Electronics World

JULY, 1963
50 CENTS

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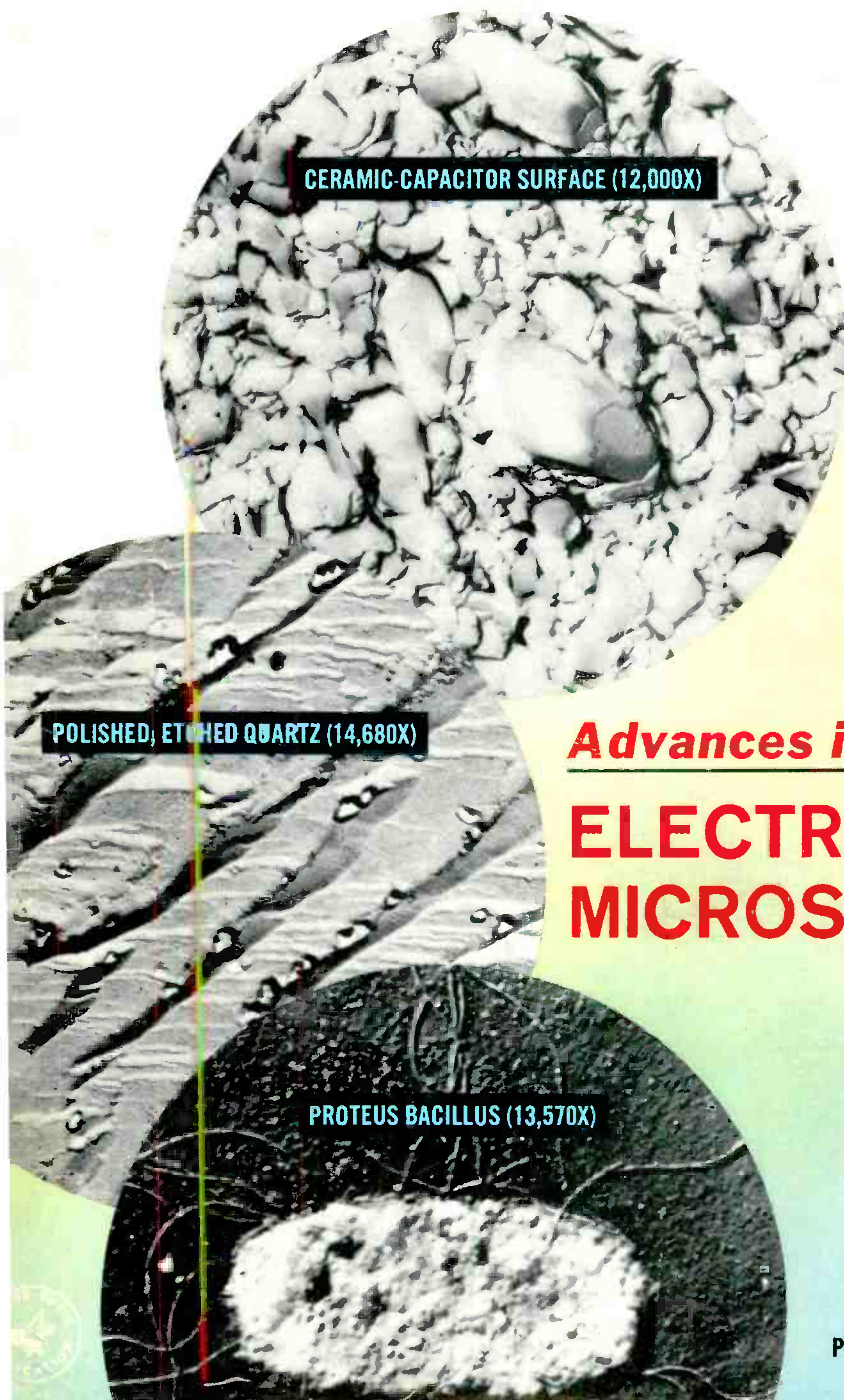
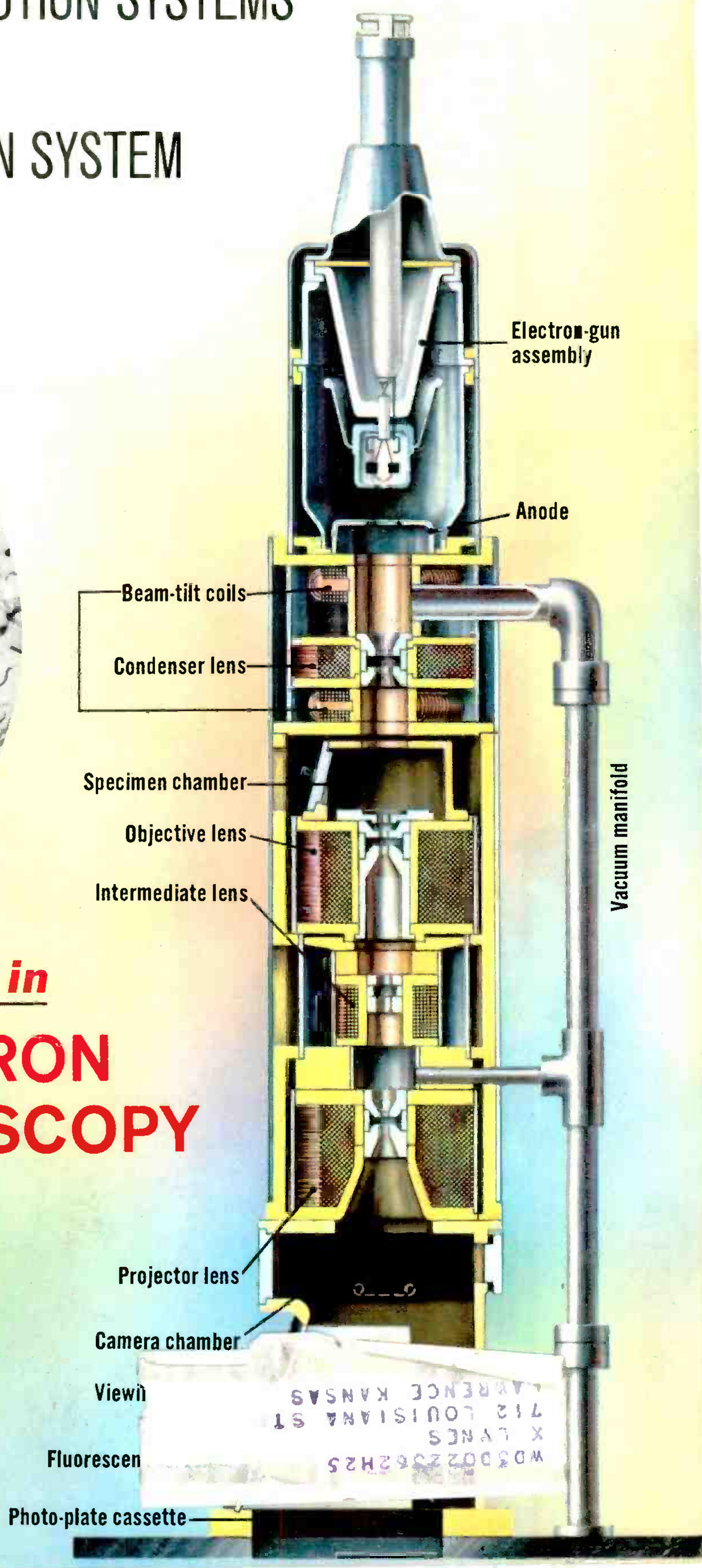


Advances in

ELECTRON MICROSCOPY



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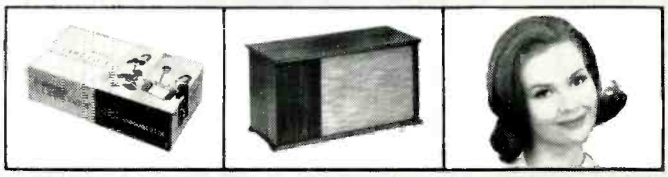

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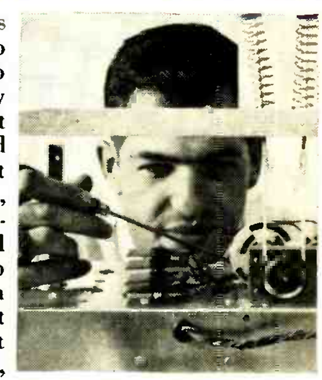

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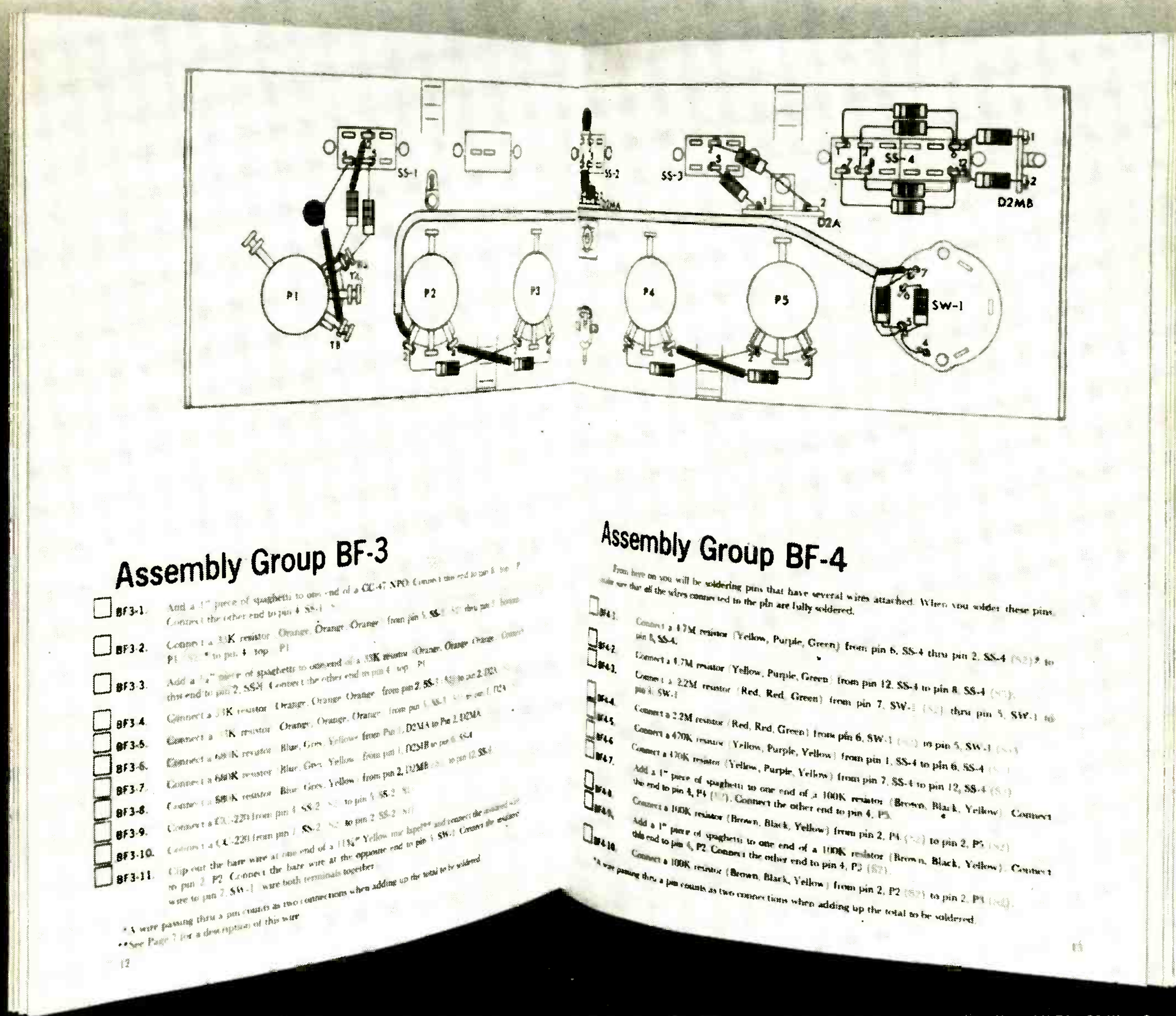

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Electronics World

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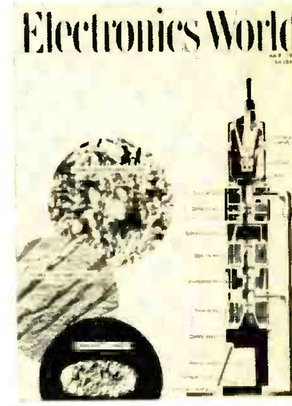

THIS MONTH'S COVER ties in with our lead story on electron microscopes. Shown at right is cross-section view of an RCA electron microscope. The photomicrographs at the left were all taken with such a microscope at the electronic magnifications indicated. (Figures do not take into account photographic enlargement.) The view of the surface of a ceramic capacitor disc before electrodes are applied was taken at Sprague Electric Co. The quartz photomicrograph is from Dow Chemical, and the view of the bacillus is courtesy National Institute of Health. . . . . (Cover illustration by Otto E. Markevics)

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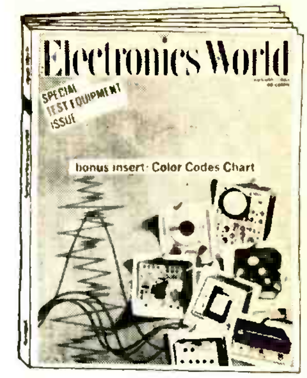

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SPECIAL FEATURE: COLOR CODES CHART—A Full-Color Gatefold

By popular demand, another handy wall chart for the lab, workshop, or production line. EIA color codes for ceramic, paper, and mica capacitors; resistors; transistor bases; semiconductor diodes; and transformer windings are all included for fast and ready reference use.

PLUS . . .

1963 DIRECTORY OF KIT TEST EQUIPMENT
A revised and completely up-dated listing of some 200 instruments available in kit form for applications ranging from the home workshop to the engineering laboratory . . . with prices and complete specs.

THE INSTRUMENT CALIBRATION & REPAIR TECHNICIAN
The growing field for the qualified electronics technician and engineer in government, military, and industrial labs around the world is surveyed by General Electric engineers as to job opportunities and the technical prerequisites.

DETECTION OF NUCLEAR RADIATION BY SEMICONDUCTORS
In order for radiation to be useful, it must be capable of being measured easily, precisely, and inexpensively. Semiconductors are finding wide application in this important field, as Harold S. Renne reveals in this informative article.

CALIBRATING TEST EQUIPMENT
How accurate should test equipment be? This will depend on its application and the quality of the instruments involved, according to Walter Buchsbaum. He discusses standards and basic meter tests.

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

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For the record

WM. A. STOCKLIN, EDITOR

"Let's Woo the Woman Engineer"

PERSONNEL experts from industry and various Government agencies have continually stressed our need for at least 80,000 engineering graduates a year if we are to meet the requirements of our space-age "industrial revolution." As against this need we are, in actual fact, graduating less than 40,000 engineers a year. If the shortage of engineers is as critical as the President's Science Advisory Committee says it is, then both educational institutions and industry are faced with a gigantic task of convincing prospective students of the benefits and satisfactions to be derived from a career in engineering.

Today the average annual salary for electronics engineers is approximately $7500—a rather unimpressive figure considering the educational investment an engineering degree represents. Although the going rate of $5200 for electronics engineering graduates embarking on their first jobs is above that for many other professions, this lure has apparently failed to attract potential students. In the minds of most would-be engineers their profession has lost status during the past few years. Where, say, ten years ago it was considered to be the No. 2 career, directly behind the legal profession, today it is running a poor third, with the medical profession moving into the top spot.

Recent interviews with high-school graduates planning their college careers indicate all too clearly that they are fully aware of these facts and that their opinions of the engineering profession are far from flattering. One remark heard time and again was: "We don't like the idea of getting cornered behind a slide-rule." It is obvious that these students visualize some future for themselves more satisfying and grander than that of being an engineer. Although educators and vocational counsellors have attempted to combat this attitude by presenting facts about the challenges involved and the country's need for engineers, they must have more ammunition if they are to channel more students into engineering courses. They shouldn't have to tackle the job alone. Industry itself must do more than it has been doing in the past.

An interesting sidelight on this problem was touched on recently by Herbert W. Hartley, president of *Northrop Institute of Technology*, in the course of a series of talks to students in Southern California. Speaking on the subject, "Let's Woo the Woman Engineer," Mr. Hartley suggested that if industry cannot meet its quota of electronics engineers from among the male student body, women should be encouraged to enter the profession. Many women work as electronics draftsmen, and there is no reason why a mathematics- or science-oriented woman can't handle an engineering curriculum.

C. T. Reid, director of graduate placement for *Northrup*, surveyed more than 200 aerospace and electronics firms on their attitudes toward hiring women engineers. Without exception they replied that not only were they willing but eager to accept trained women for employment in various engineering categories.

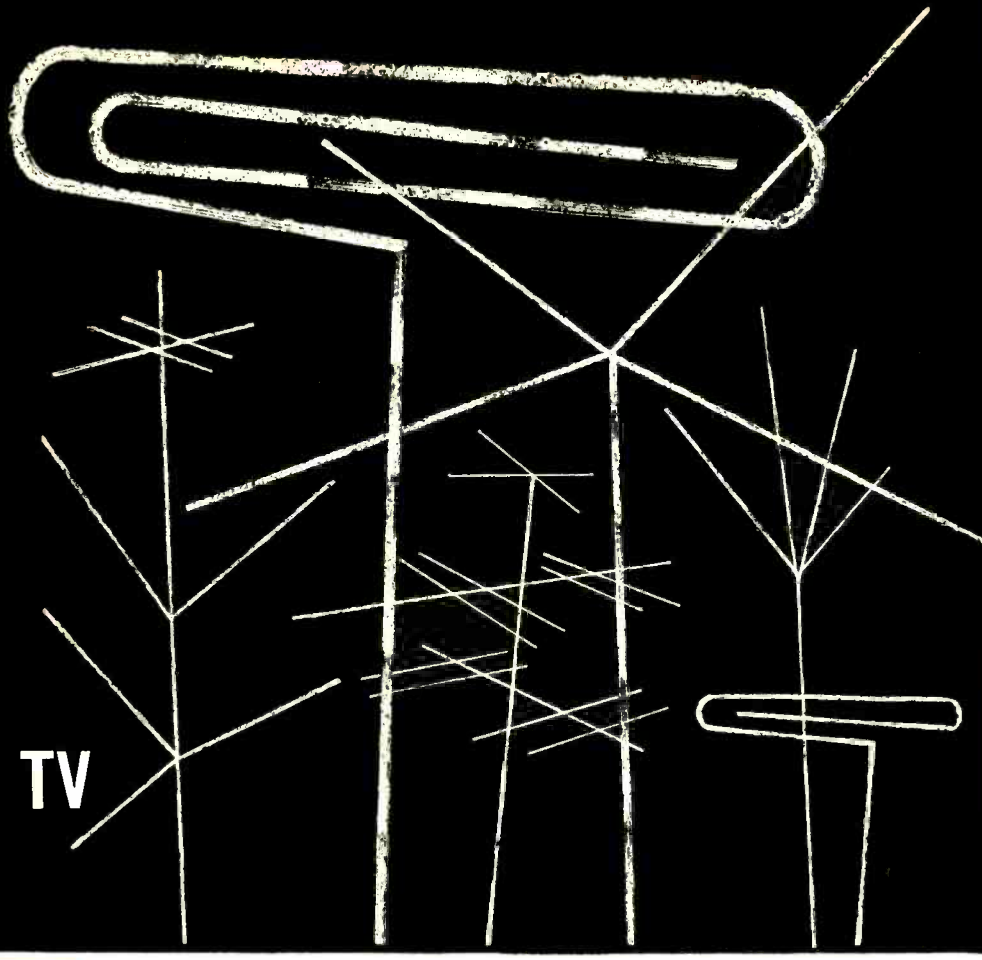
"We find that women make excellent designers," reported *North American Aviation's* Space & Information Systems Division. "They have done well for us in aerodynamics, stress analysis, and weight analysis."

Hughes Aircraft employs 80 women engineers. *IBM* has discovered that women perform better than men as computer engineers and programmers. Women have also demonstrated their competence in every other phase of computer engineering they've tackled.

One of the five design engineers on the "Tiros" weather satellite project was Mrs. Sima Miluschewa of *RCA's* Astro-Electronics Division. One of the most attractive and capable women you'll meet anywhere is Mrs. Marily Peck, an engineer with *North American Aviation*. Jack Leadbetter, president of *Associated Aero Science Laboratories*, goes so far as to say "the average woman going in for engineering is better than the average man." Perhaps she has to be in order to compete successfully in a profession that is predominantly male.

The Society of Women Engineers reports that out of 800,000 engineers in the United States today, only 5000 are women. It is the consensus, however, that this situation will change drastically before the start of the next decade. Whether or not women will enter the engineering profession in large numbers, as has been the case in many other countries, is problematical as the path to an engineering degree is still a thorny one for most women. In addition to some altering of physical facilities at what are now predominantly male engineering strongholds, it will be necessary for educators and industry alike to change the average woman's conception of engineering as a purely masculine career and that to follow such a profession is "unladylike." This will take time—but once started—it is a trend that could gather momentum—depending on how carefully the initial steps are planned. ▲

2 GREAT BELDEN CABLES FOR COLOR TV RECEPTION



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					200	1.64	75′ coils
					300	2.12	100′ coils
					400	2.5	500′ spools
					500	2.98	1000′ spools
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					900	4.3	

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AWG & (Stranding)	Color	Nom. O.D. (Inch)	Nom. Velocity of Propagation	Nom. Capacitance (mmf/ft)	Nom. Attenuation per 100′ mc	db	Standard Package Lengths in ft
22 (7x30)	Brown	.255 x .468	73.3%	5.3	100	1.4	50′ coils
					300	2.8	75′ coils
					500	3.8	100′ coils
					700	4.8	500′ spools
					900	5.6	1000′ spools

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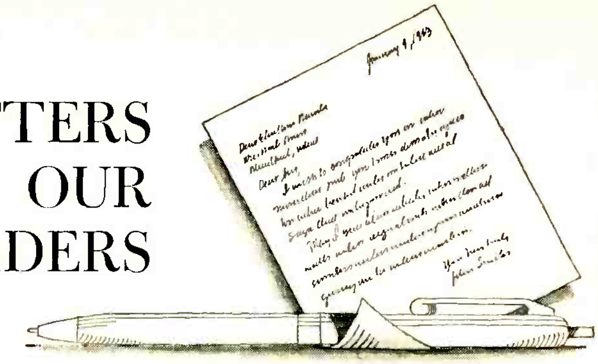

CITIZENS BAND TECHNICIAN LICENSE

To the Editors:

As a member of Door Operators and Remote Control Manufacturers Association (DORCMA) and because our company is vitally interested in the Citizens Band frequency, we sincerely wish to compliment you on your article in the March, 1963 issue of ELECTRONICS WORLD relative to setting up a Technician License for CB equipment.

Although we cannot directly attribute many of our problems to the operation of communications equipment that is outside of FCC specifications, we feel that in many cases where spurious actuation of garage-door controls operating in the Citizens Band is experienced, it is due to equipment, either licensed or unlicensed, that is not transmitting a legal signal.

If Mr. Conhaim's proposal were to be adopted, it would go far toward eliminating some of the signals now present which are causing difficulties with the satisfactory operation of garage-door controls.

We are in the position of having our legal equipment competing in the spectrum with equipment that may be outside of specifications as set down by the FCC and because our equipment causes the homeowner considerable expense and inconvenience, if spurious operation is experienced, it becomes an expense for us and is detrimental to our sales.

It would be quite easy, but expensive, to go to more sophisticated control equipment that would solve the problem but, as we see it, the problem does not lie in that direction only.

B. A. SMITH, General Manager
Operator & Electronics Division
Berry Industries, Inc.
Birmingham, Michigan

To the Editors:

Mr. Conhaim's proposal of a Citizens Radio Technician License in your March issue seems at first to be practical, but certain underlying reasons make the feasibility of the idea uncertain.

First of all, the general process of licensing presents problems. As stated in the article, the examination would be taken by mail. This method has worked fine for the lower classes of amateur licenses, where people are taking an examination so that they can pursue a hobby. But when a commercial servicing license such as proposed makes a difference whether or not a man can service his local CB trade, there is some doubt in my mind if this mail licensing could stay completely honest.

I feel also that the difficulty of the second-class commercial license requirements was subtly exaggerated. Any TV or radio repair man worth his signal generator has enough technical know-how that can easily be brushed up to FCC second-class standards. As for the laws and regulations, they are quite easily learned and should not provide much difficulty for any serious aspirant.

I think that the service man that is really interested in getting CB business should get a second-class phone license which would give him a greater horizon of work, rather than try to get a limited, scaled-down license for exclusive CB work.

STEPHEN T. CURWOOD
Westtown, Penna.

To the Editors:

Let's face it—a large portion of the CB operators *do not want* "good" service by a qualified man—they do not want frequency, power, or modulation checks by a licensed technician. Case in point—the writer offered frequency checks to members of a CB club with some 30 members. Charge to be less than 50¢ per channel and the money received to go in the club treasury. *Four* members took advantage of the offer! In fact, general opinion in this area seems to be that the holder of a first- or second-class FCC license is automatically an FCC monitor—therefore don't let him get near your unit!

The writer has purchased a frequency meter and other equipment to furnish service on CB gear—and hasn't had enough calls for the service to pay for the gear. You can't pay for equipment, maintain a shop and inventory, and meet the other expenses of a business unless you can take in some money—enough money to meet these expenses and have a little left over. You can't work on CB gear at cheaper hourly rates than you apply to your other work. I don't know of any shop that turns down CB work—if it is profitable. The reason the CB

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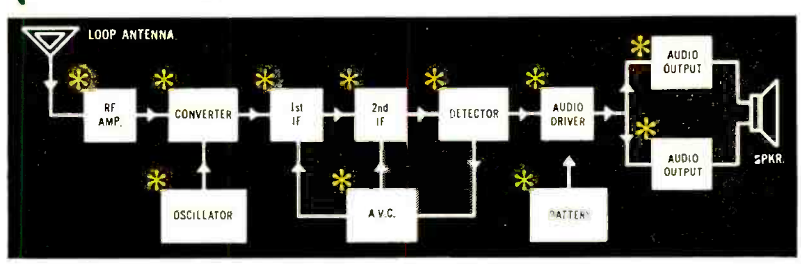

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user can't obtain the service Mr. Conhaim says he wants is not that it isn't available—it is because either he doesn't want a licensed man to check his "souped-up" unit or because he won't pay enough for a business man to do his work at a profit. Unfortunately, the kind of technical license a man has or doesn't have has no effect on his overhead.

G. J. HORNADAY
Quality TV Service
High Point, N. C.

To the Editors:

Let me speak as a technician and a licensed FCC commercial operator. I read your article by R. L. Conhaim. What this gentleman proposes to do is exactly what is wrong with the Citizens Band, in general. Generally, the type of equipment is substandard. The operators of this equipment are even more poorly trained. Housewives, garage mechanics, pool-hall operators, all have a hand in the pie. And now the gentleman proposes to unleash these quasi-technicians into the only field in electronics where there is still some measure of order.

Those people who bought such equipment knew in advance what the FCC expected of them. They are no different than thousands of other people, operating in other bands, who must also conform to the rules. Any commercial operator who is actively in the field will handle their business, reasonably, as long as he is not hampered by cheapness.

DOUGLAS W. COOK
Master Technicians, Inc.
Kenmore, N. Y.

Author Conhaim proposed a special FCC license for servicing CB equipment. This proposal represents only one possible solution to the problem of getting better adherence to the technical standards and to reduce the number of off-frequency over-modulated CB signals.—Editors.

° ° °

DIGITAL READOUTS

To the Editors:

Our compliments on Mr. Walter H. Buchsbaum's article, "Digital Readouts," which appeared in your February, 1963 issue. I realize that space is always limited in articles of this type; however, in the discussion of the *Union Switch & Signal* readout instruments, several important features are omitted and there are questions raised which you should permit us to answer.

There are thousands of the *Union* "Readall" instruments in service and these units have extended ratings of one million random readouts before maintenance is required. This means that on the basis of one readout every minute, twenty-four hours per day, it would be two years before maintenance would be required.

We have had no reports of operational difficulties due to wiring failures.

Of the thousands of "Readalls" in service, motor replacements have been less than .8%; only 25 motors in 3500 required replacement.

T. C. SCHROEDER
Union Switch & Signal Div.
Pittsburgh, Pa.

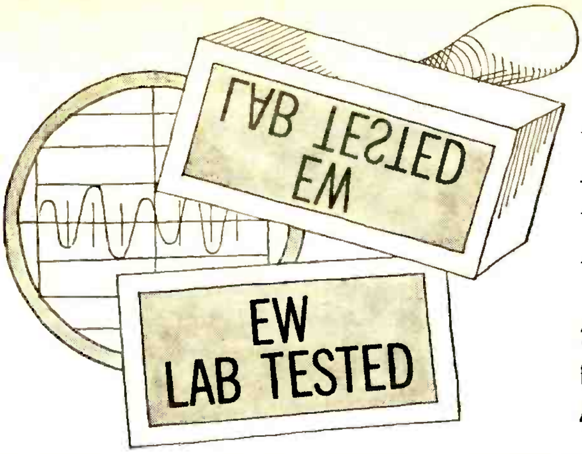
° ° °

KOBE ("TEN") TRANSISTOR SUBSTITUTE

To the Editors:

In your "*Kobe* Transistor Substitution Directory" (March, 1963 issue), one of the *Sylvania* substitutes for the *Kobe* No. 2SA30, 2SA254 is listed as a *Sylvania* 2N1058. Although this transistor is a fine converter, it is an *n-p-n* type and, therefore, cannot be substituted for the *p-n-p Kobe* types.

MERLE F. BARKER
Barker Electronics Service
Concordia, Kansas ▲



HI-FI PRODUCT REPORT

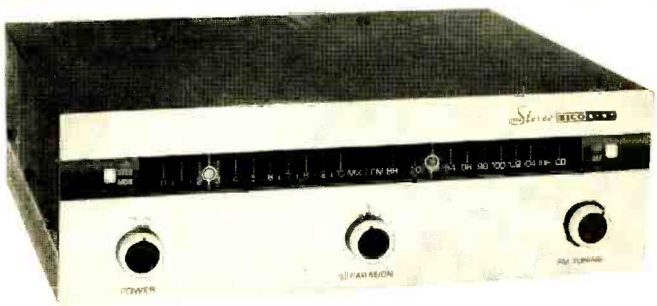
TESTED BY HIRSCH-HOUCK LABS

Eico Model ST97 FM-Multiplex Tuner

Audio Dynamics ADC-3 Phono Cartridge

Eico Model ST97 FM-Multiplex Tuner

For copy of manufacturer's brochure, circle No. 56 on coupon (page 19).

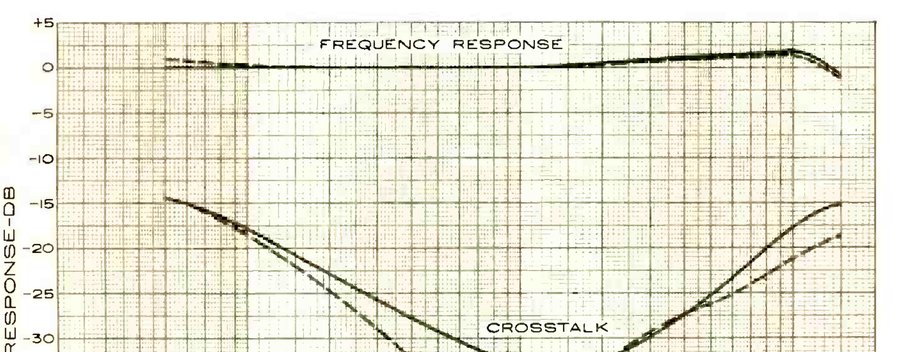


THE *Eico* ST97 is a high-performance, moderately priced FM-multiplex tuner, styled to match the company's other audio components, such as the ST70 amplifier and RP100 tape recorder.

Its pre-assembled and aligned front end is fully shielded to meet FCC radiation requirements. It uses an ECC85 dual triode as a neutralized r.f. amplifier and self-oscillating mixer. The a.f.c. is supplied by a silicon diode voltage-variable capacitor.

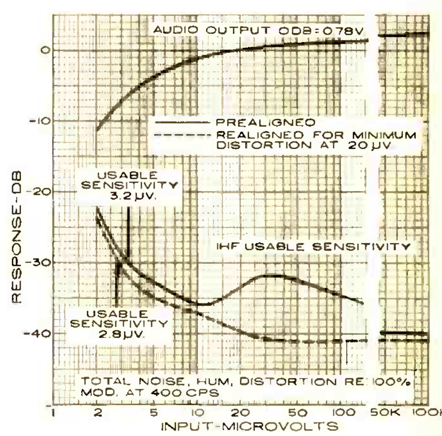
The i.f. amplifier is constructed on a printed board. It has four 6AU6 amplifier/limiter stages and a 6AL5 wide-band ratio detector. The rectified grid bias of the first limiter stage supplies a.g.c. voltage to the r.f. amplifier. The grid voltage of the last limiter operates the tuning-eye tube, a DM70. The eye tube serves as a dial pointer, traveling along the horizontal dial scale. It normally glows green, and the size of its glowing area shrinks when a station is tuned in.

The multiplex demodulator uses the filter-less switching circuits employed in the company's MX-99 multiplex adapter. The 19-kc. pilot carrier is full-wave rectified to develop the synchronizing voltage for the 38-kc. oscillator. The d.c. component of the rectified pilot signal, after amplification, lights a neon lamp to indicate the presence of a stereo broadcast.



The neon stereo indicator, like the tuning eye, serves as a traveling pointer along a logging dial scale. The tuning and logging scales are side by side, spanning almost the entire width of the tuner. In addition to the tuning knob and power switch, the panel of the tuner has a stereo separation control. Normally set at mid-position, it may be trimmed as needed on suitable stereo broadcasts (when only one channel at a time is used) to obtain maximum separation.

Our lab measurements confirmed the quite impressive performance specifications of the ST97, with due allowance for normal measurement error. Its IHF usable sensitivity, rated at 3 μv., measured 3.2 μv. After a touch-up alignment, this improved slightly to 2.8 μv. Minimum harmonic distortion at 100% modulation, rated at 0.6% was 0.9% (−41 db).



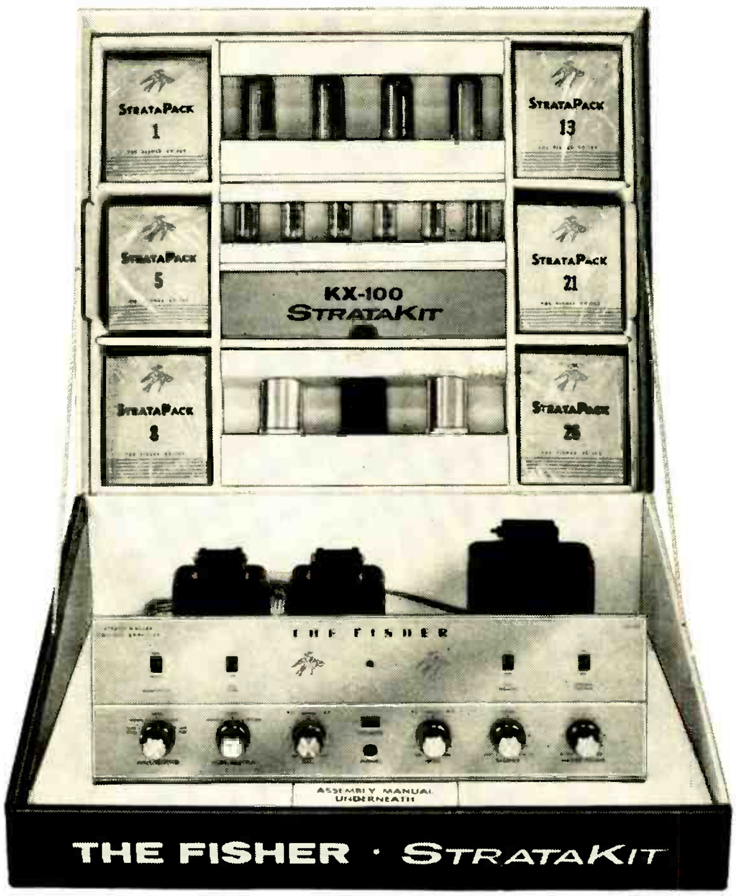
Hum was −55.5 db *re* 100% modulation. The over-all frequency response was ± 1.5 db from 50 to 15,000 cps, it is rated at ± 1 db from 20 to 15,000 cps. The capture ratio, rated at 3 db, was measured at 2.4 db. This is an exceptionally good figure. The a.f.c. action was extremely powerful, reducing drift and mistuning by over 8 times. Drift, even without a.f.c., was very small. The audio output was 0.9 volt at 100% modulation with strong signals. There is no level control, but this level should be compatible with any amplifier.

The stereo channel separation at 1000

No manufacturer can make a top-quality 50-watt stereo control-amplifier for less than $130.

But you can.

(With the Fisher KX-100 StrataKit, for only $129.50.)



If you want a no-compromise amplifier at a compromise price, you can't buy it—you have to build it yourself. And no one can build a better 50-watt single-chassis stereo control-amplifier than the Fisher KX-100, at *any* price!

Here is today's most spectacular value in amplifier kits. The 50-watt music power output (IHFM Standard, both channels) assures superior dynamic range regardless of speaker efficiency. Harmonic distortion at rated output is only 0.5%. A special power output is provided for driving a third speaker (center channel or mono extension) without the use of an additional amplifier. The exclusive Fisher DIRECT-TAPE-MONITOR* permits the use of all controls and switches during tape monitoring without any change in cable connections. The convenient front-panel headphone jack is equipped with a switch for silencing the main loudspeakers, if desired. All other control and switching facilities are equally professional in their flexibility.

And *who* can build the KX-100? Anyone. Previous experience is immaterial. The exclusive Fisher StrataKit method makes kit construction so easy and error-proof that there is no longer a difference between the work of a skilled technician and that of a total novice. You can't *help* ending up with a faultless Fisher amplifier. All you need is the desire, a few evenings of free time and $129.50.**

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CIRCLE NO. 117 ON READER SERVICE PAGE

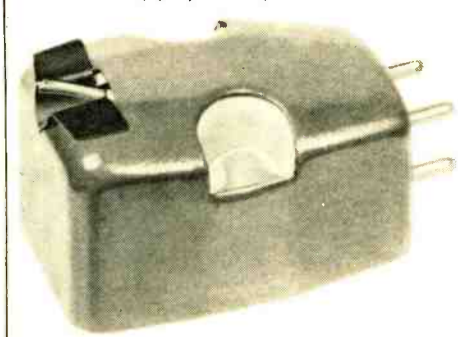
cps was in excess of 30 db, as rated (it actually averaged about 36 db). The separation fell off smoothly to 15 db at 50 cps and 15,000 cps. Critical adjustment of the separation control was needed to obtain the best mid-range figures, but even when it was set to its mid-position, the separation was about 25 db. This is better than many good phono cartridges.

The construction manual states that no alignment is needed after wiring the kit. We found that the eye closure did not coincide with the proper tuning point. A slight re-adjustment of the discriminator transformer corrected this. Otherwise, there was no need for any alignment on our test unit, which was assembled in only 9½ hours from a kit. Instrument alignment for minimum distortion resulted in a slight reduction of distortion at low signal levels, but would not be warranted for the average user.

In sensitivity, listening quality, and tuning ease, the ST97 is in the same league with many wired tuners costing far more. In kit form, it sells for $99.95, factory-wired it is $149.95. ▲

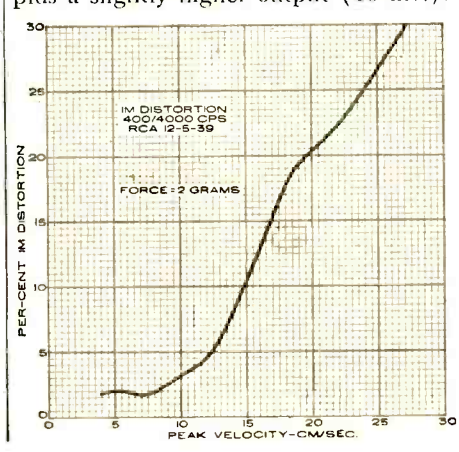
Audio Dynamics ADC-3 Phono Cartridge

For copy of manufacturer's brochure, circle No. 57 on coupon (page 19).



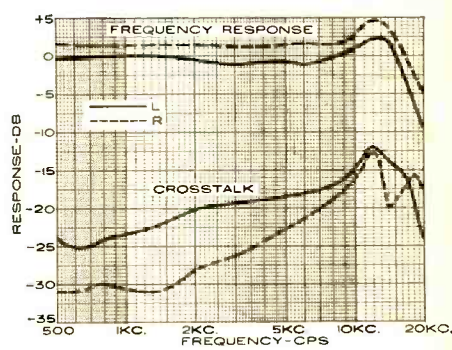
THERE are many people who would like the effortless, clean sound of the *Audio Dynamics Corp.* ADC-1 stereo phono cartridge (March issue), but who have tonearms or possibly record changers that are not suited for the fractional gram tracking force of the ADC-1. For them, and others who wish to get top-quality sound for bottom-dollar prices, *ADC* has recently brought out the ADC-3.

Basically, the ADC-3 is a moving-magnet cartridge much like the ADC-1 and ADC-2. It has a replaceable "winged" stylus assembly, with a 0.7-mil diamond stylus and a minimum compliance of 15×10^{-6} cm./dyne. Its rated response is 10 to 20,000 cps ±3 db, with 30-db rated separation between 50 and 7000 cps. The ADC-3 differs from the ADC-1 chiefly in its lower compliance, slightly greater tip mass (0.8 mg.), and higher tracking forces (2 to 6 grams), plus a slightly higher output (10 mv.).



Checking the tracking ability of the cartridge, we found that it would play the *Cook* 60 record (32 cps) at 2.5 grams and the *Fairchild* 101 record (1000 cps, 30 cm./sec.) at 2.25 grams. Since either of these is a far more severe test of a pickup's tracking ability than ordinary music records, we used the minimum recommended tracking force of 2 grams in our tests.

The frequency response of the cartridge, playing the *CBS Labs* STR-100 test record, was ± 2 db up to 16 kc. Its channel separation was 27.5 db at middle frequencies, reducing to 15 db at 10 kc. and exceeding 12.5 db all the way up to 20 kc. The output of the cartridge was 8.9 mv. at 5 cm./sec. lateral velocity.



The outputs of the two channels differed by 1.5 db at 1000 cps. The 1000-cps square wave of the *CBS Labs* STR-110 record was reproduced with a single overshoot of about 20% amplitude, which was quickly damped. The hum shielding of the ADC-3 was quite good.

The intermodulation distortion, measured with the *RCA* 12-5-39 record, was low up to about 10 cm./sec. peak velocity, rising rapidly at higher velocities. The distortion at higher velocities could probably be reduced by using higher tracking forces, but this did not seem to be necessary on the basis of our listening tests.

The cartridge has a bright, highly defined sound. It must take its place with a select group of fine phono cartridges on the basis of its performance, yet it is rugged enough for any record changer. It is priced at $29.50. ▲

the HIDDEN 600*

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*The "Hidden 600" are Sprague's behind-the-scenes staff of 600 experienced researchers who man the largest research organization in the electronic component industry and who back up the efforts of some 8,500 Sprague employees in 26 plants.

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MOLDED TUBULAR CAPACITORS

The world's most humidity-resistant molded capacitors. Dual dielectric—polyester film and special capacitor tissue—combines best features of both. Exclusive HCX® solid impregnant produces rock-hard section—nothing to leak, or drip. Tough case of non-flammable phenolic—cannot be damaged in handling.

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DIPPED TUBULAR CAPACITORS

Especially made for exact, original replacement of radial-lead tubulars. Ideally suited for printed wiring boards. Dual dielectric combines the best features of both polyester film and special capacitor tissue. Exclusive HCX® solid impregnant—no oil to leak, no wax to drip. Double dipped in bright orange epoxy resin to beat heat and humidity.

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The most dependable capacitors of their type. Built to "take it" under torrid 185°F (85°C) temperatures—in crowded TV chassis, sizzling auto radios, portable and ac-dc table radios, radio-phono combinations, etc. Hermetically sealed in aluminum cases for exceptionally long life. Withstand high surge voltages. Ideal for high ripple selenium rectifier circuits.

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ELECTROLYTIC CAPACITORS

The smallest dependable electrolytics designed for 85°C operation in voltages to 450 WVDC. Small enough to fit anywhere, work anywhere. Low leakage and long shelf life. Will withstand high temperatures, high ripple currents, high surge voltages. Metal case construction with Kraftboard insulating sleeve.

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Tiny, tough, dependable in practically every application. Low self-inductance of silvered flat-plate design gives improved by-pass action in TV r-f circuits. Higher self-resonant frequency than tubular ceramics or micas. Tough moisture-proof coating. Designed for 85°C operation.

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VOID AFTER JULY 31, 1963 **7**

EICO ST70, 70-WATT STEREO AMPLIFIER

EICO ST97 FM STEREO TUNER

Beyond the performance level of these two units, possible improvement is merely marginal and very expensive. That's why with EICO's ST97 and ST70 you strike the optimum balance of cost and performance—each costs less than $100 as a kit. You can also get the ST70 and ST97 factory-wired for $149.95 each—and you couldn't find comparable wired units at the price.

If high power isn't your primary need, you can get superb sound for even less with EICO's ST40, the 40-watt counterpart of EICO's outstanding ST70. The ST40, essentially equal to the ST70 in all but power, costs $79.95 as a kit, $129.95 factory-wired.

ST70 DATA: As the center of your stereo system, the ST70 accommodates all program sources. It even has separate inputs for both turntable and record changer, preamplified tape signals and tape head with correct equalization for both fast and slow tape speeds. A center channel output feeds directly on a center channel speaker or, where desired, extension speakers throughout your house without any additional amplifier. Critical parts — filter capacitors, rectifiers, output tubes—all operate well below their ratings to assure long, trouble-free life. Oversize output transformers deliver full rated power all the way down to 30 cps. . . . And as a kit builder, you'll like the spacious layout. We got rid of all those tight places. Kit $99.95. Wired $149.95 (includes metal cover).

SPECIFICATIONS ST70 *Output Power:* 70 watts (continuous sine wave 35-watts per channel) *IM Distortion:* 1% at 70 watts. *Harmonic Distortion:* less than 1%. *Frequency Response:* ±½ db 10-50,000 cps. *Inverse Feedback:* 17 db. *Stability Margin:* 10 db. *Hum and Noise Level:** mag. phono —63 db; tape head —54 db; tuners, auxiliaries —78 db. (all measurements according to IHFM standards.)

ST97 DATA: Building the ST97 FM stereo tuner requires no instruments, no critical adjustments. The front end and IF stages are fully pre-wired and pre-aligned. The tunable coils of the stereo demodulator are factory-adjusted. With four IF stages plus a stable, sensitive front end, the ST97 pulls in clear stereo even under fringe conditions, and EICO's filterless zero-phase shift stereo detector (patents pending) maintains reliable channel separation. EICO's unique traveling tuning eye makes tuning simple and precise. Stereo stations are automatically identified by a pilot light. Semi-kit **$99.95**, Wired **$149.95.** (Includes metal cover and FET.)

SPECIFICATIONS ST97. *Sensitivity:* 3μv (30 db quieting), Sensitivity for phase-locking (synchronization) in stereo: 2.5μv. *Full limiting sensitivity:* 10μv. *Detector Bandwidth:* 1 megacycle. *Signal-to-Noise Ratio:* —55 db. *Harmonic Distortion:* 0.6%. *Stereo Harmonic Distortion:* less than 1.5%*. *IM Distortion:* 0.1%. *Frequency Response:* ±1 db 20 cps-15 kc. *Capture Ratio:* 3 db. *Channel Separation:* 30 db. *Controls:* Power, Separation, FM Tuning, Stereo-Mono, AFC-Defeat (all measurements to IHFM standards).

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

See these superb components at high fidelity dealers everywhere. For FREE 32-page catalog, 36-page Stereo Hi-Fi Guide (enclose 25c for handling) and dealers name, write: EICO ELECTRONIC INSTRUMENT CO. INC., 3300 Northern Boulevard, Long Island City, New York. Export Dept.: Roburn Agencies Inc., 431 Greenwich Street, New York 13, N. Y. EW-7

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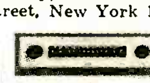
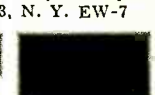
semikit $299.95 wired $399.95



HFT-90 FM TUNER
kit $39.95 wired $65.95



HFS-6 3-WAY, 3-SPEAKER SYSTEM
kit $52.50 wired $62.50

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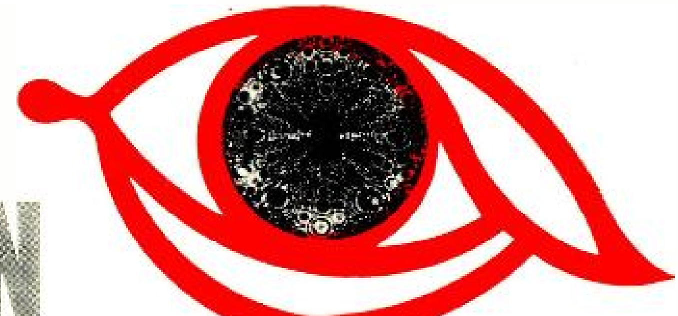
ADVANCES IN ELECTRON MICROSCOPY



New techniques and instruments now under construction may allow researchers to actually see the atomic structure of matter for the first time. Description of the transmission microscope, electron- and ion-emission types, proton microscope, and ultraviolet type.

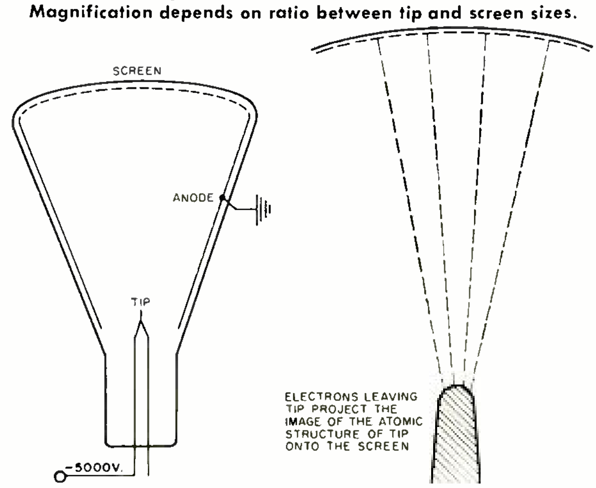
By KEN GILMORE

SOMETIME during this year, a dramatically improved electron microscope may open up to scientists a completely new view of the universe. Where current electron microscopes reveal for the most part only molecules, these new devices may allow researchers to actually see the *atomic* structure of matter—a long-time dream of scientists.

If the new instrument, now under construction at the University of Arizona, works as well as preliminary experiments indicate it will, it could have far-reaching effects on electronics, metallurgy, medicine, and other fields of science. But perhaps its most important impact will be in biology, where scientists are now on the threshold of decoding the complex DNA molecule, the substance which may hold the key to the mystery of Life itself.

The instrument that promises to play a starring role in this coming scientific triumph is the latest in a family of electronic magnifying devices stretching back to the early part of the century. Included among its ancestors and current relatives are several generations of electron microscopes as well as a group of such related devices as the electron-emission microscope, ion-emission microscope, the proton microscope, and the ultraviolet flying-spot scanner.

