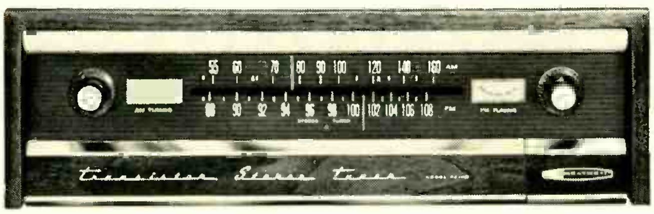
"Okay, okay," Mac said, "but you'd better go on home to lunch now and fortify yourself for some more heavy thinking. You're doing so well I don't want to see you run out of steam!" ▲

13 Heathkit® Values... See the other



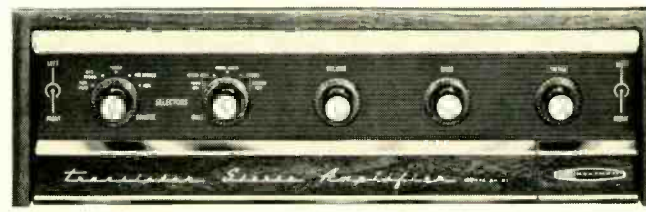
$195.00 All-Transistor AM/FM/FM Stereo Receiver, AR-13A

Just add 2 speakers for a complete stereo system! 46 transistor, 17 diode circuit for cool, instant operation, plus the quick, uncompromising beauty of "transistor sound." Compact, yet houses two 20-watt power amplifiers (33 watts each, IHF music power), two preamplifiers, and wide-band AM/FM/FM Stereo. Attractive new "low-silhouette" walnut cabinet styling. 34 lbs.



$129.95 Deluxe All-Transistor AM/FM/FM Stereo Tuner, AJ-43C

Up to the minute AM, beautifully quiet FM, thrilling, natural FM stereo . . . all reproduced in the exciting new dimension of "transistor sound." Features 25 transistor, 9-diode circuitry, automatic switching to stereo, AFC, filtered outputs for direct, beat-free stereo recording, and new walnut cabinet styling. 19 lbs.

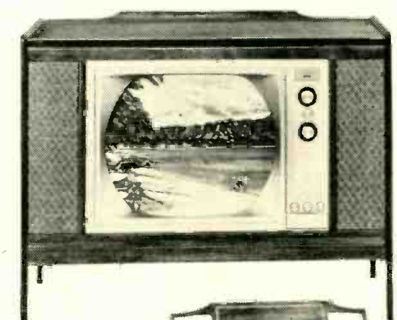


$149.95 Matching Deluxe All-Transistor 70-Watt Stereo Amplifier, AA-21C

Enjoy the quick, unmodified response of each instrument with its characteristic sound realistically reproduced. No compromising! Enjoy 100 watts IHF music power at ± 1 db from 13 to 25,000 cps. Enjoy cool, instant operation from its 26 transistor, 10 diode circuitry. Unusual value. 29 lbs.

Deluxe 21" All-Channel Hi-Fi Color TV, GR-53A . . . $399.00

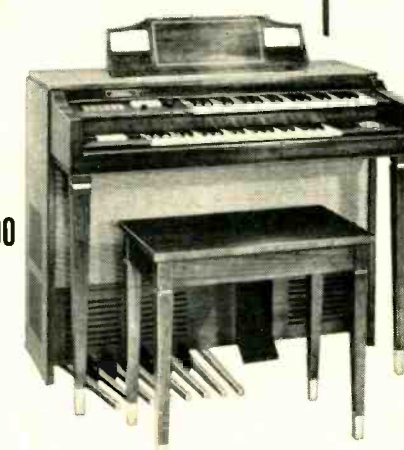
Compares to sets costing up to $200 more! Only color TV you can build yourself, only color TV you can adjust & maintain yourself with exclusive "built-in service center," only color TV you can install 3 ways . . . wall, custom cabinet, or either of Heath factory-built cabinets. Tunes all channels, 2 thru 83, to bring you 21" of true-to-life color and black & white pictures, plus *hi-fi* sound. Features 24,000 volt regulated picture power; deluxe Standard-Kollsman VHF tuner with push-to-tune fine tuning & new transistor UHF tuner; 26 tube, 8-diode circuit. All critical assemblies prebuilt & aligned . . . goes from parts to picture in just 25 hours. GR-53A, chassis, tubes, VHF & UHF tuners, mount. kit, speaker, 127 lbs. . . $399.00 GRA-53-7, deluxe walnut cabinet, 85 lbs. . . $115.00 GRA-53-6, economy walnut-finished cabinet, 52 lbs. $49.00



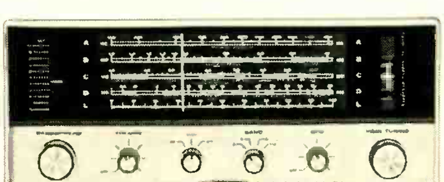
GR-53A
$399.00
(less cabinet)

New! Deluxe Heathkit/Thomas "Coronado" All-Transistor Organ, GD-983 . . . $849.00

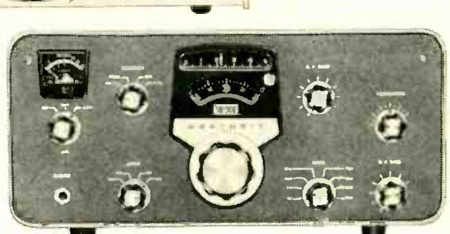
No extras to buy! Easy to build & play! Saves up to $400! Every organ feature you've ever dreamed of . . . 17 true organ voices; 28-notes of chimes; built-in Leslie, plus 2-unit main speaker systems; 13-note heel & toe pedalboard, C thru C; two full-size 44-note keyboards; attack, sustain & repeat percussion—the only organ with all 3; stereo chorus control for exciting "stereo" effects; reverb; 5-year warranty on transistor tone generators; 75-watt EIA peak music power amplifier; and hand-crafted, hand-rubbed, full-bodied walnut-finished cabinet & matching bench. Hear it yourself!—Send 50c for demonstration record GDA-983-2, 7", 33⅓ rpm. 242 lbs.



GD-983
$849.00



GR-64
$39.95



SB-300
$265.00

New! Heathkit 4-Band Shortwave Listener's Radio, GR-64 . . . $39.95

Covers 550 kc to 30 mc in 4 bands to bring you international, ham, weather, marine, Voice of America, and AM broadcasts. Features built-in 5" speaker; lighted bandspread tuning dial, relative signal strength indicator, and 7" slide-rule dial; 4-tube superhet circuit plus 2 rectifiers; simple circuit board construction; "low-boy" cabinet. 13 lbs.

Deluxe SSB Amateur Radio Receiver, SB-300 . . . $265.00

Covers 80 through 10 meters with all crystals furnished, plus provision for VHF converters. 1 kc dial calibrations—100 kc per dial revolution. Crystal-controlled front-end for same tuning rate on all bands. Prebuilt Linear Master Oscillator. Matching transmitter and KW linear amplifier also available. Less speaker. 22 lbs.

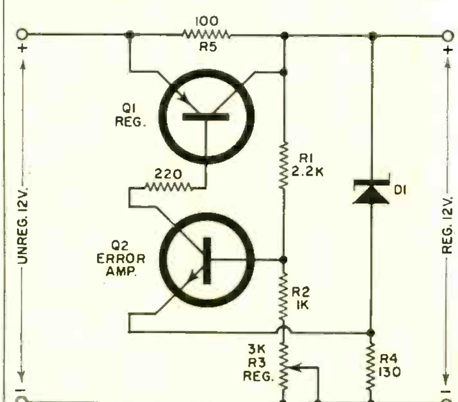
LOW-VOLTAGE REGULATOR

THE low-voltage regulator as used in the *G-E* 9-inch transistorized TV set is shown in the schematic.

After passing through a power transformer and full-wave rectifier, the d.c. output voltage is connected to the emitter of *Q*1, a *p-n-p* germanium transistor acting as a series voltage regulator whose internal resistance can be varied by changing the amount of forward bias applied to the emitter-base junction.

*Q*2 is an *n-p-n* silicon transistor that functions as an error amplifier. It will respond to voltage variations appearing at the collector of *Q*1 and adjusts the base bias of *Q*1 to maintain the output amplitude constant. The base voltage for *Q*2 is supplied from the series voltage divider consisting of *R*1, *R*2, and *R*3. A constant reference voltage of 6.3 v.d.c. is developed across zener diode *D*1. The base-emitter voltage of *Q*2 will always be equal to the difference between 6.3 v.d.c. and the collector voltage of *Q*1.

If the power line rises, the power supply voltage will rise as will the collector voltage of *Q*1. This causes the base voltage of *Q*2 to go more positive than its emitter, effectively increasing the amount of forward bias applied across the emitter-base junction.



This raises the emitter-collector current of *Q*2 which is also flowing through the emitter-base junction of *Q*1. This current change will decrease the amount of *forward* bias applied to the emitter-base junction of *Q*1 and the transistor will not conduct as heavily. The internal resistance of *Q*1 rises and the voltage drop across it increases. This change in resistance will lower the available d.c. output voltage.

*R*5 supplies the initial voltage to the base of *Q*2 and assures that the regulator circuit will start to function when power is turned on. Since *R*5 is connected across *Q*1, its resistance has no effect when *Q*1 is operating because the transistor resistance is less than 8 ohms when conducting. *R*3 sets output to 12 v. ▲

New Look in Radar

(*Continued from page 35*)

height finder for elevation determination. These three coordinates would then be applied to one of the tracking sets. Similarly, the second tracker would be directed to a target. In such a simple system the information file could be a memo pad or a simple display board.

Fig. 9 shows how a number of individual systems similar to Fig. 8 could be tied together. The system is already becoming complex even though it is still elementary in terms of its space-tracking capabilities. The complexity of the system of Fig. 9 is compounded by the fact that the individual radars are designed to operate independently. The individual groups of sets, to minimize interference, may be miles apart and therefore require extensive land-lines or microwave links for interconnection; and all information will require parallax corrections before the various returns can be correlated. Individual groups will still require manual control as in Fig. 8.

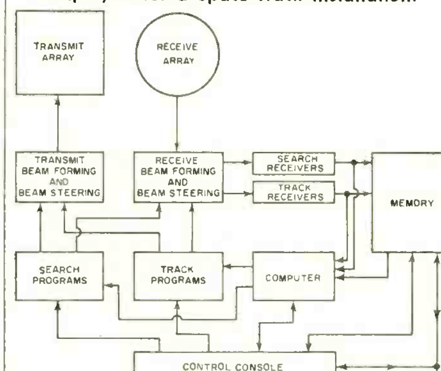
Fig. 10 illustrates a workable phased-array radar system. Even though it may appear complex compared with Fig. 9, it must be remembered that:

1. Its capabilities can be twenty times greater than that shown in Fig. 9.
2. All equipment is located at one site.
3. All equipment has been designed to work as an integral part of the whole.

The AN/FPS-85 uses separate transmit and receive antennas as shown in Fig. 10. The AN/FPS-46 (XW-1) used the same array for both functions.

What is the cost of an equipment that will be capable of finding and identifying any earth-orbiting object irrespective of its origin? The AN/FPS-85 Space Track is being constructed under a $30 million fixed-price contract. This may be many times the cost of most conventional radars but it is only a small fraction of the price that would have to be paid for enough conventional radars and the necessary connecting links and data processors to even approach the Space Track capabilities. ▲

Fig. 10. The control arrangement that is employed for a Space-Track installation.



ELECTRONIC CROSSWORDS

By JAMES R. KIMSEY

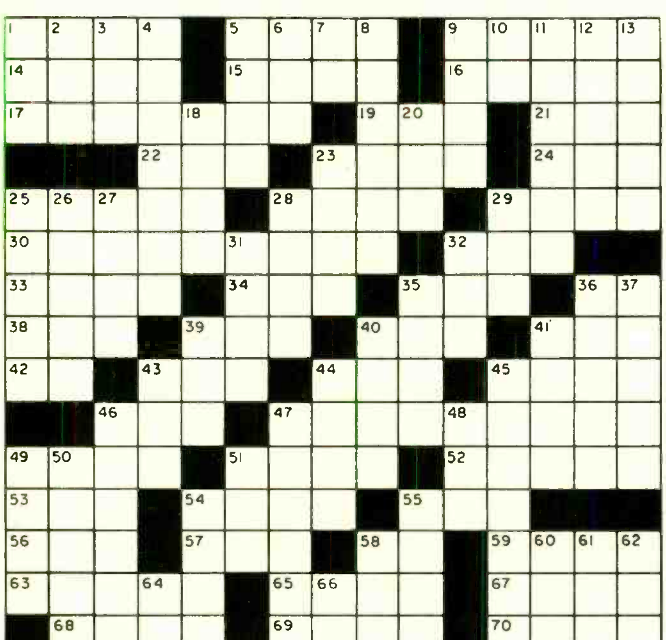
(*Answers on page 96*)

ACROSS

1. A utilizer.
5. "— -top response," a response characteristic in which a definite band of frequencies is transmitted uniformly.
9. Optical maser.
14. In this place.
15. To burden.
16. Greek letter to designate ohm.
17. Unit of electricity equal to 96,500 coulombs.
19. Short sleep.
21. Craft.
22. Wheel tooth.
23. Musical instrument.
24. Hawaiian garland.
25. Dark purplish-grey color.
28. Concern.
29. A prohibition.
30. Also called a monotron.
32. Coniferous tree.
33. Danube tributary.
34. Possessive pronoun.
35. Popular term for pulse or peak on a pattern of a CRT screen.
36. California city (abbr.).
38. Allow.
39. Nothing.
40. Combine.
41. Theresa, for one.
42. Radioactive element produced artificially (abbr.).
43. Male heir.
44. "—detector," a psycho-integroammeter.
45. White spots on a TV picture caused by inherent noise.
46. Distortion in sound reproduction caused by speed variations in the turntable.
47. Electromagnetic wave whose frequency is above 300 mc.
49. Type of examination.
51. "— Lisa," da Vinci painting.
52. More mature.
53. Night letter (abbr.).
54. Belonging to me.
55. "Big —," London landmark.
56. Hardwood tree.
57. Sort, kind.
58. Apiece (abbr.).
59. Unit of force in c.g.s. system.
63. Blue pencils.
65. Right-angled extensions.
67. One who tells falsehoods.
68. Radio receivers.
69. Ferromagnetic material, without windings, that permanently connects two or more magnetic cores.
70. Long, narrow weapon.

DOWN

1. FCC designation for band from 300 to 3000 mc. (abbr.)
2. Large body of water.
3. Make a mistake.
4. Coil or capacitor.
5. Sheet which shields a TV camera from extraneous light.
6. Length of one complete turn in a spiral-wound cable.
7. Paid public notice.
8. Holding property or office.
9. Easy, bounding gait.
10. Process by which constant frequency is varied in amplitude by signal frequency (abbr.)
11. Type of compound used to protect components.
12. Great white heron.
13. Value obtained by dividing one number by another.
18. Accomplishes.
20. Consumed.
23. Folds over.
25. A pleasant expression.
26. Fails to win.
27. Medical school course (abbr.).
28. Wire-wound circuit component.
29. A "big shot" (slang).
31. Part of the face.
32. Position determined by RDF.
35. Wharf.
36. Heating unit.
37. Lesser amount.
39. At this time.
40. Transparent insulation.
41. Break suddenly.
43. Ancient Roman sun god.
44. In TV, a single trace of the electron beam from left to right on the screen.
45. Get by fraud.
46. "—talkie," a portable receiver-transmitter unit.
47. "—chatter," garbled speech.
48. Metal in its natural state.
49. American Indian.
50. In a computer: copies, from one form of storage to another.
51. One thousandth of an inch.
54. Unmarried woman.
55. Insulated part through which the electrodes of a vacuum tube are connected to the pins.
58. Large deer.
60. Beagle "talk."
61. Scottish "no."
62. Before (poetic).
64. Long-distance typewriting machine (abbr.).
66. Expression of wonder.



Lasers

(Continued from page 49)

stimulated emission is in phase with the original, it augments it, as the wave travels from the left to the right. As would be assumed, if the wave were to strike an atom in the lower energy state, it would excite the atom but also lose energy in the process. Thus, for amplification of the light wave, the number of atoms in the upper state must outnumber those in the lower state.

In order to convert this simple amplifier into an oscillator, all that need be done is to terminate the active medium (ruby rod) with reflecting end walls. Since the stimulated light moves in the same direction as the stimulating light, the only light that will be strongly amplified is that which moves parallel to the axis of the rod. A standing wave between the reflecting end walls can be formed. Sustained oscillations are obtained if the amplification of the wave traveling from one end to the other exceeds the loss on reflection at the ends. In order to obtain an output beam of light, one of the end walls is made partly transparent.

The light output from the laser is perpendicular to the reflecting end walls and is almost monochromatic as well as coherent. This feature, along with its intense output and easy "focusability," make the laser uniquely suitable for point-to-point communications. ▲

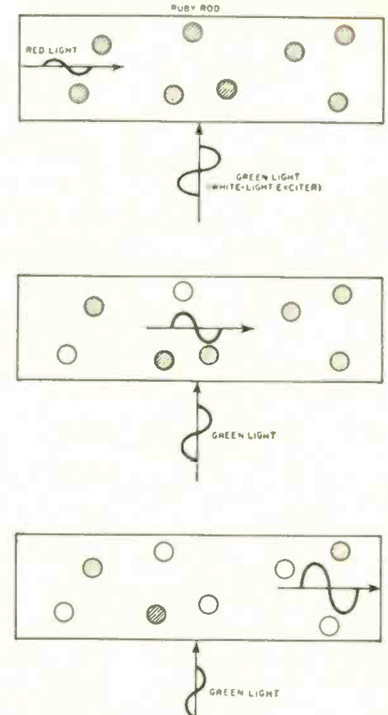
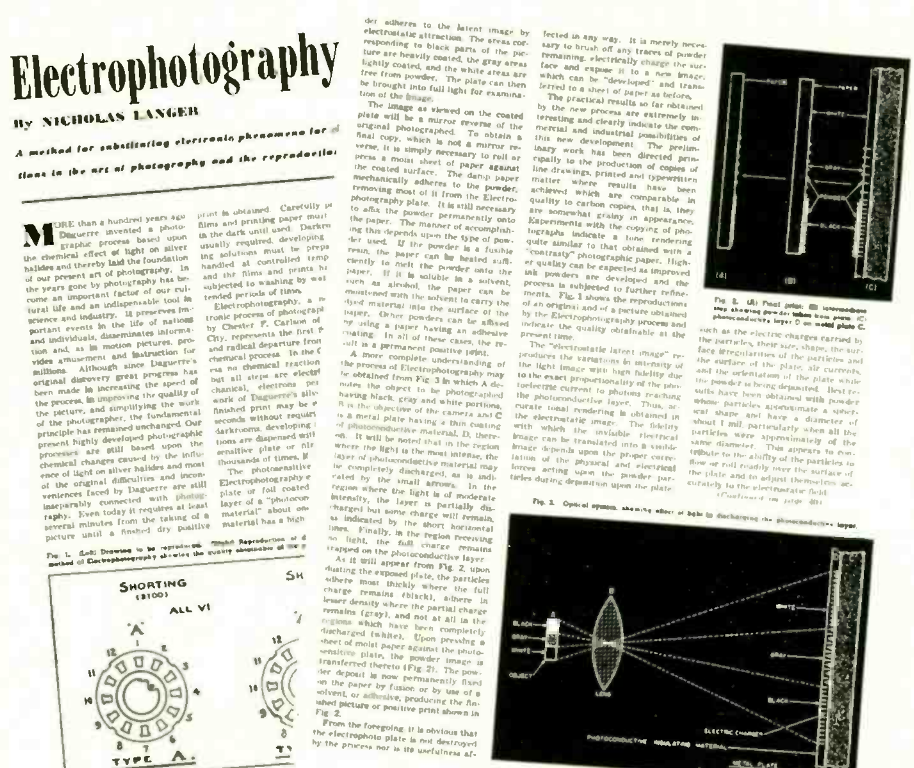


Fig. 2. Production of amplified red light.

Reproduced below are the first two pages of the article "Electrophotography" which played a key role in the dynamic growth of Xerox Corporation. According to the article's subhead this is "A method for substituting electronic phenomena for chemical reactions in the art of photography and the reproduction of drawings." Although the basic techniques discussed in the article are the same as those in present use, much development work and many improvements have been made both in equipment design and the quality of reproduction. See this month's editorial "Research & Development" on page 6.



Electrophotography

By NICHOLAS LANGER

A method for substituting electronic phenomena for c... tions in the art of photography and the reproductio...

