Electronics World

JUNE, 1963
50 CENTS

Construction of—HIGH-PERFORMANCE TRANSISTORIZED IGNITION SYSTEM

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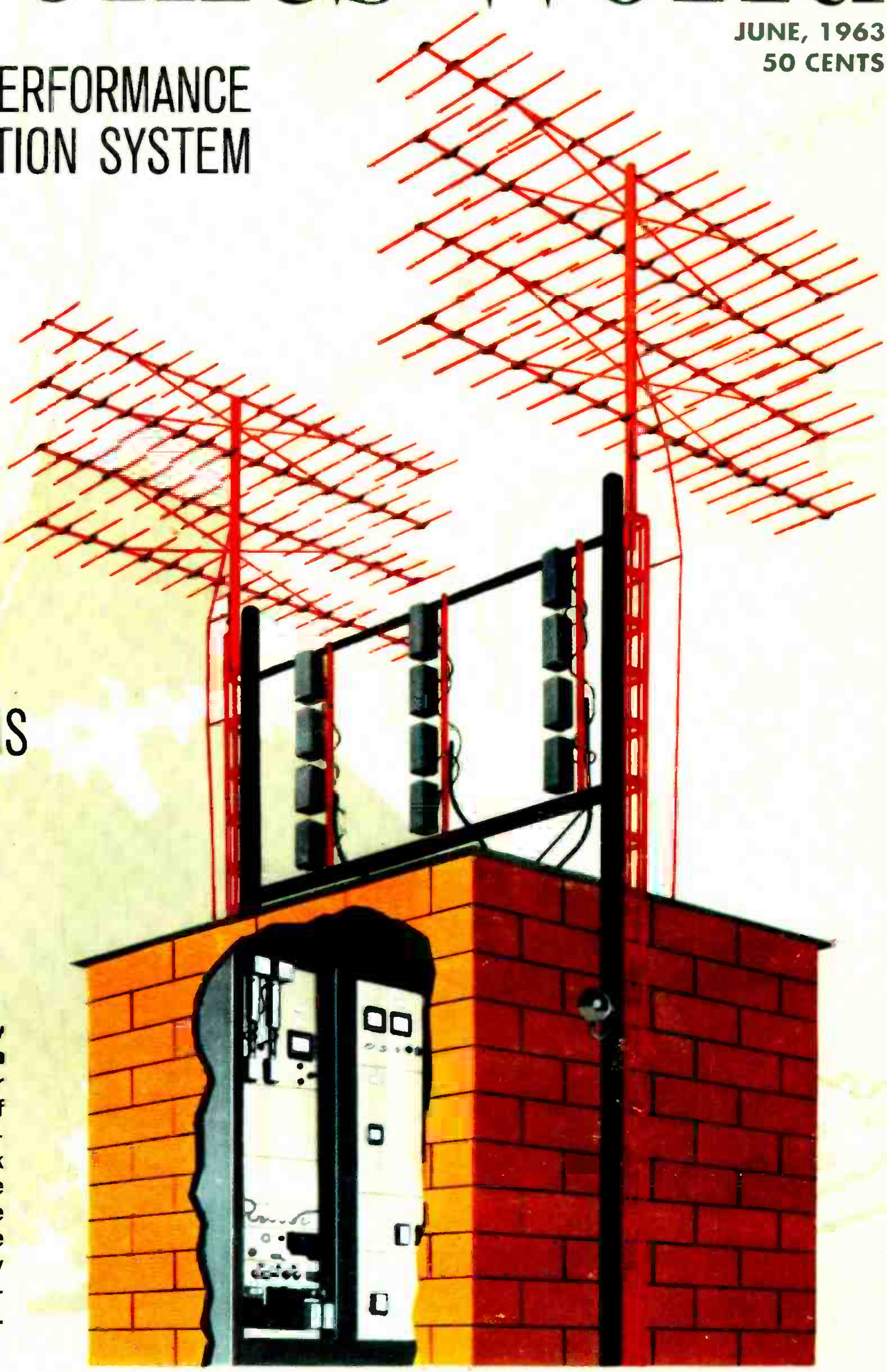
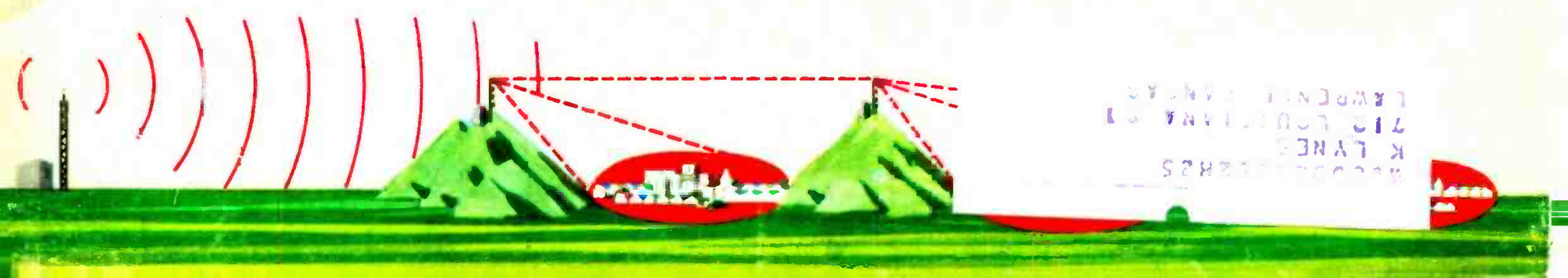
Survey of—COLUMN-TYPE P.A. LOUDSPEAKER SYSTEMS



WILL U.H.F. TV AFFECT YOU?

The approaching u.h.f. boom may change the entire, national pattern of TV signal distribution. Wherever you live, whatever your choice of viewing fare today, you will be affected. Will you have more to pick from or less? Will your signals be better or worse? Will there be more or fewer reception problems to cope with? Available techniques, many already tested, including translators, hold bright promise for all.



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Electronics is a growing and expanding industry. That's why so many ambitious men are deciding to train for careers in this exciting field. They recognize the opportunities to advance and prosper. But, where a man trains and how the school of his choice teaches Electronics . . how it encourages him to reach his goals and realize his nbitions . . . is most important to his success.

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Multiplex Version of the Famous 310 Tuner Selected for "Telstar" Experiment

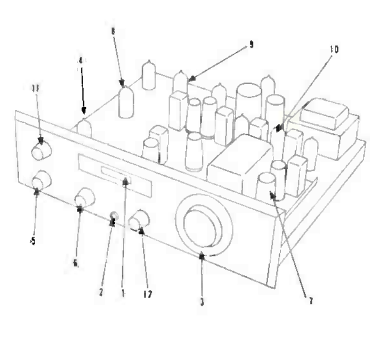
Now the world famous 310 tuner is fully equipped for Stereo Reception. The 310 is considered the most outstanding FM tuner available. It is used for commercial applications and critical broadcast relay work throughout the world. Its extreme sensitivity, selectivity and low distortion make it the logical choice for the most critical installations. The new 310E is equipped with the famous Time-Switching multiplex circuitry, pioneered by Scott, and universally accepted as the best way for achieving optimum stereo separation. Here is a tuner of broadcast quality, suggested for use in critical reception areas where its extreme sensitivity, excellent capture and low distortion are required. It is also recommended for the audio enthusiast who requires the very finest tuner possible at the present state of the art.

310E Technical Specifications

IHFM Sensitivity 1.9 microvolts; Drift .02%; Capture Ratio 2db; Selectivity (adjacent channel) 50 db; FM Detector Bandwidth 2 mc; FM Limiting Stages, 3; FM IF Stages, 4; Frequency Response (± 1 db) 30 to 15,000 cps (IHFM limits); Harmonic Distortion less than 0.5%; Spurious Response Rejection 85db; Separation 35 db. Controls: Main Tuning, Interstation Noise Suppressor, Level, Sub-Channel Filter. Size in accessory case: 15½W x 5¼H x 13¼D. Price: $279.95 *

310E FM Stereo Tuner Outstanding Features:

1. Sensitive illuminated tuning meter for optimum orientation and station selection. **2.** Convenient front-panel recorder output jack. **3.** Laboratory-type precision vernier tuning control. **4.** Auto-Sensor circuitry for fully automatic operation. **5.** Mode Control with these positions (FM Monophonic, FM Stereo, FM Stereo Automatic). **6.** Interstation noise suppressor. **7.** Silver plated RF Cascode front end. **8.** Scott's unique "Time Switching" multiplex circuitry. **9.** 2 megacycle wide-band detector. **10.** Three limiting stages, assuring fully quieted performance on even the weakest signals. **11.** Power/Filter (with these positions: Off, On, Sub-channel Filter, Stereo Filter). **12.** Stereo Threshold.



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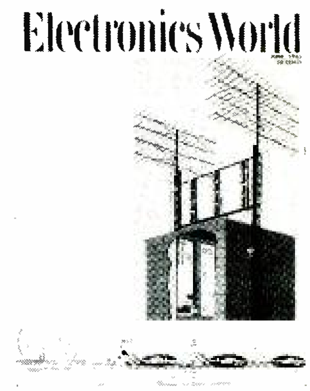
Electronics World CONTENTS JUNE 1963 / VOL. 69 NO. 6

MONTHLY FEATURES



THIS MONTH'S COVER features a shelter housing the electronics of a translator system. This one receives signals from 3 v.h.f. stations on the 2 large arrays shown, translates them to u.h.f. with equipment visible through the cutaway, and retransmits them locally. The background map is of metropolitan New York, which has one u.h.f. transmitter on the Empire State Building, assisted by a translator on the George Washington Bridge. A multi-hop translator relay (bottom) shows how u.h.f. can cover distance. For complete story, see page 21.... (Cover illus. by Dan Todd)

COMING NEXT MONTH

ADVANCES IN ELECTRON MICROSCOPY
With the new techniques which have been developed and the new instruments now under construction, researchers may soon be able to see the atomic structure of matter. Ken Gilmore describes transmission microscopes, electron- and ion-emission types, proton microscopes, and ultraviolet flying-spot scanners.

CONSTANT-VOLTAGE SOUND-DISTRIBUTION SYSTEMS
More and more public-address installations are utilizing the constant-voltage technique. Abraham B. Cohen discusses the principles involved and outlines practical applications.

V.H.F. MARINE RADIOTELEPHONY
For limited-range communications, the v.h.f. band may offer one answer to the problem of noise and congestion to be found on the m.f. marine bands.

UNDERSTANDING COLOR DEMODULATORS
Since there are actually only three circuits in a color receiver that are unique, the transition from black-and-white shouldn't be too difficult. This article covers operation of the color demodulating section and describes circuitry being used in present-day color television receivers.

SEMICONDUCTOR STRAIN GAGES
More sensitive and critical measurements can now be made with the new strain gages developed by such firms as Kulite-Bytrex, Century, and Baldwin-Lima-Hamilton.

"DELCOTRONIC"—TRANSISTOR-CONTROLLED IGNITION SYSTEM
J. C. Norris of Delco-Remy describes the unique magnetic-pulse-type ignition system being used by General Motors. With this system, breaker points are entirely eliminated.

MUST STEREO DISCS SOUND BAD?
Duane H. Cooper of the University of Illinois points out practical ways of eliminating tracing distortion and vertical tracking error which are largely responsible for audiophiles' dissatisfaction with stereo discs.

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

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For the record

WM. A. STOCKLIN, EDITOR

IEEE BREAKS ALL RECORDS

OVER 70,000 of the world's leading engineers and scientists in electronics, space technology, and communications participated in the first international convention held by the IEEE (Institute of Electrical and Electronics Engineers). The IEEE, officially formed January 1 of this year, is the result of the merger of the IRE (Institute of Radio Engineers) and the AIEE (American Institute of Electrical Engineers). With a total membership of 160,948, this new organization is now the largest technical professional society in the world.

The four-day convention, held in New York starting March 25, was an international show attracting experts from 53 different nations, including four Russian scientists who were permitted to attend on an exchange basis.

With two and a quarter miles of exhibits covering the latest electronic technical developments of 860 electronics firms, all previous records were broken, making it the largest technical exhibition ever staged.

It would be difficult, for those who have never had the good fortune to attend any of the previous IRE conventions, to visualize the magnitude of this show. Some 25,000 different pieces of electronic equipment of nearly every type and size, ranging from microminiature electronic apparatus to large computing machines, were on display. There were two and a quarter miles of exhibits.

Fifty-four technical sessions were held at the Waldorf-Astoria and the Coliseum. The 250 papers that were presented covered new developments in almost every field and phase of the modern world of electronics science. The sessions covered advances in 29 branches of the art, ranging from space technology to artificial intelligence and from biomedical electronics to educational television.

Although many exhibitors reported that business over the last few months had not come up to expectations, they all seemed to feel that the balance of the year will be good. There was also deep concern over pending profit restrictions on Government contracts; obviously, this would represent a serious threat to companies concentrating on defense work.

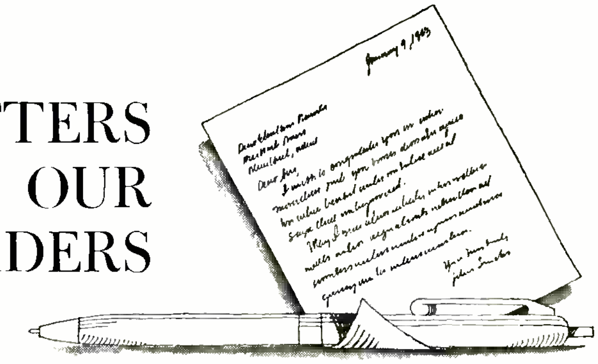
There is no doubt that the profit and loss status of an industry is important, but the recent IEEE convention seems to be much more than a statistical report. This show is, in a way, quite similar to Wescon, held on the West Coast, and the NEC (National Electronics Conference), held in Chicago. All three, open to the public, are technically slanted in that they provide a central meeting ground where electronically oriented engineers and scientists can openly discuss latest developments, specific designs, and even philosophies. These shows are inherently successful in that all participating companies want to prove, beyond any doubt, that they have the capabilities of developing the most sophisticated equipment possible.

Large sums are spent by Government and military agencies for our space program and much of this program is directed towards basic research and development. It is, therefore, important for a company to announce any new developments or breakthroughs they have made. The ultimate purpose, of course, is a subtle form of marketing.

This is good, not only for all engineers and scientists in furthering their own knowledge, but it is a tremendous incentive to an industry, particularly the electronics industry, which has moved at an unimaginable pace over the past ten years with one new breakthrough after another.

As long as we have such ideal opportunities for the free exchange of knowledge, everyone, even those who are only remotely concerned with electronics, should take all possible advantage of them. ▲

LETTERS FROM OUR READERS



FM MULTIPLEX GENERATOR

To the Editor:

We were very glad to see our organization named as a source of the 19-kc. crystal unit listed in your article on the "FM Multiplex Signal Generator" described in the January, 1963 issue of ELECTRONICS WORLD.

We immediately prepared a quote for one crystal per customer and even had our Network Engineering Department examine and derive a quote on the 53-kc. filter which would be pre-aligned and ready to insert in the instrument, such quote based on a production volume of one filter per prospective customer. Every person who wrote to us received a copy of this quote which listed the crystal at $12.75 each and the filter at $39.00 each.

Further, to insure that the crystals were as specified our Crystal Engineering Section built the oscillator circuit and the two succeeding stages in accordance with the schematic, photographs, and written construction information. This was done to accurately measure the effective load capacitance and drive level seen by the crystal, both of which have considerable effect on a crystal in this type circuit.

We have already supplied a surprising large number of "one per customer" items to all parts of the globe.

CHARLES W. MANN
Chief Crystal Engineer
Reeves-Hoffman Division
Carlisle, Penna.

° ° °

ELECTRONIC WEIGHING

To the Editors:

We have just read the story which appears on page 28 of your December, 1962 issue entitled "Electronic Weighing," by Walter H. Buchsbaum. We compliment you upon the interesting article on weighing and appreciate the use of our data in Fig. 7 and the picture of our Shadograph scale in Fig. 8.

We, however, take exception to paragraph 5 on page 38 which states, "In practically all industrial scales the counterweight is much less than the weight to be measured and balance is obtained by mechanical leverage." This statement is only true in part. We produce thousands of scales every year and have turned out hundreds of thousands over the last 45 years that are even-balance levers, where the counterweight is exactly the weight of the product being weighed.

On page 40 under the sub-head "Electronic Weight Indication," the second paragraph states in part, "One unique method of providing both a visual scale indication and a digital read-out is used in the *so-called* shadowgraph scale" (our italics). The Shadograph scale is one which we developed 23 years ago; the term is a registered trade-name spelled without the "w."

J. E. KONKLE
The Exact Weight Scale Co.
Columbus, Ohio

° ° °

BIONIC COMPUTERS

To the Editors:

Reference is made to the Ken Gilmore article in the March ELECTRONICS WORLD on "Bionic Computers."

You refer to the "Artron" and its inventors. I feel your readers should know that the "Artron" was developed by R. J. Lee, mostly in his spare time. It was an outgrowth of an earlier device that he developed while attending Oklahoma University in 1952.

Mr. Lee is Vice President for Research of *Adaptronics, Inc.* At present, Mr. Lee is developing a more advanced device which he calls the "Neurotron," and which provides both analog and digital capability.

JULIE B. HAUPTLI
Executive Staff Assistant
Adaptronics, Inc.
Alexandria, Virginia

° ° °

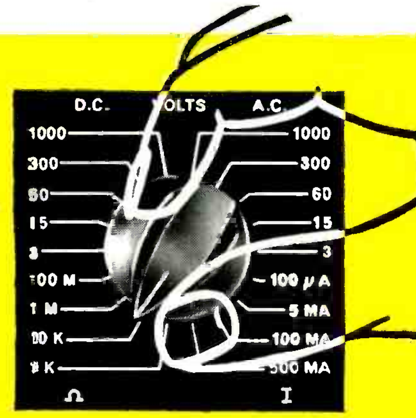
TRANSISTORIZED IGNITION SYSTEM

To the Editors:

I have built the transistorized ignition system described in your August and December 1962 issues, and installed it in my car, a *Studebaker* V8. I thought you might be interested to hear that it is operating excellently. The most noticeable improvement is the very easy starts that I have been able to get in cold weather.

I do not know if you have noticed that all Europe and especially Scandinavia have had an extremely cold winter for more than six weeks, the coldest dur-

See Only the Scale You Want . . . in the Exact Range You Want



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ing this century. Here in Stockholm there are thousands of car owners who park their cars in the streets.

Normally I do not drive very much during winter and have my car garaged. However, in order to test the new ignition system I had my car parked in the street a couple of nights and tried to start it early in the morning. On these occasions the temperature was between −12 and −17°C (9 to 0°F), and each time the engine started at the very first turn of the key.

GOESTA H. SPRITT
Stockholm, Sweden

° ° °

DIGITAL READOUTS

To the Editors:

I am writing with reference to the article on "Digital Readouts" which appeared in your February issue. Being the manufacturers of one of the products covered in the article, Nixie® indicator tubes, we were very interested in the comments made about our own and competitive devices. While the article was quite comprehensive, the author attempted not only to discuss and describe the various devices available, but also to evaluate them. It is in this area that I feel I must write to you to point out several conclusions which were drawn which were not only misleading, but actually inaccurate. I refer specifically to page 34, paragraph 2, in which the following sentences appeared:

> "Nixies usually are reliable but have a limited life. Numerals get dim, don't light up at once, flicker, or only part of a number glows. The only remedy is replacement, which is simple since they plug into a socket."

In fact, of all of the attributes of the Nixie tube, none is more outstanding than its tremendous life. As an example of this, we have subjected the Ultra Long Life series of tubes to continuing life tests which were started in September, 1958. We have particularly analyzed a group of 100 tubes which began their tests at that time and have operated to date (36,000 hours) with only one electrical failure. This represents a mean time between failures for this type of 3,580,000 hours. Based upon these tests, we predict with confidence a life expectancy for Nixie tubes operated under normal conditions of 300,000 hours. Returns from customers indicate that this prediction is realistic. Other parts of the quoted statement, such as dimming of light, partial illumination, or flicker are not readily understood. As far as the only remedy being replacement, our customers report that long-life Nixie tubes sometimes outlive their equipment designs.

RICHARD J. BRADY, Manager
Advertising & Sales Promotion
Burroughs Corporation
Plainfield, N. J.

▲

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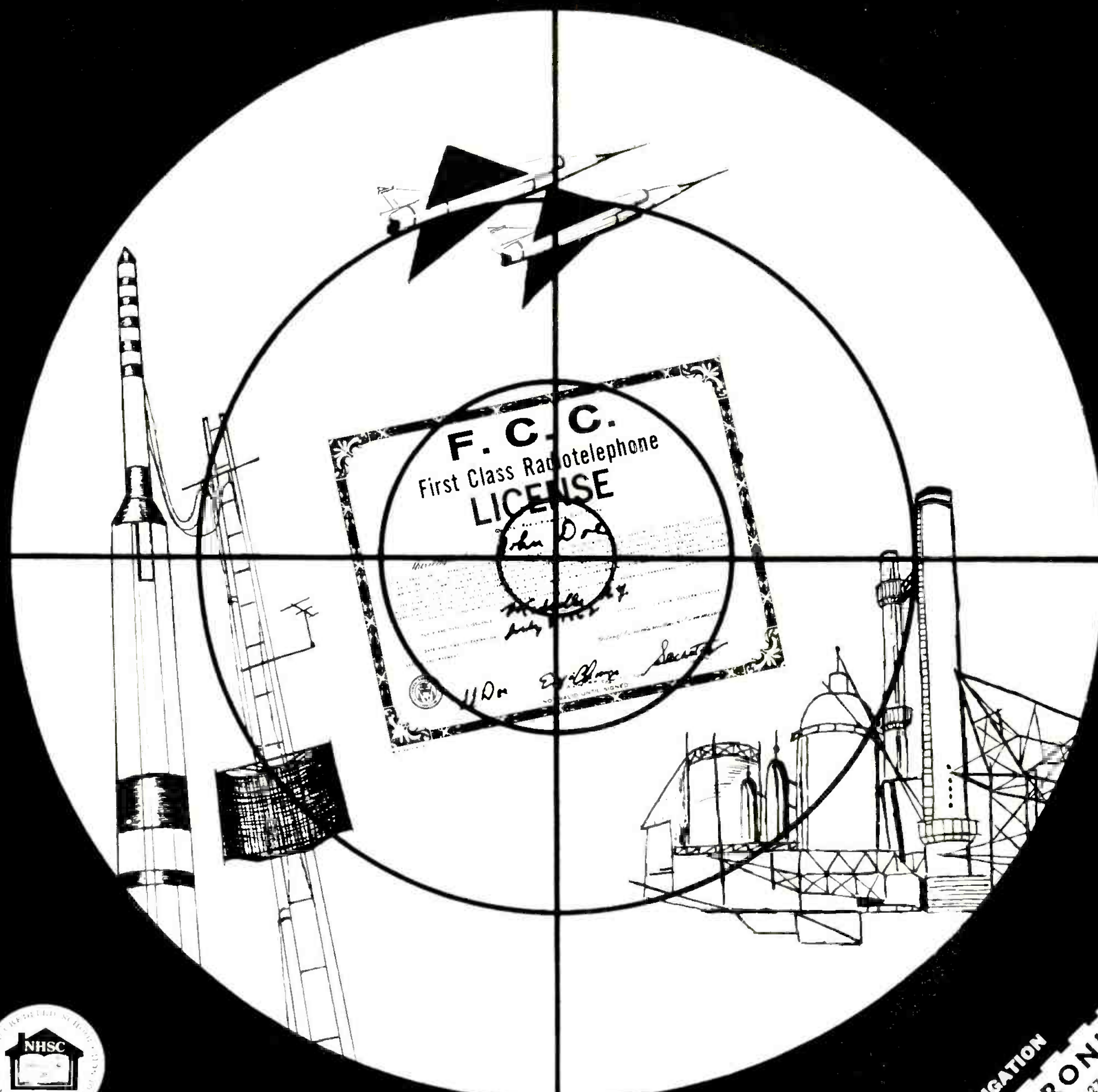

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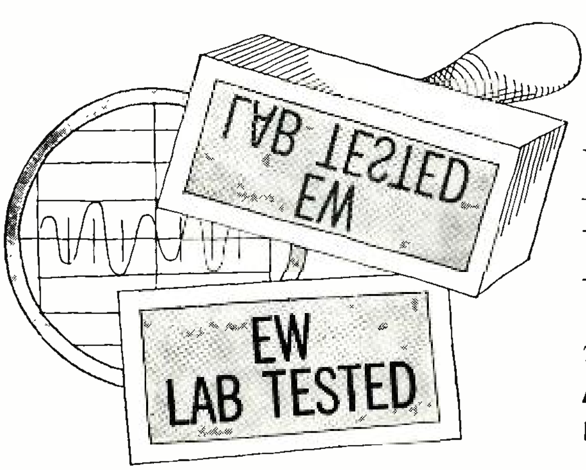


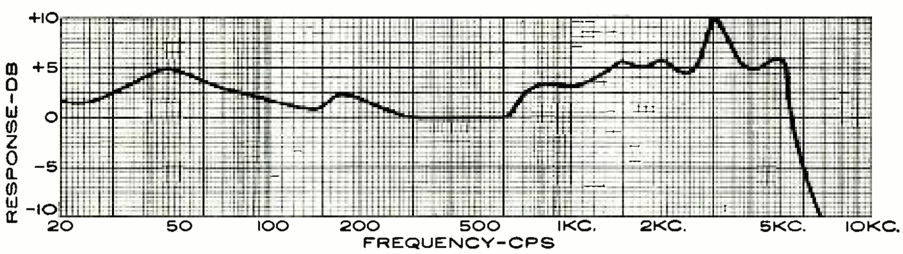
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Audiotex Model B-206 Microphone
Eico ST70 Integrated Stereo Amplifier

Audiotex Model B-206 Microphone

For copy of manufacturer's brochure, circle No. 57 on coupon (page 15).



MANY popularly priced tape recorders are supplied without a microphone, or with a microphone of minimal quality. The recordist who wants to make "live" recordings needs a reasonably good microphone (or two for stereo). A recording, after all, can be no better than the microphone used in making it.

Professional quality microphones, of which there are many, are very expensive—often costing more than some tape recorders. There is an intermediate category of microphones, suitable for serious amateur or semi-professional recording, but these also are too expensive for many hobbyists. Finally, there are low-priced microphones of a better quality than those usually supplied with inexpensive recorders. The *Audiotex* Model B-206 is in this class.

Manufactured in this country by the makers of the well-known *American* microphones, the *Audiotex* unit is a ceramic microphone, with a rated response of 40 to 12,000 cps. It is in the form of a tapered plastic cylinder, with a chrome end housing the element and diaphragm. It can be hand-held or desk-mounted on the clip-on stand supplied with it. There is also a neck cord for lavalier use. The six-foot integral shielded cable has a molded phono plug on the end and an adapter is supplied for plugging into the phone jacks used on many recorders.

We tested the microphone by comparing its response to that of our calibrated *Altec* 21BR150 laboratory microphone, with both units fastened together as closely as possible. A wide-range speaker system was used as a sound source. The resulting response curve (with the microphone being tested terminated in 0.5 megohm) shows a response within ± 5 db from 20 to 5400 cps. There is a peak at 3000 cps and response falls off rapidly above 5000 cps. The sensitivity is such that a 90-db sound-pressure level referred to 0.0002 dyne/cm.^{2} (typical close-talking level) develops about 10 millivolts output.

In listening tests, the microphone had a crisp, rather bright quality. Its response is suitable for many types of home-recording applications. The peak in the response, which gives the sound its bright character, should make this microphone very satisfactory for many communications applications, such as in amateur radio or Citizens Band stations.

The Model B-206 microphone carries a list price of $16.50. ▲

Eico ST70 Integrated Stereo Amplifier

For copy of manufacturer's brochure, circle No. 58 on coupon (page 15).

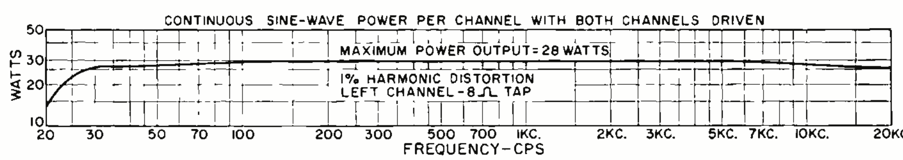
THE *Eico* ST70 is an integrated stereo amplifier, rated at 35 watts per channel.

It is styled to match the other recent *Eico* high-fidelity components, such as the ST97 tuner, ST84 preamplifier, and RP100 tape recorder.

The ST70 has all the operating convenience and flexibility one could desire in a stereo amplifier. There are inputs for two phono cartridges, with 47,000- and 100,000-ohm terminating resistors. These are selectable from the front panel, allowing the use of both a record changer and a turntable in a system. There is tape-playback equalization for both 7.5 and 3.75 ips speeds. The four high-level inputs accommodate AM, FM-AM stereo, FM multiplex stereo, and tape preamplifier signals.

The mode selector can route either input channel signal alone to its speaker, channel 1 input through both speakers, the sum of both channels through both speakers, and of course normal and reversed-channel stereo. The balance and level controls operate conventionally. The tone controls are of the variable inflection point (feedback) type giving considerable control of response at the frequency extremes without affecting middle frequency response. The tone controls are concentrically mounted on the unit.

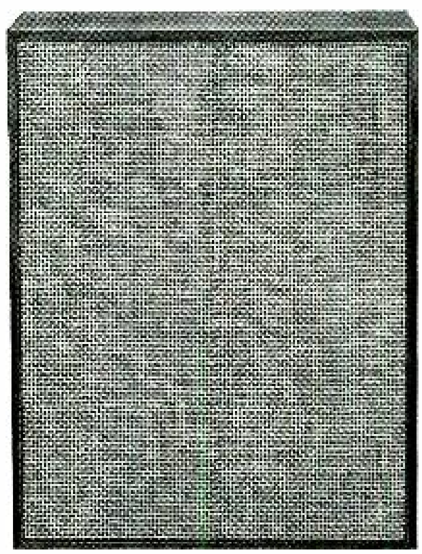
An array of seven slide switches selects tape-head equalization for either 7.5 or 3.75 ips, tape monitoring operation, loudness compensation, low cut filter, high cut filter, speaker phase, and channel balancing. The latter is an interesting feature, although its usefulness depends on a very close matching of speaker characteristics. In the balance position, one input signal is fed to both channels, and the output of one channel is reversed in phase and combined with the other.



Who could possibly build a genuine 3-way speaker system, with LC dividing network and 5 pounds of magnet, into a true Slim-Line enclosure—for only $59.50?

You!

(with the Fisher KS-1 StrataKit)



A 10-inch free-piston woofer with 30-cps free-air resonance . . . a 5-inch closed-back midrange driver . . . a 3-inch super-tweeter . . . a combined magnet structure weighing approximately 5 pounds...an inductive-capacitive dividing network with heavy air-core coils and crossovers at 1500 and 5000 cps . . . a magnificent 18-by-24-inch cabinet only 5¾ inches deep . . . plus lots of high-absorbency AcoustiGlas padding.

That's what goes into the *only* true Slim-Line loudspeaker system you can buy in kit form.

What comes out? The kind of sound you'd expect to hear from a $150 speaker system. How do you do it? Simply by installing the driver units, connecting the network and completing the preassembled cabinet. How does Fisher do it? With ingenious driver and crossover design and by balancing all speakers at the factory for over-all smoothness of response.

The Fisher KS-1 can be mounted on a wall, placed in a bookshelf or allowed to stand on the floor. Legs optional. Price, in unfinished sanded birch, $59.50.*

FREE! $1.00 VALUE! The Kit Builder's Manual: a new, illustrated guide to high-fidelity kit construction.

The Kit Builder's Manual

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Please send me without charge The Kit Builder's Manual, complete with detailed information on all Fisher StrataKits.

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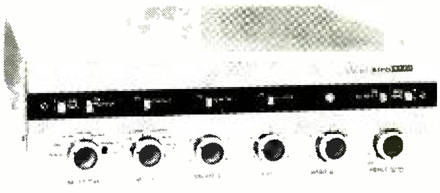


When the balance and tone controls are adjusted for exact equality of channel response, there is a distinct null in the audible output. However, if the speakers differ even slightly in frequency response or efficiency, this electrical null will not produce a true acoustical balance.

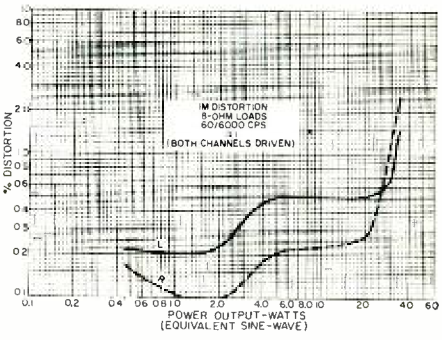
The output stages, each using a pair of 7591 tubes, are rated at 35 watts (continuous) output at 1% IM distortion. Each output stage has its own fixed bias adjustment and d.c. balance control. The bias setting requires a d.c. voltmeter capable of reading 0.38 volt.

Our lab measurements indicated a maximum power output of about 28 watts per channel, with both channels driven. Operating only one channel, we measured 34 watts output. These were measured at 1% harmonic distortion, at 1000 cps. The IM distortion was very low at normal listening levels, reaching 1% at 30 watts per channel output with both channels driven. The power response was very uniform, with substantially full output obtained from 25 to 20,000 cps. The volume control tracking was excellent, showing less than 1-db variation over a 40-db control range.

The loudness compensation, while effective from a listening standpoint, can provide some unexpected results. Switching off the loudness compensation with the volume control at less than half its maximum setting increases the volume level considerably.

RIAA phono equalization was within 1.5 db from 50 to 15,000 cps. NAB tape playback equalization (7.5 ips) was accurate above 50 cps, but fell off below that frequency. The hum level, on all inputs, was very low (better than 80 db below 10 watts). The gain is sufficient to develop 10 watts output from a 2-millivolt phono signal, or a 0.25-volt high-level signal.