Fig. 1. The field-emission microscope is closely related to the cathode-ray tube. Electrons are stripped by a high voltage from the tip of a needle made of a metal whose structure is to be investigated. These electrons are fired at a screen. Magnification depends on ratio between tip and screen sizes.



Need for Electronics

The marriage of microscopy and electronics actually had its origin in a discovery in the 19th century, although no one knew it at the time. Ernest Abbe, a British scientist, published an analysis in 1875 showing that no object could be seen if it were much smaller than the wavelength of the light used to illuminate it. This meant that nothing smaller than about 2000 angstroms* (approximately 1/125,000th of an inch) could ever be seen with a light microscope. Since microscopes of the day didn't have lenses good enough to approach 2000 angstroms resolution, the point was academic.

But, in time, lenses improved. With a resolution of 2000 angstroms, the best instruments could reveal a few large molecules and many bacteria, microscopic plants, and other fascinating particles never before seen by man. But small molecules, viruses (whose existence was not even suspected at the time), and atoms were far beyond the instrument's power.

One early attempt to get around the fundamental law of nature which limits resolution took place in the early years of the 20th century when J. E. Barnard, an English microscopy expert, developed an instrument using ultraviolet, rather than visible light. The image couldn't be seen by the eye, since ultraviolet light is invisible, so it was focused onto a photographic plate which *is* sensitive to ultraviolet.

The ultraviolet microscope offered improved resolution, twice as good as a visible light microscope, but its greatest magnification was still far less than researchers wanted.

The first real step toward major improvement in microscopy came in 1924. Louis de Broglie, the distinguished French nuclear physics pioneer, speculated that elementary particles, especially electrons, in some ways demonstrate a wave-like nature similar to light. He derived the formula: *wavelength* $= h/mv$, where h is Planck's constant, m is the mass of the particle involved, and v is its velocity. If an electron were accelerated to a velocity produced by an accelerating field of

*One angstrom unit equals 3.937×10^{-9} inch or one hundred millionth of a centimeter (1×10^{-10} meter).

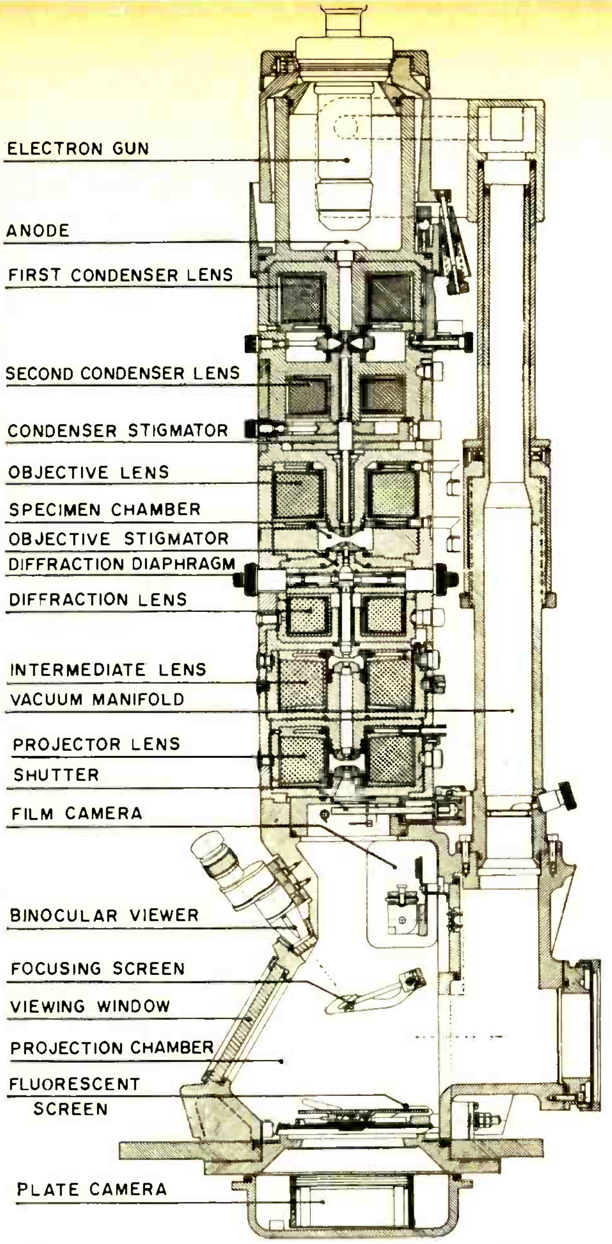


Fig. 2. Cross section of Norelco EM-200 electron microscope.

60,000 volts, its wavelength accordingly would work out to be close to one-twentieth of an angstrom—*about 1/40,000th of a wavelength of light.* If an instrument using electrons, instead of light, could be built, its theoretical resolution would then be 40,000 times better than that of the finest light microscopes in existence.

Early Instruments

During the next fourteen years, scores of instruments were built, and many worked, to a degree. First to operate were the emission microscopes (Fig. 1). A stream of electrons from the cathode was magnified as it passed through a series of electrostatic or electromagnetic lenses (not shown), then projected onto a fluorescent screen. It gave a tremendously enlarged picture of the cathode itself, since the electrons from the cathode projected the cathode's microscopic structure onto the screen. The emission instrument, the first true electron microscope, was bypassed because the only image it can magnify is the image of the cathode itself. But recently, both emission and ultraviolet microscopes have been the subject of renewed interest, since they still offer certain unique advantages.

Although the work with emission instruments was encouraging, most early efforts went into the building of transmission microscopes—the kind generally used today. Here the electron stream passes through a thin specimen and projects the picture of that specimen on the screen. Almost anything of interest to science can be viewed with such an instrument.

Several working transmission instruments were built in the mid-1930's. Then, in 1938, came a milestone in the history of microscopy. H. O. Müller and E. Driest, working in Germany, completed the first electron microscope whose resolution exceeded that of the best light instruments.

Development from that point was rapid. Less than a year later came an instrument that could resolve 100 angstroms and see particles 20 times smaller than anything viewed before. By 1940, resolution had improved so that objects only 20 angstroms across could be seen and *RCA* put the first commercial instrument on the market. By 1945—with dozens of the devices now making vast contributions to fundamental sciences in laboratories around the world—resolution reached about 10 angstroms. There, improvement all but stopped and even today the best instruments resolve no more than approximately 6-8 angstroms under optimum conditions.

Operating Principles

The modern electron microscope (see cover and Fig. 2) is actually nothing more than a large, highly specialized cathode-ray tube. An electron gun at the top of the column generates a cloud of electrons which are attracted by the anode a short distance away. This electrode, normally operated at 50,000-100,000 volts positive with respect to the cathode, attracts the electrons strongly. They move toward the anode. (Actually, the anode and the rest of the instrument are usually at ground potential for safety's sake, and the insulated electron gun is held at a high negative potential.)

The electrons accelerate to a high speed, shoot through the hole in the anode, and continue on down the column to the viewing screen and photographic plate at the bottom. They pass through a magnetic field (generated by the con-

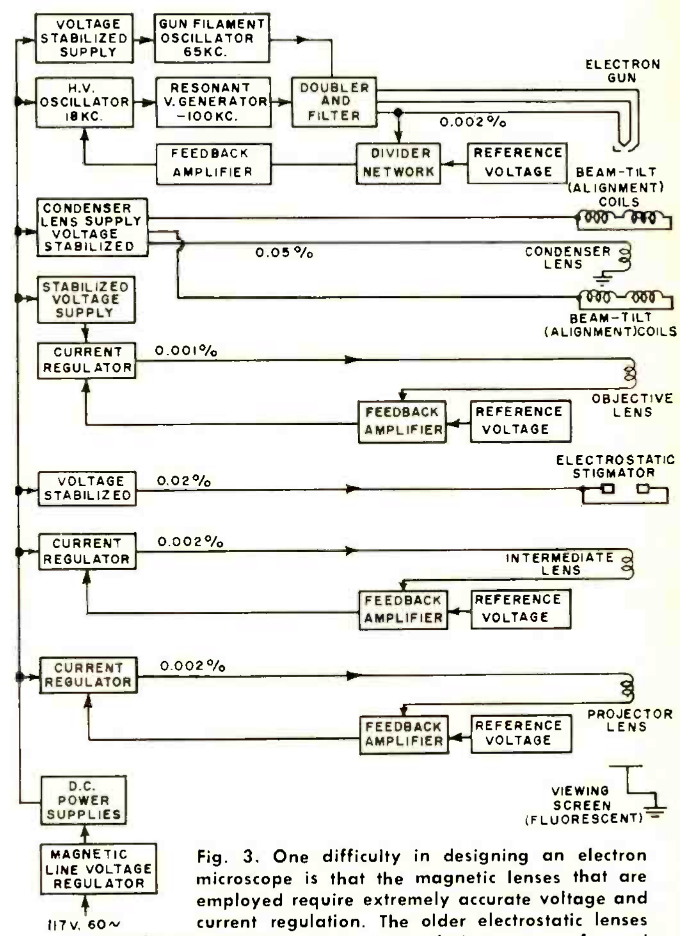


Fig. 3. One difficulty in designing an electron microscope is that the magnetic lenses that are employed require extremely accurate voltage and current regulation. The older electrostatic lenses worked fairly well with rather poor regulation, so were favored many years ago when voltage-regulation techniques were poorer. The inherently greater distortion of these designs, though, has made their use in microscopes quite rare today.

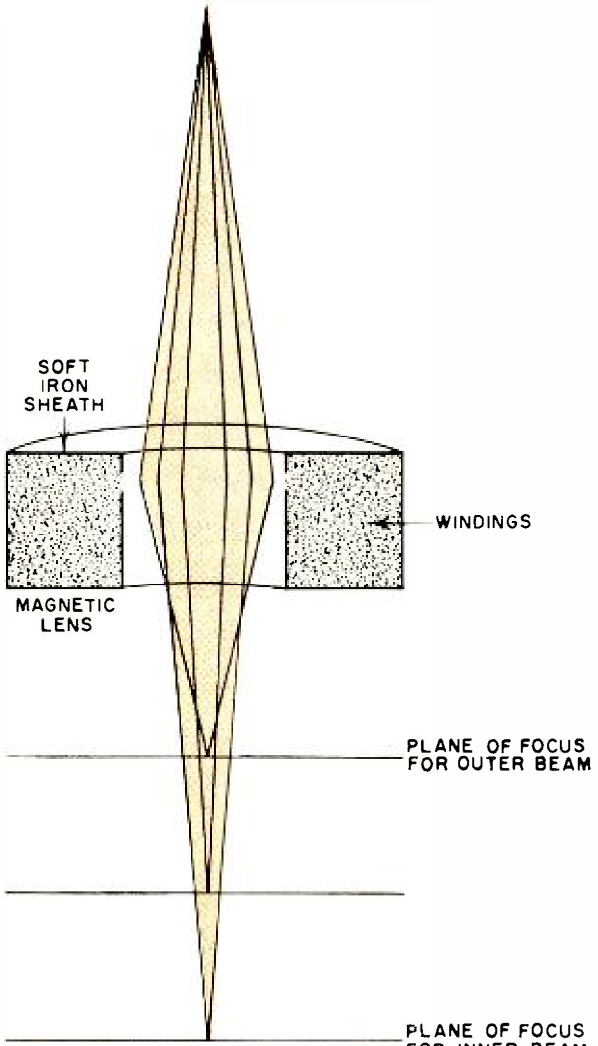


Fig. 4. Parts of the electron beam passing through a magnetic lens near the center do not come into focus at the same plane as those passing through nearer the outside of the electron beam. This phenomenon is known as spherical aberration.

denser lens, actually a coil) shortly after leaving the anode, and are focused into a tight beam as they hit the specimen. A section of the beam hitting the dense section of the specimen is largely absorbed, another part hitting a thinner area passes through with little or no attenuation.

The beam, retaining the varying pattern of electron density impressed on it as it went through the specimen, then goes through a series of magnetic objective and projector lenses (coils) which magnify it. Finally, it reaches the bottom of the column where it falls on a fluorescent screen and reproduces—much magnified—the image of the specimen. A camera is arranged either to photograph the luminous screen, or else to allow the electrons themselves to fall directly on an electron-sensitive photographic plate.

Construction is Critical

Although the electron microscope is simple in principle, its mechanical and electronic design (Fig. 3) present severe problems. Most of them—especially those which limit resolution—are associated with the electronic lens.

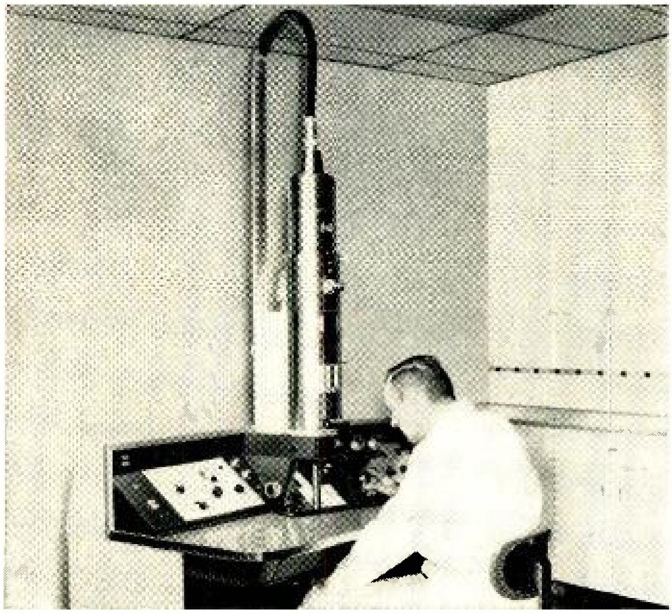
In a modern magnetic lens (electrostatic lenses, once popular, are rarely used today because of their greater inherent distortion) the magnetic lines of force are confined by a soft-iron-sheathed coil. The electron beam, shooting through this field, spreads into a cone shape and is greatly magnified, like a light ray passing through a glass lens.

The trouble comes in meeting critical construction tolerances. Pole pieces machined to the highest standards consistent with current production techniques and the most accurate lens coils available are not good enough. Minor, but unavoidable, imperfections and traces of contamination put kinks in the magnetic field big enough to distort the electron beam. For this reason, compensating circuits are included and final alignment is done by watching the image produced while adjusting the instrument for least distortion.

Another problem is spherical aberration. Electrons passing through the center of the magnetic lens converge (come into focus) at one distance, those passing through the lens away from the center, at another (Fig. 4). If the part of the picture represented by the center of the beam is in focus, other parts are hazy.

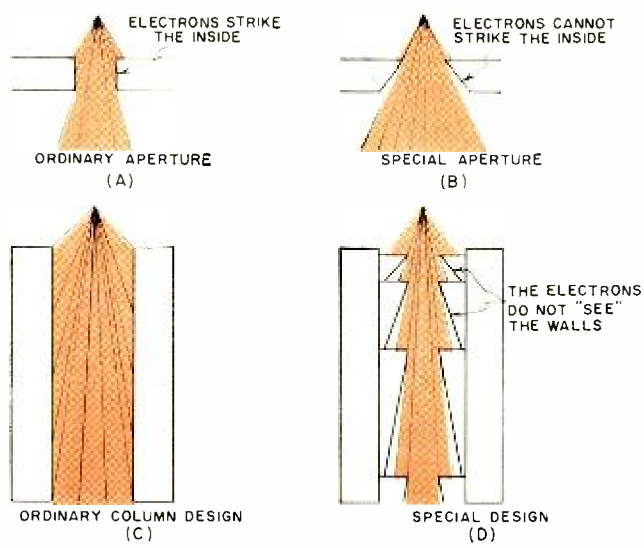
One reason electron microscopes are operated at high voltages is that high-velocity electrons, like a speeding bicycle rider, are more stable than slow-moving (low-voltage) ones. But this high-voltage technique—used almost exclusively on modern instruments—brings its own problems.

The most serious one is that fast-moving electrons have relatively greater penetrating power. They are likely to whiz right through even the densest parts of the specimen with



Researcher at work on new RCA EMU-3G electron microscope.

Fig. 5. (A) Configuration of conventional and (B) improved lens structure. The lens is cone-shaped, with the angle of the cone's inner surface being greater than the angular divergence of the electron beam. The beam then "sees" only the thin lip of the lens and is not affected by imperfections on most of the inner surface. (C) and (D) show how this new technique has been applied to the design of a complete column.



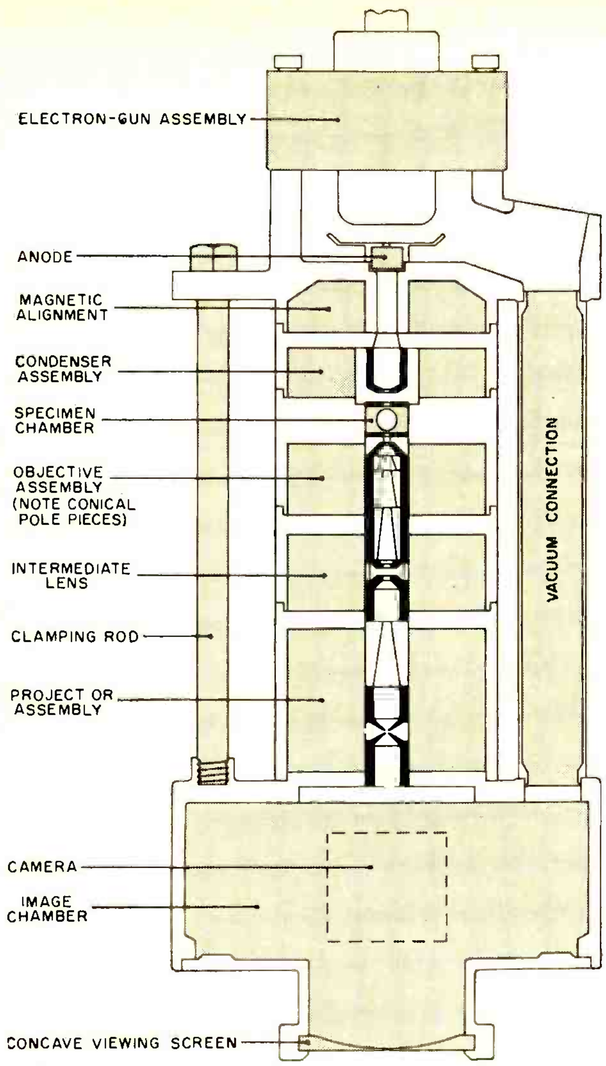


Fig. 6. Cross section of microscope designed by Dr. Wilska.

few being stopped, and no image being formed. Consequently, microscopists use relatively thick specimens, which contain enough matter to stop part of the electron beam. In practice, the thinnest practical specimen is about 200 angstroms. And, as a general rule, it is impossible to see specimen details in an electron photomicrograph smaller than about 1/10th the thickness of the sample. With a 200-angstrom-thick specimen, maximum resolution is about 20 angstroms. In some cases it can be reduced to half that and, in exceptional cases, objects 6 to 8 angstroms have been resolved.

This puts scientists tantalizingly close to one of their major goals—to see the atoms in biological molecules of greatest interest, such as DNA. These atoms, it is estimated, are some 2 to 3 angstroms in diameter. This is within the theoretical resolving power of the electron microscope, but it has not as yet been achieved.

Promising New Developments

The work of Dr. Alvar Wilska, a Finnish-born scientist now at the University of Arizona, is attracting attention because his two major improvements in the electron microscope promise to extend its resolving power into this vital region. To get around the thickness problem, Dr. Wilska lowered the accelerating voltage so that the electrons could be stopped by thinner sections. But slower-moving electrons are far more sensitive to lens imperfections, electrostatic charges on the column, and stray magnetic fields.

Dr. Wilska built a series of low-voltage instruments in which he gradually improved the lens design to the point where he got usable pictures with accelerating voltages as low as 1000 volts. His main design innovation was to build a special cone-shaped lens so that the electron beam would "see" less of the lens as it passes through, and therefore be less affected by its imperfections (Figs. 5 and 6).

This improvement gave high-contrast pictures from specimens only a few angstroms thick and thus eliminated one fundamental limitation to better resolution. But the resolving power of the microscope was improved little, if any, because of the effects of spherical aberration.

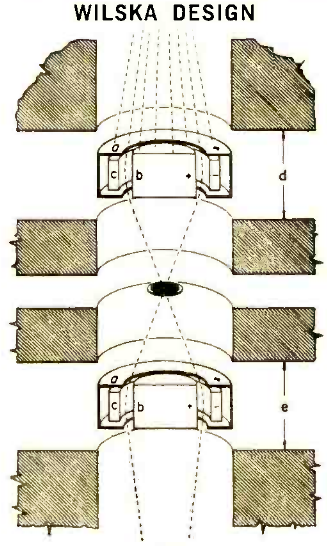
Several years ago, Wilska set to work on this problem. Since spherical aberration is caused by electrons passing through various parts of the lens and coming into focus at different planes, the solution was to make them all go through the lens at the same distance from its axis.

Wilska blocked the center of the lens (Fig. 7A) so that all electrons must pass through a narrow annular slit. An experimental lens built on this principle worked as predicted. A full-scale microscope, using both the low-voltage and spherical-aberration-correcting techniques worked out by Wilska is now under construction. Within the year, it may let man see the atoms of which living matter is made.

Other Approaches

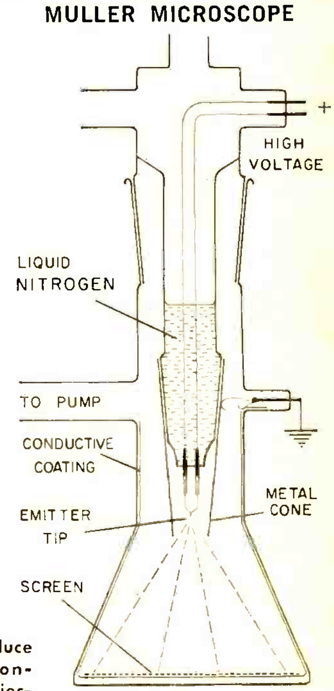
As de Broglie's formula shows, mass of the illuminating particle is inversely proportional to wavelength. Therefore, greater theoretical resolution could be achieved by using particles heavier than electrons. Such particles might also be more stable and less subject to distortion by lens contamination and stray magnetic fields. Putting these principles to work, a team of French scientists at the National Research Center in Paris has built a microscope which uses protons instead of electrons. Although this approach has attractive possibilities, there are many practical (*Continued on page* 60)

WILSKA DESIGN



(A)

MULLER MICROSCOPE



(B)

Fig. 7. (A) Special design to reduce spherical aberration. (d) is condenser lens gap while (e) is objective lens gap. Of the total cross section of the electron beam, only a narrow annular portion passes between marginal ring (a) and central stopper (b). Both (a) and (b) are at the same positive potential as the column itself, while there is an electrostatic field between negatively charged ring electrode (c) and the central stopper (b). This field increases in strength toward the center thus counteracting effects of spherical aberration within the zone between (a) and (b). (B) Dr. Müller's ion emission microscope achieves greater resolution than its predecessor, the field emission microscope, by using ions instead of electrons to fire at the screen and reproduce an image of the atomic lattice of the emitting tip. If the tip is cooled enough, by use of liquid nitrogen, helium molecules will stick long enough to lose kinetic energy. Thus, these molecules become much easier to ionize.

RC FILTER CHART

By ROBERT K. RE

Graph for use in calculating proper values of resistance and capacitance for coupling, decoupling, and bypassing.

CAPACITORS perform many vital functions in amplifiers, such as extending the frequency response, increasing gain, and inhibiting "motorboating" tendencies. Choosing the proper value of capacity for each job can be a difficult problem, but this chart (based on a simple design rule) solves each problem easily.

Adequate coupling, bypassing, and decoupling in *RC* filters (C_c-R_g, R_k-C_k, R_s-C_s, R_f-C_f) are assured when the capacitive reactance, at the lowest frequency of interest, equals about one-tenth of the filter resistor's value. This chart gives the required capacitor values from 1 μμf. to 1000 μf. for resistors of 1 to 100,000 ohms over a frequency range of 10 cps to 16,000 mc.

Using the Chart

From the known resistor value go up to the frequency curve of interest, go across to the left, and read the capacitor value from the appropriate scale. The key shows which capacity scale to use for each frequency curve. For example, a 2000-ohm resistor (point A) is adequately bypassed by 20 μf. at 40 cps, 0.02 μf. at 40 kc., or 20 μμf. at 40 mc.

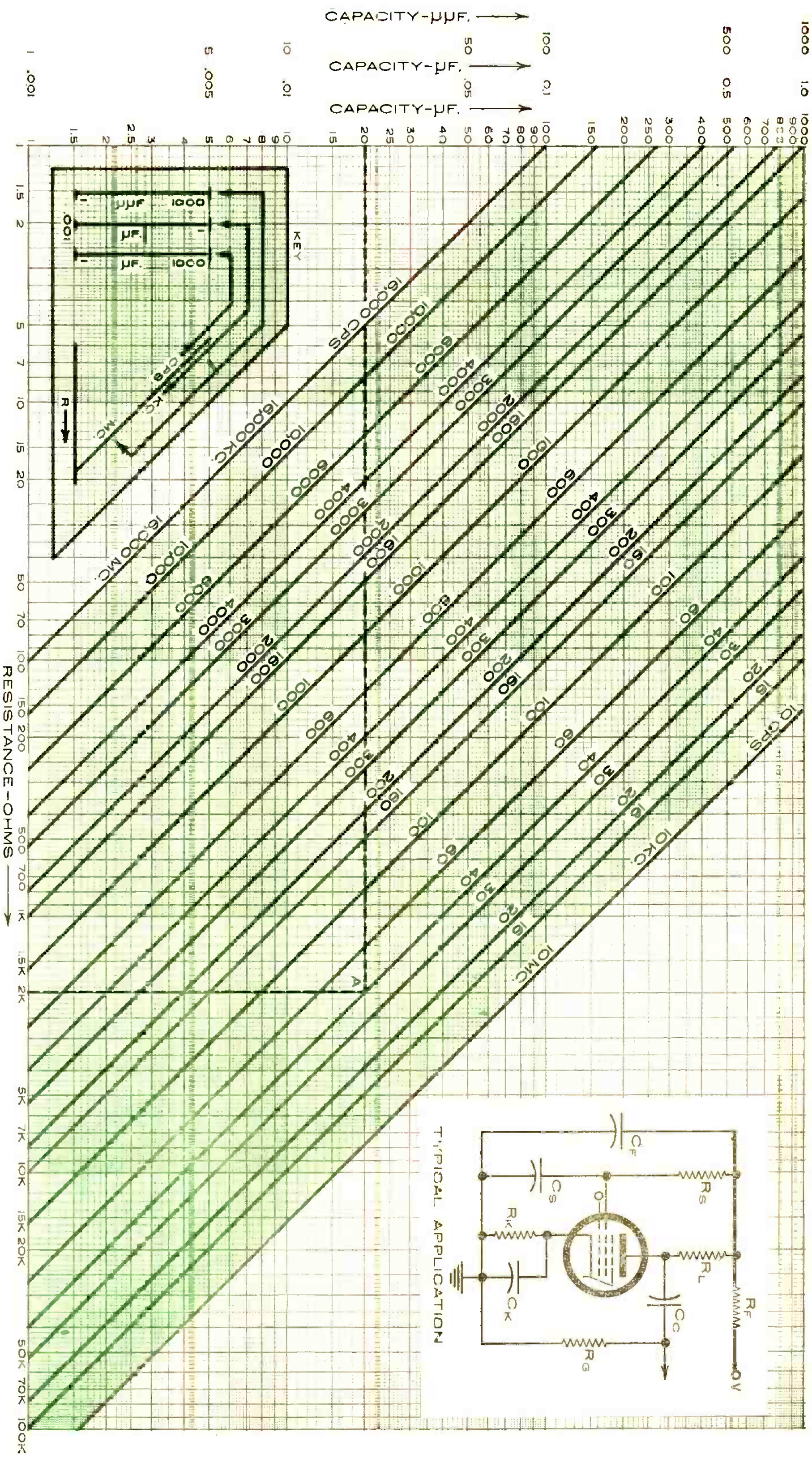
R_g, R_k, and R_s are normally fixed by circuit requirements, but R_f, when used, in most low power amplifier stages should be about 1/5 to 1/10 of R_L. R_f-C_f isolates stages from the effects of a common power-supply impedance. If R_L, R_f, and C_f are used as a power-supply filter, this chart can determine the minimum value of capacity for filtering applications.

Extending the Chart

The chart can be "extended" for very low frequency use by dividing each cps scale by 1000 and increasing the high *C* scale by 1000; thus the chart would now cover from 1000 μf. to 1 farad over the range 0.01 to 16 cps.

Additional frequency scales can be added by computing X_c for two different capacitors at the same frequency. Multiply each X_c value by 10 and plot points to get the new curve.

Posted near your bench or lab table, this chart will save time and effort. ▲



DOMESTIC REPLACEMENTS

By JERRY EIMBINDER / Derivation & Tabulation Assoc., Inc.

An unusual tabulation of available substitutes for current models in 34 brands, European as well as Japanese, is based on specific applications and sets rather than correlation of transistor-for-transistor similarity.

REPLACEMENT of foreign-made transistors and other semiconductors with American-made types continues to be a serious problem, partly for want of interchangeability data, but also because such information is not always adequate when available. The listing included here was compiled to help solve both basic difficulties.

For reasons that will become clear, the equipment using the transistor or diode was chosen as the starting point, rather than the semiconductor itself. The comprehensive tabulation covers not only the popular Japanese-made radios, but those imported from European countries as well. In addition, receivers assembled on these shores from semiconductors obtained abroad are listed. Since they represent no replacement identification problem, foreign-made sets using transistors that are either made here or carry domestic type numbers (assigned by the Joint Electron Devices Engineering Council) are not considered.

Although the approach used here is somewhat unusual, it was not chosen arbitrarily. In fact, it was developed after an evaluation of the merits and drawbacks of other methods now being used for the listing of replacement recommendations.

In one system widely used by domestic transistor manufacturers, foreign types are listed first. Each is then followed by the compiling source's recommendation for his own replacement. There will generally be some qualification similar to "Our Nearest Type to the Original." This conservatism has merit. Suppose the suggested replacement will satisfactorily replace the original in some applications, but not in others. The manufacturer will obtain the business in some cases, but won't be held responsible where replacement does not work.

If the user of the guide is designing equipment, he can alter his circuit somewhat, if necessary, to accommodate the domestic unit. If he is a service technician or consumer, however, he may be reluctant to invest where there is risk.

In another approach, the original transistor is listed, followed by several possible equivalents from various sources. The degree of equivalence and the particular characteristics that may be similar or different are not indicated. Often the user, although he is unfamiliar with the original unit, has full specifications on two or more of several possible replace-

RADIO NAME AND MODEL	CONVERTER OR MIXER		OSCILLATOR		1st I.F. AMPL.		2nd I.F. AMPL.		A.F. DRIVER		A.F. AMPLIFIER		OTHER		
	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	USE
ALADDIN															
AL-65	2SA152	2N412			2SA151	2N410	2SA151	2N410	2SB75	2N406	2SB156	2N408			
AL-80	2SA94	2N412	2SA15	2N412	2SA133	2N410	2SA12	2N410	2SB75	2N406	2SB156	2N408	2SB75	2N406	1st A.F. Ampl.
AMERICANA															
FC-60	2SA15	2N412			2SA12	2N410	2SA12	2N410	2SB75	2N406	2SB77	2N408			
FP-64	2SA15	2N412			2SA12	2N410	2SA12	2N410	2SB75	2N406	2SB77	2N408			
FP-80	2SA84	2N412	2SA15	2N412	2SA12	2N410	2SA12	2N410	2SB75	2N406	2SB77	2N408			
ST-6	2SA152	2N412			2SA151	2N410	2SA151	2N410	2SB75	2N406	2SB156	2N408			
TP-7	2SA15	2N412			2SA12	2N410	2SA12	2N410	2SB75	2N406	2SB77	2N408			
BULOVA															
672, 673	2SA102	2N1527			2SA102	2N1525	2SA102	2N1525	2SB171	2N406	2SB172	2N408			
675, 676	2SA102	2N1527			2SA102	2N1525	2SA102	2N1525	2SB171	2N406	2SB172	2N408			
742, 743	MC102	2N1527			MC102	2N1525	MC102	2N1525	0C71	2N406	0C72	2N408			
745, 746	MC102	2N1527			MC102	2N1525	MC102	2N1525	0C71	2N406	0C72	2N408			
782, 785	2SA103	2N412			2SA144	2N410	2SA144	2N410	2SB171.	2N406	2SB176	2N408	2SB171	2N406	1st A.F. Ampl.
786	2SA103	2N412			2SA144	2N410	2SA144	2N410	2SB171	2N406	2S8176	2N408	2SB171	2N406	1st A.F. Ampl.
792, 793	2SA160	2N412			2SA155	2N410	2SA156	2N410	2SB111	2N406	2SB111	2N406	2SB111	2N406	1st A.F. Ampl.
795	2SA160	2N412			2SA155	2N410	2SA156	2N410	2SB111	2N406	2SB111	2N406	2SB111	2N406	1st A.F. Ampl.
7822, 7855	MC102	2N372			0C44	2N1525	0C44	2N1525	0C71	2N406	0C72	2N408	0C71	2N406	1st A.F. Ampl.
7866	MC102	2N372			0C44	2N1525	0C44	2N1525	0C71	2N406	0C72	2N408	0C71	2N406	1st A.F. Ampl.
BUTOBA															
T-5			0C75	2N406					0C76	2N406	0C74	2N408	0C71	2N406	1st A.F. Ampl.
CHANNEL-MASTER															
6501-6504	2T73	—			2T76	—	2TS20	—	2T66	2N649	2T66	2N649			
6505	2SA52	2N412			2SA49	2N410			2SB54	2N406	2SB56	2N408			
6508, 6509	2SA52	2N412			2SA49	2N410	2SA53	2N410	2SB54	2N406	2SB56	2N408			
6510	2SA52	2N412			2SA49	2N410	2SA53	2N410	2SB54	2N406	2SB56	2N408			
6511	2SA52	2N412			2SA53	2N410	2SA53	2N410	2S54	2N406	2S56	2N408			
6512, 6514	2S60	2N412			2S53	2N410	2S45	2N410	2S44	2N406	2S44	2N408	2S44	2N406	A.G.C. Ampl.
6515	2SA52	2N412			2SA49	2N410	2SA53	2N410	2SB54	2N406	2SB56	2N408	2SA72	2N412	R.F. Ampl.
CLAIRTONE															
CXR			0C170	2N1177									0C75	2N406	2nd Osc.
COLUMBIA															
400	2S52	2N412			2S53	2N410	2S45	2N410			2S56	2N408			
600	2S52	2N412			2S53	2N410	2S45	2N410	2S54	2N406	2S56	2N408			
605	0C44	2N219			0C45	2N218			0C71	2N406	0C72	2N408			
610	0C44	2N219			0C45	2N218	0C45	2N218	0C71	2N406	OC72	2N408			
615	0C615	2N1178			0C614	2N1180	AF105	2N1180	0C304	2N406	0C318	2N408	0C615	2N1177	R.F. Ampl.

for FOREIGN SEMICONDUCTORS

ments listed. When he compares these, he may be quite disconcerted. He will often find that the various replacements recommended are quite different from each other.

In an improvement over the method just noted, certain parameters of the transistors involved are spelled out for comparison. Even here, however, the provided information is often insufficient for a reliable decision in terms of the specific application. For example, suppose two comparable transistors differ in minimum current transfer ratio. A reliable decision on interchangeability could not be made without resort to experimental tests, electrical measurements, or considerable calculation.

The unique presentation of replacement information here eliminates both the need for analysis and uncertainty. For one thing, it is based on the demands made of the transistor in its particular application, rather than on specifications that may or may not apply.

The list has another advantage. Not only is it unnecessary to know something about the original unit being replaced, but it needn't always be identifiable as to type number. In use, the markings on a transistor very often become illegible or obliterated altogether. If there is a schematic or other identifying sticker on the radio's chassis or case, the circuit function of the defective component can be determined readily and its replacement found here. When there is no diagram, relatively minor circuit tracing should establish circuit position and function of a transistor by identifying it in relation to other stages in the receiver circuit.

For some foreign transistors listed here more than once, alert readers will note the recommended domestic equivalent is not always the same. This is neither an error nor an inconsistency. In fact, it is further evidence of the advantage offered by a chart of this kind over straightforward, transistor-for-transistor listings. Depending on differences in specific characteristics, one transistor may work very well when replacing a similar but not identical type in one application, whereas it may be a poor substitute for the same original unit in another position.

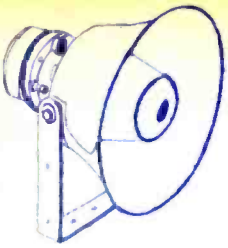
As an example, voltage rating may be a factor. Transistor *A* may replace transistor *B* adequately in a set with a 4.5-volt battery supply. In a 12-volt receiver, however, transistor *A* may be in danger of breakdown. In another case, frequency characteristics may be a factor. Whenever possible, the most economical replacement is given.

There are some precautions concerning replacement procedure that should be mentioned. First, if the power is not turned off while making a substitution, high transient current may damage the transistor. The suggestion seems elementary, but the possibility is all too easily overlooked when plug-in transistors are involved. Second, some re-alignment for optimum performance may be necessary when r.f. or i.f. circuits are involved.

Every recommended replacement is made by at least one domestic manufacturer and is available here; most are made by more than one source. *RCA*, for example, makes all listed here. Thus no attempt was made to list manufacturers. ▲

RADIO NAME AND MODEL	CONVERTER OR MIXER		OSCILLATOR		1st I.F. AMPL.		2nd I.F. AMPL.		A.F. DRIVER		A.F. AMPLIFIER		OTHER		
	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	USE
CONTINENTAL															
MB-7	2SA17	—	2SA81	—	2SA12	2N218	2SA12	2N218	2SB75	2N215	2SB77	2N217	HV-15	1N2326	Diode
SW-7	HJ60	—	HJ71	—	2SA12	2N218	2SA12	2N218	2SB75	2N215	2SB77	2N217			
TR-100	2S30	2N412			2S31	2N410			2S33	2N406	2S33	2N408			
TR-150, TR-160	HJ23D	2N411			HJ22D	2N409	HJ22D	2N409	HJ15	2N405	HJ17D	2N407			
TR-215	2S30	2N412			2S31	2N410	2S31	2N410	2S32	2N406	2S33	2N408			
TR-300	2S30	2N412	2S31	2N410	2S31	2N410	2S31	2N410	2S32	2N406	2S33	2N408			
TR-394									2SB175	2N215	2SB176	2N215			
TR-632, TR-650	2SA15	2N219			2SA12	2N218	2SA12	2N218	2SB75	2N406	2SB77	2N408	HV-15	1N2326	Diode
TR-683	2SA142	2N412			2SA141	2N410	2SA141	2N410	2SB135	2N406	2SB136	2N408			
TR-720	2SA52	2N412			2SA49	2N410	2SA53	2N410	2SA54	2N406	2SA189	2N408			
TR-751	2SA80	—			2SA83	—	2SA83	—	2SB75	2N406	2SB77	2N408	HV-15	1N2326	Diode
CORONADO															
RA-50	2S52	2N412			2S45	2N410	2S53	2N410	2S54	2N406	2S56	2N408			
RA-60	2SA101	2N1527			2S101	2N1525	2SA101	2N1525	2SB171	2N406	2SB172	2N408			
CROWN															
TR-666	HJ23D	2N412			HJ22D	2N410	HJ22D	2N410	HJ15	2N408	HJ17D	2N408			
TR-875	HJ73	2N219	HJ71	—	2N218	2N218	2N218	2N218	HJ62	2N215	2N217	2N217	HV-15	1N2326	Diode
TR-999	2SA152	2N412	2SA152	2N412	2SA14	2N410	2SA151	2N410	2SB153	2N406	2SB154	2N408	HV-15	1N2326	Diode
EXCEL															
T-7	2S52	2N140			2S13	2N139	2S13	2N139	2S14	2N109	2S56	2N109			
FLEETWOOD															
NTR-6G	2S30	2N412			2S31	2N410	2S31	2N410	2S32	2N406	2S33	2N408			
FUJI															
TRA-611	2SA30	2N412			2SA31	2N410	2SA31	2N410	2SB32	2N406	2SB33	2N408			
TRS-701	2SA112	2N372	2SA111	2N371	2SA31	2N410	2SA31	2N410	2S32	2N406	2S33	2N408			
FUJIYA															
MTR-252									2SB75	2N215	2SB77	2N217	2S75	2N215	1st A.F. Ampl.
TRP-61	2SA15	2N219			2SA12	2N218	2NSA14	2N218	2SB75	2N215	2SB89	2N217			
TRP-72S	2SAB0	2N372			2SA12	2N218	2SA12	2N218	2SB75	2N215	2SB89	2N217	2SB75	2N215	1st A.F. Ampl.
HITACHI															
TH-621	HJ23D	2N140			HJ22D	2N139	HJ22D	2N139	HJ15	2N109	HJ17D	2N109			
TH-627R	2SA84	2N412			2SA12	2N410	2SA12	2N410	2SB75	2N406	2SB77	2N408			
TH-660	2SA94	2N412			2SA151	2N410	2SA133	2N410	2SB77	2N406	2SB156	2N408			
TH-664	HJ23	2N412			HJ22	2N410	HJ22	2N410	HJ15	2N406	HJ17	2N408			
WH-761M	2SA84	2N412	2SA84	2N412	2SA12	2N410	2SA12	2N410	2SB75	2N406	2SB77	2N408			
TH-862R	HJ74	2N219	2N219	2N219	2N218	2N218	2N218	2N218	2N215	2N215	2N217	2N217			

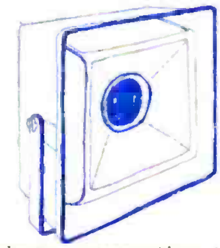
RADIO NAME AND MODEL	CONVERTER OR MIXER		OSCILLATOR		1st I.F. AMPL.		2nd I.F. AMPL.		A.F. DRIVER		A.F. AMPLIFIER		OTHER		
	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	ORIG. TYPE	REPLACE. TYPE	USE
KOWA															
KTF-1	0C171	2N1179	0C171	2N1177	2SA80	2N1180	2SA80	2N1180	2SB76	2N408	2SB79	2N270	2SA80	2N1180	Limiter
KTS-1	MC103	2N412	MC103	2N412	MC101	2N410	MC101	2N410	0C71	2N406	0C72	2N408	0C71	2N406	1st A.F. Ampl.
LINMARK															
T-60, T-61	2S52	2N412			2S53	2N410	2S53	2N410	2S24	2N408	2S56	2N408			
T-62	2S52	2N412			2S45	2N410	2S45	2N410	2S44	2N408	2S56	2N408			
T-63	2S52	2N412			2S49	2N410	2S53	2N410	2S44	2N408	2S56	2N408			
T-80	ST333	—			2S156	—	2S156	—	2S159	2N406	2S163	2N408			
T-40	2S52	2N412			2S49	2N410	2S53	2N410			2S44	2N408			
MACO															
T-16	0C44	2N219			0C45	2N218	0C45	2N218	0C71	2N408	0C72	2N408			
MARVEL															
6YR-05	2SA52	2N412			2SA49	2N410	2SA53	2N410	2SB54	2N406	2SB56	2N408			
8YR-10A	2SA52	2N412	2S56	2N412	2SA49	2N410	2SA53	2N410	2SB54	2N406	2SB56	2N408			
MATSUSHITA															
T-13	2SA102	2N1527			2SA102	2N1525	2SA102	2N1525	2SB171	2N406	2SB172	2N408			
T-22	2SA102	2N372	2SA102	2N371	2SA145	2N1525	2SA55	2N1525	2SB171	2N406	2SB172	2N408			
T-30	2SA71	2N1179			2SA70	2N1180	2SA70	2N1180	2SB171	2N408	2SB176	2N270	2SB171	2N406	1st A.F. Ampl.
T-41	2SA103	2N1527	2SA102	2N1527	2SA102	2N1525	2SA102	2N1525	2SB171	2N406	2SB172	2N408			
T-70	2SA102	2N372	2SA102	2N371	2SA145	2N1525	2SA145	2N1525	2SB171	2N406	2SB171	2N408	2SB171	2N406	1st A.F. Ampl.
T-92	2SA102	2N1527			2SA102	2N1525	2SA101	2N1525	2SB175	2N406	2SB172	2N408			
MINUTE MAN															
6T-170	2S52	2N412			2S45	2N410	2S45	2N410	2S44	2N406	2S56	2N408			
NANOLA															
GTP-106	2S52	2N412			2S49	2N410	2S45	2N410	2S44	2N406	2S56	2N408			
NORELCO															
L-0X95T	0C49	—			0C45	2N218	0C45	2N218	0C71	2N406	2N217	2N217			
L-1X75T	0C44	2N219			0C45	2N218	0C45	2N218	0C71	2N406	0C72	2N217			
L-2X97T	0C44	2N219			0C45	2N218	0C45	2N218	0C71	2N406	0C72	2N217			
L-3X76T	2N247	2N274			2N218	2N218	2N218	2N218	0C71	2N406	2N270	2N270			
L-3X86T	0C170	2N371			0C45	2N410	0C45	2N410	0C71	2N406	0C72	2N217			
L-3X88T	0C170	2N371			0C45	2N410	0C45	2N410	0C71	2N406	0C72	2N408			
L-3X95T	0C170	2N371			0C45	2N410	0C45	2N410	0C71	2N406	0C72	2N408			
L-4X95T	0C170	2N371			0C45	2N410	0C45	2N410	0C75	2N406	0C72	2N408			
NORDMENDE															
Mambo	2N113	2N412			0C612	2N410	0C612	2N410	0C304	2N406	0C74	2N408			
Transista	0C615	2N1178			AF105	2N1180	AF105	2N1180	0C304	2N406	0C74	2N408	0C614	2N1180	I.F. Ampl.
OLYMPIC															
770	HJ230	2N412			HJ54	2N410	HJ54	2N410	HJ15	2N406	HJ170	2N408			
778	2SA15	2N412			2SA12	2N410	2SA12	2N410	2SB75	2N406	2SB77	2N408			
PETITE															
NTR-120	2S30	2N412			2S31	2N410	2S31	2N410	2S32	2N406	2SB33	2N408			
NTR-150	2SA30	2N412			2SA31	2N410	2SA31	2N410	2SB32	2N406	2SB33	2N408			
POLYRAD															
P-86	2N219	2N219			HJ62	2N410	HJ62	2N410	2N215	2N215	2N215	2N215			
REALISTIC															
90L665	2SA101	2N1527			2SA101	2N1525	2SA101	2N1525	2SB175	2N406	2SB172	2N408			
90L696	2S52	2N412			2S53	2N410	2S53	2N410	2S54	2N408	2S56	2N408			
REALTONE															
TR-555	2NJ8A	2N219			2NJ5A	2N218			2NJ9D	2N215	2NJ9A	2N217			
TR-801	2NJ8A	2N219			2NJ5A	2N218	2NJ5A	2N218	2NJ9D	2N215	2NJ9A	2N217			
RIVIERA															
RV-62	2SA142	2N412			2SA141	2N410	2SA141	2N410	2SB135	2N406	2SB136	2N408			
SHARP															
TR-182	2S52	2N411			2S45	2N409	2S53	2N409	2S54	2N407	2S56	2N407			
TR-203	2SA93	2N412	2SA92	2N412	2SA53	2N410	2SA49	2N410	2SB54	2N406	2SB56	2N408	2SB54	2N406	1st A.F. Ampl.
SONY															
TR-710A	2T201	2N412			C76	—	C76	—	D64	2N649	2T312	2N408			
TR-711	2T201	2N412			2T76	—	2T76	—	2T65	2N649	2T85	2N649			
TR-714	2T201	2N412			2T75	—	2T76	—	2T64	2N649	2T65	2N649			
TR-812	2T201	2N412	2T201	2N371	2T76	—	2T76	—	2T64	2N649	2T323	2N408			
TRW-621	2SC73	—			2SC76	—	2SC76	—	2SD64	2N647	2SD65	2N647			
STUZZI															
671-B									0C304	2N217	0C308	2N217	0C360	2N217	A.F. Preampl.
TOSHIBA															
6TP-304	2S52	2N412			2S49	2N410	2S53	2N410	2S54	2N408	2S56	2N408			
6TP-309	2S52	2N412			2S53	2N410	2S53	2N410	2S54	2N408	2S56	2N408			
6TP-314	2S52	2N412			2S49	2N410	2S53	2N410	2S54	2N408	2S56	2N408			
6TP-354	2S52	2N412			2S49	2N410	2S53	2N410	2S54	2N408	2S56	2N408			
6TP-357	2S52	2N412			2S49	2N410	2S53	2N410	2S54	2N408	2S56	2N408			
7TP-352	2S60	—			2S49	2N410	2S53	2N410	2S54	2N408	2S56	2N408			
8TR-294	2S52	2N412			2S53	2N410	2S53	2N410	2S54	2N408	2S56	2N408	2S44	2N406	A.G.C. Ampl.
VICTORIA															
TR-650	MC101	—			MC101	—	MC101	—	0C71A	2N406	0C72	2N408			
YAOU															
909	2SA30	2N412			2SA31	2N410	2SA31	2N410	2SB32	2N406	2SB33	2N408			
YASHICA															
YT-100	MC101	—			0C44	2N219	0C44	2N219	0C71	2N406	0C72	2N408	MA23	1N2326	Diode



CONSTANT-VOLTAGE SOUND-DISTRIBUTION SYSTEMS

By ABRAHAM B. COHEN, Executone, Inc.
Chief Electroacoustic Engineer

Principles and practical applications of this important and widely used p.a. hookup system that permits simple adjustment of loudspeaker power without considering impedance matching.



THE constant-voltage sound-distribution system is an extremely useful aid to the sound-system installer and technician. Advantages of the constant-voltage system include: (*a*) easy, on-the-spot sound-power adjustment of loudspeakers without worrying about impedance matching on the line as a whole, and (*b*) conservation of audio power.

The constant voltage system also assures that the installation is not an electrical hazard. Section 640.5 of the National Electrical Code states the following with respect to an audio distribution system:

"*640.5 Conductors:* Amplifier output circuits carrying audio-program signals of 70 volts or less and whose open circuit voltage will not exceed 100 volts, may employ Class 2 wiring as covered in Article 725.

"The above is based on amplifiers whose open-circuit voltage will not exceed 100 volts when driven with a signal of any frequency from 60 to 100 cps sufficient to produce rated output (70.7 volts) into its rated load. This also accepts the known fact that the average program material is 12 db below the amplifier rating—thus the average r.m.s. voltage for an open-circuit 70-volt output would be only 25 volts."

The graphical presentation of these audio line voltages is shown in Fig. 1. By meeting these standards, the requirements for installation and wiring are far less stringent than in the case when higher voltages, such as those of a.c. power lines, are employed. Hence audio wiring need not be enclosed in conduit or BX to meet *Underwriters'* approval.

The constant-voltage distribution system is as simple to use for sound networks as is the 117-volt a.c. power utility system. We plug a 100-watt lamp into an electric outlet to get bright illumination or a 15-watt lamp into the same power line for low illumination. See Fig. 2A. The user knows that all he has to be concerned with is how much light he wants in any particular location, and he chooses a bulb rated in power accordingly. The power is very clearly marked on the light bulb. It isn't necessary to figure the lamp's impedance. For a constant-voltage (70.7-v.) sound-distribution line, transformers are used that are marked directly in watts. If one wants a lot of sound (see Fig. 2B), he might connect the loudspeaker-transformer combination to the 30-watt taps. If, on the other hand, he is after just background-level sound, he may choose the transformer input terminals marked "½ watt." Impedances are automatically taken care of by the transformer design and the manner in which the transformer is connected to the loudspeaker.