MORE than a hundred years ago Daguerre invented a photographic process based upon the chemical effect of light on silver halides and thereby laid the foundation of our present art of photography. In the years gone by photography has become an important factor of our cultural life and an indispensable tool in science and industry. It preserves important events in the life of nations and individuals, disseminates information and, as in motion pictures, provides amusement and instruction for millions. Although since Daguerre's original discovery great progress has been made in increasing the speed of the process, in improving the quality of the picture, and simplifying the work of the photographer, the fundamental principle has remained unchanged. Our present highly developed photographic processes are still based upon the chemical changes caused by the influence of light on silver halides and most of the original difficulties and inconveniences faced by Daguerre are still inseparably connected with photography. Even today it requires at least several minutes from the taking of a picture until a finished dry positive print is obtained. Carefully p... films and printing paper must ... in the dark until used. Darkr... usually required, developing ... ing solutions must be prepa... handled at controlled temp... and the films and prints ha... subjected to washing by wa... tended periods of time.

Electrophotography, a ... tronic process of photograp... by Chester F. Carlson of ... City, represents the first ... and radical departure from ... chemical process. In the ... ess no chemical reaction ... but all steps are electr... chanical, electrons pe... work of Daguerre's silv... finished print may be ... seconds without requiri... darkrooms, developing ... tions are dispensed wit... sensitive plate or fil... thousands of times. ...

The photosensitive ... Electrophotography ... plate or foil coated ... layer of a "photocon... material" about on... material has a high ...

Fig. 1. (Left) Drawing to be reproduced. (Right) Reproduction of ... method of Electrophotography showing the quality obtainable of ...

SHORTING (3100) ALL VI ... "A" ... TYPE A.

...der adheres to the latent image by electrostatic attraction. The areas corresponding to black parts of the picture are heavily coated, the gray areas lightly coated, and the white areas are free from powder. The plate can then be brought into full light for examination of the image.

The image as viewed on the coated plate will be a mirror reverse of the original photographed. To obtain a final copy, which is not a mirror reverse, it is simply necessary to roll or press a moist sheet of paper against the coated surface. The damp paper mechanically adheres to the powder, removing most of it from the Electrophotography plate. It is still necessary to affix the powder permanently onto the paper. The manner of accomplishing this depends upon the type of powder used. If the powder is a fusible resin, the paper can be heated sufficiently to melt the powder onto the paper. If it is soluble in a solvent, such as alcohol, the paper can be moistened with the solvent to carry the dyed material into the surface of the paper. Other powders can be affixed by using a paper having an adhesive coating. In all of these cases, the result is a permanent positive print.

A more complete understanding of the process of Electrophotography may be obtained from Fig. 3 in which A denotes the object to be photographed having black, gray and white portions, B is the objective of the camera and C is a metal plate having a thin coating of photoconductive material, D, thereon. It will be noted that in the region where the light is the most intense, the layer of photoconductive material may be completely discharged, as is indicated by the small arrows. In the region where the light is of moderate intensity, the layer is partially discharged but some charge will remain, as indicated by the short horizontal lines. Finally, in the region receiving no light, the full charge remains trapped on the photoconductive layer.

As it will appear from Fig. 2, upon dusting the exposed plate, the particles adhere most thickly where the full charge remains (black), adhere in lesser density where the partial charge remains (grey), and not at all in the regions which have been completely discharged (white). Upon pressing a sheet of moist paper against the photosensitive plate, the powder image is transferred thereto (Fig. 2). The powder deposit is now permanently fixed on the paper by fusion or by use of a solvent, or adhesive, producing the finished picture or positive print shown in Fig. 2.

From the foregoing it is obvious that the electrophoto plate is not destroyed by the process nor is its usefulness affected in any way. It is merely necessary to brush off any traces of powder remaining, electrically charge the surface and expose it to a new image, which can be "developed" and transferred to a sheet of paper as before.

The practical results so far obtained by the new process are extremely interesting and clearly indicate the commercial and industrial possibilities of this new development. The preliminary work has been directed principally to the production of copies of line drawings, printed and typewritten matter where results have been achieved which are comparable in quality to carbon copies, that is, they are somewhat grainy in appearance. Experiments with the copying of photographs indicate a tone rendering quite similar to that obtained with a "contrasty" photographic paper. Higher quality can be expected as improved ink powders are developed and the process is subjected to further refinements. Fig. 1 shows the reproductions of an original and of a picture obtained by the Electrophotography process and indicate the quality obtainable at the present time.

The "electrostatic latent image" reproduces the variations in intensity of the light image with high fidelity due to the exact proportionality of the photoelectric current to photons reaching the photoconductive layer. Thus, accurate tonal rendering is obtained in the electrostatic image. The fidelity with which the invisible electrical image can be translated into a visible image depends upon the proper correlation of the physical and electrical forces acting upon the powder particles during deposition upon the plate.

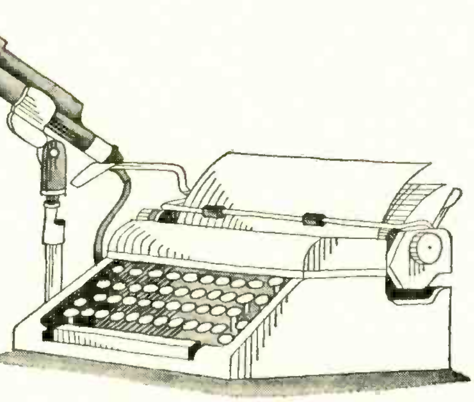
Fig. 2. (A) Post plate; (B) intermediate step showing powder taken from plate; (C) photoconductive layer D on metal plate C.

...such as the electric charges carried by the particles, their size, shape, the surface irregularities of the particles and the surface of the plate, air currents, and the orientation of the plate while the powder is being deposited. Best results have been obtained with powder whose particles approximate a spherical shape and have a diameter of about 1 mil, particularly when all the particles were approximately of the same diameter. This appears to contribute to the ability of the particles to flow or roll readily over the surface of the plate and to adjust themselves accurately to the electrostatic field.

Fig. 3. Optical system, showing effect of light in discharging the photoconductive layer.

BLACK, GRAY, WHITE, OBJECT, LENS, WHITE, GRAY, BLACK, ELECTRIC CHARGES, PHOTOCONDUCTIVE INSULATING MATERIAL, METAL PLATE

RADIO & TV NEWS



According to Dr. Mauro H. Zambuto of the *Newark College of Engineering*, someday motion-picture and TV companies may film their productions in black-and-white and rely on the theatre or home TV set to reproduce the shows in color.

The system suggested is not an electronic one, but depends on a knowledge of how human beings see.

The eye-brain-consciousness relationship of vision is a combination of chemical, electrical, and psychological phenomena according to the *NCE* professor, so closely linked that the precise role of each and their interdependence have not been determined.

It is well known that the human eye has three types of organs in the retina which are sensitive to red, green, and blue. The information each transmits to the brain, when coordinated and correlated to the impulses sent by the other color sensors, allows man to see light in values of brightness, hue, and color purity. This phenomenon apparently works much like the process of color printing in which graduations of prime colors are superimposed to produce a picture.

Early experiments at *NCE* include projecting three black-and-white images through a prism arrangement to obtain a full-color response. Dr. Zambuto has since been able to produce a large range of colors from a white light.

Image Intensifier

Electronic image intensifiers added to conventional optical telescopes are capable of tripling the observable brightness of the image according to *RCA*.

For example, the new image-intensifier tube will enable a 60-inch reflector telescope to photograph faint star images or objects now only obtainable with 180-inch telescopes.

The image intensifier is placed at the focus of the telescope optical system. The optical image falls on a photocathode deposited on the inside of a glass window at the receiving end of the image tube to release photoelectrons.

These photoelectrons are accelerated within the tube and the image is focused onto a phosphor screen at the rear end of the first stage. The resulting light output passes through a thin membrane to a second photocathode. Resulting photoelectrons are "re-imaged" onto an output screen of the second stage.

The new, much brighter image formed here can then be photographed with conventional optics and emulsions.

Tunnel Radio

Usually when an automobile goes into a tunnel, the radio goes dead. Now, however, the Chesapeake Bay Bridge-Tunnel is rigged to allow motorists to listen to their car radios while driving through the two-mile-long tunnel which dips as much as 90 feet below the surface of Chesapeake Bay.

The new radio system consists of AM antennas mounted at each end of the tunnel and connected with amplifiers. The amplifiers boost the signals received by the antennas and feed them to antenna cables running the length of the tunnel.

These ceiling-antenna cables were built into the tunnels to provide two-way short-wave communication for patrol cars, maintenance, and emergency vehicles. Only the outside antennas and amplifiers had to be added to make the system serve car radios.

Laser Space Tracker

NASA scientists have been successful in their experiments to track a space vehicle using a laser beam. The satellite used was the Explorer XXII which was equipped with an array of optical corner reflectors.

Using a ruby laser coupled to a telescope, the scientists aimed the telescope along the predicted flight path and flashed the laser a number of times as the Explorer passed overhead. The corner reflectors returned the laser beam back along the same path. The optical returns were converted to electrical signals and displayed on an oscilloscope. The expected range accuracy is within ten feet.

According to the NASA scientists, when these new laser techniques are fully understood and worked out, they will greatly simplify satellite tracking or permit communications between the earth and deep-space vehicles. ▲

CIRCLE NO. 232 ON READER SERVICE PAGE →

Broadband CATV System

(*Continued from page* 40)

Just how good is Logansport cable reception? It's good, but no one claims it is perfect. On some channels, occasionally there is slight ghosting and ringing. A trained eye can detect a small loss of detail. If signal levels are not kept in proportion, faint cross-hatching may be seen. During a heavy rainstorm, precipitation static produces sparkles in some pictures.

These transient defects seem minor as you flip from channel to channel without having to readjust brightness or contrast and see no perceptible snow, fading, ignition noise, or airplane flutter. Friends visiting from Chicago, New York, and other metropolitan areas say reception is as good as or better than what they are used to seeing.

The cable company, however, is not satisfied and is constantly working to improve reception. They plan on microwaving FM stations in from Chicago for better stereo reception. Microwave links are still being adjusted. Knowing perfect coaxial cable is the key to perfect cable reception, *Jerrold* is working to produce even lower loss cables with more uniform characteristics at reasonable cost. Newly developed transistorized amplifiers are being tried out here.

A swarm of engineers, linemen, and installers were here during the bitter 1963-64 winter to put the system into operation, but now it is run by eight people: a manager, two office girls, a chief technician with three assistants, and a man in charge of advertising and promotion. This last activity is handled by the local manager of the *Alliance Amusement Company*. The four members of the technical staff make all new installations, take care of all complaints, and perform regular preventive maintenance. The latter includes checking all amplifiers in the system three times a year. Each amplifier is carefully tested, retubed, and realigned before being put back into service. A sharp eye is kept on signal levels in all parts of the system. When complaints come in, reference to a large wall map that shows every cable, amplifier and pole in the system permits trouble to be pinpointed in minutes.

What about the impact on dealers and service technicians? There is no denying that the sale, installation, and maintenance of antennas, towers, and rotators has been dealt a terrific blow in Logansport by the cable company, and this impact is still being felt. A non-subscriber who suffers storm damage to his antenna is likely to take a cash settlement and apply it toward the installation ($18.50) and monthly rental ($4.90) of the cable service.

On the other hand, most dealers agree

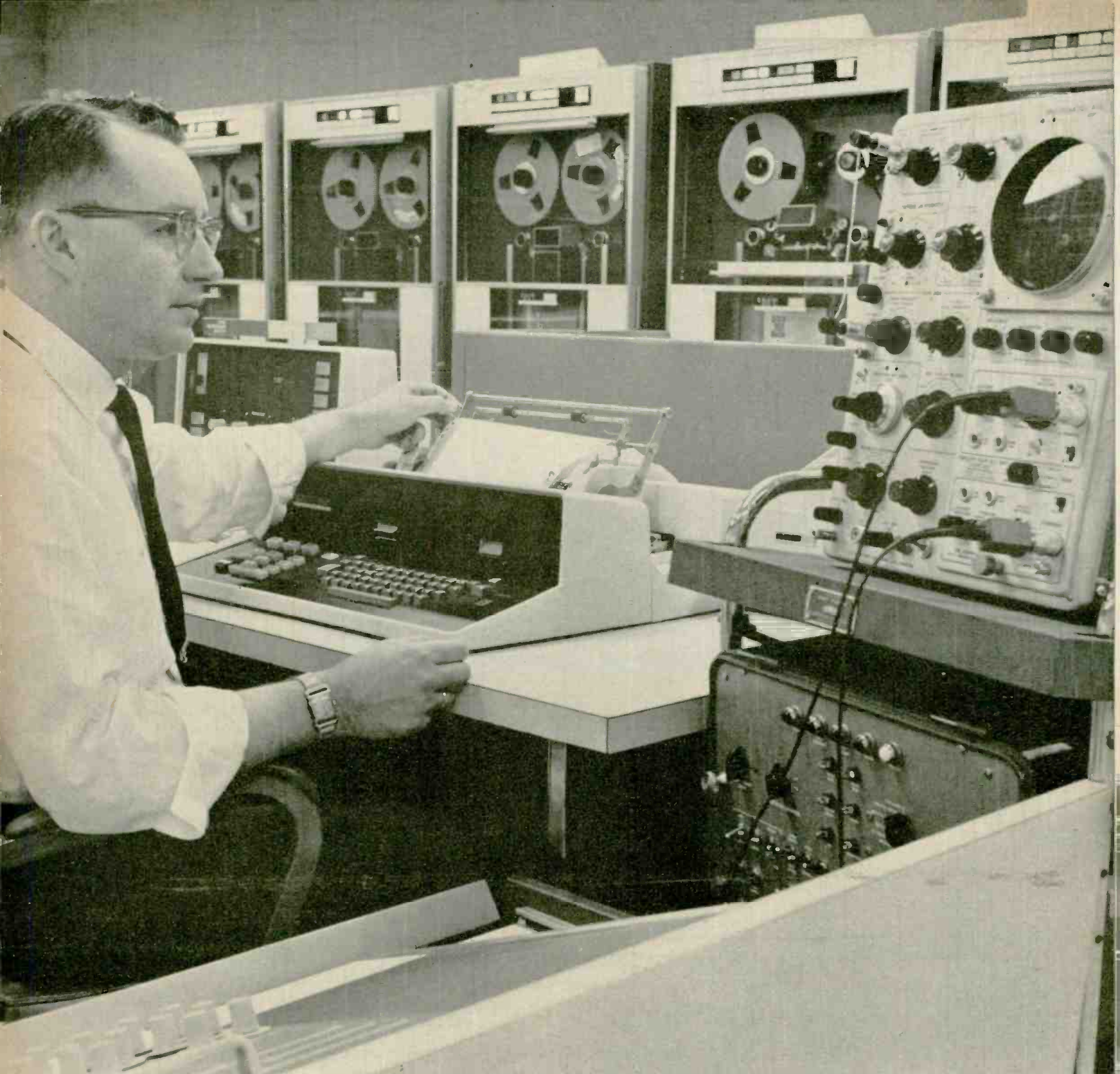
that the cable has stimulated sales, especially of color-TV receivers. A set can now be demonstrated on the floor with assurance it will work equally well on cable in the customer's home—something not true before. Servicing is much easier with a consistently strong signal. Receivers do not have to be maintained in tip-top shape to provide good reception. Those frustrating marginal weak-reception cases do not occur on cable reception.

Special service problems are mainly concerned with deteriorated a.g.c. systems that were unmasked when a reasonable signal was fed into the receiver. In a few cases another problem was caused by persons trying to "poach" on the cable service. To avoid paying an additional $1.50 a month for service to a second set, these people have rigged up their own arrangements for feeding the other receiver. Radiation from the extra line is sometimes strong enough to affect antenna reception on a neighbor's receiver. Technicians are learning to recognize the source of this kind of interference, and the cable company has equipment to run down the cheating installation.

When the cable system was proposed, there was sharp opposition from many service technicians and some dealers and distributors. Most of this has evaporated, partly through the friendly efforts of the cable company, but mostly because there didn't seem to be much point in continued hostility toward the inevitable. People in Logansport wanted cable reception and they were not to be denied.

After watching the enormous cost of installing the system here and observing the painstaking lengths to which the cable company must go to bring in and maintain good reception, one simple fact stands out: CATV is not going into any community where good reception can be achieved at reasonable cost by other means. To do so would be to court financial suicide. To stay in business, a CATV system has to demonstrate, and keep providing, better reception, which means it can only operate in areas where it is definitely needed. This thought should be a comfort to antenna and tower installation people and to the manufacturers of this equipment whose constant efforts to improve their products have contributed so much to the growth of the TV industry.

The author wishes to express his deep appreciation to Mac Ferguson, Chief Engineer of *Jerrold Electronics Corporation*; Jerry Looby, Acting Manager of the *Logansport Cable TV Company*; Don Hyman, Chief Technician for the company; and Alfred Rodriquez, Local Manager for the *Alliance Amusement Company*. Without their patient and candid answers to my questions, this article could not have been written. ▲



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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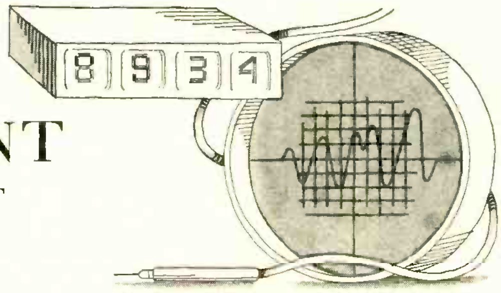
TEST EQUIPMENT
PRODUCT REPORT



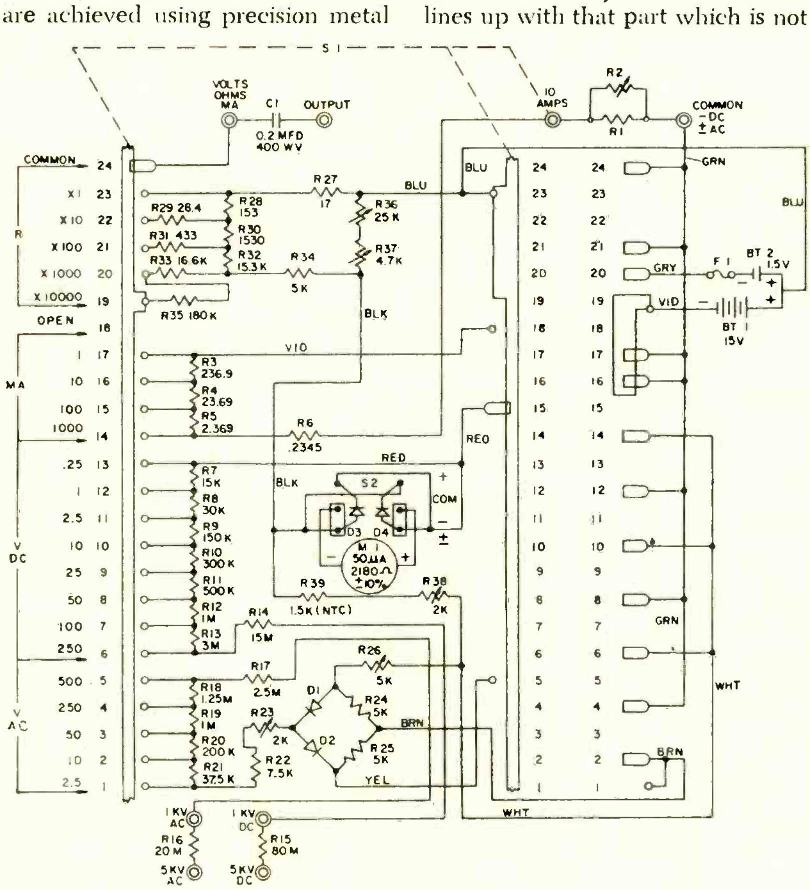
Weston Model 80 V.O.M.

For copy of manufacturer's brochure, circle No. 58 on coupon (page 17 or 88).

THE *Weston* Model 80 analyzer is a v.o.m. with many unique and unusual design features. It has a console-type case with a large 5½" panel meter equipped with a new anti-parallax scale. An accuracy of 1% on d.c. and 1.5% on a.c. are achieved using precision metal film or wirewound resistors, except for the higher voltage ranges. In addition to the usual v.o.m. ranges, several of the most often required voltage ranges have been added; also there are five ohmmeter ranges. While designed as a bench tester, it is well adapted for portable use since its resilient and rugged ABS resin case combined with a meter with spring-backed jewels can withstand considerable abuse.