In all respects, the ST70 is an excellent, highly flexible amplifier, and a good value at its price of $99.95 in kit form, or $149.95 factory-wired. ▲



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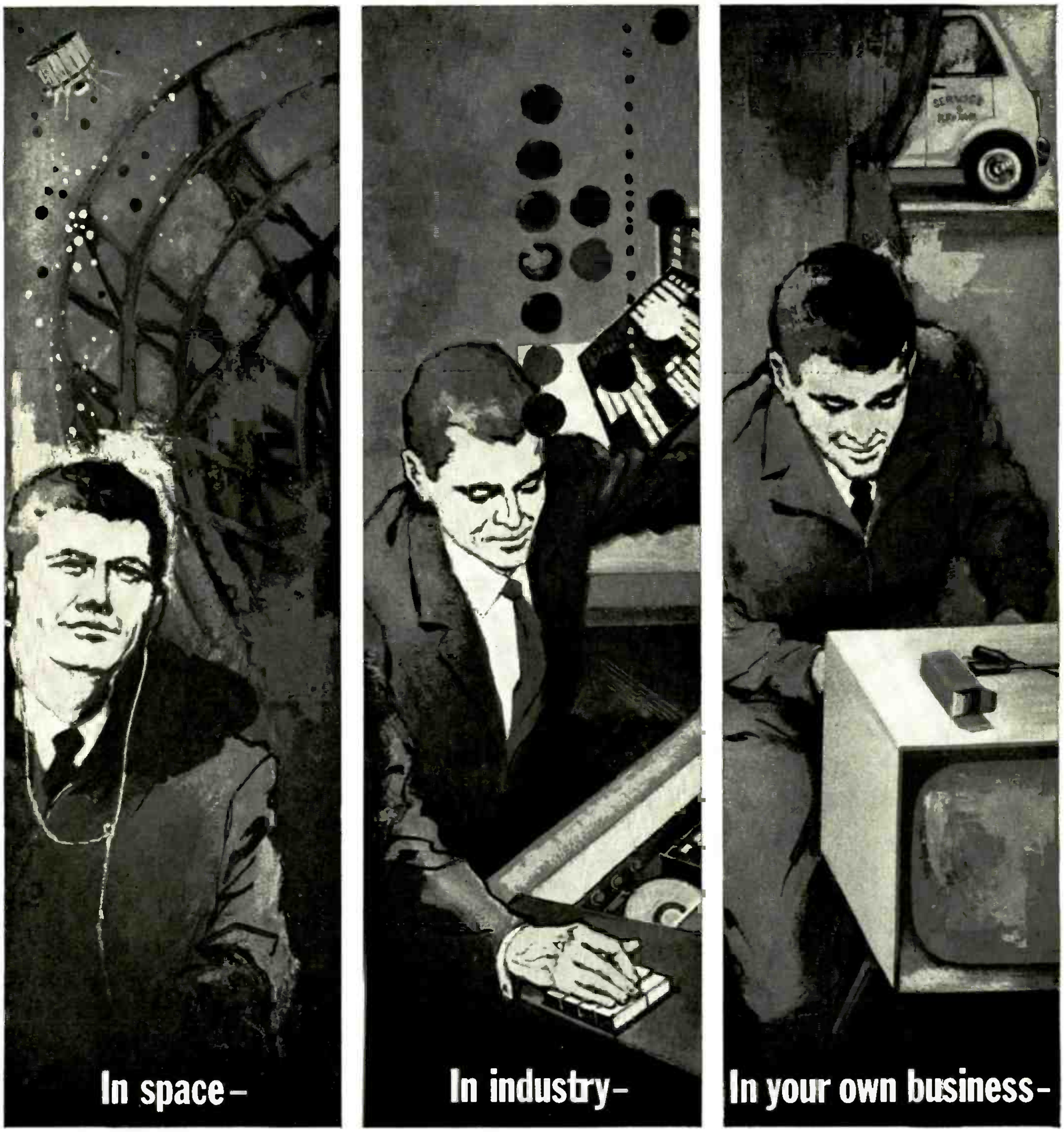

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EICO ST70, 70-WATT STEREO AMPLIFIER

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-6

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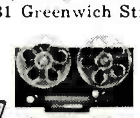

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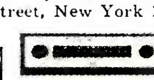
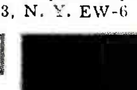


HFT-90 FM TUNER kit $39.95 wired $65.95



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

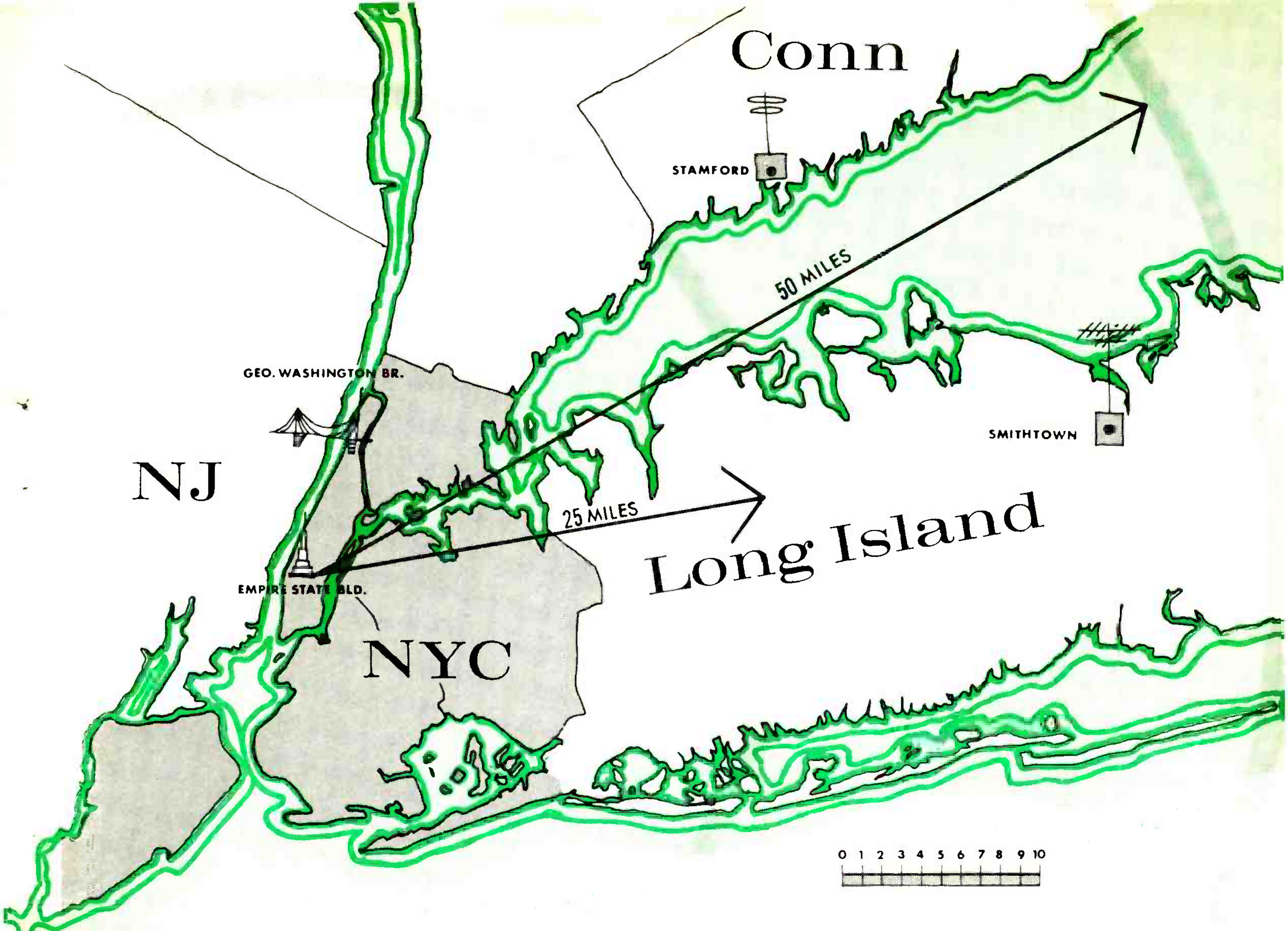


Fig. 1. The New York metropolitan area is a good choice for evaluating many u.h.f. problems. Between the Empire State Bldg. (ch. 31) and George Washington Bridge (ch. 77) lies a unique density of tal. buildings.

HOW WILL U.H.F. TV AFFECT YOU?

By SIDNEY C. SILVER, Service Editor

The coming ultra-high boom may push out v.h.f. altogether. How will TV coverage be affected? Will present viewers gain or lose? A variety of techniques, including the use of translators, holds great promise.

WILL I still be able to enjoy my favorite TV shows a few years from now—or will "Gunsmoke" vanish in a puff of snow? Millions of TV viewers have started asking questions like this one since passage of the "all-channel TV bill" by Congress last year. Briefly, the law mandates that every TV set made in this country, beginning early next year, must have the capability of receiving u.h.f. transmissions.

Ensuing events will then resemble this mixed chain of virtual certainties, high probabilities, and strong possibilities: Traditional patterns of TV broadcasting, as we now know them, will change. The u.h.f. band will become the predominant transmission vehicle and, if strong pressures already building take effect, it will end as the only vehicle. The military and other public and private agencies, starved for spectrum space, eye present v.h.f. TV allocations hungrily. As now constituted, the FCC tends to regard their eventual abandonment by TV with favor.

If the last likelihood materializes, the impact of u.h.f. will be all the more profound. It will portend a direct effect on all present v.h.f. viewers. Will changes be for the better or for the worse? The question begets many others, some dealing with receiver installations (the sets themselves, converters, antennas, and associated costs). But these are secondary to propagation problems. No one can get a signal unless it's there to be taken. Can u.h.f. signals, then, be stretched as far as those on v.h.f.? Notwithstanding certain well publicized difficulties, there is much encouraging evidence already on hand, based on experience.

Propagation Differences

Problems arise from the fact that, as frequency is increased, radiated signals show important changes in propagation behavior. They tend more to follow straight lines and less to bend around obstructions. Also, for a given amount of radiated power, the higher frequency will begin to dissipate more rapidly as it travels away from the antenna. In other words, the area surrounding the transmission point that can be covered with good u.h.f. signals would make a smaller circle than that described at v.h.f. The latter characteristic, of greatest concern to the fringe or border-line viewer, gives the impression that a switch to u.h.f. will rob him of reception.

The tendency to follow an unbending, straight-line path is of greatest concern to the metropolitan viewer. He may be quite near the transmitter site, where signal generally abounds, but, if he happens to be behind a tall building or other structure (in area *A* or *B* of Fig. 2), his share of the signal will be blocked off. He is in a hole, or shadow area. This obstruction effect may be produced by other man-made structures and, as well, by such natural formations as hills and mountains, or even trees and foliage.

Filling City "Shadows"

If some of the signal, or another signal carrying the same program material, is beamed toward the same general area from another angle (the hill to the right in Fig. 2), this viewer's problem is solved. Such measures have, in fact, been tested and are in use today. Their technical and economic feasibility has been established. The alternate source we have identified loosely as a "secondary radiator" may be one of several things, depending on the situation, but one or more of them can work.

One of the more recent and better publicized applications of the general technique was part of the extensive testing of metropolitan u.h.f. reception in New York City. The transmitting antenna of channel 31 was placed atop the Empire State Building (Fig. 1). Northeast of this point lies the heavily peopled "canyon area" of Manhattan, which has earned its name from the density of tall buildings that contribute to the island's impressive skyline—buildings that produce numerous holes or shadow areas for signals from channel 31.

An *Adler* translator installed on the George Washington Bridge is high enough to intercept plenty of good, unobstructed signal—and beam it right back into the problem area from another direction, on channel 77. Because of the narrow beamwidth of its own transmitting antenna, it can hurl abundant signal into the holes with very little power. A 100-watt transmitter does the job. The complete installation is shown on the bridge in Fig. 3. The skyline in the background includes the Empire State Building, from which the original signal emanates. A translator, which combines a receiver with an other-channel retransmitter, is not the only device that can be used. Before alternate solutions are discussed, however, other problems and other variations of the basic approach merit a careful review.

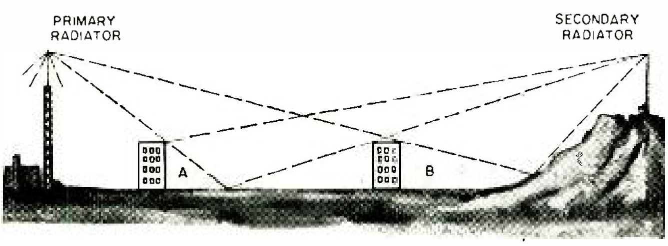


Fig. 2. Shadow areas (A, B) blocked to signals from the left can obtain identical service from another, secondary radiator.

Fig. 3. Adler translator installation at east end of G. Washington Bridge faces fabled New York skyline, in background.

Getting Distance

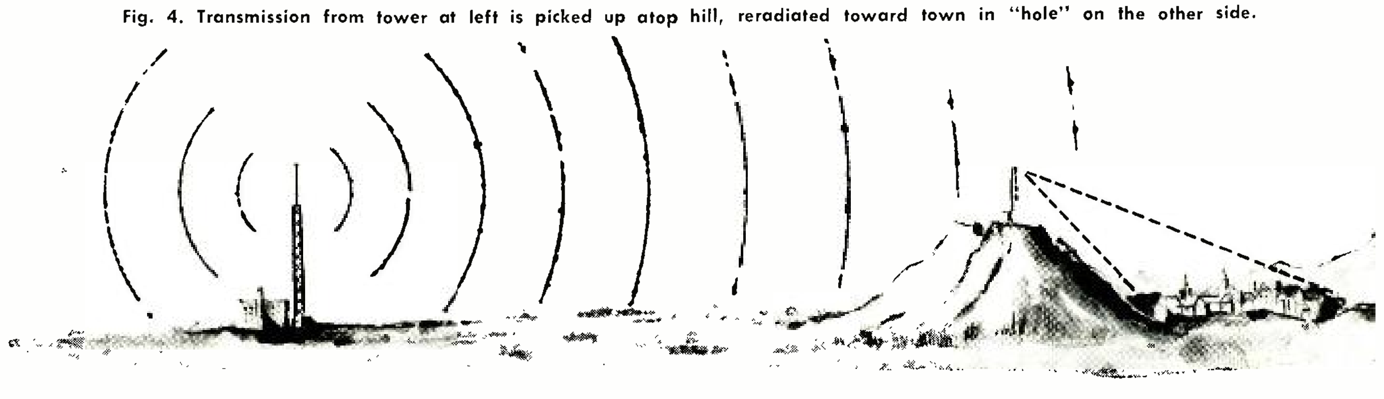
These hole-filling measures, however, do not do the viewer in outlying areas much good—or do not seem to. How will he fare in a u.h.f. world? For example, set owners in Smithtown on Long Island (Fig. 1), lying east of Manhattan, presently enjoy the full complement of v.h.f. pleasure on seven channels originating from Manhattan. The same applies to their brethren in Connecticut, say in Stamford, northeast of the transmitting site. The chief, present difference between these people and city dwellers is that the suburbanites generally need better antennas for similar results. Much has been made of the fact that, on u.h.f., signals would evaporate before reaching these outlying points. But the "fact," in reality, is only a half-informed assumption.

Legal limitations can be as formidable as technical ones, and u.h.f. does not suffer from some now holding back v.h.f. The FCC has had to limit each user of one of the dozen, scanty v.h.f. TV channels so that he will not infringe on others who share his frequency. There is a top limit on effective radiated power *vs.* antenna height. A 500-ft. antenna, for example, cannot exceed 100 kw., e.r.p. on a low-band v.h.f. channel. With an isotropic radiator—an omnidirectional transmitting antenna—the line of Grade B coverage would be a circle whose radius is 57 miles. (This coverage designation is not an absolute standard of signal quality, but a convenient assumption, worked out in a prescribed way, for setting propagation limits.)

With the same antenna height and e.r.p., a high-band v.h.f. transmission would rate as Grade B only 46.5 miles out, and the u.h.f. signal would have that rating only to 32 miles. But, since maximum allowable e.r.p. increases with frequency, the u.h.f. station could legally develop up to 5 megawatts! This would move the Grade B coverage line to 56.5 miles, practically corresponding to that for the low-band v.h.f. station. This possibility is often overlooked.

Making full use of this capability, however, will not always be practical. At very high powers, transmitter costs multiply alarmingly, especially in terms of the extra coverage achieved. Something else is more likely to happen. There will be some

Fig. 4. Transmission from tower at left is picked up atop hill, reradiated toward town in "hole" on the other side.



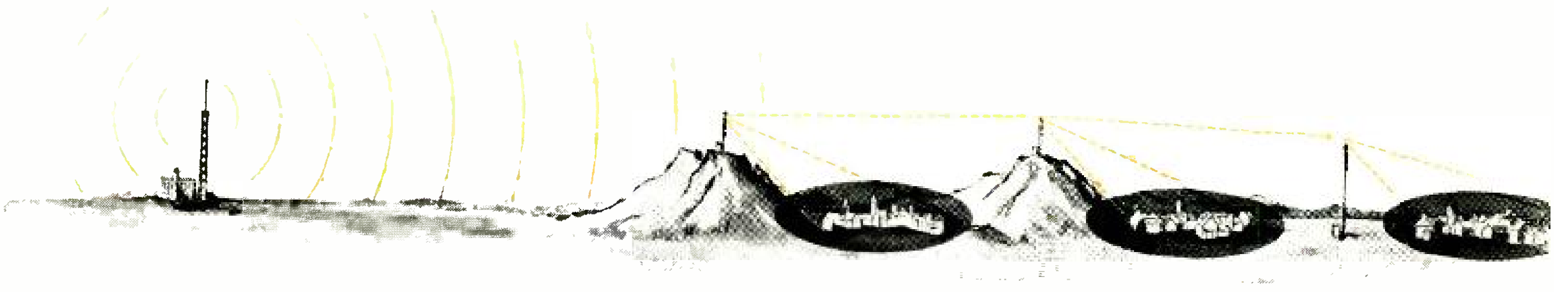


Fig. 5. Multi-hop method: three secondary radiators in tandem carry signals from primary source across impressive distances.

increase in power, short of the legal maximum. If a present v.h.f. broadcaster in New York, for example, should have to go u.h.f., he might step up power enough to reach not only Stamford, Conn., 32 miles away, but Smithtown on Long Island, over 40 miles out, and even points beyond. (Also assisting distant viewers is an encouraging fact about receiving antennas. For the same approximate size and cost, a u.h.f. array will be able to include many more elements and have noticeably better sensitivity than a v.h.f. unit.)

For very distant areas a broadcaster now reaches, it may be cheaper to use additional, low-power transmitting sites. Besides, simply making his isotropic radiator more powerful will still leave many populated shadows unfilled while signal is indiscriminately lavished on other, uninhabited areas. Such waste can be avoided with the selective use of secondary radiators of the general type noted in Fig. 2.

Proof of Experience

The foregoing statement is more than a theoretical assumption. The fact is that there are hundreds of such radiators now picking up and redistributing TV signals to millions of otherwise deprived viewers with little fanfare but great success. There are about 400 u.h.f. translators alone (compare this with 650 regularly allocated TV broadcast stations) serving about 2 million people. In most cases, they redistribute signals that were born on v.h.f. Let's see how adroitly they can be used.

In the simplest case, the secondary distributor of Fig. 2 is simply turned around to beam signal farther out, instead of back in. This is the case in Fig. 4, where an outlying town is in the shadow of a hill. The method is economical enough to be feasible for relatively small groups of people. The modest installation in Fig. 7 is aimed at a small community in a valley, from which ordinary transmissions are cut off by surrounding high ground.

Possibilities do not end with such modest applications. It is technically and legally feasible to set up a chain of secondary radiators, with one feeding another (the so-called multi-hop system of Fig. 5) to cover impressive distances. Consider an actual case in Minnesota (see map of Fig. 6). Signals from a large TV station in Duluth are picked up in the city of Virginia, about 50 miles away, and radiated locally. Virginia signals, however, are then picked up in Orr, more than 40 miles away, for local rebroadcast. The next link in the chain is Kabetogama, 30-odd miles to the northwest. Another jump of more than 20 miles brings Kabetogama signals to International Falls, at the Canadian border. Two antennas in the last community beam signal to two areas of population concentration. Here, dwellers near the border have no trouble picking up and viewing programs that originated in Duluth, more than 140 air miles away.

Nor is that the end of it. Duluth is a two-station market. Each of the stations here (KDAL and WDSM) is operating its own translator in the northeast corner of the state to serve the towns of Grand Portage and Grand Marais. In this way, a single locale serves a very large portion of a good-sized state, with half a dozen secondary radiators. In this case, all of the latter happen to be translators. Before considering these devices as such, let us consider a few more of the many possible configurations.

There are two u.h.f stations in Peoria, Ill., WTVH and WNBD. They have installed translators in La Salle, about 50 miles northeast, to serve the latter community. It is not unusual to see a translator "farm," consisting of two or more such devices at a single site to provide a town with more than one station. The modest structure in Fig. 8 is located in Blythe, Calif. It picks up the three network stations in Phoenix, Ariz. on channels 3, 10, and 12 with the two v.h.f. receiving arrays shown. Inside the shelter are three translator racks, each radiating through one of the u.h.f. transmitting antennas shown, for the benefit of local listeners.

Fig. 6. Duluth signal, in four jumps, gets as far as a Canadian border community about 140 miles away, with technique of Fig. 5. Other facilities serve Grand Marais and Grand Portage.

Fig. 7. This translator's u.h.f. antenna (mounted on arm) shoots into deep valley at Yosemite National Park, bringing TV to a signal-blocked community of forest-ranger families.

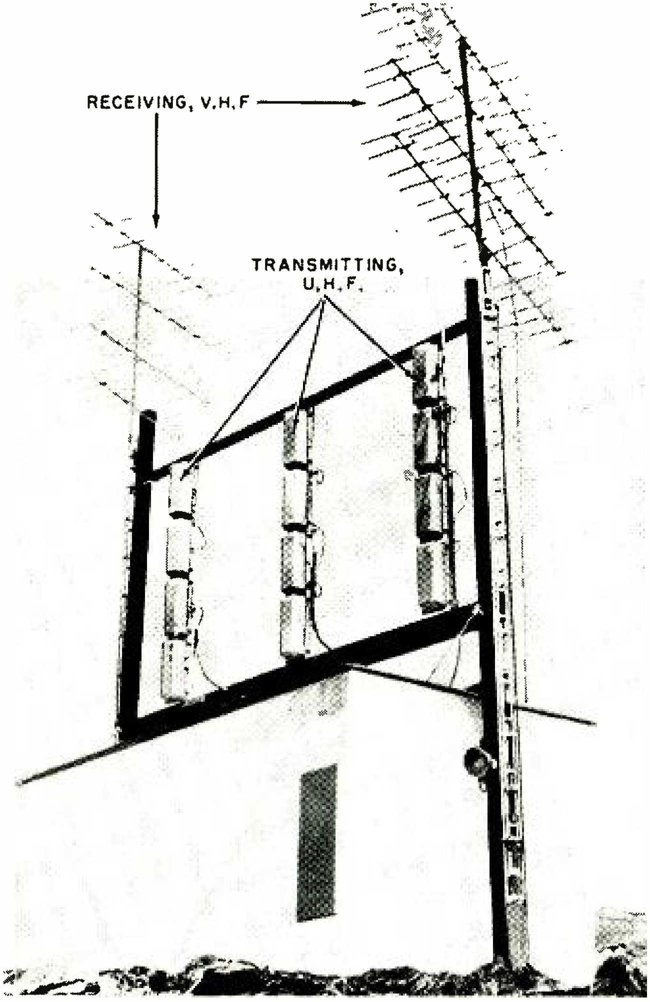


Fig. 8. Two arrays pick up three v.h.f. network stations from Phoenix, Ariz., redistribute strong signals via three translators to local residents. The site: Blythe, California.

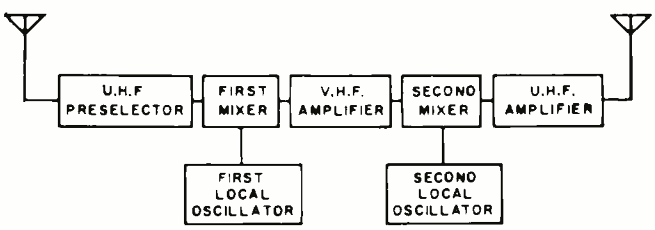


Fig. 9. Adler u.h.f.-to-u.h.f. translator in block diagram. Simpler v.h.f.-to-u.h.f. operation omits first three blocks.

While the usual "farm" serves a single community, the originating signals need not all come from the same place. For example, the citizens of Dubuque, Iowa will soon enjoy clear viewing on three stations from a farm now under construction. Two of the stations cooperating in this venture are about 60 miles southwest, in Cedar Rapids. The other is more than 80 miles to the west of Dubuque, in Waterloo.

Repeater Equipment

It is clear that the ability to bring u.h.f. signals wherever they are wanted not only exists but has passed the test of experience. But will it be practical to make use of the techniques? By their nature, secondary propagators serve limited populations. Do they make economic sense? For an answer, we must first evaluate the types of devices that can provide auxiliary coverage.

The most obvious solution is the satellite—a regular broadcast station, albeit a modest one. It relies on affiliation with a network or larger independent station for most of its programming, but can substitute shows and commercials of local origin and interest to help pay its own way. Channel allocations are available—on u.h.f.

To date, attempts to establish satellites have not been very successful. Since the scarcity of u.h.f. receiving equipment has been a factor, such operations will doubtless become more common when all-channel sets are widely used, but other drawbacks will still exist. The most modest separate station takes a sizable investment in original equipment and continuing operating costs—including salaries, since a station must be manned.

The booster-repeater eliminates personnel costs. This is a same-frequency relay that receives (on one antenna), amplifies, and retransmits (over another antenna) to the desired area. It copies the master station's signal exactly, but cannot originate programs. There are legal strictures on this practice, but also technical ones. The two antennas must be well separated, or feedback from one to the other can set up effects that do more harm than good. Aside from interaction of the antennas, some areas will receive both the original and the repeated signals in different phase, resulting in ghosting and cancellation. Some people would then be deprived of good reception although others benefit.

Translators are repeaters that always retransmit on another channel. If the received signal is on v.h.f., it is amplified on channel, then heterodyned with a local oscillator to u.h.f., passed through a power amplifier, and fed to a transmitting antenna. Such a system comprises the four blocks to the right in Fig. 9.

If the original signal is u.h.f., it is stepped down to v.h.f. for preamplification before translation. The u.h.f.-to-u.h.f. chain is completed by adding the three blocks to the left in Fig. 9. The entire electronics of a basic, 20-watt translator fits into a rack the height of an average man. The only needed additions are a shelter for housing and the antennas.

The UST-20, made by *Adler Electronics, Inc.*, is shown in Fig. 10. Blank panels are filled with the first three blocks of Fig. 9 in all-u.h.f. models. Where higher power is required, a companion rack of the same size is placed beside the UST-20 to make up the 100-watt UST-102. Such a pairing in fact, is the heart of the channel-77 repeater in New York shown in Fig. 3.

Use of another frequency for retransmission not only avoids the introduction of interference problems, but provides an extra weapon against them. Consider the channel-31 transmitter and channel-77 translator in New York City (Fig. 1). Plentiful signal from both sources will be available in many locations throughout the city. Hospitals, industrial enterprises, and other possible sources of interference abound. Simply by rotating their tuning dials, large numbers of viewers will be able to choose between two versions of the same signal transmission for the clearest reception.

Operation

Being automatic, the translator is not manned. Output frequency is crystal-controlled to FCC standards. Flat bandwidth across 6 mc. maintains relative carrier amplitudes as long as the original source does. Steep-sided response eliminates off-channel interference problems. An a.g.c. system maintains output within ±1 db even in the unlikely event that received signal varies as much as ±15 db.

A.g.c. is also used for automatic on-off control. When received signal goes off the air, the translator is cut off and draws only a small amount of standby power. The return of received signals turns it on again. The translator may also be controlled remotely.

It has its own call letters (*e.g.*, K74AL, signifying channel-74 operation), but the viewer does not know them. For identification by such agencies as the FCC, they are amplitude-modulated in code by an automatic timing device during station breaks. Rejected by the receiver's FM sound system, they are inaudible to the viewer, who will only see them as momentary streaks while the original station identifies itself.

Adler uses as many commonly available tube types as

(*Continued on page* 78)

COLUMN LOUDSPEAKER SYSTEMS

Employed mainly in sound reinforcement public-address applications, this particular type of system provides concentrated sound coverage and at a moderate cost.

By GEORGE L. AUGSPURGER

TWO or three years ago the use of column loudspeakers in sound reinforcement work was almost unknown in this country even though such units had been popular in Europe for some time. *Philips* of the Netherlands (*Norelco* in the U.S.) is one of the leading users and manufacturers of this type of speaker system, having several commercial models available and numerous successful installations to its credit. No one knows why the idea took so long to catch on in the United States, or why, once it did, the surge of interest was so rapid. Part of the answer lies in the fact that there is today considerable popular interest in audio equipment and in quality sound reproduction.

A person used to high-quality sound at home and at movie theaters is able to tell immediately that what used to be called "p.a. quality" does not usually sound right—it does not sound like the real thing.

But there are difficulties in achieving natural-sounding voice reinforcement which the average person—even the average high-fidelity enthusiast—does not usually appreciate. For one thing, the acoustics of an auditorium may preclude intelligibility whether electronic amplification is used or not. Also, the necessity of having microphones and loudspeakers close together in the same room gives rise to a number of rather frustrating problems, the most obvious being the familiar p.a. howl.

To keep microphones and loudspeakers from interacting, they must allow some control over the direction in which they pick up or project sound. We have had directional microphones for years: bi-directional ribbon mikes, unidirectional cardioid mikes, and, recently, extremely directional "shotgun" mikes. But loudspeakers have not received the same degree of attention. There were the very-high-quality horns made by *Altec-Lansing*, *JBL*, and others, which offer a variety of directional patterns, but the audio specialist designing an economical installation did not have much choice. This gap has now been filled by a variety of column loudspeakers offered by a number of manufacturers, such as *Argos*, *Atlas*, *Bozak*, *Electro-Voice*, *Jensen*, and *University*.

Basic Principles

The basic principle of the column loudspeaker isn't hard to understand. We know that, in general, the larger a sound source, the more directional it is. But, to be technical about it, size must not be measured in inches or centimeters; to a sound wave, size is always measured in relation to wavelength. And this of course means that a reproducer of constant *physical* size may be very large compared to a short

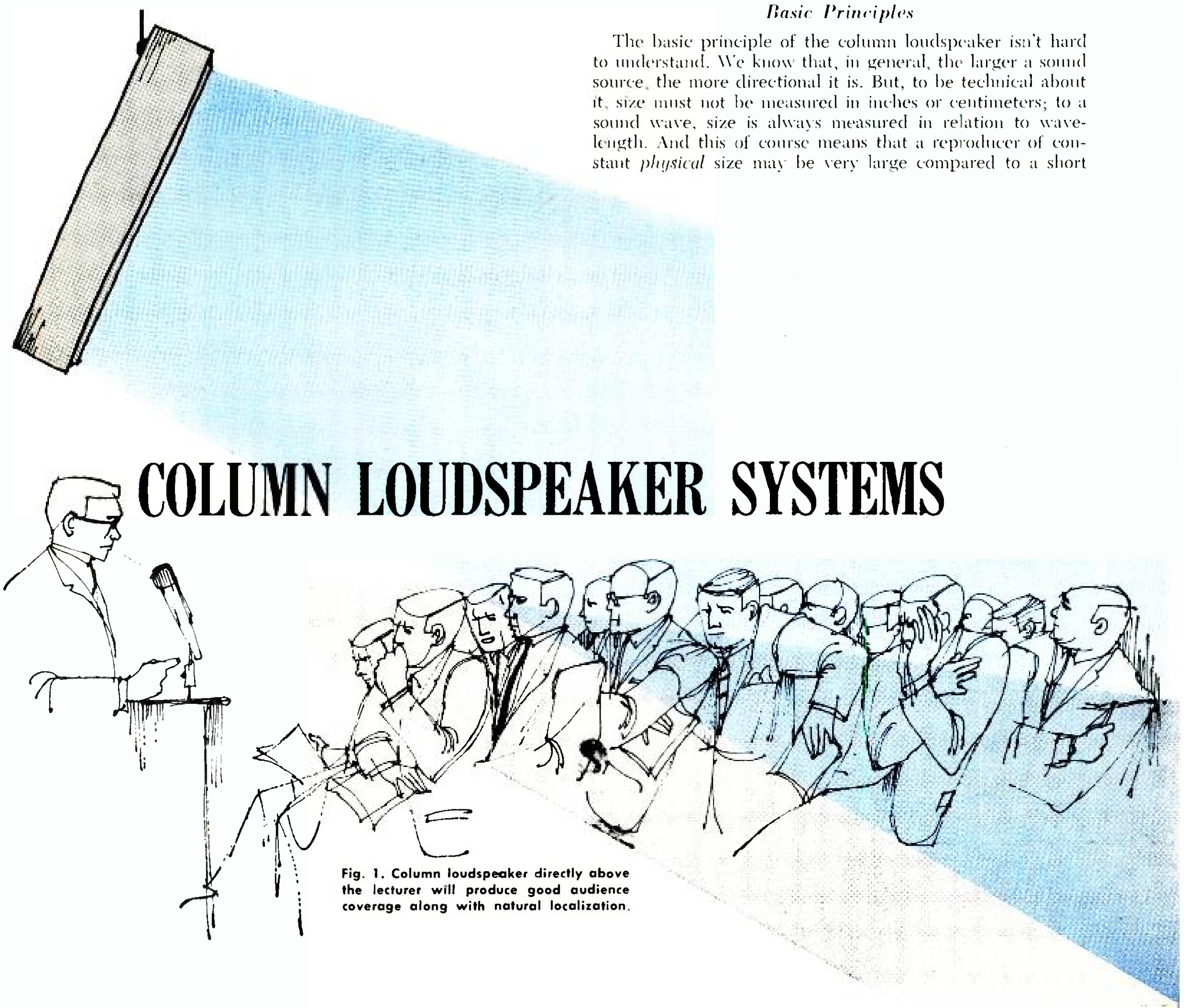


Fig. 1. Column loudspeaker directly above the lecturer will produce good audience coverage along with natural localization.