In the case of an 8-ohm speaker connected to the 8-ohm output terminals of the transformer, we just match numbers at the secondary. But the *input* or primary terminals of the transformer will be marked in *watts*, say 10, 5, 2½, 1¼. We simply connect the line to the appropriate wattage tap on the transformer primary to give us whatever sound power is necessary to cover the area effectively. In most cases, then, changes in power *to the loudspeaker* may be made quickly by simply changing the primary connection to the transformer without considering impedance problems in any way.

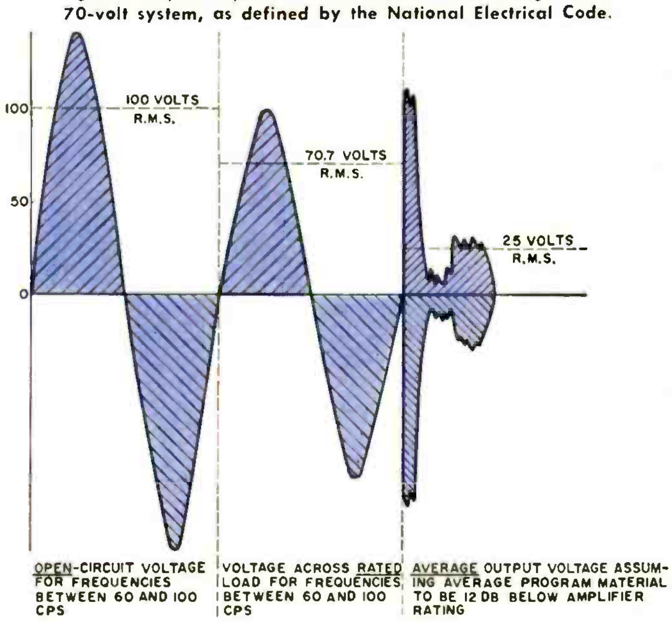
How the System Works

The foregoing doesn't mean, however, that transformer impedances are forgotten. While most transformers designed for the constant-voltage system specify the primary taps in terms of power, there are some transformer manufacturers who still rate their sound-distribution transformers in primary impedance instead of watts. From the following discussion we will show how to convert one notation to the other for power-adjustment purposes.

In an audio-distribution system, a transformer transmits *power*. This power transfer is usually from a source of one impedance to a load of a different impedance. Fig. 3A, for example, shows a step-down transformer accepting power from a high-impedance source, such as the plate circuit of a tube of perhaps 5000 ohms, and transferring that power to a low-impedance load, such as an 8-ohm speaker. Assuming an ideal loss-less transfer device within the black box of Fig. 3B, we know that for maximum power transfer to the 8-ohm load, power must be fed from an 8-ohm source. Thus if the tube is delivering an output of 50 watts and the loudspeaker is receiving 50 watts, then the ideal box with its "transfer unit" inside is actually transferring (or transforming) a 5000-ohm impedance from the left to 8 ohms on the right.

The measure of this impedance transfer is the *ratio* of these two impedances as seen, respectively, by the generator and

Fig. 1. Graphical presentation of audio line voltages in a 70-volt system, as defined by the National Electrical Code.



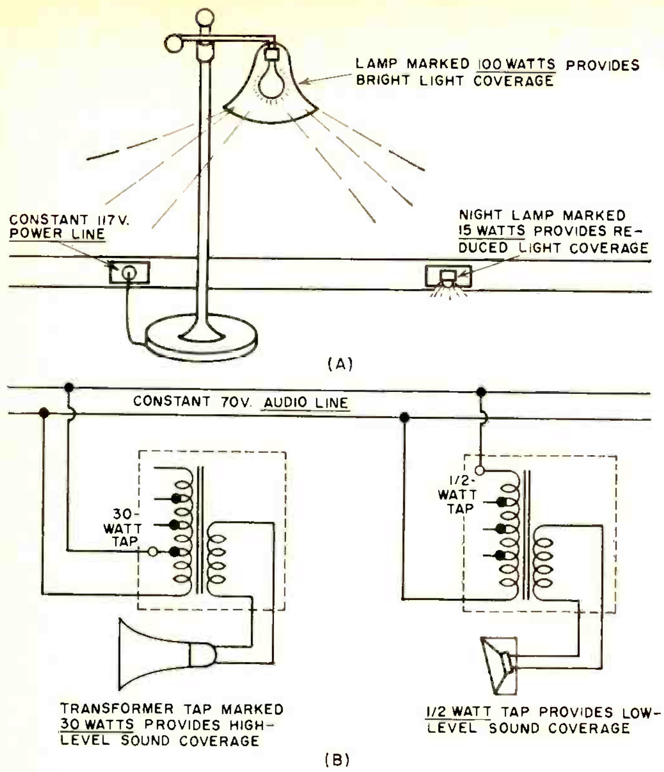


Fig. 2. Comparison of 70-volt audio line with 117-volt a.c. power line showing the ease of meeting required power needs.

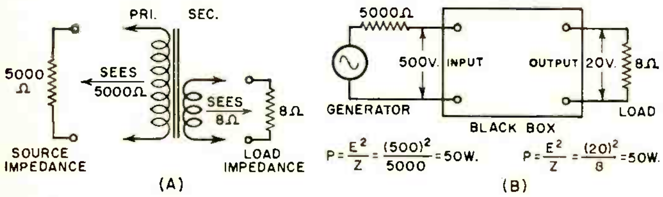


Fig. 3. An ideal transformer transfers power from a generator of one impedance to a load of another impedance, without any loss, by means of the impedance ratio of two windings used.

by the load. When fully connected, the secondary winding "sees" the load impedance of 8 ohms. Now this 8-ohm impedance is stepped up to, or transformed to, the higher primary impedance, which "sees" the 5000 ohms of the source. The system is now matched on an impedance basis for maximum transfer of power to the load.

In reality, the voltage across the "70-volt" constant-voltage line is 70.7 volts for a very simple reason. Power across an impedance is $P = E^2/Z$: thus in the "70-volt" system $P = (70.7)^2/Z = 5000/Z$. This figure of 5000 makes it very easy for us to select a transformer input impedance to accept any power we want and, on the basis of an even figure of 5000, mark the input impedance terminals in power.

Let us assume that we want to deliver one watt of power to an 8-ohm speaker, using the transformer shown in Fig. 4A. The simple calculations accompanying this figure show that to transfer one watt from the line side to the load side of the transformer, the input impedance of the transformer will have to be 5000 ohms. For 2, 4, and 8 watt transfer, the input impedance taps would vary according to the simple tabulation shown. These various taps may then be simply marked with their corresponding power-acceptance number, as in Fig. 4B. But, it must be remembered that this numbered notation of the primary in terms of power will hold only for a 70.7-volt feeder line *and* when the secondary impedance figure is matched to the corresponding speaker impedance.

The transformer shown in Fig. 4B may then be used directly without any additional calculations for drawing as much audio power from the line as desired and in whatever steps are desired (usually in steps of 3 db—double the power) up to the capabilities of the amplifier. In a noisy location it may be necessary to connect the transformer as in Fig. 4C under which condition the loudspeaker will draw the power marked, 8 watts. Note that the equivalent impedance of the 8-watt input, which one doesn't have to worry about, is 625 ohms.

Normally, then, the constant-voltage transformer will have the *secondary* marked in terms of the speaker *impedance*, and the *primary* winding will be marked in terms of *power*. If, however, one should run into a line transformer with impedance markings as in Fig. 4A, embracing the familiar figures of 5000, 2500, 1250, 625, and so on, one may be fairly sure that the transformer is intended to be used on constant-voltage systems. The corresponding equivalent power rating of these taps may then be determined from $P = 5000/Z$.

Uses and Misuses of the System

The great advantage of the constant-voltage sound-distribution system is that it eliminates the purely electrical design problems of multiple speaker mesh network impedances for the sound-system installer. This leaves the sound man free to concentrate on providing specified audio power as required by the ambient conditions. A second, but very important aspect of the constant-voltage system for the distribution of audio power is the saving of that expensive commodity—audio power. When using 70-volt transformers for power tapping, the only losses in the system are line and transformer losses. However, when using an attenuation system of line-level control, power is wasted in the various resistive elements that go to make up the pads. In an extensive sound distribution system where there may be as many as thirty or forty speakers with attenuator-type controls, considerable audio power would be thrown away in the form of heat rather than made available as useful reserve power.

While it is true that the sound man may hook loudspeakers indiscriminately across the constant-voltage line (using the proper transformers, of course), he is nevertheless *limited by the total audio power available to him*. He may tie on as many loudspeakers as he pleases just as long as the wattages he has selected for each do not add up to more than the power rating of the amplifier.

If one throws too many speakers across the line, the amplifier is loaded down too much, the constant-voltage characteristic begins to droop, and the over-all sound level goes down. When this happens, usually someone turns up the gain of the amplifier in an effort to return the sound level to normal. But what actually happens is not more output but more distortion from an already overdriven or overloaded amplifier. This makes the amplification system sound even worse, and eventually, it may also cause the output tubes, rectifier, as well as associated components to fail.

Amplifier Considerations

It is not possible to take any amplifier and simply load it down with constant-voltage transformer-loudspeaker combinations unless the amplifier is designed for such operation. Such a condition can be obtained only in amplifiers with heavy over-all negative feedback and with as low an internal impedance (at the output terminals) as possible.

An amplifier, like any power generator, has some degree of internal resistance. A flow of electrical current cannot be obtained without that flow, of necessity, traveling through the generator itself (Fig. 5). In traveling through the generator, the current must travel through the internal resistance of the generator itself. There will be a voltage drop across the internal resistance equivalent to IR_{int} which will drop the generator's terminal voltage. As the load demands more current, the higher will be the voltage drop across the generator internal resistance and the lower will be the terminal voltage across the load. Thus we see that if we want the terminal voltage to remain as constant as possible, then the amplifier

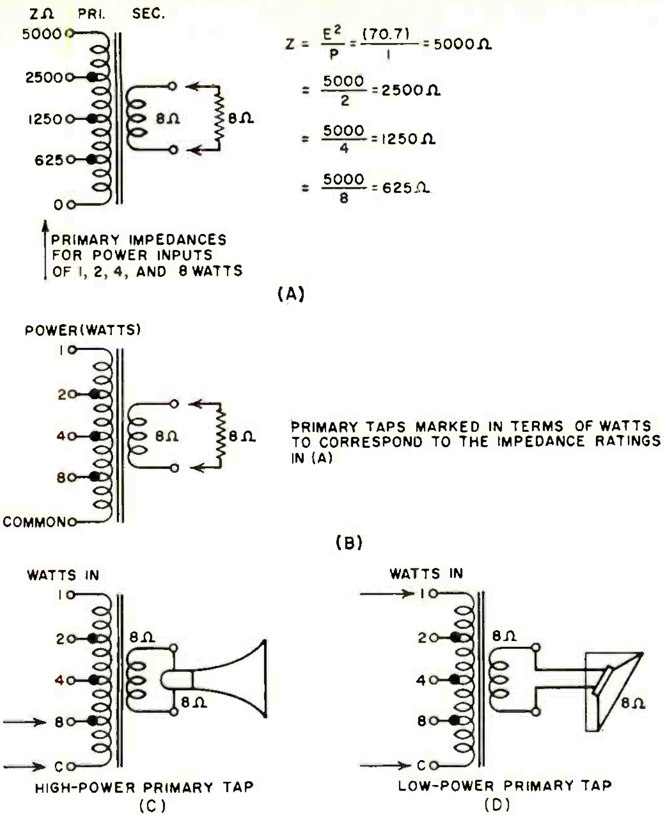


Fig. 4. Correspondence between impedances and power ratings.

(generator) should have the lowest possible internal impedance since this will keep the internal voltage drop correspondingly low.

The ideal constant-voltage generator or amplifier should have zero internal impedance. This condition is, of course, physically unrealizable. But, with the help of properly designed feedback systems, the internal resistance can be kept low enough so that the unloaded voltage rises no more than 3 db over the fully loaded voltage. Such an amplifier, having a loaded output voltage of 70 volts and an unloaded output of no more than 100 volts, falls within the amplifier characteristics outlined by the National Electrical Code at the beginning of this article.

Setting the gain of the constant-voltage amplifier has sometimes been not too well understood. The gain of the amplifier, once set properly, should be left alone irrespective of the load power it is called upon to deliver. *The amplifier gain is set so that, when the amplifier is driven by a predetermined input, such as one volt, then it will deliver its full undistorted power to its load.*

As an example, suppose the amplifier is rated at 50 watts and it is to deliver 70.7 volts to the distribution line. Then the full-load impedance should be $Z = E^2/P = 5000/50 = 100$ ohms. With a 100-ohm resistor rated at a minimum of 50 watts across the output of the amplifier and with the amplifier fed a constant frequency signal such as 1 kc. at an amplitude of one volt, the gain should be adjusted so that an output voltmeter across the load resistor reads 70.7 volts. When this is accomplished, the gain control of the amplifier should be locked down and left untouched.

A question may arise as to why the amplifier is adjusted to deliver a full 50 watts when all that is necessary for a particular coverage is, say, 20 watts. The answer is quite straightforward. The amplifier delivers only what it is asked to deliver by the load it sees. If the speaker transformer primary is tapped for only 1 watt, and that is the only load on the system, then the amplifier will deliver only 1 watt, even though the gain control is set for the potential delivery of 50 watts. The amplifier is standing ready to deliver power only as called for by the load, up to the limiting capacity of the amplifier that is used.

Transformers with Tapped Secondaries

The usual constant-voltage transformer has, in addition to its primary tapped in terms of power, a secondary with several impedance taps, such as 4, 8, 16, or 45 ohms. Obviously this permits a wide variety of loudspeakers of different impedances to be integrated into one system. This allows a hookup such as that shown in Fig. 6. Here an 8-ohm cone speaker is tied on to the 8-ohm secondary tap of the transformer with the primary set at, say, ½-watt input. At the same time a 16-ohm outdoor trumpet is connected to the 16-ohm secondary of its own transformer with the primary tapped for perhaps 8 watts. In a case like this, the great simplicity of the constant-voltage distribution system shines forth.

Suppose we were to try to lay out this system on an over-all impedance basis. Whether you try to arrange the two speakers in parallel, which would result in a combined impedance close to 5 ohms, or in series with a combined impedance of 24 ohms, where do you find a transformer with these output impedances? But, more important, if we set the gain control of the amplifier so that 8 watts is delivered to the 16-ohm trumpet, then (assuming the 8-ohm speaker is in parallel with it), the 8-ohm unit would draw twice as much power as the 16-ohm unit, or about 16 watts, when all we want in this unit is ½ watt. Obviously, then, we have to put some type of volume control unit ahead of the 8-ohm speaker to soak up and waste, as heat, several watts of precious audio power.

Still another advantage of the transformer with a multi-impedance secondary is that small branch circuits or groups of similar loudspeakers can all be fed from one transformer. As shown in Fig. 6B, if a given distributed sound layout is

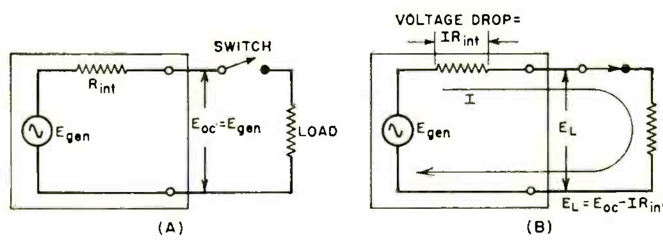
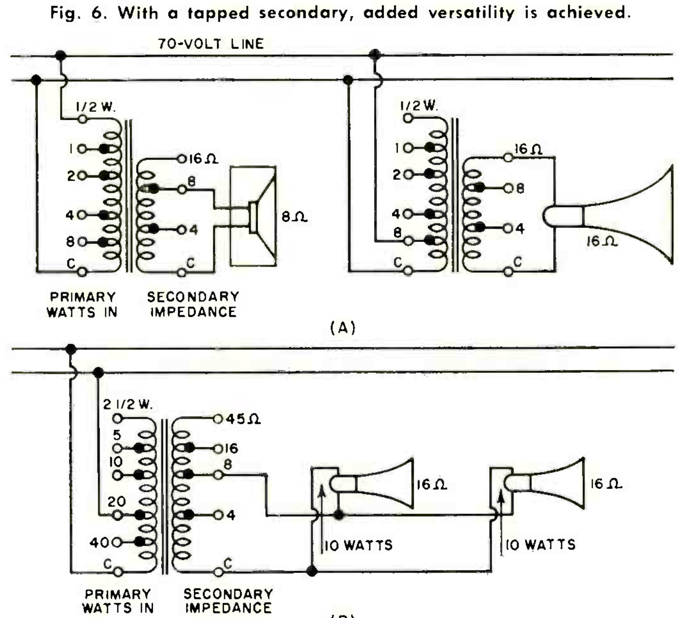


Fig. 5. The internal resistance of a generator develops a voltage drop that reduces the terminal voltage when current is delivered to the load. Constant-voltage generators must have the lowest possible amount of internal resistance.

Fig. 6. With a tapped secondary, added versatility is achieved.



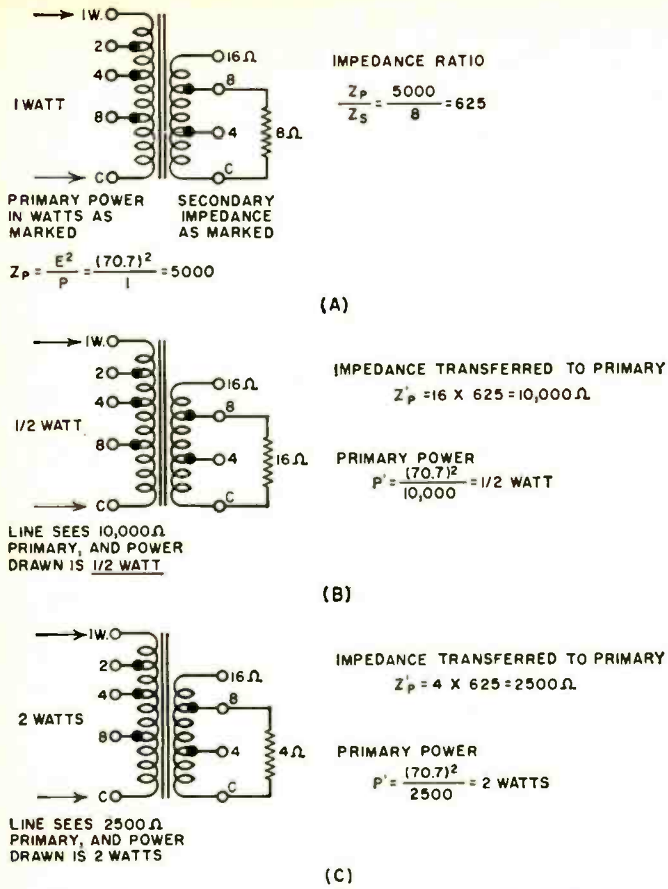


Fig. 7. Effect on power drawn of changing the value of the load.

specified where one has to use two 16-ohm trumpets, they may be connected in parallel across one transformer using the 8-ohm secondary tap. Now if it is required that each speaker deliver 10 watts, then the 20-watt primary tap would be used. This, then, would draw 20 watts from the amplifier to be distributed equally between the two units. If, however, the speakers in one small group are not of the same impedance, or are not expected to draw equal power, then give each speaker its own power matching transformer.

Transformer Versatility

Let us see how much more versatile the multi-impedance transformer may be beyond those ratings shown on the transformer itself. Despite the actual markings on the secondary, we can arbitrarily give them any rating we want. This is provided that, if we change the "specs" on one side to suit our purpose, we change the other side accordingly, and that we do not exceed the maximum power rating of the transformer. Refer to Fig. 7.

When the 8-ohm secondary is loaded with 8 ohms and the primary is tapped for 1 watt, then the primary impedance is $Z = E^2/P = 5000/1 = 5000$ ohms. The impedance ratio of the transformer for the condition given is $5000/8 = 625$. Now let us forget that the secondary is marked 8 ohms or that the transformer tap is marked 1 watt. What we will simply deal with is the fact that between these two windings we have an impedance step-up from load to source of 625. With this in mind, let's hook a 16-ohm speaker load across the 8-ohm tap on the secondary winding. All that the transformer now knows is that it is loaded down by 16 ohms and that it must transform this upwards by a factor of 625. Thus the primary tap will now look like $625 \times 16 = 10{,}000$ ohms to the amplifier. Now the 70.7-volt line from the amplifier will be loaded down not by 5000 ohms but by 10,000 ohms, and the power drawn from the line will now be $P = E^2/Z = 5000/10{,}000 = ½$ watt. We see then that *doubling* the impedance of the load will cause only *half* of the specified primary tap power to be delivered to the loudspeaker load.

Going in the other direction, if we connect a 4-ohm load across the 8-ohm secondary tap, we will end up with a primary impedance of $Z = 625 \times 4 = 2500$ ohms. Accordingly, the power drawn from the amplifier will be $P = E^2/Z = 5000/2500 = 2$ watts. In this case, the load impedance has been halved and the input power to the transformer primary tap marked "1 watt" has been raised to 2 watts.

From the foregoing, we may generalize as follows: *If the load presented to the secondary is K times the impedance specified for the tap to which the load is connected, then the power drawn by the primary will be 1/K of the power indicated by the tap to which the line is connected.* This formulation is summarized in the table of Fig. 8.

Other Voltages

In addition to the popular 70.7-volt system, there is also a 25-volt system and a 141-volt system. The 25-volt system is sometimes used in schools and institutions where a maximum of safeguards against hazardous conditions is required. On the other hand, for lines extending over long distances, the 141-volt system may be used. With such higher line voltage, line currents for a given power will be reduced for quite a saving in copper in the initial installation, and in power losses in the line during actual operation.

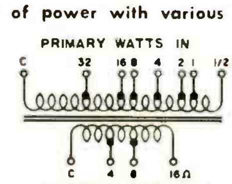
However, for audio-distribution work, the 70.7-volt system is by far the most common. It permits an economically installed system since for this voltage level conduit runs are not required by the National Electrical Code. For some permanent installations, however, neatly installed conduit would certainly be more professional and more desirable.

The same general basic considerations concerning load impedances and input power hold for all three systems mentioned, namely:

For the 25-volt system, $P = E^2/Z = 25^2/Z = 625/Z$
For the 70-volt system, $P = 70.7^2/Z = 5000/Z$
For the 141-volt system, $P = 141^2/Z = 20{,}000/Z$

And similarly, the same K and $1/K$ factors hold for the three systems. ▲

Fig. 8. Tabulation of power with various output connections.



Ⓐ Ⓑ Ⓒ

Ⓐ	Ⓑ AND POWER TAP USED IS →	1/2 W	1	2	4	8	16	32
WHEN 4Ω LOAD IS CONNECTED TO	4Ω TAP	1/2 W.	1	2	4	8	16	32
	8Ω TAP	1	2	4	8	16	32	
	16Ω TAP	2	4	8	16	32		
WHEN 8Ω LOAD IS CONNECTED TO	4Ω TAP	1/4 W.	1/2	1	2	4	8	16
	8Ω TAP	1/2	1	2	4	8	16	32
	16Ω TAP	1	2	4	8	16	32	
WHEN 16Ω LOAD IS CONNECTED TO	4Ω TAP	1/8 W.	1/4	1/2	1	2	4	8
	8Ω TAP	1/4	1/2	1	2	4	8	16
	16Ω TAP	1/2	1	2	4	8	16	32

Ⓒ THEN THIS IS RESULTANT POWER DELIVERED TO LOAD

WHEN $\frac{\text{LOADING IMPEDANCE}}{\text{SECONDARY SPECIFIED IMPEDANCE}}$ = "K"

THEN - POWER DELIVERED TO LOAD IS "$\frac{1}{K}$" OF POWER SPECIFIED BY PRIMARY TAP USED

Upgrade from CB to Business Radio

By LEO G. SANDS, Hammarlund Mfg. Co.

Some advantages include greater coverage and reduced interference. Comparison is made between such services.

AFTER learning first hand about the convenience of two-way radio, many Citizens Banders would like to operate on less congested channels and to have greater range. Those who are engaged in commercial enterprises and who need mobile communications for business purposes are eligible for licenses in the Business Radio Service. More than 160 channels in the 25-50 mc. low band, 152-174 mc. high band, and the 460-470 mc. u.h.f. band are available to Business Radio licensees. Citizens Band radiotelephone users, on the other hand, have only 23 channels in the low band and 49 channels in the u.h.f. band.

While the class D Citizens Bander can operate on any of the 23 channels in the low band, the Business Radio licensee is assigned just one channel in one of the bands. A second channel will be granted when there is adequate justification. However, a single Business Radio channel may be far more useful than one of any of the 23 more congested CB low-band channels.

The CB licensee can talk with other CB stations, but the Business Radio licensee must confine his communications to the stations covered by the same station license. Personal and ham-type communications are not permitted.

Cost of Equipment

Until recently, the cost of equipment for use in the Business Radio Service was prohibitive to many who would like to upgrade themselves from the class D Citizens Band. But now there are several sets on the market priced under $400, and one under $200. You can spend more than $800 for a transistorized mobile unit, but it may not "talk" any farther than a tube-type set. Transistor sets, on the other hand, generally draw less battery current in standby, which is important if the set is to be left on for long periods with the vehicle's engine shut off or idling slowly.

The lowest priced Business Radio on the market (under $200) employs AM and is rated at 10-watts input. This set, operable on channels in the 25-50 mc. band, is claimed to be able to cover areas ranging from 400 to 1600 square miles, depending upon local terrain conditions.

Priced higher, but well under $400, is another unit which is available in low-band and high-band types, rated at 35-watt and 50-watt outputs respectively. These sets, which employ FM, are compatible with all other makes of FM sets and can be used in existing FM systems and mixed with other brands.

Power & Range

Power input on Business Radio channels may be as high as 500 or 600 watts on some frequencies, 180 watts on many, and 3 watts on the few low-power channels reserved for short-range use. If you install low-power Business Radio equipment, you can add a booster power amplifier on many of the channels.

If you require extended communication range, such as an entire county, you should consider the low band (25-50 mc.). However, you will encounter more ignition noise, particularly if you use AM, than in the high band (152-174 mc.) where ignition noise is seldom a significant problem.

For coverage of fairly large cities with only a single base station, the high band is recommended. Because of reflection of the v.h.f. signals, you will often be able to communicate with mobiles when they are being operated in underpasses, on bridges, or even when they are in some tunnels.

The u.h.f. band has many advantages which are not well known. There is virtually no noise problem and reflection characteristics are better than in the high band.

Communicating range in the u.h.f. band is generally about two-thirds that obtainable in the high band under the same conditions. But, this is not necessarily so. In Baltimore, a taxicab company reported better coverage at u.h.f. than at v.h.f., particularly in shielded areas. A base station with an indoor antenna and located on the eighth floor of an office building, was able to communicate with a mobile unit 22 miles away across flat terrain, occupied most of the way by apartment and office buildings.

Excellent communications can be expected in any of the three bands if an adequate base station antenna system is provided. Base-station antenna height is not restricted as it is for class D CB stations. The antenna may be mounted at any height provided the structure is not a potential hazard to aircraft.

Since a class D CB station cannot legally be controlled from a remote point and because antenna height is limited to 20 feet above the ground or existing structure, range is limited. But a Business Radio station can be installed at a high location and can be remotely controlled. Hence, the base station and control point can be miles apart.

The cost of the base station can vary from under $400 for a 35-watt desk mount type plus less than $100 for the antenna system, to more than $2500 for a 250-watt station including a high-gain antenna that quadruples the effective radiated power.

The cost of mobile equipment for the low band and high band is comparable. Several makes on the market are priced at less than $400. The u.h.f. equipment, however, is more expensive, starting at around $550 for a 10-watt FM unit to $800 or more for a higher powered set.

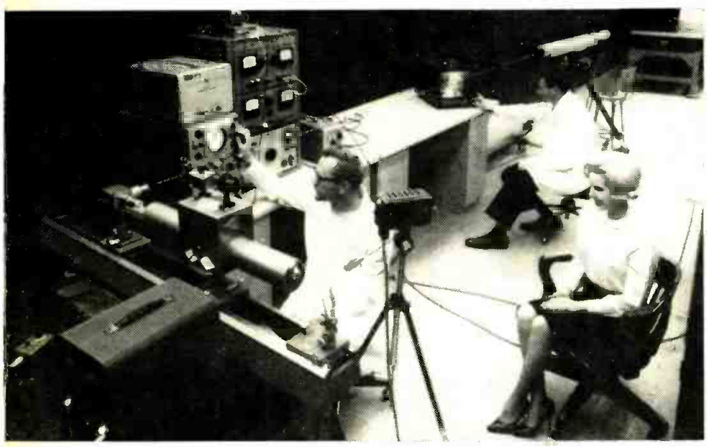
Incidentally, all equipment in the Business Radio Service must be approved by the FCC as meeting certain technical requirements. No home-built or kit-type equipment may be used.

While it will cost approximately twice or more as much for equipment for use in one of the three Business bands as for top-grade CB equipment, greater communicating range and much less interference from other stations can be expected. ▲

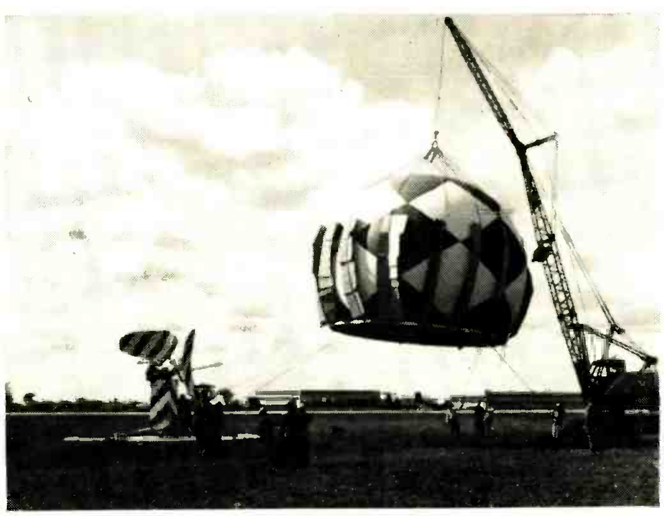
Table 1. Comparison between Citizens Band and Business Radio.

	CLASS D CB	BUSINESS RADIO
Bands	26.96-27.26 mc.	25-50 mc. (approx) 152-174 mc. (approx) 460-470 mc. (approx)
Modulation	AM only	AM or FM
Maximum Power (input)	5 watts	600 watts
Maximum Antenna Height	20 feet	Any height
Remote Control	No	Yes
Personal Communications	Yes	No
Business Communications	Yes	Yes
Home-built or Kit	Yes	No
Operator's License	No	No
Station License	Yes	Yes
Price Range (mobile)	$40-$350	$200-$800
(base)	$40-$350	$200-$2500

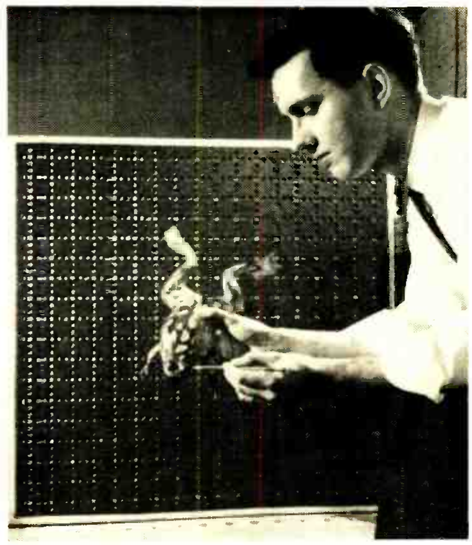
RECENT DEVELOPMENTS in ELECTRONICS

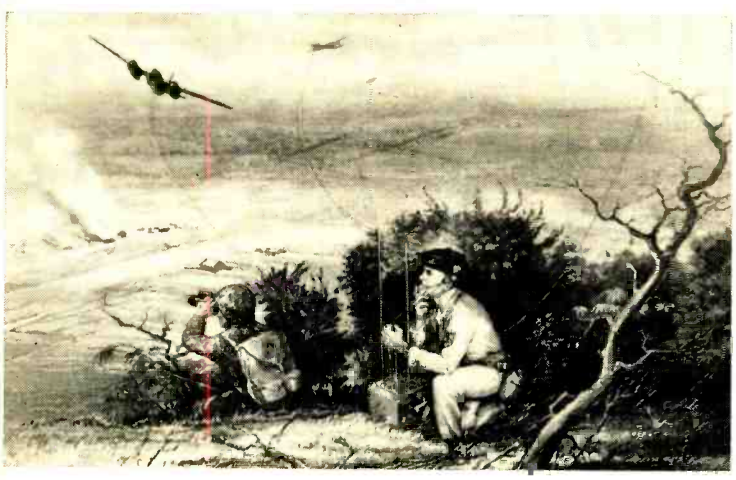


TV Via Laser Beam. (Above) A continuous beam of light, generated by a helium-neon gas laser and directed into a hand-size optical modulator at the left, carries a television image in a demonstration by North American Aviation. The light is directed into the telescope-like optical receiver at the rear right where it strikes a photocell, is converted into the original TV signals, and applied to a picture tube in the monitor. This system has been demonstrated over a distance of five miles. The same operating principles could be used for a space communications system. . . . **Portable TV Tape Recorder.** (Above right) No larger than a suitcase, the new transistorized Precision Instrument portable tape machine records all the sight and sound of television. The unit weighs 68 pounds and can record 96 minutes of video on a single reel of 1-inch tape at a speed of 7½ ips. The tape recorder, designed mainly for closed-circuit TV users, places the video signal on the tape by means of a helical-scan method using 180° tape wrap and two video tape heads. . . . **Portable Foam Radome.** (Below right) A 26½-foot radome, made entirely of rigid fire-retardant Hetrofoam polyurethane foam, is swung into place over radar antennas at Air Force base in Canada. The 3½" thick electrically transparent foam panels from which the radome is made provide good weather protection.

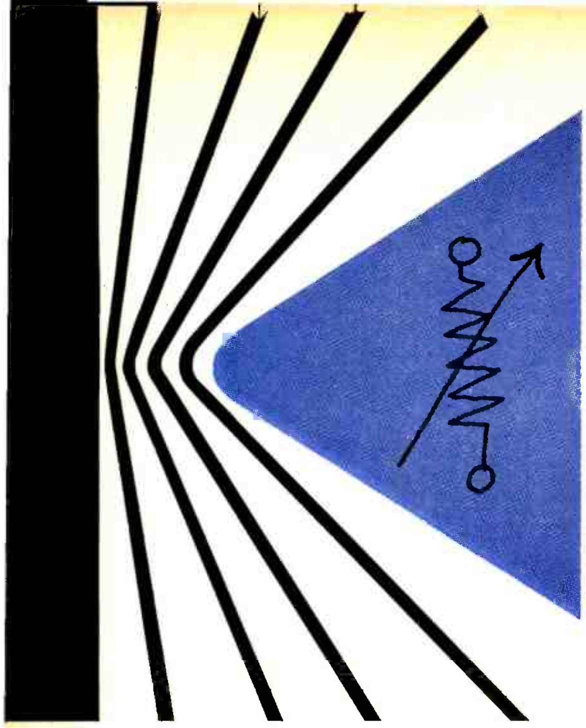


Electronic Frog's Eye. (Right) The 40-inch square, 6-foot long machine in the background doesn't compare in compactness with a frog's eye, but it performs the same functions. Built by RCA for the Air Force, the computer will be used for experiments in automatic pattern recognition. The device uses circuits that simulate living nerves. . . . **New Integrated Circuitry.** (Below) Pilot production of a new form of integrated circuitry has been started by Sylvania. Formed on a small chip of silicon, the circuits are epitaxial planar constructed, and incorporate the equivalent of 22 regular components.





Electronic Golf-Ball Tester. (Above) To electronically test its new golf balls, A. G. Spalding has developed this device, a sort of indoor driving range. The machine propels each ball through a small opening on a simulated 280-yard drive, with the ball traveling nearly 255 feet per second. A high-speed camera with strobes has "stopped" the ball being tested for this photo. The electronic equipment at the top of the unit measures the initial velocity of the balls to insure that they reach but do not exceed the U.S. Golf Association limitation. . . . **Anti-Guerilla Command Set.** (Left) A new parachutist-carried command pack set, which permits anti-guerilla fighters to maintain radio contact with friendly forces, base headquarters, field personnel, and aircraft pilots while operating behind enemy lines, is being field tested by Sylvania. Consisting of 4 separate 2-channel transceivers, the 37-lb. pack replaces about 300 lbs. of equipment previously used for the same job.



SEMICONDUCTOR STRAIN GAGES

By HAROLD S. RENNE

New solid-state transducers that detect and measure movement of beam or rod with far greater sensitivity than previously possible with resistance-wire gages.

SEMICONDUCTOR materials have been invading more and more fields. They are used in transistors, solar batteries, diodes, radiation detectors, and thermometers—and now they have invaded the strain-gage field, in a big way. As we will see later, they add a new dimension to the usefulness of strain gages and introduce orders of magnitude of improvement in their operation.

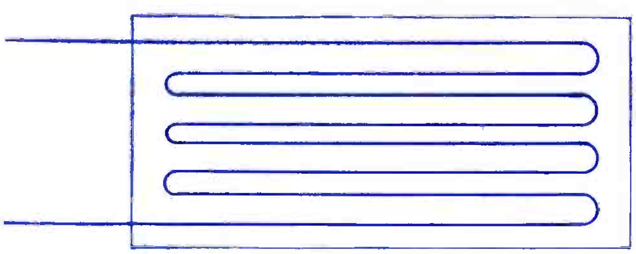
What Is a Strain Gage?

A strain gage is a device for detecting and measuring movement of a beam or rod on which it is mounted. This movement can be the result of tension, compression, bending, twisting, or any other motion that it is desired to measure. A typical application is to determine the amount of load on a beam by measuring how much it bends. With proper calibration, this load can be calculated very precisely.

Conventional strain gages are made of wire or foil. The wire of the gage is looped back and forth to produce the desired resistance, as shown schematically in Fig. 1. The gage is then bonded to the beam under test by means of a special adhesive. If the beam is bent so that the gage is compressed, the resistance decreases, as the cross-section of the wire increases. If the gage is stretched, the cross-section decreases and the resistance increases.

Gages of this type have been employed for years and they are extremely useful. However, there is one disadvantage to such a device. It is not very sensitive, that is, the change in resistance is very small for moderate strains. The sensitivity is usually indicated by a term called the "gage factor," G, which is a measure of the fractional change in resistance with strain. In most commonly used wire gages, a gage factor of two to four is obtained. The equation for the gage factor may be expressed as follows: $G = \Delta R/RS$ where ΔR is the change in resistance, R is the original resistance, and S is the strain (which is also referred to as the change in the length per unit of length).

Fig. 1. Wire in a strain gage is looped back and forth in order to produce desired resistance change when it is bent.



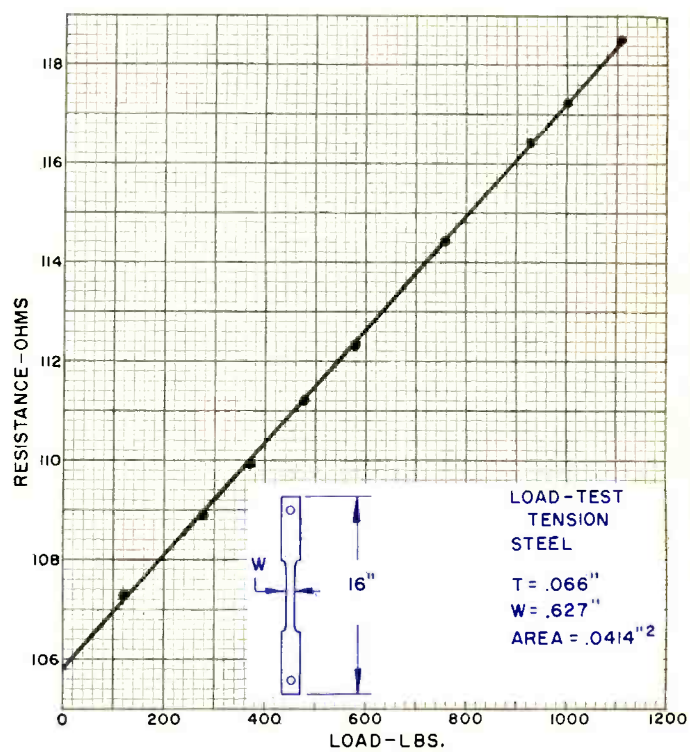


Fig. 2. Resistance-load characteristics of gage mounted on steel.

Early Work with Semiconductors

A few years back, scientists at *Bell Telephone Laboratories* began a study of the piezoresistive properties of semiconductor materials. The term "piezoresistive" refers to a change in resistance with mechanical deformation. They found that bars of silicon and germanium exhibited changes in resistance far greater than other materials when mechanically deformed by compression or tension. This led to further exploratory work on these materials to determine their suit-ability for strain gages. Results were extremely favorable.

Early experiments showed that strain gages fabricated of properly doped semiconductor materials could have gage factors as large as 150 to 200, nearly two orders of magnitude greater than wire gages. This work at *Bell Labs* led to the development of commercial semiconductor strain gages by a number of manufacturers.

Both silicon and germanium have proved to be useful materials for strain gages. In general, silicon has a somewhat higher gage factor and can be used at a much higher temperature than germanium, and so is used most widely. Doping can be either *p*-type or *n*-type, and can be either heavy or light, depending on the desired characteristics. Heavy doping reduces the resistance and alters the sensitivity somewhat.

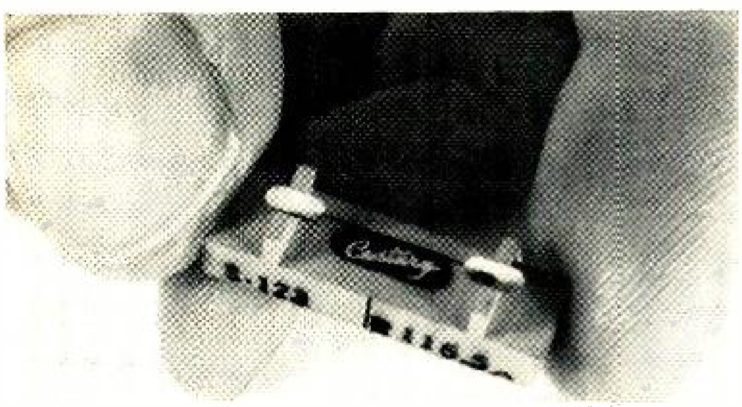
Semiconductor Gage Characteristics

Semiconductor strain gages are usually designed to have the same resistance as standard wire gages, such as the *Baldwin-Lima-Hamilton* SR-4. Standard resistances are 50, 120, and 300 ohms, but much higher resistance units can be fabricated if desired. The gage is usually made in the form of a bar or strip cut from a properly doped single crystal. The bar or strip must be oriented properly with respect to the crystalline structure of the single crystal, as the piezoresistive properties are maximum for only certain directions. Units having the same dimensions can be made with resistances from a few ohms to several megohms by adjusting the doping during crystal growth. Leads must be attached carefully to avoid the formation of rectifying junctions.

Semiconductor strain gages, particularly those made of silicon, have other desirable properties besides high sensitivity. They exhibit very low hysteresis loss. This means that their characteristics are highly reproducible whether a particular point is reached by increasing the strain from a low value, or decreasing it from a high value. The material is quite rugged when properly prepared and is very elastic. Hence, it can be deformed to quite a degree and will return to its original state when the deforming forces are removed without acquiring any permanent "set." The frequency response is very high, on the order of kilomegacycles, and in general is limited by the external circuitry. There is one disadvantage, however. Both the gage factor and the actual resistance are extremely temperature-sensitive, but there are several ways of compensating for this effect.

Great care must be exercised in bonding semiconductor strain gages to the surface on which they are mounted so that there is no slippage or creep. A number of cements are satisfactory if used according to directions. Some require curing at elevated temperatures which may introduce a permanent compression or stretching because of the unequal coefficients of expansion of the gage material and the surface on which it is mounted. This permanent "set" can be used to advantage in some applications. Typical cements that are used

Fig. 3. Typical commercial silicon strain gage in its holder.



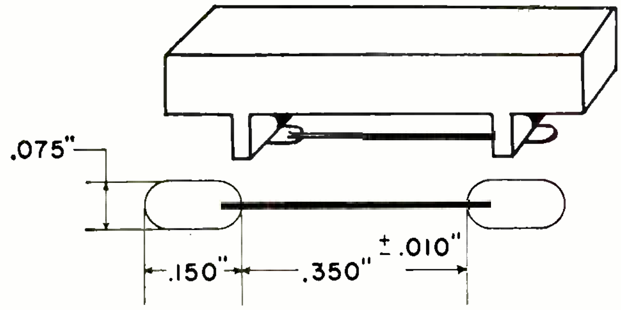


Fig. 4. Dimensions of the strain gage that is shown in Fig. 3.

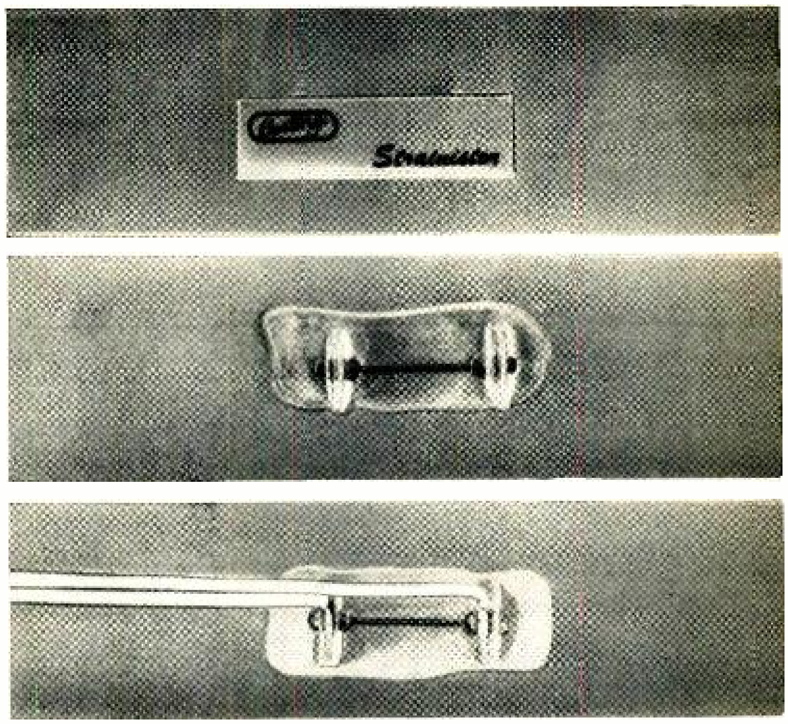


Fig. 5. (A) Gage is first forced by its holder into adhesive on prepared surface. (B) Holder is removed. (C) The leads are attached. Unit is ready for use as soon as adhesive has cured.

include *Eastman* 910, *EPY*-150, *Mithra* #200, and others.

Linearity of silicon strain gages is very good—particularly for the lower-resistance units. A typical curve is shown in Fig. 2, which is a plot of the load in pounds on a steel bar *vs* the resistance of a *Century Electronics'* semiconductor strain gage mounted on the bar.

Commercial Semiconductor Strain Gages

As mentioned previously, semiconductor strain gages are commercially available from a number of companies. A few typical units will be described, but it should be understood that this listing is by no means comprehensive.

Fig. 3 shows a silicon strain gage manufactured by the *Century Electronics Co.* of Tulsa, Oklahoma, and tradenamed the "Strainistor." A dimensional diagram of this unit is shown in Fig. 4. This "Strainistor" can be used at temperatures up to 700°F and at strains of greater than 2000 microinches per inch. The gage factor at 72°F for a 120-ohm unit is from 120 to 140.

The "Strainistor" is supplied on a combination handling and mounting fixture. The series of photos in Fig. 5 shows how the "Strainistor" is mounted on the prepared surface by first embedding it in the cement with which the surface has been coated, then removing the fixture, and finally attaching the leads.

It is possible to use a strain gage to measure pressure. Fig. 6 shows a gage designed for such a purpose. This particular unit can be used with most gases and liquids and is

Fig. 6. Pressure transducer with silicon gage active element.

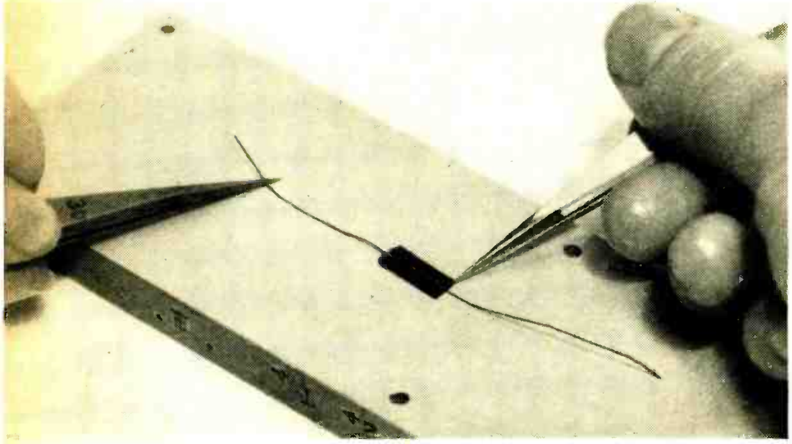


Fig. 7. This silicon strain gage has an active length of 0.18".

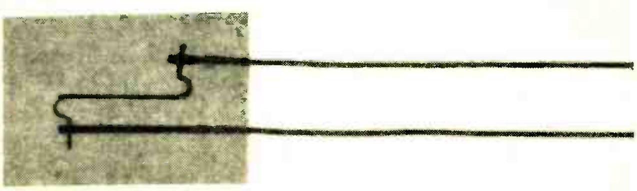


Fig. 8. A different lead configuration is used in this gage.

available in ranges from 25 to 10,000 pounds-per-square-inch. Linearity is very good and hysteresis is negligible. The output is compensated to 3% maximum change over a temperature range of 0°F to 250°F.

The *Baldwin-Lima-Hamilton Company* of Waltham, Mass., a major manufacturer of wire and foil-type gages, also makes a line of silicon gages. These units have an active length of about 0.18 inch, a resistance of 120 or 350 ohms as desired, and a gage factor of 120. Photographs of typical units are shown in Figs. 7 and 8.

Another major manufacturer of semiconductor strain gages is the *Kulite-Bytrex Corp.* of Newton, Mass. The active element in this company's line is a filament of silicon having a cross-section of about 1 by 5 mils and an effective gage length of ¼ inch (dimension *B* of Fig. 9). An interesting sidelight is that units are available with a negative gage factor of as high as 140. This means that the resistance decreases with tension and increases with compression.

Kulite-Bytrex lists a number of interesting applications for its strain-gage transducer systems. Some of these are: the automatic weighing of pipe in a tube mill (Fig. 10), monitoring the weight change of a bedridden patient, control of screw-down pressure on a 5,000,000-pound rolling mill, and measuring the six components of reaction force of a ballistic missile during captive firing.

Measuring Resistance Change

For a strain gage to be useful, it must be teamed with instrumentation capable of measuring the change in resistance that takes place when the gage is undergoing strain. Two methods are in general use: the Wheatstone-bridge technique and the voltage-drop technique.

If a strain gage forms one arm of a Wheatstone bridge, the bridge can be balanced for the initial conditions and then any deflection of the gage, resulting in a change in resistance, will produce an indication on the null detector. This detector can be a meter calibrated directly in units of strain. Such a circuit is shown in Fig. 11. It is interesting to note that one, two, or all four arms of the bridge may be made up of active gages.