The instrument is sloped back at 25°, giving it excellent readability from either a sitting or standing position. The meter is calibrated for test accuracy in this one position.

The new refractive-type parallax scale-corrector is considered by the manufacturer to be an improvement over the mirror scale. A clear plastic overlay is mounted on the scale plate so that it splits the upper set of scale lines. The correct reading position is obtained when the section of any line under the overlay lines up with that part which is not covered. In use, a line is selected at about the same deflection at which the reading is to be taken.



The meter has an uncluttered control panel with color-coded jacks at the left, the ohms-adjust knob at the center, and a single combination range and function switch at the right. The 5-kv. range high-potential jacks are on the left side of the case away from the user, and a d.c. reversing switch is located on the right side of the case away from the leads; both positions are for the maximum safety of the user.

The reversing switch is used when a down-scale reading is obtained on d.c. It is not necessary to break the electrical connection, except for the 1- and 5-kv. ranges, since protective silicon rectifiers are wired across the switch. On break, or if the switch contact should fail, the maximum voltage cannot exceed about 0.8 volt. The switch reverses the meter connections and the rectifiers also protect the movement from overload. The black or common lead is provided with a clip and in use is normally connected to ground for voltage measurements. This keeps the panel and meter at low potential, regardless of the position of the reversing switch.

It is unusual to find a v.o.m. with a place for lead storage except in an associated carrying case. The Model 80 case has a rear recess with a clip for holding the leads. It also allows the top of the case to be used as a carrying handle.

The instrument has been designed for ease of servicing. The meter, printed-circuit board, reversing switch, and battery holders can be readily removed from the case completely wired. All parts are accessible and the instruction book includes a step-by-step procedure for testing and adjusting the instrument. The price of the v.o.m. is $79.50. ▲

McMartin AM-25 Noise Meter

For copy of manufacturer's brochure, circle No. 59 on coupon (page 88).

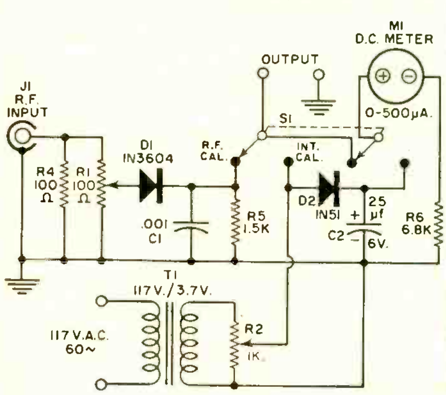
THE *McMartin* AM-25 noise meter was developed to assist the broadcast engineer in making the required FCC noise measurement of FM, AM, and TV aural transmitters. AM noise of an r.f. carrier may be defined as the residual modulation of the carrier by power-supply noise, hum, or other component or tube noise, such as thermal disturbance. The FCC requires that this noise be at least −50 db in most commercial classes of transmitters. It is necessary, therefore, that some means of measuring this noise be available to the station engineer. The AM-25 noise meter was made available to replace the usual collection of parts assembled during the proof-of-performance measurement. The unit contains all the necessary parts, in-

cluding a calibrating meter packaged in a portable case.

Since it is impossible to amplitude modulate an FM transmitter, a theoretical 100% AM-modulation level must be established. It is known that the peak voltage of the modulating audio signal is equal to the peak voltage of the r.f. carrier at 100% amplitude modulation. The r.f. output of the FM transmitter is sampled and rectified through a high-frequency diode. A peak value is read on a self-contained meter. A 60-cps audio signal is then adjusted to the same peak voltage value. This audio voltage, which represents the peak value of an audio signal which would AM modulate the r.f. carrier 100%, is used to establish the 100% modulation reference point on an external a.c. voltmeter. If the voltmeter is calibrated in decibels, the AM noise may be read directly in db below this 100% modulation level.

The sample loop at the output of an FM transmitter is connected to the r.f. input of the noise meter. The power level should be between 0.5 and 4.0 watts into 50 ohms. The output of the noise meter is connected to an a.c. voltmeter or to the input of a noise and distortion meter.

With the switch in the "R.F. Calibrate" position, adjust the "R.F. Calibrate" control (*R*1 in diagram) for convenient reading (half scale). Throw the switch to the "Internal Calibrate" position and adjust the "Internal Calibrate" control (*R*2) for the same meter reading as before. If a noise meter is used at the output terminals, adjust the signal obtained to 0 db or 100% calibrate reading. If an a.c. voltmeter is used, set the meter-



range switch so that an accurate reading is obtained.

The reading obtained is an audio signal that is equal to the theoretical signal necessary for 100% modulation of the r.f. signal just calibrated. Place the switch in "R.F. Calibrate" position, and the AM-noise level of the carrier may be read directly on the noise meter calibrated in decibels. On an a.c. voltmeter, another reading must be taken of the noise voltage of the carrier. The two a.c. voltmeter readings may be used in the formula $db=20 log E1/E2$ to obtain the signal-to-noise ratio.

The unit is contained in a small plastic box, 6¾" long, 3¾" wide, and 2¾" high, and uses a u.h.f.-type r.f. connector input. The output connection is a pair of banana jacks spaced ¾" apart to accept a standard dual banana plug. It will accept 50-ohm r.f. input at frequencies as high as 500 mc. and up to 4 watts of power. The output calibrating signal is 3 volts maximum at 10,000 ohms.

The AM noise meter may be used equally with the aural transmitter of a TV station below 500 mc. or with a standard AM broadcast station. It is available for $24.50. ▲

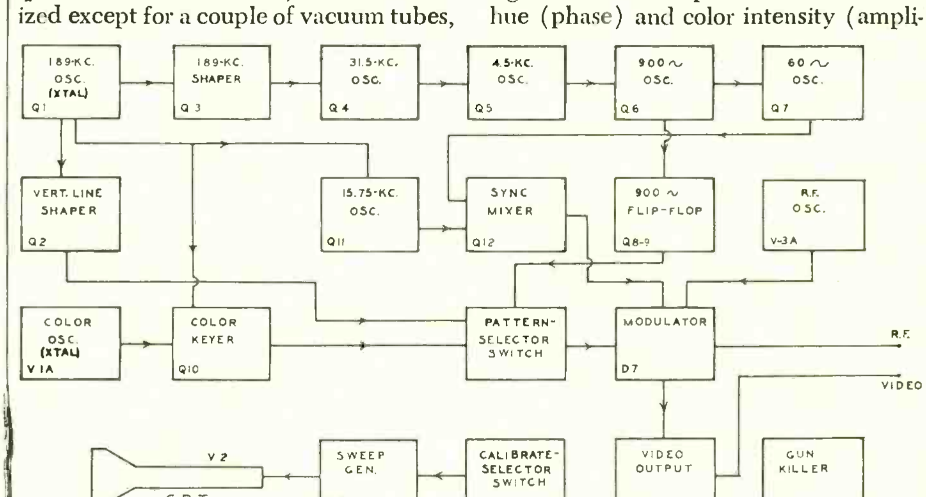
Lectrotech Model V-7 Color Generator/Vectorscope

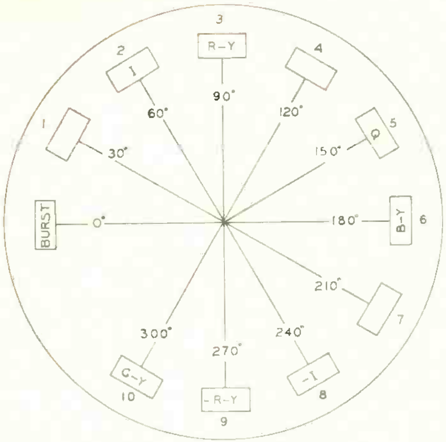
For copy of manufacturer's brochure, circle No. 60 on coupon (page 17).

THE new *Lectrotech* Model V-7 is a two-for-one piece of test equipment that is designed to be of much practical value to the TV service technician who must now handle color-TV sets. The instrument is a complete color-bar generator using the widely employed offset-subcarrier, gated-rainbow technique for generating ten spaced color bars across the face of the color picture tube. These bars, available either as straight video or as video modulation on an r.f. carrier, are used to adjust the color circuits in a TV receiver. In addition, vertical lines, horizontal lines, a cross-hatch pattern, and a dot pattern are available for the usual convergence and linearity adjustments. So far, the unit appears to be quite conventional. True, it is transistorized except for a couple of vacuum tubes, it does use silicon unijunction transistors in the divider circuits, and it permits an adjustment of the thickness of the horizontal line width to suit the technician's requirements.

However, when we examine the instrument we find that it has built in a cathode-ray tube, sweep circuits for the tube, and various operating controls such as we might find on a scope. The tube is not to be used as a conventional scope to view waveforms; instead, its function is to operate as a vectorscope. This is a very useful type of display that is widely employed in color-TV broadcast stations. By employing a circular sweep and by viewing demodulated color-bar signals, it is possible to obtain a vector display of the signals. The display resembles the spokes of a wheel. The position of each spoke shows its relative phase while the length of each spoke shows its relative amplitude. The ideal position of the ten spokes, representing the ten color bars, are shown in the diagram on the next page. The burst signal, at zero degrees phase, does not appear on the display.

The vectorscope display is very practical for adjusting the color circuits in the receiver, both as to phase and amplitude. This is true since it permits the direct observation of those characteristics of the signals that are responsible for the color hue (phase) and color intensity (ampli-





tude). The instruction manual supplied with the instrument shows a variety of vectorscope patterns representing typical faults in a color-TV receiver.

The video signals for the vectorscope are obtained right at the color picture tube itself. The color set's picture-tube socket is removed from the tube and an adaptor socket from the Model V-7 is substituted. Then the set's picture-tube socket is replaced onto the adapter. The interconnection arrangement also permits the use of three gun-killer switches on the front panel of the instrument. These switches are used in the normal purity and convergence adjustments.

The block diagram of the unit gives the arrangement of circuits.

Another plus feature provided by the built-in CRT is that the timing circuits can be readjusted without the use of external test equipment. The proper waveforms that must be obtained are simply viewed directly on the instrument's CRT.

The Model V-7 has permanently attached cables that are stored in a compartment within its 8¾" x 7½" x 12⅞" cabinet. The unit sells for $189.50. ▲

"MUSIC FESTIVAL" CONTEST

EMPIRE Scientific Corp. is sponsoring a "Round-the-World Music Festival" contest in which the grand prize will be a 21-day tour of Europe's great music and drama festivals for the winner and his guest.

The object of the contest will be to arrange ten features of the company's "Royal Grenadier Speaker System" in their order of importance. The person whose entry comes closest to the order established by music editors and critics will be the winner.

The trip will be made via Alitalia Airlines with luxury hotel accommodations and all expenses paid by the company.

Fifty additional prizes, consisting of the Deutsche Grammophon album of all nine of the Beethoven Symphonies, conducted by Herbert Von Karajan, will also be awarded.

Entry forms and details are at audio dealers now. All entries must be postmarked no later than midnight June 1, 1965. All entries become the property of Empire Scientific Corp. and none will be returned. ▲

Multiset Couplers

(*Continued from page* 36)

As previously mentioned, most efficient operation of these multiset couplers depends on the impedance of the antenna being 300 ohms and the TV set's antenna-terminal impedance being very close to 300 ohms. However, this is not always the case as the input impedance of the TV set can vary considerably with channel selection and fine tuning.

Such wide variation in impedances connected to the different output terminals of the multiset coupler can produce extreme changes in signal level being passed to each set. In fact, measurements made using some commercial couplers showed as much as 26-db variation across the low v.h.f. band. The test setup shown in Fig. 2 was used to make the measurements The sweep generator is a conventional type covering the entire v.h.f. band. The amplifier splits this into the high v.h.f. band (174-216 mc.) and the low v.h.f. band (54-88 mc.). The oscilloscope probe can be connected to the input of either TV set. While observing the signal entering one set, the other set is channel-switched and fine-tuned. A typical result is shown in Fig. 3. Here, the low band is on the left and the high band is on the right side of the photo. Note that across the low v.h.f. band as much as 26-db variation of signal strength can take place within a few mc. This curve may explain why some color sets do not operate cleanly when using some of these passive multiset couplers. As the second TV set is channel-switched or fine-tuned, the color set may lose the chromatic signal in a steep, trap-like, response curve.

This article was prepared from information supplied by *Jerrold* and *Blonder-Tongue*. ▲

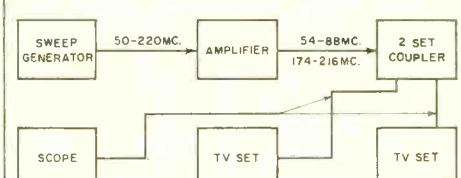
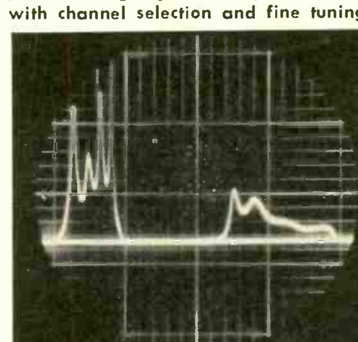


Fig. 2. Test setup for checking couplers.

Fig. 3. Typical curve of multiset coupler showing signal strength variation with channel selection and fine tuning.



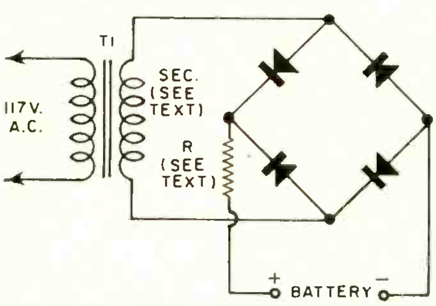
CHARGING NICKEL CADMIUM CELLS

WITH the ever-increasing use of rechargeable nickel-cadmium cells and batteries, many users may wonder just how they should be charged. Although chargers are available on the market, one can be built in accordance with information supplied by *G-E*.

The normal method of charging sealed cells is with a constant-current at a rate not exceeding the ten-hour rate ($C/10$) for 14 to 16 hours. The diagram shows a constant-current charging circuit that can be used. Rated temperatures and the ten-hour rate should not be exceeded in constant-current charging without special instructions.

For cylindrical cell batteries under rated conditions, the ten-hour rate can be maintained for several weeks without cell damage. Button cell batteries are more critical, and excessive overcharge at the ten-hour rate must be avoided. To obtain maximum life of the button cell batteries, a 15-hour charge rate is recommended.

Constant-voltage charging, which is acceptable but more critical, results in a



Circuit of the nickel-cadmium battery charger. Rectifier diodes capable of carrying the current should be used.

higher initial charging rate. At the start of the charge, current may greatly exceed the ten-hour rate, but the charging circuit must be designed so that the ten-hour rate (or less) flows toward the end of charge.

Assume that a 5-cell, 4 AH battery is to be charged. In the schematic, the rectifier diodes can be any type which will supply the necessary current. The calculation of *T1* secondary and the value of *R* is as follows:

End-of-Charge Voltage: ≈ 1.45 v./cell.

T1 Sec.: end-of-charge voltage times number of cells (*i.e.*, $1.45 \times 5 = 7.25$ v.) Transformer secondary is 7.25×2 or approximately 15 volts.

Charge Current: at ten-hour rate = $4/10 = .4$ ampere.

R Value: should drop approximately 8 v. ($15 - 7.25$) at .4 ampere. Therefore *R* is approximately 20 ohms at 5 watts, (3.2 w. actual plus factor of safety). ▲

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USING DIODES TO PROTECT CIRCUITS

By TIMOTHY KAARTO

INEXPENSIVE silicon diodes can easily be selected for protection of some a.c. and most d.c. moving-coil meters. All silicon diodes conduct only about 3 μa. in the forward direction with as much as 350 mv. applied. Yet, they conduct their full rated current with only two or three times this voltage. Thus, these diodes can be connected across most d.c. meter movements since most of them require less than 100 mv. for full-scale deflection. If the voltage across the meter tries to rise above .6 to .8 volt, the diode will bypass the current, clamping the voltage to a safe value.

When the meter is to be used for d.c., it can be protected as shown in Fig. 1A. If the load is accidentally shorted, the diode will carry the excess current and cause the fuse to open. Thus, the diode protects the meter and the fuse protects the diode.

Where the instrument is intended for all-around use, and it encounters a circuit containing ripple, considerable error may result because the diode may conduct the peak current that should go through the meter. In the half-wave rectified circuit (Fig. 1B), the meter measures average value.

The diode may start conducting at 314 mv.; however, meter current must be kept below 100 mv. to avoid damage.

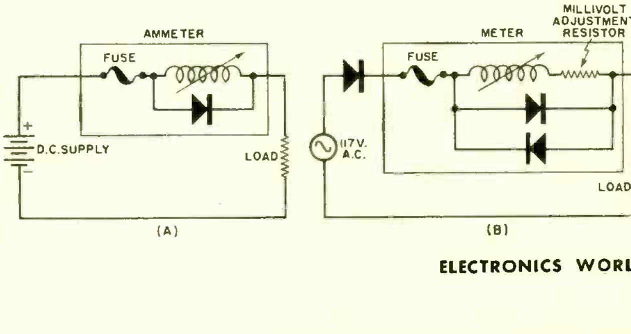
At the same time, the millivolt drop should be as high as possible. For example, if the drop across the meter is 10 mv. and the diode clamped the voltage to .75 v., there would be a 75 times meter overload. On the other hand, if the drop were increased to 50 mv., the meter would be overloaded by 15 times. This adjustment can be made with the millivolt adjustment resistor shown in Fig. 1B.

Most meters can withstand a 15 times overload long enough for the fuse to blow. Some diodes conduct only three microamperes in the forward direction with about 360 mv. applied. When this diode is used, the meter can be safely adjusted for 100 mv. and thus have its overload limited to 15 times. If the meter movement voltage cannot be adjusted below 100 mv., then further consideration must be given to the operating conditions. Perhaps the meter should be used in a circuit where only a fairly smooth d.c. is applied, or where a few microamperes of leakage will not matter.

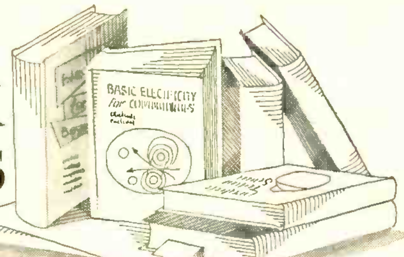
Fuses have been used in instrument protection for many years. However, they may add unwanted resistance to the circuit. For example, a *Bussmann* AG3, 1/200-ampere fuse has about 200 ohms resistance. When diodes are used in conjunction with a fuse, this unwanted resistance is essentially eliminated and excellent protection is provided. The fuse can be a larger size, since its purpose is to protect the diode, and therefore it will have a low resistance. For example, the *Bussmann* GLX, ½-a. fuse measures only .2 ohm.

Two diodes connected back-to-back offer protection against accidental current overload. ▲

Fig. 1. (A) Using a diode to protect a meter. (B) A milliwatt adjustment resistor can be used to reduce meter overloading.



BOOK REVIEWS



"FUNDAMENTALS OF TELEVISION" by Walter H. Buchsbaum. Published by *John F. Rider Publisher, Inc.*, New York. 282 pages. Price $9.95.

This is a carefully organized text which can be used for classroom instruction or as a home-study book. For classroom use, the publisher offers an "Teacher's Guide" and a companion "Laboratory Manual" for the student with 16 progressive projects, keyed to the text.

Each circuit and receiver section is explained in considerable detail with illustrative examples from the latest color and black-and-white models. New circuit design features are described and their differences from earlier designs pointed out.

After each circuit or section is discussed, the various possible defects and their symptoms are described. Practical troubleshooting procedures and alignment data are included.

Readers of this magazine are familiar with Mr. Buchsbaum's lucid presentation of technical material and will find this volume in the same strain. The text is lavishly illustrated with schematics, line drawings, photographs, and each chapter has a list of "review questions"—all amplifying the text material and aiding the student.

* * *

"ELECTRONIC GADGETS FOR YOUR CAR" by Len Buckwalter. Published by *Howard W. Sams & Co., Inc.*, 126 pages. Price $2.95.

This little volume carries instructions for building ten useful electronic devices for the car, including an ammeter, a spare-tire alarm, an emergency flashlight, a transistorized battery charger, a troubleshooter meter, a directional-light beeper, a dwell indicator, a car radio p.a. system, a trunk alarm, and a tachometer.

Schematics, pictorials, parts lists, and actual step-by-step construction photos make these projects easy for even the non-technically inclined motorist to build.