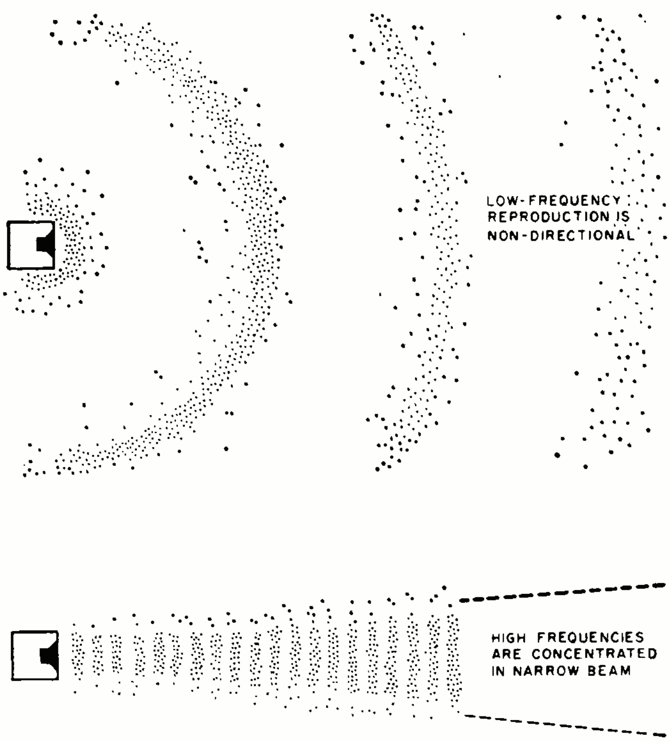


Fig. 2. Ordinary cone-type speaker is non-directional at low frequencies, but increasingly directional at higher frequencies.

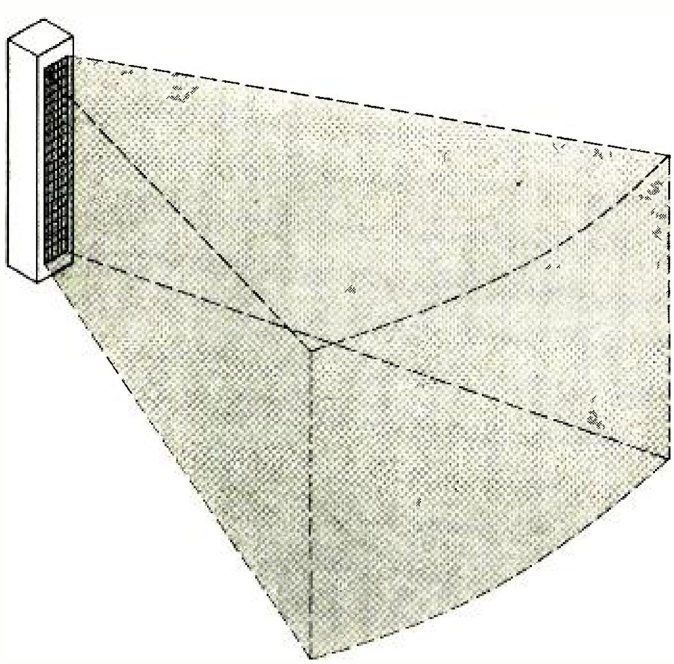


Fig. 3. Tall, thin "line radiator" concentrates sound into a fan-shaped beam with wide horizontal and narrow vertical coverage.

(high-frequency) wavelength, while at the same time it is very small compared to a long (low-frequency) wavelength.

For example, an ordinary 12-inch cone loudspeaker mounted in a closed box will radiate in all directions at 100 cps, but begins to beam the sound at frequencies above 1000 cps (Fig. 2). A 100-cps wavelength is about eleven feet long—large compared to the speaker cone—while at 1000 cps the wavelength and the cone diameter are about the same.

If the speaker behaved as a perfect piston, the sound energy would tend to be more and more directional at higher and higher frequencies. In practice, this is offset to some degree by the fact that the speaker cone breaks up and only the central portion reproduces the treble range.

Since the ordinary speaker cone is round, its sound distribution pattern is essentially symmetrical. If we had a sound source which was quite narrow, but several feet high (a "line source"), distribution in the horizontal plane would be spread over a wide angle while its vertical distribution would be concentrated in a narrow beam (Fig. 3).

Suppose that instead of one fairly large speaker, we consider a group of smaller units arranged in a vertical column, as in Fig. 4. The horizontal dispersion of such an array is, as we would guess, about the same as that of one of the individual speakers. But the vertical coverage is much narrower because all the cones move together and the array behaves as a single source. If the column is made up of five 6-inch speakers spaced as close together as possible it will be one wavelength *high* at about 350 cps, while it is not one wavelength *wide* until the frequency reaches about 2200 cps. Between these two limits, we can therefore expect wide horizontal and narrow vertical sound distribution.

If such a sound column is hung directly over a lecturer's podium, considerable sound amplification can be beamed at the audience without spilling over into the microphone (Fig. 1). A single source of amplified sound directly over the live performer is the ideal arrangement for natural-sounding reinforcement; both sources are localized by ear at about the same position, and they are the same distance from the audience so there is no problem of time delay.

There are additional advantages to the sound column. An array of speakers has greater power-handling capacity (and thus greater dynamic range) than a single speaker, even one of somewhat larger cone size. Also, a group of six to ten good-quality cone loudspeakers is less expensive than a top-notch horn-driver combination. And the slim, shallow configuration of a column makes it easy to conceal without "building in."

Column Refinements

But for a sound column to approach the quality and controlled directional characteristics of a good multicellular horn, or horn and acoustic lens, it must be refined beyond the point of a group of identical speakers connected in parallel.

Remember, the line source tends to become *increasingly* directional at higher and higher frequencies. This means that beam width is not constant—it may become so narrow in the upper voice range that the audience cannot be covered with one or two columns. Also, the fact that the individual loudspeakers in the column are necessarily separated from each other results in interference which can degrade both the frequency response and the directional characteristics of the array. Instead of concentrating the sound in a single direction, additional beams of energy are actually produced, as shown in Fig. 5.

What is needed is some way to make height of the column automatically change with frequency, so that its size *with regard to wavelength* remains constant. It should be half as high at 2000 cps as it is at 1000 cps, and so on. In practical terms, the center speakers should be the only ones to reproduce the full frequency range; the upper limit of the other speakers must be restricted more and more toward the top and bottom of the column.

This is called "tapering." It can be done by feeding the speakers through electrical filters, by placing acoustic filters in front of certain speakers, or by using speakers with differing high-frequency limits.

The last-named method is used by *University* in three commercial sound columns made by them. The speakers in the center of the column have wide-range response, but the treble response of those at the top and bottom is deliberately rolled off. At progressively higher frequencies, fewer speakers reproduce the signal—the column is effectively shortened and vertical coverage remains substantially uniform.

The acoustic filter method of tapering has been suggested, although it is not available commercially. This was described in a paper by David L. Klepper and Douglas W. Steele at the 1962 annual Audio Engineering Society meeting. As shown in

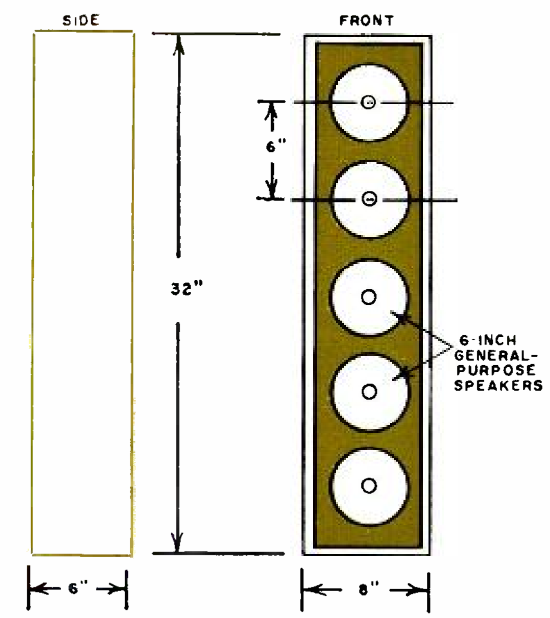


Fig. 4. Simple column-loudspeaker configuration. All the speakers are identical and connected together in phase.

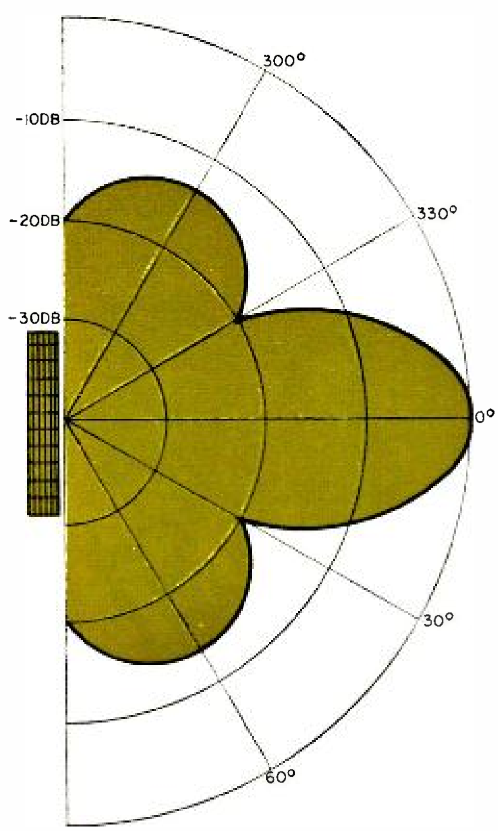


Fig. 5. Vertical distribution graph of a simple column loudspeaker showing unwanted lobes occurring at certain frequencies.

Fig. 6A, a group of identical speakers is employed, but glass-fiber wedges are placed in front of the array. The thicker the wedge, the greater its high-frequency absorption. The result of this increased absorption is a smooth gradation of effective length in proportion to wavelength.

Other Techniques

Jensen adds a further refinement in its units by designing what amounts to two sound columns side by side—a low-frequency column and a high-frequency column—fed by a standard 2000-cps crossover network (Fig. 6B). Individual groups of speakers in each of the two columns are connected through high-frequency roll-off filters. Thus the frequency range handled by the column is broken into two bands, each reproduced by its own in-line array. And each array is electrically tapered to maintain uniform sound distribution.

Straight-line arrays usually have a vertical coverage angle of about 30 degrees. Theoretically, this could be made smaller or larger, but when other factors are considered, and practical components employed, this is the way that things work out. Now 30 degrees is fine in many installations, but where speakers must be located quite a distance above the performers (a theater, say, with a high proscenium opening) or where the audience area is especially deep, it may be necessary to use several sound columns, tipped at different angles, to give satisfactory coverage.

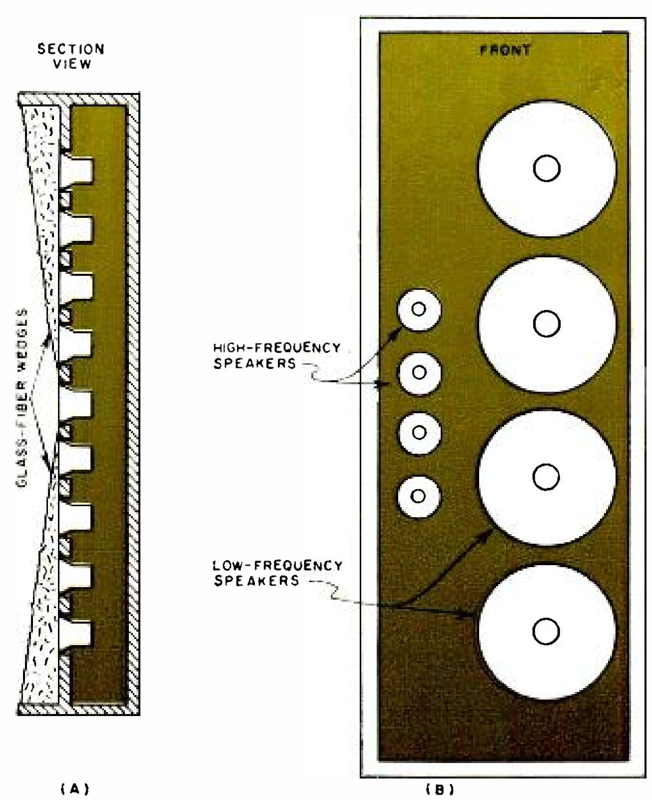
Electro-Voice makes two sound columns especially designed to provide a greater vertical coverage angle than the straight-line radiator, yet with directionality still highly controlled. These sound columns are curved-line arrays in which the speakers are mounted in a concave configuration rather than a straight line. The vertical coverage of the curved-line radiator is about 60 degrees, so it can be used in cases where two sound columns would otherwise be needed.

The fact that such a number of variations on the basic sound column are now available attests to the versatility and popularity of these devices. But they inevitably have their limitations and the audio specialist should keep in mind that the sound column is not the ideal loudspeaker for *all* applications.

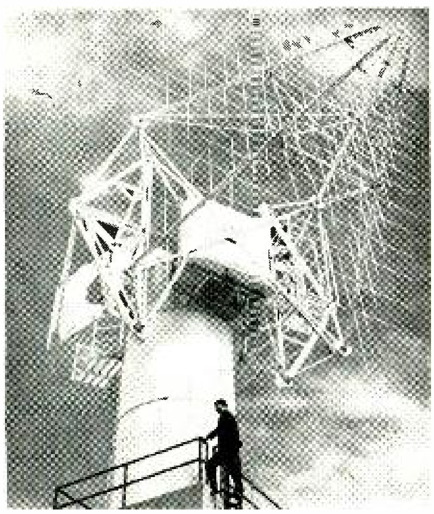
For one thing, neither a sound column nor anything else will change a reverberant gym into a concert hall. Sound columns, like other directional loudspeakers, tend to minimize reverberation and feedback by beaming sound energy toward the audience, where it is largely absorbed. But there is inevitably some "spill" and if the room is substantially an echo chamber, bare intelligibility may be the *most* which can be achieved. The author has seen architectural consultants spend dollars and hours diddling with directional microphones and odd-looking clusters of speakers when a single stamp of the foot or snap of the fingers would establish that some

(*Continued on page* 76)

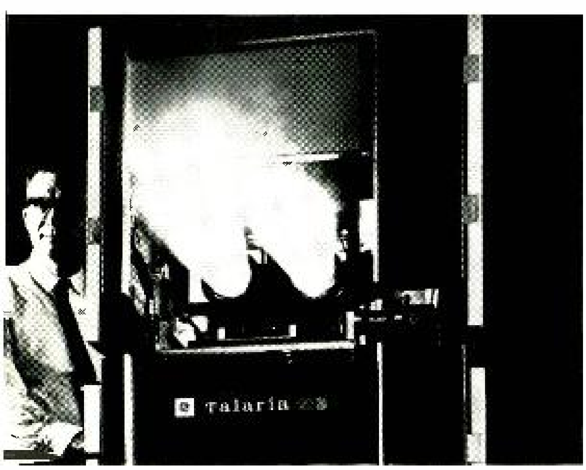
Fig. 6. (A) Column loudspeaker with acoustic filter for tapering. (B) Configuration of Jensen "Calstar" column speaker.



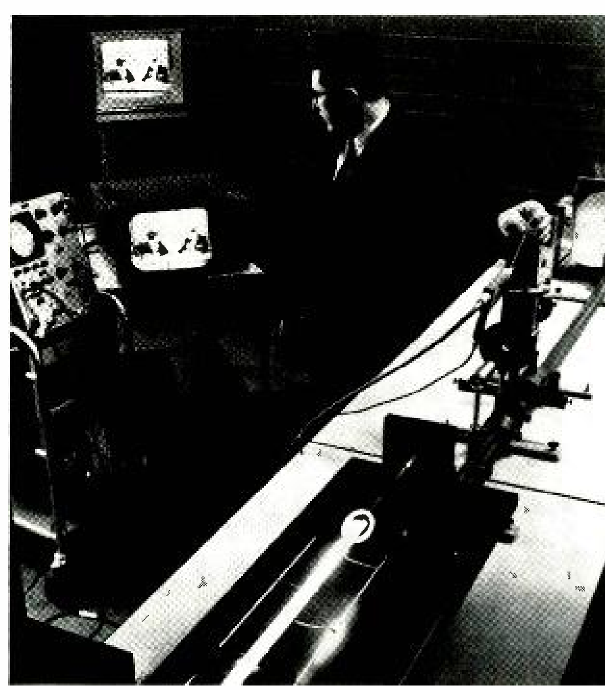
RECENT DEVELOPMENTS in ELECTRONICS

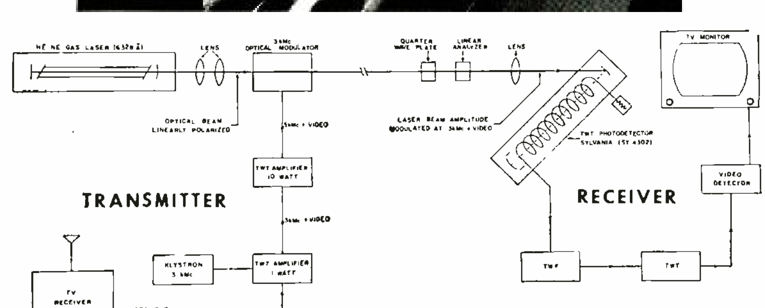


Log-Periodic Tracking Antenna. (Left) A "porcupine" antenna array consisting of log-periodic dipoles has been developed by Collins Radio to accurately track and monitor low-level earth satellites. Operating in the 30- to 300-mc. range, the antenna can acquire and lock in on a signal in its frequency range from any object passing above the horizon. Beamwidth is in the order of 30-35 degrees. . . **Laser Communications System.** (Below) A laboratory model of a system that transmits and receives TV pictures on a light beam generated by a laser was demonstrated by General Telephone & Electronics Corp. Video from the TV receiver in the background was used to modulate a 3000-mc. microwave subcarrier. This signal was then amplified by traveling-wave tube amplifiers and used to modulate the intensity of the radiated laser beam. The modulated light beam was picked up a short distance away by a special photodetector, amplified, video detected, and then applied to the TV monitor beside the scope. By using a large number of microwave subcarriers on the same beam, it should be possible to provide a communications system with a theoretical capacity of about 16 times that of our entire present broad-band point-to-point microwave radio system.

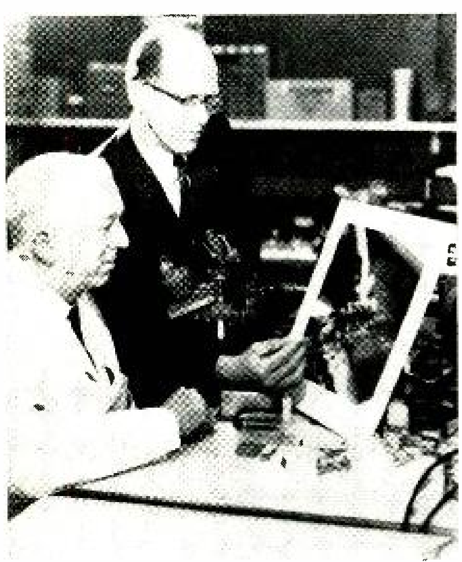


Color TV Projector. (Above) The new large-screen television projector shown here uses only two light beams (green and magenta) instead of the usual three primary colors (red, green, and blue) to produce a full-cover image. This two-beam projection technique, used in General Electric's "Talaria" unit, simplifies problems of color registration. The new projector will be used by the National General Corp., a 220-theater movie exhibitor, in a nationwide pay theater-television network. Formerly, most color systems were limited to small screens. With the new projector, display of color TV pictures having adequate brightness is possible on full-sized (25 by 33 foot) theater screens.

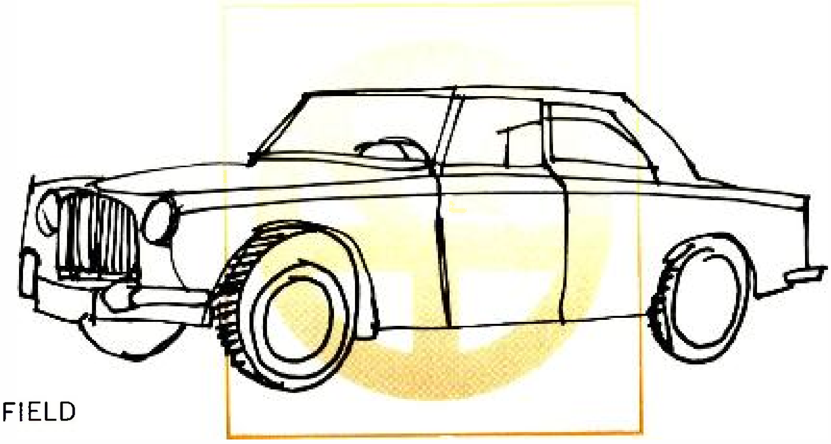




Plastic and Liquid Lasers. (Above right) Laser action has been achieved by use of clear plastic fibers containing traces of europium, a rare earth. The fibers are placed in a liquid nitrogen filled dewar and exposed to intense flashes of ultraviolet light from a xenon flash lamp. The energy from the light is transmitted by the transparent polymer plastic fibers to the europium atoms, causing them to emit bright flashes of coherent red light. Developed by RCA Laboratories, the technique may lead to low-cost lasers that can be mass-produced in fiber, sheet, or molded form. Lasing action has also been produced at laboratories of the General Telephone & Electronics Corp. by a europium compound dissolved in alcohols. The solution is poured into a quartz tube (below right), cooled to −130°C, and pumped by a flash tube.



Light-Operated Transistors. Scientists at IBM's Research Center are examining a photomicrograph showing the three-layer structure of a new optical transistor. In operation, electricity is converted to light at one of the junctions between layers. The light travels across the middle or base layer and is reconverted into electricity near the second junction. Since light travels through the middle layer so rapidly, the optical transistor operates at very high speed. The material used for the experimental transistor is gallium arsenide. Note that while the energy is actually carried by the light, the input to the transistor is an electrical signal as is its output. The transistor at the right, however, is a phototransistor. In this case, light shining on the device produces a voltage that is amplified by transistor action. The unit shown is a new Fairchild Semiconductor phototransistor, type 2N2452. Sensitivity of the transistor, available at about $27, has been increased recently.



By M. R. MAYFIELD

HIGH-PERFORMANCE TRANSISTOR IGNITION SYSTEM

Complete construction details on a proven and efficient solid-state system that features good performance, low cost, minimum battery drain, little ignition maintenance.

THIS article describes the construction and operation of a simple, inexpensive, and efficient solid-state ignition system. This system has many advantages, including much greater point life, less ignition maintenance, longer spark-plug life, greater acceleration, better mileage, easier engine starting in any weather and any ambient temperature, less radio interference from arcing points, positive instantaneous combustion at high engine revolutions, virtually no point heating, and smoother idling.

Its disadvantages are its complexity compared to a standard ignition system and its greater power consumption. With the engine not running, this system consumes about 100 watts (only 2 watts with the optional circuit) as compared to about 45 watts for a conventional ignition system. Power consumption during engine operation is about 60 watts for this system (with a point gap of 0.006") compared to about 30 watts for a conventional system (with a point gap of 0.018"). The electric systems of present-day automobiles can easily handle this extra power. The extra power is needed because of the low inductance in the primary winding of the coil.

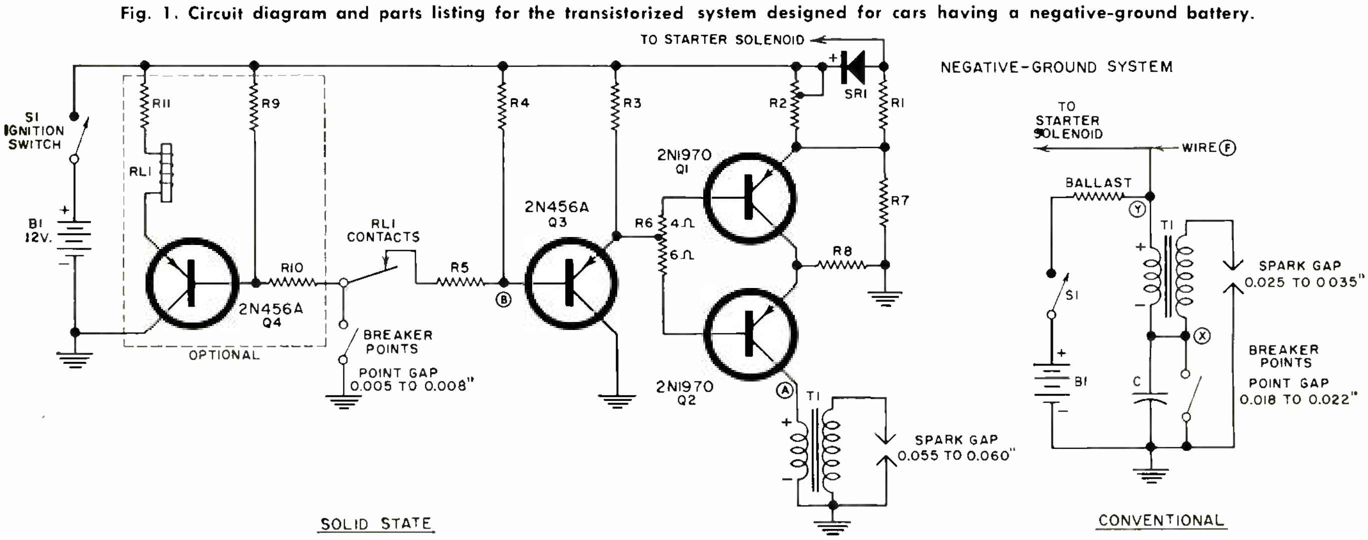
Balancing out the disadvantages and the advantages, the advantages greatly outweigh the disadvantages. Another "plus" is the fact thaat total construction cost of this particular unit is only approximately $35.00.

Circuit Description

Figs. 1 and 2 show the complete circuit diagram for both negative- and positive-ground systems. The functions of the various components are as follows:

$Q1$ and $Q2$ are the main current switches for the ignition-coil primary winding; $Q3$ is an emitter-follower to minimize point current. $Q4$ activates $RL1$ in case the engine stops inadvertently. This relay disconnects ground from the base of $Q3$ in the event the points remain closed for 30 seconds. This will stop the main current flow through the circuit and power drain from the battery will then be 2 watts continuous

Fig. 1. Circuit diagram and parts listing for the transistorized system designed for cars having a negative-ground battery.



R1—2 ohm, 10 w. res.
R2—1 ohm, 100 w. adj. res.
R3—10 ohm, 25 w. res.
R4—200 ohm, 2 w. res.
R5—7.5 ohm, ½ w. res. (two 15-ohm units wired in parallel)
R6—10 ohm, 10 w. adj. res. (set to 6 ohms, one side)
R7—5 ohm, 25 w. res.
R8—100 ohm, ½ w. res.
R9—1500 ohm, ½ w. res. (optional, see text)
R10—220 ohm, ½ w. res. (optional, see text)
R11—25 ohm, 5 w. res. (optional, see text)
RL1—Amperite delay relay 6C30T
RL2—12 v. or 6 v. relay, as required (Potter & Brumfield KASDY, not used in Fig. 1)
T1—Ignition coil; 1:250 turns ratio for transistor circuits (Mallory F-12T, available from auto parts dealers handling Mallory line)
B1—12-volt car battery
SR1—1N1115 silicon rectifier (1.5a., 100 p.i.v., Texas Instruments)
Q1, Q2—2N1970 transistor (Delco: types 2N1412, 2N1100 can also be used)
Q3, Q4—2N456A transistor (Delco)
1—Heat sink 7270606 (Delco)

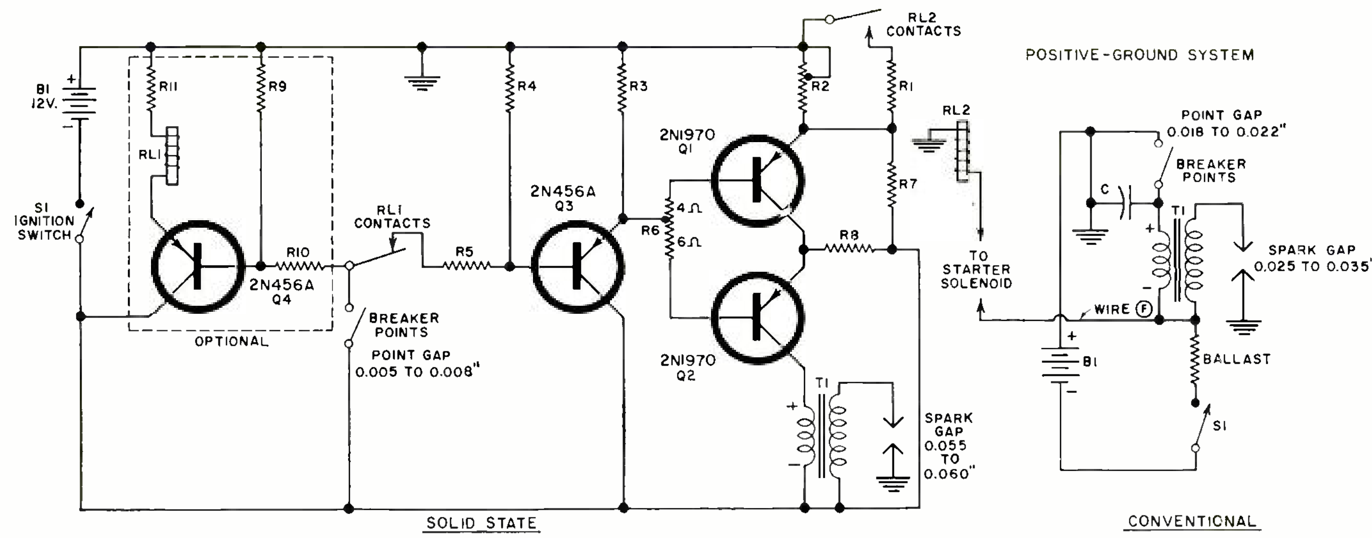


Fig. 2. Circuit diagram for cars with positive-ground system. The parts list of Fig. 1 also applies to this circuit.

instead of 100 watts. *RL2* (in Fig. 2) is to aid in engine starting on the positive-ground electrical system. This relay and *R1* will not be necessary if wire *F* is not on the conventional coil.

R1 is used to shunt *R2* only during cranking of the engine. Current flow through *Q1* and *Q2* at this time will be 8 to 10 amperes. On some automobiles battery voltage will sometimes drop to about 9 volts because of the excessive current drain from the starter, hence, more current through the ignition-coil primary is desirable. *R1* will also facilitate sub-zero cranking. Some automobiles remove the voltage from the ignition switch during cranking and rely entirely on wire *F*. *R2* sets the required current flow through *Q1* and *Q2*, as well as through *R7*.

R3 is a bias resistor used to cut off current flow through *Q1* and *Q2* while *R4* is the bias resistor for *Q3*. This resistor cuts off the current flow through *Q3*, determines the ease of engine start, and the point current.

R5 regulates the base current of *Q3*. This current flow determines whether *Q3* is turned on sufficiently to allow enough base current for *Q1* and *Q2* through the collector-emitter of *Q3*. *R6* controls the base current to *Q1* and *Q2*. This current flow determines whether *Q1* and *Q2* will be completely on or just partly on. With this design there is sufficient current flow to turn *Q1* and *Q2* completely on, an action which will reduce the dissipated power across these transistors.

R7 is used to draw a steady current through *R2*. The lower voltage on the emitter of *Q1* back-biases the emitter-base junction of this transistor to insure positive and complete turn-off of *Q1* and *Q2* even at extreme junction temperatures. *R8* is used to bleed off excess electrons from the *Q2* emitter.

R9 is the bias resistor for *Q4*, *R10* determines the base current for *Q4*, while *R11* limits the relay current.

The components shown inside the dashed boxes are optional. They are used only as a safety feature. When the engine is inoperative, this circuit will automatically disable the ignition system. This will occur only when the ignition switch is left on either purposely or inadvertently and thus prevent excessive battery drain. The only requirement, then, is to leave the ignition switch off for a minimum of 30 seconds. This will reset the automatic circuit. Total cost of this optional feature is around $5.00 and is well worth the money. The reason for using a transistor to operate the relay is to keep point current at an absolute minimum.

Ignition system operation for the positive-ground electric system is the same as for the negative-ground system. Insulated breaker points and chassis isolation of *Q3* and *Q4* are required. In some cases, *RL2* might be necessary, as mentioned previously. Special points for most automobiles can be purchased in auto supply stores.

Elimination of the zener diode usually employed in these circuits was made possible by the use of two inexpensive transistors, in series. This allows full use of the primary-winding back voltage for maximum secondary-voltage buildup.