If current is passed through a gage, a voltage drop will appear across it. Any change in the resistance of the gage resulting from applied strain will change this voltage drop. By balancing out the original voltage, a voltmeter may be employed to read only the voltage resulting from the change in resistance, and this can be calibrated directly in units of strain. Care must be taken to avoid excessive current through the gage, as it might result in overheating. The manufacturer usually specifies the maximum current—a figure of 30 ma. is fairly typical.

Temperature Compensation

As mentioned previously, the electrical properties of semiconductor materials are extremely sensitive to temperature changes. However, several techniques are available for minimizing or eliminating temperature effects in such gages.

Tiny thermocouples, which can be used to determine the exact temperature at the gage at all times, are available. Then, by means of a calibration chart, the necessary correction for the specific temperature can be determined and the meter reading adjusted accordingly.

In most applications, the temperature coefficient of expansion of the gage is different from the material on which it is mounted. Thus, if the temperature changes during a typical run, this difference in expansion can introduce a considerable error. A very good technique for compensating for this effect is to mount a dummy gage next to the active gage in such a position that it does not undergo strain, but is maintained at the same temperatures as the active gage. The output of this dummy gage can then be used to cancel out the apparent strain due to temperature change.

Another method for temperature compensation is to select two gages with the same temperature (*Continued on page 83*)

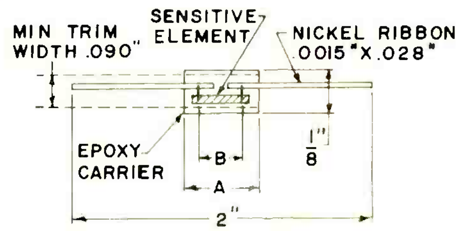
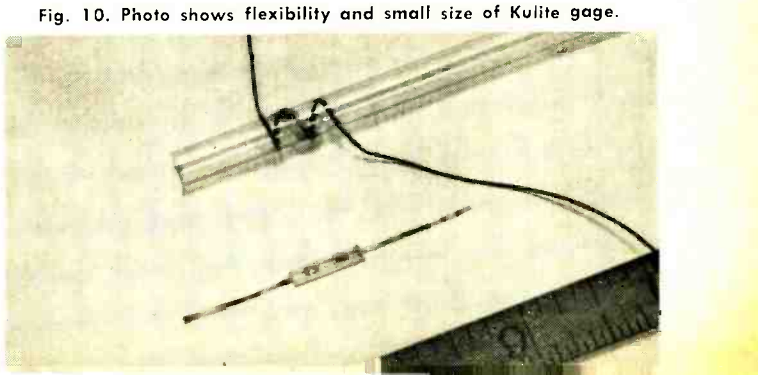
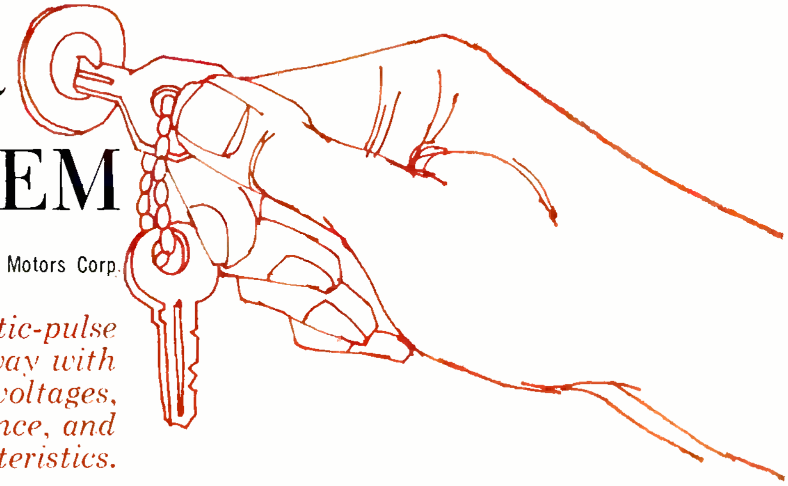


Fig. 9. Dimensions of Kulite-Bytrex silicon strain gages. The dimensions A and B are typically ½ and ¼ inch respectively.

Fig. 10. Photo shows flexibility and small size of Kulite gage.



"DELCOTRONIC" TRANSISTOR IGNITION SYSTEM



By J. C. NORRIS, Exec. Engineer, Delco-Remy Div., General Motors Corp.

A transistor-controlled magnetic-pulse system, used by General Motors, does away with breaker points. Higher spark-plug voltages, freedom from maintenance, and a longer life are its characteristics.

THE *Delco-Remy Division* of *General Motors* has announced and is now producing, a new electronic ignition system that provides higher and more uniform firing voltage at all engine speeds, freedom from periodic maintenance, and a longer, more reliable lifetime. The new ignition system is currently being offered by the *Pontiac Motor Division* as part of an optional electronic package on its 1963 model cars.

An outstanding feature of the new full-transistor system is that the current interruption necessary for ignition is accomplished electronically rather than mechanically. This feature eliminates the familiar contact points and capacitor and with them the necessity for periodic service or replacement due to normal wear and erosion. Timing in the new system is achieved by a voltage pulse generator which consists of an iron pole piece which rotates within a permanent magnet and a winding assembly inside the distributor. The timed pulses from the distributor are passed on to the ignition pulse amplifier which, in turn, controls primary current to the ignition coil.

Contrary to popular belief, ignition systems incorporating transistors are not new. *Delco-Remy* engineers developed workable ignition systems using transistors several years ago. However, reliable transistors suited to ignition circuitry have just recently become commercially available.

Contact-Triggered Transistor System

First, we will discuss briefly a contact-triggered transistorized ignition system. This is the simplest transistor system possible since it retains the distributor "points" for timing the ignition pulse. Fig. 1 compares this simple transistorized system with a standard 12-volt system. Here, the transistor is in series with the ignition coil primary and controlled by contacts in the distributor.

When the contacts are closed, electron current can flow from the transistor base (B) to the emitter (E) rendering the transistor conductive; therefore, current will flow through the transistor from collector (C) to emitter and through the coil primary. When the contacts open, the transistor base-to-emitter current is broken, making the transistor non-conductive; thus the coil primary current is broken, causing a high-voltage surge in the coil. Ignition timing is therefore accomplished by the cam and breaker points in the same manner as in today's conventional system.

The major difference between the two systems is the amount of current handled by the contacts. In the standard system the contacts break as much as 4.5 amperes at low speeds; in the transistor circuit the contacts break about 1 ampere or less. Fig. 2 shows a contact-life comparison. On the left, it can be seen that the point life is short if low currents are used. This is explained by the fact that extremely low currents do not keep contacts clean; hence small amounts of contamination may cause trouble and failure. On the right, it can be seen that contacts fail quickly due to dissipation and oxidation when currents exceed 4.5 amperes. Transistor systems can be engineered to operate at current levels which allow maximum point life, while standard systems, for adequate output, must operate near the maximum current compatible with "satisfactory" point life.

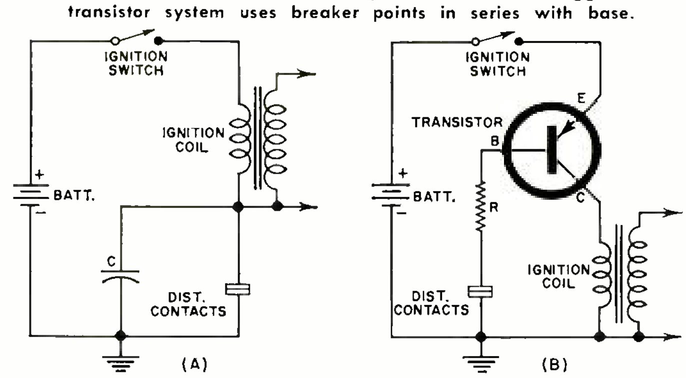
The distributor used with this contact-triggered transistor system would be standard except that the capacitor would be omitted. The transistor control unit would provide a heat sink for the transistor and would house the resistors and other required circuitry. The control unit would have to be mounted away from the engine because germanium transistors frequently are not reliable above approximately 160°F. The coil and separate primary resistor would be tailored to system needs. The advantages of such a system would be: (1) extended point life—points could be left in use at least two times as long as in a standard system, although adjustment would be necessary; (2) higher output; and (3) lowest possible cost for transistor system—simple circuitry using only one transistor.

Because this system leaves unanswered the problem of rubbing block wear (which in itself makes periodic service necessary), and the problem of high-speed lever bounce, *Delco-Remy* has concentrated on the development of a transistor-controlled magnetic pulse-type ignition system.

Magnetic-Pulse Transistor System

In the development of this "Delcotronic" ignition system, the objective was a system that would provide long life, high reliability, and require no periodic maintenance attention for

Fig. 1. (A) Standard 12-volt system. (B) Contact-triggered transistor system uses breaker points in series with base.



the life of the vehicle. In addition, the system was to be sufficiently versatile to be used over a wide variety of vehicle and engine applications.

The end product is a full-transistor ignition system which makes use of a timed voltage pulse from a pulse generator to operate a transistor amplifier; this, in turn, controls the ignition-coil current. The conventional breaker points and capacitor have, of course, been eliminated. System components include: the special distributor, the ignition coil, two external ignition resistors, and, of course, the transistorized amplifier.

A circuit diagram of the system is shown in Fig. 3. Three transistors, three capacitors, a diode, and the associated resistors are housed in the amplifier box. The pulse generator is housed in the distributor. Two resistors and the ignition coil are mounted externally. $Q3$ is the output transistor; $Q2$, the driver; and $Q1$, the trigger transistor. The function of $Q3$ is primarily to control the current through the ignition coil.

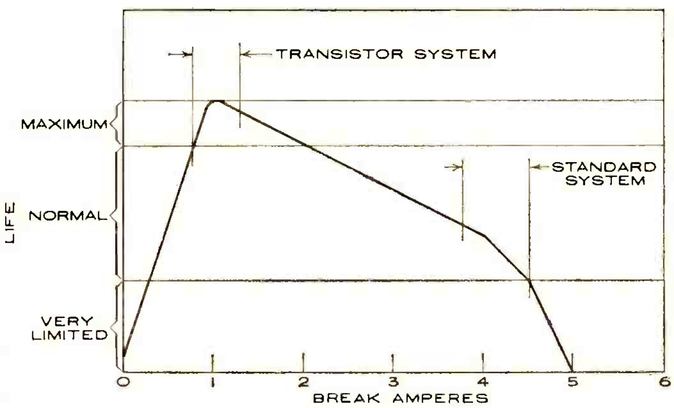


Fig. 2. Contact-point life for standard and transistor systems.

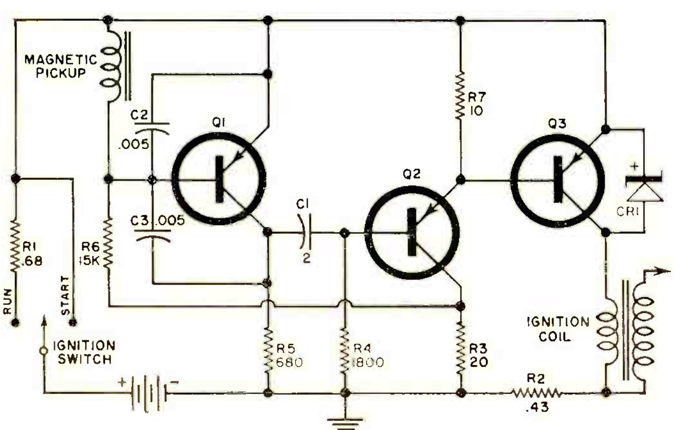


Fig. 3. Circuit diagram of the transistor-controlled, magnetic-pulse-type system. Specially tested semiconductors are used.

The remainder of the circuitry is used to control $Q3$. In order for the system to operate properly, it must do two things: (1) turn the coil current off at the proper time (this is a function of the pulse generator and $Q1$); and (2) turn the current back on again at the proper time (this is the function of the capacitor $C1$ and the resistor $R4$).

Consider first current flow for the system in the "on" condition. The ignition switch is on "run" and the distributor is not generating a pulse. Current flows through the base of $Q2$. This turns $Q2$ on and allows current to flow in the base of $Q3$. This, of course, turns $Q3$ on, allowing current to flow through the primary of the ignition coil. At the same time this is taking place, capacitor $C1$ assumes a charge, positive on the right and negative on the left. Note that there is no current flow in the $Q1$ portion of the circuit at this time. By turning the distributor further a pulse is generated in the pickup coil, positive on the top and negative on the bottom. This applies a forward bias to $Q1$ and turns $Q1$ on.

When $Q1$ becomes conductive, capacitor $C1$ is then connected from the base of $Q2$ to the emitter of $Q2$. With a charge on the capacitor, the base of $Q2$ is now more positive than the emitter. This polarity applies reverse bias to $Q2$ and turns it off, thus interrupting the base current for $Q3$ and turning $Q3$ off. Turning $Q3$ off interrupts the coil primary current which, in turn, causes the magnetic field to collapse in the ignition coil, and the coil to send a high-voltage surge to the spark plug. This series of events can be compared with the points-opening sequence on a standard system. The charge on capacitor $C1$ will hold $Q2$ off until it is bled to ground through $R4$. $Q2$ will then again become conductive and allow $Q3$ to return to the on state, after which current will again flow through the ignition coil. As $Q2$ becomes conductive, the voltage rise feedback through $R6$ will then turn off $Q1$ and the system is now ready for the next pulse. This completes a description of one cycle of operation, yet no mention has been made of the zener diode $CR1$ or capacitors $C2$ and $C3$. These are protective devices and have no bearing on the operation of the circuit as such.

The zener diode is used to clip any voltage pulse which would exceed the voltage rating of the output transistor $Q3$. If it were not for the zener diode, the system would have to be designed so that the primary induced voltage would not exceed 120 volts under the most abnormal conditions of operation. This would mean that under normal conditions the output transistor would be operating at two-thirds of its rating. With the zener we can operate normally closer to the rating of the transistor and, when abnormal conditions appear, the zener diode will hold the voltage to a level below the rating of output transistor $Q3$.

Capacitors $C2$ and $C3$ are used merely for transient voltage suppression. They reduce transients generated by the system which would normally exceed the rating of the trigger transistor $Q1$.

In order to make the system adaptable to a wide variety of applications, it was necessary to design a completely waterproof housing for the pulse amplifier. This feature allows the unit to be mounted outside the hot engine compartment without concern for road splash. Concern over mounting position stems from the natural temperature limitation of the germanium transistors involved. For purposes of reliability, this system should not be operated in an environment of more than 160°F. Since underhood temperatures exceed this limit on most applications, the pulse amplifier must be mounted either forward of the radiator or in the passenger compartment of the automobile.

Special Distributor

The housing, vacuum unit, and cap of the distributor are of a design and construction familiar to the automotive industry. The circuit-breaker plate and contact-set assembly has been removed and in its place a magnetic pickup assembly is installed on the center bearing of the housing. A rotating toothed pole piece is mounted on the shaft in place of the conventional breaker cam. Both vacuum and centrifugal advance in this distributor are obtained in the same manner as in the standard battery ignition system.

A ceramic ring-type magnet is located under a stationary toothed pole piece. A nylon spool with a coil wound on it is also part of the assembly. Both pole pieces contain a tooth for each cylinder of the engine. The teeth are shaped to give the desired triggering waveform. The teeth on both of these pole pieces must be accurately spaced to prevent significant timing variation from cylinder to cylinder. Once these assemblies are built up and placed in the distributor, there is absolutely no necessity, and no provision, for adjustment of any kind.

The manner in which the triggering pulse is induced into the pickup coil is illustrated in Fig. 4. When the distributor shaft is in a position such that the teeth on the rotating pole piece are lined up with those on the stationary pole piece, a flux path is established as shown in Fig. 4A. This is the minimum air-gap condition. As the shaft is rotated to a point where the teeth on the rotating pole pieces are half way between those on the stationary pole piece, a maximum air-gap condition is established and the flux field collapses, as shown in Fig. 4B. Thus, as the distributor shaft rotates, the magnetic field is made to alternately build up and collapse, thereby inducing a transistor-triggering voltage into the pickup coil.

System Performance

Performance of this system as compared with that of the standard 12-volt system is shown in Fig. 5. The output of the system, it will be noted, is fairly constant throughout the speed range. Such performance is due, in part, to the design of the amplifier circuitry as well as to the design of the coil winding. Note also that the characteristic drop-off of output voltage as speed is increased, which is normal with the standard 12-volt system, is not present with the "Delcotronic" system. The pulse-to-pulse voltage output of this transistor system is more consistent than the standard system, particularly at low speeds where the latter is affected by contact arcing.

Ignition performance during cranking is another basic consideration. To insure starting, adequate voltage must be supplied to fire the spark plug even when cranking under the most adverse conditions. The system meets these requirements well as the break current is high, thus permitting maximum build-up of current through the ignition coil.

Fig. 6 shows the peak current of this system as compared with that of the standard 12-volt system. Here, the current (approximately 7.5 amps) is considerably more than that of the standard system because the contacts are no longer a limiting factor. The average current draw of this system in the idle range is approximately 6.25 amps compared with approximately 2 amps in a standard system.

The principal disadvantages of this system are: (1) higher average current consumption; and (2) higher initial cost due to the addition of semiconductors.

The principal advantages are: (1) The system will yield higher output than a standard system. (This allows spark plugs to operate for longer periods of time.)

(2) The system will operate at extremely high speeds without losing ignition performance. (On test fixtures, it has operated successfully at more than 9000 engine rpm.)

(3) The system is essentially maintenance-free. (Absence of parts subject to rapid deterioration gives top reliability. The system will operate indefinitely at high efficiency without any of the usual tune-up attention.)

Some of the recommended applications for a system of this type are for: (1) high-performance, high-speed engines; (2) heavy-duty truck engines; (3) heavy-duty stationary engines; and (4) future engines.

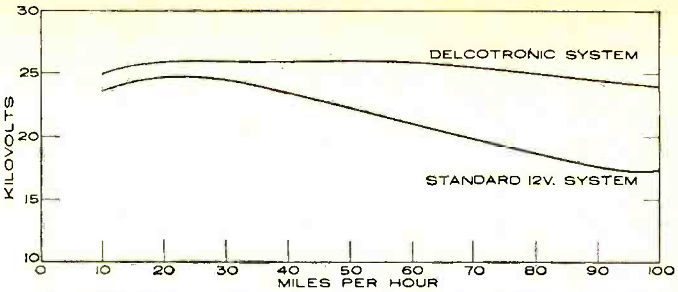


Fig. 5. Spark-plug voltage generated by the two ignition systems.

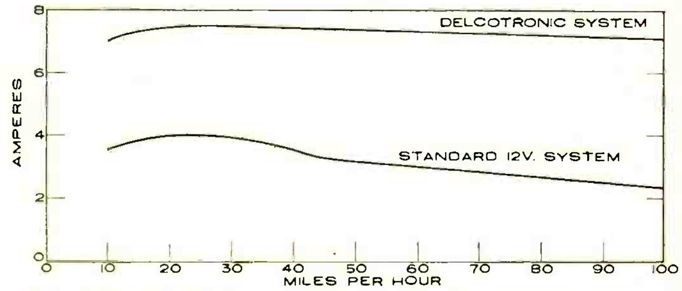


Fig. 6. Note the higher current switched by the transistor system.

Test Program

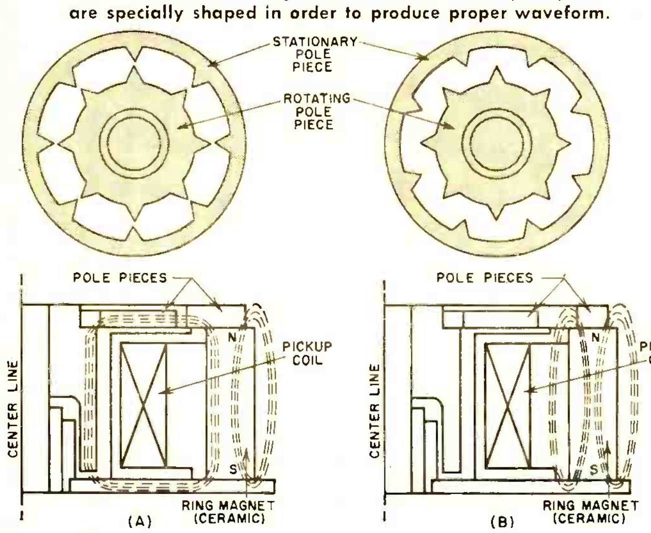
The manufacturer has conducted an extensive test program in an effort to prove the reliability of this system. Over 200 units have been placed on a wide variety of vehicles, and more than 250 units have been operated in the laboratory on various types of endurance testing. Upwards of one million miles and 100,000 hours of testing have been accumulated. An example of long life is: Two systems on bench endurance running an equivalent of 120 mph, have each operated for over 9000 hours.

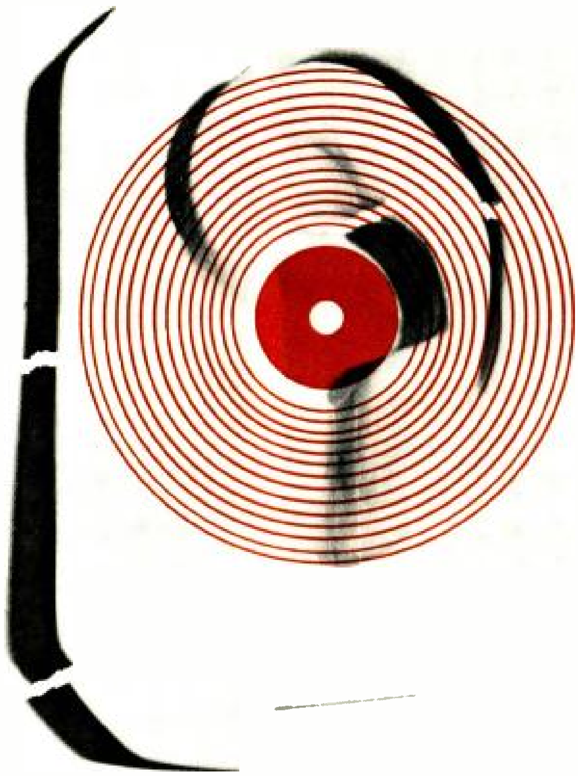
In all types of testing on prototype units, a semiconductor failure rate of less than 0.8% has been experienced. Of this, two-thirds of the failures could be traced directly to improper installation or to error on someone's part. In other words, the natural failure rate experienced has been only 0.25%. In no instance was any periodic service or attention given these units.

Indicated semiconductor reliability is certainly very encouraging. However, it was not accomplished by merely buying shelf-item semiconductors and using them as purchased. As a matter of fact, a major part of the development effort was the formulation and use of certain evaluation techniques for semiconductors. First, we made sure that the semiconductors chosen were compatible with the circuit. Next, we ascertained that the semiconductor characteristics did not tend to shift with time or varied environment. Finally, we established a comprehensive receiving inspection test to assure consistency and dependability.

In conclusion and in summary, the new transistor-controlled magnetic pulse-type ignition system provides the long maintenance-free life and high reliability which have been sought for many years. It accomplishes this end by totally eliminating the components which traditionally have been the most subject to inaccuracy, to unusual wear, and to deterioration. ▲

Fig. 4. (A) Magnetic circuit in distributor for minimum air gap and (B) for maximum air gap. There is one stationary tooth and one rotating tooth for each cylinder of the engine. As the teeth pass each other the magnetic field sweeps across the coil and generates a trigger pulse that is applied to transistor Q1, turning it on. The teeth in the pole pieces are specially shaped in order to produce proper waveform.





MUST STEREO DISCS SOUND BAD?

Growing dissatisfaction with stereo discs may be due to greater tracing distortion and increased vertical tracking error. Means for reducing these effects are suggested, leading to improved stereo.

By DUANE H. COOPER / Dept. of Electrical Engineering, University of Illinois

EVERYBODY knows that stereo sound is a more opulent sound than is monophonic sound. The improvement over mono is so remarkable that low-fidelity (called "high-fidelity," of course) stereo phonographs sell themselves on the crudest listening tests, in preference to mono, practically every time. As is to be expected, prolonged listening at home brings an inevitable disappointment. Can it be that the same disaffection is creeping, however slowly, upon the owners of top-quality component systems? There are reasons to think so.

The fact is that serious listeners are becoming increasingly aware of a stridency in the sound of their stereo records, as more and more letters to the editors of hi-fi magazines testify. The charge is made that the recorded sound has been "doctored" to produce a more brilliant effect on cheap phonos. Some hope, with a certain measure of desperation, that 12-inch, 45-rpm records will restore to stereo the clean sound of the mono LP, while others turn to pressings mastered from 35-mm. magnetic film.

In selecting recordings, broadcast engineers and programmers are finding that FM stereo imposes severe requirements on recorded material. Many listeners will receive only the compatible mono signal. Thus it happens that stereo recordings must meet the test of sounding good when heard in the mono mode, as good as mono recordings sound.

With a good system, it is easy to discover that the stereo recordings that will meet such a test are rather few. One simply switches the stereo system to the mono mode and resolves to leave it that way for a week or so in order to condition the critical faculties to the values of mono sound. During this period, both high-quality mono and stereo discs are to be played, using a variety of labels. Lush orchestral passages, recorded at high level and great separation, are more likely to offend, but small string ensembles can grate as well. Of course, it is scandalous to listen to stereo records in the mono mode when the full stereo system is available. The greater scandal is that, shorn of the sumptuous stereo effect, too few stereo discs will stand comparison with mono recordings.

It is not necessary to conclude that distortion, currently running to dozens of percentage points, is sounding the death knell of the stereo disc, or that tape must displace it. What is necessary is that the sources of distortion be more widely understood, so that preventive measures can be undertaken by the recording industry. The two principal sources of distortion are tracing error and vertical tracking angle error.

Tracing Distortion

Tracing distortion is the more difficult to correct, although audio-design authority Professor F. V. Hunt of Harvard has recently proposed a method of tracing-error compensation. Line *a* of Fig. 1 illustrates an extreme case of tracing error. It depicts a sine wave recorded with such a wavelength and amplitude that the spherical stylus tip just fits in the depressed portion of the groove. No sooner does the tip fit into the depression, than it must pop out again, so that the center of the spherical tip, *c*, traces a curve with sharp turning points. The total harmonic content of such a wave is about 23 per-cent.

The acceleration at the turning points is several thousands of G's, in familiar space-age terminology. With milligram stylus masses, the record material yields (elastically, it is hoped) under the resulting force so that the corners are actually slightly rounded. Otherwise, the accelerations would be infinite.

While the case illustrated is extreme, it can occur if a 2-kc. tone, recorded at 20 cm./sec. (r.m.s.), is played with a 0.7-mil stylus. A definite sharpening of the troughs is noticeable in one of the author's frequency-test records for an 8-kc. tone recorded at 5 cm./sec. When the maximum curvature is one-fifth that needed to make a close fit to the stylus, the harmonic distortion is five per-cent. The same distortion is less severe in mono recordings since the other groove wall carries an exactly complementary signal. The resulting push-pull geometry prevents an asymmetric tracing, so that the dominant second harmonic content cancels out.

Professor Hunt's scheme for tracing compensation calls for an intermediate cutting to be traced by the intended stylus, as in *a* of Fig. 1. The resulting signal is to be used, with reversed polarity, to make a second cutting, as shown at *b*, to serve as the master. Here the groove wall, with its projecting sharpened corners, may be traced as a distortion-free sine wave, as would be the case in the final pressing. Also, the dynamic stylus forces are substantially reduced, with the result that the record material suffers smaller deformations, making for an extended life.

Other means of reducing tracing distortion require (1) a reduced recording level, resulting in sacrifices in dynamic range, or (2) a more sharply pointed stylus, requiring lighter stylus forces, if record life is not to be reduced.

Vertical Tracking Error

The cure for vertical tracking angle error, however, requires only a meeting of minds within the recording industry and among cartridge manufacturers. Distortion arises on this account because the surfaces in which the reproducing stylus and cutter stylus move are not at the same angle from the groove. The disagreement has primarily to do with the vertical. For a long time the *Westrex* cutter, with a "vertical" motion 23 degrees from the true vertical, has established a standard for the industry. However, the RIAA voluntary standard is 15 degrees. The corresponding European standard (IEC) has not yet been set, but 15 degrees has been proposed. Meanwhile, pressings are being made with vertical cutting angles ranging from true vertical (0 degrees), and 8 degrees, to the 23-degree *Westrex* angle, by the various companies.

The cartridge makers are in a similar state of disagreement. One famous cartridge has a vertical tracking angle of 40 degrees, another, equally famous, uses 30 degrees, while yet a third uses 15 degrees.

It is easy to see how the distortion comes about. One simply gets out a table of sines and plots a sine wave, as was done in *a*, Fig. 2. A skew projection of these plotting points is made onto a new axis, line *b* of Fig. 2. The original plotting points are no longer equally spaced along the new axis. They are the basis for the erection of the distorted curve at *c*, using the same values from the sine table, as before. The harmonic content of the distorted wave is about 35 per-cent, for this tracking angle error of about 27 degrees and an r.m.s. velocity about equal to the groove speed.

Harmonic distortion is not the whole story. There is an intermodulation and a crossmodulation of an FM character. The plotting points may be imagined to mark the alternating crests and troughs of a weak high-frequency wave superposed on the one plotted. The varying spacing in these points on the axis of line *b* displays the frequency modulation. In the case plotted, the peak frequency shift is 70 per-cent of its nominal value (50 per-cent, r.m.s.). The r.m.s. phase-modulation index is 4.5 (450 per-cent!). It does not matter whether the plotting points mark the peaks and troughs of the high-frequency wave as recorded in the same channel (intermodulation), or in the other channel (crossmodulation) in the same groove; the modulation is the same, as long as the large-amplitude lower frequency wave is traced askew.

The ear is not insensitive to such modulation. Psychoacoustic experiments have shown that the ear can hear as

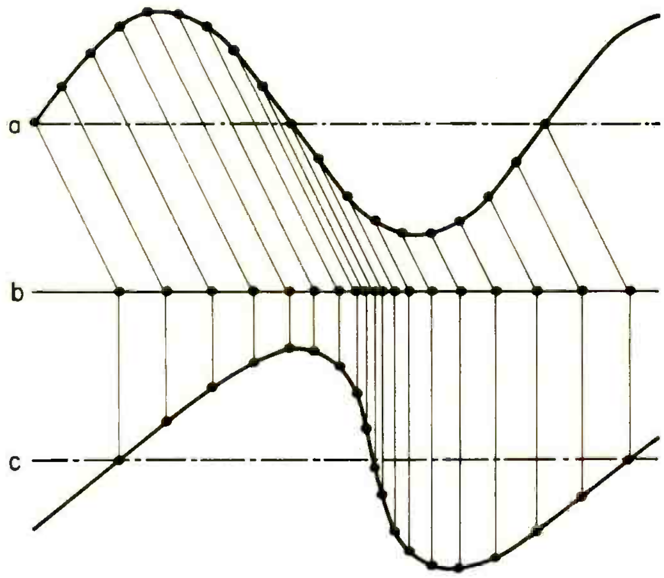


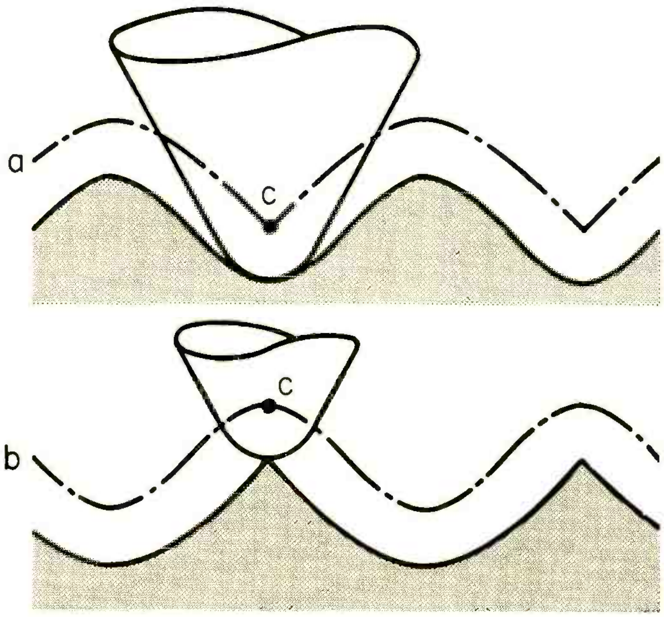
Fig. 2. Construction showing tracking distortion. The plotting points of the sinusoid at "a" are projected by skew lines to "b." These points, whose spacing is now modulated, are the basis for the construction of the distorted wave shown at "c." The angle of the skew lines differs from the vertical by the amount of tracking angle error, shown as about 27 degrees.

little as 0.15 per-cent frequency modulation and, under certain circumstances, as little as 0.015 per-cent. It sounds like ordinary amplitude intermodulation, if the modulating frequency is in the ordinary audio range.

The case plotted is extreme, but much less severe cases can still result in dozens of percentage points of distortion, a distortion plainly evident to the ear. The mono case is not plagued with this amount of distortion. Tonearm designers have long made it a practice to keep lateral tracking errors to only a degree or so. Their efforts are of little help for stereo, however, in the face of the present varying practices for the vertical angle. Also, because of crossmodulation, switching to the mono mode is of no help in reducing the distortion, as long as there is a substantial vertical signal tracked with an incorrect angle.

The day will come, as it must, when the distortion built into stereo records will be as small as in mono recordings, or even as that in our fine amplifiers, speakers, and matching cartridges. On that day, distortion percentages of one or two points will mean something. Until that day comes, we can only say, "You haven't heard anything yet!" ▲

Fig. 1. Generation and remedy for tracing distortion. Line "a" shows a groove wall being traced by a stylus whose spherical tip just fits in the hollows of the recorded sinusoid. The center of the stylus, "c," traces a curve with sharp turning points. At "b" is shown the effect of tracing compensation proposed by Professor Hunt. The tracing from "a" is used to drive a cutter, but with reversed polarity, to form the groove wall at "b." The resultant is then traced without distortion.



UNDERSTANDING COLOR TV DEMODULATORS

With more set makers drawn into the tinted picture, circuit innovation is inevitably under way. Covered here: function, characteristics and adjustment of the latest demodulators.

By WALTER H. BUCHSBAUM
Industrial Consultant, ELECTRONICS WORLD

IT has been said often, and it is true, that most of the circuits in today's color TV receivers are not very different from those found in their black-and-white counterparts. The tuner, i.f., audio, sync, and deflection circuits perform essentially the same functions in both types of sets. Anyone who has come to know what happens inside of a monochrome receiver will have little trouble following the same action in a color design, despite the occasional addition of some refinements. Anyone who has worked on black-and-white defects is well on his way to matching that performance when the same circuits are involved in color.

The great difference involves three special circuit sections. The color tube and its associated driving circuits generate the color display. The color synchronizing and color demodulating sections respond to the special color video information in the composite signal and process it so that it may be used intelligibly.

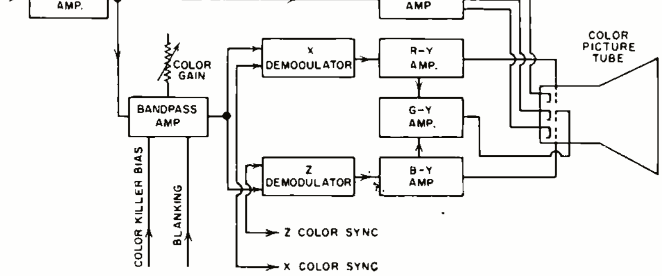
Of the last two sections, we deal with the demodulating systems here. They are of particular interest now because, with color-set sales under way, there is today more than one design in use. The manufacturer's data is still the best guide to detailed alignment instructions for each of them. A comparison of the various circuits, however, and how they work, provides a better insight into each of them. This understanding is particularly helpful when troubles occur, as fault development grows out of the particular design.

Color Demodulator Functions

Color information is recovered from the 3.58-mc. subcarrier in the form of two signals, the *X* and *Z* signals, which are 62.1° apart in phase. To remove these signals from the 3.58-mc. subcarrier, the correct color-synchronizing signal must be available. This sync signal, generated in the color-synchronizing section of the receiver, is locked to the 3.58-mc. sync signal transmitted by the TV station in short bursts with each horizontal-sync pulse.

The *X* and *Z* color signals are recovered from their subcarrier by a process known as synchronous demodulation. It differs from ordinary AM or FM detection in that the sync signal must be present. The process may be compared to observing fast rotation with a stroboscopic light. If the rate of rotation and the rate at which the strobe light goes on and off are in synchronism, the motion will appear to stand still. If a small speed difference exists, this will appear as slow motion. A practical example of this is the observation of flutter in a phonograph drive mechanism with a strobe light. Without the strobe light, the speed of the phono motor is too great to show the flutter. When the strobe light "stops" the rotation, the flutter becomes visible. In the same manner does synchronous demodulation permit the color video information to be separated from the higher frequency 3.58-mc. carrier.

Fig. 1. Despite minor variation from one circuit to another, this general system for color detection is used in most sets.



The *X* and *Z* signals each have a bandwidth of about 1 mc. and contain the elements of the three basic color (or color-difference) signals, Red-*Y*, Green-*Y*, and Blue-*Y*. (The *Y* or brightness signal is the same as the black-and-white video signal, with a bandwidth of about 4 mc.) When the three color-difference signals are properly combined with the *Y* signal, the color-picture information is complete.

The addition of the three color-difference signals to the brightness or *Y* signal is accomplished in the color picture tube by driving each of its three grids with their respective difference signals and simultaneously driving all three cathodes with the *Y* signal. To obtain the three color-difference signals from the 3.58-mc. color subcarrier, three distinct steps are necessary. Fig. 1 illustrates, in block diagram form, how this is done.

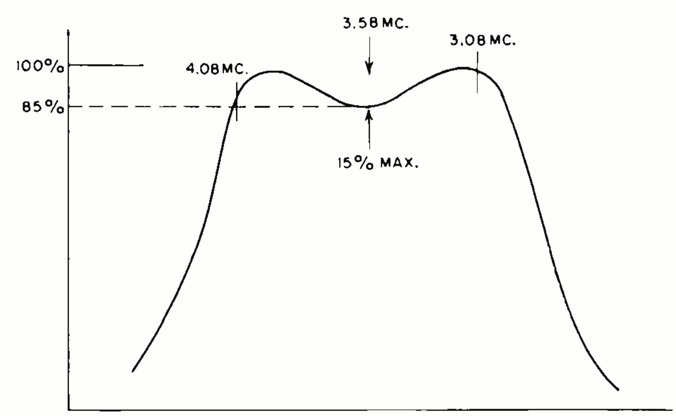


Fig. 2. Normal bandpass-amplifier response for Fig. 3 circuit.

The first step is to amplify the color subcarrier within the bandpass limits required for the *X* and *Z* signals. In the bandpass amplifier, the color (or chroma) gain control regulates the amplitude of the color signals before they are separated. Here the color-killer bias is applied to suppress any signals during monochrome transmissions and horizontal-blanking pulses are also applied to suppress all color signals during the retrace period.

The output of the bandpass amplifier is applied to both the *X* and *Z* demodulators, in the second step. These stages consist generally of one tube each and operate as synchronous detectors. In each the chroma signal is applied to one tube element and the correct color-sync signal to another tube element. At the input of the demodulators, the signals are still encoded on the 3.58-mc. color subcarrier. At the output, the *X* and *Z* signals contain all the color information. *LC* filters remove the 3.58-mc. components.

The third step consists of addition, subtraction, and inversion (in the three amplifiers of Fig. 1) to change the *X*,

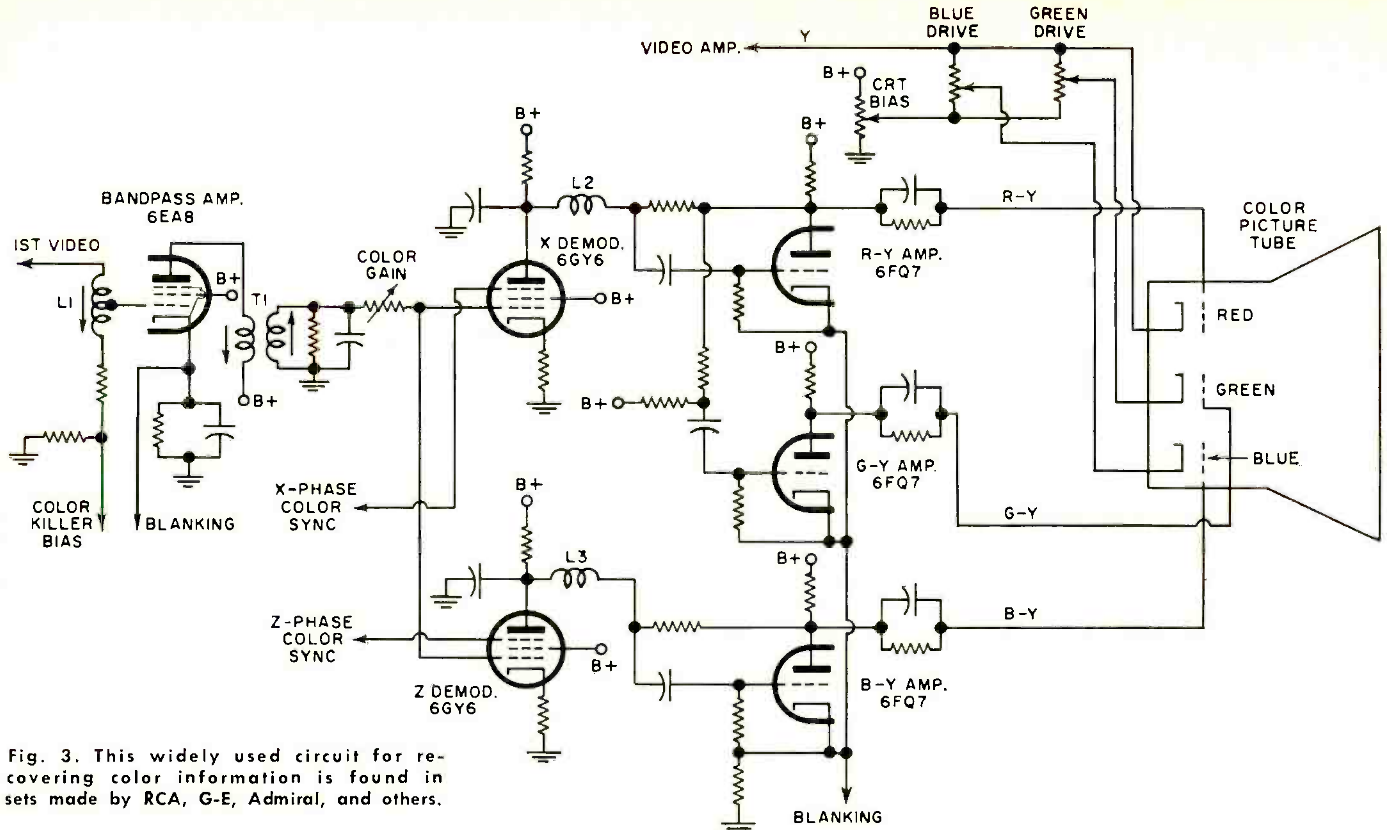


Fig. 3. This widely used circuit for recovering color information is found in sets made by RCA, G-E, Admiral, and others.

and Z signals into the three color-difference signals. Note that the green color-difference signal is made up from elements of the red and blue. Addition is performed by simply combining signals across a resistor and subtraction is accomplished in the same manner, except that one signal is inverted or negative. This is also called matrixing.

The three color-difference signals are applied to their respective picture-tube grids, while the Y signal is added at the cathodes. In the block diagram, the three color-drive controls are shown located in the cathode circuit, but in some sets they set the bias at the grid. In either system, these controls determine the gain of the respective color signal or the dynamic color balance, by varying the cathode-grid bias of each electron gun until they are matched.

While the basic functions outlined in Fig. 1 are accomplished in every type of color TV receiver, the actual circuits differ. Those manufacturers who pattern their circuits after the *RCA* model invariably use separate stages for X and Z demodulators and the color-difference amplifiers. *Zenith* has its own demodulator system, which combines the functions of demodulating and matrixing in two special stages.

Adjustments and Problems

Although there are a number of adjustments involved in these circuits, the simplified presentation in Fig. 1 shows four basic ones. The color-gain control is on the receiver's front panel, for customer operation. It determines the intensity or saturation of the color in the picture, much as the contrast control establishes the black-and-white level. The three separate gain or drive controls for each of the colors to the CRT are secondary adjustments to be set by the technician. They are adjusted with respect to each other, preferably with a color generator, so that the reproduced levels of red, green, and blue signals are correct and matched to each other. The proper reproduction of white on the screen indicates that these controls are balanced properly.

As for finding defects other than misadjustment, a few simple rules can help localize a problem to a particular stage. If no color appears at all when it is being transmitted, the bandpass amplifier is the first object of suspicion. It is also possible that both X and Z color-sync information is missing. Sometimes the bandpass amplifier itself may be sound, but it is prevented from operating because color-killer bias is being incorrectly applied to it even during color transmission. This can be determined by a quick check of killer bias with a v.t.v.m. (A defect in the blanking circuit could also cause the continuous application of the bias, although this is relatively rare.)

If only the X demodulator is defective, the red component will appear to be missing, while the blue will come through and the green will appear off in color. Conversely, if the Z demodulator is defective, neither blue nor green will appear, but red will seem normal. A defect in any of the color-difference amplifiers will appear as loss or distortion of the corresponding color, but note that both the blue and the red, or *B-Y* and *R-Y* stages, have some effect on green. If the second video-amplifier section is defective, the picture will lack detail and the coloring will be wrong with respect to picture content. Of course, if the first video-amplifier section is dead, no picture at all will appear.

Typical Demodulator Circuits

The most widely used demodulator, in all probability, is the one shown in simplified form in Fig. 3. It appears in all new *RCA*, *G-E*, and *Admiral* sets, as well as others. The bandpass amplifier consists of a single stage, with tuned grid and tuned plate to get maximum gain at the 3.58-mc. color subcarrier. Alignment of both tuned circuits is performed with a sweep generator to produce a response curve like that in Fig. 2.

If a generator that can sweep roughly between 3 and 5 mc. with a center frequency of 3.58 mc. is not available, a higher frequency sweep can be used. Signal swept from about 40 mc. to 50 mc. is injected at the i.f. section, to cover the bandwidth of this part of the receiver. A signal at about 45.75 mc., provided by a single-frequency r.f. generator, is also added. When mixed, these signals produce a heterodyne output at the bandpass amplifier that sweeps the desired range. For specific connections, tuning sequence, and bias arrangements, manufacturer's data should be followed.

Note that, in the circuit of Fig. 3, the color-killer bias is applied at the grid of the bandpass amplifier while the blanking signal goes to the cathode. The output of the bandpass amplifier goes to the control grids of the *X* and Z demodulators which are 6GY6 tubes, each having a separate suppressor grid. The color-sync signals, in *X* and Z phase at 3.58-mc., come from the color-sync section and control the gain of each 6GY6 by driving the suppressor grids. At the plate of the *X* demodulator, inverted *R-Y* signal appears; at the Z demodulator plate, inverted *B-Y* is detected.

The *LC* filter at each demodulator plate keeps the 3.58-mc. component from reaching the color-difference amplifiers, which are essentially simple triode amplifiers with a few additional features. All three cathodes are connected together, which automatically supplies a portion of the red and blue signal to the green amplifier. It also permits cutting off all three stages by the horizontal-blanking amplifier. In addition, the *R-Y* and *B-Y* stages contain some plate-to-grid feedback and, in the case of the *R-Y* tube, some of the plate signal is applied to the grid of the *G-Y* tube. This produces the subtraction mentioned earlier. The common cathode connection adds red and blue to the cathode of the green stage, but the signal from the plate of the red stage applied to the grid of the green tube is inverted and therefore subtracted in the green stage. The *RC* network in each difference-amplifier plate circuit is part of a voltage divider to reduce the d.c. applied to the picture-tube grids.

The proper ratio among the three colors is determined by the adjustment of the green and blue drive controls. This is performed on a black-and-white picture to give the proper shade of white because, if the color balance is correct in the absence of color signals, the three electron guns should add to give a good clear white.

A somewhat different version of the demodulator circuit of Fig. 3 is the one shown in Fig. 4. This circuit is used in some *RCA* models and in the *Packard-Bell* color sets. A quick comparison shows that here two stages of bandpass amplification are used. The number of tuning adjustments is the same, however, since tuning of the output transformer for the second stage is fixed. Alignment of the bandpass response is the same as previously described. The color-killer bias and the blanking signal are applied respectively to the grid and cathode of the second stage.

The major difference between this and the previously described circuit is in the *X* and Z demodulator stages. The *Packard-Bell* circuit uses two triode stages, with the color subcarrier applied to the grids and the color-sync signals applied to the cathodes. This arrangement provides less amplification in the demodulator stage than the pentode circuit of Fig. 3, but the preceding two stages of bandpass amplifiers compensate for it. The matrixing is done again in the three color-difference amplifiers, whose cathodes are connected together in the already described manner. Instead of mixing *R-Y* plate signal at the green grid, the circuit of Fig. 4 mixes *B-Y* plate signal with green-plate signal.

All three picture-tube cathodes are tied together and each of the three control grids is biased by a separate potentiometer. In adjusting these controls, the procedure is first to set the green and blue controls to cut-off and then set the red control for a suitable brightness of that color on a monochrome picture. Next, the other two controls are adjusted for correct white balance on monochrome.

The *Emerson* and *DuMont* color sets use a demodulator very similar to that shown in Fig. 4. The only differences are in the bandpass amplifier, which is a single pentode stage, and in the color-difference amplifier output. The three plate circuits are connected together through a resistance network and returned to a potentiometer that sets the d.c. bias for all three CRT control grids. The cathodes of the color tube are connected as shown in the circuit of Fig. 3.

An entirely different color-demodulator system is used by *Zenith*. Here the functions of demodulating and matrixing are combined in two special, sheet-beam tubes, as shown in Fig. 5. Two stages of bandpass amplification are used to bring the color subcarrier up to the required amplitude. Only two tuning adjustments are required, since the tapped coil in the second-stage output is fixed-tuned. The bandpass response required here is shown in Fig. 6. The sharp ledge at the left results from the use of a 4.5-mc. trap before the first bandpass amplifier stage.