* * *

"GLOSSARY OF DATA PROCESSING AND COMMUNICATIONS TERMS" compiled and published by *Honeywell Electronic Data Processing*, Wellesley Hills, Mass. 85 pages. Price $1.00. Soft cover.

The lack of standardization in data processing terminology is somewhat of a handicap and a deterrent to full understanding among those working in the field. Although the American Standards Association has such a standard under consideration at the present time, it hasn't been adopted and this "Glossary" fills an urgent need.

The listing is in standard dictionary format with appropriate cross-referencing when required. Four appendices cover the company's character codes, the standard *Honeywell* template, a binary extension table, and octal-decimal conversion.

* * *

"TRANSISTOR SPECIFICATIONS AND SUBSTITUTION HANDBOOK" compiled and published by *TechPress Publications*, Brownsburg, Ind. $1.95. Soft cover.

This is a second edition of a handy listing which first appeared early in 1964. It includes both the specifications and recommended substitutions for transistors from a great number of manufacturers. Specifications are those supplied by the manufacturer and substitutions were selected by a computer.

Besides tables, the book includes text on making transistor substitutions, transistor specifications, manufacturer codes, transistor symbols, and transistor case diagrams.

* * *

"MATHEMATICAL BAFFLERS" compiled and edited by Angela Dunn. Published by *McGraw-Hill Book Company,* New York. 217 pages. Price $6.50.

This is a compilation of some of the most popular and best puzzles that have appeared in *Litton Industries'* well-known series, "Problematical Recreations," along with a choice selection of original posers. The book is divided into seven sections which permits the reader to select his "favorite" way of driving himself crazy. There are algebraic, geometric, and diophantine problems, problems in logic and deduction, probability, insight puzzles, and assorted number theory problems. Difficulty ranges from simple posers requiring logic and insight to problems which may stump the advanced mathematician. Answers are provided in all cases.

Most of the posers are illustrated with cartoon-type woodcuts by Ed Kysar.

* * *

"THE RADIO-ELECTRONIC MASTER" compiled and published by *United Catalog Publishers, Inc.,* Garden City, N.Y. 1728 pages Price $10.00. 29th Edition.

The 1965 edition of this electronic parts listing carries more than 185,000 items with specifications and prices and over 12,000 illustrations, making it the largest "Master" to date.

For rapid reference, the products of electronics manufacturers are organized into 30 product sections. All the latest standard electronic products are shown, including miniature and subminiature components, printed-circuit components, silicon rectifiers, new semiconductor types, CB, SSB, and new mobile ham gear, color-TV test equipment, among others. A detailed index facilitates location of specific products while a manufacturers' directory completes the volume.

* * *

"TRANSISTOR MANUAL" edited and published by Semiconductor Products Dept., *General Electric Company,* Syracuse, N.Y. 651 pages. Price $2.00. Soft cover.

This is a Seventh Edition and is roughly ten times the size of the first edition published in 1957, so rapidly has transistor technology grown. New and updated material accounts for more than

80% of the contents with emphasis on practical information.

The manual is divided into twenty sections covering basic semiconductor theory, small signal characteristics, large signal characteristics and transistor choppers, biasing and d.c. amplifiers, logic, switching characteristics, digital circuits, oscillators, feedback and servo amplifiers, regulated d.c. supplies, audio and hi-fi amplifier circuits, radio receiver circuits, unijunction circuits, tunnel diode circuits, circuits for experimenters, silicon controlled switches, silicon signal diodes and snap diodes, transistor measurements, transistor specification sheet and specifications, and application notes.

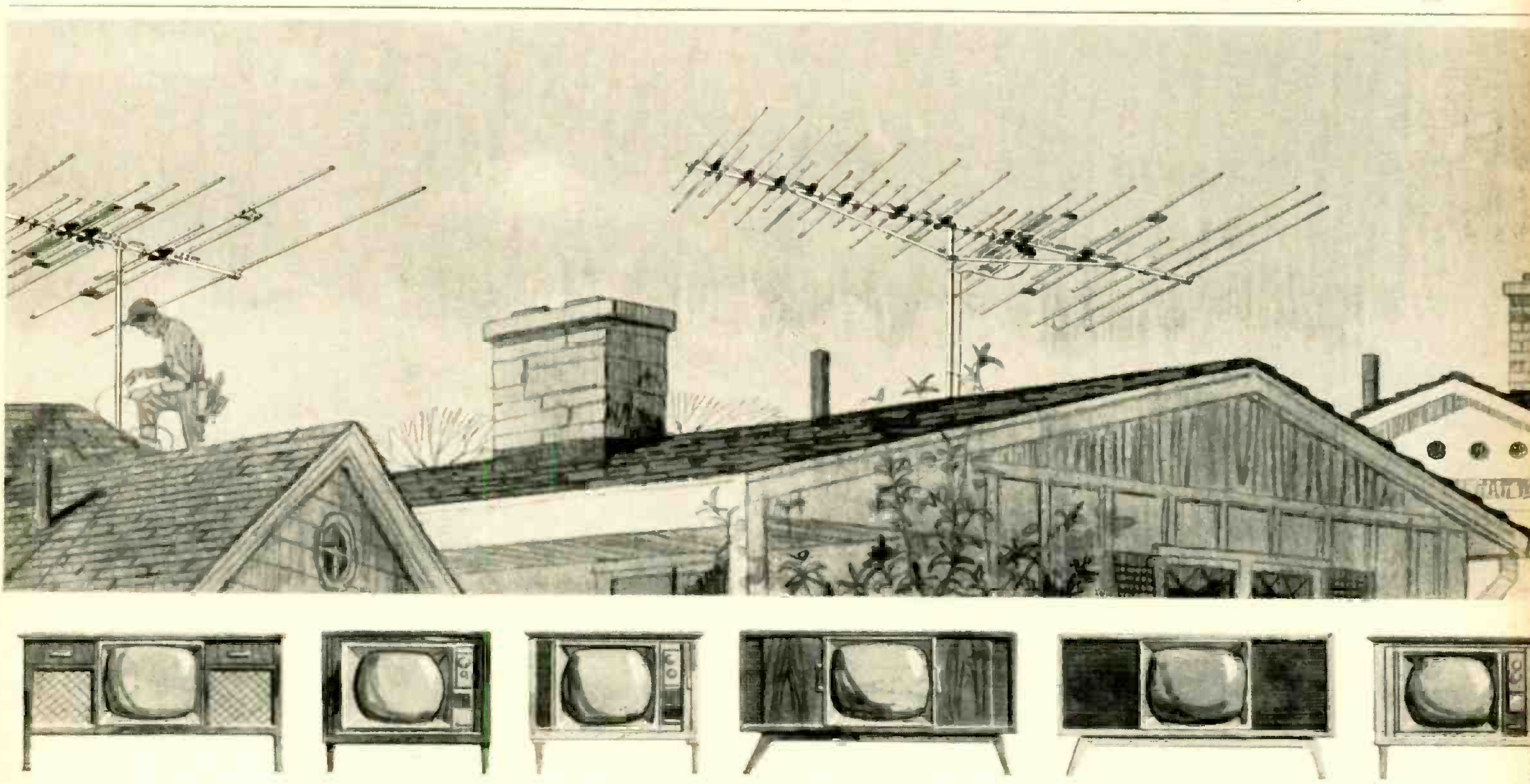
Hundreds of schematics are included. A detailed index would be a worthwhile addition to this useful manual.

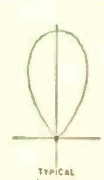
"ADVANCED SERVICING TECHNIQUES" prepared under the sponsorship of the EIA. Published by *John F. Rider Publisher, Inc.*, New York. Vol. I (288 pages) $8.25. Vol. II (172 pages) $5.95.

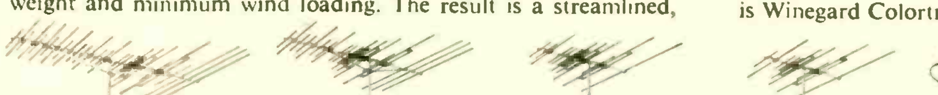
These two volumes, appearing under a common title, have only their level in common. The first volume by Paul B. Zbar and Peter W. Orne, deals with color and black-and-white TV servicing while the second volume by Neely, Massaro, Harris, Rosenthal, and Kist involves the servicing of stereo amplifiers, FM and FM-multiplex equipment, record changers, tape recorders, home intercoms, and receivers.

Vol. I is a revised and updated edition of "Advanced Television Servicing Techniques" which the EIA sponsored some ten years ago. In the interim, color television, printed circuits, transistors, all-channel u.h.f.-v.h.f. receivers, and other important new developments have made their appearance making it necessary for technicians to acquire new skills and techniques. The text is divided into 20 chapters which cover all facets of TV receiver servicing, from the test equipment to be used and its application, to the troubleshooting and repair of specific circuits. The text is lavishly illustrated with graphs, schematics, photographs, and even color plates.

Vol. II which deals with various types of audio equipment is written by a "specialist" in each category. It includes the latest information on maintenance, repair, and troubleshooting procedures and, like Vol. I, is a practical, no-nonsense treatment of the subject. ▲







Soldering Tools

(*Continued from page* 48)

soldering of individual joints is generally employed, and the ultrasonic action is really only an assistance to the soldering itself. A bath of molten solder, as shown in Fig. 7, contains an ultrasonic transducer. The dots near the tip of the transducer indicate the area of cavitation where the component lead or the joint to be soldered is placed. The cavitating solder cleans the lead of oxides and other foreign matter just as vigorous scrubbing would do. As the lead is moved from the cavitation region, the molten solder clings to the oxide-free surface. The entire process, which takes less than a second, is effectively the same as if the component lead were scraped perfectly in a vacuum and molten solder applied immediately. Because all oxides are removed and no flux or other chemicals are needed, the temperature of the solder can be kept much lower, making this process particularly useful for semiconductors and microminiature assemblies where high temperature may be a problem. One of the limitations of the ultrasonic process is that it does not work with ferrous metals which need a flux under all circumstances. Another limitation is the need for changing the solder bath relatively often to get rid of oxides and other dirt which would now be dispersed through the solder and which might adhere to the already soldered material forming non-solderable spots.

Automatic Soldering

The widespread use of printed wiring has brought about a small revolution in soldering methods. When it became possible to solder many connections simultaneously simply by dipping a printed wiring board into molten solder, many hand-soldering operations could be eliminated, and solder pots took the place of soldering irons. Hand dipping was quickly replaced by semi-automatic dipping. But this required frequent refilling to keep the solder level constant. Dross forms easily at the top of the solder pot due to oxidation of the molten solder where it contacts the air. Both of these limitations are overcome by the wave- or fountain-soldering method. Oxidation of the solder surface is reduced by the fact that the solder is constantly moving and also by employing oil which is often used to cover the surface of the molten solder. Instead of a constant solder level in the pot, only the solder wave which contacts the printed wiring has to be constant.

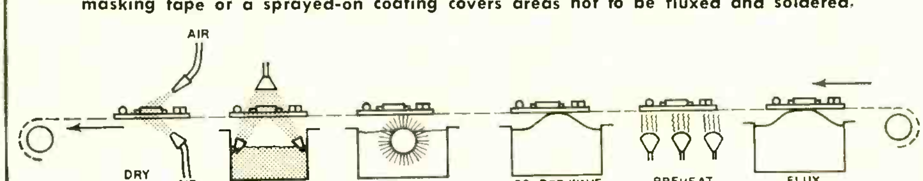
The subject of automatic production soldering could fill a thick book, but to get an understanding of what is involved, a typical wave-soldering system will be described. Fig. 8 shows the major components and processes used. Instead of a single conveyor, several different conveyors may be used and the printed wiring boards are usually held in a fixture which itself is attached to the conveyor. On many printed wiring boards it is desired that certain parts, such as connector contacts, do not receive any solder. Either manual application of masking tape or a sprayed-on coating covers those areas and prevents action of the flux or adherence of the solder.

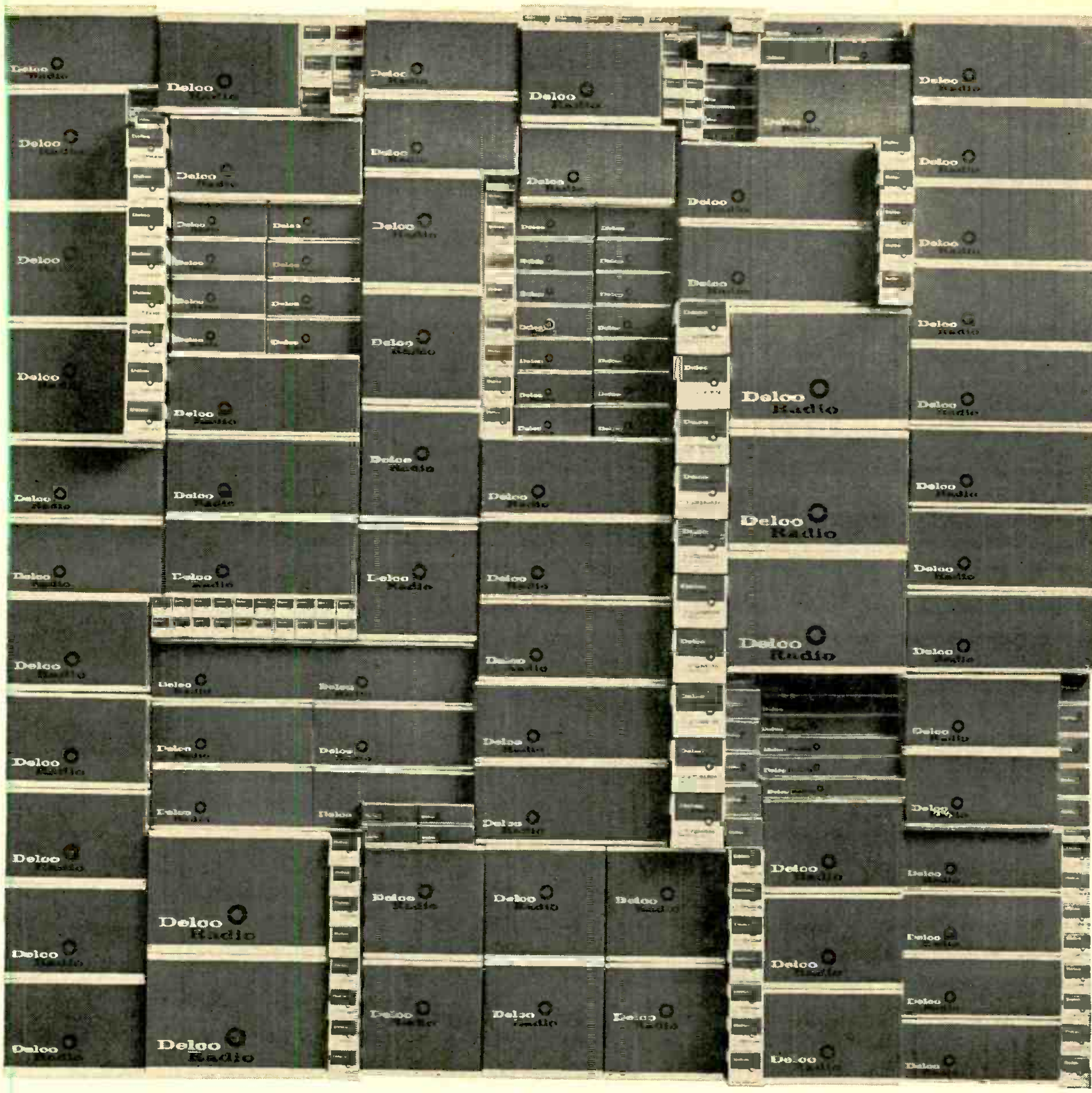
Starting on the right of Fig. 8, the bottom of the printed wiring board is coated with flux. In some instances, flux is sprayed on, in others it is applied by passing the board over a rotary brush which is partly submerged in the flux, and in still others a small fountain of foaming flux is created which touches the printed board. After the flux is applied, it is customary to pre-heat the printed wiring board by passing it over some infrared lamps. The solder-wave equipment consists of a heated container which keeps the solder at the desired temperature and a simple pump which creates a wave by forcing the molten solder through a rectangular chimney. The height of the solder wave can be carefully controlled. Most systems use a thin blanket of oil to reduce oxidation both of the solder wave and of the solder joint during the short hardening period.

The flux residue and the oil must be removed as soon as the solder has hardened on the printed wiring board. Two or more stations of washing and rinsing, the first with flux remover, the second usually with warm water, are followed by an air-pressure jet which blows the water off the board.

Automatic-wave soldering systems, though simple in concept, require a great deal of careful adjustment, constant inspection, and maintenance. Close temperature control, replacement of the various chemicals, and inspection of the finished printed boards are essential in producing uniform and reliable soldered connections. ▲

Fig. 8. Layout of a typical automatic soldering production line. Usually several conveyors are used and the printed-circuit boards are mounted in fixtures. Either masking tape or a sprayed-on coating covers areas not to be fluxed and soldered.





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CIRCLE NO. 123 ON READER SERVICE PAGE

READER SERVICE PAGE

As a convenience to our readers, we have included two separate reply coupons in this issue which should simplify the process of requesting information on products and services appearing in this issue.

Unfortunately, many companies will not furnish additional information to a home address. Therefore, to assure a reply, make certain that the proper coupon is used.

To get more information, promptly, about products and services mentioned in this issue, simply circle the number corresponding to the ad or editorial mention and send the proper coupon to us. Your request will be sent to the manufacturer immediately.

FOR PROFESSIONAL USE: In requesting information on products and services listed in the coupon below it is necessary to fill out the coupon COMPLETELY, stating your company, address, and your function or title. If the coupon is incomplete it cannot be processed.

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ELECTRONICS WORLD (VOID AFTER MARCH 31, 1965) 2
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NEW PRODUCTS & LITERATURE

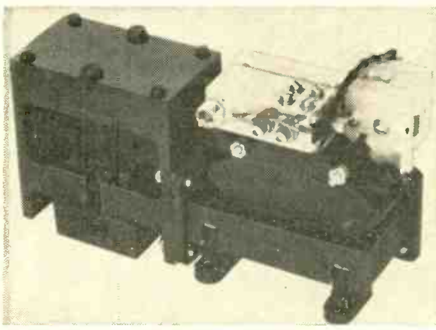
Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupons appearing on pages 17 and 88.

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

TUNNEL DIODE AMPLIFIER

1 The Micro State Electronics Corp. has developed an x-band tunnel diode amplifier which incorporates its own protective limiter.

The tunnel diode amplifier's gain exceeds 17 db with a noise figure of less than 5.5 db over an



8850-8950 mc. range. The solid-state active limiter covers this frequency range with more than 45 db of isolation for handling peak powers of 5 kw. for protection to the tunnel diode amplifier. Additional loss allowed for the switch assembly over the temperature range is less than 1 db.

AUTOMATIC DEGAUSSING KIT

2 Colman Electronic Products Inc. has developed a completely automatic degaussing kit for all 1963-64 color TV sets. The kit is designed for those who want to move their color sets from one location to another without having to have the set readjusted.

The degaussing kit comes complete with detailed instructions for its use. It consists of two specially designed degaussing coils, an automatic degaussing control, and all the necessary wiring. No drilling is required in most cases and it is not necessary to remove the chassis from the cabinet when installing the kit.

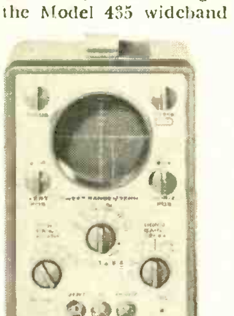
SILICON FOCUS RECTIFIER

3 Sarkes Tarzian Inc. has announced a new silicon focus rectifier which it claims provides permanent correction for color focus problems. The rectifiers are permanent, direct replacements for the selenium rectifiers in many **Airline, Dumont, Emerson, Magnavox, Olympic, Packard Bell, Philco, RCA, Silvertone, Sylvania, Warwick, Wells Gardner,** and **Zenith** sets.

The new units are catalogued as Type CV650.

3" WIDEBAND SCOPE

4 Eico Electronic Instrument Co., Inc. is currently introducing a compact oscilloscope, the Model 435 wideband unit which employs a flat-face, 3-inch cathode-ray tube. Distortionless vertical and horizontal trace expansion to several times the screen diameter and drift-free vertical and horizontal positioning permit examination of waveforms with as much detail as with 5" scopes, according to the company.



Vertical response is flat within +1 db, −3 db from d.c. to 4.5 mc. and sensitivity is 18 mv. per cm. r.m.s. and 50 mv. per cm. peak-to-peak. Input impedance is 1 megohm shunted by 35 pf. Horizontal response it flat within +1 db, −3 db from 1 cps to 500,000 cps and sensitivity is 0.7 volt per cm. r.m.s.