Adapting this circuit to a 6-volt system is easily accomplished. Each resistor in the circuit should be halved in resistance value and power rating. *R11* must be eliminated entirely for 6-volt operation. The same current flow must be maintained in the 6-volt system as in the 12-volt system, how-

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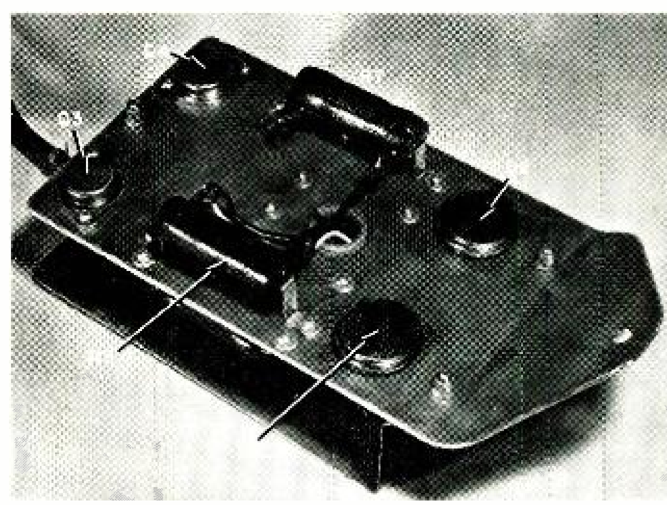
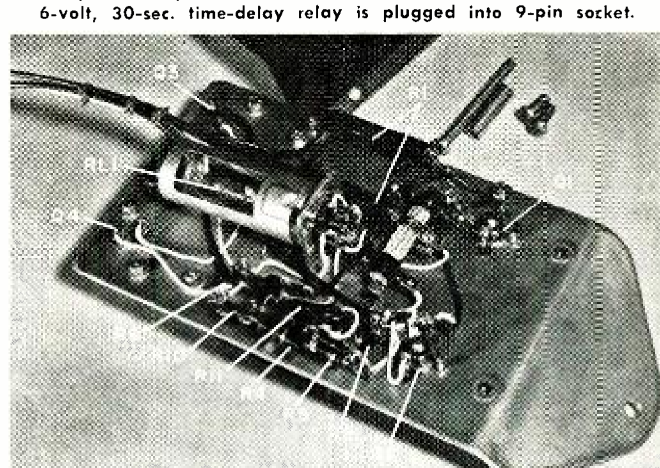


Transistor-side of unit. Q1 and Q2 are insulated from plate.

Relay-side of plate shown here with the cover removed. The 6-volt, 30-sec. time-delay relay is plugged into 9-pin socket.

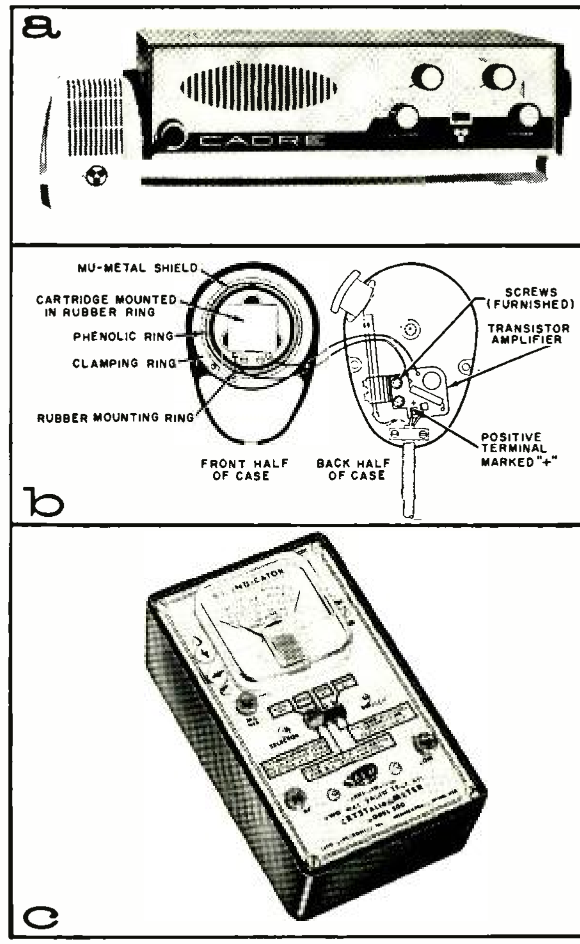


NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

A transistorized 5-watt transceiver, a mike conversion kit, and a CB service instrument.

THE transistor is featured in all three CB circuits this month. In one case we'll see how *Cadre* engineers obtained five watts from r.f. transistors without excessive d.c. voltages. The second circuit is a tiny conversion kit by *Shure* which eliminates hiss and humidity effects of an aging carbon mike. And there's the *Seco* "Cryst-align-Meter," a versatile CB service instrument that relies on the transistor for a half-dozen test functions.



(A) Cadre 510 Transistorized Transmitter

CB radio is essentially a mobile medium (by FCC definition) but the route to full transistorization has not been an easy one. A key problem has been in the design of a transmit section that could develop full 5-watt r.f. input—not that husky 27-mc. transistors are not available—these have been available for some time. Rather, it is a practical question of supply voltage. Suitable semiconductors often need d.c. sources in excess of 12 volts. In CB applications this means a quite elaborate conversion process to boost the normal 12-volt battery system of the car. This problem is neatly circumvented in the recent *Cadre*[1] Model 510, a transistor rig in the 5-watt r.f. class. By lining up three identical transistors in parallel, the design goal of a final amplifier powered by a 12-volt source is achieved.

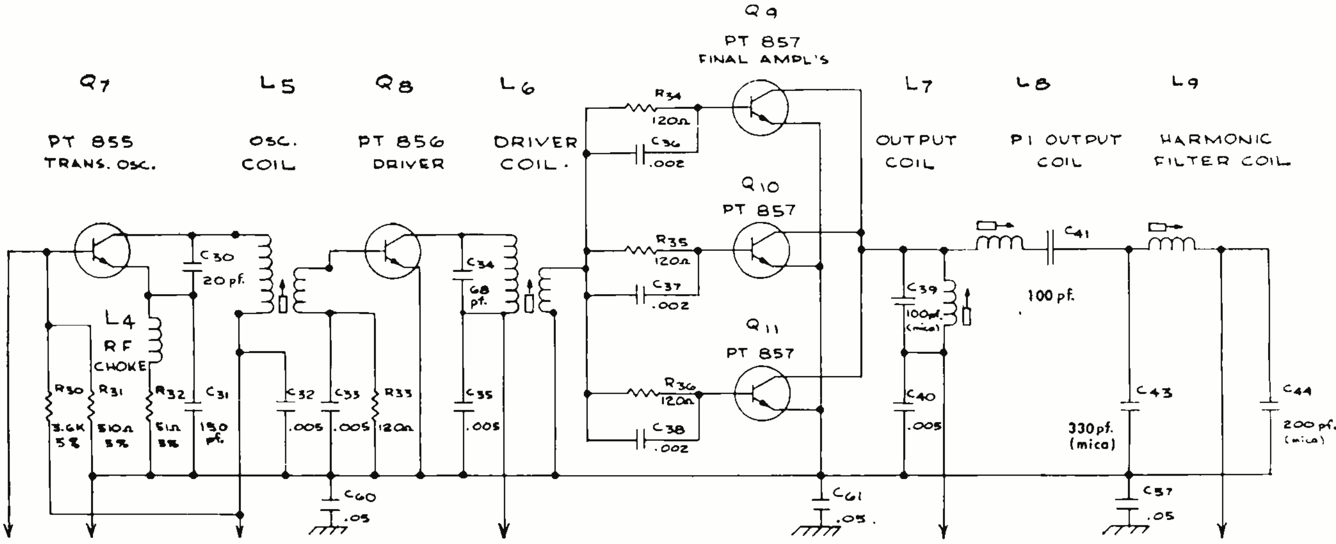
The partial schematic illustrates the transmit section of the Model 510. It is a conventional 3-stage line-up of crystal oscillator, driver, and final r.f. amplifier. The early stages, Q7 and Q8, are straightforward in concept. The oscillator performs in a Colpitts circuit, deriving feedback between series capacitors C30 and C31. Output r.f. is coupled to the driver which boosts it for the final. Upon examining input to the final, it is seen that each transistor base (Q9 through Q11) is connected in parallel across the driver coil, *L6*. A separate base bias network for each transistor assures equal signal distribution.

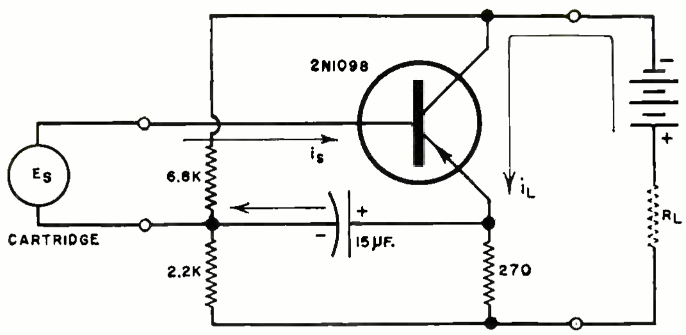
Again, the parallel connection is in evidence at the output side of the stage. Three collectors converge at a single point to feed the 27-mc. tank composed of *L7* and *C39*. Output of the three transistors is additive and the 5-watt r.f. power input rating is readily attained.

(B) Shure Microphone Conversion Kit R5T

To upgrade both their own and other makes of carbon microphones, *Shure*[2] has devised a compact conversion kit.

Circuit diagram of the r.f. portion of the Cadre transmitter showing the use of three paralleled output transistors.





Circuit diagram of the Shure transistorized mike preamplifier.

The package consists of a controlled-magnetic cartridge and a tiny one-transistor amplifier. Once the old carbon element is removed, the new components remount into the original case. The physical layout is shown in the drawing. The new cartridge clamps into place at the left, as shown, while the transistor amplifier screws directly to the mike switch.

In operation, the transistor supplies the audio gain formerly provided by the carbon-mike arrangement. Thus, it is comparable to the first voltage preamp found in CB rigs equipped to handle low-level mike signals. This stage is normally absent in carbon-mike transceivers.

The schematic shows that the transistor is wired as a conventional audio amplifier, but certain measures are used to make the kit compatible with the audio input circuitry common to the carbon mike. In most installations, it is not necessary to make major rewiring changes inside the CB set to match the modified mike. For example, the load resistor in the schematic may actually be the primary of the carbon-mike transformer. Transistor output is intended for operation into loads in the 100- to 500-ohm range. When unfamiliar circuitry is encountered, the sample schematics provided by the manufacturer should prove helpful during the conversion. They also give methods for utilizing the carbon-mike bias for powering the transistor with approximately 9 volts.

Signal output of the converted mike is comparable to that obtained with the carbon element. Voltage across a 100-ohm load is −18 db (where 0 db = 1 volt at 100 microbars).

(C) Seco 500 "Cryst-align-Meter" Test Set

The *Seco*[3] Model 500 strives to accommodate the CB troubleshooter with the same "test-set" approach common to commercial two-way radio service. Housed in a single instrument are three principal circuits and a versatile switching arrangement for numerous CB measurements. Transistorized and self-powered, the device helps uncover signal problems in both transmit and receive sections of the rig.

The complete schematic of the unit is shown here, along with three simplified sections which form the heart of the circuit.

Assume that a handy signal source is needed for receiver checking or alignment. With a CB crystal plugged into the appropriate socket, the overtone oscillator behaves like a low-powered transmitter with a range of several feet. If audio modulation is required, the a.f. oscillator can superimpose tone on the carrier.

Another useful function of the overtone oscillator is checking CB crystal activity. The test is based on the fact that good crystals display relatively high "Q" and, consequently, high output. Crystal-controlled r.f. is fed to the diode (in the modulation circuit) and d.c. is developed for driving a 0-1 ma. meter. A scale on the meter is calibrated in degrees of relative crystal output.

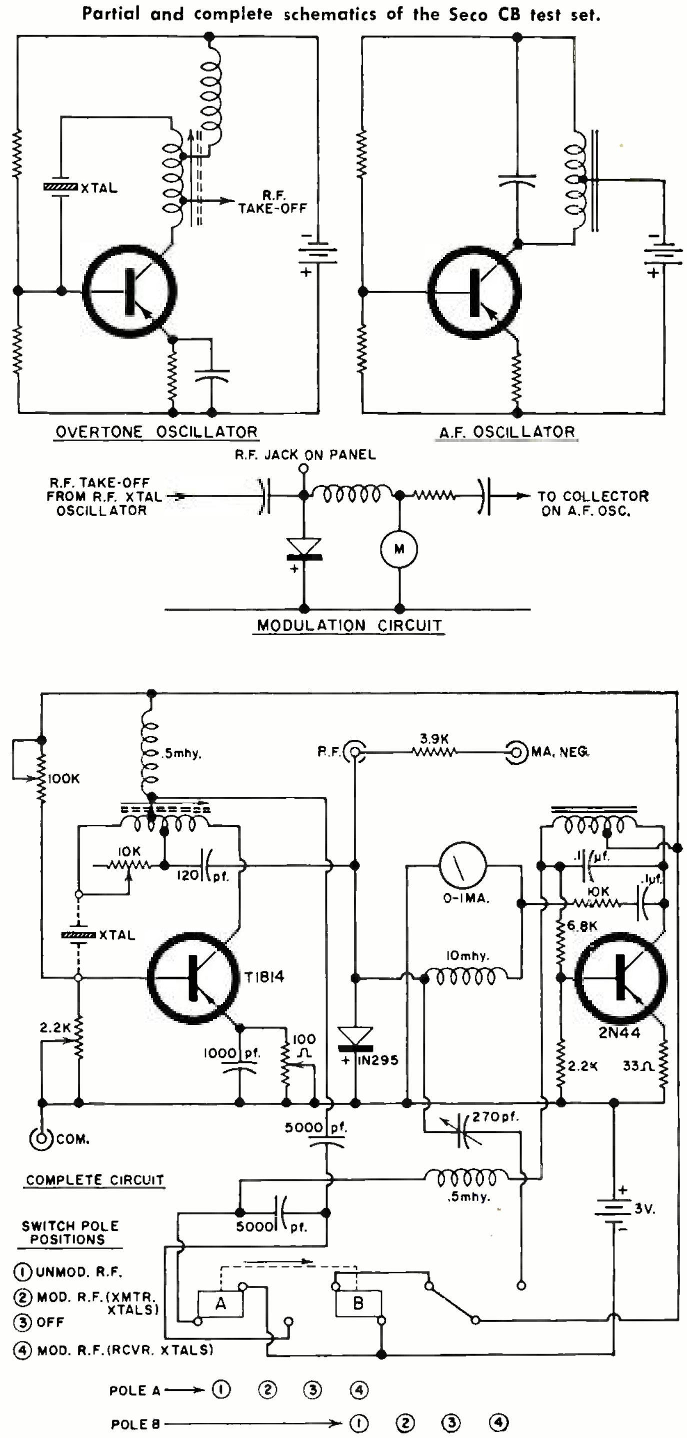
The unit acts as a receiver of r.f. signals in its second major mode of operation. Both oscillators are now disabled. When the technician wishes to read transmitter output or compare antennas, the instrument is held near the r.f. source to provide energy to a pickup loop within the Bakelite case. The signal travels from the tuned circuit in the r.f. oscillator (now passive) and couples to the diode and meter, as before. Now the meter serves as an r.f. indicator. During this test, the modulation quality of the CB transmitter is readily monitored by earphones plugged into a pair of tip jacks on the front panel. In the over-all schematic these points are "MA. Neg." and "Com," a source of detected audio.

Another circuit provision is the availability of the meter for measuring plate current of a CB transmitter's r.f. output stage. It is arranged to work with those rigs which contain a 100-ohm resistor in the "B+" leg to the final tube. Placed across the resistor, the meter indicates 0-50 ma. without the need for unsoldering "B+" connections. ▲

REFERENCES

1. Cadre Industries Corp., Commercial Products Div., Endicott, N.Y.
2. Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Ill.
3. Seco Electronics, Inc., 1201 So. Clover Dr., Minneapolis, Minn.

Partial and complete schematics of the Seco CB test set.



CRYSTAL CONTROLLED TIME STANDARD

Construction of a practical quartz-crystal clock and a discussion of multivibrator frequency dividing circuits and techniques.

By J. H. PHILLIPS / Process Computer Section, General Electric Co.

THE clock described in this article is the most recent of several similar electronic timekeepers the author has designed and built over the past two years. This improved model will make an unusual and interesting project for the ambitious electronics experimenter and will also serve to demonstrate the operation as well as the performance of practical frequency-divider circuits.

Circuit Details

The essential sections of the clock, as shown in Fig. 1, are: a crystal-controlled 120-kc. oscillator, 2000:1 frequency-

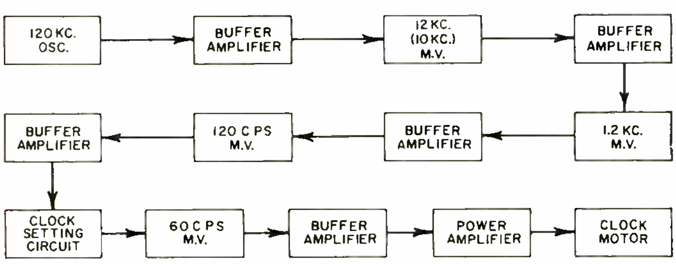


Fig. 1. Block diagram shows total frequency division of 2000.

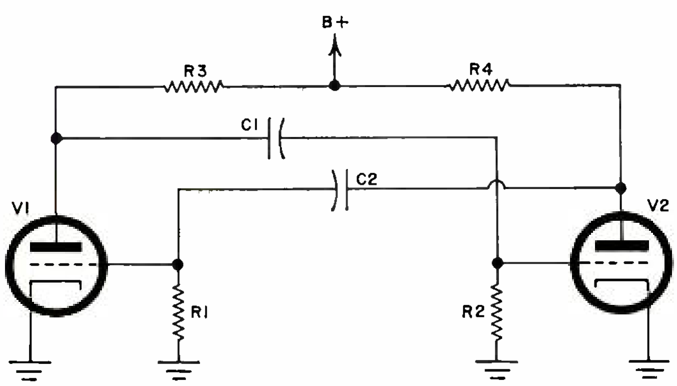


Fig. 2. Basic free-running (astable) multivibrator circuit.

dividing cascade, a 60-cps power amplifier to drive an ordinary kitchen clock, and a power supply.

The master oscillator is a modified Pierce type made by *International Crystal Mfg. Co., Inc.* The Model FO-1L is a PC unit available wired and tested for $7.50. The author added a vernier frequency adjustment (a quartz and invar piston capacitor) and also wired the crystal into a surplus *Bliley* crystal oven. The crystal is *International's* F-13, a 5° X-cut type ($15.00). Because of the X-cut's relatively poor frequency stability with varying temperature, an AT-cut would have been preferable for use with an oven, or else the more expensive GT-cut will perform satisfactorily without an oven.

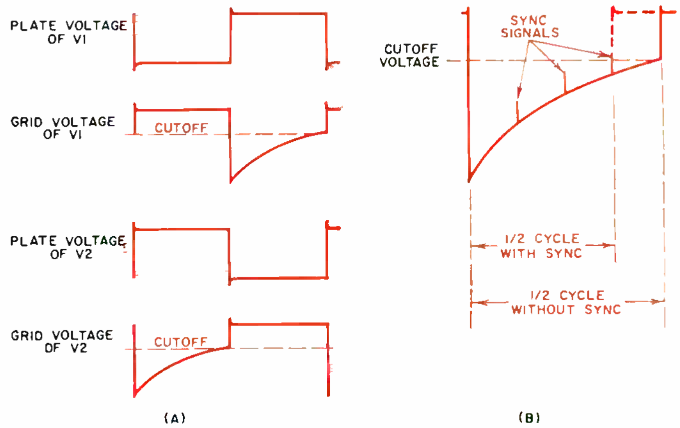
The frequency divider consists of four multivibrators and associated buffer amplifiers. Operation of the synchronized astable (free-running) multivibrator as a frequency divider is covered in detail in most standard circuit textbooks. Briefly, the action is this.

In the basic free-running multivibrator, Fig. 2, the plate of each tube is tied to the grid of the other through "looping" capacitors *C*1 and *C*2. Because of any slight imbalance, one of the tubes, say, *V*1, will conduct a little more than the other when power is first applied. As the plate voltage of *V*1 goes down, *V*2 is driven toward cut-off. The resulting rise in the plate voltage of *V*2 drives *V*1 toward saturation. *V*1 becomes saturated and *V*2 is cut off very quickly. When this condition is reached, *C*1 begins to discharge through *R*2 and the voltage at the grid of *V*2 becomes less negative until *V*2 starts to conduct. Almost immediately *V*2 goes into saturation and *V*1 into cut-off. *C*2 then discharges through *R*1 until *V*1 begins to conduct, and one cycle is completed. The voltage waveforms produced by this continued interaction are shown in Fig. 3A. Obviously, the frequency at which a multivibrator will oscillate depends on time constants *R*1-*C*2 and *R*2-*C*1.

If a signal having a frequency several times the natural frequency of a multivibrator is applied to one grid and if other conditions are favorable (*i.e.*, we don't have a borderline case), the multivibrator speeds up slightly and locks to a subharmonic of the input signal. This synchronizing action (Fig. 3B) is a result of the incoming signal controlling the exact instant the cut-off tube begins to conduct.

While a multivibrator can be synchronized by applying

Fig. 3. (A) Voltage waveforms of free-running multivibrator. (B) The effect of synchronizing pulses applied to one grid.



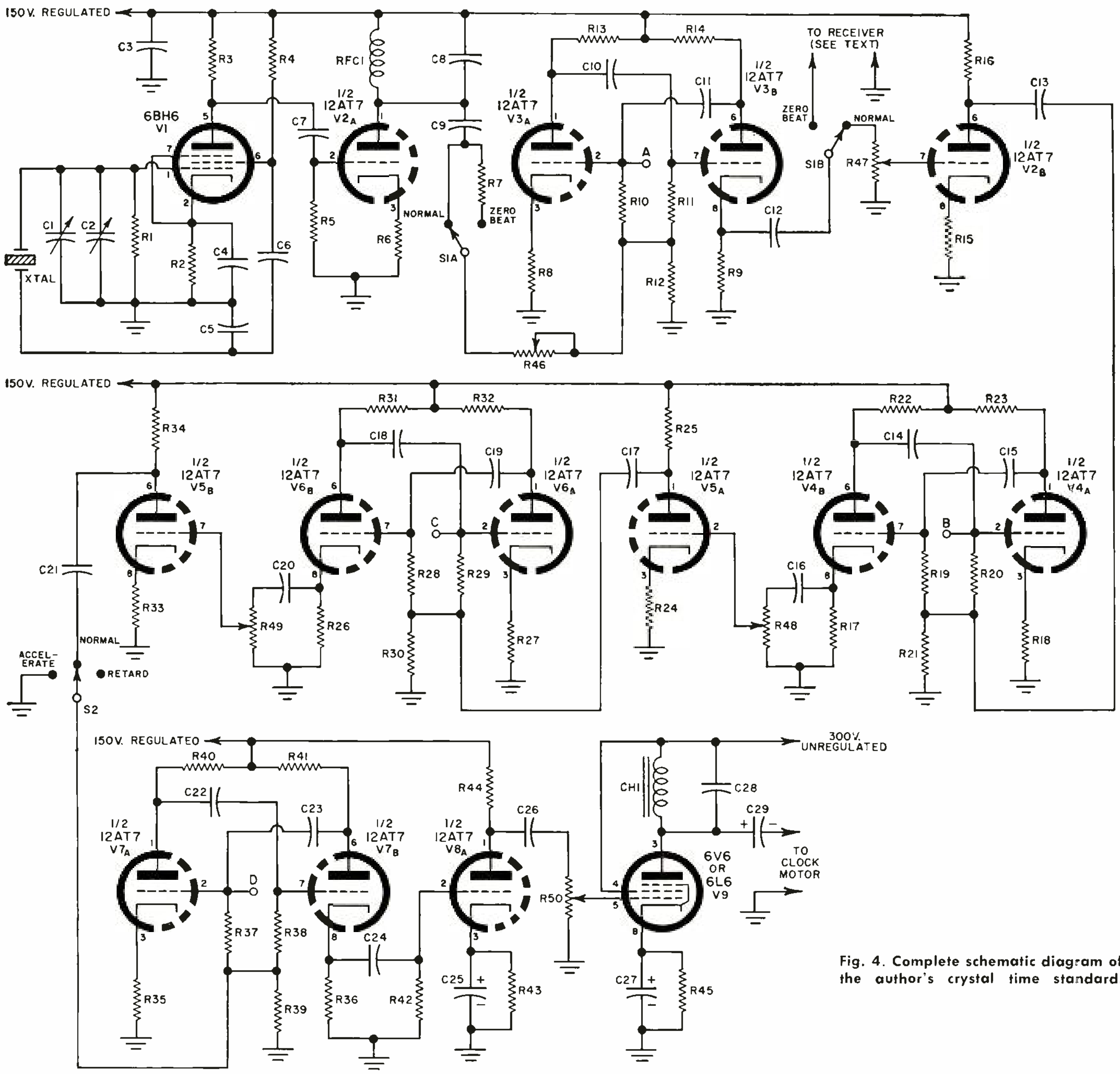


Fig. 4. Complete schematic diagram of the author's crystal time standard.

R1—1 megohm, ½ w. res.
R2—470 ohm, ½ w. res.
R3—18,000 ohm, ½ w. res.
R4—47,000 ohm, ½ w. res.
R5, R42—750,000 ohm, ½ w. res.
R6, R8, R9, R15, R17, R18, R24, R26, R27, R33, R35, R36, R43—1000 ohm, ½ w. res.
R7—39,000 ohm, ½ w. res.
R10, R11, R12, R13, R14, R19, R20, R21, R22, R23, R28, R29, R30, R31, R32, R40, R41—68,000 ohm, ½ w. res.
R16, R25, R34, R44—110,000 ohm, ½ w. res.
R37, R38—33,000 ohm, ½ w. res.
R39—36,000 ohm, ½ w. res.
R45—350 ohm, 5 w. res.
R46, R47, R48, R49, R50—1 megohm linear taper pot
C1—7-45 pf. var. ceramic capacitor
C2—.7-4.5 pf. trimmer capacitor
C3, C4, C7—.01 μf., 400 v. paper capacitor
C5, C12—100 pf., 400 v. mica capacitor
C6, C20, C21—.005 μf., 400 v. paper capacitor
C8, C10, C11—330 pf., 400 v. mica capacitor
C9—400 pf., 400 v. mica capacitor
C13, C17—200 pf., 400 v. mica capacitor
C14, C15—4700 pf., 400 v. paper capacitor
C16—.002 μf., 400 v. paper capacitor
C18, C19—.025 μf., 400 v. paper capacitor
C22, C23—.068 μf., 400 v. paper capacitor
C24, C26—.1 μf., 400 v. paper capacitor
C25—5 μf., 50 v. elec. capacitor
C27—25 μf., 25 v. elec. capacitor
C28—1 μf., 450 v. paper capacitor
C29—16 μf., 450 v. elec. capacitor
RFC1—5.5 mhy. r.f. choke
CH1—15 hy., 85 ma. filter choke
S1—D.p.d.t. toggle switch
S2—S.p.d.t. spring-loaded both directions from normal
Xtal.—120-kc. crystal in oven (Bliley TC-92, see text)
V1—6BH6 tube
V2, V3, V4, V5, V6, V7, V8—12AT7 tube
V9—6V6 or 6L6 tube

the signal to only one grid, much more reliable performance and easier adjustment are the result of introducing the signal into both grids of the two triode sections simultaneously.

If the signal is fed in the same phase and amplitude to both grids, the multivibrator will be forced to lock in at an even sub-multiple (1/2, 1/4, 1/6, etc.) of the signal frequency. However, if the signal is first split in phase and one of the resultant equal-amplitude, opposite-polarity signals is fed to one grid and the other signal to the other grid, the multivibrator will lock to an odd (1/3, 1/5, 1/7, etc.) sub-multiple. Because they require more circuitry and are "touchier" to adjust, multivibrators producing odd-numbered frequency-division ratios are not used in this construction.

Now it is possible to cascade multivibrators without using buffer amplifiers. The author did this in an earlier model but unbuffered, cascaded multivibrators are maddeningly difficult to adjust, and reliability is uncertain; therefore simple buffer amplifiers are used between the working stages.

The reader may note that the tuned plate circuit in the power amplifier will not resonate at 60 cps by itself; however, the output coupling capacitor and the clock motor contribute to circuit parameters and a fairly clean sine wave

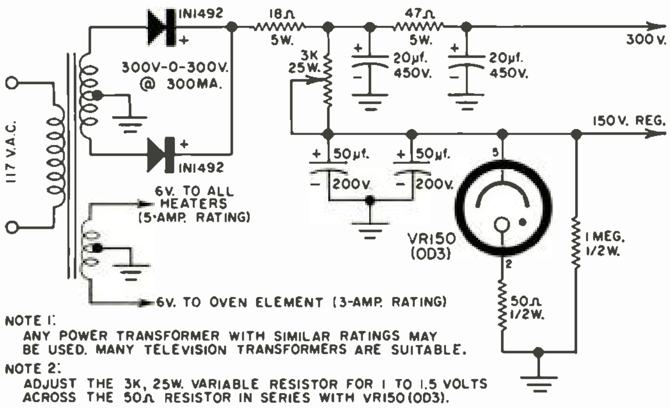
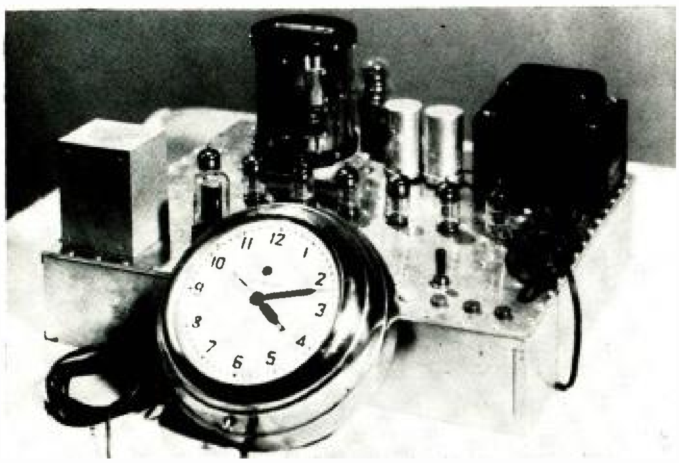
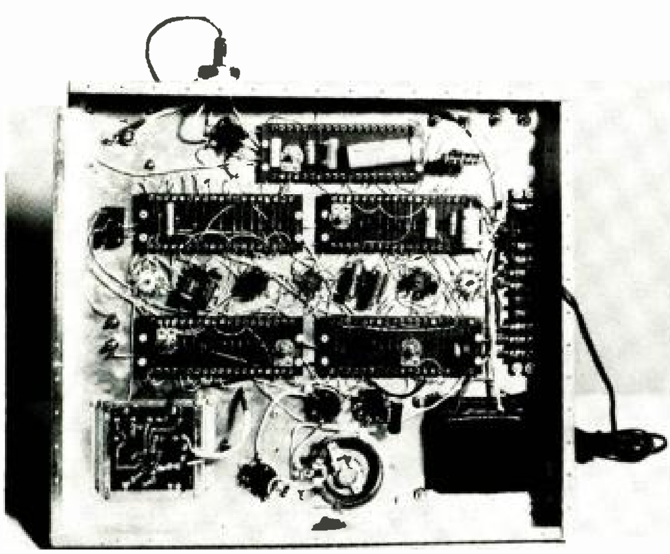


Fig. 5. Circuit diagram of the integral power supply used.



The electric clock is driven to a high degree of accuracy by means of an electronic circuit consisting of a highly stable crystal oscillator followed by a string of frequency dividers. The oven for the crystal is at the left rear of the chassis.



Under-chassis view. Components for each of the dividing multivibrators are mounted on individual circuit boards. The printed circuit for the crystal oscillator is located at bottom left.

appears across the clock motor. A different size inductor can be used in this circuit if the values of the capacitors are adjusted experimentally for a reasonable waveform across the motor.

During normal operation, the four multivibrators (*V3*, *V4*, *V6*, and *V7* in Fig. 4) run at frequencies of 12 kc., 1.2 kc., 120 cps, and 60 cps. Two special circuits are used to alter this arrangement when adjusting the oscillator and synchronizing the clock. The first is controlled by S1, a d.p.d.t. toggle switch. When this switch is thrown from the "Normal" position to "Zero Beat," the 12-kc. multivibrator frequency drops to 10 kc. and its output is fed to a "Receiver" terminal. With this 10-kc. square-wave signal fed to the antenna input of a short-wave receiver tuned to WWV at any one of its carrier frequencies, the oscillator can be tuned so that a harmonic of the 10-kc. square wave zero beats with the WWV carrier.

Switch S2 is a lever-type, spring-loaded in both directions from normal. When the switch is held in one position, the synchronizing signal is removed from the 60-cps multivibrator which slows it to its natural frequency of 55 or 56 cycles per second. When the switch is held in the other direction, the synchronizing signal is removed and *R39* is shorted. This allows the multivibrator to run free at 64 or 65 cycles per second. By operating this switch, the clock's second hand can be brought into exact step with WWV while calibrating or correcting as needed.

The author built the clock on a 16" x 14" x 3" chassis using terminal-board construction. As an alternative, a large printed-wiring board may be used, but point-to-point wiring is not recommended because of component density around the multivibrators.

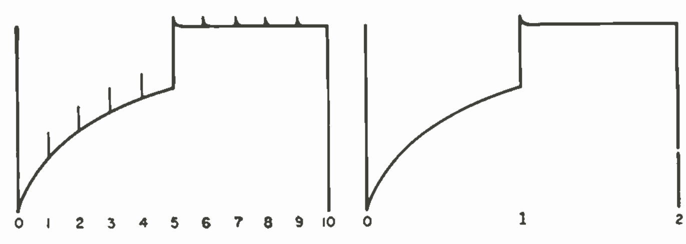
Initial adjustment of the frequency divider requires the use of a good oscilloscope. Place the vertical probe at point "A" (Fig. 4) and adjust *R46* for a scope trace indicating a steady division ratio of 10:1, as shown in Fig. 6A. Move the probe to "B" and adjust *R47* for another division by 10. At point "C," adjust *R48* for a third division ratio of 10:1. Finally, adjust *R49* for a ratio of 2:1 as viewed at "D" (Fig. 6B). Repeat these adjustments to check for interaction, then adjust *R50* for about 110-volts a.c. into the clock motor.

To calibrate the oscillator, set the vernier capacitor (*C2*) to mid-range and, using the "Coarse" adjust (*C1*), zero beat against WWV as described earlier. After synchronizing the clock's second hand with the "ticks" broadcast by WWV, observe the deviation over a period of time and adjust the vernier capacitor, as necessary. Adding capacitance will lower the oscillator frequency and *vice versa*. The chances are that it will take a period of several months for the crystal to age; during this period, it will be necessary to touch up the vernier occasionally.