The demodulator itself produces the *R-Y* and *B-Y* difference signals directly without going through the *X* and Z signal steps. Color-sync signals are applied in push-pull fashion to the two deflection plates of each 6JH8 sheet-beam tube in such a manner that the electron stream from the cathode is switched back and forth between the two plates at the same 3.58-mc. sync frequency. If the color-sync signal is of the correct phase, it will direct the electron beam to the *B-Y* plate only during the appropriate phase interval. The color subcarrier itself is applied to the grid of the *R-Y* stage

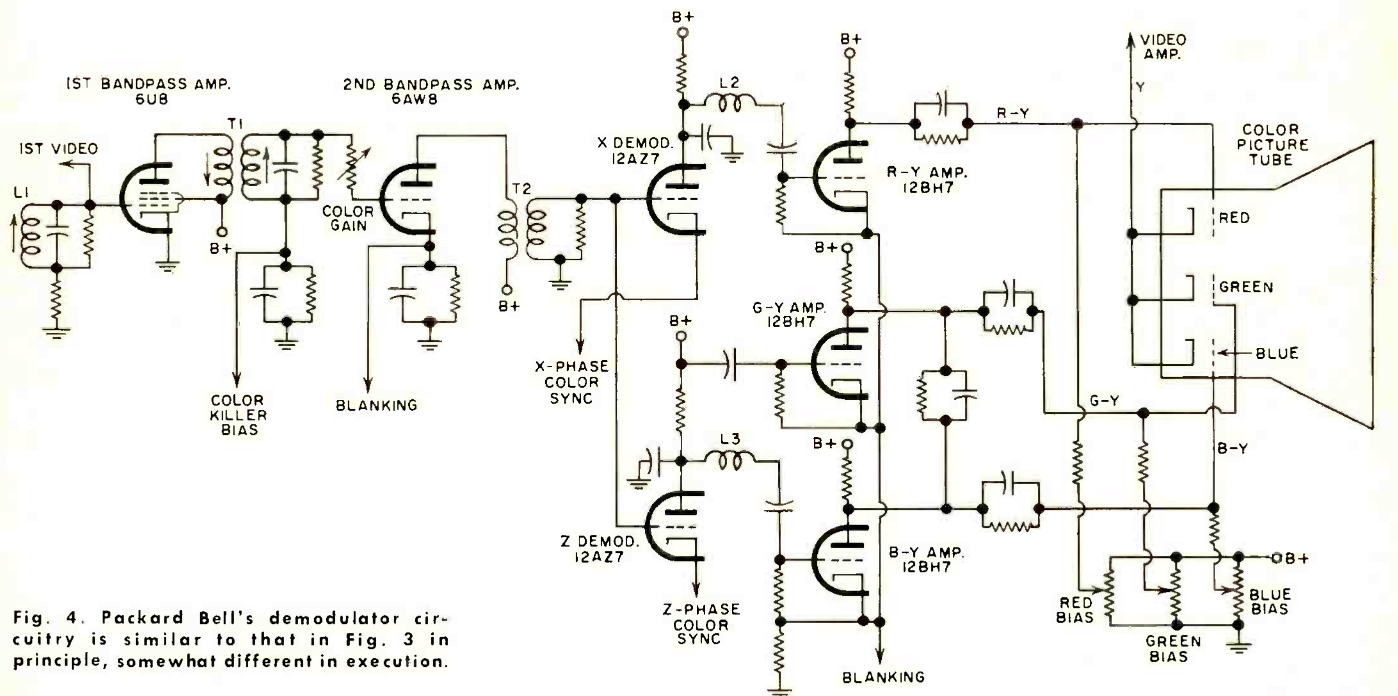


Fig. 4. Packard Bell's demodulator circuitry is similar to that in Fig. 3 in principle, somewhat different in execution.

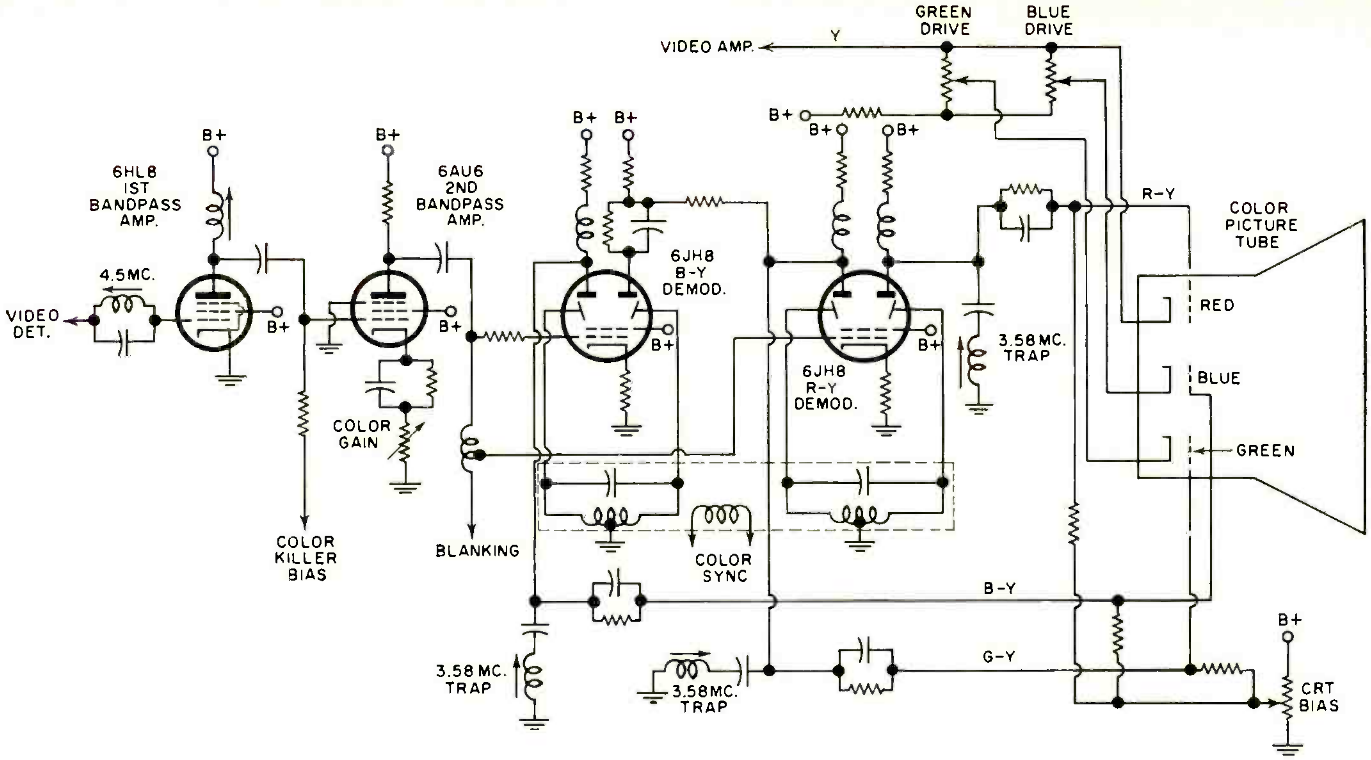


Fig. 5. A pair of beam-switching tubes that eliminates the need for separate inversion distinguishes the Zenith system.

with a small phase difference as compared to *B-Y* due to the tap on the output coil of the second bandpass amplifier.

This phase difference, together with the phasing of the color-sync signals due to the center-tapped, dual-transformer arrangement in the color-sync section, provides the proper demodulating phase relationships. The synchronous switching effect of the sheet-beam tubes takes care of the proper polarity of the detected information, with the signal at one plate of each stage being opposite in polarity with respect to the other. With the need for other inversion circuitry eliminated, only the task of matrixing remains.

One plate of the *B-Y* demodulator is resistance-coupled to one plate of the *R-Y* stage. These two are combined to form the green color-difference signal, which is applied to the grid of the green gun in the CRT. The complementary or opposite plate of each demodulator, *B-Y* and *R-Y*, correspondingly feeds the blue and red CRT grids. Since the 3.58-mc. color subcarrier is still present at each of the demodulator plates, it must be removed. This is accomplished with the three *LC* networks shown, each one connected between the output to one of the CRT grids and ground. The addition of the black-and-white or *Y* signal to the three color-difference signals is accomplished in the picture tube, with *Y* information being applied to all three cathodes. The method used is actually similar to that in the circuit of Fig. 3.

Although the circuit used by *Zenith* is quite different from the roughly similar ones found in other designs, it is too early to assess all advantages or disadvantages between the two systems. As far as tube-use savings go, there are two special, sheet-beam tubes, on the one hand, as compared, on the other, to five fairly conventional triode sections—which are accounted for by two and a half tube envelopes. There are certainly fewer circuit components in the *Zenith* design, but alignment of the color-sync output stage seems rather more complex. As to reliability, there has not yet been sufficient service experience, particularly with respect to the newer *Zenith* system, for dependable evaluation.

Conclusion

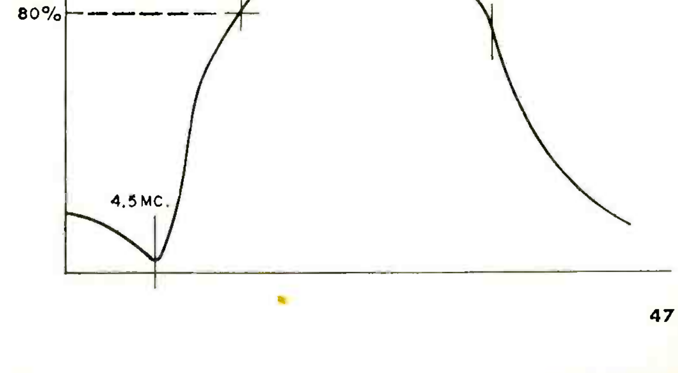
Whatever system is used, there are three basic steps required to remove the color information from its subcarrier and present the appropriately detected signals to the color CRT for display. The first step always involves amplification of the 3.58-mc. subcarrier with the appropriate bandwidth, and this is done in the same manner, by and large, in all designs now available.

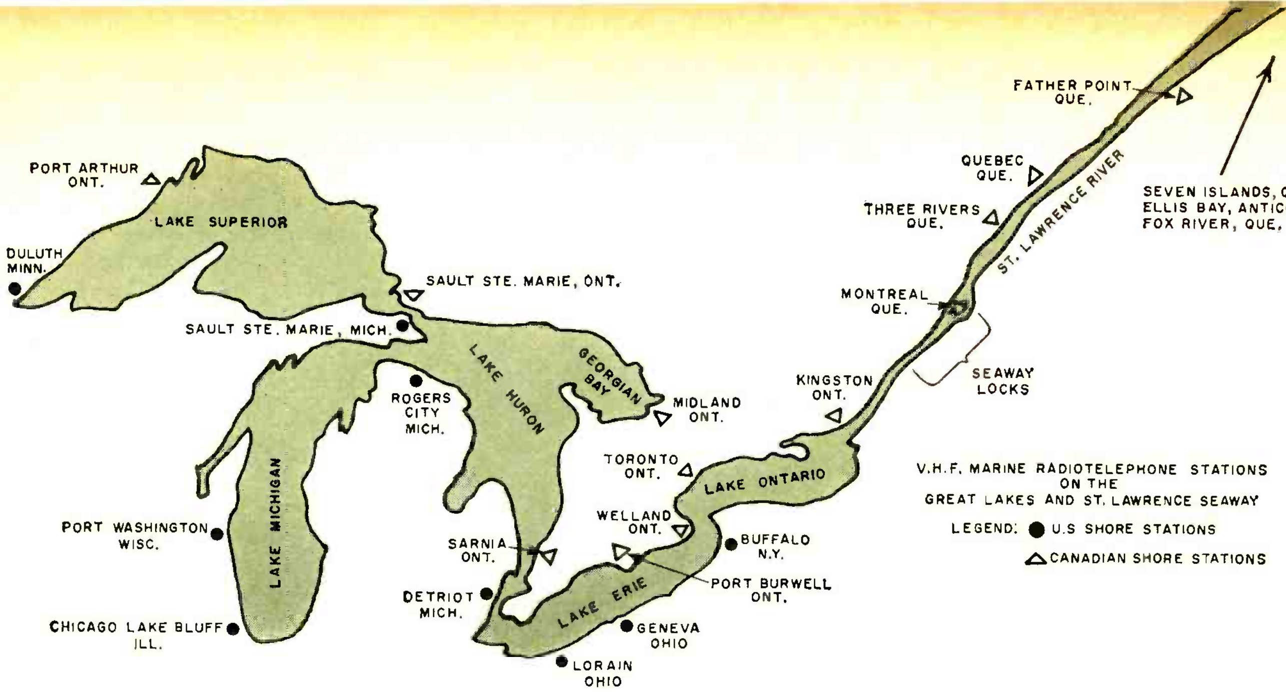
The second step basically involves the removal of color information from the subcarrier by synchronous detection. In all systems, with the single exception of the circuit employed by *Zenith*, this is accomplished by first reconstructing the *X* and *Z* signals. Then, in the third and final step, inversion of the signal and matrixing yield the color-difference signals for application to the CRT.

Although *Zenith's* distinctive system is like the others in the first step, it combines synchronous demodulation with inversion in the second step, taking advantage of the properties of the dual-plate, sheet-beam tubes. Matrixing finally occurs in the third step as the signal is being applied to the picture tube.

Adjustment and troubleshooting details, as always, are best achieved with reliance on the manufacturer's instructions. However, a basic understanding of the circuits and their functions is important before alignment or fault detection is attempted, even with such aids. Also, based on this understanding, the logical steps that pertain to all circuits, as well as the different ones that apply to circuit variations, become clearer. ▲

Fig. 6. Normal bandpass-amplifier response for Fig. 5 circuit.





V.H.F. MARINE RADIOTELEPHONY

By LEO G. SANDS / Hammarlund Mfg. Co.

For limited-range communications with far less noise and congestion than on medium-frequency marine bands, a v.h.f. transmitter-receiver is recommended.

WHILE the majority of boat owners put up with the static and congestion in the 2-3-mc. medium-frequency marine radio band, many have installed Citizens Band equipment, but relatively few have switched to the uncrowded, almost noise-free v.h.f. band. Hundreds of Great Lakes vessels and commercial sea-going ships and tugs all over the world use FM in the v.h.f. band for ship-to-shore and ship-to-ship communications.

Channels Available

Eleven channels in the 152-174-mc. band have been allocated on an international basis for marine communications. There is an all-station *Calling* and *Safety* channel, 156.8 mc., which is used for the same purposes as 2182 kc. in the medium-frequency band. For ship-to-ship communications, 156.3 mc. is available for use anywhere in the world for communications involving the vessel's safety.

Some of the other channels are for such uses as communicating with government shore stations to arrange for passage through locks and waterways, port operations (dredging and docking), and ship-to-ship business conversations. These channels are generally used on a simplex basis, with transmission and reception on the same channel.

In addition, there are three pairs of channels for semi-duplex operation (transmit and receive on different frequencies), which are used for making telephone calls to shore and other vessels out of direct v.h.f. range, *via* public coast stations. One pair of these public correspondence channels is commonly used by nearly all public coast stations, while the other two pairs are intended for use when extra capacity is required.

Communicating range in the v.h.f. band is generally shorter than in the medium-frequency band, but there is seldom any significant static, skip, or congestion. Ignition noise problems are minimized since FM is used and this inherently discriminates against impulse-type noise.

Equipment Requirements

Equipment for the v.h.f. marine band is similar to v.h.f. mobile radio equipment. In fact, regular vehicular mobile radio equipment may be used on boats as long as it is *FCC-type-accepted* for maritime service.

While all land mobile FM radio systems must narrow down frequency deviation from ±15 kc. to ±5 kc. by November 1963, marine v.h.f. systems may employ ±15 kc. deviation which ensures somewhat better transmission, all other factors remaining the same.

In addition to permanently installed v.h.f. equipment licensed as a Ship Station, portable FM transceivers ("walkie-talkies") may be used. These can be licensed as Marine Utility Stations and can be used on board ship or ashore.

The transmitter frequency stability requirement, when plate input power is less than 3 watts, is 0.01%, and trans-

Lorain, Ohio station which communicates with Great Lakes ships.

Compact two-channel v.h.f. radiotelephone unit for marine use.

mitters up to 100 watts in power must hold frequency to within 0.005% of the assigned channel. Land mobile stations of more than 3 watts transmitting power must hold frequency to a much tighter 0.0005%. The power limit of marine utility stations is 10 watts.

It is desirable to have a multi-channel set which can transmit and receive on at least two channels. The use of 156.8 mc. for calling and distress messages is mandatory. The use of 156.3 mc. for safety ship-to-ship communications is also a must. A third channel may be for communicating with shore stations for arranging passage through locks and waterways, or for public correspondence (telephone calls) through a public coast station.

Channel selection is accomplished by pushing a button or operating a selector switch on the control unit, which may be any one or more remote controls or integral with the transmitter-receiver. Within the transmitter and receiver, different crystals or oscillators are selected when changing operating channels.

The block diagram, Fig. 1, is that of a typical v.h.f. transmitter-receiver used on shipboard. The switches shown connecting the oscillators to the transmitter and receiver circuits are generally relay contacts which are remotely controlled. The receiver may employ one or two r.f. amplifier stages ahead of the first mixer and several low-frequency i.f. amplifier stages to provide the required sensitivity. The filter ahead of the low i.f. amplifier section provides the required selectivity.

Transmitters generally range in r.f. power output from 15 to 60 watts. The a.f. limiter automatically prevents frequency deviation in excess of ±15 kc. and the low-pass filter attenuates audio frequencies above 3000 cps.

On small craft, the transmitter-receiver frequently has a transistor-switching or vibrator-type power supply to permit operation from a 12-volt battery. Standby battery drain is typically under one ampere, if the receiver is transistorized, and during transmission battery drain is usually less than 20 amperes.

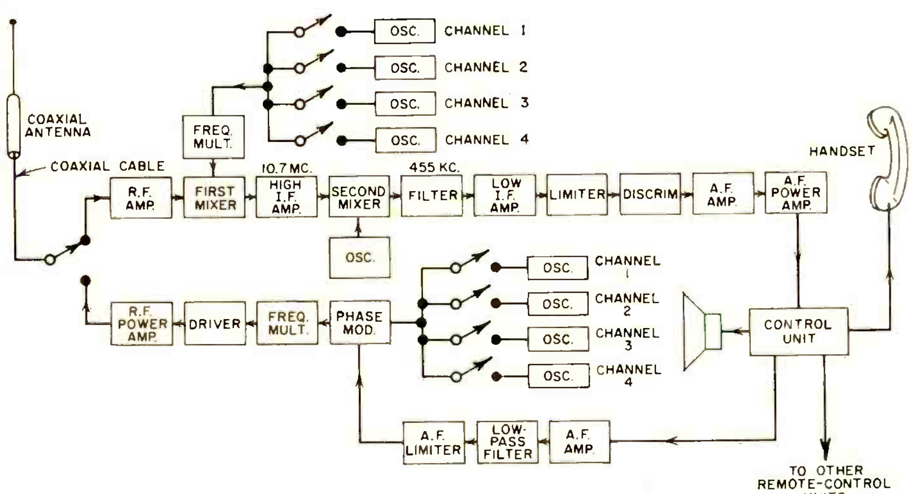
On larger craft equipped with a 32-volt or 110-volt d.c. electrical system, an a.c. set is often used with a transistor, vibrator, or rotary d.c.-to-a.c. inverter.

The remote-control unit may be (*Continued on page 78*)

ALL AREAS EXCEPT GREAT LAKES					GREAT LAKES AREA ONLY		
Frequency (mc.) Transmit	Frequency (mc.) Receive	Primary Purpose	Communicate With	Available To	Primary Purpose	Communicate With	Available To
156.3	156.3	Safety	Ships	All Vessels	Safety	Ships	All Vessels
156.4	156.4	Business	Shore	Intra-Port Commercial Vessels	Business	Shore	Ferries
156.5	156.5	Business	Shore	Intra-Port Commercial Vessels	Business	Shore	Commercial Vessels; Fishing Boats
156.6	156.6	Port Operations	Shore	All Vessels	Docking Operations; Navigation	Shore & Tugboats	All Vessels
156.7	156.7	Radio Location	Shore	All Vessels	Safety; Passage Through Locks	Ships; Shore	All Vessels
156.8	156.8	Calling	All Stations	All Vessels	Calling	All Stations	All Vessels
156.9	156.9	Operations	Ships & Shore	Pilot Vessels	Business	Shore	Tugboats
157.0	157.0	Business Operations	Shore; Ships when more than 150 miles from nearest land	Commercial Vessels	Safety	Ships	Commercial Vessels
157.3	161.9	Public Correspondence	Shore	All Vessels	Public Correspondence	Shore	All Vessels
157.35	161.95	Public Correspondence	Shore	All Vessels	Public Correspondence	Shore	All Vessels
157.4	162.0	Public Correspondence	Shore	All Vessels	Public Correspondence	Shore	All Vessels

Table 1. Listing of the v.h.f. frequencies that are available for marine use.

Fig. 1. Simplified block diagram of a typical marine v.h.f. transmitter-receiver.



Typical speaker and remote-control unit.

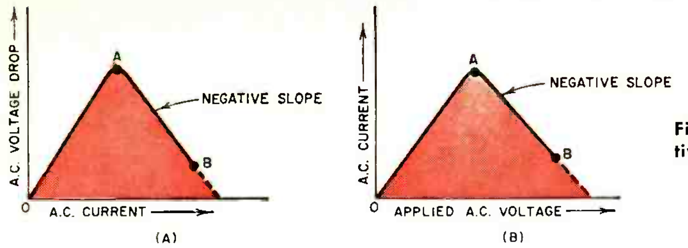


Fig. 1. Basic curves of the a.c. negative-resistance devices discussed below.

A.C. NEGATIVE-RESISTANCE DEVICES / Description of ferroresonators, nonlinear-type capacitors, semiconductor capacitors, and other similar components.

By RUFUS P. TURNER

THE author's earlier article on negative resistance was devoted to direct-current devices.[1] However, that article stated in conclusion that certain a.c. devices also exhibit the property of negative resistance, or negative impedance. This article describes devices of this type.

For simplicity's sake, throughout this article the term "negative resistance" will be used in a generic sense. But the reader will recognize that the negative quantity may be impedance or reactance, rather than resistance.

Such a.c. negative-resistance devices are not nearly as numerous as the d.c. devices, but we may reasonably expect additions to the family as research and development continue. The external manifestations of a negative characteristic are substantially the same in a.c. and d.c. devices, that is, the conduction curve has a negative slope over some part of it. In one instance, current will be the independent variable; in another, voltage will be. Thus in Fig. 1A, current is the independent variable. As the a.c. current is continuously increased, the a.c. voltage drop across the device first increases from 0 to *A* and then decreases (showing a negative resistance) from *A* to *B*. In Fig. 1B, voltage is the independent variable. As the applied a.c. voltage is continuously increased, the a.c. current flowing through the device first increases from 0 to *A*, and then decreases (showing negative resistance) from *A* to *B*.

The following sections describe the action of devices which exhibit one or the other of these conduction characteristics.

Ferroresonator

The *ferroresonator* (also called "ferroresonant circuit," saturable-reactor switch," and "ferristor") is a special type of series-resonant *LC* circuit. It really is quite simple, consisting only of a coil and capacitor connected in series (see Fig. 2A). The capacitor is a conventional one but the coil is not. The special feature of the coil is its core which saturates readily. Because of core saturation, the inductance and reactance of the coil decreases as the current is increased. An ordinary iron-core filter choke will exhibit saturation and a resulting decrease in inductance if current is raised high enough, but this usually requires a rather large current at power-line frequencies. A ferroresonator coil intended for operation between 100 kc. and several megacycles, however, is wound on a tiny, thin core of high-permeability metal and will saturate on only a few milliamperes.

The *LC* combination resonates at a frequency, f_r, determined by the inductance and capacitance values. (Resonant frequency $f_r = 1/(6.28\sqrt{LC})$. Capacitance *C* is constant, but inductance *L* varies with the current, *I*, flowing through the circuit, so the resonant frequency changes with current. (As *I* increases, *L* decreases, and f_r increases.) This is the basis of ferroresonator operation.

Fig. 2B shows a typical ferroresonant circuit. Here resistance *R* is non-inductive. The generator provides an adjustable a.c. output voltage. By adjusting the voltage, the operator varies current *I* flowing through *R, L, C* in series. The voltage (E_{LC}) across the *LC* combination is measured with a high-impedance a.c. vacuum-tube voltmeter. Fig. 2C shows circuit response. As the current is steadily increased, voltage E_{LC} rises to a peak (point *A*), then decreases to a valley (point *B*), and finally rises again to *C* and beyond. Thus, *AB* is a negative-resistance region bounded by two positive-resistance regions (0*A* and *BC*). This is a typical negative-resistance curve.

The circuit behavior may be explained in the following manner. (1) The *L* and *C* values are selected to give a resonant frequency somewhat lower than the generator frequency. Increasing the current decreases inductance *L* and tunes the circuit up to the generator frequency and finally to some still higher frequency. (2) As *I* is increased from zero, E_{LC} rises and would continue to do so if the core of the coil did not begin to saturate. Saturation (starting at point *A* in Fig. 2C) lowers the inductance and tunes the circuit toward resonance at the generator frequency. (3) At generator resonance, the net reactance of the *LC* combination is theoretically zero, therefore E_{LC} is theoretically zero. As resonance is approached, E_{LC} accordingly decreases. At resonance (point *B*), E_{LC} does not drop fully to zero because resistance losses remain to act in the circuit after resonant cancellation of the reactance. (4) As *I* is increased further, core saturation increases, inductance lowers still more, and the circuit is tuned to a frequency higher than the resonant frequency. Thus, the voltage once more rises—in this case from *B* to *C*.

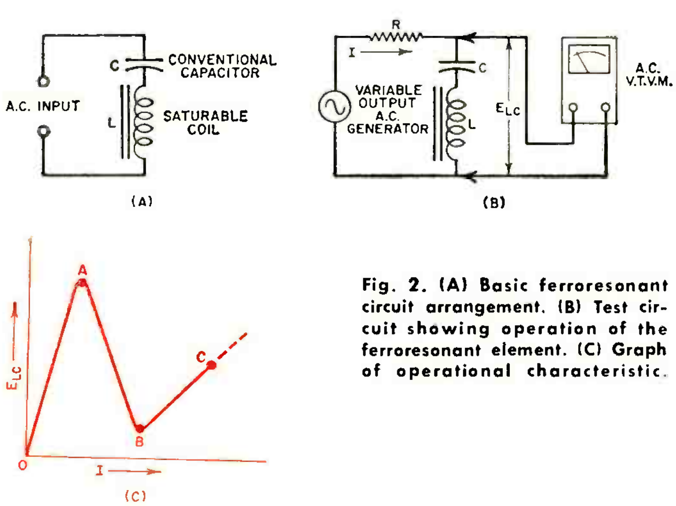


Fig. 2. (A) Basic ferroresonant circuit arrangement. (B) Test circuit showing operation of the ferroresonant element. (C) Graph of operational characteristic.

Tiny r.f. ferroresonators have been used as active elements in flip-flops, electronic counters, gates, and other computer-type devices.[2,3,4] They also have been employed as magnetic amplifiers at audio frequencies. In these particular units, C usually is a fairly small mica capacitor, while L is a coil that has been wound on a core of Permalloy foil.

Nonlinear Capacitor Element

Fig. 3A shows a series-resonant negative-resistance circuit which resembles the ferroresonant circuit described in the preceding section but behaves somewhat differently. This arrangement uses a conventional air-core coil and a nonlinear (voltage-variable) capacitor. Suitable capacitors of this type contain a high-K ceramic dielectric, such as specially processed single-crystal barium titanate. As the voltage applied to the capacitor is increased, the capacitance decreases.

As in the standard ferroresonant circuit, the L and C values in Fig. 3B are selected so that the zero-voltage resonant frequency of the circuit is lower than the generator frequency. As the voltage is increased, the current rises from zero to a peak point (A in Fig. 3C). As the voltage is increased further, the current decreases. Thus, the current-voltage curve has a negative slope from A to B.

Behavior of the circuit may be explained in this manner. (1) The increasing voltage lowers the capacitance and tunes the LC circuit up toward the resonant frequency (generator). The current increases because increasing capacitive reactance causes the net reactance of the circuit to decrease. (2) At resonance with the generator, the net reactance is theoretically zero, and maximum current flows. This corresponds to point A in Fig. 3C. (3) As the voltage is increased beyond this point, the circuit is tuned to frequencies higher than resonance. The capacitance continues to fall but the net reactance of the circuit increases, so the current decreases. This is represented by the negative slope, AB.

Semiconductor Capacitor Circuit

A ceramic nonlinear capacitor, such as C in Fig. 3, usually requires relatively high-voltage operation for appreciable capacitance change. Furthermore, such capacitors are quite temperature-sensitive because of the Curie point of the dielectric material. To obtain low-voltage operation (from a few tenths of a volt to 1 to 6 volts r.m.s.) and at the same time to secure comparative freedom from temperature effects, semiconductor voltage-variable capacitors may be substituted in the circuit, as shown in Fig. 4. Response is the same as that shown in Fig. 3C.

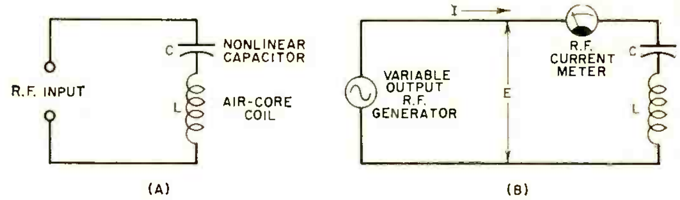
In Fig. 4, the semiconductor voltage-variable capacitor (also known as Varicap, varactor, Semicap, etc.) is d.c.-biased in a reverse direction to set its initial capacitance to a desired value and to prevent positive peaks of the maximum r.f. voltage from driving the semiconductor junction into the low-resistance forward direction. $C1$ is a blocking capacitor to keep d.c. out of the current meter and generator. As in the preceding example, values of L and $C2$ are chosen for zero-signal resonance below the generator frequency. Because the capacitance of $C1$ is very high with respect to that of $C2$, it has negligible effect on circuit tuning.

Nonlinear Parallel-Resonant Circuit

It is well known that the current in the line supplying a parallel-resonant circuit dips to a low value when the circuit is tuned to resonance at the generator frequency. If a voltage-tuned element is included in the parallel-resonant circuit, the circuit will then resonate at only one value of input voltage. The line current will then decrease at this voltage level, showing a negative slope.

Fig. 5A shows a circuit for displaying this negative-resistance effect. The parallel-resonant circuit is composed of air-core coil (L)and a 56 pf. ($\mu\mu$f.) Varicap semiconductor voltage-variable capacitor ($C2$). $C1$ is a blocking capacitor (.005 to .01 μf.) whose capacitance is so high with respect to $C2$ that only the latter determines the circuit tuning. The values of L and $C2$ are chosen such that the zero-signal-voltage resonant frequency of the circuit is somewhat lower than the generator frequency. As the generator voltage ($E_{R.F.}$) is increased, the current ($I_{R.F.}$) increases from zero to point A in Fig. 5B. The increasing voltage reduces the capacitance of $C2$. At the particular level of signal voltage, the corresponding $C2$ value tunes the circuit to resonance at the generator frequency, and the line current dips to point B. As the voltage is increased further, the capacitance decreases still more, tuning the circuit above resonance, and the current again rises to point C and beyond. Along the negative slope, AB, the current is decreasing as voltage is increasing.

For best results, the generator frequency should not be lower than 20 mc. The higher the frequency, the more pronounced is the negative-resistance effect.



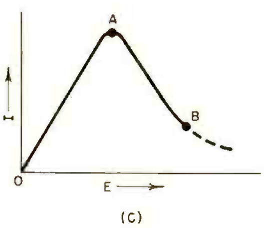


Fig. 3. (A) Basic circuit arrangement using a nonlinear capacitor. (B) Test circuit showing operation of the nonlinear element. (C) Response of the test circuit.

Diodes at Higher Frequencies

At high radio frequencies, the combined action of nonlinear capacitance and a.c. rectification provided by the semiconductor voltage-variable capacitor gives rise to an a.c. negative-resistance effect (as well as to hysteresis, in some cases).

Heizman has described a microwave setup in which the capacitor diode is operated in a tunable waveguide.[5] The negative resistance and hysteresis obtained with this arrangement have been utilized for switching at microwave frequencies. The response curve is similar to those of Figs. 1B and 3C.

The conventional point-contact germanium diode has been known to exhibit negative resistance at very high frequencies.

(*Continued on page 62*)

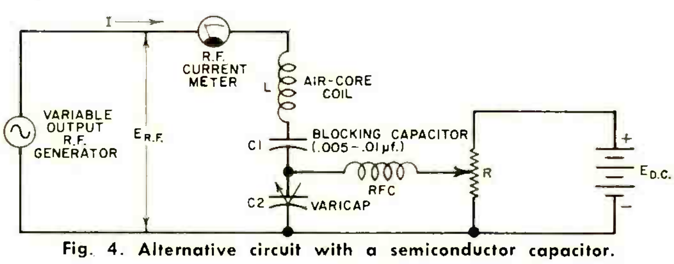
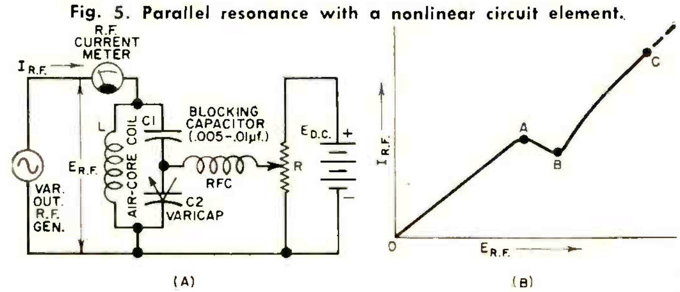


Fig. 4. Alternative circuit with a semiconductor capacitor.

Fig. 5. Parallel resonance with a nonlinear circuit element.



THE OPERATIONAL AMPLIFIER

By JACK E. FRECKER / Applied Research Lab., University of Arizona

PART 1 / These circuits are widely employed in industrial test equipment and analog computers. Theory of amplifier along with design and construction of a unit are covered.

THE operational amplifier was originally invented to perform precise mathematical operations in electronic analog computers. Yet some of its most fascinating uses are in other than computing applications. How would you like one device that could be used, simply by connecting a few external parts, as an amplifier, an oscillator, a voltmeter calibrator, a regulated power supply, a precision oscilloscope sweep generator, a capacitance bridge, and even as an analog computer. This is the operational amplifier.

Its uses are literally unlimited. The sheer act of building and using operational amplifiers could no doubt cause the reader to discover some new applications. This article will acquaint the reader with the operational amplifier, show the design and construction of a two-amplifier unit, and describe in detail several representative uses of same.

Basic Concepts

Just what is the operational amplifier? How is it different from any other amplifier? First of all, it is a feedback ampli-

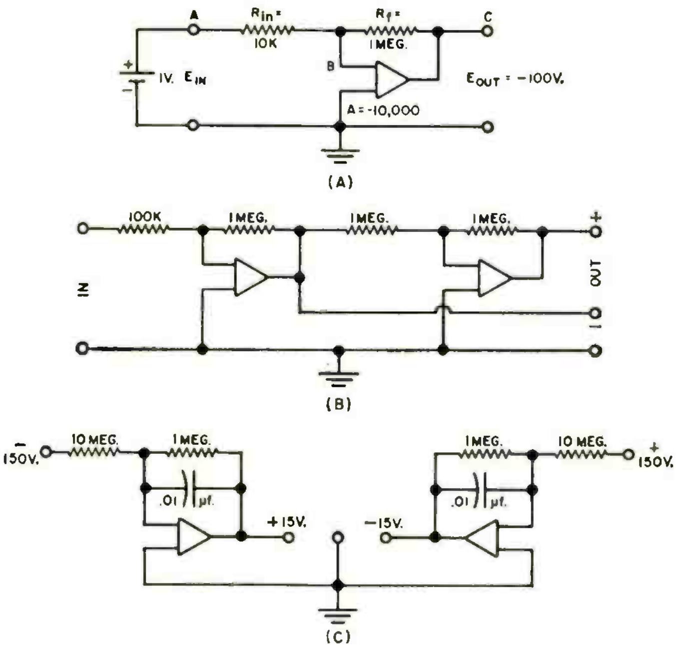


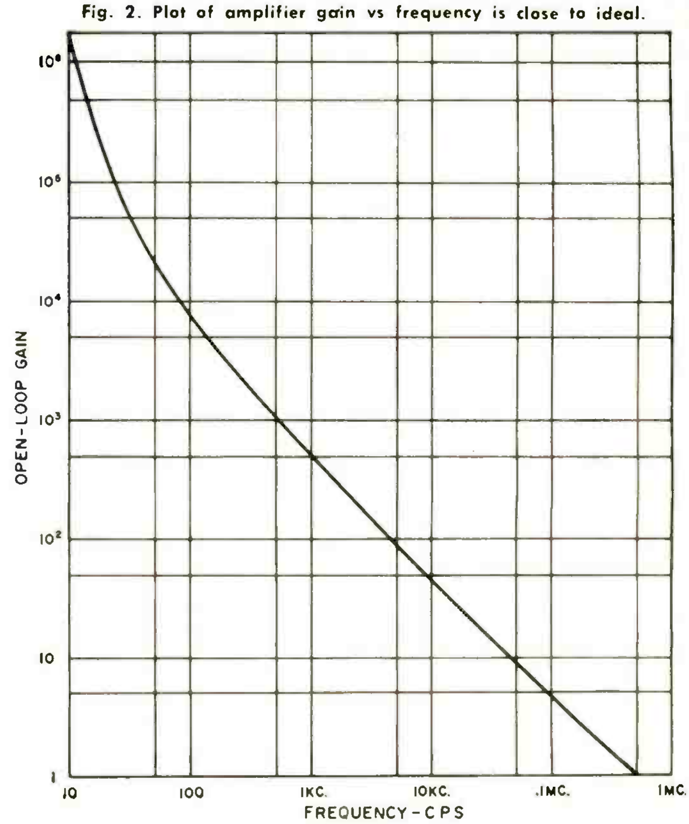
Fig. 1. (A) Typical use for operational amplifier. (B) An audio phase inverter with a gain of 10. (C) Method of using operational amplifiers as an extremely well-regulated supply.

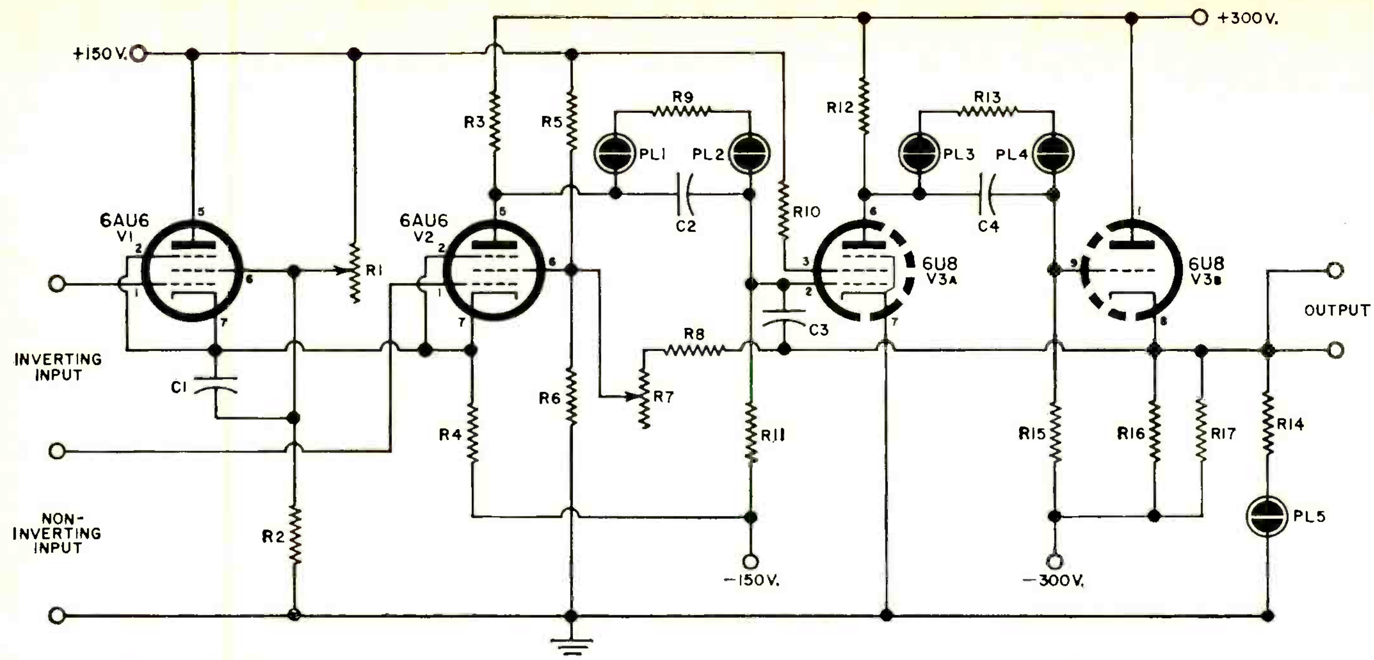
fier for which the user supplies the feedback components. These components, incidentally, may be resistive, reactive, or non-linear. It is capable of any amount of feedback. One usage that will be described later involves reducing the amplifier open-loop gain (gain without feedback) from several million to a gain of 1/10 by means of feedback. An ordinary audio amplifier would break into oscillation or motorboating if this were tried. Such operation is possible with an operational amplifier because of two of its characteristics. It is direct coupled (this makes motorboating impossible), and its gain is rolled off to less than unity before the necessary phase shift to sustain oscillations takes place. Second, its characteristics are determined to the greatest degree possible by the feedback components. If you have ever tried to calculate feedback components for an ordinary amplifier you will know that amplifier gain, output impedance, and various stability criteria enter into the calculations. For the operational amplifier the calculations simply involve the ratio of two external impedances.

Basically, the operational amplifier is a direct-coupled amplifier, and with the input grounded the output is at zero volts d.c. in respect to ground. Its gain is exceedingly high, 1000 to 15,000 being typical for simple devices and gains to one billion being found in laboratory units. Its output impedance is quite low by nature and, with feedback, it is further reduced to where it becomes negligible.

A typical application is that of Fig. 1A. An amplifier with a gain of $-10{,}000$ is shown for illustration, the minus sign denoting a phase inversion between the input, point A, and the output, point C. The external feedback components are resistors R_{in} and R_f. With the $+1$-volt battery connected to the input, the output will start to go highly negative. This output will be fed back to the summing junction, point B, in a degenerative manner, tending to prevent the output from going negative. The circuit will reach a state of equilibrium with the output at about -100 volts, which is -100 times the input voltage, or equal to the ratio $-R_f/R_{in}$. It can be shown that if the amplifier open-loop gain were infinite the system gain would simply be $-R_f/R_{in}$. And it can also be shown that if the amplifier gain were only $(-R_f/R_{in}) \times 100$, the system gain would be within one per-cent of the ratio

Fig. 2. Plot of amplifier gain vs frequency is close to ideal.





R1—100,000 ohm "Zero" pot (Ohmite CU-1041)		*C1—.01 µf., 500 v. ceramic capacitor*
R2,R6—390,000 ohm, ½ w. res., ± 10%	*R9,R13—750,000 ohm, ½ w. res., ± 10%*	*C2,C4—6.8 pf., 500 v. ceramic capacitor*
R3—220,000 ohm, 1 w. res., ± 5%	*R10—10,000 ohm, ½ w. res., ± 10%*	*C3—22 pf., 400 v. mica capacitor*
R4—91,000 ohm, 1 w. res., ± 5%	*R11—2.2 megohm, ½ w. res., ± 10%*	*PL1,PL2,PL3,PL4,PL5—NE-2 neon pilot light*
R5—47,000 ohm, 1 w. res., ± 5%	*R12—200,000 ohm, 1 w. res., ± 10%*	*V1,V2—6AU6 or 6136 tube*
R7—5 meg "Regen" pot (Ohmite CLU-5052)	*R14—910,000 ohm, ½ w. res., ± 5%*	*V3—6U8 tube*
R8,R15—3.9 megohm, ½ w. res., ± 10%	*R16,R17—130,000 ohm, 2 w. res., ± 5%*	*10—Red binding posts*
		10—Black binding posts

Fig. 3. Schematic diagram of one of two identical operational amplifiers that are employed in the author's design.

$-R_f/R_{in}$. Similarly, if the output impedance of the amplifier without feedback were about 500 ohms and the gain reduced by a factor of 100 by feedback, the output impedance would also be reduced by more than a factor of 100, to less than five ohms. By the same token, amplifier noise and distortion are reduced by similar amounts.

Another point to remember about the operational amplifier is the nature of the summing junction, point B of Fig. 1A. With +1 volt at the input, point A, and −100 volts at the output, the voltage at the summing junction will be −100/−10,000 or .01 volt. This point behaves as a very low resistance to ground, and since it does so we can define the input impedance to the system as simply the value of R_{in}, or 10,000 ohms in Fig. 1A.

Figs. 1B and 1C are very practical applications of the above principles and both are possible with the unit to be described. Fig. 1B is an audio phase inverter with a gain of 10. The first amplifier provides a gain of 10 and furnishes the negative or inverted output. It also drives the second amplifier which is connected as a unity-gain inverter. This amplifier re-inverts the first amplifier's output to provide a positive or non-inverted output. The circuit is useful for driving audio power amplifiers. It could provide a balanced low-impedance output for a single-ended audio generator, or it could drive the deflection plates of an oscilloscope which has no d.c. amplifier.

Fig. 1C is an extremely well-regulated electronic power supply which furnishes plus and minus 15 volts at 4 ma. each for experimental transistor circuits. The first amplifier amplifies the −150-volt reference source by −(1/10) to provide +15 volts. The second amplifier amplifies the +150-volt reference source by −(1/10) to provide −15 volts. The two capacitors provide a.c. feedback which is employed in order to give the circuit a very low output impedance.

Two-Amplifier Unit

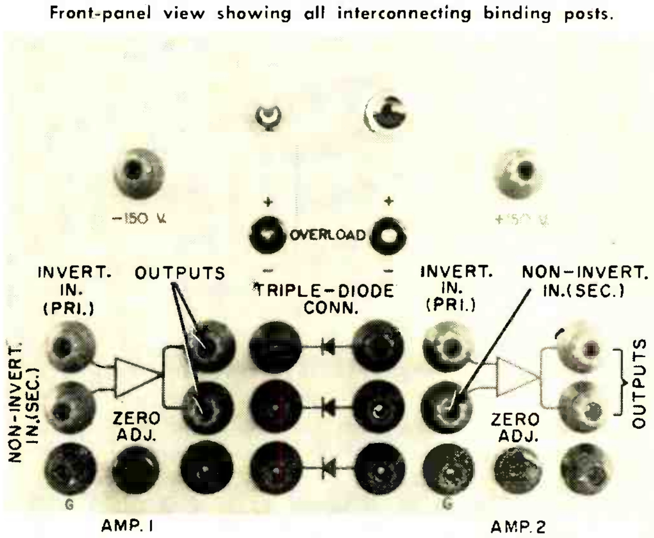
After much planning and experimenting, it was decided to design and construct two operational amplifiers within a single housing, their power supply, a 6BJ7 triple diode for auxiliary functions requiring diodes, and plus and minus 150-volt reference voltages. Two amplifiers are far more useful than one, but three would have complicated the power-supply requirements and made the unit quite costly.

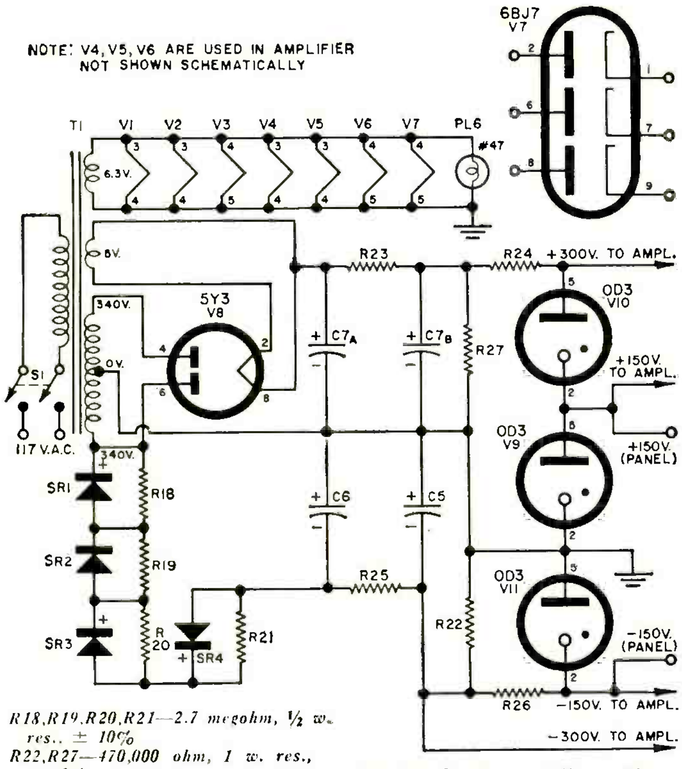
The requirements of an operational amplifier are that with the inputs grounded, the output should be at zero volts d.c. with respect to ground; that the gain be quite high; and that the output impedance without feedback be fairly low. In addition, the unit must be direct coupled and its open-loop gain must be rolled off to less than unity before unwanted amplifier phase shift reaches 180 degrees. These last two requirements make it possible to use any amount of feedback without danger of oscillation. Another requirement is that d.c. drift be quite low.

The following discussion of amplifier No. 1 (see Fig. 3), composed of V1, V2, and V3, also applies to amplifier No. 2 which is identical.

In the circuit, V1 and V2 comprise a differential amplifier. (Such an amplifier consists of a cathode-coupled pair with output taken at the second stage. It takes its name from the

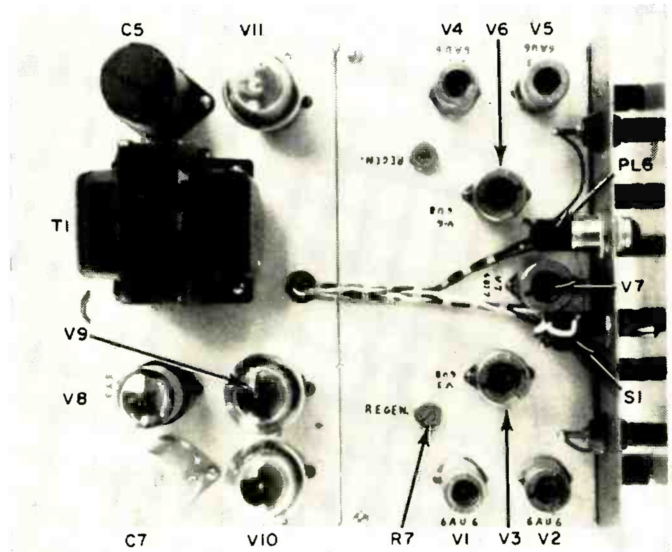
Front-panel view showing all interconnecting binding posts.





R18,R19,R20,R21—2.7 megohm, ½ w. res., ± 10%
R22,R27—470,000 ohm, 1 w. res., ± 10%
R23,R24—2000 ohm, 5 w. res.
R25—3000 ohm, 5 w. res.
R26—4000 ohm, 5 w. res.
C5—135 μf., 350 v. elec. capacitor
C6—8 μf., 450 v. elec. capacitor
C7—60/60 μf., 450 v. elec. capacitor
PL6—#47 pilot light and holder
SR1,SR2,SR3,SR4—1N1694 rectifier or equiv.
S1—D.p.d.t. toggle switch
T1—Power trans. 340-0-340 v. @ 70 ma., 5 v. @ 2 a., 6.3 v. @ 2.5 a. (Stancor PC-8408 or equiv.)
V7—6BJ7 tube
V8—5Y3 tube
V9,V10,V11—0D3 tube

Fig. 4. Single power supply used for both operational amplifiers.



Top view showing the two-chassis construction used by author.

fact that with inputs applied to both grids simultaneously, the output responds approximately to the difference between the two input signals.) This circuit is invariably used as the first stage of an operational amplifier because any change in heater voltage, the major cause of drift, will affect both tubes in an equal and opposite fashion, tending to cancel out the effect of drift. In addition, the existence of a differential input permits many applications of the unit which would not otherwise be possible.

The amplifier has two inputs. The grid of $V1$ is the primary input. There is phase inversion between this input and the output. This input is the upper one used in all the diagrams. The grid of $V2$ is the secondary input and is the lower one in the drawings. There is no phase inversion between this input and the output.