The scope, which is offered in both kit and factory wired versions, weighs only 15 pounds and measures 8½" h. x 5¾" w. x 12⅝" d.

ALL-CHANNEL ANTENNA

5 JFD Electronics Corp. has developed a new version of its "Log-Periodic" concept, the LPV-VU all-channel v.h.f.-u.h.f.-FM "Cap-Electronic" dipole antenna.

By introducing parallel plate capacitors into the dipoles and adjusting their capacitance and location, the new design creates more driven elements than ever before possible. Only one downlead is required; an AC80 signal splitter is included so lead-ins can be run to v.h.f. and u.h.f. TV set inputs and FM tuner inputs.

Five models are currently available with from 6 to 18 active cells to provide reception for FM from 30 to 75 miles, u.h.f. from 25 to 90 miles, and v.h.f. from 75 miles to 175 miles.

COLOR-BAR GENERATOR

6 Seco Electronics, Inc. is now marketing the Model 990 color signal generator which the company claims is so stable that it needs only 15 seconds to lock in and remains stable all day.

Crystal-controlled keyed color bars provide 10 standard colors for accurate alignment and troubleshooting of color circuitry. A rainbow color pattern can also be selected to supplement keyed

color-bar tests. Color gun killer switches allow the technician to actuate any combination of color guns.

Variable dot patterns of 54 or 144 dots can be selected for d.c. or static convergence. Variable crosshatch patterns of 6 or 16 horizontal bars and 9 vertical bars can be selected for dynamic convergence, overscan, and linearity adjustments.

The unit is housed in a sturdy steel case. Two clip-on antenna leads hook the unit up to the TV set. It is factory adjusted to channel 3 and can be tuned to channels 2 or 4.

ELECTROLUMINESCENT KIT

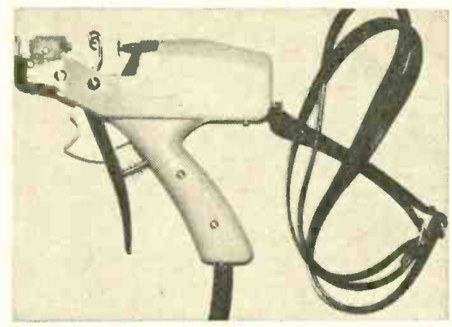
7 Sylvania's Lighting Products Division is now offering an applications development kit containing sample materials and a power supply for investigating design applications of its flexible electroluminescent light source called "Tape-Lite."

"Tape-Lite" provides medium-level illumination and operates on the principle of electroluminescence. The new light source is only 1/32" thick and has a lighted width of one inch. It can be produced in continuous lengths up to 150 feet. Since it can be twisted, coiled, and bent in wrap-around form, even while lit, the new tape is applicable to numerous fields.

The kit includes one-foot lengths of the four basic colors: green, white, yellow, and blue. An additional three-foot length of green tape is included and all strips are equipped with end caps and line cords for 120-volt operation.

BATTERY-OPERATED SPLICER

8 Jonard Industries Corp. is now offering a newly patented splice gun which will handle cable sizes 16 to 30 in an automatic operation. The new four-in-one instrument will twist cables, burn off the insulation, weld the conductors, and



cut off surplus wire. The two conductors to be joined are inserted into the jaws of the gun. Operation of one trigger actuates an electric motor which twists the conductors together for a set number of turns. Operation of a second trigger applies battery potential to the twisted conductors which burns off the insulation and completes the splice.

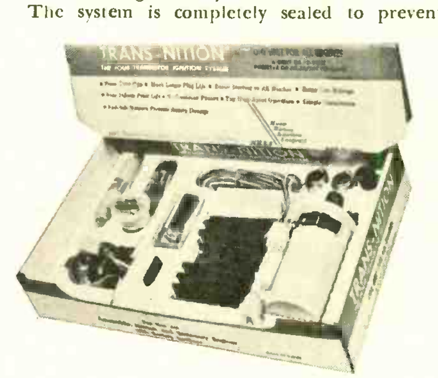
The tool which is 6" long x 6" high weighs 1¼ pounds. It may be operated from a portable 6-volt d.c. source or a battery.

IGNITION SYSTEM KIT

9 Heath Company is now marketing a kit version of The Nuclear Electronics Laboratories Inc.'s "Trans-nition" transistorized ignition system.

Designed for 6- or 12-volt operation, positive or negative ground, the system can be installed on any car, foreign or domestic. It features a 4-transistor, zener-diode-protected circuit. A built-in conversion plug is provided to switch to the car's conventional ignition system if desired.

The system is completely sealed to prevent



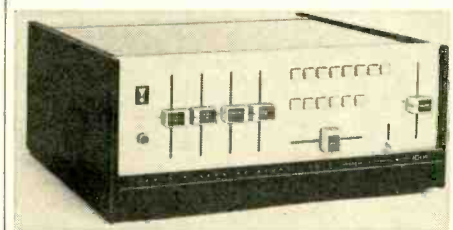
damage from moisture and corrosion. The kit includes instructions, ballast resistor, all mounting hardware, wire, terminals, and a special high-output coil.

HI-FI — AUDIO PRODUCTS

HI-FI STEREO PREAMPLIFIER

10 **James B. Lansing Sound, Inc.** is now offering the Model SG520 "Graphic Controller," a stereo preamplifier of unique design. The instrument features professional straight-line attenuators which permit precise adjustment, instant visual recognition of control settings, and adjustment of multiple functions separately or simultaneously.

Illuminated push-button selectors permit instantaneous switching from any function to any other function. Buttons are illuminated when depressed and function designations are engraved directly on the button to eliminate switching errors. Behind the hinged front panel are output level set controls, gain controls for phono in-



puts, high- and low-frequency filters, a tape monitor switch, etc. The hinged panel also conceals the main power fuse and signal jacks for connecting auxiliary equipment such as portable recorders, microphones, and headphones.

The SG520 has built-in provisions for use with the company's "Aural Null" stereo balancing system. A test button on the "Graphic Controller" allows all elements of the stereo installation to be balanced instantly and positively.

Response is within ¼ db from 20 to 20,000 cps. Distortion is less than 0.15% within this range at full rated 3-volt output. Hum and noise is inaudible—1 µv. or less referred to the low-level phono input. An accessory case is available as optional equipment.

4-TRACK MONO/STEREO RECORDER

11 **Roberts Electronics** has developed a four-track stereo/mono tape recorder, offering professional features at low cost. The Model 1630 includes four-track stereo and mono record and playback; two-speed electrically switched motor; 1⅞, 3¾, and 7½ ips tape speeds with 15-ips kit available; automatic shut-off; 20 watts of music power; 5" x 7" elliptical speakers; and recording capability from 40 to 18,000 cps.

TAPE-HEAD CLEANER

12 **Electronic Chemical Corp.** has recently added a tape-head cleaner to its "No-Noise" line of electronic chemicals in aerosol form.

Known as the "Tape-Reco Head Cleaner," the new product dissolves the oxide and tape lubricant deposits resulting from normal tape recorder operation. The product contains no carbon tet, will not affect plastics, is non-inflammable, and non-toxic.

The product is used by simply spraying the tape recorder head and removing all loose, un-

wanted oxide and residue with a cotton swab or soft clean cloth. The cleaner is applied with a 5" extender push-button assembly for pinpoint application.

MID-RANGE SPEAKER CHANGE

13 **Acoustic Research, Inc.** has announced a change in the mid-range speakers used in its Model AR-2a. Instead of two 5-inch speakers, a single 3½" broad-dispersion cone tweeter, heavily damped by fiber glass on both sides of its diaphragm is being used. The main improvement is in dispersion, although there is also some improvement in smoothness and, for the AR-2, in high-frequency range.

The new speakers are designated the AR-2ˣ and the AR-2aˣ. They will be supplied with a new style of grille cloth. Conversion kits for those wishing to change the older models are now available. They are entirely compatible for use in stereo with the older AR-2 or AR-2a speakers.

WIRELESS MICROPHONE

14 **E. J. Sharpe Instruments Inc.** is now offering a low-priced FM wireless microphone which is no larger than a package of regular cigarettes.

The Model FMT-2 is tunable over the entire FM band with one control and requires no modification or external connections to the receiver. The unit is fully transistorized and is powered by a 9-volt battery. Boasting a 300-foot range, the microphone is practically tamper-

proof and provides for many short-range communication and transmitting applications in industrial and commercial use, for entertainment, home use, and experimentation.

COMPACT SPEAKER SYSTEM

15 **Sonotone Corporation** has added a compact speaker system, the "Sonomaster," to its line of enclosures.

The Model RM-1 measures 14½" x 10½" x 7¼" deep and can handle up to 80 watts peak. The system is designed with two speakers, a 6" flexible-suspension, linear-type, high-compliance woofer and a high-frequency tweeter, acoustically matched by means of an integrated LC network. The tweeter is equipped with a calibrated level control which permits each listener to adjust highs to his personal taste.

Frequency response is 45-20,000 cps with crossover at 5000 cps. Impedance is 8 ohms.

150-WATT SOLID-STATE AMP/PREAMP

16 **Sherwood Electronic Laboratories, Inc.** is now offering a compact, integrated amplifier-preamp as the S-9000 all-silicon, solid-state stereo amplifier.

Peak power is 300 watts, continuous sine-wave power rating is 100 watts while the unit puts out 50 watts per channel with both channels operating. Power bandwidth is 12-23,000 cps at 1%. Harmonic distortion at the continuous power rating is less than 1%. At normal audio levels, distortion does not exceed 0.15%, according to the company. Sensitivity for rated output is: phono 1.8 mv., tape head 1 mv., and tuner 0.25 volt. Maximum noise and hum below rated output is −70 db phono and −80 db tuner.

Output circuits are transformerless, direct-coupled through low-loss 3000-µf. capacitors. The output handles speaker systems with impedances ranging from 4 to 16 ohms.

ELECTRONIC ORGAN KIT

17 **The Schober Organ Corporation** has introduced a new all-transistor organ kit, the "Consolette II." which the company claims can be assembled by anyone who can use a pencil soldering iron.

The unit has two 60-note manuals instead of the usual 44-note home organ keyboards. It has the same number and kind of keys found in

pipe organs. It is equipped with 17 pedals and its 22 stops cover the gamut of organ sounds from flutes to strings and reeds.

Complete kits may be purchased at once or portions bought and assembled before the next set of components is purchased. The keyboards, wood console, and organ bench are supplied fully assembled.

POWER AMPLIFIER

18 **McMartin Industries, Inc.** has added the MA-20 to its line of economy audio components.

The amplifier has two microphone and one program inputs. Power output is 20 watts r.m.s., 28 watts music, and 40 watts peak. Frequency response is 30-20,000 cps. The unit also incorporates separate bass and treble controls, a master gain control, balanced 70.7-volt/ 25-volt speaker outputs, and a bridged output for feeding a basic amplifier.

Optional features include a tamperproof control cover, universal microphone and line input transformers, and professional push-lock microphone connectors.

TRIPLE-PLAY TAPE

19 **Reeves Soundcraft Division** is now offering a new Mylar-base recording tape which triples the playing time of each reel without sacrificing quality.

TP-18 provides 1800 feet of 0.5-mil Mylar on each 5" reel. It offers 3 hours and 12 minutes of playing time at 1⅞ ips or 1 hour and 36 minutes at 3¾ ips. The new tape may be interspliced or programmed with standard tapes without causing differences in playback level, according to the company.

AUTOMATIC TAPE RECORDER

20 **Concord Electronics Corp.** is now offering a new automatic tape recorder, the Model 994. One unique feature of the new unit is its built-in "electronic memory" which enables the user to program the tape recorder for such manual or automatic operations as: single play, automatic reverse, and continuous play or record. It can be programmed to play for any length of time: half-hour, hour, or all day,

The recorder has four heads: two erase and two record/playback. Tape speeds of 7½, 3¾, and 1⅞ ips can be selected by means of a switch. Frequency response is 40-16,000 cps ±2 db at 7½ ips. Signal-to-noise ratio is better than 55 db. Flutter and wow is less than 0.15% r.m.s. at 7½ ips.

The unit has built-in power amplifiers and two speaker enclosures, each of which contains two speakers with crossover network. The unit measures 15½" w. x 11½" h. x 17" d. and weighs 44 pounds.

NEW TURNTABLE

21 **Elpa Marketing Industries Inc.** has added the PE-34 turntable to its line of audio components.

Special features of the new turntable include an automatic foolproof glide to and from the record groove; a semi-pneumatic cueing and indexing tonearm control for 7", 10", and 12" records to permit start or stop at any point during record play; and automatic tonearm lift at end of play.

The four-speed, non-magnetic heavy aluminum weighted turntable is mounted on precision bearings. Rumble has been pushed below the auditory level by using belt plus idler wheel drives. The four-pole heavy-duty induction motor has reserve torque and floats in a triple rumble-isolation system. Tonearm resonance is

low. The arm has a double suspension in both vertical and horizontal planes.

The turntable measures 13" x 10¾" and is 3" above the mounting board and 3⅞" below. The turntable is recessed and sits on spring-loaded shock mounts which minimize feedback problems.

PROFESSIONAL AUDIO SYSTEM

22 **RCA Audio-Visual Products** has introduced a new professional audio system that provides broadcast quality in the tape recording and playback of music and speech. The new system is adaptable to a large auditorium or small linguistics laboratory.

Fully transistorized, the system is available in both mono and stereo models. Components include the RT-21B tape recorder, BA-31B amplifier, and the LC-1B loudspeaker and speaker housing. The system's speaker covers the extended range of 40 to 16,000 cps. It employs a series of acoustical domes on the cone to eliminate interference inherent in a symmetrical shape and to produce the smooth response for which the LC-1B speaker is known.

STEREO AMPLIFIER KIT

23 **Heath Company** is now marketing a newly styled 70-watt transistorized stereo amplifier as the Model AA-21C.

The new walnut cabinet, coupled with the amplifier's charcoal gray upper front panel, soft-refracted panel lighting, and walnut-finished hinged lower front panel, adds a modern touch to any room.

The amplifier features a 26-transistor, 10-diode circuit for smooth transient response and cool operation, while providing full continuous power from 13-25,000 cps ±1 db at 30 watts per channel (50 watts IHF music power).

All controls are front-panel mounted. The hinged lower front panel conceals and protects all secondary controls such as the tape-monitor input switch, speaker phase reversal switch, loudness switch, and all input level controls. Major controls include 5-position mode switch, and dual concentric volume, bass, and treble controls.

The kit comes with complete assembly instructions with the preamp circuit components encapsulated in six epoxy covered modules, all factory wired and sealed.

DICTATING MACHINE

24 **American Geloso Electronics, Inc.'s** "Sten-Otape" division is now offering a new dictating-transcribing machine, the Model RV 4-10. The all-solid-state, 12-transistor, 10-hour dictating-transcribing machine features a full control microphone with review position.

The unit incorporates a digital counter, for

fast dictating reference; built-in handle for easy portability; vu meter; and clear, high-impact dust cover and latch. Available accessories include foot-pedal control, finger-tip control, transcribing earphone, telephone pickup, dual-conference mixer and automatic voice control.

FM-STEREO TUNER

25 **Lafayette Radio Electronics Corporation** has added a new FM-stereo tuner, the LT-250, to its line of audio components. A new "Stereo Search" system locates stations broadcasting in FM-stereo by sending an audible signal through both channels. A tuning eye and switchable a.f.c. facilitates accurate tuning and stability.

The built-in multiplex circuit provides a stereo separation of 38 db at 400 cps with less than 1% distortion. A three-gang tuning capacitor provides a tuned r.f. stage for sensitivity of 2 μv. for 20 db quieting.

The instrument measures 12¾" w. x 5⅝" h. x 9½" d. with legs. It has a gold extruded aluminum front panel.

ULTRA-HIGH-POWER HORN

26 **LTV University** has added the Model DH, a dual-horn driver trumpet, to its line of super-power trumpets for p.a. applications. The unit is made up of two horn sections forming one rectangular-shaped bell, each section being driven by an individual driver.

For applications demanding super power, two of the company's ID-75 drivers used in conjunction with the Model DH trumpet provide 150 watts of power in a 20⅜" x 9⅜" x 13⅝" package.

PROFESSIONAL RECORDING TAPE

27 **Superscope, Inc.** has announced the availability of Sony PR-150 professional recording tape, a quality polyester-back recording vehicle that is impregnated with a "Lubri-cushion" that cannot wear off, assuring smooth tape movement, intimate head contact, and minimum head wear.

The tape is wound on reels of a computer-reel type for easy threading. Distinctive markings on each side of the reel are for quick reference. Even the leader is color-coded for fast loading and operation.

GUITAR AMPLIFIER

28 **Perma-Power Company** has added an all-transistor guitar amplifier to its "Ampli-Vox" line of audio products. The Model S-800 includes two high-quality speakers, housed with

the amplifier in a luggage-type case of scuff-proof durable "Royalite."

The amplifier can be used with electric guitar, bass, and accordion, singly or in combination. The complete self-contained unit weighs only 6 pounds. The acoustical case houses a cabinet-coupled bass and mid-range speaker as well as a 3" tweeter to provide full coverage of the complete instrument range.

FM SOLID-STATE PREAMP

29 **Jerrold Electronics Corporation** has introduced a new FM preamplifier, designed specifically to overcome the problems of FM-stereo reception.

The Model SRX provides 18 db of amplification and, according to the manufacturer, extends the range of FM tuners, allowing them to receive good FM-stereo broadcasts from distances greater than normally covered by mono transmissions.

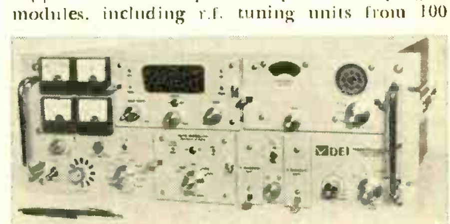
The solid-state device is compact and can be mounted anywhere indoors between the antenna and the FM set. Serrated washers provide fast, easy connections. An added feature is a built-in TV-FM splitter, enabling the use of a TV antenna to supply FM signals. This device isolates TV from FM, preventing interference.

CB-HAM-COMMUNICATIONS

TELEMETRY RECEIVER

30 **Defense Electronics, Inc.** has developed a new solid-state telemetry receiver which is being marketed as the Model TR-711. According to the company, it is virtually spurious free and offers an order of magnitude improvement in strong signal-handling capabilities.

Modular in construction, the receiver can be supplied with a complete complement of plug-in modules, including r.f. tuning units from 100



to 2300 mc.; i.f. amplifiers with 10-kc. to 3.3-mc. bandwidths; AM, FM, and phase demodulators; and plug-in spectrum display unit, oscilloscope, pre-detection up and down converter, or high capture ratio discriminator.

A rear apron 30-mc. i.f. input connector allows the TR-711 to be used as a 30-mc. "receiver" in conjunction with any tuning unit or device having a 30-mc. output frequency.

LOW-COST CB TRANSCEIVER

31 **Metrotek Electronics, Inc.** has introduced an inexpensive CB transceiver, the "Pacer," that has a dual power supply for base station or mobile operation.

The unit has seven built-in, crystal-controlled channels for transmit, plus a quick-change external socket for plugging in an additional crystal of any desired frequency. The receiver portion has eight crystal-controlled channels and is tunable to all 23 channels. The receiver is a superhet with a tuned r.f. stage for a high sensitivity of 0.3 μv. usable. The crystal receiver local oscillator is 455-kc. above channel frequency.

Output is 3.4 watts minimum. A built-in speech clipper maintains 100% modulation with wide ranges of voice levels. A high-impedance ceramic microphone is standard equipment.

The dual power supply operates on 110 volts a.c. and 12 volts d.c. All power cords and fuses are supplied.

TWO-WAY RADIO EQUIPMENT

32 **Du Mont Laboratories** is now offering the first unit in a complete new line of high-power, two-way mobile radio systems for use in commercial and municipal vehicles.

Known as the "Statesman" series, the new units will be produced in all three commercial frequency band, with transmitter/receivers in the 132-174 mc. band the first to be available.

Transmitter output is rated at 90 watts with an optional 110 watts when required. Receiver power is 5 watts with only 35 ma. of battery drain once squelched.

The front-mounting version of this unit is designated T-301F while for rear mounting it is tagged T-301R. With the control head, receiver, transmitter, and power pack as separate units, all vehicle installation requirements can be met without special equipment.

100-WATT RADIOTELEPHONE

33 **Apelco** has recently added a transistorized 100-watt radiotelephone to its line of marine electronic equipment.