The reader may have difficulty in locating an exact duplicate of the crystal oven called for in the parts list. This is not really necessary, of course. The important thing to remember is that the crystal, oven, and oscillator circuit must be carefully matched according to the recommendation of the crystal manufacturer. This, as it turns out, will not be as expensive as it sounds. Any good-quality oven can be used if the crystal is ordered with a matching temperature rating. It would not be difficult to build an oven from scratch if a suitable thermostat and heating element could be found conveniently or else fabricated by the constructor.

The ultimate accuracy of the clock is, of course, completely dependent on the frequency accuracy and stability of the crystal oscillator. If the builder wants to pay the price, he can purchase oscillator assemblies that will assure him of clock stability of less than one second variation every three-hundred years. ▲

Fig. 6. (A) Waveform obtained when dividing frequency by 10. In practice, higher frequency components from earlier stages will be seen at low amplitude along with the sync pulses. (B) Waveform obtained in the 2:1 frequency divider stage.



RESISTOR POWER CALCULATOR

By ROBERT K. RE

Computations of power dissipation for a given resistor when current or voltage is known is simplified with this chart.

USING Ohm's Law to compute resistor power dissipation is fairly routine, but it becomes tedious and time-consuming if many short problems must be solved during a repair or design-construction job.

Applications

This calculator helps the user to compute quickly two often-used variations of Ohm's Law: $P = I^2R$ and $P = E^2/R$, when either current or voltage is known. It covers the ranges of current, voltage, and resistance commonly used in electronics today. To assist the user in choosing the proper wattage replacement, only standard, readily available values are listed on the nomogram.

Two small triangles (Keys #1 and #2) show for each equation which set of scales and curves to use.

Examples of Use

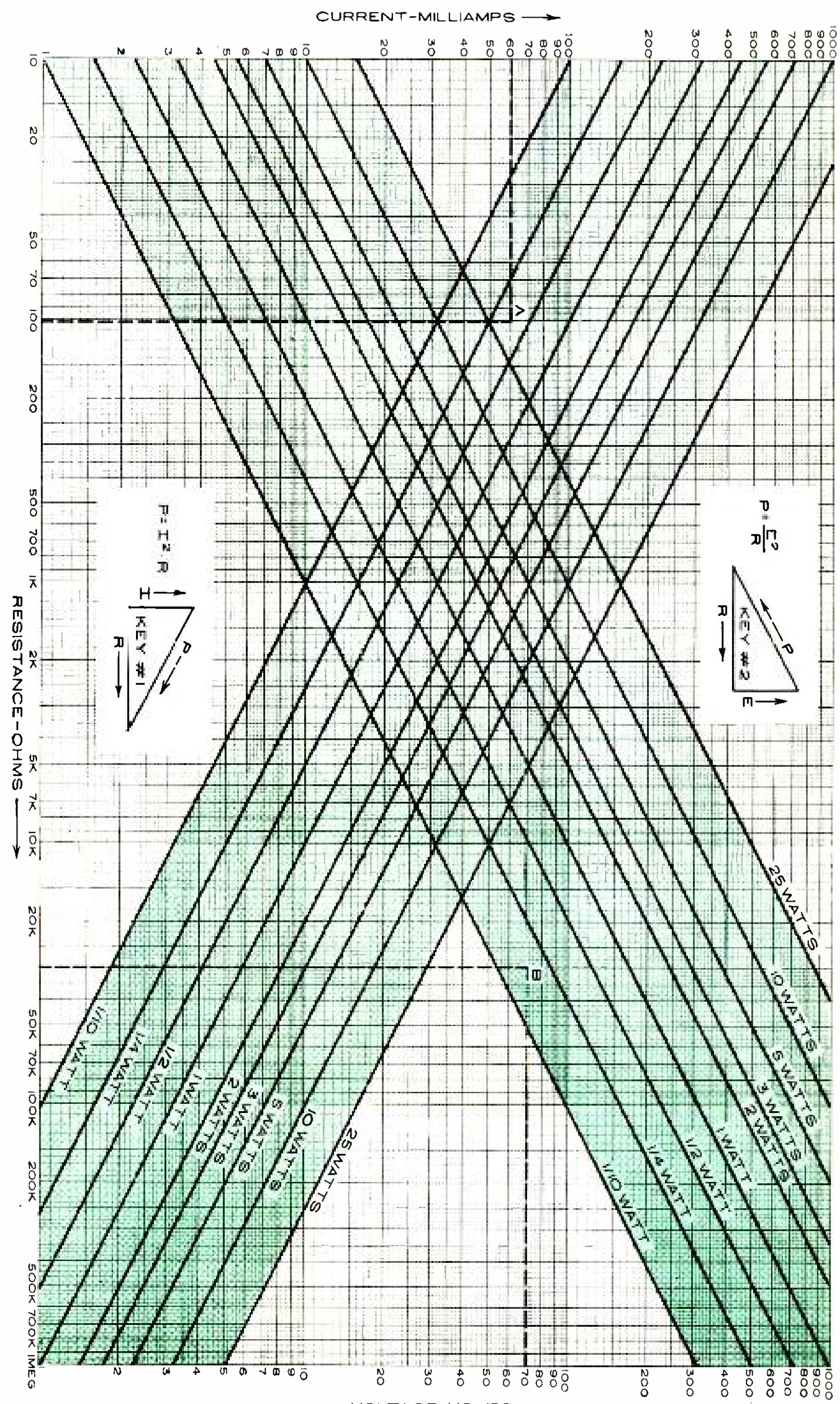
For example, the calculator, according to Key #1, shows that 60 ma. through a 100-ohm resistor dissipates about ⅜ watt (point A). Because this is not a standard wattage value, a ½-watt unit (or larger) should be used for replacement purposes.

Similarly, the graph, according to Key #2, shows that 70 volts across 30,000 ohms consumes a power of about 160 mw. (point B); a ¼-watt unit or larger should be used.

An adequate safety factor (about 50%) should be added whenever a resistor is first chosen for or replaced in a circuit to assure stability and long life. If at any time the computed wattage falls within two lines, use a resistor with the next higher wattage value.

Posted near your bench, this calculator can shorten design and construction time to a worthwhile degree.

Although it will not take the place of Ohm's Law for all design problems, it will be useful if a large number of such calculations are to be made and if those calculations involve the standard, readily available power rating for the resistors. ▲



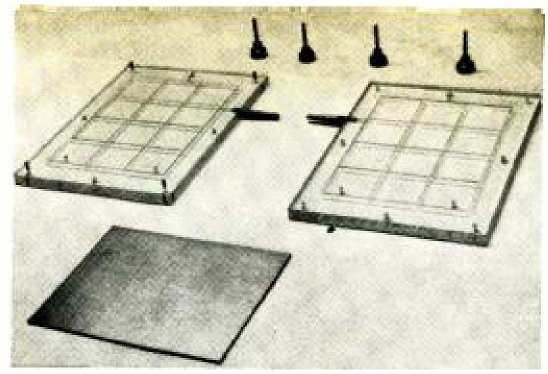


Fig. 3. Blank board and printing frame for 2-sided boards.

MAKING ETCHED CIRCUIT BOARDS

A simple technique for small laboratories of making high quality printed boards using readily available materials.

By R. W. BAILEY / Research Associate
Department of Physics, Ohio State University

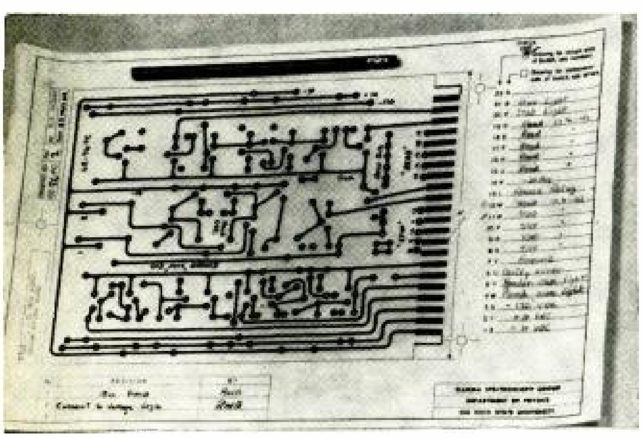
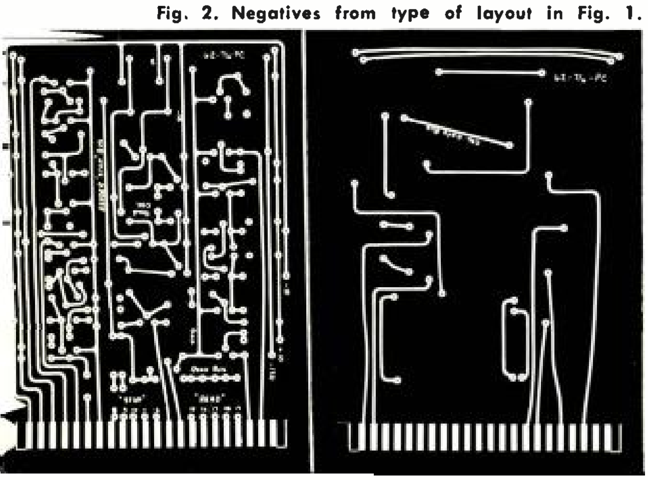


Fig. 1. A layout drawn on transparent grid paper.

Fig. 2. Negatives from type of layout in Fig. 1.



ETCHED or printed-circuit boards are an ideal solution to the problem of packaging transistor circuits. Most people working in small electronics laboratories and home workshops have not made their own etched circuits because they believe that etched circuit construction requires a large investment and special talents. This article outlines an easy method—using readily available materials—for making quality printed-circuit boards.

The Circuit Layout

The first problem is the layout of the circuit. The layout can be drawn on any of several materials. Since a photographic negative will be made from the drawing, plain white paper will serve quite adequately. The circuit layout may be inked or even pencilled. Care must be taken to assure enough contrast so that a good negative may be prepared from the layout. The layout may be drawn from full size to several times full size. For general use, layouts of twice size produce excellent etched boards.

Another method of preparing the layout is that of using special, self-adhering tape. This tape is pressed to the paper to form an outline of the desired circuit. Several manufacturers produce this tape. (See Item 1 in the list of materials.) In addition to the tape, several shapes, such as 90° bends, tee's, and fillets are available. A typical layout made with this press-on material is shown in Fig. 1. This layout is prepared on 1/10" x 1/10" transparent grid paper. The grid makes the layout easier because most electronic components have their leads spaced in multiples of tenths of an inch. This grid, a very light blue, may be blocked out by a filter when the photographic negative is made.

We found that a 4½" x 5" circuit board is adequate in most cases and this is our standard size. Our layout sheets are preprinted, twice this size. This makes preparing a new circuit layout easy. Our layout sheets are printed on "Albenene" (a product of *K & E*) which is transparent and has adequate dimensional stability. The fact that the "Albenene" is transparent enables one to easily make diazo copies. These copies are very useful for checking a layout because the components can be drawn in without harming the original.

Layout for Double-Sided Boards

Layouts for double-sided boards can be made using two of these layout sheets back-to-back. Three registration marks on the layout sheets register the two sides during the board construction step. A description of the printing frame required for making double-sided boards is given later.

The Photographic Negative

After having prepared the layout, one makes a photographic negative, the size of which will be the final circuit size. Fig. 2 shows two of these negatives. These particular negatives are for a pair of double-sided boards. The next step applies to the etched circuit board itself.

Materials

First, we turn to the problem of the base material, the copper-clad board (Item 2 on the materials list). Several types are available. Three of these are phenolic, epoxy-paper,

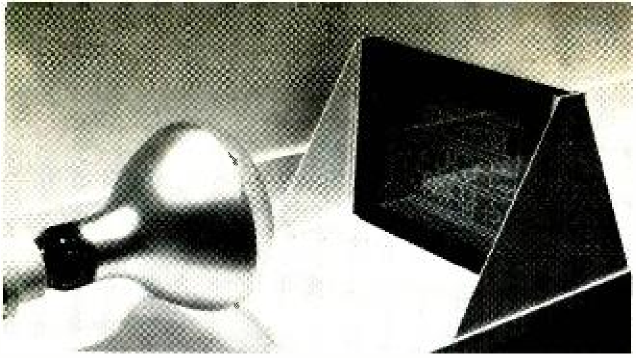


Fig. 4. Setup used to expose a single-sided circuit board.

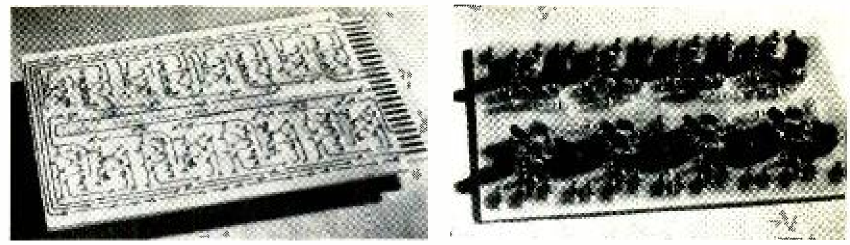


Fig. 5. Etched circuit boards made by technique described.

and epoxy-glass. All types come in one-, two-, or three-ounce copper. Two-ounce copper is about .0027-inch thick. Basic board thickness is from 1/32" to ⅛" in 1/32" steps. With any thickness copper and a constant board thickness, the phenolic board is the cheapest and the epoxy-glass is the most expensive. Epoxy-glass is the most dimensionally stable of the materials. This type of board is made by several manufacturers. A piece of ⅛" blank material is shown in the foreground of Fig. 3. This particular board is epoxy-glass with two-ounce copper.

The next materials of concern are photo-resist and photo-resist developer. Since these materials are used for lithograph plates, they are usually sold at local photographic supply houses. One quart of resist will make about 100 circuit boards of the 4½"x 5" size. Ten to sixteen ounces of developer will develop about 10 boards before requiring replacement. The etching material is ferric chloride ($FeCl_3$). This is an inexpensive chemical and readily available.

Hardware

In addition to the chemicals, one needs an ultraviolet light source (a home sun lamp is ideal), a contact-printing frame (Fig. 4), a shallow glass tray, and a glass beaker. If double-sided boards are required, a suitable contact-printing frame is needed. Fig. 3 shows a home-made Plexiglas frame for double-sided boards. This frame uses vacuum to hold the negatives in place—one negative to each plastic half. The registration marks on the original layout sheets and on the negatives are also scribed on the plastic frame. One needs only to align the negatives with the registration marks and put the boards between them.

Procedure

One can make quality etched circuit boards by the following procedure. First apply a uniform coat of photo-resist (Item 3 in the materials list) to the copper side of the board (to both sides if one is making a double-sided board). This can be done in normal room lighting. Bright fluorescent light should, however, be avoided. The photo-resist must be allowed to dry thoroughly or the negative will stick to it. Cleanliness is of utmost importance to insure that minor imperfections will be avoided.

Next, place the photographic negative in the contact printing frame so that, looking through the glass face, the circuit outline appears as it was originally laid out; *e.g.*, so that written words read correctly. The extension of this step in making double-sided boards is to check both faces.

The exposure time should be approximately 4 minutes if the printing frame uses single-strength glass, and the sun lamp is at a distance of 10 inches. For the plastic frame, the exposure time can be less than 2 minutes for the same lamp-to-printing-frame distance. For developing, pour 10 to 16 ounces of photo-resist developer solution into the shallow tray. Then place the board in the tray, copper side up, and agitate by rocking the tray for about 3 to 5 minutes. For the double-sided board a rack must be used in the tray to assure one surface is not marred by scraping on the bottom.

Next, remove the board from the tray and dry thoroughly. An infrared lamp with a red face works very well as a drying device. The developer will dry quickly. An outline of the circuit may then be seen on the board. This outline is the photo-resist not washed off during the developing.

The final step in making the board is etching away all the copper not covered by the photo-resist. This is where the ferric chloride is used. A solution of ferric chloride is prepared by mixing approximately 5 quarts of ferric chloride crystals and 5 to 10 ounces of HCl with 5 gallons of water. Care should be taken when preparing the solution because the heat of reaction is such that one may end up with a boiling solution. The best temperature for etching is 70 to 80 degrees C. Having prepared the ferric chloride solution, the developed board is now agitated in it until all of the copper not covered by the photo-resist, is etched away.

The time required for etching depends on the thickness of the copper, the circuit area, and the newness of the ferric chloride solution. For a 4½"x 5" board with one-ounce copper, about 10 minutes is required using a newly prepared etching solution. Approximately twice this time is needed for two-ounce copper.

After removing the board from the etching solution, the remaining photo-resist should be cleaned off. Practically any organic solvent, including photo-resist thinner, may be used. Xylene and methylene chloride are two of the best solvents for this particular purpose.

Corrosion or Oxidation Protection

Electroplating or immerse-plating the copper board will prevent oxidation and retain its solderability. Gold, silver, and tin are three plating substances in common use. Of these, perhaps the simplest to use is a gold immersion solution. Several companies manufacture a solution for this purpose (see Item 4).

To prepare this plating solution, simply follow the maker's instructions for diluting with distilled water. A shallow tray is required in which to immerse the board to be plated. The most efficient temperature of the plating solution as well as the most effective pH are also given by the manufacturer. About one minute is required to plate a 4½"x 5" board.

This completes the printed-circuit board to the point of drilling the holes needed for component placement and the soldering of the components in place. All of the major solder manufacturers have solder for this purpose. It has been noticed, however, that rosin-core solder of 60% tin and 40% lead works quite well. A completed board is shown in Fig. 5. Below is listed a number of manufacturers for the materials used in this process. Items which have not been listed are readily available from local supply houses.

The author wishes to acknowledge the assistance of the Department of Photography of The Ohio State University for the photographs. Thanks are also due to R. P. Sullivan and C. Piatt for their helpful suggestions and comments. ▲

Materials & Supplies

1. *Layout materials: W. H. Brady Co., Milwaukee, Wisc.*
2. *Copper-clad board: Formica, Cincinnati, Ohio; Laminated Products Dept., Chemical & Metallurgical Div., General Electric Co., Coshocton, Ohio*
3. *Photo-resist, photo-resist developer, and photo-resist thinner: Eastman Kodak Co., Rochester, N.Y.*
4. *Gold immersion solution: Engelhard Industries, Inc., Newark, New Jersey*

BURNED-OUT PILOT-LAMP INDICATORS

By RONALD L. IVES

Description of various types of bridge and zener diode circuits that can be employed to indicate the failure of pilot lamps in electronic equipment.

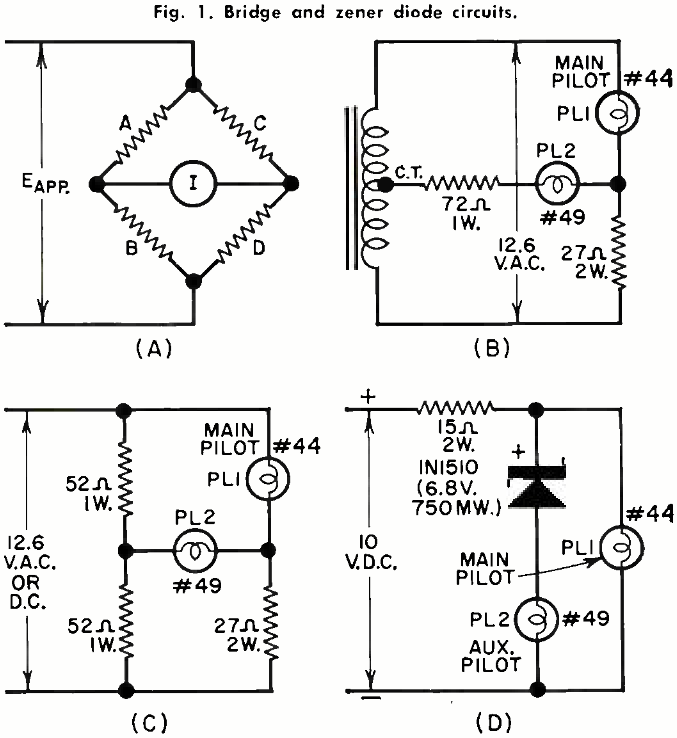
THE AMOUNT of embarrassment and unnecessary troubleshooting caused by reporting equipment malfunctions which later turn out to be a dead pilot light, is almost incalculable. Only a few of the more experienced electronics men, most of whom have been "burned" by a similar experience, seem to know enough to check pilot lamps and fuses before pulling a chassis.

Basic circuitry for building a dead pilot-light indicator has been known since the days of the coherer. Recent developments in solid-state electronics provide another effective circuit. Unhappily, these proven circuits have seldom been applied to this specific problem, even though their application is relatively simple and amazingly inexpensive.

Bridge Circuits

Two very effective dead pilot-lamp indicator circuits depend on the bridge circuit (Fig. 1A) for their operation. When the bridge is balanced, *i.e.*, $A = B$ and $C = D$, current I across the bridge is zero. When the bridge is unbalanced, as will occur if any arm is open, current flows across the bridge. If one arm of the bridge becomes the main pilot, and a subsidiary pilot is connected across the center of the bridge (replacing I in Fig. 1A) the subsidiary pilot will light only if the main pilot is open. A bridge of this type, operating from a center-tapped transformer, which in itself comprises two arms of the bridge, is shown in Fig. 1B.

Fig. 1. Bridge and zener diode circuits.



Where a center-tapped voltage source is not available, the requisite tap is provided by a pair of resistors, as in Fig. 1C. If these are properly selected, the main pilot will operate at rated current until it opens, then the subsidiary pilot will light to normal brilliance and stay so until the main pilot is replaced. Chance of both main and subsidiary pilot lights going dead at the same time is almost nil, so that when both pilot lights are inoperative, something other than lamp failure is probably wrong with the equipment (look for plug out and open fuses before pulling the chassis).

The circuit of Fig. 1B operates on a.c. only and requires twice the power of the main pilot alone. The circuit of Fig. 1C operates on either a.c. or d.c. and requires roughly 2½ times as much power as the main pilot light alone. In a few instances the 27-ohm resistor can be made a useful load, such as a tube filament or a crystal-oven heater, minimizing both power wastage and unnecessary heating of the chassis.

Zener Diode Circuit

The commercial availability of zener diodes makes practicable a very elegant pilot-light indicator, operable on d.c., which is quite economical of power. The basic circuit of this is shown in Fig. 1D.

In this circuit, when the main pilot light is operating, the voltage drop across the subsidiary pilot circuit is less than the conducting voltage of its zener diode, so that the subsidiary pilot light is inoperative. When the main pilot lamp opens, reducing current through the 15-ohm dropping resistor, voltage across the subsidiary circuit rises, the zener diode conducts, and subsidiary pilot lamp *PL2* lights. Working constants, which are not the only usable values, are given on the circuit diagram.

When a number of similar dead pilot-light alarms of the resistive center-tap type (Fig. 1C) are used, power can be saved if they share the same center-tapping resistors. Care should be used here to prevent unwanted circuit interconnections and "sneak circuits."

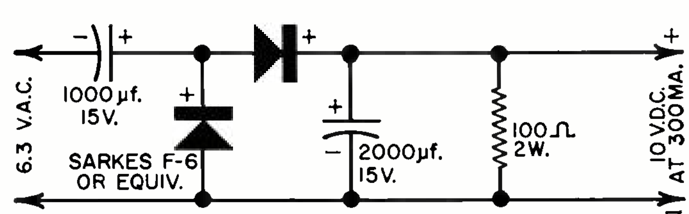


Fig. 2. Simple d.c. indicator supply.

The d.c. power for the zener indicator is conveniently obtained from a 6.3-volt a.c. source, such as a filament source, by use of a voltage-doubler circuit, which is shown in Fig. 2 with constants. This type of indicator supply is particularly desirable in low-level audio installations, where the number of leads carrying a.c. must be kept to a minimum.

Life of these indicator circuits is problematical, but very long. That of Fig. 1B has been in continuous use in a Conelrad monitor for over five years, only failing elements being the pilot lamps. The resistive center-tapped circuit has only been in use for three years, again, with failures only of the main pilot light. Both circuits should outlast the equipment in which they are installed.

The zener indicator circuit has been bench-tested for 500 hours, and cycled 12 times per hour during that time. As zener diodes, when operated within their current and temperature limits, are apparently immortal, so should be all parts of this circuit except the pilot lights—which have a definitely limited life span. ▲

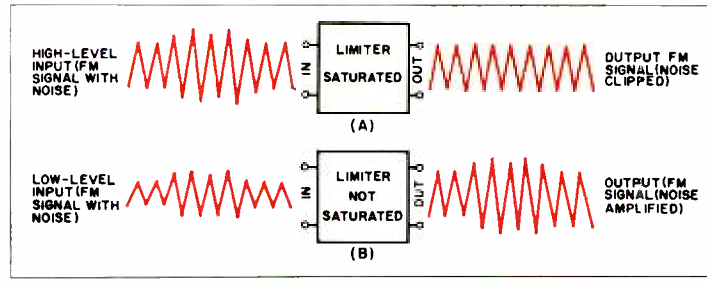


Fig. 1. (A) Output of the saturated limiter will be free of amplitude variations, and the receiver will be free of noise. (B) When limiter is not saturated, it will act as an i.f. amplifier and increase noise level which is now heard in speaker.

SELECTIVE CALLING FOR 2↔WAY RADIO

By MARTIN GOLDEN / Hammarlund Mfg. Co.

Causes of interference and tone-squelch techniques to reduce noise when signals are not being received.

IN the early days of industrial two-way radio, squelch control was sufficient to quiet a receiver when no communication was going on between the base and mobile stations. The squelch control prevents tube hiss and noise generated within the receiver from being heard in the speaker.

Noise Sources

This noise is similar to that heard in an FM broadcast receiver when tuning between stations and can be broken down into two classifications: circuit noise and tube noise. Circuit noise is caused by irregular motion of free electrons in a conductor. If the conductor were at absolute zero (273° K) there would be no electron movement, but since the equipment is at some temperature above this figure, thermal agitation of the electrons takes place. Usually there are more free electrons moving in one direction than in the other. This movement of free electrons (current flow) produces a voltage that is proportional to the resistance of the conductor and the summation of the total current flow. Since the direction of the current flow is changing constantly, depending on which way the maximum number of free electrons are flowing, polarity of the voltage will also vary. Because of the changing voltage and polarity that is developed, the noise produced will be distributed throughout the frequency spectrum and will be heard in the speaker as a crackling sound.

The noise that is generated within the tube is a result of a change in the rate at which the electrons are emitted from the cathode. Since the electrons leave the cathode at random instances of time and with random variation in velocity, their arrival at the plate is not uniform. This variation in plate current represents a noise current and will produce a noise voltage when this current flows through the load resistor.

The change in the number of electrons which pass the grid on the way to the plate will also induce a varying noise voltage in the grid circuit which will add to the total noise.

A third cause of tube noise is the change in the amount of secondary emission. If all the electrons that are driven off the plate are attracted back to the plate so that a space charge does not exist, a noise current is developed by the returning electrons.

Another phenomenon that takes place in the tubes which contributes to the total noise voltage is the change in the number of ions that are produced by electron collision.

Since these noise voltages are basically caused by rate changes, they too will cover a large portion of the frequency spectrum and will be AM in nature. The limiter stage of an FM receiver will eliminate all AM signals, whether they are produced externally (static) or internally (noise) when an on-frequency carrier is present. These annoying signals will not be heard in a loudspeaker of a BC receiver when tuned to a station or in a communications receiver when a system transmitter goes on the air.

A limiter is an i.f. amplifier, with the values of the components and operating potentials so designed that after a

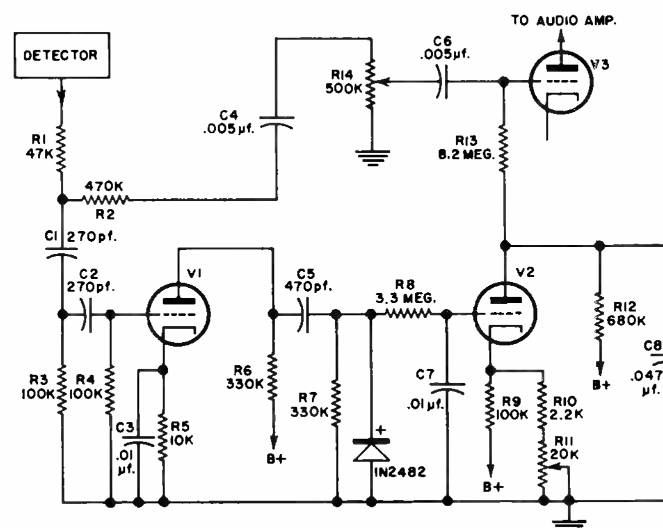
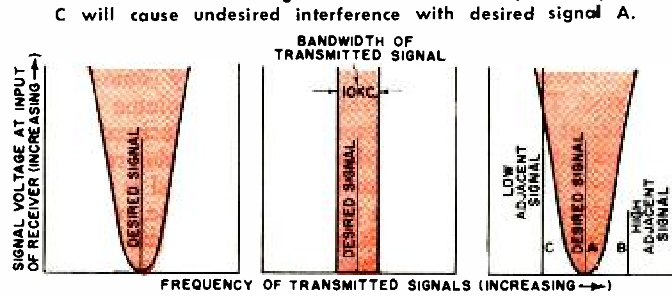


Fig. 2. Noise developed in the detector is amplified by noise amplifier V1. This signal is then rectified and fed to d.c. amplifier V2. Output is used to bias off the first audio tube V3. Squelch control R11 is set to a point where the weakest signal can overcome squelch bias, allowing audio to be heard.

Fig. 3. (A) Selectivity curve of typical FM communications receiver. (B) Ideal selectivity curve is only as wide as bandwidth of transmitted signal. (C) The lower adjacent signal C will cause undesired interference with desired signal A.



certain point, a further increase in the input signal will not produce a change in the amplitude of the output signal. When this happens the limiter is said to be "in saturation" and all signals of greater amplitude are clipped or limited to the desired value, removing any AM signals present (Fig. 1A).

When a carrier is received, the input signal is strong enough to produce sufficient voltage in the stages ahead of the limiter to drive it into saturation. The output of the saturated limiter will be free from AM signals and any variation of amplitude (or noise) in the received signal or developed within the receiver will be eliminated. However, when the carrier is removed, the input voltage, which consists of random noise, is not strong enough to operate the limiter at saturation or beyond. In this condition the limiter will act as an amplifier to the low-level signals. Since the receiver's internal noise, circuit and tube, are low level and produced from amplitude variations, they will be amplified and appear at the speaker as a loud hiss. See Fig. 1B.

In a high-gain FM communications receiver, this noise output, present whenever the carrier is removed, is sufficient

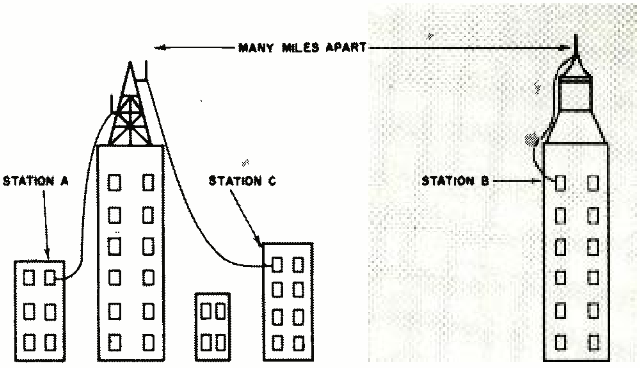


Fig. 4. When the antennas of communications units operating on adjacent channels are close together, interference occurs.

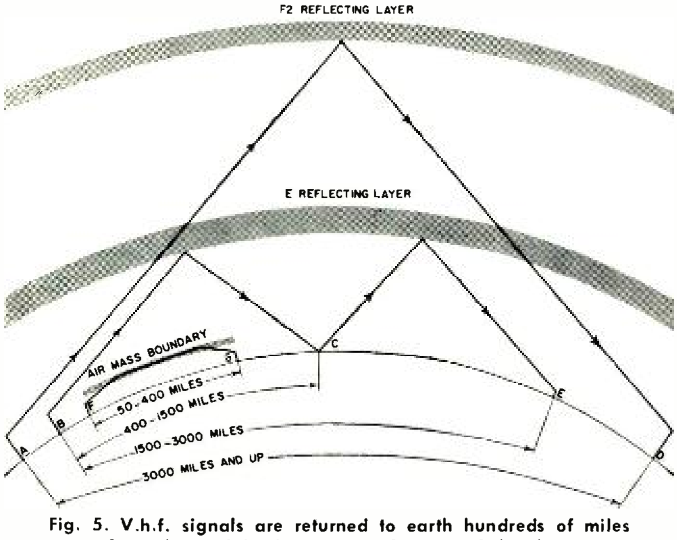


Fig. 5. V.h.f. signals are returned to earth hundreds of miles away from their origin due to the refraction of the sky waves.

to be very annoying to the operator who must monitor the channel for a long period of time. If the volume is turned down, there is a possibility that a message may come in and be missed. The squelch control permits the volume control to be set at a comfortable listening level by decreasing the audio output of the receiver when no signal is being received, and allows it to operate normally when a signal is present. This is done by amplifying a portion of the noise, rectifying it, and using the rectified voltage to bias the audio tube off. See Fig. 2. By varying the output of the d.c. amplifier, the point at which the squelch operation takes place can be adjusted to permit the weakest useful signal voltage to be able to open the squelch. This control is made variable because of the different conditions of reception that require different signal voltages for reliable communications.

When an on-frequency signal is received, the noise is reduced by the action of the saturated limiter. The d.c. which was the result of the rectified noise is reduced which, in turn, decreases the bias on the audio tube to a point where it is no longer cut off and the audio will be heard in the loudspeaker.

This squelch control worked fine in eliminating electrical interference, however, as more users of two-way radio came into being, the spectrum allocated by the FCC became so crowded that it became necessary for users to share frequencies in order that all services could be accommodated.