$V2$ could have been coupled to $V3A$ by means of a 2.2-megohm resistor from $V2$ plate to $V3A$ grid, and then another 2.2-megohm resistor from this grid to −150 volts. However, this would have resulted in 6-db attenuation of the signal. A better way is the use of neon lamps. Neon lamps work much like gas regulator tubes; that is, the d.c. voltage drop across them remains nearly constant with a fairly wide variation of current flow through them. The plate voltage of $V2$ is about +160 volts. This is dropped 55 volts by $PL1$, 50 volts by $R9$, and 55 volts by $PL2$. Any amplified signal at the $V2$ plate will be coupled without loss by $PL1$ and $PL2$ and will be attenuated only slightly by $R9$. $R11$ provides the current to keep the lamps lit, about 70 μa.

$R1$ is the amplifier zero-adjust control. By varying the screen voltage of $V1$, $R1$ adjusts the d.c. operating point of the amplifier and is used to set the amplifier output to zero volts d.c. with both inputs grounded.

$V3A$ is a d.c. amplifier with a gain of −200. $R10$ limits the screen current of this tube to a value safe for the tube under amplifier overload conditions. This stage drives cathode-follower $V3B$ which has an output impedance of about 400 ohms. The neon light at the output terminal glows when the output goes plus or minus 70 volts and indicates an overload.

$R7$ and $R8$ are connected from the output to the screen of $V2$ and provide positive feedback to increase the amplifier gain from about 15,000 to a value approaching infinity at d.c. $C3$ provides negative feedback in $V3A$ at frequencies above d.c. and is used to reduce amplifier gain, at a rate of 6 db per octave, to less than unity before a total of 180 degrees additional phase shift in both stages takes place. As this capacitor is for all practical purposes connected from plate to grid instead of plate to ground its effective capacity is multiplied by the gain of the stage. Its value was selected by trial and error and is just large enough to give the amplifier a damping factor of .5 to a square-wave input. A plot of amplifier gain *versus* frequency is (*Continued on page* 84)

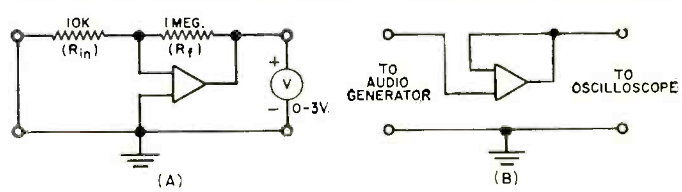
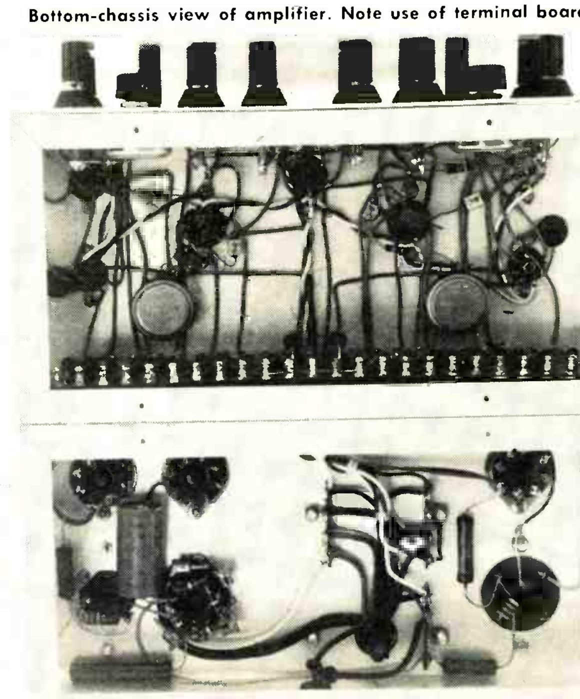


Fig. 5. (A) Connections used to check for reduced line-voltage operation. (B) Setup to check for distortionless unity gain.

Bottom-chassis view of amplifier. Note use of terminal board.



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SENCORE ADDISON, ILLINOIS

JOHN FRYE

Mac and Barney discuss the frequency, amplitude, dangers, and control of random voltage surges as a storm rages outside.

Taming Transients

IT was a hot, muggy, July afternoon. Even before lunch Mac and Barney had noticed characteristic lightning-caused flashing on the screens of the TV sets on which they were working, and now at one-thirty the sun disappeared behind dark anvil-shaped clouds towering in the southwest and the earth shook with the growl of distant thunder.

"That does it," Mac said as he pulled the big switch that completely disconnected all test equipment and service bench outlets from the line. "I know this will probably break your industrious heart, but we'll take a break until the thunderstorm passes. Lightning-induced voltage surges are not going to get my service equipment, me, or my valued assistant if I can help it."

"Gee, thanks!" Barney retorted as he tilted his stool on two legs so that his back could rest against the wall; "I notice you listed things in the order of their importance."

"Yes, how about that?" Mac said with a teasing grin. "You know I've always been a little hipped on the subject of how lightning damage can ruin electronic equipment, and I'm even more so after reading a short article that appeared in the March, 1963, issue of 'Newsletter,' published by the Rectifier Components Department of *General Electric*."

"You don't need to sell me on the danger," Barney sniffed. "I've seen too many radio and TV sets on the bench that had been clobbered by lightning that 'came in' over the owners' light lines. That stuff sure is freakish. Sometimes it skips all over a set blowing tubes, burning out coils, breaking down the insulation of transformers, and even fusing the plates of a tuning capacitor together. Again it only pops the line bypass capacitors, but what a job it does on those! I've seen dozens of cases in which all that's left of the line bypass is the two wire leads with little disks on the end that originally connected to the foil. The capacitor itself is entirely gone except for a few shreds of foil and paper splattered against the flame-smoked chassis. Those surges must really pack some voltage."

"That's pretty evident, and I've always wondered just *how much* voltage, but I never had equipment suitable for measuring the amplitude and duration of the surges. The boys at *G-E*'s Advance Technology Laboratories in Schenectady apparently got to wondering, too, and they *had* the equipment. Their transient measuring set-up used a *Tektronic* automatic oscilloscope and a *Beattie & Coleman* automatic camera. Every time a transient came along it was displayed on the scope and its picture was automatically taken to indicate the peak-to-peak voltage amplitude and the duration. With this kind of equipment set up in various locations in two different states, 8000 hours of testing time was logged at the time the article was written. The tests are still going on."

Mac stopped speaking, and the thunderstorm hit with roaring wind and sheets of rain splashing against the windows. The thunder was almost continuous.

"You say the equipment was set up in 'various locations.' What kind of locations?" Barney wanted to know.

"All the tests were made across 120-volt lines, but since voltage surges are produced by a wide variety of causes, varying all the way from bolts of lightning striking near the lines to different types of electrical apparatus being connected to and disconnected from the lines, it was decided to monitor a number of locations in order to photograph a wide range of transients. To this end the equipment was set up in seven private homes, two hospitals, one hotel, one motel, and one department store. Results showed the wisdom of this deployment, for some locations had considerably more and higher transients than did others. Equipment that probably would have operated without injury on some of the lines would very likely have suffered transient damage on other lines."

"What was the highest voltage surge measured?"

Before Mac could answer, there was a terrific flash of lightning accompanied by a sharp snapping sound followed almost immediately by a crash of thunder. The lights in the shop flickered momentarily.

"Whew! That was a close one!" Mac said as the unmistakable odor of ozone came in the open door. "I think it was trying to answer your question, for the highest transient measured on a 120-volt line was one that reached 3740 volts peak-to-peak, and this occurred in a Florida home during a lightning storm. That's the kind of surge that pops those line capacitors you were talking about. A voltage of that order can easily hop across the closely spaced contacts of an open line switch in a radio or TV receiver; so just turning the set off during a thunderstorm is no insurance against lightning damage. Pulling the plug during the storm is the only way to be sure lightning can't get at the set *via* the power line."

"I'll buy that," Barney agreed emphatically. "I keep all the plugs of my ham equipment pulled when the station is not in use, especially during the thunderstorm months. More than one of my ham acquaintances has had his entire station wrecked by a single bolt of lightning that struck near the power line feeding the station. While most hams are not stupid enough to operate during a thunderstorm and are careful to ground the transmitting and receiving antennas, a lot of them leave the back door unguarded, so to speak, and forget that lightning damage is much more likely to arrive *via* the power lines than it is to come in over the antenna. What else did the *G-E* boys learn from their surge survey?"

"Well, they found relatively frequent transients occur up to 1600 volts, but the most common ones fall in the 500-600 volt bracket. Most of the voltage surges last less than fifty microseconds."

"Offhand I'd say the presence of these voltage surges on the line is a more serious threat to modern semiconductor apparatus operating from the line than it is to vacuum-tube apparatus," Barney suggested. "Take for instance two radios that use the same tube line-up except for the rectifier. One uses a half-wave vacuum-tube rectifier and the other uses a germanium or silicon diode. Both rectifiers are fed directly from the line so that any transient appearing on the line appears across the rectifier. I've got a hunch the semiconductor would

be more likely to suffer damage than would the tube."

"Speaking of ordinary semiconductor rectifiers, I'd go along with your hunch," Mac agreed. "The reason semiconductor diodes are sensitive to transient damage is not too hard to grasp. While a typical 12-ampere silicon rectifier of the conventional type can momentarily dissipate 1000 watts of heat in the forward conduction direction of current, it will be permanently damaged by only a few watts of power dissipation in the reverse or blocking direction."

"How come?"

"In the forward direction the current and its attendant heat losses spread out uniformly over the entire silicon junction area, allowing the rectifier to take maximum advantage of its cooling mechanism and heat capacity. However, under the influence of even a brief voltage transient, the rectifier leakage current driven by a momentary high blocking voltage peak will find some tiny flaw or weakness in the junction at which to concentrate. Such weak spots usually occur at the junction surface where the rectifying junction emerges from the silicon pellet. At these microscopic spots a fraction of a watt of concentrated heat may be enough to destroy the blocking properties of the rectifier, no matter how big it is."

"I notice you keep saying 'ordinary semiconductor rectifiers.' Is there another kind not so easily damaged by voltage surges?"

"Yes. The controlled avalanche silicon rectifier, such as *G-E*'s Model ZJ-218, can dissipate about as much heat in its reverse as in its forward direction. This is accomplished by making the high reverse energy dissipation take place in the avalanche breakdown, or zener, region of the diode characteristic. You know this zener behavior characteristic of a silicon diode permits it to be used as a voltage regulator. As long as you stay within the thermal limitations of a zener diode, it will maintain virtually constant voltage across itself regardless of the avalanche current through it. No damage will result from true avalanche action to a diode with a uniform junction.

"A rectifier diode with uniform avalanche breakdown taking place at a voltage below that at which local dielectric surface breakdown occurs can dissipate hundreds of times more reverse energy caused by transient high voltage than one in which the surface breakdown point is reached before avalanche current starts. Once the avalanche current begins, it holds the voltage down so the level where surface damage to the rectifier might occur is never reached. Such a device has its own 'built-in' transient voltage suppressor."

"How do you go about making a controlled avalanche silicon rectifier?"

"There are two important steps: 1. You control the geometry of the junction surface very precisely to reduce the voltage gradient at that surface and make it capable of supporting high voltage. 2. You carefully control the impurity concentration determining voltage at which avalanche occurs so that avalanche always begins *below* the voltage where surface damage might be encountered."

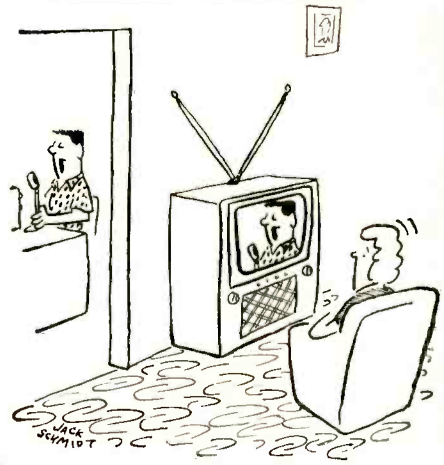
"Is such a rectifier similar in other ways to an ordinary silicon diode?"

"Generally speaking, yes. The CASR's big advantage lies in its ability to cope with high reverse currents. Its forward current handling ability is very similar to that of a conventional diode. However, the high degree of surface stability should pay off in increased reliability. Also CASR's can be operated in long series strings at very high voltage without the use of voltage equalizing resistors, since each cell can be operated in its avalanche region without damage. Voltage safety factors can be greatly reduced. Instead of the usual 2:1 or 3:1 safety factor between rectifier peak reverse voltage and steady-state line peaks, CASR's can often be applied with little or no safety factor. A 1200-volt p.r.v. CASR can be used instead of a 2000-3000 p.r.v. conventional rectifier."

"Sure sounds like they'd be a natural for use in the high-voltage power supplies for table-top kilowatt linear amplifiers now becoming so popular with SSB hams," Barney said, cocking one ear to the sound of the storm. "Sounds like it's coming back," he observed, settling comfortably back against the wall.

"I just was thinking we could be working on that stack of transistor radios with the v.o.m.'s without any danger of the big, bad lightning getting to us," Mac said, standing up. "On your feet, Buster!"

"Your trouble is you think too much," Barney answered disgustedly. ▲



Electron Microscopy
(*Continued from page 24*)

problems. So far, no proton or other heavy-particle instrument has achieved the resolution possible with electron microscopes.

Meanwhile, as the transmission electron microscope held the center of attention of both the scientific community and the world at large, other earlier devices, bypassed in the search for more widely useful instruments, have not been allowed to languish completely. For example, a number of scientists, including Dr. Erwin Müller of Pennsylvania State University, have continued to work on emission microscopes. As early as 1936, Müller demonstrated an instrument of

Norelco EM-200 electron microscope.

this type with a resolving power of 20 angstroms, far better than results achievable with transmission microscopes of the day. Its resemblance to an ordinary cathode-ray tube is striking.

The maximum resolution of Müller's instrument was limited by the fact that electrons, being very light, are apt to be easily diverted by stray magnetic fields or other conditions. So Müller decided to use a heavier particle. Several years ago, his first operating model of the *ion-emission microscope* (using ions instead of electrons) was demonstrated. (The ion, being heavier, also has a shorter wavelength and is thus inherently capable of better resolution than the electron.) Just a short time ago, the first commercial model, made by *Cenco Instruments*, came on the market.

The ion microscope (Fig. 7B) is quite similar to the electron-emission instrument. A small amount of helium gas is introduced into the evacuated tube. As an atom of helium floats to within a few angstroms of the tip, the high voltage there tears an electron away from it. The helium—now a positively charged ion with an electron missing—is repelled violently from the tip of the needle toward the screen. The patterns of ions hitting the screen is a faithful reproduction of the atomic lattice at the end of the needle.

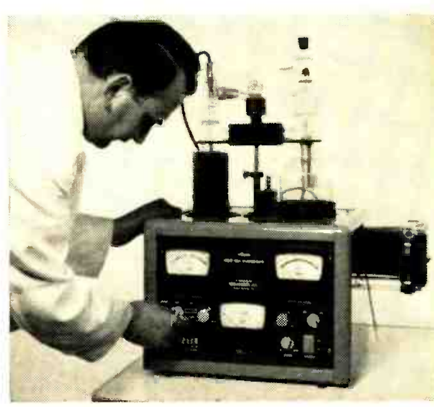
With this arrangement, Müller has succeeded in getting magnification up to 10,000,000 and resolution of less than 3 angstroms. At 10,000,000 the picture is very dim, so 2,000,000 is the approximate maximum practical amount of magnification.

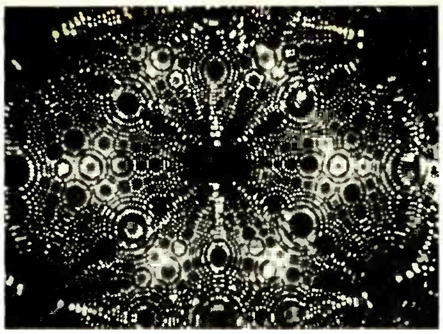
The ion-emission microscope has one serious drawback; it can be used only to examine metals, and then only a handful which have melting points above 1400°C. Metals which melt at a lower temperature vaporize when subjected to the high voltage necessary to ionize the helium atoms, and therefore cannot be used.

In spite of its limited applications, Müller's ion microscope is becoming increasingly important. Scientists are now using it to find out what really happens when a wire is annealed, to learn more about the crystalline structure of metals, to understand metal fatigue. Soon, we may approach a broader understanding of the mysterious action of catalysts.

Experimental model of Wilska's short-column low-voltage unit.

Newly commercialized version of Müller field ion microscope.





Crystalline structure of tungsten is shown on photomicrograph taken with field ion microscope. Each luminous spot in the photomicrograph represents an individual atom of matter.

Another offshoot from the early days of microscopy is the flying-spot ultraviolet microscope. The original ultraviolet instrument had several important defects which kept it from becoming widely used back in the early years of the century. One of the most important was that ultraviolet light quickly kills most forms of microscopic life which scientists were interested in observing. (It shared that fault with the electron microscope, of course.)

But two researchers at the University of Texas came up with a variation a few years ago which overcame this problem. They generated a spot on the face of an ultraviolet cathode-ray tube, which they swept in a raster through an ultraviolet microscope onto a specimen they wanted to study. The spot scans the specimen just as the beam in a TV camera scans the scene before it. Under the specimen, a photomultiplier tube collects the light, which varies in intensity as the transparency of the specimen it is sweeping varies.

The fluctuating signal developed by the photomultiplier is used to modulate the beam of a television picture tube, which is sweeping in synchronism with the ultraviolet spot. Since the spot is small and sweeps rapidly across the specimen, it has no effect on the organism being studied.

Although the combination of electronics and microscopy has already produced results of incalculable value, it seems likely that its future contributions may be even more spectacular. *RCA's* Dr. V. K. Zworykin, a pioneer in the field, recently put his thoughts on the electron microscope and its importance this way:

"Today, we know that the electron microscope has opened a great new dimension for human exploration in the world which we once labeled submicroscopic. The knowledge that has already resulted is surely only a small portion of that which has been brought within our ultimate reach as science continues to apply the electron microscope to the endless task of research." ▲

Negative-Resistance Devices

(*Continued from page* 51)

North observed that individually welded whisker diodes showed this effect when used as v.h.f. superhet converters.[6]

Such a.c. negative resistance has been observed in some conventional diode tubes operated at u.h.f.[7,8] This is a secondary effect resulting from electron transit time in the tubes. The mechanism involves the *dynamic* plate resistance of the diode, which decreases at ultra-high frequencies. When the transit time equals the period $(1/f)$ of the applied voltage, $R_p = 0$. At higher values of transit time, R_p is first above then below zero, its oscillating curve showing a negative slope in some portions.

Feedback Amplifiers

An amplifier provided with the proper amount of positive feedback may present negative resistance to circuitry connected to its input terminals. This applies to amplifiers of all types, such as vacuum-tube, transistor, magnetic, dielectric, and varactor. It is this very property that is utilized so widely in oscillating and regenerative circuits; the negative resistance provided by the feedback amplifier cancels the losses of the tank circuit into which it operates. A familiar example, in which loss cancellation results in a large increase in figure of merit, is the "Q"-multiplier.

The grounded-grid amplifier[1] operates very effectively as an a.c. negative-resistance device and has been exploited in telephony as a two-way repeater.

A general limitation of all a.c. negative-resistance devices is their requirement of an a.c. supply, which is sometimes inconvenient and which always limits the maximum speed at which the device operates. When a.c. supply and circuitry are already provided, however, or the application is of an a.c. nature to start with, and the supply frequency is high enough to permit maximum desired operating speed, a.c. negative-resistance devices offer distinct advantages. ▲

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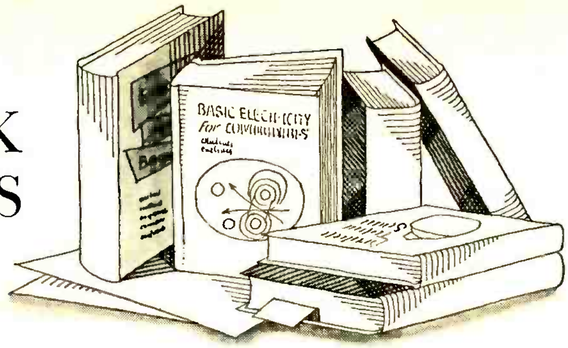
BOOK REVIEWS



"BASIC ELECTRICITY" by Bureau of Naval Personnel. Published by *Dover Publications, Inc.* 439 pages. Price $2.65.

This book comprises the text of a training course prepared by the Bureau of Naval Personnel as Navy Training Course NAVPERS 10086-A. Long considered one of the best things of its kind, this handy volume should find wide acceptance both as a text and a reference source.

The material is divided into two major parts, the first covering electrical theory while the second deals with the applications of the theory to the structure of electrical generators, motors, transformers, and magnetic amplifiers. The book is well illustrated with line drawings, schematics, graphs, and tables. A quiz is appended to each chapter for self-testing or classroom exam. Appendices include navy cable type and size designations, the Greek alphabet with definitions of those letters used in electricity and electronics, common abbreviations and letter symbols, electrical terms and formulas, and trig tables.

° ° °

"TROUBLESHOOTING HIGH-FIDELITY AMPLIFIERS" by Mannie Horowitz. Published by *Radio Magazines, Inc.* 125 pages. Price $2.95.

This handy little volume is written for the audio serviceman or the technician who wishes to add the servicing of audio equipment to his skills. Even the knowledgeable and experienced audio kit builder will find much information in this book that is well within his scope.

There are twelve chapters dealing with instruments and techniques, the power supply, troubleshooting a single stage, the output stage, the phase inverter, troubleshooting typical power amplifiers, distortion measurements, troubleshooting tone-control networks, the equalized preamp, heater-cathode leakage problem, the ground loop, and servicing stereo.

° ° °

"ELECTRICITY AND MAGNETISM" by Ralph P. Winch. Published by *Prentice-Hall, Inc.* 583 pages. Price $9.75. Second Edition.

As a result of experience gained in using the First Edition of this text in his college courses, Dr. Winch has made a number of meaningful changes in this new version. Although at least a year of college physics and a year of differential and integral calculus are prerequisite to an understanding of the material, we believe the average student will find this presentation more accessible and easier to grasp.

° ° °

"ELECTRIC CIRCUITS" by E. Norman Lurch. Published by *John Wiley & Sons, Inc.* 558 pages. Price $7.50.

This text will be equally acceptable to the student and those concerned with the broad field of electronics since the author covers power, instrumentation, and electronics with pertinent application data in each instance.

On the assumption that this book will be used as a classroom text, the material is presented progressively and in rigorous no-nonsense fashion. A strong mathematical background is prerequisite since the author has assumed that such techniques are part and parcel of the student's equipment. There are problems, review questions, and references appended to each chapter and six appendices provide basic data required of the student but not covered in the main body of the text.

° ° °

"MICROWAVE SYSTEMS FUNDAMENTALS" by F. Jonathan Mivec. Published by *Howard W. Sams & Co., Inc.* 281 pages. Price $5.95.

Like it or not, more and more engineers and technicians are getting involved in microwave systems as the means or adjunct to communications installations. It is to meet this need for an up-to-date single source of microwave data that this book has been written.

There are seven chapters in the book covering an introduction of microwaves, the behavior of microwaves, microwave transmission systems, cavity resonators, microwave transmitter oscillators, microwave receivers, and microwave antennas. The appendices cover the mathematical construction of the profile diagram and waveguide mathematics and equivalent circuits of amplifier and quartz crystal. ▲

THE MANY USES OF SOLDER

By HARRY J. ENTRICAN

The versatile commodity is handy, in and out of electronics, in numerous, seldom-realized ways.

IF YOU'VE ever splashed hot solder on your bare skin or fingernail, the experience doubtless made you a sadder but soberer solderer, sizzling but sincerely alert. It shouldn't prejudice you against that valuable commodity, however; for the ever-present roll of radio solder has many uses, in electronics and out, that are seldom dreamed of by those who work with it constantly.

For example: When storing away test leads, cheater cords, or other light wires, keeping them neatly bundled and untangled is always a problem. I've tried such things as rubber bands, twine, wire, and clamps, but none works as well as a short length of solder. Simply wrap a turn or two around the leads to be bundled and give it a twist. The length of solder can be reused when the test leads are to be bundled up again, but it may come in handy before then, as in the next application:

When a temporary hook-up, for testing or other bench work, is made, test leads or other long, interconnecting wires usually spread over the bench in a random way. It is exasperating and perhaps even dangerous, to equipment and to yourself, to have such leads interfering with what you are doing. Short strips of solder, used as temporary lacing cords, are excellent for turning such a rat's nest into an orderly arrangement.

Another application: A shorting bar is often needed on the bench, perhaps to short out the input of a circuit for a particular test or some other purpose. Simply reach for that handy roll of solder and use a suitable length. The medium is easily inserted under almost any kind of screw connector, can be fitted into a jack, or simply twisted around a lug.

Still another: When any equipment is pulled from its cabinet or rack, leads are usually too short to reach cabinet-mounted components. For example, when a TV set is pulled, short leads on a speaker plug may prevent connection to the speaker. There is an easier solution than unbolting the latter. Insert short lengths of solder (about one inch will do) into the female speaker plug. The flexible lengths can then be positioned so that the other ends can be fitted into the receptacle of any ordinary cheater cord, which then provides the needed extension.

A fifth use: You want to mount a component to a hole in a chassis with a self-tapping screw, but the hole is too large and the screw does not grip well. You might use a larger self-tapping screw, but an oversize one may not be handy and you might have to drill out a larger mounting hole on the component, which may cause deforming. Avoid trouble by filling the hole with a small length of solder. It will let the screw grip securely.

Applications do not end with electronics. If you also happen to be a fisherman, you should always carry a small hank of solder in your tackle box. Use it to apply sinkers quickly anywhere on a line; to equip flies, spinners, or plugs with more weight; to make temporary equipment repairs; or anything else you can think of.

Solder has also had romantic overtones. The tinkers of central Europe used to melt a spoonful of solder scraps and then pour it into a shallow bowl of cold water. The shape assumed by the hardened solder was then used to determine the fortune of the individual, as is done with tea leaves. The practice has been picked up and perpetuated by electronic technicians in that part of the world.

About the only place solder isn't helpful, as noted, is on the bare skin or fingernail, when hot. ▲

EUROPEAN COLOR-TV DEVELOPMENTS

By PATRICK HALLIDAY

DURING 1963 firm decisions are expected in several European countries on color television services which so far have not advanced beyond the experimental stage. Britain, for example, is committed to a 625-line u.h.f. color service but final technical characteristics are still unknown.

The main reason for the hesitation is the growing belief that a compatible color-TV system developed in France—"Secam" or "sequential and memory"—may prove more suitable than the adapted NTSC systems which have been used experimentally for several years by the *BBC* and other European broadcasting organizations.

This alternative color system, "Secam," already has many supporters and is currently under evaluation at the *BBC* high-power u.h.f. (450-mc.) transmitter in London, built in readiness for the new British black-and-white 625-line service scheduled to start in April 1964. "Secam" was originated by Henri de France and is now being actively developed by the *Compagnie Francaise de Television* in cooperation with other British and European companies. It differs in a number of important respects from the NTSC color system.

The "Secam" system transmits much the same basic information as NTSC: a luminance signal and two color-difference ("chroma") signals. But whereas in the NTSC system all this information is being transmitted simultaneously, with "Secam" only one chroma signal is being radiated at any given moment.

What happens is that during one line-period the first chroma signal is radiated on the subcarrier; during the next line-period the other chroma signal goes out, and so on in sequence. Since only one chroma signal is going out at a time the subcarrier can be frequency-modulated and the complex NTSC technique of two simultaneous signals in quadrature on a suppressed carrier is avoided.

At the receiver, a "memory" device—consisting of an electrical delay—is introduced to hold the information received from the first chroma transmission until the second chroma signal begins to arrive. Both chroma signals are then applied simultaneously to the matrixing and hence to the display tube—which can be a Shadowmask—over two line-periods. The usual form of memory device in "Secam" receivers is a quartz block in which signals are stored briefly by reflection from face to face. Such delay components are fairly expensive—about $11—but the total receiver costs are roughly the same or a little less than for NTSC receivers.

Since each chroma signal is sent out for half the total time, the vertical definition of the color is only half that of the NTSC system. However, because of the imperfection of human vision, there is little point in providing color definition equal to that of the luminance signal. In both NTSC and "Secam" systems the color definition in the horizontal direction is reduced to allow the information to be sent on the subcarrier. In "Secam" the color definition is similarly reduced in the vertical direction, permitting the chroma signals to be sent sequentially, but having little observable effect on the picture.

When first mooted several years ago, "Secam" demonstrations were watched by *BBC* engineers who then came to the conclusion that the new system would not supersede NTSC. Recent improvements, however, have made them much less certain and many now support the full-evaluation testing of "Secam" taking place in London and elsewhere. "Secam" has also been tested by the Swiss broadcasting authorities.

What are the practical advantages claimed for this color system? These are substantial both at the transmitting end and for the viewer.

The "Secam" waveform is considered to be much easier to handle, particularly for network distribution and for recording on magnetic tape. Again, since the strict phase conditions imposed on NTSC color signals no longer apply, the transmitted signal is much less affected by multipath propagation—that is by "ghost" signals. Since color TV is to be radiated in Britain on u.h.f. rather than v.h.f., this could be an especially important consideration.

Because there is no synchronous demodulation, "Secam" color receivers do not require a reference oscillator and —very important to the viewer—do not need "hue" or "saturation" controls. It is claimed that the unnatural colors which can arise from inaccurate setting of these controls on NTSC cannot occur on "Secam." Receiver servicing, with emphasis on accurate phase conditions, is also held to be much more straightforward.

An early problem with "Secam" was

the rather noticeable pattern on black-and-white pictures arising from the unsuppressed subcarrier. The adoption of frequency-modulation of the subcarrier and other modifications have reduced this patterning.

The chief engineer of one of Britain's commercial TV broadcasting companies which has been working on "Secam" for more than 18 months, has expressed a number of findings distinctly favorable to "Secam" although he states frankly, "No one can express an objective opinion on this matter until after the high-power tests have been carried out."

On the other hand, those who would like to see Britain adopt the NTSC system point out that experience in the United States and Japan has shown it to be a basically sound and practical system and that, unlike "Secam," most of the development work on receiver circuits and components has already been carried out.

Most Western European countries are anxious that the same color system be adopted in each country in order to facilitate the exchange of color programs. Some are also investigating a German *Telefunken* color system which combines features from both the basic NTSC and "Secam" ideas.

This year will see much color testing and talking in Europe. But the decision cannot now be long delayed. ▲

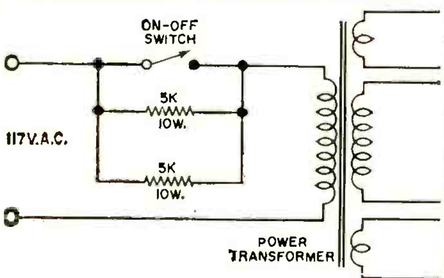
DAMP CHASER

By GEORGE P. OBERTO, K4GRY

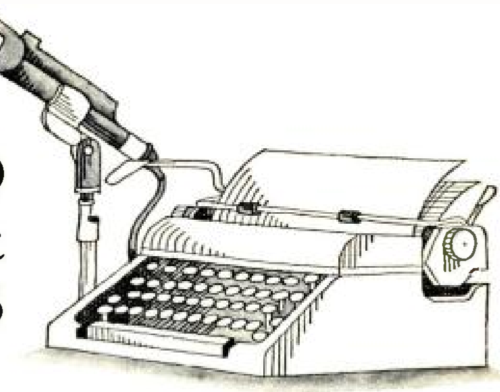
TROUBLED with extreme warm-up drift, dampness ruining components, and corrosion with TV and other electronic equipment? The remedy is to install a "damp chaser" made up of two resistors wired as shown in Fig. 1. These resistors should be located up under the chassis, around critical circuits. Here they will provide daily protection from dampness and extreme temperature changes because of the constant heat being radiated from the resistors.

By wiring the resistors across the equipment "on-off" switch, the resistors are automatically cut out of the circuit once the switch is in the "on" position. The network of two 5000-ohm resistors draw approximately 50 ma. and produce about 6 watts of heat. In cases where more heat is necessary, change the resistors to two 3000-ohm units which draw about 80 ma. from the a.c. line. These resistors produce 9½ watts of heat. ▲

Fig. 1. For more heat, reduce the value of the resistors to 3000 ohms @ 10 watts.



RADIO & TV NEWS



IN APRIL we took mournful note, in this space (page 86), of declining profit margins throughout the electronics industry, often in the face of rising unit production and sales. Exemption was hopefully extended to a relatively "new" component: "There may be nothing wrong in the price reductions on transistors."

So we thought. We are chastened by a sobering statement from *Raytheon*. During the rest of this year, that firm will be phasing out its semiconductor operations in Lewiston, Maine. Production of transistors and diodes will be consolidated at the company's Mountain View facility in California. Said *Raytheon* president C. F. Adams, "Our reasons for closing down this operation are based on the continued deterioration of semiconductor prices."

This manufacturer was among the first to produce transistors commercially, as well as an early transistorized, portable radio. Continued semiconductor production will be directed toward specialized military and industrial types rather than "entertainment" units.

Trade with Japan

It is no secret that a major brake on the production of domestic transistors and transistorized radios is the heavy influx, at low prices, from Japan. That same nation is now becoming a big factor in shipping Citizens Band gear to these shores. Tape recorders, TV receivers, and other electronic equipment from the island nation are significant—and growing—factors in our economy.

Many have taken an alarmist view of the situation, calling for voluntary "Buy American" campaigns, on the one hand, and protectionist action by Congress, on the other. In Japanese-made electronics, they see a serious threat to our economy. Since the problem is far from being a simple one, we espouse neither this position nor its opposite. That opposing view, however, is worth some consideration here, especially since the reasons for it are seldom publicized.

The most obvious one is that Japan is today a friend, and a needed one, of this nation. Trade between the two nations is more than a bribe to buy support. Japan's economy leans heavily on manufacture for export, with our country one of its leading customers. Loss of this business would weaken an ally.

Less well known is the fact that trade between both powers is a two-way street. Japan, in fact, is one of our best world customers. What is more, it is one of the few foreign powers with which we enjoy a favorable balance of trade. In other words, we sell more to them than they sell to us.

Nor is it a matter of electronics playing the goat for the benefit of other domestic industries. When attempts have been made to organize pressure for trade barriers against Japan, it is significant that many electronics firms have remained silent. They have good reasons. In the first half of 1962, Japan ranked sixth among principal markets for U.S. exports of electronic products! In other years, it has stood higher.

The type of electronic gear this customer buys from us obviously does not fall into the home-entertainment class. Complex industrial and lab equipment accounts for a good part of the purchases. Cheap labor is not much of a factor here. Even the latter advantage, we may note, has dwindled. As Japan (or any nation) prospers, the standard of living and wages rise.

This is not a plea for uncontrolled international trade. But there are two points worth considering: it is not conclusive that trade between the two nations is impairing domestic electronics more than it is helping it; and an important stand should not be based on appraisal of one side of an issue.

On the Service Front

Another attempt to organize service associations nationally outside the National Alliance of TV & Electronic Service Associations was launched recently. Representatives of groups from eight states and observers from four others met in Chicago to form the National Electronics Associations. Included were those who parted company with NATESA in the past year, as well as others never affiliated. Only time will tell whether this try can succeed where others failed. ▲

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Note to professionals: The Model 211 can be used as a highly efficient design and measurement tool. Recorded levels, frequencies, etc. have been controlled to very close tolerances—affording accurate numerical evaluation when used with test instruments.

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The Model 211 Stereo Test Record is a disc that has set the new standard for stereo test recording. Due to the overwhelming demand for this record, only a limited number are still available thru this magazine. They will be sold by ELECTRONICS WORLD on a first come, first serve basis. At the low price of $4.98, this is a value you won't want to miss. Make sure you fill in and mail the coupon together with your check ($4.98 per record) today.

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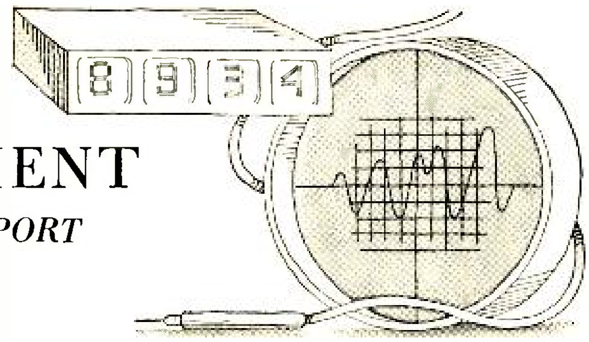


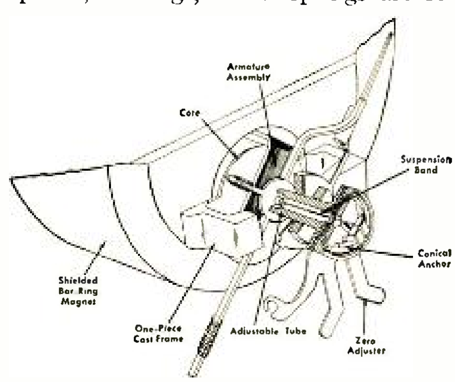
Triplett Model 630-NS Volt-Ohm-Microammeter

For copy of manufacturer's brochure, circle No. 58 *on coupon (page* 19).

SOME interesting advances in both meter and v.o.m. design are featured in the new *Triplett* Model 630-NS volt-ohm-microammeter. It incorporates a suspension-type meter movement and features a wide selection of voltage and current ranges. The high sensitivity of the 5-microampere meter movement (200,000 ohms per volt) allows its use in many measurements previously restricted to v.t.v.m.'s only.

The instrument's low-voltage ranges and high input impedance make it especially useful in transistor servicing. The low meter current allows voltage measurements with negligible loading on the circuit being measured. Even base-to-emitter bias voltages may be measured directly in most cases with minimum effect on the circuit. In most cases the Model 630-NS can effectively perform all the functions of a v.o.m. and a v.t.v.m. with its inherent advantages of greater accuracy, no warm-up, and no external power requirements. The input impedance on the 30-volt d.c. range is 6 megohms, allowing readings of 3 volts and lower at v.t.v.m. impedances. This will allow most a.v.c. and grid-bias voltages to be measured accurately.

The construction of the suspension meter movement is shown in the drawing. The moving coil of the d'Arsonval-type movement is "suspended" by two ligaments, or bands, of a special platinum alloy. These ligaments are approximately one tenth the thickness of a human hair (they measure .003 by .0003 inch) and yet have a strength five times greater than that of ordinary steel. They serve three functions in the meter: to support the moving coil in the magnet, to conduct the current to the coil, and to provide the torque or spring force to return the pointer to zero. Since no pivots, bearings, or hairsprings are required, the meter is extremely rugged; it has no friction and has greater sensitivity and repeatability than previously possible with pivot-type meters. Only 0.5 microwatt is required for full-scale deflection of the basic meter. The meter also employs a special bar-ring magnet structure which provides self-shielding against stray magnetic fields.



The meter is compensated for changes in temperature from 32°F to 104°F by a special thermistor compensating circuit. This is of particular value to the serviceman since it allows accurate measurements even when the instrument has been left in a cold service truck. Selected silicon diodes are used in the meter circuit to provide protection against accidental overloads which would normally bend the meter pointer.

Ranges on the Model 630-NS are selected by a single 24-position selector switch in conjunction with a "divide-by-two" (V-A)/2, switch. This switch effectively doubles the ranges available and results in greater accuracy of measurement since all voltage readings may be taken in the upper 60% of the scale.

D.c. volts may be measured in 13 ranges from 150 mv. full scale to 1200 volts full scale. Voltages on the (V-A)/2 ranges are at 200,000 ohms per volt, others are at 100,000 ohms per volt, except 0-150 millivolts, which is at 60 microamperes. A.c. volts are measured in 10 ranges from 1.5 v. full scale to 1200 v. full scale. Sensitivity is 20,000 ohms per volts in the (V-A)/2 positions and 10,000 ohms per volt on other ranges.

D.c. current may be measured in 13 continuous ranges from 5 μa. full scale to 12 amps full scale. The low voltage drop on the current ranges (150 millivolts in the (V-A)/2 range, 300 millivolts on others) is particularly valuable for measurements in transistor circuits where a higher voltage drop would affect circuit operation. The 5-microampere range allows accurate leakage measurements on all types of semiconductors including silicon transistors. Ohms are measured from 1000 ohms full scale to 100 megohms in six ranges. The maximum open-circuit voltage on any range of the ohmmeter is 3 volts or less. This allows ohmmeter tests on most transistors at safe voltage levels. The ohmmeter circuit is protected against accidental damage by a fuse in the input circuit.

The accuracy on all d.c. ranges is 1½% of full scale and 3% on the a.c. voltage ranges. The a.c. ranges are frequency-compensated to the rated accuracy from 30 cps to 20 kc. and will maintain 5% accuracy to 100 kc.

All readings are taken on a 5½" meter which is separately housed and protected by an unbreakable front. Seven scales are provided with a knife-edge pointer and a mirror for accurate measurements. The Model 630-NS is priced at $99.50. ▲

DeVry Transistorized Meter

For copy of manufacturer's brochure, circle No. 59 *on coupon (page* 19).

ONE of the most useful pieces of test equipment, particularly for checking voltages in high-impedance circuits, is the v.t.v.m. Such a meter can be shunted across very large resistors and, because of the minute amount of current drawn by the instrument, will have negligible loading effect on the circuit. Such v.t.v.m.'s are usually a.c. operated however, so they lack the convenience and portability of a completely self-contained instrument, such as a v.o.m. What is more, the v.t.v.m. is not usually able to measure current directly—and this is a real drawback when working on transistor circuits.

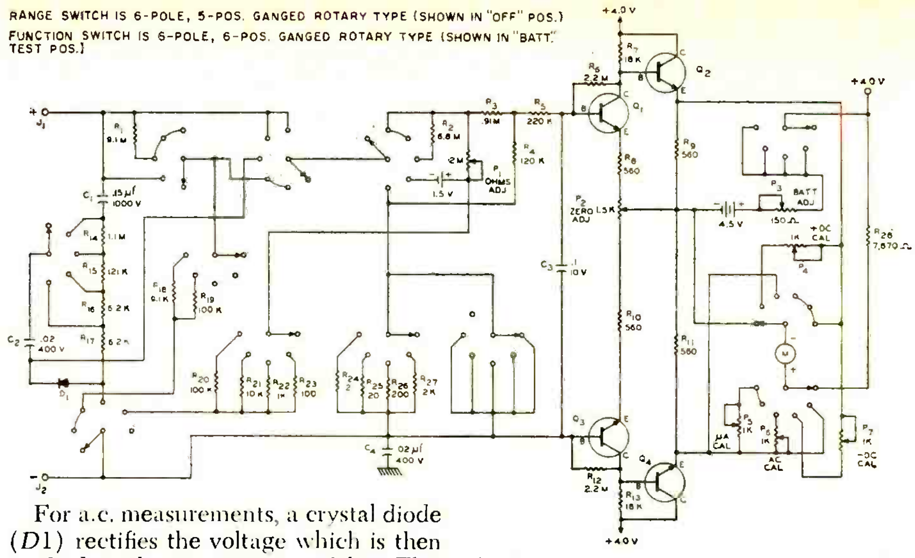
The new *DeVry* transistorized meter (TRVM-1) incorporates the best features of the v.t.v.m. and the v.o.m. in a single instrument. The unit is actually a "v.t.v.m." but with transistors taking the place of the usual vacuum tubes. The meter is completely battery-operated from four flashlight cells. It is ready to take measurements the instant the switch is turned on; there is no warm-up delay.

Four d.c. current ranges are included, from 50 μa. full scale to 50 ma. full scale. Even on the lowest current range, the meter will not be damaged by excessive current. In addition, there are four d.c. voltage ranges, from 1 v. to 1000 v. full scale, at an input resistance of about 1 meg. on the lowest range and 10 meg. on the three higher ranges. There are four a.c. ranges, from 5 v. to 1000 v., at an input impedance of up to almost 2 meg. These ranges are useful from 10 cps up to 500 kc. (± 1.5 db). Four resistance ranges are also included, from 10,000 ohms to 10 meg. full scale. The over-all accuracy of the instrument is specified as ± 3%.

The heart of the transistorized meter is the four-transistor differential amplifier shown in the schematic diagram. This is basically a two-stage push-pull amplifier with emitter-follower output. The total drain on the battery is approximately 6 ma. This means hundreds of hours of operation from one set of batteries, or as much as 1000 hours with intermittent use.

All transistors are silicon *n-p-n* types and provide extreme reliability. Operated far below normal voltages, they should never require replacement. The output transistors, *Q*2 and *Q*4, drive the one-milliampere meter movement that is connected from one emitter to the other. The amplifier circuit is designed so that the current through the meter movement can never exceed a safe value regardless of overload at the amplifier input.

Separate calibration potentiometers are switched in series with the meter movement on + d.c. voltage, − d.c. voltage, d.c. current, and a.c. voltage positions of the function switch. A separate position of the function switch connects the meter movement as a conventional voltmeter to check battery condition. A potentiometer adjustment can then be easily made to compensate for battery aging.



For a.c. measurements, a crystal diode (*D*1) rectifies the voltage which is then applied to the transistor amplifier. This diode operates at the same voltage on all a.c. ranges. As a result only one a.c. scale is required. No a.c. balance of the type used in v.t.v.m.'s is necessary.

The ohmmeter circuit permits the use of external batteries to extend resistance measurements to 100 megohms and higher if this is ever required. It also eliminates any drain on the ohmmeter battery if the function switch is left in the ohmmeter position for long.

The transistorized meter is available directly from the manufacturer completely wired at $89.50, and in kit form at $64.50. ▲

Keithley Model 121 Wide-Band R.M.S. Voltmeter

For copy of manufacturer's brochure, circle No. 60 *on coupon* (*page* 19).

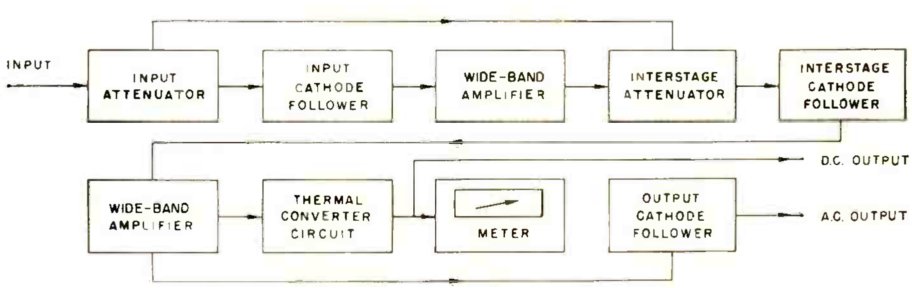
BY measuring the heating effect of an applied a.c. voltage, the new *Keithley* Model 121 wide-band voltmeter is capable of indicating the true r.m.s. values of complex a.c. voltages. The instrument is able to do this over a frequency range from 15 cps to 50 mc. The wide-band response of the unit minimizes errors due to attenuation of harmonics. For example, ten harmonics of a pulse train having a 5-mc. fundamental will be passed. Accuracy is within 1 percent up to 10 mc. Twelve voltage (and db) ranges are provided, from 1 millivolt full-scale to 300 volts full-scale.

In addition to measuring complex voltages, the voltmeter can be used to measure noise in components, white noise in electronic equipment, and waveform distortion. It will also find use in the fields of vibration, sound, and optics, and for the calibration of other a.c. equipment. The meter amplifier can be employed as a low-noise scope preamp, with a usable frequency response from 10 cps to 100 mc.

Special epitaxial transistors are utilized for the wide-band amplifiers because of their high gain-bandwidth product. The basic circuit is that of a conventional feedback amplifier, and no inductive peaking is used to extend the high-frequency response. The high-gain transistors permit the use of sufficiently low value collector load resistors to minimize the effects of shunt capacitance. Hence, the high frequencies are not rolled off. Also, 100 db of negative feedback keeps the response flat and provides gain stabilization.

The input cathode follower is a nuvistor tube. This provides an input impedance of 1 megohm shunted by 20 pf. The tube is used in order to withstand signal overloads. For example, it withstands overloads of 50 volts r.m.s. at signals below 100 mv. and up to 400 volts r.m.s. on the 300-volt range.

The thermal converter circuit employs a thermocouple and a chopper-stabilized amplifier to insure stability and fast response. It is self-balancing with the output voltage of the thermocouple always maintained at a constant 100-mv. d.c. level. With no applied a.c. signal, the thermocouple output is maintained by



applying a d.c. bias current to its heater. When an a.c. signal is applied to the heater, its heating effect unbalances the circuit. Balance is restored by reducing the quiescent bias current. The change in bias current is proportional to the r.m.s. value of the applied a.c. signal and is read directly on the meter. A second thermocouple serves as an ambient-temperature compensator. Hence, the reading is stable and is not affected by normal changes in surrounding temperature.

The price of this special-purpose voltmeter is $870. Input impedance can be increased to 10 meg., 15 pf. by a separate cathode-follower probe for signals up to 300 mv. ▲

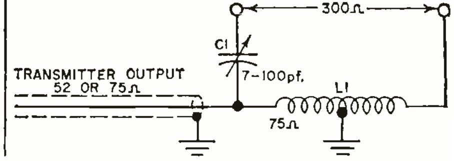
6-METER ANTENNA COUPLER

By PAUL FALK, K3EJU

MOST six-meter transmitters have an antenna output impedance of 52 or 75 ohms and are designed to work directly into the coax antenna cable. However, many antennas and components have an impedance of 300 ohms or more. It is customary to use a coax balun or coil-type balun to match such components with the transmitter output circuit.

The circuit shown here is a "Q"-type impedance transformer and provides a more exact impedance match than most baluns, resulting in no loss of signal strength, less radiation of unwanted frequencies, and better standing-wave ratio.

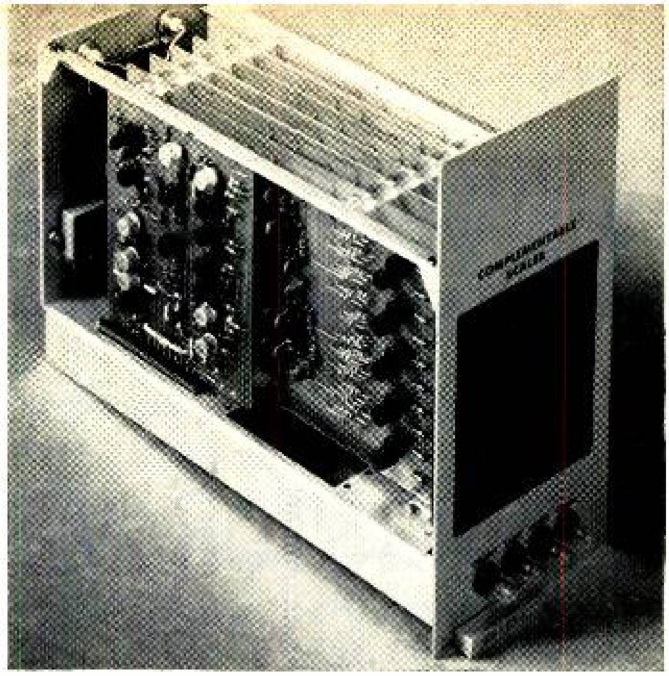
L1 consists of 8 turns of #10 enameled copper wire wound on a 3/4" dowel which is then removed. The coil should be stretched so that there is a 1-wire-diameter spacing between turns. Center-tap at 4 turns. C1 is a 7 to 100 pf. (μμf.) mica trimmer capacitor. ▲



SILK-SCREEN PRINTING FOR PANELS

By RICHARD W. BAILEY
Research Associate, Ohio State Univ.

Simple technique for labeling equipment panels that can be employed by small electronics laboratories.