The Model AE-100M provides two-way communications on any eight crystal-controlled channels in the marine band. In addition, the full broadcast band is available for listening to news, weather, and general programs.

Transistorized audio amplifiers in the set cut the receiver's battery drain to only 1.1 amps despite a six-stage receiver employed for extra sensitivity and selectivity.

HAM RECEIVER

34 **Lafayette Radio Electronics Corporation** is now marketing the HA-225 amateur communications receiver, a 14-tube superhet with dual conversion on 6 meters.

Frequency coverage is from 150 kc. to 54 mc. in five bands: 150-400 kc. (marine beacon), 1.6-4.8 mc., 10.5-30 mc., and 48-54 mc. A separate filament transformer provides constant heater voltage to the mixer and oscillator tubes for increased frequency stability. The unit has calibrated electrical bandspread on amateur bands 80 through 10 meters (6 meters is tuned with the main tuning control).

Sensitivity is 0.5 microvolt for 10 db signal-to-noise ratio. Other features include product detector circuit for SSB reception, separate b.f.o. and "Q"-multiplier circuits, crystal calibrator, automatic noise limiter, built-in "S" meter, and regulated power supply.

FLASHER-TYPE DEPTH SOUNDER

35 **Pearce-Simpson, Inc.** has recently introduced its Model DS-464 flasher-type depth sounder which incorporates a new concept for solving the problem of obtaining depth readings under any lighting conditions—even in the brightest sunshine.

A variable controlled illuminated depth scale is fully enclosed and horizontally mounted, insuring readability by providing complete protection against the glare of sunlight. The unit also features a calibrated scale, 21" in circumference. The entire scale can be rotated to bring

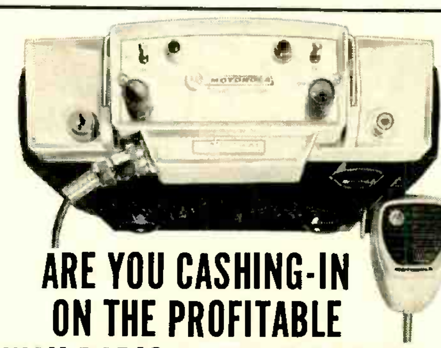
the desired operating depth into the most convenient viewing position.

Range is 240 feet, 12-volt d.c. operation. The unit measures 9-7/16" wide x 6-9/16" high x 9⅜" deep and weighs 14 pounds. It includes transducer, mounting bracket, connecting cable, and fairing block.

EMERGENCY COMMUNICATIONS KIT

36 **E. F. Johnson Company** has designed a lightweight, self-contained communications kit which will provide two-way radio communications in emergencies.

Each kit contains two hand-held "Personal Messenger" transceivers with rechargeable nickel-



cadmium batteries, leather carrying cases and flexible 11" fiberglass antennas, plus two extra rechargeable batteries.

The transceivers are FCC type—accepted for use in the 25-50 mc. range in public safety, industrial, or land transportation radio services.

All of the items are packed in a rugged carrying case just 5" wide x 11" high x 17" long. The case, fully equipped, weighs 10 pounds.

PORTABLE DIRECTION FINDER

37 **Bendix-Marine** has added a new portable direction finder to its line of marine electronics equipment.

Known as the "Navigator 420," the new model features a tone generator for receiving consolan broadcasts, push-button dial light, external an-

tenna jack, sensitive null meter circuit for reading weak stations, a battery saver plug-in cord allowing the unit to be operated from external power, and an optional a.c. power pack.

The unit covers the beacon, broadcast, and marine bands from 190 kc. to 4500 kc.

CB/HAM COMPRESSOR

38 **Galaxy Electronics** is now offering a new CB/ham compressor which the company claims will boost "talk power" 3 to 4 times. In CB service, the unit automatically amplifies the low levels of speech, allowing more power, clear transmission, and maximum utilization of the 5-watt output power.

The unit is completely transistorized and is adaptable to most AM and SSB transmitters for CB and amateur equipment. The unit is wired for push-to-talk. Operation is from a 9-volt battery (not supplied). The amplifier is housed in a small case measuring 2⅜" x 6¼" x 3⅜". An optional 117-volt a.c. supply is also available.

CB CRYSTAL LINE

39 **Guardian Crystals** is now offering a complete line of CB crystals for both receiver and transmitter applications in all 23 frequencies for most CB equipment.

The crystals are hermetically sealed in standard MIL HC-6/U and subminiature HC-18/U housings. Tolerance on nominal frequency is ±.002% at room temperature with tolerance ±.005% over a temperature range of −40°C to +80°C. Crystals are available with various diameter pins or wire leads.

COMMUNICATIONS RECEIVER

40 **National Radio Company, Inc.** has recently introduced the HRO-500, a solid-state communications receiver which covers the entire v.l.f. and h.f. spectrums continuously in sixty 500-kc. bands. Coverage is 5 kc. to 30 mc.

The receiver operates from 12-volt batteries or 115/230-volt, 50/60-cycle sources. Frequency is determined by a phase-locked crystal frequency synthesizer which eliminates multiple crystal oscillators for high-frequency oscillator injection. All signals are synthesized from the output of a single 500-kc. master crystal oscillator for maximum stability and the elimination of band-to-band recalibration.

The HRO-500 measures just 7⅝" high x 16½" wide x 12¾" deep and weighs 32 pounds.

SSB TRANSMITTER/RECEIVER

41 **Hammarlund Manufacturing Company, Inc.** has announced the availability of a compact SSB transmitter/receiver, the CSB-125C. The new unit has a power output of 125-watts SSB-p.e.p. and will provide up to six channels (two supplied and four optional) to cover the frequency range of 2 to 30 mc.

The new unit is designed for medium- and long-range point-to-point communications and is suitable for many industrial, commercial, and government-service applications. Sensitivity is less than 0.5 µv. for SSB/c.w. and 1 µv. for 10 db signal-to-noise ratio, 30% modulation on AM. The separately housed power supply is designed for universal 115/230-volt, 50/60-cycle operation.

PORTABLE TRANSCEIVER

42 **Singer Products Company, Inc.'s Communications Division** has recently introduced an all-transistor v.h.f.-FM portable transceiver which has been especially designed for the overseas market. The new "Sintronic" unit comes equipped with its own power supply, a rechargeable nickel cadmium battery. It measures 4" wide x 7" high x 2" deep and weighs less than 3½ pounds. It has an effective range of about five miles and operates in the 150-mc. band.

The set is supplied with speaker-microphone, whip antenna, earphone, carrying case and waist band, and complete instruction book. The 14.4-volt battery provides up to 8 hours continuous transmission.

11-CHANNEL CB UNIT

43 **Raytheon Company** is now offering a completely transistorized CB transceiver, the 11-channel TWR-5. The new model uses 14 transistors and 5 diodes.

Despite its compact size, it measures 8¼" wide x 3¼" high x 10¼" deep, the TWR-5

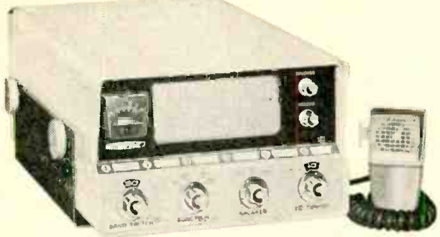
has a sensitive speaker installed in the front panel for distortion-free listening even in noisy surroundings. The front-panel location also makes it possible to install the transceiver in any attitude. The new set is pre-wired to accept selective calling accessories.

TRANSISTORIZED RADIOTELEPHONE

44 **Heath Company** has announced the availability of a new factory-assembled and tested 75-watt transistorized radiotelephone, the MWW-14.

The new unit features six crystal-controlled transmit and receive channels to cover the 2-3 mc. marine band; an all-transistor receiver with a new r.f. stage for greater sensitivity, plus 15 watts of audio power for deck hailing.

The unit is powered by a transistorized, heavy-duty power supply. A panel meter indicates received signal strength and relative transmitter power output. The receiver covers the AM broadcast band and has an external speaker provision for remote monitoring. An adjustable



squelch control and automatic noise limiter quiet background noise during standby.

The radiotelephone is housed in a black and white rustproof aluminum cabinet with sea blue and gray accents. Covered relays protect against dirt and dust and all circuitry is moisture sealed.

The MWW-14 operates on the boat's 12-volt battery (positive or negative ground), and includes a push-to-talk microphone, crystals for 2182 and 2638 kc., and a copy of the FCC regulations plus license information and forms.

MANUFACTURERS' LITERATURE

POWER TRANSISTORS

45 **Motorola Semiconductor Products Inc.** is offering a new 16-page brochure (T1258) which contains the latest developments in power transistors, reliability data, device selection, and replacement cross-reference charts. Intended for industrial, military, and space applications, the booklet covers over 2000 different device types.

Featured are new developments in both silicon and germanium transistors and a special section describing actual results of five years of reliability testing on industrial power transistors.

COMPONENTS CATALOGUE

46 **American Relays' Electronic Division** has published its 1965 electromechanical component and equipment catalogue, a 32-page, fully illustrated booklet listing components of all major manufacturers.

Included are variable transformers, motors, transducers, gyros, gyro-test tables, and a complete section of relays.

R.F. POWER MEASUREMENT

47 **Bird Electronic Corporation** is now making available a comprehensive 56-page catalogue of coax load resistors and attenuators, absorption wattmeters, directional wattmeters, coax switches, and r.f. filters.

Fully illustrated, the publication (GC-65) includes a v.s.w.r. nomogram.

PHOTOSENSITIZATION

48 **Hanovia Lamp Division** has released a new 12-page booklet entitled "Photosensitization" describing high-intensity mercury-vapor arc lamps, which produce radiations for many photochemical processes.

The brochure includes a table of photochemical rearrangements of selected organic molecules, along with an electrical-circuit schematic of a typical installation and an extensive bibliography.

FOUR-LAYER DIODES

49 **ITT Semiconductors Inc., National Transistor Division**, has issued a 4-page engineering application bulletin on the use of miniature glass four-layer diodes.

An explanation of theory of operation is provided, as well as a large variety of specific applications giving schematic diagrams and a description of how each circuit functions. Among the applications are relaxation oscillators, pulse generators, memory drivers, and multivibrators.

WIREWOUND RESISTORS

50 **General Resistance, Inc.** is now offering a 16-page catalogue containing a complete listing and illustrations of various types of resistors manufactured by the company.

A technical discussion of resistance technology

new SAMS BOOKS

Understanding Electronic Circuits

by Farl J. Waters. A down-to-earth explanation of all the basic circuits used in most electronic equipment. Begins with basic principles applicable to *all* circuits, then describes the use and operating principles of amplifiers, oscillators, modulators, frequency mixers, frequency converters, limiters, detectors, FM discriminators, rectifying power supplies, pulse generators, volume controls, and automatic frequency controls. Written so clearly it takes the "mystery" out of understanding electronic circuits. Supported by many helpful illustrations. 160 pages; 5½ x 8½". Order **UEW-1**, *only* $2.95

Understanding Electronic Components. An ideal companion volume to the above book, by the same author. 160 pages; 5½ x 8½". Order **UEC-1**, *only* $2.95

Acoustical Tests & Measurements

by Don Davis. Provides a solid understanding of the entire subject of acoustical measurements; based on actual field test work, using commercial equipment. Contains practical, time-saving solutions to actual problems encountered in the field; minimum math required for understanding. The author is an expert in this field, and an authority on auditorium acoustics. An invaluable book for phone company special service engineers, plant maintenance engineers, communications engineers, noise control specialists, architectural engineers, broadcast engineers and technicians, hi-fi fans and students. 192 pages. 5½ x 8½". Order **ADS-1**, (softbound), *only* $4.95
Order **ADH-1**, (hardbound), *only* $6.95

Amateur Radio Mobile Handbook

by Charles Caringella. Complete coverage of this increasingly popular ham activity; information both for the "old-timer" and the newcomer to mobile radio. Explains the design differences peculiar to battery-operated mobile equipment; explains circuitry and construction of commercially built equipment for **HF-VHF** ham bands. Tells you how to build mobile transmitters, transceivers, converters, modulators, etc.; gives full details on dynamotors, vibrator supplies, transistorized DC-DC power units, mobile-type mikes, antennas, etc.; discusses elimination of ignition noise and other interference. Complete and authoritative. 160 pages; 5½ x 8½". Order **AMH-1**, *only* $2.95

The Elements

by Samuel Ruben. A quick-reference single-volume compilation of available information covering the 103 accepted elements. Invaluable to students, lab technicians, engineers and anyone interested in the properties of the elements. Gives the following constants where applicable: Atomic number and weight, natural occurring isotopes, density, melting and boiling points, latent heat of fusion, specific heat, coefficient of lineal thermal expansion, thermal conductivity, electrical resistivity, ionization potential, electron work function, oxidation potential, chemical valence, electrochemical valence, ionic radius, valence-electron potential, electronic configuration, valence electron, crystal form. Includes periodic table of the elements arranged according to Atomic Number Z and columnal relation to the inert gases. 112 pages; 5½ x 8½". Order **TER-1**, *only* $1.95

Chain Saw Service Manual

Includes servicing diagrams and data for the following chain saw brands: Bolens, Canadien, Clinton, Cobra, Comet, David Bradley, Eclipse, Hoe, Hoffco, Homelite, Indian, Lancaster, Lombard, Mall, McCullough, Mono, Partner, Pioneer, Poulan, Power Products, Remington, Root, Sears, Solo, Tecumseh, West Bend and Wright. Special section describes general operating principles and basic service fundamentals applying to all chain saw motors. A special Sams service manual prepared to meet the increasing demand for information on this subject. 176 pages; 8½ x 11". Order **CSM-1**, *only* $3.35

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is given, as well as wattage rating curves and a temperature-coefficient chart of commercial alloys.

SHOCK-PROOF TOOLS

51 **Millers Falls Company** has released a 12-page illustrated catalogue (SPIE-64) announcing the development of a complete line of shock-proof electric power tools. Complete specifications are given for 39 different models.

Included are drills, saws, screwdrivers, impact wrenches, and feather edgers.

THRESHOLD EXTENSION

52 **Radio Engineering Laboratories** has released a 4-page report containing a discussion of threshold extension. This edition of "Technical Notes" covers techniques for extending the threshold of FM receivers used primarily in tropospheric scatter communications systems.

MINIATURE TOOLS

53 **Jensen Tools and Alloys** has issued a 50-page illustrated catalogue of miniature electronic assembly tools. Included are screwdrivers, pliers, files, soldering equipment, and tool kits.

An added feature is the inclusion of seven pages of "technical tool tips"—charts and tables of engineering data relating to screwdriver and plier selection, solders, mathematical conversions, and other areas.

ELECTRONIC PROJECTS

54 **H. F. Parks Laboratory** is now distributing its Catalogue #8 of professional electronic projects. The 30-page booklet lists 160 projects, each of which is classified as either very easy, moderately difficult, or extremely difficult.

SOLDERING FLUX

55 **Alpha Metals, Inc.** has released a new technical bulletin describing the company's #830 water-soluble soldering flux. Bulletin #35 covers uses for the material, residue removal, thinning, physical properties, and manufacturing specification.

PILOT LIGHTS

56 **Industrial Devices, Inc.** is offering a 4-page illustrated brochure describing the company's line of "Omni-Glow" pilot lights. Seven different lens configurations and a wide range of colors are available. Dimensional specifications are included to assist the designer in his selection of pilot lights for new equipment.

ERRATUM

In the December 1964 issue, the photographs accompanying Items 10 and 13 were inadvertently interchanged. Our apologies to **Hewlett-Packard Company** and **Grace Electronics, Inc.** for this mistake.

PHOTO CREDITS

Page	Credit
22	Harvard Electronics Co.
26, 32, 33	Bendix Corporation
27, 28	Du Mont Laboratories, Div. Fairchild Camera and Inst. Corp.
30 (top right)	Raytheon Company
30 (top left)	Airborne Instruments Laboratory
30 (center right), 47	General Electric Co.
30 (bottom left)	Bell Telephone Laboratories
31 (top)	Univac Division, Sperry Rand Corp.
31 (center)	General Motors Research Labs
31 (bottom left)	Honeywell Research
48	Development Associates
72	Weston Instruments, Inc.
73	McMartin Industries, Inc.
74	Lectrotech, Inc.

Answer to Electronics Crosswords

(Appearing on page 63)

U	S	E	R	■	F	L	A	T	■	L	A	S	E	R
H	E	R	E	■	L	A	D	E	■	O	M	E	G	A
F	A	R	A	D	A	Y	■	N	A	P	■	A	R	T
■	■	■	C	O	G	■	L	U	T	E	■	L	E	I
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M	O	N	O	S	C	O	P	E	■	F	I	R	■	■
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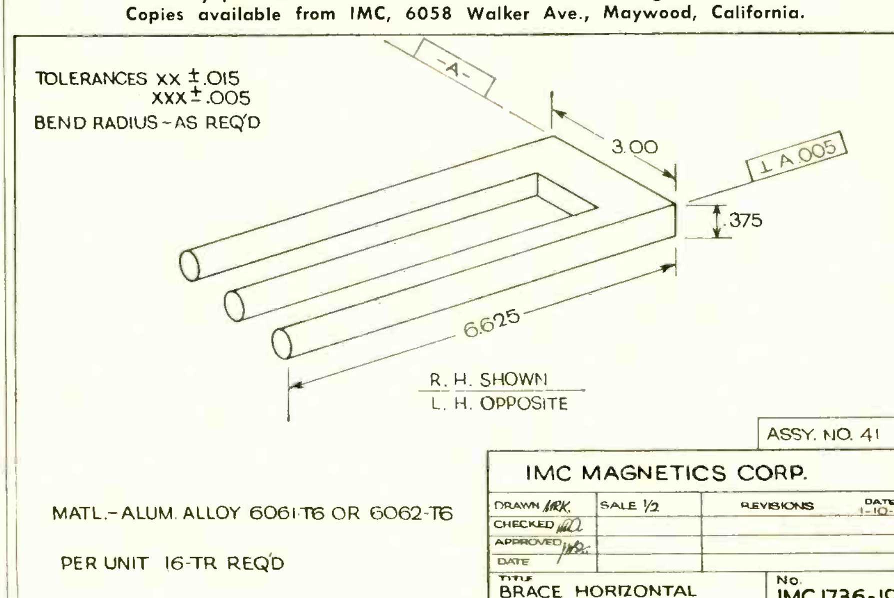
E	D	I	T	S	■	E	L	L	S	■	L	I	E	R
■	S	E	T	S	■	Y	O	K	E	■	E	P	E	E

IMC Magnetics Corp. is circulating this drawing of a so-called "problem brace" which has aroused an immediate and overwhelming response. Since the drawing, a purely "tongue-in-cheek" affair, was printed in mock seriousness, responses in the same vein have poured in. One reader referred to the device as "an anti-resonant tuning fork, which would simultaneously produce the third non-harmonic of the missing fundamental." Copies available from IMC, 6058 Walker Ave., Maywood, California.



Semiconductor Cartridge
(*Continued from page* 51)

which may be in the d.c. supply. The low impedance of the cartridge makes it ideally suited for the conventional grounded-emitter transistor circuit. Due to high level and low impedance, no expensive low-noise or high-impedance transistors are required for this circuit.

The good low-frequency response allows considerable tone-control bass without equalizer loss—which would require additional gain. Thus, the output of 25 mv. can be equivalent to a 100-mv. high-capacity ceramic cartridge into several hundred thousand ohms. And this is for a unit with only 600 to 1200 ohms impedance; hence, far more power is delivered to the load.

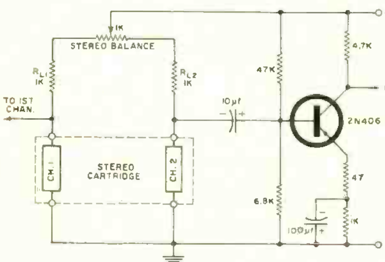
In most applications originally designed for ceramics, one stage of gain can be eliminated from each channel. In magnetic cartridge circuits, three stages can be eliminated from each channel—a possible saving of six transistors plus associated components.

To utilize all the potential advantages of the U-15 cartridge in high-fidelity applications, a complete system has been developed. This includes the cartridge, power source, and tonearm. As apparent from the photo, one of the major design objectives was to get away from the tendency for arms to be overmassive and complicated. The high compliance of the semiconductor cartridge makes it possible to reduce arm mass to an optimum 14 grams, with a fundamental resonance that is below the lowest audible frequency. Resonance is partially damped by a frictionless damper in the counterweight and by light viscous damping in the pivot.