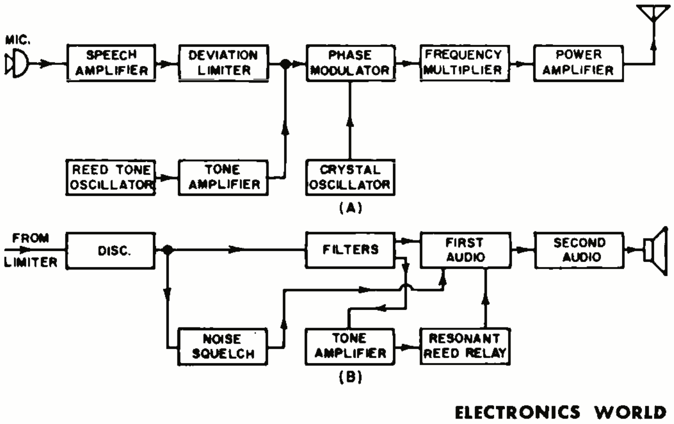
Frequency Sharing & Selectivity

With many services sharing the same frequency, a new noise problem confronted the user of two-way radio. All receivers tuned to a particular frequency would be unsquelched whenever a transmitter of another service, sharing that frequency, took to the air. All the receivers would hear the message whether they wanted to or not. Since the number of services sharing one frequency in an area is unlimited, the message traffic increased to a point where the dispatcher was once again plagued with the problem of whether to decrease the volume with the possibility of missing an important message or listening to all the chatter on his channel.

In order to give two-way radio users more privacy by making more frequencies available to them within the allocated band, the FCC decreased channel width of the assigned channels to ±15 kc. and in some cases to ±5 kc., with corresponding closer spacing between channels. In other words, the users found that they now have neighbors a little closer to them on either side of the frequency on which they had been authorized to operate. However, this approach was only temporary because as more and more stations went on the air, the possibility of an adjacent-channel transmitter opening the squelch of the on-frequency receiver increased. This condition, known as adjacent-channel interference, will occur when the interfering signal is either one channel higher or lower than the desired channel and the antennas are close enough so that the signal from the interfering transmitter is strong enough to open the squelch of the on-frequency receiver.

Fig. 3 illustrates why this will happen. Fig. 3A is a typical selectivity curve of a commercial FM communications receiver showing the ability of the receiver to select one transmitted frequency and reject all others. The narrower the curve the more selective the receiver. The ideal curve shown in Fig. 3B would have straight sides and be only as wide as the transmitted channel width. But, in practice, this is not yet obtainable and the selectivity curve will look like the

Fig. 6. (A) Block diagram of continuous-tone encoder. The encoder tone frequency is controlled by a resonant reed in the tone oscillator. (B) Block diagram of continuous-tone decoder.



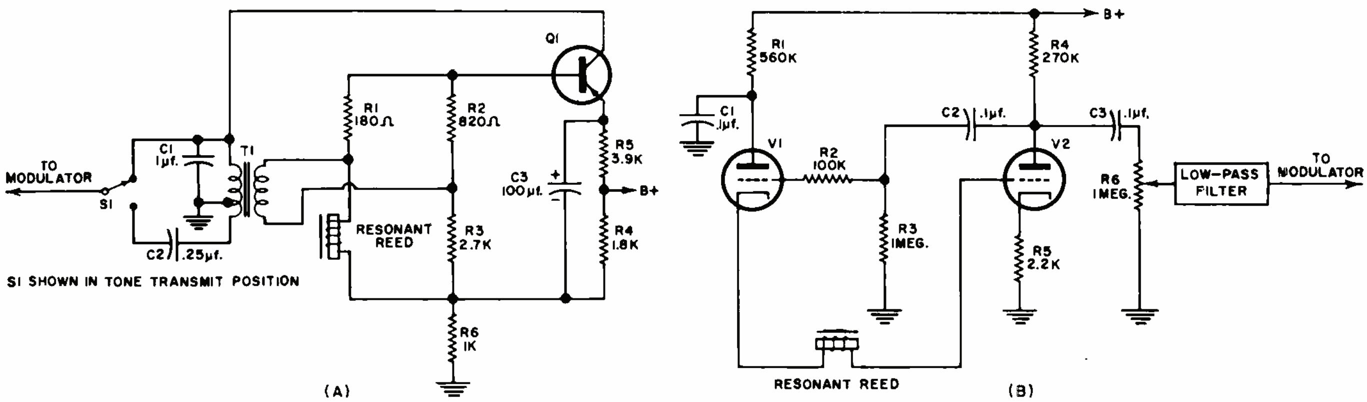


Fig. 7. (A) A typical transistorized continuous-tone audio oscillator. The resonant reed controls frequency of encoder similar to crystal in r.f. oscillator. Switch S1 permits tone to be injected into modulator when transmitter is on. (B) Typical tube continuous-tone audio oscillator. Resonant reed determines the oscillator frequency. The low-pass filter prevents high-frequency harmonics from getting into transmitted signal. R6 controls tone levels to prevent over deviation of transmitter.

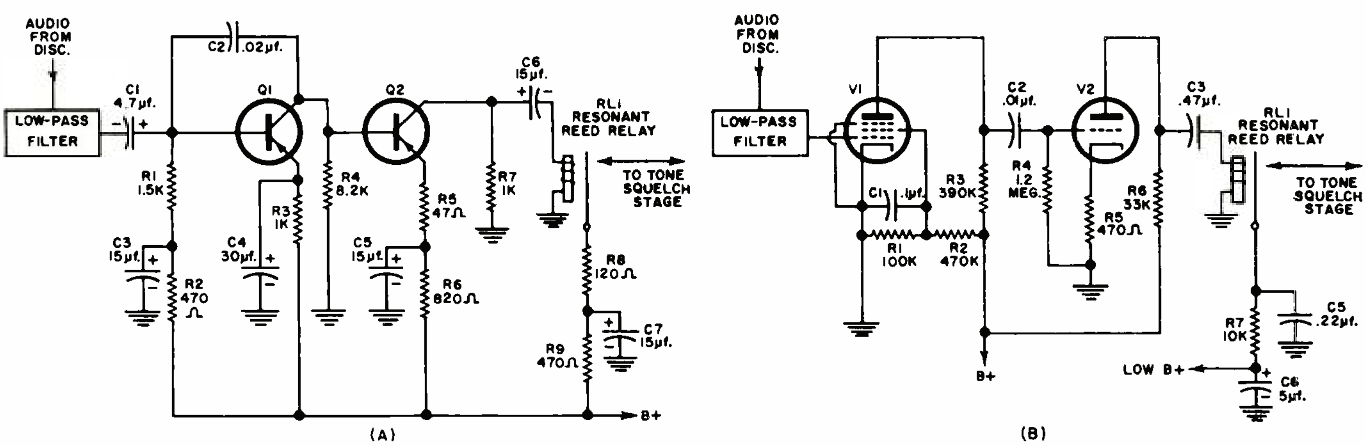


Fig. 8. (A) Typical transistorized continuous-tone decoder. The low-frequency tone from the discriminator is applied to the audio amplifier Q1 through the low-pass filter. The amplified tone is then fed to resonant reed relay driver Q2. If the tone is of the proper frequency, the reed will vibrate and close its contact. "B+" will be applied to the stage that is keeping the audio tube cut off and thereby unsquelch it. As long as the tone is present, audio will be heard in the speaker. (B) Typical tube continuous-tone decoder. The audio amplifier V1 receives the low-frequency tone from the discriminator, amplifies it, and feeds it to the resonant reed relay driver V2. If the frequency is proper, the reed will close its contact and apply a low value of "B+" to the tone squelch stage that is biasing the audio tube off, thus unsquelching it.

one in Fig. 3A. Any signal that appears within the curve will be heard in the receiver. Fig. 3C shows how a transmitter with an assigned frequency adjacent to the desired one can cause interference to the receiver. The line marked "B" represents a high adjacent-channel transmitted signal and the "C" line represents the lower adjacent-channel transmitted signal. The upper adjacent-channel signal is not strong enough to open the receiver's squelch as it does not fall within the selectivity curve of the receiver. The lower adjacent-channel signal falls within the curve and can cause interference to the receiver.

The reason for this condition is illustrated in Fig. 4. Station B has a higher power output than Station C. Station B's antenna is in a different geographic location than Station A's antenna. The signal strength at A's antenna from Station B is not strong enough to cause the receiver squelch to open. But, due to the physical restrictions that frequently confine the antennas of many stations to an area, Station C, which is a low-power station, will cause a strong signal to be present at A's receiver. This proximity of antennas is the major cause of adjacent-channel interference.

Skip Signals

Another bothersome condition that adds to the annoyance of two-way radio users is skip signals which open the receiver's squelch. These signals originate in locations that are geographically separated from the receiver by hundreds of miles but, due to the peculiarities of very-high-frequency radio waves and atmospheric conditions, they are received by communications units tuned to the same frequency. The strength of these skip signals may be equal to that of the local system's signal and may cause confusion for the dispatcher if they are not prevented from reaching him. Fig. 5 shows how skip signals are received. The reflecting layers are media that cause v.h.f. signals to be bent and returned to earth at points far removed from their origin.

The layer marked F2 will cause signals that originate at Station A to be heard in Receiver D, 3000 miles or more away. The E-layer can cause signals to be heard in receivers 1500 miles away while a condition known as "double skip" can increase this distance to 3000 miles. "Close bending" of v.h.f. signals is also caused by air mass boundaries which will cause interference 50 to 400 miles from the transmitter.

With all of these interference conditions present, two-way radio users needed help to eliminate all unwanted noise from co-channel signals, skip signals, and the remote cases of adjacent-channel signals when antennas cannot be separated.

The dispatchers, forced to monitor all the chatter on their channel to prevent "lost" messages, sought a means by which they could hear only those messages intended for them.

Tone-Coded Squelch

To alleviate this problem, manufacturers of commercial two-way radio equipment have developed a tone-coded squelch system which does just that. The receiver remains quiet until it is called by a transmitter coded with a tone akin to its own system. Messages can be heard only when the coded tone and carrier are received.

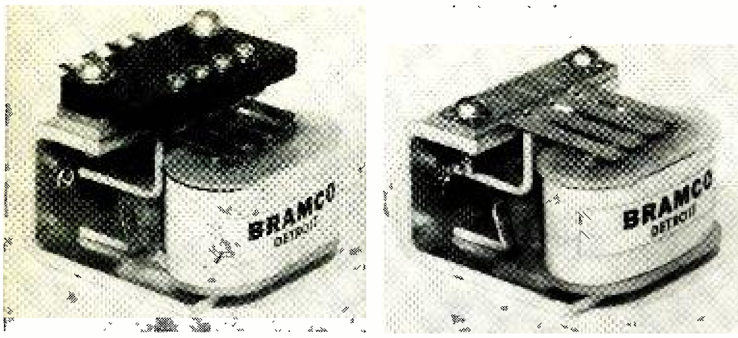


Fig. 9. (Left) The four-reed resonant reed relay used in Hammarlund tone-burst squelch system shown here before modification. (Right) The same relay with its fixed contacts removed.

A typical continuous-tone encoder may be either transistorized or a tube type (Figs. 7A and 7B) and consists of an audio oscillator (controlled by a resonant-reed coil), an audio amplifier, a low-pass filter (to reduce harmonics), and a switching device to inject the tone into the speech circuit. The reason that the tone is switched in and not applied directly as the transmitter is turned on is due to the operation of the resonant reed. The resonant reed, being a high "Q" device, is used to control the audio-oscillator frequency in a manner similar to that of the crystal in an r.f. oscillator. When current flows through the reed it energizes it causing it to vibrate at its natural frequency. But, unlike the crystal, the reed is slow to come up to full amplitude and thus the reed oscillator must be operating continuously and the tone switched into the transmitter's audio circuit when needed.

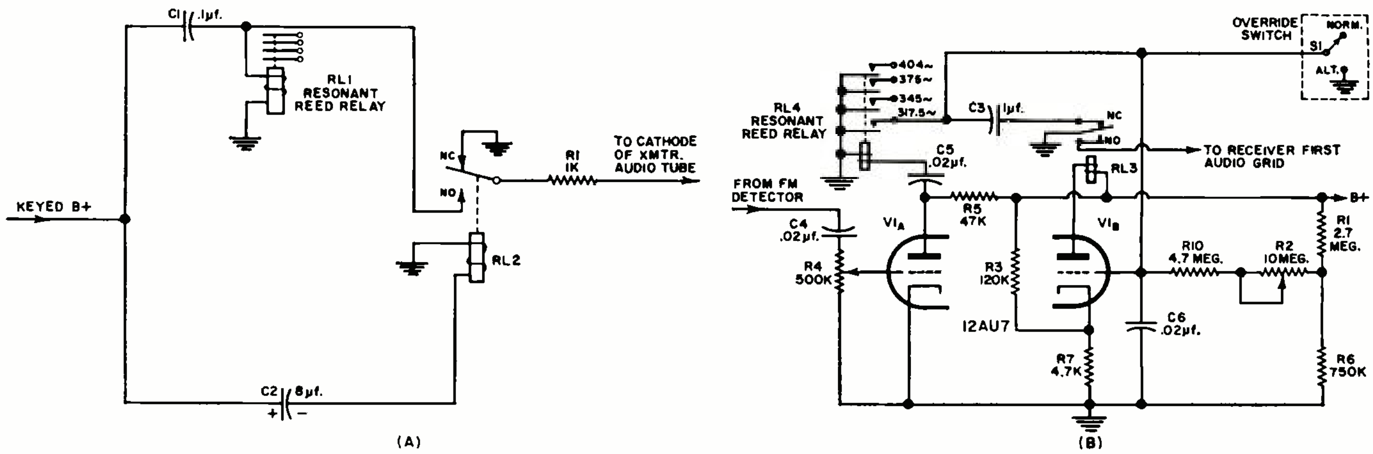


Fig. 10. (A) Circuit diagram of tone-burst encoder. (B) Circuit arrangement used for the tone-burst decoder.

The *Motorola* "Private Line," *General Electric* "Channel Guard," and *RCA* "Quiet Channel" systems are basically similar in performance and operation. One system, made by *Hammarlund* for its "Outercom" units, operates on a different principle than the first three. This unit uses a tone burst while the others use a continuous tone to obtain a quiet receiver that is activated only when it is called by a station in the same service. The accuracy and reliability of the tone in all four systems is maintained by means of a resonant reed and a resonant-reed relay. A resonant-reed relay is an electromechanical frequency-sensitive device consisting of steel reeds mounted in a magnetic circuit.

The magnetic circuit is composed of a permanent magnet which establishes the operating point on the magnetization curve and a field coil which receives the a.c. excitation and produces an alternating flux. When the field coil is excited by a frequency that is the resonant frequency of the reed, the alternating flux causes the reed to vibrate, producing a contact closure once every cycle.

If the contacts are removed and the reeds are mechanically or electrically vibrated, a tone will be induced in the field coil. The frequency of the tone is determined by the mass and length of the reeds.

In the continuous-tone system, a low-frequency tone is produced electronically in the transmitter with a resonant reed as the frequency-determining element. The tone is amplified and fed to the modulator along with the speech (see Fig. 6A) so that the carrier will contain speech and the tone.

In the receiver, which has its audio tube cut off, the tone from the discriminator is separated from the speech by use of filters, as shown in Fig. 6B. The extracted tone is amplified and fed to a resonant-reed relay. If the tone is of the proper frequency it will cause the relay reed to vibrate. The vibrating reed will close a contact which will activate the circuit that is holding the audio tube at cut-off. When the audio tube is permitted to conduct, the speech will be heard in the receiver's speaker.

The decoder in a continuous-tone system may also be transistorized or a tube type (Figs. 8A and 8B) and consists of a low-pass filter (for separating the tone), tone amplifiers, resonant-reed relay, and tone-squelch circuits to keep the audio tube cut off when a tone is not present.

Since the continuous-tone systems used by different manufacturers are fundamentally the same, a tone from one system could activate the receiver of another system if the tones are the same. This could possibly cause annoying interference in the receiver.

To eliminate this adverse condition, *Hammarlund* uses a tone burst instead of a continuous tone to activate the receiver.

The tone burst is produced in a unique way. The encoder does not use tubes, transistors, or an electron oscillator to produce the tones to be transmitted. The tone-producing component of the encoder is a four-reed resonant-reed relay that has been modified by removing the relay contacts (Fig. 9).

The *Hammarlund* system works as follows: the mobile operator wants to call the base station whose receiver is in the quiet position, he depresses his press-to-talk switch on the mike and calls his base station. When he keyed his transmitter the encoder sent out a very short tone burst which, when received by the base-station decoder, activates the receiver for 7 to 13 seconds. This is long enough for the operator to be made aware that there is a call for him.

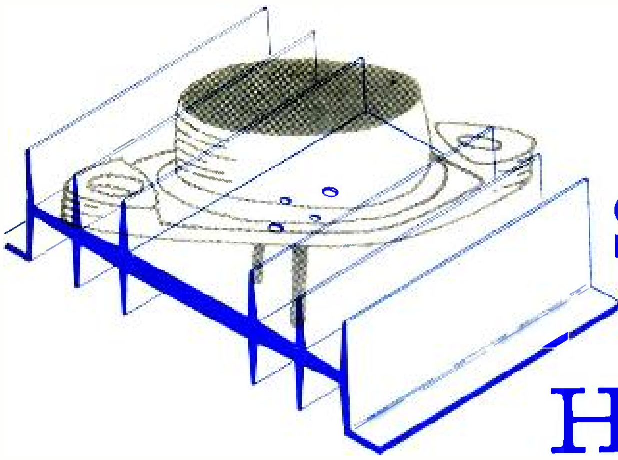
He answers the call by pressing his press-to-talk switch half-way down. In this position his receiver changes from a quiet condition to a listening position. If he does not hear another station transmitting on his channel, he puts his transmitter on the air by pressing his press-to-talk switch all the way down. When he is finished with his message and releases the press-to-talk switch, the receiver goes to the listening position and the normal press-to-talk release to listen operation takes place until the entire message is completed.

(*Continued on page* 65)

NIPPON ELECTRIC CO. TRANSISTOR SUBSTITUTION DIRECTORY

NIPPON NO.	TYPE AND SERVICE	AMERICAN TYPE	AMERICAN MFGR.
2SA204	P—h.s. sw.	2N394	G-E
		2N425	RAY, SYL
		2N520	GI, UST
		2N578	GI, RCA, TUNG
2SA205	P—h.s. sw.	2N395	G-E, RCA, SYL, TI
		2N426	GI, MOT, RAY, SYL, UST, TI
		2N1303	G-E, GI, RCA, SYL
2SA206	P—h.s. sw.	2N111, 2N112	CLE
		2N123	G-E, IND.
		2N629-4	RCA
		2N396	G-E, GI, RAY, SYL, TI
		2N427	G-E, GI, RAY, TI
		2N428	G-E, GI, MOT, RAY, SYL, UST
		2N450	G-E
		2N579	GI, RCA
		2N1000	GI, RCA
		2N1093	TI
		2N1305	G-E, GI, RCA, SYL, TI
2SA207	P—h.s. sw.	2N397	G-E, RAY, SYL, TI
		2N580	GI, RCA
		2N1307	G-E, GI, RCA, SYL, TI
2SA240	P—h.p., l.f. sw.	2N1184	RCA
2SA245	P—vhf.	2N1142	MOT, TI
		2N1143	MOT
2SB100	P—l.p., l.n. amp.	2N175	SYL
2SB101	P—l.p. amp.	2N34	RCA, SYL
		2N105	RCA
		2N133	GI
		2N238	TI
		2N367	IND, RAY, UST
		2N565	GI
		2N566, 2N567, 2N568	GI
2SB102	P—l.p. amp.	2N1273	TI
2SB103	P—l.p. amp.	2N104	RCA
		2N591	RCA
2SB107	P—h.p. amp.	2N155	RAY
		2N255	BEN, SYL
		2N256	BEN, CLE, SYL
2SB107A	P—h.p. amp.	2N176	MOT, RCA
		2N178	MOT
		2N236B	BEN
		2N242	CLE, SYL
		2N257	CLE
		2N301	RCA, SYL
		2N350A	MOT
		2N351A	MOT, RCA
		2N376A	MOT
		2N399	SYL
		2N400	BEN
		2N401	SYL
		2N463	WE
2SB111	P—l.p. amp.	2N1392, 2N1394	GI
2SB218	P—l.p. amp.	2N59C, 2N60B, 2N61B, 2N61C	WEST
2SB219	P—l.p. amp.	2N44	G-E, GI
		2N186, 2N189	G-E
		2N284-12	AMP
		2N319	G-E, MOT
		2N381	SYL, TUNG
		2N402	WEST
		2N460	TUNG
		2N464	GI, MOT, RAY, SYL
		2N506	ETC
		2N1097, 2N1098	G-E
2SB220	P—l.p. amp.	2N43	G-E, GI
		2N61A	WEST
		2N187A, 2N190, 2N191	G-E
		2N215	RCA
		2N238, 2N291-14	TI
		2N320	G-E, MOT
		2N403	WEST
		2N422	RAY, SYL
		2N461	G-E, TUNG
		2N465	GI, MOT, RCA, SYL
2SB221	P—l.p. amp.	2N109	RCA
		2N185	TI
		2N188A, 2N192	G-E
		2N217	RCA, SYL
		2N321	G-E, SYL
		2N322	G-E, MOT
		2N383	SYL, TUNG
		2N408	RCA, SYL
		2N591	RCA
		2N1130	PHIL
2SB222	P—l.p. amp.	2N59, 2N60	WEST
		2N220, 2N270-5	RCA
		2N323, 2N324	G-E, MOT
		2N466	GI, MOT, RAY, SYL
		2N585	GI, RAY, SYL
		2N1129	PHIL
		2N1273, 2N1274	TI
2SB223	P—l.p. sw.	2N1129	PHIL
2SB224	P—l.p. amp.	2N44	G-E, GI
		2N186A	G-E
		2N284-12	AMP
		2N381	SYL, TUNG
		2N402	WEST
		2N405	SYL
		2N406	RCA, SYL, TUNG
		2N464, 2N465	GI, MOT, RAY, SYL
		2N506	ETC
		2N524	G-E, MOT, SYL
		2N1144, 2N1145	G-E
2SB225	P—l.p. amp.	2N43	G-E, GI
		2N61A	WEST
		2N187A	G-E
		2N215	RCA
		2N238	TI
		2N291-14	AMP
		2N331	BEN, GI, MOT, RCA
		2N403	WEST
		2N461	G-E, TUNG
		2N525	G-E, MOT, SYL
		2N586	RCA
		2N597	GI, PHIL
		2N1057	G-E
		2N1192	MOT
		2N1273, 2N1274	TI
		2N1373	SYL, TI
2SB226	P—l.p. amp.	2N109	RCA
		2N185	TI
		2N188A	G-E
		2N217	RCA, SYL
		2N270-5	RCA
		2N321	G-E, SYL
		2N361, 2N363	IND, RAY, UST
		2N383	SYL, TUNG
		2N408	RCA, SYL
		2N526	G-E, MOT, SYL
		2N1128, 2N1130	PHIL
		2N1192	MOT
		2N1375	SYL, TI
2SB240	P—h.p. sw.	2N307	BEN, RCA, SYL
		2N1038	TI
		2N1172	DEL
		2N1183, 2N1184	RCA
2SB240A	P—h.p. amp.	2N143/13	SYL
		2N1039	TI
A2SB240A	P—h.p., l.f. sw.	2N1183, 2N1184	RCA
B2SB241	P—h.p., l.f. sw.	2N1040	TI
		2N1183, 2N1184	RCA
2SB241A	P—h.p. sw.	2N1041	TI
A2SB242A	P—h.p., l.f. sw.	2N1183	RCA
2SB242	P—h.p. amp.	2N176	MOT, RCA
		2N307	BEN, RCA, SYL
		2N1183	RCA
2SB242A	P—h.p. amp.	2N143/13	SYL
B2SB244	P—h.p., l.f. sw.	2N1183	RCA
2SB246	P—h.p. amp.	2N378	TUNG

(Continued on page 64)



SELECTING A SUITABLE HEAT SINK

By JOHN R. GYORKI / Burroughs Corp.

Characteristics of a heat radiator, types of heat sinks available, and how to read and use the sink spec sheets.

POWER transistors and high-current diodes can generate more heat than their own mass can safely dissipate. For this reason, power semiconductors must be securely fastened to a suitable heat sink to effectively increase the mass and surface area of the heat-dissipating junction. Heat sinks and radiators are commercially available in a wide variety of shapes, sizes, and surface finishes for specific and general applications in transistorized circuitry.

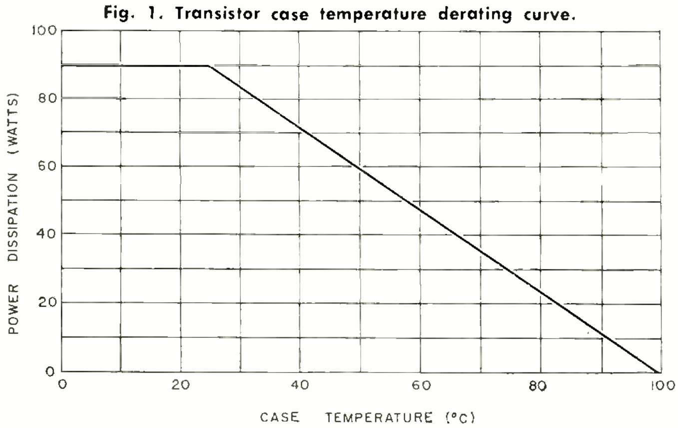
Power-Transistor Heating

Before we become deeply involved in heat sinks themselves, let us study for a moment the characteristics of the heat-generating device. The amount of heat that a semiconductor actually generates depends upon the mode of operation, bias level and signal amplitude, and shape of the applied signal.

A transistor used as a square-wave oscillator or as a class B square-wave amplifier results in much less heating of the collector junction than if it were used as a class A amplifier for sine or complex waves. When the power transistor is used with square waves, collector voltage will be high with low current, then high collector current with very low voltage, during the cut-off and saturation periods. The total result is a very low average power dissipation. However, any rounding of the square-wave corners indicates d.c. power losses and results in additional junction heating.

Class B operation is responsible for somewhat more heat dissipation because of the higher average current in the collector circuit. Class AB operation eliminates the crossover distortion found in class B operation by applying slight forward bias which produces a relatively small steady-state collector current. The bias alone will produce collector-junction heating which will reach a steady-state temperature level.

Fig. 1. Transistor case temperature derating curve.



With the use of sine and complex waves as found in audio, average current time-on is increased and power dissipation per transistor is also increased until it reaches a level approximately 20% of the maximum stage output power.

Class A operation yields a much greater amount of heat dissipation. The quiescent collector current is set near the midpoint of the linear portion of the $I_c - I_b$ transfer curves or the midpoint of the collector load line. With such a large no-signal collector current (about half the peak collector current), considerable power is dissipated in the junction.

Thermal Gradient & Temperature Differential

A power transistor or high-current diode that must be heat sinked has an allowable maximum collector junction temperature of usually 100° C for germanium and somewhat higher for silicon. If the heat generating semiconductor were not connected to a greater mass of surface area, the amount of allowable junction current and voltage as given in a typical specification sheet could hardly be approached before the device would exceed the maximum collector junction temperature. The reason is that the specification sheets list their characteristics with the transistor or diode mounted on a heat sink of considerable size.

The temperature of the ambient surrounding the heat generating device must be much less than the maximum allowable junction temperature if any cooling is to take place at all. The heat sink attempts to lower the temperature of the junction to that of the surrounding medium. If the heat sink were thermally perfect, the transistor junction temperature could always be kept the same as the lower ambient. However, this is not possible in practice.

The thermal conductivity path from the transistor junction to the ambient air contains physical connections between the junction and case, case and heat sink (through an insulator if one is used), and heat sink and ambient. These connections are not thermally perfect and therefore produce a temperature differential. They are known as thermal resistances and each thermal resistance has a unique coefficient number. The coefficient of thermal resistance is expressed as a temperature in degrees centigrade per watt of dissipation (°C/W). Due to these resistances, there will always appear a temperature differential between the collector junction and ambient. This is an important factor that we will try to keep to a minimum.

The actual amount of temperature difference depends upon the amount of power the junction is dissipating. The average power dissipation may be approximated as: $P_d = I_c \times V_{ce}$, where P_d = power dissipation in watts of constant current generation; I_c = collector current; and V_{ce} = collector-to-emitter voltage.

To get a clearer understanding, let's study the characteristics of a single-ended class A amplifier stage. The transistor to be used has a peak collector current of 15 amps. and a power dissipation capability of 90 watts at a case temperature of 25° C. The power dissipation decreases linearly from 25° C to zero watts of dissipation at 100° C case temperature. See Fig. 1. Conveniently assume a collector supply voltage of 60 volts and a load impedance of 20 ohms; all within the ratings of the typical transistor chosen. This would give a peak collector current of 3 amps. during operation. The stage power is given as: $P_{out\ max.} = (V_{cc})^2/2R_l$ or $P_{out\ max.} = (60)^2/2 \times 20 = 3600/40 = 90$ watts. Stage power output is 90 watts peak. The quiescent collector current will be about 1.5 amperes at 30 volts collector to emitter. Using the above formula for power dissipation, the class A stage produces 45 watts ($P_d = 30 \times 1.5 = 45$ watts). The product of collector current and voltage either side of this quiescent state results in less power dissipation. Therefore, 45 watts will be the maximum power dissipation we will consider.

Going further, let us investigate a class AB push-pull power output stage delivering 90 watts, also. Assume a peak collector current per transistor of 3 amps. and the same 60-volt supply. The collector-to-collector impedance is now 80 ohms. The peak power output for class AB operation is given as: $P_{out\ max.} = 2(V_{cc})^2/R_{cc}$ or $P_{out\ max.} = 2(60)^2/80 = 2(3600)/80 = 90$ watts. Real power dissipation varies with signal here and requires a calculus integration for accurate results. However, for our purposes, assuming sine-wave operation, we can use the approximation: $P_d = .4 \times P_{out}$ for two transistors class B (or class AB) or $P_d = .2 \times P_{out}$ for each transistor. The P_d per transistor in our example is: $P_d = .2 \times P_{out}$ or $.2 \times 90 = 18.0$ watts of dissipation. We end up with a considerable reduction in power dissipation per transistor for the same amount of power delivered to the load.

Heat Sink Characteristics

The heat sink to be used can now be studied in detail. As the amount of power dissipation in the device is increased, the size of the heat sink must be increased and allow more surface area to be exposed to the surrounding ambient. The heat sink material is an important consideration as well as the size. Thermal conductivity of the material should be as high as possible. Copper is about the best for thermal conductivity and aluminum follows a close second. The difference in cost between copper and aluminum exceeds the difference in their thermal conductivity, therefore, aluminum heat sinks have almost been made an industry standard.

The real ability of aluminum to conduct heat to the ambient is measured in °C/W of power dissipation. This depends on its surface area and finish.

Let us consider, first, a square piece of bright aluminum, ⅛" thick with a surface area of 5 square inches per side, positioned vertically. From actual laboratory measurements, the thermal resistance is about 9° C/W. Refer to Fig. 2. If it is increased to 10 square inches, thermal resistance reduces even more, until a practical limit is hit at about 140 square inches of heat sink area. Here, the thermal resistance is about 1.4° C/W in free air and increasing the surface area doesn't decrease the thermal resistance any further. More than 140 square inches in this case would be considered an infinite heat sink. Copper positioned vertically, ⅛" thick by 140 square inches, has a thermal resistance of about 1.0° C/W as compared to aluminum at 1.4° C/W.

Heat sinks may be black anodized or painted flat black to further facilitate radiation of heat. Although some heat sinks may be found anodized in green, red, gold, or blue, black seems to have the most desirable properties. There are other finishes and colors available on special request from the various manufacturers.

The most popular type of commercially available heat sink is the finned extruded aluminum style, as shown in Fig. 3A. It is usually painted flat black with a bare exposed area for mounting the transistor upon or is completely black anodized. It can be punched to accommodate types TO-3, TO-10, TO-13, or TO-36 power transistors and diodes. This shape of radiator is the most desirable because much surface area is exposed to the surrounding air within a comparatively small volume. Approximately 80 square inches of radiating surface can be contained in a volume measuring 4½ x 1½ x 3 inches. These same heat sinks can be given a serrated surface to increase even more the available surface area per given unit volume.

Fig. 3B shows a type of radially finned heat sink used with stud-mounted semiconductors. It has the same general properties as the previous style. Still other types are made which connect to the cases of TO-1 or TO-5 (and other) transistor packages and stud mount to a chassis or are exposed to free air (Fig. 4).

Since the caps of transistors are relatively thin sheet steel (which is not a very good conductor of heat), securing a heat sink to it affords little heat radiation and results in a high total thermal resistance. This is all right, however, since the lower-power TO-5 transistor was not specifically designed to

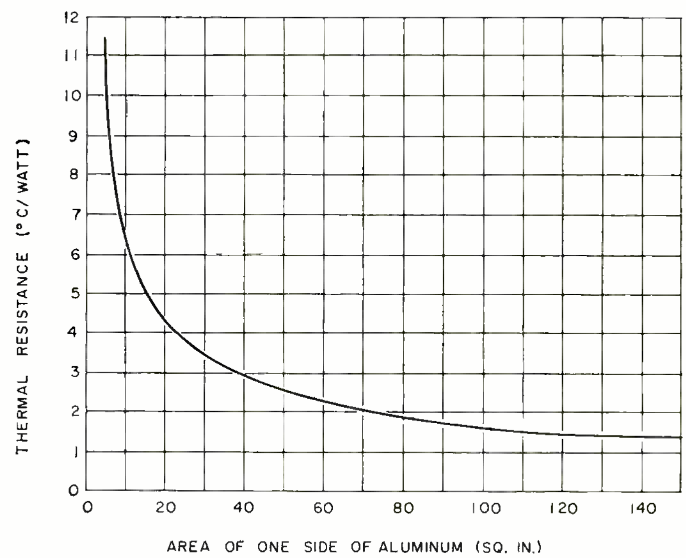


Fig. 2. Heat transfer of square ⅛" aluminum heat sink.