Equipment with small panel that has been printed by this method.

THIS article outlines a technique for silk-screen printing, directed principally at the small electronics laboratory that finds itself with a completed piece of electronic equipment and is faced with the problem of making it look presentable.

The general idea of silk-screen printing is to make a stencil with no pieces of the letters missing. This is accomplished by using a gelatin-base film that will adhere to a piece of silk, nylon, or stainless steel of sufficient mesh to give the resolution required by the process.

Equipment & Hardware

The first piece of hardware needed is a wooden frame with the silk, nylon, or stainless steel mesh attached to it. This frame should be of about 1⅝" square stock for a screen large enough to print a regular 19" relay-rack panel. For most purposes 240 mesh nylon cloth will be satisfactory. This mesh gives quite sufficient resolution for ⅛"-high letters. The principal advantage of the nylon over the silk is strength. The stainless steel is still more durable but costs a great deal more. The cost for 240 mesh nylon cloth mounted on a frame 20" long by 12" wide is about $8.00 and it can be re-used time and again.

The second object of hardware one needs is an ultraviolet light source. A home sun lamp is ideal for this purpose.

The next piece of equipment required is a contact printing frame large enough to take the artwork of the printing. This can be a wooden frame with Plexiglas face. Careful construction is required so that the artwork fits flat against the film.

A shallow tray, large enough for washing the screen, and a rubber squeegee are needed for the actual printing. The squeegee is a hard rubber strip, fitted with a wooden handle, large enough to cover one dimension of the printing area.

The only other materials needed are the film, its developer, and a small amount of acetic acid. A solution of 1 part acid to 25 parts water is employed to size the screen before the mounting of the film that is used.

Procedure

Now by following the step-by-step procedure outlined one can do a professional job of silk-screen printing.

The initial task is that of preparing the artwork. Although photographic technique can be employed for adjusting size and contrast, it is not required. Simply use art letters with adhesive backing (*e.g.* Arttype, Crafttype, or Presstype) and lay them on a transparent backing of vellum or acetate. Use care to keep the artwork free from blemishes as they will otherwise have to be removed from the film. The art letters are available from many types of suppliers, including graphic arts supply or art supply houses. They are also relatively inexpensive, costing $1.00 or less for a standard sheet. A standard sheet has approximately 1500 letters, numerals, and various punctuation marks for a letter height of about ⅛ inch.

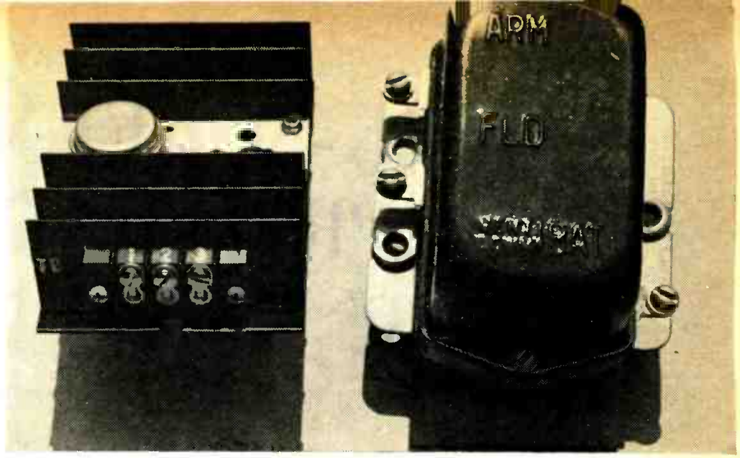
Having prepared the artwork, the next step is to expose a piece of film. Several films are available but we have found that *Ulano* "Hi-Fi" green film is very satisfactory. This film is also relatively inexpensive (about $3.20 for a 20" x 30" piece) and has a fairly long shelf life if kept in a dark place. The construction of this film consists of a gelatin layer on a rough plastic backing.

Now to prepare a film one takes the artwork, places it face down against the plastic backing of the film, and exposes it to ultraviolet light. The light travels through the artwork and the backing of the film and produces an image in the gelatin. Remember, the artwork goes face down on the film. For a home sun lamp at a distance of about 10" approximately 2 minutes are required for exposure (at this time size the screen with the acid solution). After the exposure time is up, wash the film in the developer. The developer consists of powders "A" and "B" and is made, as is the film, by *Ulano*. Mix the powdered developer in accordance with the packaged instructions.

The film is agitated in this developer for about 2 minutes. Next, using a light spray of tap water at about 100 to 120 degrees F, wash the film until the image of the artwork appears. Continue washing until all of the gelatin is removed from the letters and numerals. Place the film gelatin-side up, against the screen, blotting all excess water from the reverse side of the screen. Allow the moisture to evaporate completely from the film. Depending on drying procedure adopted, this could vary from 5 minutes (using a hair dryer) to 3 or 4 hours if left at ambient.

After the film has dried completely, peel off the plastic backing, leaving a completed screen ready for use. Now register your panel beneath the screen. Make sure the screen is about 1/16" from being in contact with the panel. When the squeegee is pressed against the screen, it will force it down to the panel and will print through the openings. The screen will then return to its position above the panel.

One should give some thought to the selection of the paint. Paints are made especially for the screen process and are recommended. Use lacquer for quick drying, enamel for slower drying if a number of identical units are to be printed. Place a generous amount of paint on the screen and force it down through the film stencil on to the panel with the squeegee. The job is now completed with the exception of cleaning up the screen. First use an appropriate washout or thinner, depending on the paint chosen, to remove all paint. The film may then be removed by washing it off with very hot (200°F) water. ▲



A simple transistorized series regulator is employed along with a conventional auto regulator.

TRANSISTOR VOLTAGE REGULATOR

By JOHN R. GYORKI / Heller's Communication Service

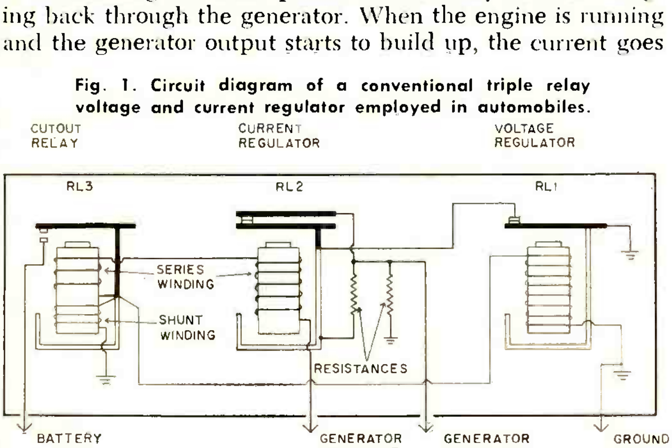
A NUMBER of mobile radio service companies use an automobile battery and a motor-generator combination to furnish the radio test bench with low-voltage, high-current power. Many more shops, however, employ a storage battery and a charger. Few companies, if any, would use just an ordinary low-voltage power supply that converts the 117-volt a.c. line to high-current d.c. The reason for this is that a conventional power supply alone usually has very poor voltage regulation for current demands that fluctuate heavily when the transmit button of the radio is depressed and released. Also, the output impedance of the power supply is normally high compared to that of a storage battery. A regulated low-voltage, high-current power supply could be purchased, but it would be comparatively expensive and the application may not warrant such an outlay.

The automobile storage battery and charger combination is probably the most popular with service technicians. The charger is connected to the battery and then turned on when a radio is put on the bench to be serviced. After the radio is repaired and disconnected from the source, the charger is allowed to run for awhile to bring the battery up to par again. Then the charger must be turned off and the battery disconnected so that it will not discharge back through the power supply. The nuisance of watching over a battery so it will not become overcharged and disconnecting it so it will not discharge, can be eliminated by using an ordinary automobile voltage regulator in the manner to be described.

Standard Voltage Regulator

The standard voltage regulator (Fig. 1) consists of three major components. The first of these is the cutout relay, *RL3*. This relay is normally open when the engine is idling slowly or not running at all and prevents the battery from discharging back through the generator. When the engine is running and the generator output starts to build up, the current goes from the generator through the series and shunt coils to ground and energizes the relay; connecting the generator to the battery. The second relay, *RL2*, is the vibrating current regulator which controls the output current of the shunt-wound generator. This regulator keeps the current output of the generator within safe limits since a shunt-wound generator does not have any inherent current-limiting features.

Fig. 1. Circuit diagram of a conventional triple relay voltage and current regulator employed in automobiles.



The third component is the vibrating voltage control relay, *RL1*. Spring tension on the armature of the voltage regulator relay holds the contacts closed until the generator output reaches a predetermined voltage. As the voltage approaches this value, the current through the coil winding magnetizes the core sufficiently to draw down the armature, thus opening the contact points. This inserts resistance in series with the field winding and reduces output voltage. A bi-metallic hinge is usually employed on the regulator armature so that more voltage will be required to open the contact points in cold weather since a higher voltage is necessary to charge the battery in cold environments.

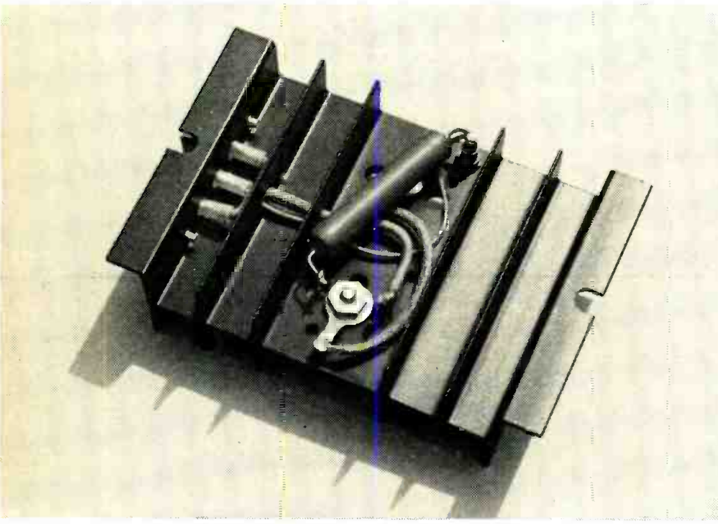
Transistorized Voltage Regulator

The transistorized electro-mechanical voltage regulator is simply a conventional automotive regulator wired to a transistor circuit which takes the place of the generator field function. See Fig. 2. It is used with an ordinary unregulated power supply or a battery charger and a 12-volt storage battery. The voltage and current regulator relays of the standard regulator control the field current of the generator by adding resistance to the normally grounded end of the field circuit. The resistors found on the original regulator must be removed in the transistorized application since the relays will now be used to control the base current of a power transistor.

The cutout relay operates the same in the transistorized system as it does in the automobile. When the power supply is turned on, current flows through the series and the shunt windings. The two resulting magnetic fields act in the same direction and add to pull down the relay armature, connecting the battery to the power supply through the transistor. When the power supply is shut off, the battery voltage being higher than the supply voltage (charge left in the filter capacitors), a reverse current flows from the battery to ground in the shunt winding and from the battery to the power supply to ground in the series winding. These two currents will now produce opposite poles in the core of the cutout and the magnetic pull on the relay armature arrests, opening the circuit so the battery will not discharge back through the power supply.

The current regulator, *RL2*, limits the maximum amount of current flowing out of the power supply. The full charging

Construction details of a simple series regulator circuit that is designed for use with unregulated bench supply or charger and storage battery. Employed for mobile radio servicing.



Underside of the transistor heat sink showing placement of the base bias resistor. Note wiring to insulated terminal board.

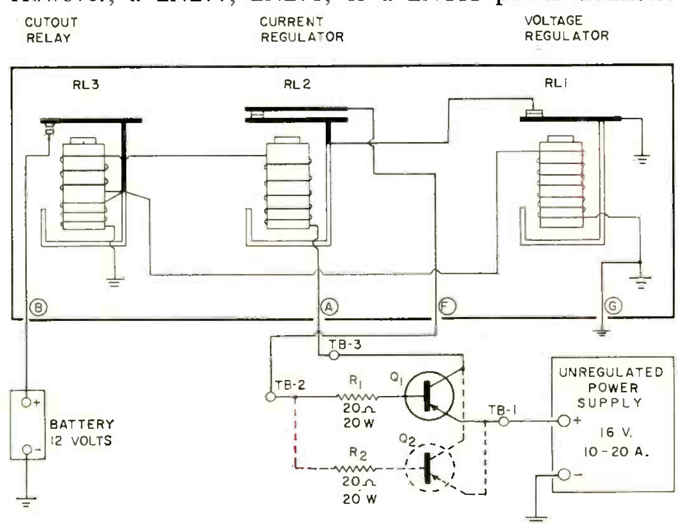
current going to the battery must pass through the current regulator coil winding. This current sets up a magnetic field and a pull on the relay armature. If the current (and resulting magnetic pull) is in excess of that for which the armature tension is set, the relay opens, disconnecting the transistor base from ground and shutting off the current going to the battery. As soon as the circuit is open, however, the regulator field collapses and the relay snaps back. This, in turn, sets up a field again and the process is repeated from 150 to 250 times per second. This action serves to keep the power supply from exceeding its maximum rated current capacity.

The voltage regulator, *RL*1, controls the maximum battery terminal voltage. When the battery voltage reaches some predetermined voltage during charge (about 15 volts), the current in the shunt winding builds up enough magnetic strength to pull the relay armature down against the spring tension. This opens the base circuit of the transistor and shuts off the charging current. When the battery voltage decreases slightly, the magnetic field weakens and allows the contacts to close again. This turns on the transistor and permits the power supply to charge the battery again. This cycle is repeated from 50 to 200 times per second to cause the armature to vibrate and so hold the voltage to a reasonably constant value.

When the power supply is turned on and *RL*1 and *RL*2 contacts are closed, about 600 ma. of base current flows; the transistor is now "turned on" or saturated. The collector-to-emitter impedance is very low (about .080 ohm) and maximum collector current (charging current) flows. When either *RL*1 or *RL*2 contacts open, however, due to excessive voltage or current, there is no base current flow and the transistor is "turned off" or cutoff. The collector-to-emitter impedance is very high; approaching that of an open-circuit condition.

*RL*1 can be adjusted over a range of voltages by changing the spring tension on the relay armature. *RL*2 should be adjusted to limit the collector current to 10 amperes when one transistor is being used. If more charging current is required, another transistor (*Q*2) can be connected, as shown in Fig. 2 in dotted lines. Two transistors can handle a current of 20 amperes, providing the power supply being used is capable of coping with 20 amperes at 16 volts d.c.

The regulator shown in the photographs was constructed for a charging current of 5 amperes at 16 volts. The transistor should have a collector current rating sufficient to handle the desired charging current. The one shown is a 2N174. However, a 2N277, 2N278, or a 2N441 power transistor



R1—20 ohm, 20 w. res.
R2—20 ohm, 20 w. res. (optional, see text)
TB1, TB2, TB3—Three-terminal barrier strip (Cinch-Jones #3-140)
Q1—2N174, 2N277, 2N278, or 2N441 transistor (see text)
Q2—Same as Q1 (optional, see text)
1—Voltage regulator (Auto-Lite No. VRX-6201A, Delco-Remy No. 11-190013, or Allstate Standard; Sears, Roebuck)
1—Single-punched heat sink (Delco No. 7270725)
1—Double-punched heat sink if Q2 is used (Delco No. 7281352)
1 or 2—½" stand-off insulator
3—Solder adapters for barrier strip (Cinch-Jones #Y-140)

Fig. 2. Circuit arrangement showing use of series transistor. For doubled current output, a second transistor may be employed.

may be used. Even some "bargain" transistors can be used in most cases since the maximum collector-to-emitter voltage is 16 volts or less.

When mounting the transistor on the heat sink, a little silicone grease should be placed between it and the heat sink for best thermal conductivity. The heat sink is electrically connected to the collector of the transistor so care should be taken to see that nothing of a different potential may short up against it.

The heat sink has an area of about 80 square inches and has a three-terminal barrier strip installed at one end for connection to the transistor emitter, base resistor, and collector. The base-bias resistor is placed under the heat sink by means of an insulating stand-off terminal, as shown in one of the photographs. The heat sink is mounted vertically under the test bench alongside the conventional automobile voltage regulator. ▲

EFFECTS of RADIATION on ELECTRONIC COMPONENTS

By EDWARD TROMANHAUSER

What happens to a capacitor, transistor, or vacuum tube when exposed to nuclear radiation? Here is what investigators have learned about this problem.

TREMENDOUS amounts of money are being spent by our government to determine the effects of nuclear radiation on electronic components and systems. The Defense Department and the National Aeronautics and Space Administration have spent over $150-million on this problem in the past few years.

Much of this research has been concentrated on the exposure effects on equipment operated near nuclear reactors—such as are used in our atomic submarines. Other tests have been equally important. If a missile or aircraft passes through an atomic cloud, the electronic equipment is exposed to intense *gamma* radiation. The effects of this radiation can be great enough to cause the missile guidance system to malfunction or the navigational equipment in the aircraft to fail. Receiving and transmitting equipment, radar, fire-control systems, and computers all can be damaged by nuclear radiation. We must know how to counter this danger by using radiation-resistant components and adequate shielding.

Reasons for Damage

Practically all materials will sustain some change in a radiation field due to the action of the radiation on the atomic and molecular structure of the materials. The degree of change is a measure of the radiation damage and is a function of (*a*) type of material, (*b*) type of radiation, and (*c*) amounts of radiation particles and their energies.

As radiation particles travel through a material they transfer part of their energies to the electrons and nucleus of the material and rupture the chemical bonds, producing ionization and atomic displacement. For example, proton damage to a transistor consists of ionization and impact damage. After exposure to large amounts, the current gains of germanium transistors have fallen from 70 to less than 20.

Some electronic components hold up very well under intense radiation, among these are the vacuum tube, ceramic and mica capacitors, copper wire, transformers, and printed-circuit boards. Air entry is the most common cause of vacuum-tube failure and is due to the deterioration of the envelope seals. Insulation will deteriorate in a radiation field long before the conductor material is affected. Ceramic and mica capacitors show almost no change in ratings although due to disassociation and disorder produced in the molecules of the dielectric, there is a tendency for all capacitors to decrease in capacitance when subject to radiation. Since the same types of components are used in our civilian commercial equipment, the conclusions reached by investigators will be of interest to everyone in the field of electronics.

Although the exact *gamma* spectrum from a nuclear blast is not precisely calculated, it may be assumed that all electronic equipment within the line-of-sight radiation area will be affected to some degree. By the time the nuclear radiation reaches the electronic system, the energy spectra will have been modified to some extent by passage through the atmosphere. It is known that at lesser radii from an atomic detonation there are proportionally greater energy *gamma* rays than one would expect at greater radii. *Gamma* rays lose their energy mainly by Compton scatter, photoelectric absorption, and pair production.

Types of Radiation

Before we discuss the effects of radiation on electronic equipment, let us find out what types of radiation we have to deal with. Radiation can be divided into two groups or types: (1) charged particles—electrons and protons and (2) uncharged particles—neutrons, *gamma* rays.

For measuring *gamma* we use the roentgen as the unit of measurement. The roentgen is defined as x-ray or *gamma* radiation producing, by ionization, 1 *ESU* (one electrostatic unit of electricity) in 1 cc. of air. For measurement of neutron radiation we use the *NVT* or number of particles present in unit volume, multiplied by their velocity ($N \times V \times T$).

Radiation-Sensitive Components

Among the most radiation-sensitive components we find the transistor. Loss

Table 1. The effects of radiation on various commonly used electronic parts.

ELECTRONIC COMPONENT	RADIATION EFFECTS
1. Resistors	In general, a 5 to 20% change
a. wirewound	5% increase in value
b. film	5% initial increase
c. carbon	15-20% decrease in value
d. composition	5% change, plus or minus
2. Capacitors	In general, a decrease in capacitance
a. mica	Very radiation resistant
b. glass	Very radiation resistant
c. paper	5 to 20% decrease in value
d. plastic	Deterioration of dielectric
e. ceramic	Very radiation resistant
f. electrolytic	Breakdown and failure in a matter of hours under constant radiation
3. Semiconductors	In general, loss of ability to rectify
a. transistors, all	Loss of amplification
b. silicon diodes	Loss of rectification
c. germanium diodes	Loss of rectification
d. cuprous oxide	Loss of rectification
4. Vacuum tubes	In general they hold up very well. When they do fail, they do so without any warning, in a matter of seconds. Loss of vacuum and failure.
5. Gas tubes	Premature firing, loss of regulation.
6. Phototubes	Radiation acts upon light-sensitive materials as do light rays.
7. CRT tubes	Glass discoloration, some go gassy. The phosphors are radiation sensitive.
8. Insulation	In general, a decrease in insulating properties.
a. plastics	Decrease in insulation
b. polyethylene	Loss of tensile strength
c. rubber	Becomes brittle
d. glass	Clouding
e. nylon	Becomes brittle
f. ceramics	Reduced thermal conductivity

of *alpha*, an increase in leakage current, and barrier failure are common. Other semiconductors, such as germanium, silicon, and cuprous oxide diodes, all fail in a radiation field through loss of rectification qualities. Radiation destroys the barrier until the diode acts as a mere resistance in the circuit and conducts in both directions. Depending on the intensity of the field, this may take from 1 to 20 hours. The time factor varies with the type of diode.

Oil-paper capacitors have their plates expanded and may burst and short out due to the gas generated by the action of radiation upon the oil or wax. Resistors may change in value as high as 24 per-cent.

Table 1 illustrates the type of damage done to the most common components. As investigation continues, many new problems will be highlighted and design changes made in vital equipment used by business, industry, and the military. Already certain recommendations can be made in the design of equipment. Inorganics should be used whenever possible because of the instability of organics when subjected to radiation. In certain applications, the substitution of vacuum tubes for transistors will have to be made. Some equipment must be made to function with wider voltage tolerances. Some types of lightweight shielding should be designed to minimize radiation damage.

Many of the problems are in the process of being solved by NASA as it extends its space program and more electronic equipment is being packed into each payload that has to pass through the Van Allen radiation belt where the delicate subminiature instrumentation can be seriously damaged by radiation. ▲

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2. *Pigg, J. and Robinson, C.: "Radiation Effects in Semiconductor Devices," Proc. Transistor, New York University Press, 1956, pg. 77.*
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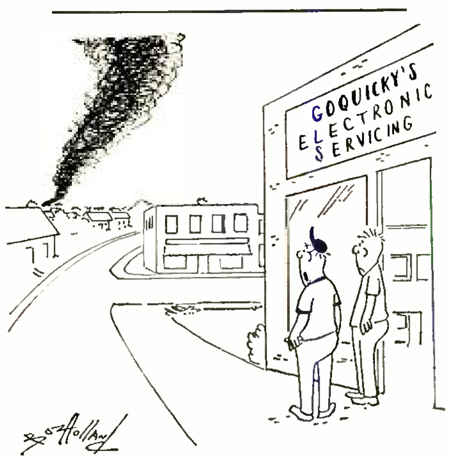


"I'm a little uneasy about it with Teely out on his first call."

V.H.F. Marine Radiotelephony

(*Continued from page* 49)

equipped with a channel selector which automatically resets the receiver and transmitter to 156.8 mc. after operation on another channel.

On some commercial vessels two or more receivers are provided so that 156.8 mc. and other channels may be monitored at all times between actual transmissions while working on other than the continuously monitored channels.

Type-accepted equipment that can be used on the v.h.f. marine band is listed in the FCC's "Radio Equipment, Part C." Procedures for obtaining type acceptance for non-type-accepted equipment are explained in Part 2 of Volume II "FCC Rules and Regulations." Complete information on maritime radio regulations is contained in Parts 7 and 8 of Volume IV "FCC Rules and Regulations." All these publications are available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C. or a field office of the U.S. Department of Commerce.

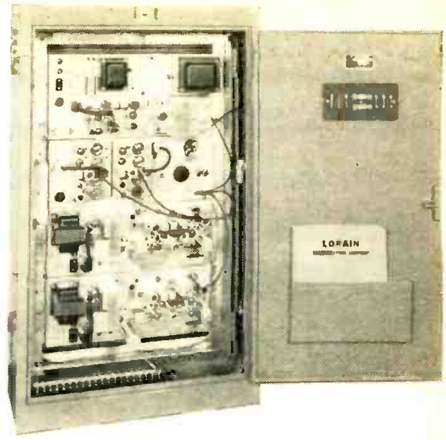
A new v.h.f. set, modified or equipped for three- or four-channel operation will cost from $400 to $900, which is not much more than the cost of a high-grade medium-frequency marine radiotelephone.

Since thousands of v.h.f. mobile radio units that do not meet the more stringent land mobile radio technical standards must be replaced by November 1963, it should be possible to pick up these sets at a considerable saving.

Antennas

An antenna system will be needed, of course, but since most v.h.f. antennas have their own ground planes, separate grounds are not usually required. One of the lightweight coaxial antennas can

Packset can be licensed as utility station.



An example of a v.h.f. frequency-modulated radiotelephone unit that produces an r.f. output of 50 watts on eight marine channels.

be easily rigged to the top of a mast or bracketed to the exterior of a cabin. Where appearance is more important than range, an 18-inch, quarter-wave flexible wire whip antenna can be mounted on the cabin roof. In this case, a screen or sheet metal ground plane extending at least 18 inches from the base of the antenna will have to be installed. If a sturdy mast is available, a ground-plane antenna with a vertical driven element and ground radials about 18 inches long will do a good job. Best is one of the colinear high-gain antennas. These may have a power gain of almost 6 db, boasting effective radiated power four times and doubling receiver sensitivity.

Coaxial cable must be used for feeding the antenna. Because of its convenient small diameter, RG-58/U cable will probably be more acceptable than the more efficient, but thicker and more expensive RG-8/U or foam-type cable. In marine applications it is particularly important to make all coaxial connectors watertight. The cable should be secured so it won't whip around in the wind.

Some ignition noise suppression may be required, but not to the extent required when operating in the medium-frequency or Citizens Band. In these bands the effective communicating range is limited considerably by noise—static and ignition interference. Also, in the medium-frequency band, range is additionally limited by the necessity to employ an antenna which is only a fraction of the length of a full quarter-wave antenna. However, in the v.h.f. band, maximum efficiency antennas can be used even on small craft.

Communicating Range

Ship-to-shore communicating range depends upon the effective elevation of the shore station antenna, the elevation of the boat's antenna above the water, the nature of the obstructions between the boat and the shore station, power output of the transmitter, and sensitivity of the receiver. Since the shore station generally has a powerful transmitter, effective communication depends largely on the shore station's ability to receive your signals.

On the Great Lakes, privately operated v.h.f. shore stations, in service more than 15 years, frequently intercommunicate across Lake Michigan, a distance of about 80 miles. The associated car ferries are able to talk with one or another of the shore stations even midway across the Lake. In areas where there are intervening islands, range would be drastically reduced.

Ship-to-ship range across open water depends on the elevation of the ship's antennas. Under typical conditions, range is around 15 miles.

Such v.h.f. ship-to-shore communication is possible only in areas where there are v.h.f. marine shore stations. The Gulf, Pacific, and Atlantic Coasts, as well as the Great Lakes and Mississippi River, are pretty well covered by v.h.f. stations. But there are many inland lakes that are not served by shore stations on these frequencies. Such areas are not covered by medium-frequency shore stations, either.

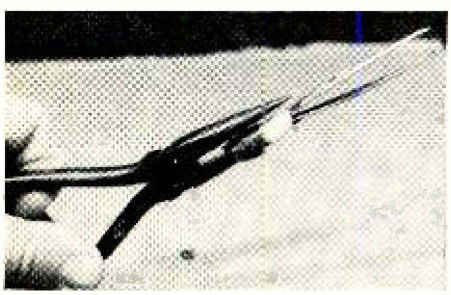
At the present, v.h.f. marine radiotelephony does not satisfy all of the communications requirements of boats operated at great distances from shore. Most v.h.f.-equipped commercial vessels are also outfitted with medium-frequency radiotelephones. But, for the part-time sailor who stays within 25 miles of shore, v.h.f. can provide more satisfactory communications—virtually free from noise—and without the congestion and interference existing on the lower frequencies. ▲

TWEEZER EXTENSION

By GLEN F. STILLWELL

TWEEZERS are sometimes needed to insert tiny screws, pins, lock keys, etc. in close places or restricted areas. Similarly, such a tool is often needed to remove tiny unwanted items from compact instruments or mechanisms. Unfortunately the working area is often so restricted that the tweezers cannot be manipulated successfully.

To provide a suitable extension for use in such places, simply tape the tweezers to one jaw of a pair of longnose pliers, as shown in the photograph. The tweezers are situated in such a way that when the jaws of the pliers are closed it will also close the tweezer jaws so that the tiny part can be picked up and held or released, as desired. ▲



NEW CONNECTORS AND TECHNIQUES

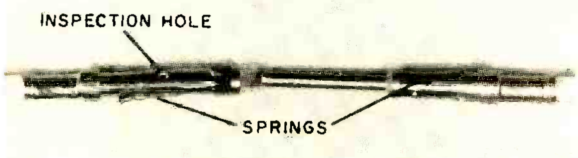


Fig. 1. A crimped pin and its mating socket, with wires already inserted. One connector may hold hundreds of these.

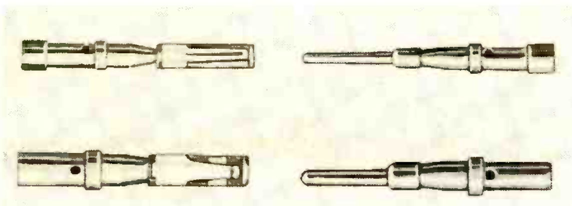


Fig. 2. Two of the many available pin-and-socket pairings.

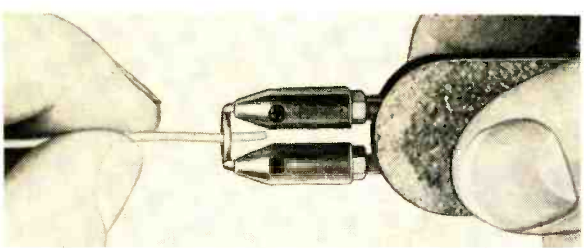
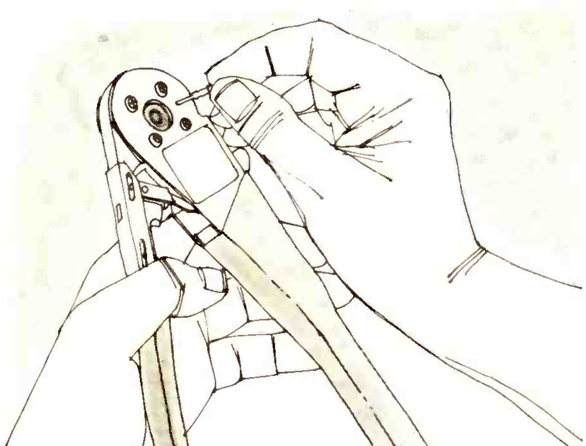


Fig. 3. Using a thermal wire stripper. Heat melts insulation.

Fig. 4. A single contact being inserted into crimping tool.



THE GREAT emphasis on reliability in electronics, originating with military and industrial requirements, has had effects everywhere. It has not only spread to other areas of electronics, but has wrought changes in all types of components used, including that indispensable class of components, connectors.

Interconnecting devices are available in a wide range of types, sizes, shapes, and cost. One may encounter a single-contact plug and jack; on the other hand, a connector in modern digital equipment may have several hundred contacts. In critical applications, these devices must be temperature-stable, moisture-proof, and otherwise have high reliability.

Until a few years ago, the contacts of most connectors were permanently fixed in the insulator body, with each wire soldered to its respective contact. If wiring up a large number of closely spaced pins without spilling solder or producing cold solder joints was a prodigious feat, inspecting the connector to make certain that all joints were good was nearly impossible. In a chain of otherwise highly reliable equipment, connectors often proved the weak links.

A well established technique borrowed from the electrical-appliance field has now superseded the soldered connector, where reliability is a factor. New connectors use removable rather than fixed contacts and each of the latter is crimped to its wire rather than soldered. The great advantage of removability is that any contact can be taken out and replaced without disturbing the rest of the assembly. As to the solderless technique, there appear, at first, to be certain disadvantages. But they are easily overcome.

In crimping, a stripped wire is simply inserted into a metal sleeve or other opening in the contact and the surrounding sleeve is squeezed tightly against the wire. If the sleeve is too large (or the wire not large enough), the individual strands will have room to shake loose. The wire can also pull loose if the squeeze is not tight enough. If the squeeze is too tight, on the other hand, strands in the wire may be broken, resulting in weakness.

The sleeve metal can also be a factor. If it is too springy, the crimp will eventually lose its tightness. If it is too brittle, the crimping operation will cause cracking and the weakened connection will eventually break off. Thus, although crimping is faster and simpler than soldering, it has its own problems. Counterbalancing these, however, is this fact: when the proper tools and techniques are employed, crimped joints can be perfect. Control of this factor is easier than with soldering. Before going into methods, however, let's consider connectors and their contacts a little further.

Connector Variety

Like earlier types, modern connectors vary in size and shape according to application. The range in the number of pins (or matching plugs), as has been noted, may be from a couple to a few hundred. Shape may be round or rectangular. There are always two mating elements and, in most cases, one of them is mounted firmly to a larger object. For example, there may be a chassis connector that mates with a cable or a printed-wiring board connector that mates with contacts directly on the board. In some instances, both connecting elements are mounted on separate, solid entities. Consider computers, laboratory oscilloscopes or generators, and other devices with removable sub-assemblies. These generally use plug-in drawers or subchassis.

Some means of keying or guiding is invariably used to make certain that pins and sockets mate correctly. A few years ago, many connectors depended only on pin distribution and arrangement for this. All newer types use some other means, to prevent damaging attempts at forcing connectors together in the wrong way. Round connectors generally use a keyway in the shell, as do octal-base tubes. Rectangular types use either non-symmetrical shell shapes or else a set of sturdy keying posts, larger than the contact pins, to prevent wrong mating.

There is also more sophistication and more reliability in the pins and mating sockets that form the contacts, some of which are shown in Figs. 1 and 2. On the glamorous side, they generally use gold over nickel plating. They also include spring elements to insure good contact and firm seating in the connector's insulating material.

Just in case a pin or socket does become defective, it can be removed and replaced without disturbing the rest of the assembly. As a rule, however, a special tool is required, just as crimping calls for its special tools.

In some cases, the implements required for one type of connector are slightly different from those used with another. Even so, anyone familiar with the tools and techniques associated with one connector type or a particular manufacturer will also be able to handle others. This ability is the key to reliability and repeatability.

Crimping

The secret of successful crimping lies in choosing the right wire size for a particular connector and in preparing that wire properly. The length of wire that is to be bared, which is specified, must be just right so that it will fit into the crimping well, while remaining insulation must fit cleanly into the sleeve provided for it. Most contacts incorporate a small hole in the crimping well for inspection.

The stripped wire should not be nicked, nor should any of its strands be severed. This simply means that a good wire stripper must be used. There are many satisfactory types popular with technicians on which the only precaution is that the correct die size be used for the wire involved. However, unless Teflon insulation is used, a thermal stripper is preferred. A simple one, which melts away insulation without damage to the conductor, is shown being used in Fig. 3.

As for crimping tools, only those designed for the particular type of contact should be used, and use of the correct die size is essential. The tools are available with assorted, changeable dies to fit the various sizes of contacts in the line and appropriate wires. Fig. 4 shows a pin being inserted in a crimper. In Fig. 5, the stripped wire has been inserted into the pin and the handle is being squeezed to make the crimp. In most cases, there is a ratchet mechanism that prevents release if the tool has not been squeezed all the way, to insure a proper crimp.

Depending on manufacturer and connector type, the crimp itself may be in the form of an oval, star, or other shape. An enlarged cross section of an oval crimp (Fig. 6) shows how tightly the individual wire strands are squeezed and how

Electronics grows more complex, interwiring more elaborate, and reliability more important. Learn how solderless connectors are used to resolve the dilemma.

By WALTER H. BUCHSBAUM
Industrial Consultant, ELECTRONICS WORLD

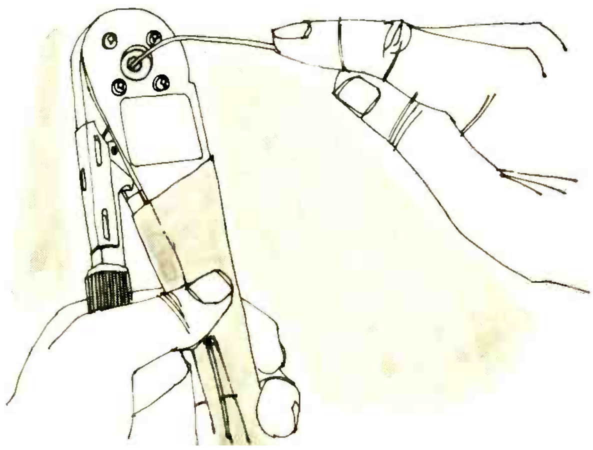


Fig. 5. A wire is inserted into contact, handle is squeezed.

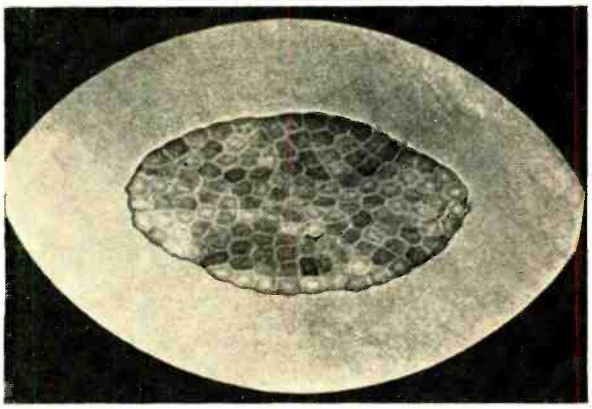
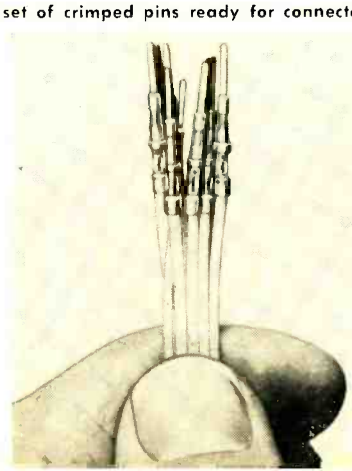


Fig. 6. Enlarged cross-section of wire strands in oval crimp.

Fig. 7. A set of crimped pins ready for connector insertion.



NEW CONNECTORS AND TECHNIQUES

Fig. 8. Contact is first inserted by hand, but only part way.

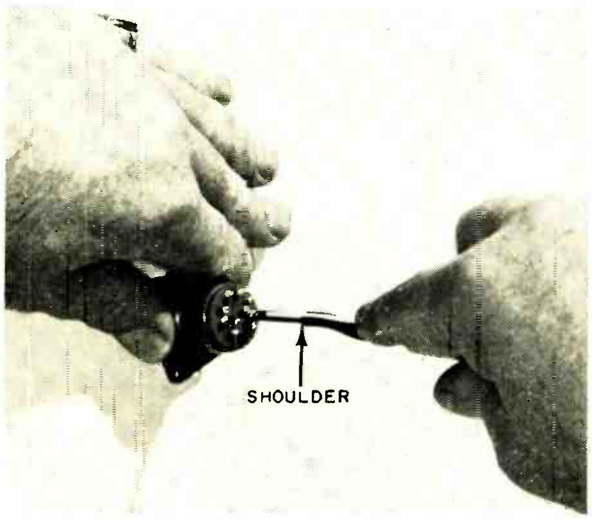


Fig. 9. A special tool, shown ready here, will do the rest.

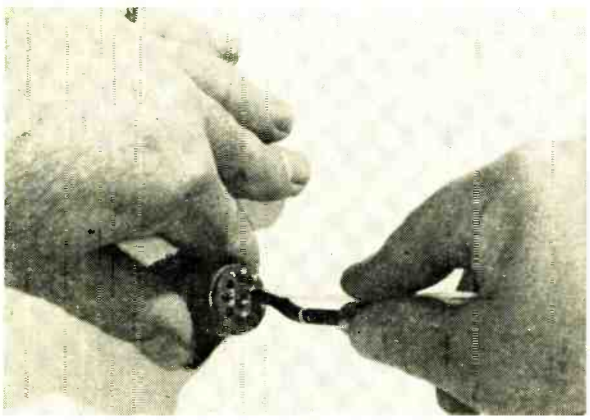
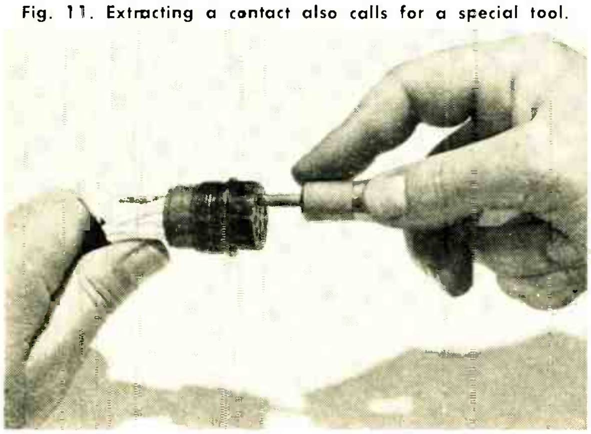


Fig. 10. Press the insertion tool and the job is completed.

Fig. 11. Extracting a contact also calls for a special tool.



they bite into the inside of the crimp well. In a properly made connection, the mechanical strength of the joint is much greater than that of an equivalent one made with solder. A portion of the insulation is supported by the sleeve extending from the crimp well, so that the wire can flex only over the insulated portion while the lower part is held rigid. Fig. 7 shows a bundle of wires crimped onto individual pins, before they are inserted into the connector.

Insertion and Extraction

Each pin (or socket) is first slipped into the correct hole of its connector (Fig. 8) by hand, then pushed all the way down with the appropriate insertion tool. Note that insertion is made through the back end of the connector; that is, the pin will go through the body to protrude at the opposite side.

The insertion tool, which is matched to the contact, is a hollow, half-open shaft, with space in the hollow for the wire, as shown in Fig. 9. It is pressed down until its own shoulder rests on the insulating material of the connector, as shown in Fig. 10. At this point, the pin or socket is held in the connector body by spring action, which is provided by springs either on the body of the pin itself (as in Fig. 1) or in the connector. The insertion tool can then be withdrawn easily.

To remove a pin or a socket, another type of implement is used to overcome the tension of the retaining spring. An extraction tool is always applied to the mating end of the connector (Fig. 11), rather than from the back, as is the insertion instrument. The extraction tool fits either around the pin or into the socket. Thus the types used for male and female connectors will not be the same.

For the type of contact shown in Fig 1, the extraction tool is designed to squeeze in the retaining springs on the contact itself as it pushes the contact out through the back of the connector. Where the retaining springs are inside the connector body, the tool is designed to press them away from the contact body. In either case, the purpose is to permit the removal of individual pins or sockets without damage. A contact can be inserted and extracted many times in safety. This is very helpful when errors occur in wiring a connector. If the wire itself should be damaged, however, a completely new pin or socket must be crimped on. The crimp itself cannot be repaired, as the metal is weakened.

Rules and Precautions

Just as certain "ground rules" must be observed when soldering connections, there are principles to follow with crimped connectors. The stripped wire must not be damaged in any way. It must be cut to the right length, so that the bare portion just fills the crimping wall. Insulation must fit into the sleeve provided for it. Both wire and insulation must be of the size specified for the connector. While it is obviously poor practice to use undersized wire, it is equally wrong to try to make oversized wire fit by cutting away strands.

Always use the correct insertion and extraction tools. The use of awls, screwdrivers, needle-nose pliers, scribers, and the like can damage the connector body or weaken the wire where it enters the sleeve. Often these devices will appear to be effective and give the impression that a repair has been completed successfully, but long-term reliability of the entire connector is almost certainly impaired.

If an emergency repair must be made when the right tools are not available, it is wiser to bridge wires across the connector. These leads will clearly mark the measure as temporary until the right implements are available.

In practice, such emergencies can be avoided easily. Most manufacturers of equipment using crimped connectors furnish a complete set of the appropriate instruments as part of the maintenance kit of spare supplies. Where this is not done, whoever is responsible for maintaining the equipment should insist that the proper tools be ordered before such tools are needed. ▲

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Semiconductor Strain Gages

(*Continued from page* 38)

coefficient of resistance but with opposite gage factors. This will compensate for the resistance change and, in addition, will provide two active adjacent arms of the bridge. The *Kulite-Bytrex Corp.* produces such a gage, a cross-sectional view of which is shown in Fig. 12. Gage factors in excess of 200 can be achieved with this configuration. This same company also makes a transducer gage in which the thermal coefficient is very nearly the negative reciprocal of the thermal coefficient of the modulus of steel. Thus, when bonded to steel, the gage is automatically compensated for thermal effects on sensitivity. This feature, together with a high degree of linearity, results in an extremely useful device.

Any article on the subject of semiconductor strain gages would be incomplete without some mention of recent work at *Bell Laboratories* on the use of semiconductor devices as pressure transducers.

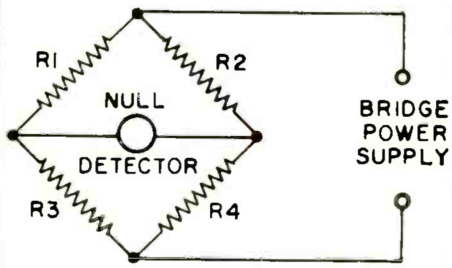
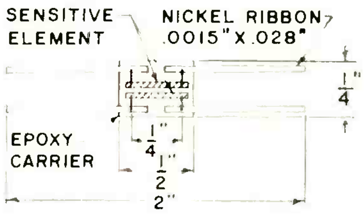


Fig. 11. Wheatstone-bridge configuration. One, two, or all four arms may be gages.

In one device, the positive- and negative-resistance characteristics inherent in a thin *p-n* junction, such as in an Esaki diode, are modulated. By properly constructing the diode and coupling the desired mechanical motion to the junction, a pressure multiplication factor of as much as a million can be obtained. Also, by utilizing the negative-resistance portion of the Esaki diode, together with a suitable value of input current and parallel resistance, gage factors as high as 30,000 may be obtained.

Semiconductor materials have made great inroads into the fields of strain and pressure measurements. Research and development are continuing and further new developments are on the way. ▲

Fig. 12. This unit is automatically compensated for any changes in temperature.



Operational Amplifier

(Continued from page 54)

shown in Fig. 2. This plot is close to the idealized curve for operational amplifiers.

The amplifier requires regulated d.c. voltages to prevent drift. The power supply is a conventional gas-tube shunt-regulated type. Its outputs are +150 volts, +300 volts, and −150 volts, all regulated, and −300 volts unregulated (Fig. 4).

Construction Details

The unit is constructed on two 9½" x 5" x 3" aluminum chassis bolted together with the power supply in the rear and the two amplifiers and the 6BJ7 triple diode in front. This two-chassis arrangement provides excellent shielding from 60-cycle hum. $C5$ and $C7$ are can-type electrolytic capacitors. The can of $C5$ must be insulated from ground and should be covered with electrical tape to prevent accidental shock to the user. Most of the amplifier components are mounted on a terminal board. Although the zero-adjust potentiometers are on the front panel, they could very well have been mounted on the chassis surface and have been of the screwdriver-adjust type as they rarely have to be touched.

All of the amplifier input and output terminals, the triple-diode terminals, and the plus and minus 150-volt reference terminals are brought to the front panel on three-way binding posts. It is on these binding posts that the external feedback components and other external circuitry components are mounted during use. The black binding posts under the amplifier output terminals are unused.

The "on-off" switch, pilot light, and overload indicator neons are also on the front panel. The neon lights are inserted in ¼" grommets and secured with rubber cement. They should be mounted with one terminal directly above the other. The upper terminal is grounded and the lower terminal is connected through the 910,000-ohm resistor to the amplifier output. When the upper electrode glows, a positive overload is indicated and when the lower electrode glows a negative overload is indicated. After the front panel is cut, drilled, and punched and before it is mounted, it should be sprayed with gray paint. Then all of the symbols are marked on it with India ink and a final coat of clear acrylic spray is applied to secure the India ink markings. The rest of the construction details are obvious from the photos.

Adjustment and Testing

After the unit is completed and the wiring checked for errors, it may be tested as follows. First insert all power-supply tubes and turn the unit on. All three regulator tubes should light. Then plug in the three tubes of amplifier No. 1 and ground the two inputs. After a minute's warm up, it should be possible to balance the amplifier. Set $R7$ to maximum resistance. Turn the zero-adjust control, $R1$, slowly from one extreme to the other. At some point the overload indicator will change from a positive indication to a negative indication. The point where this change takes place is the correct setting. If this condition cannot be met, the two 6AU6 tubes are probably not sufficiently well matched for this application. Try substituting other 6AU6 tubes until a pair is found that will permit balancing.

Then connect the amplifier as shown in Fig. 5A. Offset the zero-adjust control sufficiently to cause a mid-scale reading on the voltmeter. Note this reading. Then decrease the line voltage by 10 per-cent by switching a 25-ohm, 5-watt resistor in series with the power line. The voltmeter reading will slowly change to some new value as the tube heaters cool off. This change in the voltmeter reading should be less than one-half of a volt. If it is greater than half a volt, try different 6AU6 tubes until a sufficiently well matched pair is found to meet this specification. Then restore line voltage to normal.

To set the regeneration potentiometer, $R7$, connect the amplifier as shown in Fig. 5A, only with R_f = 10 megohms and R_{in} = 100 ohms. Use a direct-coupled oscilloscope instead of the meter. Slowly turn the zero-adjust control back and forth to cause the amplifier output to go into its upper and lower limits, and steadily decrease the resistance of the regeneration potentiometer $R7$. The zero-adjust control will get more and more sensitive. Soon a point will be reached where the amplifier output suddenly switches from one voltage to another and cannot be set to any value in between. Back off the regeneration potentiometer slightly from this position. This is now the correct setting.

Next connect the amplifier as shown in Fig. 5B. The amplifier should provide unity gain to the signal coming from the audio generator and the output should be free from any distortion or parasitic oscillations from the lowest possible frequency to 100 kc.

Repeat all the previous test procedures for amplifier No. 2 and plug in the 6BJ7 tube. When tests are completed the unit is ready for use.

Next month, some sophisticated uses of the operational amplifier unit will be presented, including a voltmeter calibrator, frequency-sensitive feedback circuits, oscillators, a capacitance bridge, multivibrators, and others.