The arm is balanced in all coordinates with a positive tracking force provided by a torsion spring in the small side knob. The force range is adjustable from .5 to 3 grams but normally is set for 1 gram.

Extensive listening tests of the semiconductor cartridge and low-mass tonearm system have confirmed the absence of audible distortion due to improper tracing. The most frequently voiced comment described the sound as "transistor sound," a term usually applied to solid-state amplifiers. ▲

Fig. 3. Typical cartridge circuit including first stage. Identical arrangement is employed for the other stereo input channel.



ELECTRONICS MARKET PLACE

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READER RATE: For individuals with a personal item to buy or sell. 35¢ per word (including name and address). **No Minimum!** Payment must accompany copy.
GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd preceding month (for example, March issues closes January 1st). **Send order and remittance to:** Hal Cymes ELECTRONICS WORLD, One Park Avenue, New York, New York 10016

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HIGHLY-EFFECTIVE home study review for FCC commercial phone exams. Free Literature! Cook's School of Electronics, Box 10682, Pittsburgh, Pa. 15235 (Established 1945, Jackson, Miss.)

REI First Class Radio Telephone License in (5) weeks Guaranteed. Tuition $295.00. Job placement free. Radio Engineering Institute, 1336 Main Street, Sarasota, Fla.

LEARN ELECTRONIC ORGAN SERVICING at home. All Makes including transistors. Experimental kit—trouble-shooting. Accredited NHSC. Free Booklet. **NILES BRYANT SCHOOL,** 3631 Stockton, Dept. A, Sacramento 20, Calif.

ELECTRONICS—F.C.C. License Training—correspondence, or resident classes. Free details, Write: Dept. 6, Grantham, 1505 N. Western, Hollywood, Calif. 90027.

CIRCLE NO. 181 ON READER SERVICE PAGE

BE YOUR OWN Television Repairman! Instruction Book, $1.25. Abrilz K2BDB, Westhampton Beach, N.Y. 11978.

DRAFTING, Blueprint reading, schematics. Send $2.00 first lesson. Complete home course $25.00. Prior Inc., 23-09 169 St., Whitestone 57, N.Y.

FOR SALE

TRANSISTOR Ignition coils, components, kits. Advice Free. Anderson Engineering. Wrentham 5, Mass.

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 6556 W. Higgins Rd. Chicago, Ill. 60656.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 20¢. Meshna, Nahant, Mass.

TRANSISTORIZED Products importers catalog. $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

DIAGRAMS for repairing Radios $1.00. Television $2.50. Give make model. Diagram Service, Box 1151 E, Manchester, Connecticut 06042.

INVESTIGATORS, free brochure, latest subminiature electronic surveillance equipment. Ace Electronics, 11500-J NW 7th Ave., Miami 50, Fla.

CANADIANS—Giant Surplus Bargain Packed Catalogs. Electronics. Hi-Fi, Shortwave, Amateur, Citizens Radio. Rush $1.00 (Refunded). ETCO. Dept. Z, 464 McGill, Montreal, Canada.

RESISTORS precision carbon-deposit. Guaranteed 1% accuracy, ½ watt 8¢. 1 watt 12¢. 2 watt 15¢. Rock Distributing Co., 902 Corwin Road, Rochester 10, N.Y.

CONVERT any television to sensitive, big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco, Box 10563, Houston 18, Texas.

TV CAMERAS, transmitters, converters, etc. Lowest factory prices. Catalog 10¢. Vanguard, 190-48 99th Ave., Hollis, N.Y. 11423.

WEBBER Labs. Transistorized converter kit $5.00. Two models using car radio 30-50Mc or 100-200Mc, one Mc spread. Easily constructed. Webber, 40 Morris, Lynn, Mass.

$100.00 WEEKLY Spare Time selling Banshee TS-30 Transistor Ignition Systems and Coils. Big Demand. Free money making Brochure. Slep Electronics, Drawer, 178ZD-EW Ellenton, Fla. 33532.

DIAGRAMS Radios $1.00 Televisions $1.00. Schematics, 618 Fourth Street, Newark, N.J. 07107.

NEW supersensitive transistor locators detect buried gold, silver, coins. Kits, assembled models. $19.95 up. Underwater models available. Free catalog. Relco-A22, Box 10563, Houston 18, Texas.

FLIP-FLOPS: Transistorized circuit mounted on a printed circuit board with plug-in connector. Operation up to 10,000 cps in set-reset or trigger mode. Can be used in counters, shift registers, and memories with no additional circuitry. $3.87 complete. Send for free literature. KOMTRON, Box 275, Little Falls, N.J. 07424.

JAPAN & Hong Kong Electronics Directory. Products, components, supplies. 50 firms—just $1.00. Ippano Kaisha Ltd., Box 6266, Spokane, Washington 99207.

CATALOG of over 200 different slide rules, calculating aids. Send 10¢. Dyna-Slide, 600 South Michigan, Chicago, Ill. 60605.

CRYSTALS—Navy 100KC Units $2.95. Electronicraft, Box 13, Binghamton, N.Y. 13902.

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SAMS Photofact Set, 38 to 414 complete. $250.00. 620 Alameda, Coronado, Calif.

NEED printed circuit boards? Complete services offered from schematic diagram or your master for commercial electronic equipment. Small or medium quantities—prototypes to several thousand boards at low cost. Fabrication, assembly, dip soldering, and checking of final assembly to your specifications from one responsible source. Orrtronics, Inc., P.O. Box 27, Opelika, Alabama.

ORDER TRANSISTORS, PARTS OF ANY PROJECT IN EW. Send 25¢ for Interchangeability Guide listing 3000 transistors. Servicemen! New accounts will receive 10% off transistors and parts during February. 30 Watt stereo amp/preamp, kit form, $36.50. Brandwein Co., 306 W. 100 Street, N.Y.C.

ACHTUNG! Das machine is nicht fur Gerfingerpoken und mittengraben. Is easy schnappen der Springenwerk, blowenfusen und poppencorken mit spitzensparken. Ist nicht fur gewerken by das Dummkopfen. Das rubbernecken sightseeren keepen hands in das pockets. Relaxen und watch das Blinkenlights. This attractive, engraved metal plaque only $2.00 ea. ppd. Southwest Agents, Box 12283, Fort Worth, Texas 76116.

CANADIANS, transistors, all semiconductors and components. Free catalogue contains reference data on 300 transistor types. J.&J. Electronics, P.O. Box 1437, Winnipeg, Manitoba, Canada.

CIRCLE NO. 243 ON READER SERVICE PAGE

16 TESTED Transistor plans—25¢. "Radio Operator's Handbook"—50¢. Catalog. Laboratories, 1131-H Valota, Redwood City, California.

INVESTIGATOR'S Electronic Surveillance Devices. 1965 Subminiature Professional Models. Free Details. Trol Electronics-EW, 342 Madison Ave., New York, N.Y.

TRANSISTORIZED Intercom Kit, with diagram, includes two-three by five inch speakers, switch, nine volt battery, fifty feet cable-misc. hook up wire, solder, and one transistorized amplifier board, that can also be used for audio gain on radios and Hi-Fi work—$4.95 for complete kit, include postage. General Surplus Sales, 10 Alice Street, Binghamton, New York 13901.

METERS—Surplus, new, used, panel and portable. Send for list. Hanchett, Box 1898, Riverside, Calif.

FREE catalog: Wholesale electronic parts and equipment. Western Components, Box 2581, El Cajon, Calif.

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Factory Tested! Gtd.!

**NEWEST TYPE! LOW LEAKAGE*

Piv/Rms	Piv/Rms	Piv/Rms	Piv/Rms
50/35 .05	100/70 .09	200/140 .12	300/210 .14
400/280 .15	500/350 .19	600/420 .23	700/490 .27
800/560 .35	900/630 .45	1000/700 .65	1100/770 Query

ALL TESTS AC & DC & FWD & LOAD!

1700Piv/1200Rms @ 750Ma$1.20 @ .10for$10
same 1100Piv/770Rms 75¢ @ . 16 for $11

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Full Leads Factory Tested & Gtd! U.S.A. Mfg.

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Sil Pressfit 18A up to 100 Piv . . . . . .4 for $1
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D.C. Amps	50 Piv 35 Rms	100 Piv 70 Rms	150 Piv 105 Rms	200 Piv 140 Rms
3	.08	.14	.17	.24
12	.30	.55	.70	.85
18**	.20	.30	.50	.75
35	.70	2.05	1.35	1.50
100	1.65	1.00	2.50	3.15
240	3.75	4.75	5.75	8.75

D.C. Amps	300 Piv 210 Rms	400 Piv 280 Rms	500 Piv 350 Rms	600 Piv 420 Rms
3	.29	.30	.40	.48
12	1.00	1.35	1.45	1.70
18**	4.00	1.50	Query	Query
35	2.15	2.45	2.75	3.33
100	3.75	4.60	5.50	8.00
240	11.70	19.80	27.90	Query

Battery Charger 6 & 12 V Charges up to 5 Amp "Approved" Heavy Duty Design with Klixon Circuit Breaker operates 220 or 110 VAC @ 50 or 60 Cys $8
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PRV	7A	16A	25A	PRV	7A	16A	25A
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50	.50	.75	1.00	300	2.00	2.45	2.80
100	.90	1.35	1.60	400	2.50	2.90	3.35
150	1.00	1.65	2.00	500	3.25	3.60	4.00
200	1.30	1.90	2.30	600	3.50	4.35	4.60

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"TAB" TERMS: Money Back Guarantee: Our 18th year. $2 Min. order F.O.B. N.Y.C. Add shpg charges or for C.O.D. 25% Dep. Prices shown subject to change.

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CIRCLE NO. 225 ON READER SERVICE PAGE

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3	.12	.18	.22	.30
12	.45	.65	.75	.90
35	.90	1.15	1.50	1.70
50	1.60	1.90	2.30	2.80
100	1.75	2.15	2.55	3.15

D.C. AMPS	300 PIV 210 RMS	400 PIV 280 RMS	500 PIV 350 RMS	600 PIV 450 RMS
3	.40	.45	.55	.65
12	1.10	1.35	1.50	1.70
35	2.35	2.55	3.00	3.50
50	3.50	4.20	5.25	7.00
100	3.75	4.60	5.65	8.00

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PRV	7 AMP	16 AMP	25 AMP	PRV	7 AMP	16 AMP	25 AMP
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50	.85	1.20	1.40	300	2.60	3.00	3.40
100	1.35	1.80	2.20	400	3.00	3.40	4.15
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3BU8	.76
3BY6	.56
3BZ6	.54
3CB6	.54
3CE5	.56
3CF6	.62
3CS6	.56
3CY5	.69
3D6	1.48
3DG4	.83

Tube	Price
3DK6	.58
3DT6	.52
3DZ4	.79
3EH7	.60
3EJ7	.60
3ER5	1.35
3FH5	.63
3FS5	1.18
3GK5	.59
3GS8	1.21
3GW5	.53
3HA5	.99
3HK5	.59
3HS8	1.29
3Q4	.61
3S4	.73
3V4	.61
4AU6	.52
4AV6	.40
4BA6	.85
4BC5	.56
4BC8	1.02
4BL8	1.00
4BN6	.72
4BQ7	.99
4BS8	.96
4BU8	.71
4BZ6	.56
4BZ7	1.00
4CB6	.55
4CS6	.59
4CY5	.70
4DE6	.60
4DK6	.58
4DT6	.87
4EH7	.60
4EJ7	.60
4EM6	.94
4ES8	1.90
4EW6	1.01
4GK5	.59
4GM6	.58
4GS8	1.29
4GZ5	1.49
4GZ6	.59
4HC7	.73
4HM6	.91
4HS8	.71
4HT6	.99
4JC6	1.64
4JD6	1.64
5AM8	.77
5AN8	.88
5AQ5	.52
5AR4	1.99
5AS8	1.75
5AT8	.81
5AV8	.98
5AZ4	.73
5B8	2.12
5BC3	1.31
5BE8	.81
5BK7	.84
5BQ7	.99
5BR8	.81
5BT8	.79
5BW8	1.31
5CG8	.79
5CL8	.74
5CM8	1.47
5CQ8	.82
5CZ5	.70
5DE8	.81
5DJ4	.77
5EA8	.78
5ES8	1.11
5EU8	1.29
5EW6	.56
5FG7	1.05
5FV8	1.21
5GH8	1.53
5GM6	1.04
5GX6	.87
5HC7	1.49
5HG8	1.95
5J6	1.09
5KE8	1.24
5T4	1.00
5T8	.84
5U4	.58
5U8	.82
5V3	.88
5V4	1.35
5V6	.54
5W4	1.75
5X4	.90
5X8	.80
5Y3	.44
5Y4	1.00
5Z3	1.50
5Z4	1.75
6A3	2.75
6A4	.78
6A6	1.95
6A7	2.50
6A8GT	1.10
6A8M	1.95
6AB4	.44
6AB5	3.00
6AB7	1.00
6AC5	1.95
6AC7	.93
6AD7	3.25
6AE5	2.50
6AF3	.71
6AF4	.99
6AF4A	.99
6AF6	2.50
6AF11	1.98
6AG5	.68
6AG7	1.42
6AH4	.99

Tube	Price
6AH6	1.05
6AJ5	1.95
6AJ8	1.73
6AK5	.90
6AK6	.80
6AL5	.45
6AL7	2.10
6AL11	1.05
6AM8	.76
6AN4	1.59
6AN5	2.65
6AN6	2.45
6AN8	.91
6AQ5	.52
6AQ6	1.00
6AQ7	1.73
6AQ8	.77
6AR5	.53
6AR6	1.50
6AR8	2.00
6AR11	1.70
6AS5	.59
6AS6	.78
6AS7	2.75
6AS8	.83
6AS11	1.98
6AT6	.47
6AT8	.84
6AU4	.83
6AU5	1.67
6AU6	.50
6AU7	.70
6AU8	.85
6AV5	.89
6AV6	.39
6AV11	1.65
6AW8	.88
6AX3	.93
6AX4	.64
6AX5	.73
6AX7	.62
6AX8	1.45
6AY3	1.15
6AZ8	1.30
6B4	3.80
6B5	4.00
6B7	2.00
6B8	2.00
6B10	1.39
6BA3	1.15
6BA6	.48
6BA7	.98
6BA8	.88
6BC4	2.10
6BC5	.59
6BC7	.88
6BC8	1.00
6BD5	1.20
6BD6	.55
6BE3	1.15
6BE6	.53
6BF5	.88
6BF6	.42
6BF8	1.70
6BG6	1.65
6BH6	.66
6BH8	.94
6BJ6	.63
6BJ7	1.21
6BJ8	1.45
6BK4	1.75
6BK5	.91
6BK7	.84
6BL7	1.05
6BL8	.97
6BN4	.60
6BN6	.70
6BN8	.74
6BQ5	.63
6BQ6/6CU6	1.08
6BQ7	.98
6BR8	.80
6BS8	.93
6BU8	.68
6BV8	1.23
6BW8	1.35
6BX7	1.09
6BY5	1.24
6BY6	.60
6BY8	.64
6BZ6	.54
6BZ7	.99
6BZ8	1.06
6C4	.43
6C5	1.40
6C6	.90
6C8	.88
6CA7	2.25
6C10	1.55
6CA4	.47
6CA5	1.23
6CA7	2.25
6CB5	2.05
6CB6	.53
6CD6	1.47
6CF6	.95
6CG7	.59
6HT6	.89
6CG8	.78
6CH8	2.03
6CK4	.69
6CL6	.92
6CL8	.77
6CM6	1.45
6CM7	.67
6CM8	1.02
6CN7	.68
6CQ4	1.35
6CQ7	1.80
6CQ8	.90
6CR6	.58
6CS6	.55
6CS7	.67

Tube	Price
6CU5	.56
6CU6	1.05
6CU8	.99
6CW4	1.09
6CW5	.78
6CX8	1.82
6CY5	.68
6CY7	1.25
6CZ5	1.80
6CZ7	1.95
6D4	1.75
6D6	2.50
6D10	1.95
6DA4	.66
6DA5	1.28
6DB5	2.05
6DB6	.52
6DC6	1.30
6DC8	1.33
6DE4	.68
6DE6	.59
6DE7	.73
6DG6	.95
6DJ8	1.17
6DK6	.57
6DN6	1.76
6DN7	1.35
6DQ5	1.89
6DQ6	1.05
6DR7	.73
6DS4	1.40
6DS5	1.30
6DT5	.79
6DT6	.51
6DT8	.92
6DV4	2.65
6DW4	1.43
6DW5	1.57
6DZ4	.78
6E5	2.25
6EA7	.88
6EA8	.77
6EB5	.71
6EB8	.91
6EH5	1.33
6EH7	1.55
6EH8	.77
6EJ7	.77
6EM5	.75
6EM7	.80
6EQ7	1.11
6ER5	1.35
6ES5	.63
6ES8	1.39
6ET7	1.04
6EU7	.66
6EU8	.77
6EV5	.73
6EW6	.55
6EW7	.78
6EY6	.73
6EX6	3.65
6EZ5	1.40
6EZ8	1.39
6FA7	1.32
6FD7	2.37
6F4	2.35
6F5GT	1.10
6F5M	1.50
6F6	.67
6F6M	1.25
6F7	2.50
6F8	1.25
6FG5	2.15
6FG7	1.35
6FG8	.65
6FH5	.73
6FJ5	2.25
6FJ7	1.79
6FM7	.77
6FQ7	.56
6FS5	1.45
6FV6	.68
6FV8	.77
6FW5	1.96
6FW8	4.25
6FY5	1.25
6G5	1.23
6GC5	.60
6G6G	1.00
6GE5	.92
6GF5	1.75
6GF7	.77
6GH8	.78
6GK5	.59
6GK6	.77
6GL7	2.35
6GM5	.78
6GM6	.58
6GN8	.92
6GQ7	1.89
6GR7	.78
6GT5	1.00
6GV5	.98
6GV6	1.85
6GW6	1.00
6GW8	1.50
6GX6	.55
6GX8	1.25
6GY5	.53
6GY6	1.10
6GZ5	.53
6HA5	.99
6HB5	2.09
6HF5	1.90
6HF8	1.25
6HG8	1.95
6HJ8	.80
6HK5	.59
6HL8	.71
6HS8	.79
6HT6	.89
6HZ6	.56

Tube	Price
6H6	.56
6J4	2.95
6JB6	2.20
6JC8	.74
6JE6	2.00
6JE8	1.50
6J5	.92
6J6	.69
6J7	1.65
6J8	1.40
6J11	1.83
6JH6	.55
6JH8	1.85
6JK8	.68
6JS6	2.95
6JT8	1.75
6JV8	.68
6JZ8	.83
6K6	.61
6K7	.95
6K7G	.75
6K8GT	.87
6K8M	1.85
6K11	1.50
6KD8	1.12
6KT8	.80
6KU8	1.05
6LB8	1.00
6L5	.90
6L6GA	1.40
6L6GB	1.50
6L6G	.98
6L6GC	1.65
6L6M	2.50
6L7	1.05
6M11	1.85
6N6	1.45
6N7	.96
6P5	.95
6Q7GT	1.27
6Q7-M	1.45
6Q11	1.05
6R7	1.25
6S4	.49
6S7	.90
6S8	.74
6SA7GT	.97
6SA7-M	1.25
6SB7Y	1.15
6SC7	1.35
6SD7	.70
6SF5	.75
6SF7	1.00
6SG7	1.10
6SH7	.97
6SJ7GT	.90
6SJ7-M	1.02
6SK7GT	.63
6SK7-M	1.46
6SL7GT	.81
6SN7	.63
6SQ7	.92
6SR7	1.00
6SS7	.95
6SZ7	.95
6T4	.96
6T8	.83
6U5	1.75
6U8	.81
6V3	1.10
6V6GT	.52
6V6M	2.50
6W4	.60
6W6	.75
6X4	.39
6X5	.51
6X8	.78
6Y6	1.00
7A4	1.15
7A5	1.25
7A6	1.15
7A7	1.15
7A8	.98
7AD7	1.15
7AF7	1.45
7AG7	1.25
7AH7	1.25
7AU7	.63
7B4	1.45
7B5	.98
7B6	.98
7B7	.98
7B8	1.25
7C4	.90
7C5	1.35
7C6	.99
7C7	.99
7E5	.99
7E6	1.15
7E7	1.25
7EY6	.73
7F7	1.75
7F8	1.75
7G7	1.25
7H7	1.35
7HG8	1.50
7J7	1.95
7K7	1.95
7L7	1.95
7N7	1.95
7Q7	1.75
7R7	1.75
7S7	1.75
7V7	1.85
7W7	1.85
7X6	1.25
7X7	1.85
7Y4	1.25
7Y7	1.25
7Z4	1.50
8AU8	.88
8AW8	.91
8BH8	.87