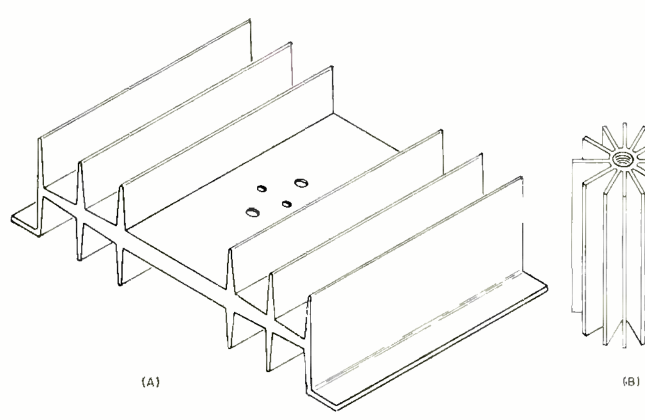
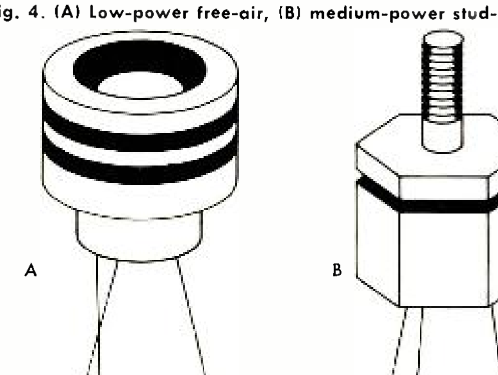


Fig. 3. (A) The common finned heat sink. (B) Vertical radial sink.

Fig. 4. (A) Low-power free-air, (B) medium-power stud-mount sink.



operate with a heat sink. Any such heat-sinking is just that much more safety. When a typical high-power transistor is mounted by its cap to a heat sink, the thermal resistance is 6 or 7° C/W compared to about 0.9° C/W when mounted in the conventional manner to its base.

Now that we have learned a few important considerations of transistors and heat sinks, let us go back to our example calculations and match them up with a heat sink.

The first thing to do is add up the applicable thermal resistances, multiply it by the power dissipation of the transistor, and add the results to the ambient temperature. This will yield a new junction temperature. If the temperature just calculated is in excess of the maximum allowable temperature for the transistor we are to use at the power dissipation, as shown on the derating graph (Fig. 1), one or more factors in the computation must be changed. The ambient temperature could be lowered or the power dissipation reduced by lowering the collector voltage and current. Also, any one of the thermal resistances could be reduced to achieve the same end.

The formula that must be used to decide the junction temperature is: $T_j = P_d (\theta_{jc} + \theta_{cs} + \theta_{sa} + T_a$, where T_j = junction temperature (°C), P_d = power dissipation (watts), θ_{jc} = junction thermal resistance (°C/W), θ_{cs} = insulator thermal resistance (°C/W), θ_{sa} = heat sink thermal resistance (°C/W), and T_a = ambient temperature (°C).

The previous calculations of the single-ended class A amplifier produced a power dissipation of 45 watts. Select a maximum ambient temperature of 50 C; a transistor thermal resistance of 0.8 C/W; silicone grease applied to give an θ_{cs} of 0.1 °C/W; and a commercial heat sink as shown in Fig. 3A, θ_{sa} of 1.8° C/W. Substitute in the formula: T_j = 45 (0.8 + 0.1 + 1.8) + 50, or T_j = 171.5 degrees C—by far an impractical temperature.

Recalling the class AB stage that had an individual transistor dissipation of only 18 watts, the T_j calculates to 98.6 degrees. This temperature is under the maximum allowable for the transistor, but a look at the derating graph shows that only 2 watts of dissipation is allowable at about 98 degrees. We would be dissipating 16 watts too much under these conditions and the transistor would soon fail. Lowering the ambient to 30 degrees from 50 degrees would yield a T_j of about 78°C. The derating graph allows over 18 watts of dissipation at this temperature; so we have arrived at a satisfactory heat sink, transistor, ambient temperature combination.

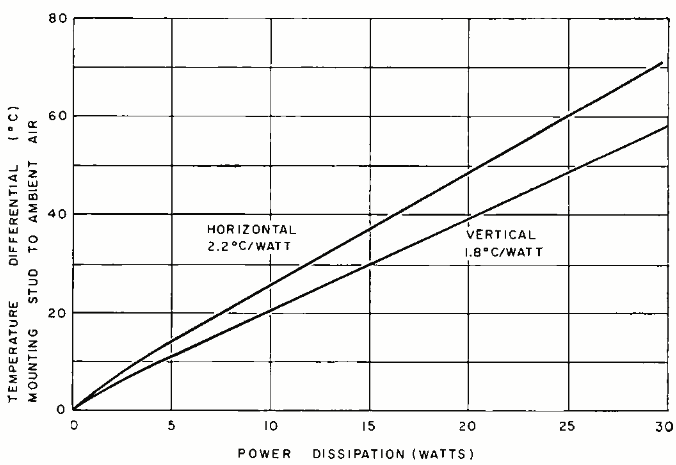
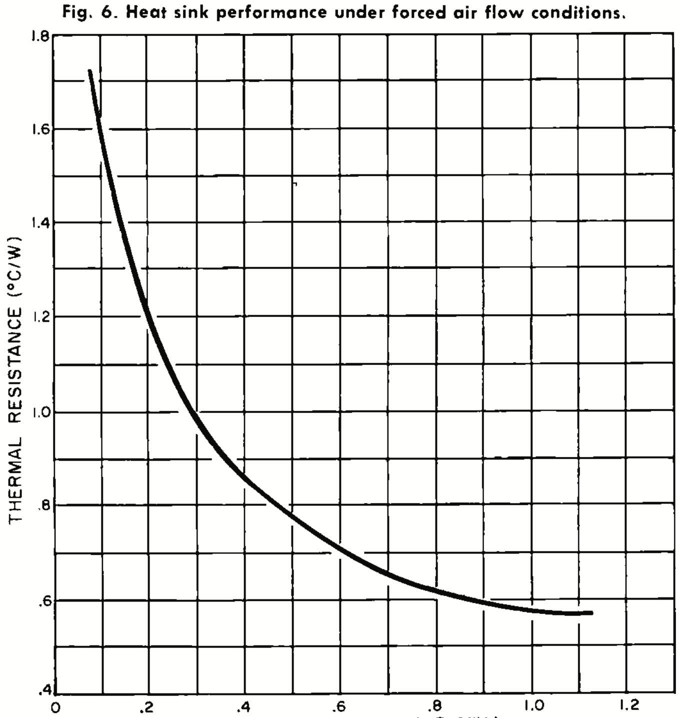


Fig. 5. Thermal characteristics of finned heat sink of Fig. 3A.

Fig. 6. Heat sink performance under forced air flow conditions.



Heat Sink Specification Sheets

Graphs and charts supplied with fabricated heat sinks yield much useful information as to how they may be efficiently used. A typical graph, as shown in Fig. 5, conveys the thermal resistance characteristics of a specific heat sink like the one in Fig. 3A.

The temperature differential is read directly in degrees centigrade from mounting stud to ambient air as seen on the vertical axis of the graph. The power dissipation capability of the heat sink in watts is indicated along the horizontal. The vertically mounted heat sink has a thermal coefficient of about 1.8° C/W and the horizontal has a coefficient of about 2.2° C/W.

The transistor can be isolated electrically from the heat sink by use of a mica or other insulator. However, the mica insulator has a coefficient of 0.8° C/W to 0.5° C/W which must be added to the thermal resistance of the heat sink. Silicone grease on both sides of the insulator will reduce resistance by about half; that is the range of 0.4 to 0.25° C/W. In any case, the transistor should be mounted near the lower edge of a vertically mounted heat sink for best dissipation.

Another special characteristic some manufacturers indicate is the performance under forced air flow of the natural convection transistor heat sink, as shown in the graph of Fig. 6. Thermal resistance of the heat sink is shown along the ordinate and the air flow in lbs./min. is given along the abscissa. As can be seen from the graph, the thermal resistance of the heat sink can be drastically reduced from 1.7° C/W to less than 0.6° C/W with an air flow of 1 lb./min. Forced air flow is very definitely superior to natural convection air current flow.

The ambient temperature of 30 degrees that was decided upon as a solution for the class AB amplifier stage is really too low to be useful in actual practice. A much more realistic maximum ambient temperature is 50° C. With an air flow of 1 lb./min. and a new heat sink thermal resistance of 0.6° C/W, an ambient temperature of 50° C will be considered. Substituting in the formula for junction temperature: T_j = 18 (0.8 + 0.1 + 0.6) + 50 or T_j = 77° C. The derating graph of Fig. 1 shows approximately 25 watts allowable dissipation at a temperature of 77° C. Forced air flow is then another solution for making circuit requirements and heat sink arrangements practical. This means, however, that one heat sink will have to be used (each with an air flow of 1 lb./min.) with each of the two power transistors in the push-pull circuit. The smaller power dissipation per transistor of the class AB stage for the same power delivered to the load made the difference between an impossible and a possible circuit-heat-sink combination. ▲

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Magnetic Products Division 3M COMPANY

JOHN FRYE

Since the term "bionics" was coined at Wright-Patterson Air Force Base, Mac lets Col. Butsch, Jr. define its true meaning.

Bionics—Its Meaning, Promise & Danger

THE sunny, sparkling June morning found Mac and his assistant, Barney, driving slowly along the river road in the shop truck. They were going back to the shop after having delivered a heavy, completely overhauled TV and hi-fi combination to a customer in the country. Mac, who was driving, kept drinking in deep breaths of the warm, scented air coming in the open window and darting appreciative glances at the gently flowing stream paralleling the road; so Barney was not surprised when the truck was pulled to the side of the blacktop pavement and the ignition was shut off.

"Nature is doing her level best to flirt with us this morning," Mac announced, reaching for a door handle. "It would be ungallant and inhuman of us not to respond. Let's commune with her for a few minutes. Matilda will mind the store."

They strolled down the green bank, freckled with wild flowers, that sloped to the edge of the river. There Mac slumped down comfortably on the sun-warmed grass, pillowed the back of his head on his folded hands, and watched a buzzard sailplaning in the deep blue sky overhead. Barney, however, spotted a leather-back turtle the size of a pie plate basking on a rock a hundred feet or so out in the stream. He scuffed a stone out of the soft earth with the toe of his shoe and threw it at the sleeping reptile. The stone missed its mark by a couple of yards, but the startled turtle scrambled from the rock into the river.

" 'Boys throw stones at frogs in sport; yet the frogs do not die in sport but in earnest,' " Mac quoted reprovingly.

"Aw I missed him a country mile," Barney retorted, throwing himself down on the grass beside the older man. "Who was the joker who made that crack?"

"A Greek named Bion who lived 300 B.C."

"Bion, huh? Hey! That reminds me of something I've been wanting to talk over with you. Ever since I read an article on bionics in the March issue of ELECTRONICS WORLD, I've been trying to decide exactly what the term means; but I can't quite nail it down. According to the article, 'bionics' is related to the Greek word '*bion*,' which I discover is simply the present participle of a verb meaning 'to live' and so means 'living.' The 'ics' suffix would indicate 'the science of,' 'the study of,' etc. So it would seem bionics would be the study of living organisms.

"But now comes the rub. While prowling around in the dictionaries and encyclopedias, I ran across two near-relatives of bionics. One was 'biophysics,' and the other was our old friend "cybernetics.' Biophysics, in its broadest sense, is the physics of living things and takes in all physical knowledge of the structure and activities of organisms or groups of organisms. Cybernetics, on the other hand, is the science of control and communication processes in both animals and machines. It seems to me there's not much room for a new science that concerns itself with 'the study of living organisms' to squeeze in among those definitions."

"I appreciate your problem," Mac said sympathetically, nibbling on a leaf of sheep sorrel, "because I had the same trouble. None of the definitions I read completely satisfied me. Finally I wrote to Lt. Col. Leonard M. Butsch, Jr., Chief of the Bionics & Computer Branch of the Electronic Technology Laboratory at Wright-Patterson Air Force Base, Ohio, and asked if he could give me a definition of bionics I could understand. He came right back with this: 'Bionics is that activity or inter-disciplinary science devoted to the creation of techniques and tools (*e.g.* hardware) that perform highly sophisticated functions now performed efficiently only by biological systems.'

"Now there's a definition I can live with. Actually the term was coined at Wright Field; so if the boys there do not know what it means, no one does. Col. Butsch went on to say the military is primarily interested in those functions of biological systems that would further relieve man of arduous duties or increase his chance of survival in an increasingly hostile environment, the world of today. He is speaking of such functions as pattern recognition, learning, adaptation, reasoning, and decision making. The military is interested in creating physical hardware and methods that will perform such functions, and they are trying to do this by analyzing the only systems doing these things effectively at the present time: living organisms. By learning how a living organism functions, the military hopes to be able to make a machine that will act in a like manner. Understand they do not expect to copy the structure of the biological system exactly. Instead, they hope to evolve an analog of the system that will do the same job."

"But in all three cases there seems to be a 'study of living organisms.' Where does the difference come in?"

Mac paused to listen to a wild canary trilling rapturously on a nearby branch. "I guess you might say the difference lies in the *purpose* of the study," he offered. "Purpose does make a difference, you know. Take that duck swimming around over there at the edge of the weeds. He would be interesting to an ornithologist, a cook, a hunter, and a game warden for entirely different reasons. An aeronautical engineer might study him to learn how he alights on the water, and a hydraulics engineer might be deeply interested in how he manages to float so high in the water.

"In the same way the biophysicist wants to know how a living thing is made and how it works simply for the sake of knowing. He merely wishes to *understand* the creature in physical terms. The man in cybernetics takes a more narrow, specialized view. He is interested in *comparing* how communication and control takes place in the creature with how these functions are managed in a machine. The coincidental analogy is what fascinates him. Better knowledge of both man and machine may well come from the comparison. For example, he learns that the principle of feedback, so useful in his control of machines, is also employed in the living creature; and just as too much feedback or the wrong kind of feedback can cause his machine control system to go into oscillation or start senseless hunting; so can fear and anxiety—a kind of emotional feedback—produce a nervous breakdown in the living animal.

"Our bionics engineer does not confine his study of a living creature to just two functions of that organism. His interest may concentrate on any aspect. But in every case he is making his study for just one hardheaded, practical reason: the biological system does something better than any of his machines, and he would like to steal its thunder!"

"Are the boys having any luck in this field?"

"Yes. Keep in mind that bionics is just starting; but, like solid-state electronics, it promises to grow mighty fast. Going back to the subject of frogs that triggered this whole discussion, bionic studies reveal a frog's eye responds only to moving things, such as bugs. The sight of anything not moving is filtered out and does not record on the brain. Already we have evolved doppler radar that will do the same thing, respond only to movement; but the same basic idea of filtering out unwanted observation is being applied to a much more sophisticated radar now under development. This radar will ignore the presence of friendly weapons, vehicles, and troops but will instantly report the presence and movement of any hostile units."

"There must be some pretty fantastic filters in living creatures."

"No doubt about that. Take bats for instance. They can fly easily about a totally dark room criss-crossed with thin wires by using only their built-in, jam-proof sonar. I say 'jam-proof' because it has been demonstrated bats can accomplish this while seventy loudspeakers in the room are pouring forth sound 2000 times the volume of their echoed supersonic beeps right on the frequency of those beeps. Ounce for ounce and watt for watt, the bat's sonar system is admitted to be a billion times better than anything man has come up with so far. Here's hoping bionics can reveal how the bat does it."

"I suppose a human being's ability to concentrate depends on his use of filters. They permit him to focus all his attention on a particular sight, sound, smell, or even thought by blocking out all distracting stimuli."

"That's right. A rejection filter keeps us from 'hearing' the loud ticking of a familiar clock. A mother's pass-band filter permits her to sleep peacefully until her infant makes a slight sound; then she immediately awakens."

"I guess we do a much better job of pattern recognition than any machine or electronic device," Barney offered. "I know I can positively recognize any one of hundreds of familiar people with a single fleeting glance, even though that person may be wearing clothing I never saw before and years may have elapsed since I last saw him. A lot of this pattern-recognition mechanism must be below the conscious level, too; because it would be very hard, if not impossible, for me to explain *how* I recognize the person."

"That's right. You might be interested to know the Electronic Technology Laboratory at Wright-Patterson is devoting about 20% of its effort to determining how property filters in the animal operate, 20% to the development of receptors to simulate the sense organs—they have yet to come up with a transducer responding to odors!—and 60% to the cognitive or decision-making centers of the living organism."

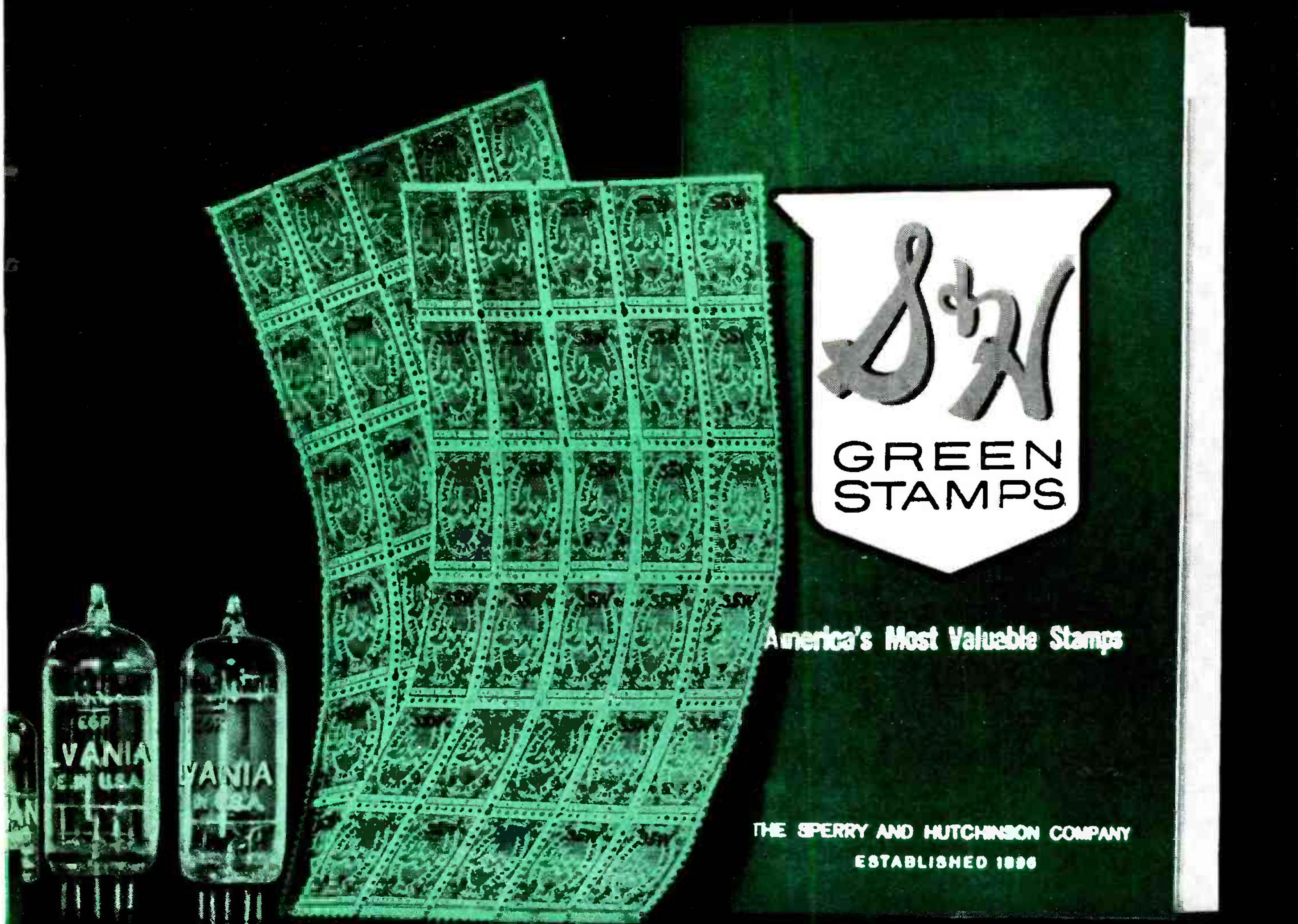
"It almost scares you to think about it," Barney observed. "*Bell Telephone Laboratories* recently demonstrated a synthetized speech machine that recites Hamlet's soliloquy at the dictation of a digital computer. Combine such a machine with another that understands speech and connect both to a decision-making computer. Think what a rousing argument you could have with one of these machines trying to change its 'mind.'"

"That sounds far-fetched now, but it may easily come to pass," Mac said soberly, rising to his feet. "One very real danger in this business of trying to make machines that behave like men is the corollary: we may end up with men that are little better than sophisticated machines, or, worse yet, a kind of hybrid half-man, half-machine. Dr. Robert Felix, Director of the Institute of Mental Health, spoke of such a monster recently when he was talking about electronic stimulation of the brain. As you know, it has been found that various actions, emotional states, and appetites can be produced in a human being by stimulating the right portions of the brain with electrical currents. Once the human brain has been completely mapped, you could connect a transistorized computer to such a brain and come up with a cheap, ultra-sophisticated robot capable of doing anything that could be programmed into the computer."

"I'm glad I'm living now," Barney said with a grin as he stretched luxuriously in the warm sunshine. "It's kind of nice to be able to enjoy this wonderful June morning, secure in the knowledge that no bucket of bolts and transistors can yet come even close to accomplishing all the things I can accomplish, or, by the same token, make all the stupid, interesting mistakes I can make."

"We may be the lucky ones at that," Mac agreed, holding out a helping hand. "But while we do not have to compete against smart-aleck robots, we still have human competitors who are probably not goofing off along a river; so come on and let's get with it." ▲

give you these 2 big bonuses:



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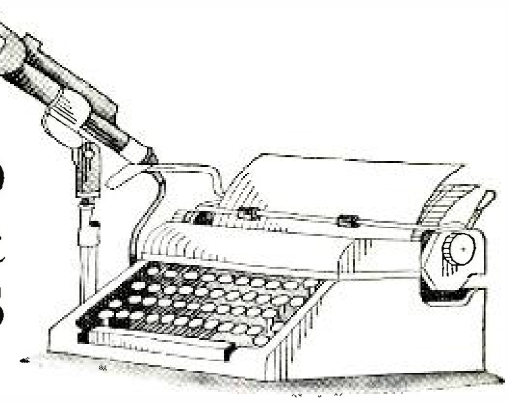


WILL small business continue to flourish in our economy, or is it doomed to wither away in time? In our own field of electronics, at least one large entrepreneur feels that smaller organizations enjoy important advantages.

Ten years ago, *Litton Industries, Inc.* was a small organization. Today it is listed among the 100 largest companies in this country, turning out its products at a current rate of more than half a billion dollars annually. With this volume, does millions of dollars of business e v year with other companies who ar s suppliers or to whom it subcontract vork. Most of these other companies, g tting most of these dollars, are classified as small businesses.

Sentimental remembrance of its modest beginning might be one reason for *Litton* following this practice. Encouragement by the Small Business Administration might be another. Without such justification, however, the policy would continue, says *Litton* v.p. George Scharffenberger, for basic economic reasons.

Small businessmen have earned the preference, Scharffenberger states. Each purchased part and service is obtained from that organization deemed best able to supply it at the optimum combination of low cost, quality, and delivery time. On this basis alone, more than 75% of the 3500 vendors on *Litton's* approved list have been in the "small" category. They are getting more than 62% of the dollar volume in *Litton* contracts, which overshot $41-million last year.

The Advantages

Some, though not all, of the reasons for the preference given to smaller companies are: (1) Many new technological developments are originating with enterprising small concerns rather than larger, less flexible ones. (2) Greater small-firm flexibility also shows in the ability to adjust delivery schedules. (3) The "smalls," eager for business, are more competitive on lesser quantities. (4) Engineering liaison and communication between *Litton* principals and those in the smaller company are easier. (5) The capabilities of a small supplier are easier to evaluate. (6) These firms cooperate better in value engineering and quality assurance programs. (7) Larger firms are often unable to supply needed but unsophisticated materials.

Theorists once felt a business indefinitely improved capability, efficiency, and economy as it grew larger. Today one hears there is an "optimum size" for each type of business, which is not always the largest size. Beyond the optimum, a firm may become less successful.

The *Litton* experience will cheer numerous small electronics firms throughout the nation. Which companies, for example, have been carrying the ball in the hi-fi component industry? The dinosaur is believed to have faded into extinction because it was too ungainly to adjust to a changing environment.

Kits and Nutrition

Manufacturers in the active test-equipment and hi-fi kit business like to boast that their construction instructions, carefully tested and fool-proof, make it easy for the layman to get factory-wired results. Most make good on the expectation, but there is still occasional failure to anticipate misunderstandings or other pitfalls for the uninitiated.

Consider the 5-tube kit radio (designed to be built by a 7-year old) that an adult constructor brought, inoperative, to his service shop. He had slipped curved sections of pale yellow tubing over component leads. When the puzzled technician squeezed these, they disintegrated. Unable to find "spaghetti" with a large enough hollow, the builder had settled for short lengths of macaroni.

Talk Isn't Cheap

A *Raytheon Co.* study of how executive time is spent reveals 90% is devoted to some form of communication. Writing accounts for 9% of this time; reading for 16%. Talking (30%) and listening (35%) add up to 65%. Thus a typical $10,000-a-year man talks away $250 a month.

Raytheon has installed 2-way CB radios in the cars of all executives to facilitate communications as these men drive from one to another of the company's 26 installations in eastern Massachusetts. Is someone hinting, "Go thou and do likewise"? *Raytheon* makes CB gear. ▲

A.C. Voltage Calibrator

By DAVID G. BETHANY

Construction of a bridge that measures or supplies a.c. by comparison to a known d.c.

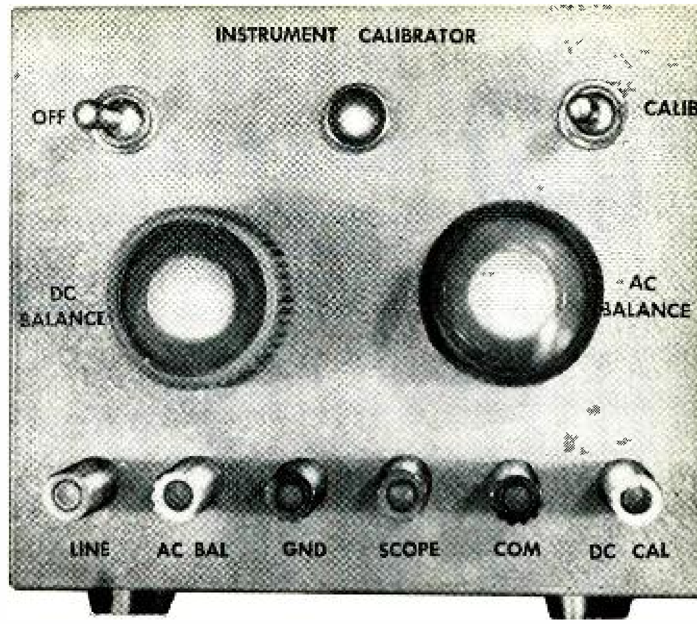
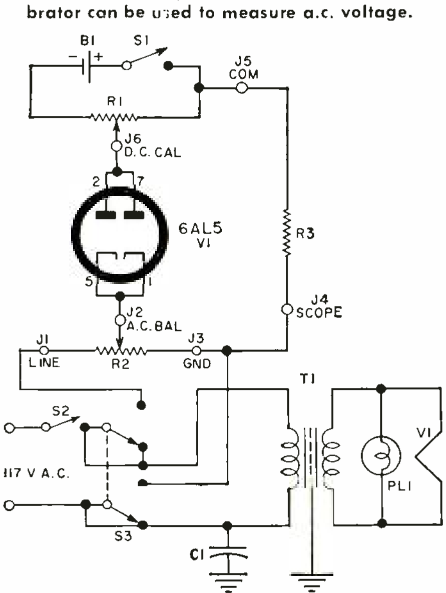


Fig. 1. Author's model. Switch S_3 is not shown.

THIS easily built voltage calibrator can be used to measure or supply a.c. voltages from zero to nearly 64 volts with a high degree of accuracy. Its range can be easily extended to 500 volts or higher. In contrast with commercial instruments, its accuracy is unaffected at high frequencies and elevated ambient temperatures.

If an oscilloscope is used as the null detector, the accuracy, to some extent, will depend on the scope's vertical sensitivity and the user's vision. Inexpensive scopes have a sensitivity of about 0.025 volt per inch. At maximum vertical gain, a person can detect a waveform amplitude of 1/25 inch. Thus, an imbalance of about 0.001 volt could be detected. However, this consideration is secondary compared to accurate measurement of the d.c. reference voltage. If this voltage is measured with a voltmeter with an accuracy of 2%, the calibrator accuracy will be 2%. If a more accurate d.c. meter is used, the calibrator accuracy is greater by the same amount. A laboratory potentiometer could be used in place of a d.c. voltmeter to give an accuracy of about 0.05%.

Fig. 2. S_3, not incorporated in author's model, is shown positioned so that the calibrator can be used to measure a.c. voltage.

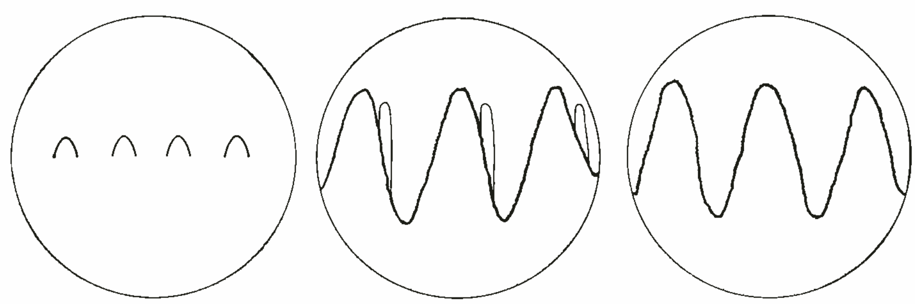


R_1—50,000 ohm linear-taper wirewound pot (Clerostat 58C1-50K or equiv.)
R_2—7500 ohm linear-taper wirewound pot (Clarostat 58C1-7500 or equiv.)
R_3—2000 ohm, 2 w. res. ±5% (Corning Glass C-42 or equiv.)
C_1—1 µf. 400 v. capacitor
T_1—Filament transformer. pri: 117 v.; sec: 6.3 v. (Stancor P-6134 or equiv.)
S_1,S_3—S.p.s.t. toggle switch ("Calib.") ("Off")
S_2—D.p.d.t. toggle switch
B_1—90-volt battery (Burgess N60 or equiv.)
PL_1—6.3-volt pilot light and holder
J_1-J_6—Six-way binding posts (Johnson type 111 or equiv.)
V_1—6AL5 tube (see text)

The circuit is an unconventional bridge that uses a diode (V_1) to compare an unknown a.c. voltage with an accurately measured d.c. voltage. In the schematic (Fig. 2) V_1's cathodes are connected to the arm of R_2 and its plates are connected to the arm of R_1. V_1's plate circuit is connected through R_1 and S_1 to a 90-volt battery. The setting of R_1 determines the voltage or bias on the plate of V_1.

When S_1 is closed and the arm of R_1 is moved to its full counterclockwise position (to the left in the schematic), the plate of V_1 will be 90 volts negative with respect to its cathode and it will be cut off. At any intermediate setting of R_1, the cut-off voltage will be less. The bridge is balanced when R_2 is set so that the peak value (r.m.s. value × 1.414) of the a.c. input applied by R_2 to V_1 equals the d.c. blocking voltage at V_1's plate.

To understand the calibrator's operation more clearly, consider each of these three operating conditions: (1) R_2 is set so that 10-volts r.m.s. (14.14 volts peak) will be applied to the cathode of V_1 and R_1 is set fully counterclockwise so −90-volts d.c. is applied to V_1's plate. No current will flow because the negative voltage at V_1's plate is greater than the peak a.c. input. (2) With R_2 set so 100 volts r.m.s. (141.4 volts peak) is applied to V_1's cathode, V_1 will conduct because the peak a.c. input exceeds 90 volts. Fig. 3A is the waveform of the voltage across R_3 in this condition. (3) If the a.c. input is 63.63 volts r.m.s., the peak value will be 90 volts. With R_1 fully counterclockwise, V_1 will remain just cut off since the two voltages are exactly equal.