(Concluded Next Month)

ELECTRONIC CROSSWORDS

By JOHN J. GILL

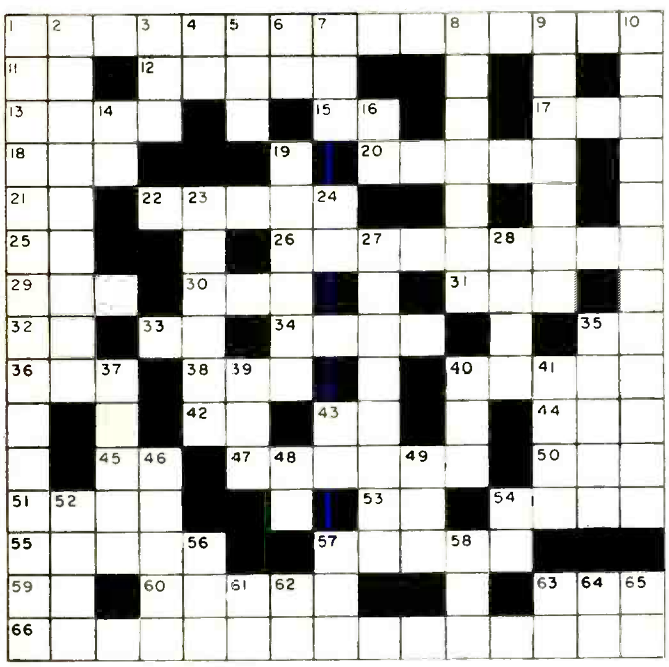
(*Answer on page 92*)

ACROSS

1. Electronic calculator.
11. Within.
12. Type of press.
13. Sweep of the screen in a picture tube.
15. Coil dimension (abbr.).
17. Girl's name.
18. Peak-to-peak indicator (abbr.).
20. Inert gas.
21. Anent (abbr.).
22. Thoughts.
25. Printer's measure.
26. Metallic element used in diodes.
29. Decade.
30. To follow a moving object with a TV camera.
31. Type of transistor.
32. Printer's measure.
33. Yankees won this pennant (abbr.).
34. Units of work.
35. Undirectional current (abbr.).
36. This committee was responsible for setting color-TV standards.
38. Consume.
40. Preplanning of a computer.
42. Inductive reactance on a schematic.
43. Atomic No. 61
44. Fish eggs.
45. Belonging to.
47. Computer numbering system.
50. Life tendencies.
51. Internal cylindrical cavity.
53. Seventh note in the scale.
54. The 15th of March.
55. Statement in computer programming system.
57. Momentary high-amplitude levels.
59. Type of circuit.
60. Rule.
63. Greek letter used to designate magnetic flux.
66. Digital computer mode.

DOWN

1. They're used in computer operations.
2. Small change in the value of a variable.
3. Adjective suffix.
4. Switching tube used in radar (abbr.).
5. TV network (abbr.).
6. Behold!
7. An electron-beam instrument (abbr.).
8. Information fed into a computer.
9. Time required for an electron to travel from one tube element to another.
10. Type of memory system used in computers.
14. By or near.
16. Russian "yes".
19. Body which attracts iron.
23. Type of two-way radio operation.
24. Compass point.
27. To hold constant.
28. One billionth (prefix).
35. Rectifier.
37. Very low resistance in a circuit.
39. Vestment.
40. Complete turn in spiral-wound cable.
41. Tube element.
43. Within.
46. Iron (chemical prefix).
48. Symbol for grid current.
49. Small stream.
52. One time only.
54. Part of "to be".
56. Biblical "yes".
57. Type of transistor.
58. Unit in which power line transformers are rated (abbr.).
61. Chemical abbreviation.
62. "Everything is ......".
63. 3.1416.
64. Greeting.
65. Not out.



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, simply fill in the coupon appearing on page 19.

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

HALL-EFFECT TEST KIT

1 **F. W. Bell Inc.** is currently marketing an experimental Hall-effect kit designed especially for research and development men, engineering and physics professors and teachers, hobbyists, and inventors to acquaint them with the basic principles behind this challenging application of the magnetic field.

The BH206 "Hall-Pak" basic kit includes one Hall-effect device, one complementary transistorized amplifier on a circuit board, a pair of magnets to provide stable fields for testing and for many Hall-effect applications, and a complete instruction booklet covering theory of operation, demonstrations, experiments, and practical applications.

For those requiring more sophisticated devices, the company is offering eight other "Hall-Paks" of varying complexity and price.

BROADBAND TV-FM AMPLIFIER

2 **Blonder-Tongue Laboratories, Inc.** is currently marketing a new broadband TV-FM amplifier which has been especially designed to overcome coaxial cable and distribution system

losses in television and FM master antenna systems without signal degradation. The MLA-FM is also suited to use as a line extender in CATV systems.

The device consists of two amplifying sections: one covering TV channels 2 to 6 plus FM (low band), and a similar section for TV channels 7 to 13. Each section features an individual gain control and a pre-set control for bandpass tilt alignment. Gain is over 33 db on channels 2 to 6 and FM and 40 db on channels 7 to 13.

The unit can be mounted either indoors or in an outdoor housing. Ruggedized tubes are also available at a slight premium.

DUAL CAMERA SYSTEM

3 **Beattie-Coleman, Inc.** has introduced a dual-camera system for high speed streak-recording of oscilloscope traces on 35-mm. film and simultaneous pulse-recording on **Polaroid** film.

Known as the "Dual Oscillotron," the new rack-mounted system records extremely high speed transients at speeds from 0 to 20 f.p.s., infinitely variable through use of a "Variac" control. The 35-mm. film capacity is 100 feet and the object-to-image ratio is 5 to 1. Through use of a beam splitter, the same trace can be recorded on 10,000 speed **Polaroid** film at the same moment with an object-to-image ratio of 1 to 0.5.

HIGH-POWER PHOTOCELL

4 **Delco Radio Division** has developed a new light-dependent resistor which is characterized by higher power-handling capabilities making it suitable for a number of applications heretofore impractical for this type of device.

The LDR-25 permits elimination of relays where the current required to operate a solenoid is on the order of ½ ampere. The unit can also be used as a speed control for fractional horsepower motors.

The device is constructed of a thin layer of sintered semiconductor applied to an aluminum oxide substrate. Hermetic sealing, which is necessary to protect the device from moisture, is accomplished through the use of film adhesives and a glass cap. Current-handling capability is ½ ampere and the power dissipation rating is 25 watts. It is designed to operate directly from 110 volts a.c. and is conservatively rated at 200 volts d.c. or peak a.c.

METAL FILM RESISTORS

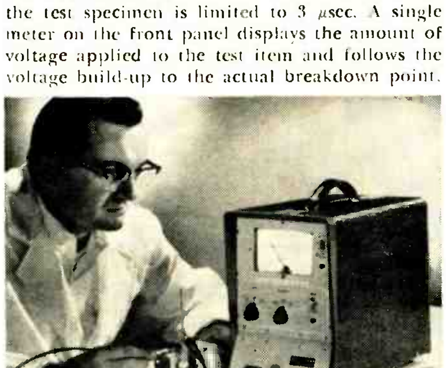
5 **Mepco Inc.** has developed a new series of rugged, low-cost, precision metal film resistors which meet MIL R 55182 specifications. The units, available in ⅛-, ¼-, and ½-watt ratings, are glass enclosed, hermetically sealed, and helium filled, making possible mass spectrometer test procedures.

Major areas of application for this new Series FH line are in aerospace and military electronics as well as in systems requiring high reliability plus resistance to environmental extremes, shock, and vibration.

VOLTAGE BREAKDOWN TESTER

6 **Microdot Inc.** is now offering a non-destructive quality-control tester for the quick determination of d.c. voltage breakdown levels in components as its Model 1901A.

The new instrument limits the time factor of the test, rather than the amount of current applied. Damage is prevented by automatically shorting out the test leads before breakdown occurs. The duration of current avalanche through the test specimen is limited to 3 μsec. A single meter on the front panel displays the amount of voltage applied to the test item and follows the voltage build-up to the actual breakdown point.



The voltmeter's memory circuit holds this reading until another test is performed.

The unit can be used for testing resistors, capacitors, tubes, r.f. cavities, transformers, and insulation.

TRANSISTORIZED TV RECORDER

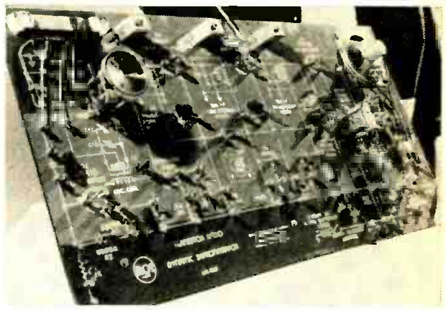
7 **Ampex Corporation** has just introduced a fully transistorized broadcast television recorder, the Model VR-1100 "Videotape."

Designed especially for medium and small market stations as well as mobile applications, the VR-1100 is equipped for operation at either 7.5 ips or 15 ips with complete interchangeability of tapes with any broadcast television recorder at either speed. Self-contained in a single 60" x 24" x 42" cabinet, the recorder employs modular construction for ease of maintenance. A closed-circuit version of this unit will also be marketed by the firm.

DYNAMIC DEMONSTRATOR

8 **RCA Electron Tube Division** has added another unit to its line of educational aids designed to help teach the principles of electronics, the WE-93A(K)—a dynamic demonstrator covering an AM superhet transistor radio receiver.

The demonstrator uses specially designed silver-plated spring connectors to provide excellent mechanical and electrical contacts for the various components. In addition, the leads of the tran-



sistors, resistors, capacitors, diodes, and other components can be temporarily removed from the circuit and then easily replaced without soldering. Inoperative conditions can be simulated by disconnecting one or more component leads. The solid mahogany frame and unfinished stand measure 12" x 24".

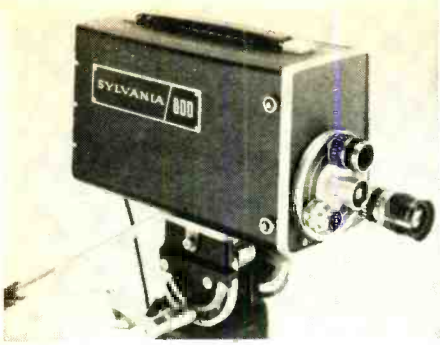
LABEL EMBOSSING TOOL

9 **Dymo Industries, Inc.** has introduced a new labeling device designed for commercial applications. Known as the M-55 "Tapewriter," the unit is equipped with clear "Lexan" embossing wheels, combined with an embossing head which allows the operator to actually see the machine emboss white raised letters against the colored plastic tapes. The embossing wheel itself has 44 characters: A through Z, 1 through 0, dollar and cents signs, a per-cent symbol, commas, ampersands, and an apostrophe.

The tape magazine holds 120 inches of tape which is available in black, yellow, orange, red, purple, grey, blue, green, gold and clear.

CLOSED-CIRCUIT TV CAMERA

10 **Sylvania Electric Products Inc.** is now offering a new closed-circuit television camera, the Model 800. The new unit provides broadcast



quality in a rugged, completely transistorized, lightweight package suitable for business, industrial, research, educational, and military uses.

Incorporated in the camera are a transmitter and a synchronizing unit. A detachable rear control panel allows complete control of the camera up to a distance of 1000 feet. Completely self-contained, the camera requires only a TV receiver to provide a closed-circuit link. The camera weighs 18 pounds and measures 6" x 8½" x 14".

SINGLE-JUNCTION POWER RECTIFIERS

11 **Bendix Semiconductor Division** is now offering a new series of four high-voltage silicon power rectifiers, JEDEC type numbers 1N3929 through 1N3932.

These single-junction, diffused silicon rectifiers have peak reverse ratings of 1000, 1500, 2000, and 2500 volts respectively and can deliver an output current of 1 amp d.c. over an operating temperature range of −65 to +175 degrees C.

Features include low forward voltage drop of 2 volts maximum at $I_f = 1$ amp d.c. because of the single junction and low reverse current of 10 μa. d.c. maximum at the rated peak reverse voltage and case temperature of 25 degrees C.

These high-voltage rectifiers are mounted in a double-ended flangeless package.

BAR AND PATTERN GENERATOR

12 **Sencore, Inc.** is now marketing a low-cost portable color-bar and pattern generator for home or shop service applications. The Model CG126 provides keyed color bars at NTSC phases, adjustable white dots, crosshatch, vertical bars, and horizontal bars. The desired pattern is

selected by connecting the instrument to the antenna terminals, setting the TV set to channel 4, and dialing any of the five patterns. Signal output is adequate to override most local channels. Other low channels can be selected if desired by simple slug adjustment in the rear.

The unit weighs less than 10 pounds and measures only 11" x 8" x 6".

TRANSISTORIZED POWER INVERTER

13 **Terado Corporation** is now offering a transistorized power inverter, the "Continental" Model #50-191. Designed to convert any 12-volt car or truck battery to 110-volt, 60-cycle a.c., the unit provides 275 watts continuous or 300 watts intermittent power without auxiliary engines or generators. It is designed to operate fluorescent or incandescent lights, cash registers, bench

grinders, soldering irons, electric drills, tape recorders, TV and radio sets, or any other electrical appliance whose load does not exceed 275 watts. Frequency is maintained within ½ cycle by means of a tuning fork or reed.

The unit is housed in a copper-clad steel case which measures 10¾" x 6" x 6". Shipping weight is 30 pounds.

CAPACITANCE-RESISTANCE ANALYZER

14 **Lafayette Radio Electronics Corporation** is currently offering a new capacitance-resistance analyzer as the Model TE-46.

Factory wired and tested, the instrument has an over-all accuracy of ±5%. It has four direct-reading scales for capacitance and resistance: .00002-.005 μf., .002-.5 μf., .2-50 μf., and 50-2000 μf.; 2-500 ohms, 200-50,000 ohms, 20,000-ohms-5 megohms, and 5-200 megohms.

The instrument measures power factor of electrolytics, shorts, opens, and leaky capacitors. Two transformer turns-ratio scales are 1:1 to 10:1 and 10:1 to 200:1; impedance ratio scales

are 1:1 to 100:1 and 100:1 to 40,000:1. A magic-eye tube is used as a capacitance-resistance indicator while a meter is provided for reading d.c. leakage and insulation.

The analyzer which measures 10½" x 7" x 5¼" comes complete with test leads and instructions.

INDUSTRIAL BINOCULARS

15 **Designs for Vision, Inc.** is now offering a new type of magnifying spectacles for use in industrial production and the inspection of fine parts.

Known as "Hague Industrial Binoculars," the new glasses have a magnification of 2.5x and the focal length can be set for 14", 17", or 21". The viewed area measures 3½" on a side at a focal distance of 17". The depth of focus is more than 2".

The units are especially suited for industry applications involving transistors and small assemblies, miniaturization in guidance systems for missile and space work, and in electrical component assembly.

VARIABLE-CAPACITANCE DIODES

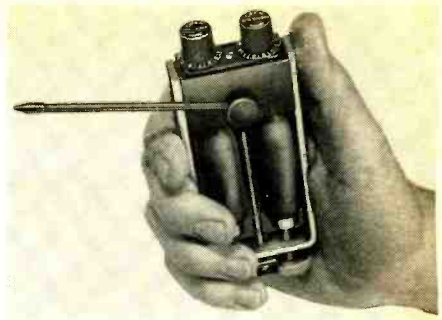
16 **Sylvania Electric Products Inc.'s** Semiconductor Division is now offering a new series of high-efficiency v.h.f.-u.h.f. variable-capacitance diodes designed especially for a.f.c., r.f. tuning, low-frequency harmonic multiplication, limiting, switching, and phase shifting applications.

Designated the D4500 series, these silicon epitaxial varactors feature three quality levels based on maximum series resistance. In addition to the choice of eight voltage breakdowns (from −6 to −120 volts) and capacitances ranging from 0.5 to 30 pf., the diodes are offered in three series resistance categories. A total of 168 types is available at the present time.

HAND-SIZE WELDING TORCH

17 **Printed Circuits, Inc.** is now marketing a new hand-size welding torch which uses two miniature compressed gas cartridges to produce a pin-point accurate welding flame of 4000° F.

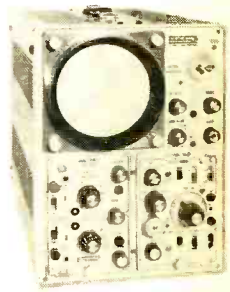
Tradenamed "Microflame," the miniature cartridges contain approximately a two-hour fuel supply and are easily replaced by readily avail-



able substitutes. Precision controls, which accurately regulate the gas mixture, also turn the torch on and off as often as needed.

BRIGHT-DISPLAY SCOPES

18 **Du Mont Laboratories Division** is now offering three new high-brightness cathode-ray oscilloscopes in its high-frequency 765 transistorized series. All three instruments are electrically identical and feature the company's newly developed frame-grid 13 kv. cathode-ray tube.



The instruments differ in mechanical configuration. The Type 767-H is for rack-mount use; the 766-H is for bench and portable applications, while the 765-H is for true field portability. All of the scopes have a frequency range of d.c. to 25 mc. with present plug-ins. Other plug-ins will soon be made available to increase the bandwidth to 100 mc.

15-WATT HEAT CARTRIDGE

19 **Ungar Electric Tools** is now marketing its "Imperial" 15-watt heat cartridge with four specially designed micro-tip thread-on soldering tips for microminiature soldering applications.

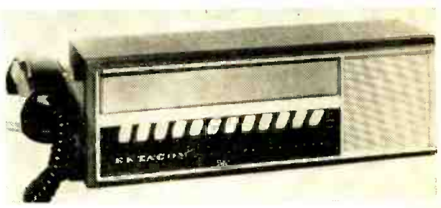
The four thread-on soldering tips are offered in the following configurations: tapered screwdriver, stepped spade, stepped chisel, and stepped pencil. All of the new tips are iron clad and 24-karat gold plated. The new 15-watt cartridge is designed to fit the company's regular "Imperial" handles and cord sets.

HI-FI—AUDIO PRODUCTS

INTERCOM EQUIPMENT

20 **Fisher Berkeley Corporation** has just introduced its newest "Ektacom" intercommunications equipment as the Series G-3.

Featuring solid-gold switch contacts, the new units in the line have been life-tested for over 5 million switching cycles and are guaranteed



for two years. The amplifiers are fully transistorized and have a push-pull output of 5 watts. Offered as standard equipment in capacities up to 48 stations, special order units may be had with capacities up to 400 stations. Special "Talk-Listen" switches are employed.

FM STEREO RECEIVER KIT

21 **Harman-Kardon, Inc.** has added an FM stereo receiver to its line of build-it-yourself high-fidelity components.

The "Award FA30XK" receiver kit is a combination of stereo tuner, preamplifier, and power amplifier on a single chassis. The unit delivers 30 clean watts of program material.

The FM section consists of a sensitive wide-band circuit and includes a new multiplex section with a frequency response of 15-15,000 cps ± 1 db and 30 db stereo separation. The circuit also incorporates a.f.c. while an FM stereo indicator light permits visual identification of stereo broadcasts.

The kit package is a complete, portable miniature workshop. Each component is placed in the sequence in which it is used. Wires are pre-cut, tube sockets and terminal strips are riveted to the chassis. The r.f. and oscillator stages are preassembled and factory aligned.

PORTABLE SOUND-LEVEL METER

22 **H. H. Scott, Inc.** is now offering the Model 450 portable sound-level meter for a variety of applications in inspection, measurement, and development fields.

This compact instrument, which measures 2"x3"x6" and weighs only 23 ounces, is designed to operate up to 25 hours on a single 22.5-volt battery. The circuit is completely transistorized and features a self-scaling, step-type attenuator.

The instrument has a built-in crystal diaphragm microphone and direct-reading scale to minimize reading error. The instrument is designed in such a way that it can be calibrated by a 117-volt a.c. line.

The Model 450 is suited for noise surveys, to measure dispersion pattern and level of reproduced sound from p.a. and theater sound systems, to determine crossover characteristics and dynamic range in hi-fi installations, and to check conformity to specifications of air conditioning, ventilating, and fluorescent lighting installations.

CARDIOID MICROPHONE

23 **The Turner Microphone Company** is now in production on the new cardioid microphone, the Model 500. Response is 40-15,000 cps with output −55 db at high impedance.

The microphone measures 6-13/16" long and is 1-17/32" in diameter. Its 12-ounce weight makes it suited to boom operations in clubs, auditoriums, and recording applications, as well as in fixed-station communications.

HI-FI SPEAKER KIT

24 **Neshaminy Electronic Corp.** is now offering a complete high-fidelity system sub-assembly designed for custom installation in existing cabinets, bookcases, or walls. Instructions are also provided for building inexpensive shelf model and console cabinets to accommodate the speaker system.

Marketed as the "JanKit 51," the speaker uses the firm's "JansZen" electrostatic mid- and high-frequency tweeter in a single-radiator version that reduces cost and cabinet space requirements. The tweeter is acoustically paired with a special 11" Model 350A dynamic woofer. Both units are pre-assembled to a rigid 16" x 20" high panel that may be used as the front panel of the speaker cabinet if desired. Both speakers may also be dismounted and used separately.

Frequency response of 30-30,000 cps is possible even in infinite-baffle cabinets as small as 2 cubic feet.

STEREO TAPE RECORDER

25 **Vernon Audio Division** has made its debut in the hi-fi field with the 47/26 stereo tape recorder and audio center. The recorder is completely transistorized and uses 47 transistors and 26 diodes. The unit provides tape speeds of 7.5 and 3.75 plus a "0" position for use as an amplifier only. Frequency response is 30-20,000 cps ± 3 db @ 7.5 ips and 30-15,000 cps ± 3 db @ 3.75 ips.

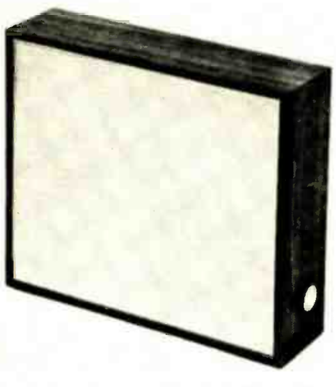
The circuit provides 10 watts of audio power per channel, all-electronic switching, independent audio power source for other hi-fi components, a complete p.a. system, three separate tapeheads and motors, two separate recording and playback amplifiers, monitor facilities, three individual inputs per channel with simultaneous intermix, outputs for preamplifiers and external speakers, plus two specially loaded built-in speakers.

The instrument measures 15⅞" x 13½" x 7⅜" over-all and weighs 44 pounds.

THREE-WAY SPEAKER SYSTEM

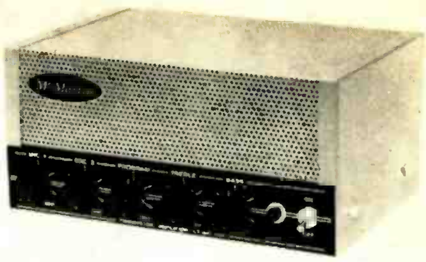
26 **Rek-O-Kut Company, Inc.** has developed a three-way speaker system which measures only 4½" x 14" x 18". Its speaker complement includes an 8" high-compliance woofer, a 6" mid-range "impact" speaker, and a 3½" cone tweeter with high-pass network filter that crosses over at 5000 cps.

Frequency response of the "Sonorette" Model S-50 is 75-16,000 cps. It is capable of handling up to 20 watts of program material. The cabinet is finished in oiled walnut and the unit comes complete with volume control for adjusting sound levels to personal listening preferences.



COMMERCIAL SOUND AMPLIFIERS

27 **McMartin Industries, Inc.** has recently introduced two completely transistorized amplifiers specifically designed for commercial sound applications.



The LT80A is an 8-watt unit which provides 12 watts of program material. Frequency response is 20-20,000 cps ± 3 db with distortion less than 1%, 50-15,000 cps.

The Model LT300 (photo) is a 32-watt continuous-duty amplifier with separate bass and treble controls and two microphone inputs, high- or low-impedance. Frequency response is 20-20,000 cps ± 3 db with distortion less than 1%, 50-50,000 cps.

Available plug-in accessories include shielded 600-ohm input transformer; phono preamp, equalized for magnetic, ceramic, or crystal cartridges; and program preamps.

CAPACITOR PROBE MICROPHONE

28 **Electronic Applications, Inc.** has announced the availability of a high-frequency subminiature capacitor probe microphone with response to beyond 50,000 cps.

Mounted at the end of a streamlined probe, the Model CKS4 probe assembly has a 4.4 mm. (⅛") diameter capacitor microphone. Response of the unit extends from audio up through 55,000 cps, making it useful for manual sound high-frequency analysis.

A free-field curve of response is supplied with each unit. The unit produces 0.05 mv./microbar. The microphone-amplifier unit (V-60) can be either battery operated or a.c. powered.

FM WIRELESS MICROPHONE

29 **Minatronics Corporation** is now offering a vest-pocket, solid-state FM wireless microphone whose range exceeds 200 feet for noise-free operation to over 600 feet when conditions are favorable.

Power input to the final stage is 100 mw, making it a license-free device. The transmitter measures ⅞" x 2½" x 3½" and weighs 10 ounces. The microphone and receiver are designed to be used in conjunction with any p.a. system. Frequency range is 27.23 to 43 mc. with ± 20-kc. deviation.

TWO-TRACK MONO RECORDER

30 **Emerson Radio Inc.** has released a low-cost two-track mono record-play tape recorder which has been designated the "Telectro" Model MM213.

The instrument, which has a 7-inch reel capacity, incorporates a 6-watt peak-power amplifier. There is a single-knob function control, record indicator, and input and output jacks.

The recorder is housed in a rugged leatherette-finished cabinet with saddle stitching. It weighs 16 pounds and comes in brown with white trim.

TAPED FOREIGN LANGUAGE COURSES

31 **Roberts Electronics, Inc.** is offering a foreign language series on tape that is designed for group or individual study. Four languages are being offered—French, Spanish, German, and Russian. The language series includes up to 48 lessons, covering 20 hours of instruction by native teachers.

The tapes are designed for four-track, 3.75-ips sound-with-sound recorders so students can record along with the teacher for conversational practice and comparison of pronunciation. The written text is in the form of a pocket-size manual which can be carried along on trips or for away-from-home study.

FM-AM MONO TUNER

32 **Sherwood Electronic Laboratories** is on the market with a new FM-AM mono tuner, the S-2000 III. FM sensitivity is rated at 1.8 μv. for −30 db quieting and distortion (IHF). This performance has been obtained by using a gated-beam zero-time-constant limiter and balanced ratio detector. A capture ratio of 2.4 db is achieved on FM.

The instrument incorporates a.f.c. with a front-panel disabling switch, flywheel assisted dial pointer movement, 8¼" communications-type dial, and an "Acro-beam" tuning indicator.

The tuner is offered in a walnut-tone leatherette-finished metal cabinet; as a chassis with deluxe front panel for custom installation; or with functional hammertone grey modular rack mounting panel for installation in standard relay racks. The tuner has 12 tubes plus rectifier and measures 14" x 4" x 10½".

FOUR-TRACK STEREO RECORDER

33 **Roberts Electronics, Inc.** has developed a moderately priced four-track stereo tape recorder which is being marketed as the Model 1055.

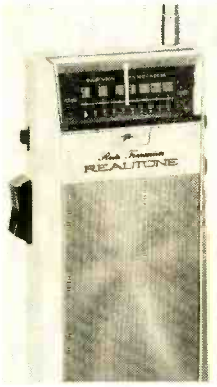
Features include four-track stereo and mono record/playback, two-track stereo and mono playback, dual self-contained stereo power amplifiers, easy-to-read vu meter with simple A-B switch, record switch with safety interlock to prevent accidental erasure, stereo preamp outputs to simplify custom installation in an existing hi-fi stereo system, automatic shut-off, index counter, and dual-speaker ouput jacks.

The unit records at 7.5 and 3.75 ips and a 15-ips accessory kit is available. There are two high-impedance mike inputs; two high-impedance, high-level radio-phono inputs; two high-impedance outputs; and two 4-16 ohm outputs for external speakers or low-impedance stereo headphones.

CB-HAM-COMMUNICATIONS

RADIO/TRANSMITTER-RECEIVER

34 **Realtone Electronics Corp.** has recently introduced a compact, hand-held unit which incorporates a broadcast-band receiver and CB transmitter-receiver in a single housing.



The Model #TR-6134 uses high-level and low-level modulation to obtain peak performance for longer range transmission, resulting in 100% linear amplitude modulation without distortion or causing interference with other channels.

The circuit uses eleven transistors and two crystals with input of 100 mw. in the CB service. The unit requires no license and its range varies from one to three miles depending on terrain.

The instrument incorporates a 2½" dynamic speaker which doubles as a microphone for transmission, a 5½ foot telescopic whip antenna, and an earphone attachment for private listening.

BASE-STATION CB UNIT

35 **Radio Shack Corporation** has added the TRC-8 transceiver to its line of CB equipment for base-station operation in homes and

offices and for use in boats, cars, and trucks.

The "Realistic" TRC-8 utilizes the maximum 5 watts of power to boost voice signals to ranges of 15 miles or more under favorable conditions. The unit conforms to all FCC regulations covering CB communications.

The multi-stage transmitter provides eight crystal-controlled channels from 26.9 to 27.3 mc., selected by a front-panel switch. It has a frequency stability rated at 0.005% or less.

With an extremely high receiver sensitivity, the dual-conversion, dual-power-supply transceiver provides high selectivity and low adjacent-channel interference. The circuit includes an automatic noise limiter, tuned r.f. stage, built-in combination "S" meter and power input meter, and planetary-drive tuning.

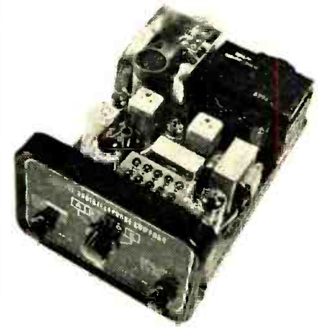
The company is offering this unit in either kit or factory-wired versions.

TRANSISTORIZED U.H.F. MOBILE

36 **Motorola Inc.** has announced the availability of a transistorized mobile two-way radio designed for operation on the u.h.f. frequencies in the 450-470 mc. range.

Known as the "Motrac" FM radiophone, the mobile unit is the featured item in the new line of u.h.f. equipment which also includes 65- and 100-watt base stations, standard model repeater stations, and a new high-gain antenna.

Available in 20- and 35-watt models, the new mobile radio features complete transistorization

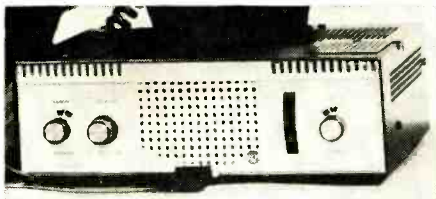


of the power supply and receiver and partial transistorization of the transmitter. Current drain on standby is less than ½ amp and the radio can be turned on without idling the vehicle engine, thus saving gasoline and reducing engine wear and tear.

COMPACT CB UNIT

37 **RCA Electron Tube Division** has announced the availability of a new CB radio which has been designated as the "Mark VIII."

Featuring low, slim design which facilitates installation in extremely cramped locations, the



new two-way unit measures 3½" x 11¼" x 8". Weight of the unit, including the impact-resistant microphone, is 8 pounds.

The instrument operates on 117 volts a.c. Separate d.c. power supplies for 6- or 12-volt mobile operation are available as optional equipment. One of these power supplies may be mounted on the firewall of the vehicle as a permanent installation and the unit moved between the car and base-station location at will.

TELEMETRY COAX-STUB ANTENNA

38 **Technical Appliance Corporation** is now offering a vertically polarized coaxial-stub antenna with 2¼" diameter tubular elements for telemetry applications in the frequency range of 220-400 mc.

Ground-plane rods of this antenna are angled 37 degrees for optimum radiating pattern. Pressurized to withstand 50 pounds per square inch, the antenna has an impedance of 52 ohms and a v.s.w.r. under 2:1. Diameter across the ground-plane rods is 23" and over-all height is 16". Connection is with a type "N" connector.

23-CHANNEL TRANSCEIVER

39 **Regency Electronics** is now marketing a new CB transceiver for two-way radio communication with greatly increased coverage and crystal-controlled selection of all 23 CB channels.

Known as the "Range Gain" transceiver, the circuit includes a double-sideband reduced-carrier feature that makes the horizon a reasonable op-

erating range for CB communications. The unit delivers maximum power within FCC regulations. All 23 CB channels can be selected with a single control for both transmit and receive.

Equipped with a dual power supply, the unit can be used either as a mobile or base station. The transceiver weighs 13 pounds and measures 11" x 4½" x 8¾".

FM COMMUNICATIONS RECEIVERS

40 **Lafayette Radio Electronics Corporation** is now marketing two new FM communications receivers, the HE-98 which tunes 30-50 mc. and the HE-99 which covers 154-174 mc.

Useful for monitoring emergency, commercial, or industrial communications, both sets offer 8-tube performance with a three-gang tuned r.f. stage. Other features include a sensitivity of 4 μv. or less for 20-db quieting, built-in all-electronic adjustable squelch circuit, built-in 5" PM speaker, illuminated slide-rule tuning dial, and transformer-type power supply.

Both units are housed in metal cabinets that measure 11¼" x 7⅞" x 6½". Operation is on 105-125 volts, 60-cycle a.c. only.

MANUFACTURERS' LITERATURE

PANEL-METER BULLETIN

41 **Assembly Products, Inc.** is currently offering copies of its 8-page Bulletin 34 which lists a complete line of indicating panel meters and pyrometers. The publication includes meters for either recessed or front-of-panel mounting, in sizes from 2¼" to 6" wide, with full-scale sensitivities beginning at 3 μa. and 2 mv. d.c.

The bulletin provides full electrical specifications, dimensions, prices, and ordering procedures on the line.

PRECISION INSTRUMENT CATALOGUE

42 **ESI-Electro Scientific Industries** is now offering copies of its condensed catalogue A-26 which describes the firm's product line of precision instruments and components.

Included are illustrations and short-form specifications for measurement systems, bridges and accessories, standards, decade resistors and capacitors, decade voltage dividers, generators and detectors, custom networks, and an algebraic computer. Descriptions are keyed to detailed catalogue sheets available for the various products.

SEMICONDUCTOR DATA

43 **Motorola Semiconductor Products Inc.** has issued 24-page condensed catalogue which provides pertinent details on the firm's extensive line of semiconductor products.

Presented in tabular form is information on integrated circuits, silicon controlled rectifiers, gate controlled switches, h.f. switching transistors, h.f. communications transistors, power transistors, milliwatt transistors, silicon reference diodes, silicon zener diodes, silicon rectifier stacks, silicon rectifiers, and military-type devices.

ELECTRONIC ORGAN LINE

44 **Artisan Organ Company** has just issued a two-page brochure which lists fourteen basic models of electronic organs available in either kit form or on a custom basis. Only basic catalogue-type information is included. Complete stop lists, specifications, and detailed literature on the individual organs can be obtained separately without charge.

HOME-STUDY COURSES

45 **National Radio Institute** has issued a 66-page catalogue which describes by means of text and photographs the school's facilities for learn-at-home training in electronics. In-

Answer to Electronic Crosswords

(Appearing on page 85)

D	I	G	I	T	A	L	C	O	M	P	U	T	E	R
I	N		A	R	B	O	R			R		R		A
S	C	A	N		C		O	D		O		A	N	N
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T	E	N		P	A	N		E		M	A	T		A
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R	C		R	E	I	G	N			V		P	H	I
S	E	R	I	A	L	O	P	E	R	A	T	I	O	N

cluded are details on the Institute's industrial electronics, radio and television servicing, and complete communications courses.

The school's facilities and staff are pictured, along with a generous sampling of the type of work expected of the student in each of the several training programs.

TAPE-RECORDING HINTS

46 **Sarkes Tarzian, Inc.** is offering a 32-page booklet entitled "Lower the Cost of Fun With Tape Recording" which provides a unique variety of information of interest to tape recorder users.

Beginning with a discussion of tape recorder applications, the booklet continues with a variety of tape tricks including how to record from various sound sources, easy tape quality tests, a handy table of recording times, and a "notes" page to carry important information about the owner's tape equipment.

FUSES AND FUSEHOLDERS

47 **Bussman Mfg. Division** has issued a 24-page catalogue, Form SFB, which lists the complete line of "Buss" and "Fusetron" small-dimension fuses and fuseholders.

This two-color publication includes a symbol and numerical index, dimensions, weights, blowing time charts, resistance of fuses, voltage ratings, vibration characteristics, UL listings, and information on special fuses, fuse clips, fuse blocks or fuse holders. Mechanical as well as electrical specifications are provided.

SCOPE PREAMP DATA

48 **Brush Instruments** has issued five two-page, two-color illustrated data sheets describing its 4200 series of interchangeable solid-state preamps for use with oscillograph recording systems.

The five data sheets are housed in an illustrated file folder for easy reference. The units covered include high-gain d.c. preamps of 100 μv. sensitivity; high-gain d.c. preamps with calibrated zero suppression from 100 μv. to 500 volts; d.c. preamps with 1 μv. sensitivity; a carrier preamp for recording from resistive, inductive, or other transducers requiring excitation; and a phase-sensitive demodulation preamp for monitoring and recording performance of a.c.-modulated carrier systems.

METALLIZED CAPACITORS

49 **Electron Products** is now offering a one-page data sheet which provides complete specifications on its line of thin-film metallized Mylar capacitors in hermetically sealed rectangular and round tubulars and in wrap-and-fill and epoxy-case styles.

TEST EQUIPMENT CATALOGUE

50 **The Triplett Electrical Instrument Co.** has available an 8-page illustrated catalogue, No. 44-T, covering its line of production and service-type test equipment.

A wide variety of v.o.m.'s is described, along with pertinent specifications of interest to those making the choice; details on the firm's transistor tester, signal generator, appliance tester, load check, probes, and complete tube and transistor analyzers are also incorporated.

SPACE ACTIVITIES BOOKLET

51 **Westinghouse Air Arm Division** has issued a three-color, 28-page booklet describing its space activities and capability.

Entitled "Into Space," the booklet illustrates and describes the division's work on the Gemini rendezvous radar, the UK-2/S-52 international scientific satellite, and other related projects.

POWER-SUPPLY SPECIFYING

52 **Kepco, Inc.** is now offering copies of its 44-page catalogue which describes a complete line of high-reliability d.c. regulated power supplies. Performance features and physical specifications for more than 230 standard models, including programmable voltage/current regulated units, are included.

MICROPHONES & ACCESSORIES

53 **American Microphone Company** has issued a product directory which provides detailed application and specification information on a complete line of microphones and accessories.

Included are sections on broadcast and professional microphones, units for high-quality p.a., advanced amateur recording, industrial sound, mobile radio, and language labs.

MICROMINIATURE CONNECTORS

54 **Amphenol Connector Division** has announced the availability of a newly revised 24-page catalogue which describes a complete line of microminiature connectors.

Included are circular connectors for cable-to-cable or cable-to-chassis applications, printed-circuit or printed-wiring receptacles, modular circuitry connectors, multi-purpose strip connectors plus contacts and contact tools. ▲

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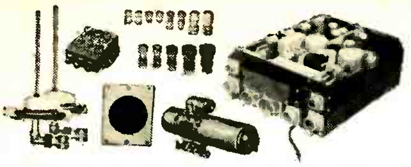
FAMOUS BC-645 TRANSCEIVER



BRAND NEW! 15 Tubes 435 to 500 MC

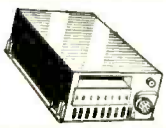
Can be modified for 2-way communication, voice or code, on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.
Shipping weight 25 lbs. **SPECIAL!** . . . **$19.50**

PE-101C Dynamotor, 12/24V input $7.95
UHF Antenna Assembly 2.45
Complete Set of 10 Plugs 5.50
Control Box 2.25

SPECIAL "PACKAGE" OFFER

BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE, BRAND NEW
While Stocks Last **$29.50**

ARC-3 RECEIVER!



Complete with All Tubes Exc. Used **$21.50**
Like NEW $33.50

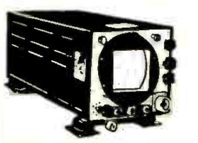
Crystal-controlled 17-tube superhet, tunes from 100 to 156 MC., AM., on any 8 pre-selected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.

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

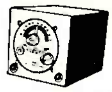
ASB-5 'SCOPE INDICATOR



BRAND NEW, including all tubes, **together with 5BP1 'Scope Tube.** Originally used in Navy Aircraft RADAR equipment. Easily converted for AC operation.
VALUE $250.00!
OUR LOW PRICE **$16.95**

APR-1 Navy VHF-UHF radar search Receiver. 80 Mc to 950 Mc in 2 bands. **BRAND NEW $79.50 TUNING UNITS** for above: TN1, TN2, TN3, **in stock**

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. BRAND NEW **$9.95**

USED, with tubes. . $6.95 | USED, less tubes . . $3.45

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**

LM FREQUENCY METER

Crystal calibrated modulated. Heterodyne. 125 Kc to 20.000 Kc With Calibration book
Complete, Like New **$69.50**

BC-906 FREQ. METER—SPECIAL

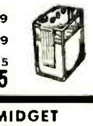
Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. **BRAND NEW. OUR LOW PRICE** . . . **$12.88**

BC-221 FREQUENCY METER

SPECIAL BUY! This excellent frequency standard is equipped with original calibration charts, and has ranges from 125 Kc to 20,000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book. Crystal, and all tables—LIKE NEW!

Unmodulated . . . **$76.50** Modulated . . . $115.00
BC-221 1000 Kc Crystal Brand New $8.95

2 VOLT BATTERY "PACKAGE"



1—2V. 20 Amp. Hr. Willard Storage Battery. Model ±20-2. 3" x 4" x 5½" high **$2.79**
1—2V. 7 prong Synchronous Plug-in Vibrator **1.49**
1—Quart Bottle Electrolyte (for 2 cells) **1.45**
ALL BRAND NEW!
Combination Price **$5.45**

WILLARD 6-VOLT MIDGET STORAGE BATTERY

3 Amp. Hour. **BRAND NEW.** 3⅝" x 1-13/16" x 2⅜". Uses Standard Electrolyte . . . . Only **$2.95**

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We specialize in the export of military surplus electronic equipment:

- **All at LOWEST PREVAILING PRICES.**
- **In addition to items shown on this page, we have in stock or can obtain for export customers, military electronic equipment made for World War II, Korean War, and later.**
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- **All packing and shipping is made directly from our own warehouse in NYC to give you substantial savings in handling costs!**

LORAN APN-4

FINE QUALITY NAVIGATIONAL EQUIPMENT

Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.

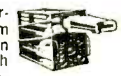
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes, Exc. Used. **$69.50**

Receiver-Indicator as above. BRAND NEW **$88.50**
Shock Mount for above $2.95

INVERTER POWER SUPPLY for above APN-4. INPUT: 24 V DC @ 75 A. OUTPUT: 115 V AC @ 10.5 Amps. 800 cycles. Complete with two connecting plugs BRAND NEW $49.50

12-Volt Inverter Power Supply for above APN-4. Like New. . . . . P.U.R.
We carry a complete line of spare parts for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR



Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. IN LIKE NEW Condition $79.50

Used, with all parts, less tubes, crystal and visor . . . . Special **$29.50**

INVERTER POWER SUPPLY for above APN-9. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. NEW **$49.50**

12-V. Power Supply for APN-9, like New P.U.R.
Shock Mount for above $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of spare parts for above.

BENDIX DIRECTION FINDERS

For commercial navigation on boats.
MN26C Receiver 150-1500 Kc continuous tuning with 12 tubes and dynamotor. Used . . $22.50
MN26C Receiver as above. BRAND NEW . . 36.50
MN20E Rotatable Loop for above 4.95
MN52 Azimuth Control Box 2.95

MN26Y 150-325 Kc; 325-695 Kc; 3-4.7 Mc. Complete with tubes, dynamotor, BRAND NEW **$19.50**
MN28Y Receiver Control Box . . . . $ 4.95

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC	$12.95	$14.95
BC-454	Receiver 3-6 Mc	12.45	17.95
BC-455	Receiver 6-9 Mc	11.50	13.95
	1.5 to 3 Mc. Receiver Brand New		$17.95

110 Volt AC Power Supply Kit, for all 274-N and ARC-5 Receivers. Complete with metal case, instructions **$8.95**
Factory wired, tested, ready to operate. . $12.50

SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. **Only** **49c**

2.1 to 3 Mc. Transmitter, Brand New $12.95
BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal, BRAND NEW. . **$9.75**
Like New $7.95
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal.
BRAND NEW **$10.95**
Like New $7.95
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

G & G RADIO SUPPLY CO.

Telephone: CO 7-4605

77 Leonard St. New York 13, N. Y.

AN/ART-13 100-WATT XMTR

11 CHANNELS
200-1500 Kc
2 to 18.1 Mc

$79.50 exc. used
Complete with Tubes

Famous Collins Autotune Aircraft Transmitter. AM, CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PP811s modulate 813 in final up to 90%, class "B." A Real "HOT" Ham buy at our low price!

AN/ART-13 XMTR. as above. In LIKE NEW condition. with all tubes and crystal **$89.50**

0-16 Low Freq. Osc. Coil for ART-13 . . . . 7.95
24V Dynamotor for ART-13 . . . . 11.95
We carry a complete line of spare parts for above.

AN/APR-4 RECEIVER only, 38 to 4000 Mc in 5 tuning unit ranges. High precision lab instrument. Input 115 V60 cy. **Like New** **$89.50**
Tuning Units TN16, 17, 18 each **$39.50**
Tuning Unit TN19. **Brand New** **$89.50**
Tuning Unit TU54 . . . . **$149.50**

ACCESSORIES for BC-603, 683 RECEIVERS

EXTRA SET OF 10 TUBES FOR ABOVE brand new in original boxes **$4.95**

12 or 24V Dynamotor for Above.
Exc. Used $4.25 . . . . Brand New **$5.50**

AC POWER SUPPLY FOR BC603, 683
Interchangeable, replaces dynamotor. Has On-Off switch. NO RECVR CHANGE NEEDED. Provides 220 VDC @ 80 Ma. 24VAC @ 2 Amps **$12.95**

Complete 240-page Technical Manual for BC-603, 604 . . . . **$3.15**

BC-604 TRANSMITTER—Companion unit for BC-603 Revr. above. With all tubes. BRAND NEW **$8.95**
4-Section Antenna for BC-604, 684 Transmitters. Complete with mounting base. BRAND NEW . . **$4.95**
We carry a complete line of spare parts for above.

ARC-5/T-23 TRANSMITTER 100-150 Mc., includes tubes: 2-832A, 2-1625. BRAND NEW, with tubes **$21.50**
Excellent Used, less tubes **$5.95**

ARC-5/R-28 RECEIVER, 2-meter superhet, 100 to 156 Mc in 4 crystal channels, complete with 10 tubes
Excellent Used, with tubes **$23.50**

SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New **$27.50**

EE-8 FIELD PHONES

Talk as far as 17 miles! Dependable 2-way communication at low cost! Ideal for home, farm, field. Up to six phones can be used on one line. Each phone complete with ringer. Originally cost govt. $65.00 each. Excellent Condition, checked out, perfect working order, complete with all parts. Each **$14.45**

MICROPHONES Checked Out, Perfect

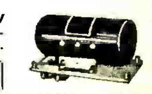
Model	Description	EXC. USED	BRAND NEW
T-17D	Carbon Hand Mike	$4.45	$7.95
RS-38	Navy Type Carbon Hand Mike	3.95	5.75

HEADPHONES Checked Out, Perfect

Model	Description	EXC. USED	BRAND NEW
HS-23	High Impedance	$2.79	$4.95
HS-33	Low Impedance	3.15	5.45
HS-30	Low Imp. (featherwt.)	.90	1.65
H-16 U	High Imp. (2 unts)	3.75	7.95

TELEPHONICS—600 ohm Low Impedance HEADSETS. BRAND NEW. PER PAIR **$3.95**
CD-307A Cords, with PL55 plug and JK26 Jack . **.99**
Earphone Cushions for above—pair . . . . **.50**

MOBILE-MARINE DYNAMOTOR



Model DM35
Input 12V DC. Output: 625 V DC @ 225 Ma, for press-to-talk intermittent operation.
Shpg. wt. 14 lbs.
BRAND NEW **$14.95**

OTHER DYNAMOTOR VALUES:

Type	Input	Output	Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V .05A	2.45	4.45
DM-33A	28V 5A	575V .16A		
	28V 7A	540V .25A	2.95	4.45
DM-34D	12V 2A	220V .080A	4.15	5.50
DM-36	28V 1.4A	220V .080A	1.95	2.95
DM-37	25.5V 9.2A	625V .225A	2.95	4.22
DM-43	28V 23A	925V .220A		
		460V .185A	—	14.50
DM-53A	28V 1.4A	220V .080A	3.75	5.45
PE-73C	28V 20A	1000V .350A	8.95	14.95
PE-86	28V 1.25A	250V .050A	2.75	3.85

DM-42A DYNAMOTOR. Input 12 V DC @ 39 Amps. Output 515 V DC @ 215 Ma. and 1030 V DC @ 260 Ma. Wt. 38 lbs. BRAND NEW, each $6.95
DM-37 DYNAMOTOR. Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each $3.25

SCHEMATIC DIAGRAMS For most equipment on this page, each . . **65c**

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CIRCLE NO. 118 ON READER SERVICE PAGE

ELECTRONICS MARKET PLACE

RATE: 60¢ per word. Minimum 10 words. September issue closes July 5th. Send order and remittance to: ELECTRONICS WORLD, One Park Ave., N. Y. C. 16, N. Y.

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ELECTRONICS! Associate degree—29 months. Technicians, field engineers, specialists in communications, missiles, computers, radar, automation. Start February, September. Valparaiso Technical Institute, Dept. N, Valparaiso, Indiana.

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HIGHLY-effective home study review for FCC commercial phone exams. Free literature! Wallace Cook, Box 10634, Jackson 9, Miss.

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DIGITAL Computers Simplified: Basic, concept level introduction, clearly illustrated. Advent Editiona, P.O. Box 124W, Sarasota, Florida. $3.00. 25¢ postage.

BASIC Mathematics. Algebra, Calculus, trial first, 4 easy lessons $1. Mathco, Cincinnati 17, Ohio.

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GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Parabolic Reflectors, Picture Catalog 10¢. Meshna, Malden 48, Mass.

INVESTIGATORS, free brochure, latest subminiature electronic listening devices, Ace Electronics, 11500J NW 7th Ave., Miami 50, Florida.

TV Tuners—Rebuilt or Exchanged $9.95 complete—all types—fast, guaranteed service. Send tuner with all parts to: L. A. Tuner Exchange, 4611 West Jefferson Blvd., Los Angeles 16, California.

DIAGRAMS for repairing radios $1.25. Television $2.50. Give make, model. Diagram Service, Box 672-E, Hartford 1, Conn.

MILITARY Discount—Name Brands Free Recording Tape and Stereo Handbook. Include Rand and Serial Number. Electronics International, Inc., Box 3066, Charlottesville, Virginia.

Save dollars on radio, TV-tubes, parts at less than manufacturer's cost. 100% guaranteed. No rebrands, pulls. Request Bargain Bulletin. United Radio 1000-W, Newark, N.J.

FREE literature keeping you informed on the latest work-saving, money-making test equipment. Learn how Easy Budget Payment Plan lets you pay out of increased earnings. Top engineered test instruments are priced for tremendous value. Write today. Century Electronics, 352 Maple Ave., Westbury, N.Y.

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

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

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

SELF-service console tube testers. Originally $149.00. Reconditioned $19.95. FOB Delmar Engineering, 3606 Delmar Road, Indianapolis, Indiana.

DIAGRAMS, Servicing Information. Television, Radios, $1.00. Supreme Publications, Highland Park, Illinois.

"LISTEN-in-coil" picks up any telephone conversation in vicinity. No connection to telephone necessary. Easily concealed. $2.98 complete. United Acoustics, 1302A Washington St., Hoboken, N.J.

COMPUTERS—Packaged Flip-Flops, Decoders, Encoders, Inverters, and Power Supplies. Write for free list: JAM Computers, 385 June Place, West Hempstead, Long Island, New York.

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TUBES—TV, Radio, Transmitting And Industrial Types At Sensibly Low Prices. New, Guaranteed, 1st Quality, Top Name Brands Only. Write For Free Catalog or Call WAlker 5-7000, Barry Electronics Corp., 512 Broadway, New York 12N, N. Y.

BEFORE you buy receiving tubes, test equipment, Hi-fi components, kits, parts, etc. . . . send for your giant free Zalytron current catalog, featuring Standard brand tubes; RCA, GE, etc.—all brand new premium quality individually boxed, one year guarantee—all at biggest discounts in America! We serve professional servicemen, hobbyists, experimenters, engineers, technicians. Why pay more? Zalytron Tube Corp., 461 Jericho Turnpike, Mineola, N. Y.

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