Tube	Price
8BQ5	.61
8CG7	.61
8CM7	.69
8CN7	.95
8CS7	.72
8CX8	.89
8EB8	.92
8EM5	1.15
8ET7	1.08
8FQ7	.54
8GN8	.97
8JV8	.93
8KA8	.84
9A8	.98
9AU7	1.05
9BR7	1.32
9CL8	.77
9EA8	.66
9U8	.80
10AL11	1.09
10BQ5	.89
10C8	1.03
10DE7	1.31
10EG7	.86
10EM7	1.75
10EW7	.97
10GN8	.93
10HT8	1.12
10JA8	.92
10KU8	1.07
10Y	.73
11CY7	.73
11JE8	1.70
11KV8	1.52
12A4	.59
12A5	.95
12A6	.85
12A7	1.45
12A8	3.00
12A11	1.74
12AB5	.58
12AC6	.53
12AD6	.55
12AE6	.48
12AE7	.92
12AF3	.71
12AF6	.65
12AG6	.60
12AJ6	.60
12AL5	.45
12AL8	.93
12AL11	1.06
12AQ5	.58
12AT6	.48
12AT7	.74
12AU6	.49
12AU7	.59
12AV5	.93
12AV6	.39
12AV7	.80
12AW6	.98
12AX3	.63
12AX4	.65
12AX6	.62
12AX7	.61
12AY7	1.42
12AZ7	.84
12B4	.66
12BA6	.49
12BA7	.82
12BD6	.48
12BE3	.67
12BE6	.51
12BF6	.58
12BH7	.75
12BK5	.98
12BL6	.54
12BN6	.97
12BQ6/CU6	1.11
12BR7	.72
12BV7	.74
12BW4	1.09
12BY7	.75
12BZ6	.75
12BZ7	.84
12C5	.56
12CA5	.60
12CN5	.54
12CR6	.65
12CS6	.63
12CT8	1.60
12CU6/BQ6	1.05
12CX6	.52
12D4	.67
12DB5	.67
12DE5	.60
12DE8	.81
12DL8	.85
12DQ6	1.02
12DQ7	1.33
12DS7	.82
12DT5	1.18
12DT7	.77
12DT8	.76
12DW7	1.20
12DW8	.87
12DY8	1.75
12DZ6	.60
12EA6	.99
12EC8	1.38
12ED5	.60
12EG6	.60
12EK6	.60
12EL6	.48
12EL8	.86
12EZ6	.55
12F5	1.50
12F8	.64
12FA6	.77
12FK6	.78
12FM6	.48

Tube	Price
12FQ8	.78
12FR8	.95
12FX5	.64
12FX8	.88
12GA6	.63
12GC6	1.04
12GE5	.93
12GW6	1.02
12J5	.95
12J8	.82
12K5	.73
12K8G	.87
12K8M	2.75
12L6	.71
12L8	.50
12Q7GT	1.35
12Q7M	2.50
12R5	1.19
12SA7GT	.87
12SA7M	2.50
12SC7	.78
12SF5GT	.98
12SF5M	1.75
12SF7GT	.65
12SF7M	1.75
12SG7	.95
12SG7M	1.10
12SH7	1.39
12SJ7GT	.99
12SJ7M	1.75
12SK7GT	.93
12SK7-M	2.00
12SL7	.78
12SN7	.65
12SQ7GT	.89
12SR7	.98
12U7	.60
12V6	.62
12W6	.69
12X4	.45
13DE7	.73
13DR7	1.31
13EM7	1.87
13FD7	1.90
13FM7	.78
13GF7	.78
14A4	1.25
14A5	1.10
14A7	1.35
14AF7	1.35
14B6	1.20
14B8	1.75
14C5	1.50
14C7	1.75
14E6	1.25
14E7	1.25
14F7	1.95
14F8	1.75
14GT8	.80
14H7	1.60
14J7	1.45
14N7	1.25
14Q7	1.35
14R7	1.45
14S7	1.65
14W7	1.25
14X7	1.25
14Y4	1.25
15AF11	1.95
15CW5	1.15
15FY7	1.29
15HB6	1.28
15KY8	.83
16AQ3	1.42
16GK6	.60
16GY5	1.95
16KA6	1.95
17AX3	.51
17AX4	.65
17AY3	.68
17BE3	1.17
17BQ6	1.10
17BS3	.86
17C5	2.35
17C9	1.18
17D4	.67
17DE4	1.29
17DM4	.78
17DQ6	1.04
17DQ7	1.85
17GE5	1.70
17GJ5	1.81
17JN6	1.60
17GV5	.99
17GW6	1.01
17H3	.95
17HC8	1.18
17JB6	1.12
17JM6	1.62
17L6	.56
17JZ8	.93
17LD8	1.20
17W6	.68
18A5	.99
18FW6	.47
18FX6	.51
18FY6	.84
19	.75

Tube	Price
19AU4	.85
19BG6	1.35
19C8	1.05
19CL8	.57
19EA8	.77
19GQ7	1.99
19HV8	1.44
19JN8	1.20
19Q9	.75
19T8	.83
2050	1.05
21EX6	1.47
21GY5	1.02
21HB5	1.62
22BH3	1.17
22BW3	1.43
22DE4	1.19
22JG6	1.06
25A7	3.00
25AC5	2.00
25AK4	.66
25AV5	1.00
25AX4	.68
25B8	1.73
25BK5	.89
25BQ6	1.12
25C5	.51
25CA5	1.85
25CD6	1.50
25DK4	1.05
25DN6	1.50
25EH5	.53
25F5	.56
25L6	.55
25W4	.66
25Z5	1.10
25Z6	.73
27GB5	1.75
32ET5	.53
32L7	.85
33GY7	1.40
34DG5	.51
34GD5	.79
35A5	2.25
35B5	.95
35C5	.49
35EH5	.83
35L6	.58
35W4	.40
35Y4	1.63
35Z3	1.20
35Z5	.58
50A5	1.49
50B5	.68
50C5	.51
50DC4	.46
50EH5	.95
50HC6	.86
50HK6	.54
50L6	.59
50X6	.67
50Y6	.95
50Y7	1.10
60FX5	.60
70L7	.89
117L7	2.50
117N7	3.95
117P7	3.95
117Z3	.83
22	.95
24A	.95
26	1.10
27	1.50
28D7	1.50
30	1.15
32	1.00
33	.85
34	.79
35-51	.85
36	.95
37	.70
38	.90
39/44	.85
41	.95
42	1.25
43	1.20
45	2.00
46	.95
47	2.10
48	3.50
50	1.45
53	2.98
55	1.90
56	.95
57	1.35
58	1.85
59	2.50
71A	.95
75	1.90
76	1.40
77	1.25
78	1.15
80	1.25
81	1.25
82	1.23
83	2.10
84/6Z4	.95
85	.98
5881	2.95
6336	5.95
6146	3.95
6550	3.75
807	.75
ECC83/12AX7	.99
EL34/6CA7	3.75
EL84/6BQ5	1.65
EZ80/6V4	.95
GZ34/5AR4	1.75

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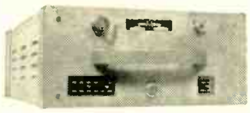

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25-50mc 20F3 Emission TX narrow banded 12 volt, 50 watt. Complete with all accessories, less crystals and antenna. **$128**

Add $40 for crystals, tuning and brand new antenna—ready to go on your frequency, also available in dual frequency Tx & Rx add $30 for tuning of second frequency

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148-172mc RCA CMC 60B 6/12v dual dynamotor 60 watt (a) Fully narrow banded complete with all accessories, less crystals & antenna **$178**

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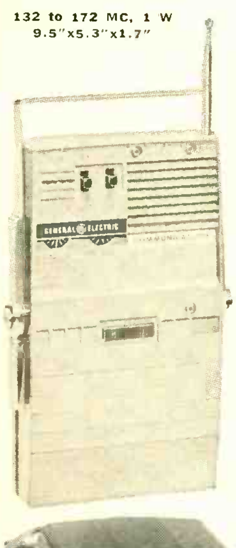
9.5"x5.3"x1.7"



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PHOTOGRAPHERS ATTENTION! Photographs and transparencies wanted—To $500.00 each. Valuable information—Free. Write Intraphoto-EW, Box 74607, Hollywood 90004.

AIRCRAFT RADIO

WANTED Aircraft Radio Sets—Collins: 51R3-51X—51Y—51V—51Z, Bendix: T-21; R21; DFA-70; RA-18C; MK-7; GSA-1, Test Sets: ARC—Boonton—Collins—Hewlett-Packard. Highest prices paid. J. Lee, Box 105, New Haven, Conn.

PHOTOGRAPHY—FILM, EQUIPMENT, SERVICES

MEDICAL FILM—Adults only—"Childbirth" one reel, 8mm $7.50; 16mm $14.95. International W, Greenvale, Long Island, New York.

SCIENCE Bargains—Request Free Giant Catalog "CJ"—148 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts, War surplus bargains. Edmund Scientific Co., Barrington, New Jersey.

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LEARN while asleep. Remarkable, scientific. 92% effective. Details free. ASR Foundation, Box 721, Dept. e.g., Lexington, Kentucky.

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FREE Education! Greater Success! Learn how to get it. Information Free! Cameo, Carrolltown 10, Pa.

INVENTIONS WANTED

INVENTORS. We will develop, help sell your idea or invention, patented or unpatented. Our national manufacturer clients are urgently seeking new items for outright cash sale or royalties. Financial assistance available. 10 years proven performance. For free information, write Dept. 42, Wall Street Invention Brokerage, 79 Wall Street, New York 5, N.Y.

COMPREHENSIVE assistance including financial, development, manufacturing and marketing services for worthwhile new or existing products or processes, patented or otherwise. Our facilities and resources are available on a participation, purchase or other basis. Call, write or visit us—at no obligation. Universal Business Technology Corporation Limited, 133 Richmond St. W., Toronto, Canada. (416) 366-3951.

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FOREIGN Employment. Construction, other work projects. Good paying overseas jobs with extras, travel expenses. Write only: Foreign Service Bureau, Dept. D, Bradenton Beach, Florida.

FOREIGN U.S. Employment. Big construction, other work projects. All trades. Salaries up to $1,600 monthly with travel expenses, and extras. Write only: Foreign U.S. Employment Bureau, Dept. D-70, The State Building, Portland, Maine.

FREE information. Resumes. JEK, 31-24 91st Street, Queens 69, New York.

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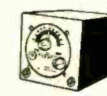
ARC-3 RECEIVER!

Complete with All tubes Exc. Used **$21.50**
Like NEW $33.50
Crystal-controlled 17-tube superhet. tunes from 100 to 156 MC., AM., on any 8 preselected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.
110 V A.C. Power Supply Kit for above 15.00
Factory Wired and Tested 19.95

ARC-3 TRANSMITTER

Companion unit for above tunes 100 to 156 MC on any 8 pre-selected channels. 9 tubes, crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6. Exc. Used .... Only **$18.95**
Like new condition $28.50
ARC-3 PUSHBUTTON CONTROL BOX .... $ 5.95

BC1206-C BEACON RECEIVER



195 to 420 Kc. made by Setchel - Carlson. Works on 24-28 volts DC. 135 Kc. IF. Complete with 5 tubes. Size 4" x 4" x 6". Wt. 4 lbs. LIKE NEW **$10.95**
USED. less tubes $4.95

SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New **$32.50**

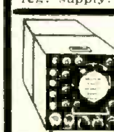
LM FREQUENCY METER

Crystal calibrated modulated. Heterodyne. 125 KC to 20.000 Kc. with Calibration book. Complete. like new **$79.50**
LM Frequency Meter as above, completely checked out, with tubes and crystal, less calibration book. Exc. Used, clean **$34.50**

BC-221 FREQUENCY METER

Equipped with original calibration charts. 125 Kc to 20.000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book. Crystal, and all tables. CHECKED OUT!
Unmodulated **$89.50** Modulated ....P.U.R.
AC Power Supply for BC221. checked out....$24.50
BC-221 1000 Kc Crystal Brand New **$8.95**
BC221 FREQ. METER CASE, aluminum, with volt. reg. supply. Shock mounted. BRAND NEW $2.95

APN-12 3-INCH SCOPE



Has vertical and horizontal sweep with focus and intensity controls, coaxial antenna changeover motor. Complete with 11 tubes and 3JP1 CR Tube. For 115 V. 400 cycle AC and 24 V DC. Circuit diagram included. LIKE NEW. **$14.95**

AN/APR-4Y FM & AM RADIO RECEIVER

High precision lab instrument, suitable for monitoring and measuring frequency and relative signal strength of signals from 38 to 4000 Mc., in 5 tuning unit ranges. For 110 V 60 cycle AC operation, built-in power supply.
LIKE NEW, SPECIAL **$79.50**
TN-16, TN-17, TN-18, TN-19 and TN-54 Tuning Units for above in stock..P.U.R.

IMPORTERS — EXPORTERS of Electronic Equipment
We specialize in military surplus electronic equipment for export and domestic customers. Huge stocks. immediate shipment from N.Y.C., Lowest Prices. Your inquiry invited!

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like New	BRAND NEW
BC-453	Receiver 190-550 Kc.	$14.95	$18.95	P.U.R.
BC-454	Receiver 3-6 Mc.	$15.95	$19.50	P.U.R.
BC-455	Receiver 6-9 Mc.	$13.95	$19.50	P.U.R.

BC946 Receiver 550-1500 Kc Complete with all tubes, Brand New, in original packing .... P.U.R.
1.5 to 3 MC. Receiver Brand New .... P.U.R.

110 Volt AC Power Supply Kit for all 274-N and ARC-5 Receivers. Complete with metal case, instructions **$8.95**
Factory wired, tested, ready to operate .$12,50
SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. Only .... **49¢**

2.1 to 3 Mc Transmitter, Brand New $12.95
BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal, BRAND NEW **$10.75**
Like New $7.95
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal.
BRAND NEW **$12.95**
Like New $7.95
BC-696 TRANSMITTER 3-4 Mc Complete with All Tubes & Crystal. Like New **$11.95**
BC-456 Modulator .... USED 3.45 NEW 5.95
ALL ACCESSORIES AVAILABLE FOR ABOVE

ARC-5/T-23 TRANSMITTER 100-156 Mc., includes tubes: 2-832A, 2-1625.
BRAND NEW, with Tubes **$26.50**
Used, with Tubes. .$12.50—Used, less tubes. .$3.95
ARC-5/R-28 RECEIVER 2-meter superhet, 100 to 156 Mc., in 4 crystal channels. Complete with 10 tubes. Excellent Used **$24.50**
Like NEW $29.50

234-258 MC RECEIVER AN/ARR-2

BRAND NEW 11-tube UHF Tunable Receiver with schematic. Only a few at this low price! Complete with tubes. Exc used $5.95 .... **$8.88**

ASK FOR OUR LATEST FREE BULLETIN OF BARGAINS IN MILITARY SURPLUS ELECTRONIC EQUIPMENT!

Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50c Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse. N.Y.C. All Merchandise subject to Prior Sale and Price Change.

G & G RADIO SUPPLY CO.
Telephone: CO 7-4605
77 Leonard St. New York 13, N. Y.

CIRCLE NO. 183 ON READER SERVICE PAGE

EQUIPMENT

WALKIE-TALKIES—Communicate with friends, business associates, up to 5 miles. Service, construction, business, boating, hunting, Fire Dept., Police. Free Details, Sheirr Electronics Lab, Dept. G, 1182 Kenniston Ave., Los Angeles, Calif. 90019

FREE electronics catalog. Tremendous bargains. Electrolabs, Department C-111E, Hewlett, New York 11557.

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$50 per 1000 possible. Addressing 1000 envelopes. Longhand-typewriter. Home-spare time. Free particulars. General Enterprises, Box 303, Island Park, N.Y.

"MAILORDER—Stop Looking!" Get your own Catalog! Methods, 1401-FD, Lafayette Hill, Pa. 19444.

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FREE Song "Hit" copy Postcard: Nordyke Publishers, 6000-3 Sunset, Hollywood, Calif. 90028.

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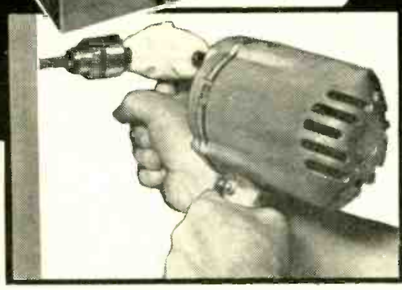
NEW! 19 PIECE POWER TOOL ATTACHMENT SET

WITH FREE POLYSTYRENE TOOL BOX



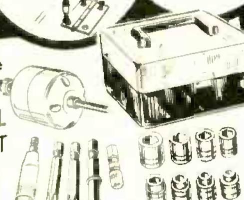
CONVERTS ANY DRILL into
- **POWER SCREWDRIVER**
- **POWER NUT DRIVER**
- **POWER SANDER & BUFFER**

with 2 SPEED ANGLE DRIVE

RETAIL VALUE $12.50 **NOW ONLY $9.95**

100% AMERICAN MADE of hardened steel with DuPont Zytel nylon housings which eliminate overheating and minimize drill load. Contains 3 screwdriver blades, a screwfinder and 8 machined sockets and adaptors. 2 SPEED ANGLE DRIVE doubles or halves the speed of any drill with 1 1/4" shank adaptor; 1 spindle adaptor; 1 chuck adaptor.

Also Available 15 PIECE POWER TOOL ATTACHMENT SET with fitted storage and carrying case



Converts any drill to a Power Screw Driver and Power Nut Driver. Contains deluxe Power Screwdriver attachment. 2 slotted and 2 Phillips type screwdriver blades, a screwfinder, power nut driver adaptor and 8 square drive machined sockets. **ONLY $7.50**

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Enclosed is $__________. Please ship me the following:

________ 19 Piece Power Tool Set(s) at $9.95 ea. plus 50c ea. for postage and handling.

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Sorry—no charges or C.O.D. orders.

ELECTRONICS WORLD FEBRUARY 1965

ADVERTISERS INDEX

Printed in U.S.A.

How "Computerized Testing" helps assure the reliability of RCA Receiving Tubes

This engineer is studying final test results of another production run of RCA Receiving Tubes. Nothing surprising here . . . except for one thing: the production run had been completed only hours before!

A few years ago, a thorough quality evaluation of a day's production run of a certain tube type took days, even weeks. But now, at RCA, it's done automatically, with computers, the same day.

Computers in conjunction with the Special Tube Analyzing Recorder (STAR) accumulate and store test data on every receiving tube type we make.

Sample tubes from the production lot are individually analyzed on STAR. As many as 60 tests may be made quickly and automatically on each tube depending on the type. Test results are recorded simultaneously on a test sheet and on punched cards. The computers compare the results with predetermined standards, make "accept" or "reject" decisions and then add the results to the historical record of the tube type.

Thus, in a mere half-hour of running time each night, a full day's receiving-tube output can be evaluated before it is released for shipment. Equally important, the test data for any day's production of a particular tube type together with the historical record for that tube type are on the desks of the production, quality-control and design engineers the following morning. With these data, the engineers can evaluate performance, analyze trends and quickly initiate any corrective measures necessary to assure the consistent quality of RCA Receiving Tubes.

"Computerized testing" is one more reason why you can depend on RCA receiving tubes for your TV-Radio-Hi-fi service jobs. RCA receiving tubes are available from your local Authorized RCA Tube Distributor.

RCA Electronic Components and Devices, Harrison, N. J.

RCA® The Most Trusted Name in Electronics

How to replace top quality tubes with identical top quality tubes

Most of the quality TV sets you are presently servicing were designed around special Frame Grid tubes originated by Amperex. More and more tube types originated by Amperex are going into the sets you'll be handling in the future. Amperex Frame Grid tubes provide 55% higher gain-bandwidth, simplify TV circuitry and speed up your servicing because their extraordinary uniformity virtually eliminates need for realignment when you replace tubes.

Amperex Frame Grid Tubes currently used by the major TV set makers include:

2ER5	2GK5	2HA5	3EH7	3GK5	3HA5	4EH7	4EJ7	4ES8	4GK5	4HA5	5GJ7
	6EH7	6EJ7	6ER5	6ES8	6FY5	6GJ7	6GK5	6HA5	6HG8	7HG8	8GJ7

If your distributor does not yet have all the Amperex types you need, please be patient—in some areas the demand keeps gaining on the supply.
Amperex Electronic Corporation, Hicksville, Long Island, New York 11802.

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