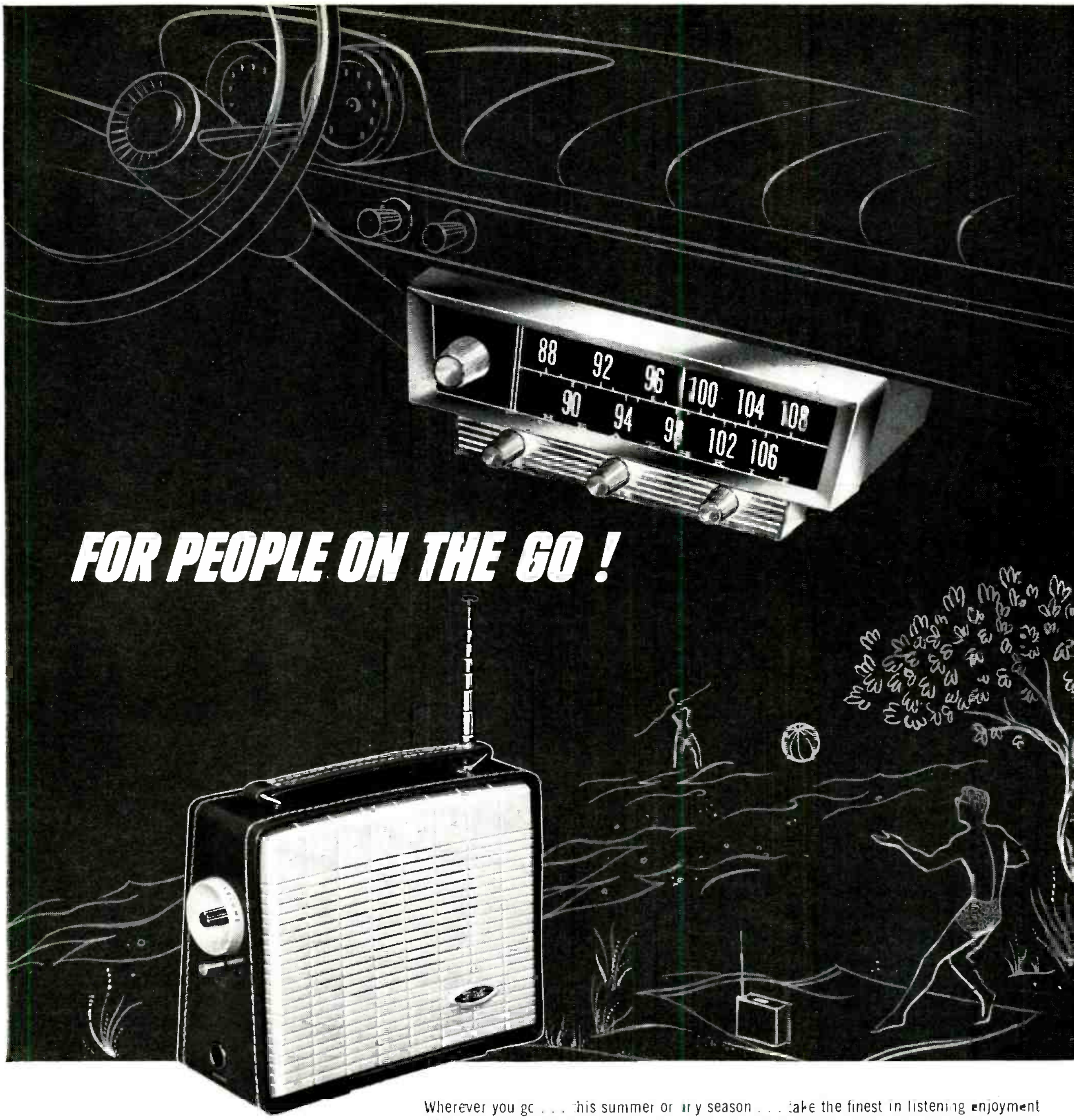


(A) (B) (C)

Fig. 3. Waveform at unbalance (A). Hum appears at near-balance (B) and balance (C).

Fig. 3B shows the voltage across R_3 at almost the null setting. The three pips indicate a positive bridge imbalance—the peak a.c. exceeds the d.c. blocking voltage very slightly. Note that these pips are superimposed on a hum voltage of considerably higher amplitude. By moving R_2 a shade counterclockwise, the pips were removed. Fig. 3C shows just hum voltage indicating the bridge is balanced. At this point a peak a.c. voltage exactly equal to the d.c. across R_1 exists at terminals J_2 and J_3.

The calibrator is very easy to use. First, turn both controls to their ex-



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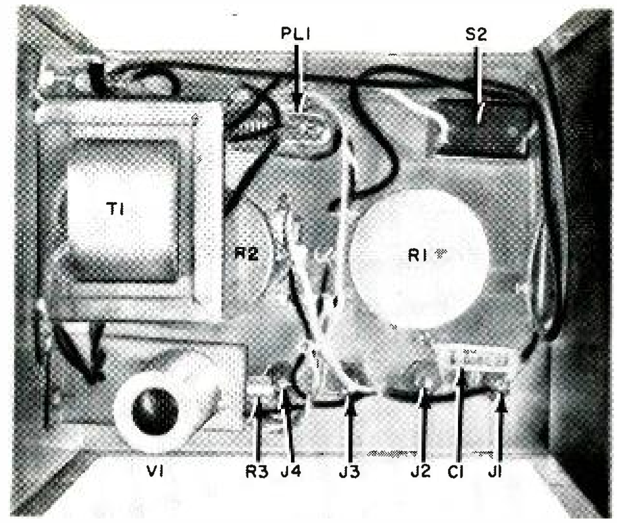


Fig. 4. Rear view shows parts arrangement. S_1 is behind T_1.

treme counterclockwise position then multiply the r.m.s. value of the desired a.c. voltage by 1.414 to obtain the peak voltage. Close S_1 and adjust R_1 until a d.c. voltmeter across terminals J_5 and J_6 indicates the calculated value of peak a.c. voltage. Connect the vertical input of a scope to J_1 and its ground terminal to J_3. With S_1 closed, adjust R_2 for a null as in Fig. 3C. Fig. 5 shows the complete test set-up.

To *measure* a.c. voltages, set S_2 to the lower position as shown on the schematic so that R_2 is disconnected from the a.c. line. Apply an a.c. voltage to J_2 and J_3. Balance the bridge by closing S_1 and by adjusting R_1 for a null. At the null point, measure the d.c. voltage across terminals J_5 and J_6 and divide by 1.414. The quotient is the r.m.s. value of a.c. applied to J_2 and J_3.

A d.c. voltmeter could be substituted for the scope if accuracy is not of great importance. Near balance, the waveform at R_3 will contain hum from T_1 and surrounding a.c. leads. There is also a small amount of contact potential current flowing through R_3 in addition to noise. Since a voltmeter cannot distinguish between induced and calibrating voltages, some error is unavoidable. A scope indicates the true balance.

After a year of normal use, B_1 should continue to supply 88 volts across R_1. Excellent battery life can be attributed to a drain of only 4.5 ma. Reduced battery voltage does not affect the accuracy, it merely limits the maximum a.c. that the calibrator can measure. Two batteries could be connected in series for higher voltage measurements, but a well-regulated d.c. power supply is better. This may, however, introduce some pips in the waveform.

The highest a.c. r.m.s. voltage that can be applied to a 6AL5 is 116 which is half its p.i.v. divided by 1.414. It is possible to use some other vacuum-tube diode in place of a 6AL5 such as a 5Y3 which will raise the limit to about 500 volts. A copper-oxide rectifier could be substituted for V_1. Selenium, silicon, and germanium diodes all conduct at low reverse voltages and their use would produce errors when small a.c. voltages are being measured.

Construction

Note: Since both sides of the a.c. line are connected to J_1 ("Line") and to J_3 ("Gnd"), care should be used when working with the calibrator to avoid the possibility of shock. To be on the safe side, use a 1:1 isolation transformer for maximum protection; a small one can be built into the unit.

All a.c. power leads should be kept close to the chassis. T_1's leads should be tightly twisted and routed away from V_1, R_3, and R_1. The switched side of the a.c. line is connected to one side of R_2 through a length of shielded lead grounded at R_2.

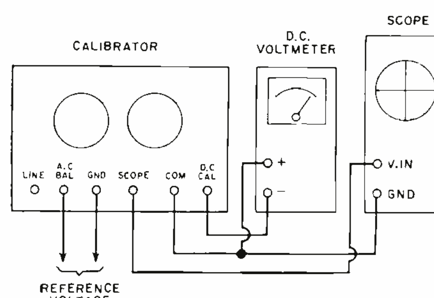


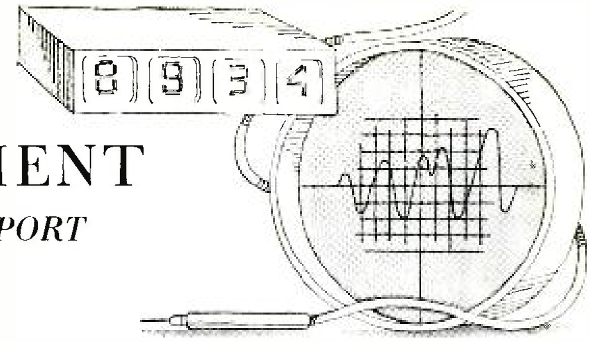
Fig. 5. Test set-up shows interconnections of calibrator, d.c. voltmeter, and a scope.

The heater leads from T_1 are brought directly to the terminals on PL_1. From these terminals a connection is made with twisted leads dressed near the chassis and away from R_3. R_3 is susceptible to hum and should be wired directly to J_1 and J_5 with short leads.

The sensitivity of the calibrator cannot be increased by changing R_3's value. Reducing the value of R_3 would decrease sensitivity and increase current beyond a safe value. Increasing its value would increase hum effects. The best way to increase sensitivity is to add a simple one-stage amplifier to the circuit beyond R_3. ▲

TEST EQUIPMENT

PRODUCT REPORT



Sencore BE124 Battery Eliminator

For copy of manufacturer's brochure, circle No. 59 on coupon (page 15).

A RECENT addition to *Sencore's* line of test equipment for the radio-TV service technician is the Model BE-124 battery eliminator. This is an a.c.-operated power supply designed to take the place of batteries while servicing and repairing transistor radios. Eight output voltages are available, ranging from 1.5 to 12 volts d.c., in 1.5-volt steps. The supply can deliver a maximum continuous output current of 50 ma. Since the average transistor set will draw only about 5 to 15 ma. with no signal, there is ample reserve current.

Since transistors are basically current-operated devices, much can be learned about circuit operation by measuring total current. To make this measurement convenient, the Model BE124 incorporates a current meter in series with its output. The user can therefore monitor the current drawn by the transistor set and check for shorted transistors or components. This meter is also useful during alignment. In this case, the individual stages are simply adjusted for maximum current indication, with a signal generator applied ahead of the stage being aligned.

The meter is also used in conjunction with a calibrating pot which correctly sets the values of the output voltages indicated. It is possible to use two or more output voltages simultaneously for radios that use a tapped supply or more than a single battery. In addition to its use as a battery substitute, the BE124 can also be used to charge small nickel cadmium batteries.

The circuit consists of a low-voltage power transformer feeding a simple half-wave silicon rectifier diode. *RC* filtering is employed, with a pair of 1500-μf. electrolytics serving to keep the ripple down to 0.9 per-cent. A tapped voltage divider supplies the various output voltages.

The battery eliminator measures 5" x 4½" x 2" and has a convenient carrying handle. The unit sells for $24.95 factory-wired. ▲

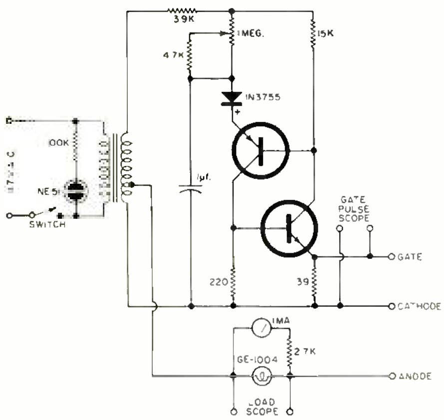
Seco Model 600 SCR Analyzer

For copy of manufacturer's brochure, circle No. 60 on coupon (page 15).

THE new *Seco* Model 600 SCR analyzer is a dynamic tester that checks the operation of silicon controlled rectifiers (SCR). These rectifiers, the solid-state equivalent of the thyratron, are widely used in industry for power rectification and control applications. An SCR has three connections; an anode, cathode, and gate. The device is called a "controlled" rectifier because a small signal applied to the trigger or gate electrode is able to switch the rectifier from fully conducting (low resistance) to completely cut off (high resistance).

By changing the phase of the gate voltage with respect to that on the anode, we are able to control the amount of rectified current that flows from the maximum amount that the rectifier is able to handle all the way down to zero current.

The Model 600 checks SCR's by use of a fixed load circuit and a gate circuit having variable phase control. A meter in the instrument reads the anode current of the SCR being tested by measuring the voltage across its load. By observing the meter, the user can perform the following checks: dynamic operation, comparison of firing requirements, comparison of SCR voltage drops, gate-open test, gate-shorted test, anode-cathode shorts, and anode-cathode opens.



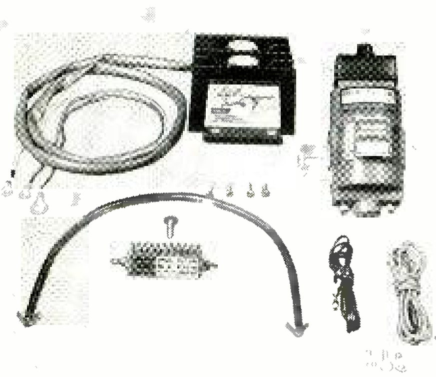
The analyzer tests SCR's rated from ½ to 225 amps and 25 to 600 volts; this includes all SCR's in production at this time. It can be used for incoming inspection and in engineering and laboratory work.

All the tests mentioned above are performed with the built-in meter. If it is desired to check the waveforms across the load or at the gate electrode, scope jacks are provided on the front panel of the instrument. The analyzer will not damage the SCR being tested should an overload of gate current occur. Also, the instrument itself is protected against damage from either shorted or defective SCR's.

The gate circuit of the Model 600 is a transistorized bootstrap multivibrator (see schematic). With this arrangement, it is possible to supply the required gate voltage (2 to 7 v.) to fire every known SCR. Phase control, with phase angle variable from 0-160°, is achieved by adding resistance in series with the bootstrap circuit.

The load circuit consists of a 12-volt source and a light bulb which draws ½ amp at 12 volts. The bulb provides enough load to "hold in" the large SCR's and not too much to damage the small 1-amp SCR's that may be tested with the analyzer.

The Model 600 is built into a black Bakelite case measuring 7¾"x5½"x4½". Price of the unit is $46.95. ▲



Transistor Ignition System

(*Continued from page* 31)

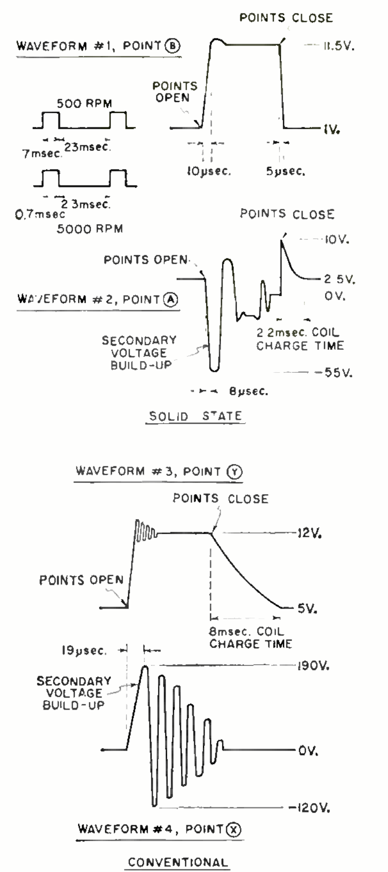


Fig. 3. Breaker-point and ignition-coil waveforms (refer to Fig. 1 for locations).

ever, power consumption will be one-half as great.

A new set of breaker points should be installed and gapped to .005"-.008". This narrow point gap results in a longer duty cycle, virtually no point-contact bounce, and utilization of all the primary-winding back voltage. Engine timing should be advanced slightly. In addition, the spark plugs can be opened up to .055"-.060" because of the higher voltages available, especially at high engine speeds. As a result of this wider gap, it should not be necessary to regap the plugs throughout their life. After resetting the spark plugs to 0.055", some engines require an adjustment of the acceleration pump. The pump shaft is merely moved from the summer position to the winter position in these cases.

The point current through this system is a maximum of 0.081 ampere, including the optional circuit. This reduces breaker-point arcing to an infinitesimal amount.

The waveforms in the circuit are shown in Fig. 3. The points are open for about 7 msec. and closed for about 23 msec. at idling speeds (500 rpm). At 5000 rpm, the points are open for about 700 μsec. and are closed for about 2.3 msec. During the times that the points are closed, transistors Q1 and Q2 conduct current through the ignition coil. The time required to completely saturate the primary winding of the ignition coil is about 2.2 msec. From this we can see that the primary winding is still being completely saturated even at these high engine speeds.

It takes 8 μsec. to stop the current flow through Q1 and Q2. The energy will then be transferred into the secondary winding, thus building up the secondary voltage. The secondary voltage at 5000 rpm is then the same as at 500 rpm.

The waveform measurements were made with a point gap of 0.006" and a spark gap of 0.065". The engine used had a compression ratio of 9.5:1. A *Tektronix* Type 561 oscilloscope was used for taking the measurements.

Note that in the system described voltage across the points is 11.5 volts and the current is .081 amp. In a conventional system, the voltage is 310 volts (190 to -120 volts) and current is approximately 3-4 amps.

Fabrication of this circuit may be accomplished in several ways since the unit should be constructed to meet individual requirements. The author used a flat piece of metal 4" x 6" x 0.062" for mounting the semiconductors and most of the components. A home-made cover for the circuitry was fashioned out of a piece of thinner metal and bent into shape (see photo). This was bolted under the dash in an out-of-the-way location. *R*2, *R*7, and *R*1 were located in the engine compartment.

Under *no* circumstances use any type of automotive ballast resistor for *R*2. When the ignition is switched on, the initial current surge through the circuit could seriously damage the semiconductors. Damage may occur the first time the switch is energized or not until after many switch cycles.

The original coil and capacitor should be removed completely and the new coil substituted. When wiring the unit, use 16-gauge wire from the unit to the coil. If the present wire from the ignition switch is a resistance type, then another 16-gauge wire will have to be installed from the ignition switch to the unit. The resistance wire or the ballast resistor *must* be bypassed.

After installation, an ammeter should be hooked in series at point *A*, Fig. 1. The ignition is then switched on and *R*2 is adjusted to an indicated 7 amps. If there is no indication on the ammeter, touch the starter button briefly to rotate the engine slightly. Then proceed to adjust *R*2 to an indicated 7 amps. This is the current flow that will be switched.

This circuit has been installed in cars that have been driven from coast to coast and into the cold climate of Canada. The unit has also demonstrated its reliability across the hot deserts of California and Arizona. ▲

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- ✓ **Flutter—a test to check whether your turntable's flutter is low, moderate, or high.**
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- **Four specially designed tests to check distortion in stereo cartridges.**
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Transistor Substitution Directory

(Continued from page 45)

NIPPON NO.	TYPE AND SERVICE	AMERICAN TYPE	AMERICAN MFGR.
2SB247	P—h.p. amp.	2N379, 2N380	TUNG
		2N463	WE
A2SB248A	P—h.p. amp.	2N350A	MOT
		2N351A	MOT, RCA
2SB248	P—h.p. amp.	2N250	TI
		2N301	RCA, SYL
		2N350A	MOT
		2N351A	MOT, RCA
		2N376A	MOT
		2N456	RCA, TI
		2N1136	BEN, CLE
		2N1137	CLE
		2N1502	MIN
2SB248A	P—h.p. amp.	2N242	CLE, SYL
		2N419	BEN
		2N457	RCA, TI
		2N637	BEN, CLE
		2N638	BEN
		2N1501	MIN
2SB249	P—h.p. amp., sw.	2N268-3	RCA
		2N296	SYL
		2N375	MOT
		2N458	CLE, TI
		2N618	MOT
		2N1261-2N1263	MIN
		2N1295	PHIL
		2N1359	MOT
2SB249A	P—h.p. amp.	2N630	MOT
2SB250	P—h.p. amp.	2N176	MOT, RCA
2SB250A	P—h.p. amp.	2N236B	BEN
2SB251	P—h.p. amp.	2N250	TI
2SB251A	P—h.p. amp.	2N301	RCA, SYL
2SB252	P—h.p. sw.	2N297A	MOT
		2N458	CLE, TI
		2N1261-2N1262	MIN
		2N1358	DEL
2SB253	P—h.p., l.f. sw.	2N1263	MIN
2SB264	P—l.p. amp.	2N133	GI
		2N175, 2N422	SYL
		2N535	PHIL
		2N1010	RCA
2SC31	N—vhf. sw.	2N1252	FSC
		2N1253	FSC, GI, TI
2SD11	N—l.p. amp.	2N35	RCA, SYL
		2N94, 2N229,	SYL
		2N306	
		2N377	G-E, GI, SYL
		2N444, 2N445	GI
		2N587	SYL
		2N647, 2N649	RCA
		2N679	SYL
		2N1010	RCA
		2N1012	GI
		2N1059	SYL
ST25A	N—h.f. sw.	2N332	G-E, RAY, TI, TRAN
		2N1149	TI
ST25B	N—h.s. sw.	2N333	G-E, RAY, SYL, TI, TRAN
		2N337	G-E, SYL, TI
		2N1150	TI
		2N1277	G-E
ST25C	N—h.s. sw.	2N334, 2N335	G-E, RAY, SYL, TI, TRAN
		2N338	G-E, SYL, TI
		2N1151, 2N1152	TI
		2N1278	G-E

h.s.—high speed; h.p.—high power; l.f.—low frequency; l.n.—low noise; l.p.—low power; sw.—switch; vhf.—very high frequency. AMP—Amperex, BEN—Bendix, CLE—Clevite, DEL—Delco, ETC—Electronic Transistors Corp., FSC—Fairchild Semiconductor Corp., G-E—General Electric, GI—General Instrument Corp., IND—Industro Transistor Corp., MOT—Motorola, MIN—Minneapolis-Honeywell Semicon, PHIL—Philco Corp., RAY—Raytheon, RCA—Radio Corp. of America, SYL—Sylvania, TI—Texas Instruments, TRAN—Transitron Electronic Corp., TUNG—Tung-Sol Electric Co., UST—U.S. Transistor Corp., WE—Western Electric Co., WEST—Westinghouse Electric Corp. P—"p-n-p"; N—"n-p-n."

Selective Calling

(*Continued from page 44*)

Then, if the base operator desires to go back to the quiet condition, he releases the press-to-talk switch from the listening position by moving a lever near the switch which releases the hold detent and allows it to spring back to the quiet position.

An important feature of this system is that the dispatcher automatically complies with the FCC ruling that the operator must first monitor the channel before transmitting. The system operation is shown schematically in Fig. 10.

The tone is produced as follows: when the transmitter is keyed, "B+" (250 volts d.c.) charges capacitor *C*1 and causes current to flow through the resonant-reed relay *RL*1. The current flow in *RL*1 produces a magnetic field which attracts the reeds to the pole piece. When *C*1 is fully charged, the current through *RL*1 stops and the reeds are released to their original position but, due to the inertia of the reeds, a damped oscillation is produced. The frequency of the oscillation is determined by the length and mass of the reeds.

The vibrating reeds will induce a voltage in the coil proportional to the rate of vibration of the reeds. Three of the four reeds are physically restricted from vibrating, resulting in a single tone being produced. This tone is applied to the first audio tube of the transmitter through relay *RL*2. This relay limits the tone to 250 milliseconds, which is the approximate squelch opening delay of the receiver, so that the tone is not heard in the loudspeaker and, since the tone is sent out before the operator speaks, intermodulation will not be produced.

The decoder is connected to the output of the detector of the receiver and operates in the following manner. When the receiver is turned on, capacitor *C*3 is charged through resistors *R*1, *R*2, and *R*10. When *C*3 is fully charged, the grid of tube *V*1*B* will have a positive charge on it. When *V*1*B* conducts, relay *RL*3 is energized and the grid of the receiver's first audio tube is grounded through the "N.O." contacts. The grounding of the first audio tube will prevent any signals from reaching the loudspeaker.

When a tone is received by the communications unit, tube *V*1*A* amplifies it. The amplified signal will cause a resonant reed of relay *RL*4 to vibrate. The vibrating reed discharges capacitor *C*3 and grounds the grid of *V*1*B* making it negative with respect to the cathode. The cathode is maintained at a positive voltage by the voltage divider *R*3 and *R*7. When the grid of *V*1*B* goes negative, the tube stops conducting and relay *RL*3 is de-energized. When *RL*3 is in this condition the ground on the first audio tube is removed, permitting audio to reach the loudspeaker, and the charging path for $C3$ is completed through the "N.C." contacts.

After the 250 millisecond tone burst, capacitor $C3$ can begin to charge again. Potentiometer $R2$ will vary the charging time for $C3$. This charging time will determine when $V1B$ will again conduct. With the values shown on the schematic, the receiver alive time can be varied between 7 and 13 seconds. When it is desired to have the receiver alive for a longer time, the override switch S1 is placed in the alternate position. This will discharge $C3$ and prevent $V1B$ from conducting by grounding the grid. With this procedure, once contact has been made with the base station, the dispatcher may sustain communications with the mobile unit and then revert back to the quiet position when the message is completed.

Whether the two-way radio uses the continuous-tone method or the tone-burst method to eliminate unwanted noise depends on the personal preference of the user as either system can be used on all communications sets, providing the encoder and decoder are of the same type.

As the state of the art of two-way radio is advancing so has the engineering—by providing radio communications that are less susceptible to unwanted noise. ▲

D.C. to A.C. Transistor Power Supply

By **CHARLES E. DIEHL**

Construction of an ordinary inverter circuit that uses inexpensive transistors, filament transformer.

MUCH has been written about power supplies driven by power transistors. Most of these call for transformers with special iron cores and a critical design to achieve operation near the saturation point of the iron. For high efficiency these requirements are necessary. However for efficiencies comparable to vibrator supplies, neither of these requirements is necessary. In fact, existing filament transformers having two center-tapped filament windings and a line-voltage primary work very well. One of the secondary windings (Sec. 1) must have a minimum capacity of 3 amperes to carry the d.c. current.

Nothing is critical about the circuit as shown. It will operate from 2 volts to 6 volts with a corresponding change in voltage output and frequency. R_2 is used to vary the output voltage and should not be set at a point that will allow more than 3 amperes to flow to the pair of transistors. A.c. output at a battery drain of 2.5 amperes is approximately 150 volts r.m.s. With ½-ampere input the output is about 25 volts r.m.s. This output is continuously variable between these limits by changing the setting of R_2. A fixed resistance of 2 ohms at 25 watts, placed in series with R_2 at the point marked "X" adapts the circuit to operation at 12 volts.

If no operation is achieved when the circuit is turned on, reverse the two outer leads of Sec. 2. If the transformer secondaries are 6.3 volts and 5 volts, use the 5-volt winding as Sec. 2. Transformers with 6.3-volt or two 5-volt windings work equally well.

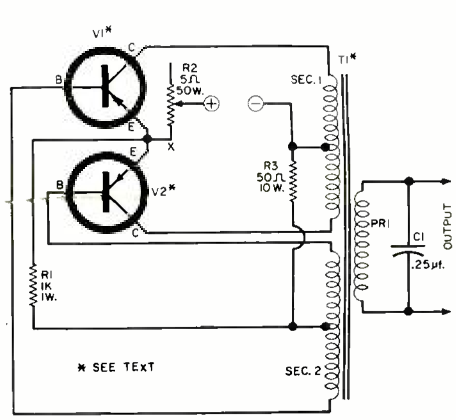
Too much of an output load will stop oscillation, or may prevent oscillation from starting. However, under such conditions the d.c. current to the transistors drops in value, thus furnishing short-circuit protection.

Output current varies with different transistors but 50 ma. is about the minimum. The output capacitor C_1 holds the maximum voltage surge (spike) to a safe limit. This value may be as high as 1 µf. The resistor R_2 buffers the d.c. inrush, and a very good waveform results. R_1 may be any value from 500 to 1500 ohms, and R_3 may be between 50 and 100 ohms. Output frequency is between 300 and 500 cps. The recommended d.c. input current to the transistors is 2.5 amperes.

The following transformers and transistors will work in this circuit: *U.T.C.* S67, *Triad* F32A, *Chicago* F3, and *Stancor* P5009; transistors types 2N255, 2N307, 2N554, and 2N155. Successful operation was also obtained with two imported transistors rated at 3-amperes collector current and selling at less than a dollar each.

Transistors with greater output and rated at a larger collector current may be used for increased load capacity. Be sure that the secondary of the transformer used as Sec. 1 has a rating as large as the transistor current. ▲

A wide variety of transistor types and transformers may be employed in circuit.



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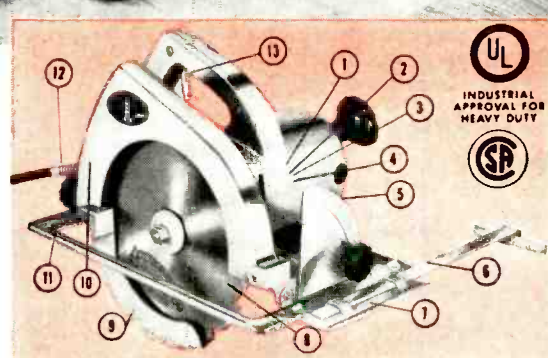
9. Retractable Safety Swing Blade Guard
10. Aluminum Die Cast Mirror Finish
11. Depth of cut adjusts from 0" - 2-8/16"—Calibrated Guide
12. 3-wire reinforced rubber cord and plug
13. Automatic Safety Release Switch



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HOW BRITAIN TRACKS TV "PIRATES"

By PATRICK HALLIDAY

IN many overseas countries, including Britain, radio and television broadcasting is largely paid for by making it illegal to use a radio or TV receiver without taking out an official license issued against payment. In Britain, TV viewers make an annual "contribution" of just over $11. Although this fee is considerably less than that extracted in many other European countries, it must be admitted that not every British viewer is exactly eager to pay his dues.

Indeed many viewers — exactly how many is of course not known — simply fail to pay up. There is an old joke in Britain which runs "What is the difference between an indoor and an outdoor antenna?" — with the answer "A TV license." For years there has been a cat-and-mouse game between the British Post Office and the reluctant payer. Last year more than 15,000 non-paying viewers and listeners were taken to court and fined. Legally the Post Office can also demand the unlicensed apparatus but this is seldom enforced except for illegal operation of unlicensed amateur transmitting stations.

How does the British Post Office track down the TV "pirates" who operate unlicensed receivers?

For some ten years a number of direction-finding automobiles have been used to pinpoint television receivers by using the slight radiation from the second harmonic of the horizontal output circuits. In the British 405-line system this is equivalent to 20.25 kc. (twice 10,125 cps). A communications receiver tuned to this frequency was used to compare the voltages magnetically induced from the receiver in three horizontal shielded-loop antennas mounted on the roof of the vehicle. This system, however, tends to be slow and limited to short distances. The high level of static and electrical interference on these very low frequencies and the improved shielding of horizontal output transformers in modern sets have made it necessary to adopt a new detection system.

Recently the author was able to inspect the first batch of nine new detector automobiles now being used in Britain. Each of these vehicles is equipped—at a cost of about $3000—with a v.h.f. panoramic receiver and directional antenna. These automobiles can detect and take bearings on the radiation from the local oscillators of TV receivers at distances up to a couple of blocks.

The receivers are triple-conversion types with a sensitivity on the order of 1 μv. and are continuously tunable through a range of about 100-150 mc. where most TV receivers have either the fundamental or second harmonic of their frequency conversion oscillators. The panoramic display on a CRT can sweep up to a maximum of 10 mc. at a time showing any signals received as "blips" on the screen. The equipment is powered from automobile batteries by means of transistor d.c.-a.c. inverters.

The directional antenna is an elliptically polarized corner reflector mounted on the roof of the vehicle and designed to respond to randomly polarized signals. This helps the operator distinguish between direct and reflected signals; and, since the phase of polarization of a signal is usually rotated on reflection, a linearly polarized antenna might pick up a reflected signal better than the direct signal.

The entire corner reflector assembly can be rotated from the operating position in the rear seat of the automobile. In step with the antenna, a scanning periscope shows the operator exactly where the antenna is pointing when adjusted for maximum height of the blip, and thus pinpoints the house or apartment where the receiver is being used.

Since it has been found that very little of the local oscillator voltage leaks back through the r.f. stage (usually a cascode), the signal is picked up directly from the receiver rather than the receiving antenna. This makes it possible, by taking cross-bearings, to pinpoint the actual room in which the receiver is located. At night a beam of light can be projected along the beam of the antenna to identify the house.

British Post Office engineers demonstrated the equipment to us in the center of London. The author was able to tune in a hefty "blip"—the panoramic sweep was then reduced to clear the screen of all other signals. The height of the blip was adjusted by an attenuator to a convenient height and then the antenna rotated for maximum signal. A final adjustment and then a peek through the periscope showed we were lined up on a building several hundred feet away where a TV receiver (fortunately licensed) was operating.

Each automobile is clearly marked "Television Detector" as it is known that the mere appearance of one of these automobiles in a town is sufficient to induce many bootleg viewers to call hurriedly at the local Post Office and take out a license. ▲

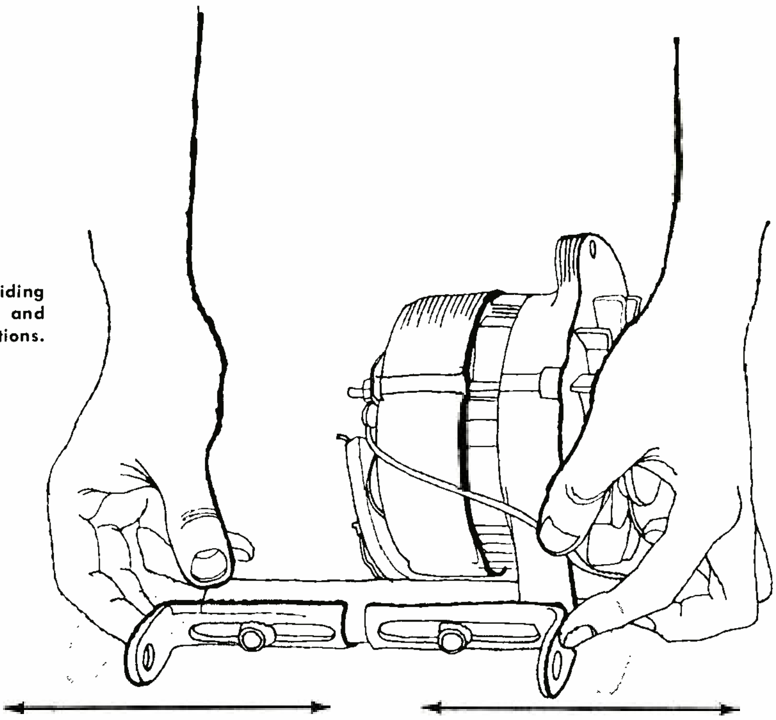


Fig. 1. Motorola uses sliding lugs to accommodate various spacing and mounting configurations.

ALTERNATORS: SELECTION and INSTALLATION

By WILLIAM J. HECTOR, K6TSZ

Many vehicle owners—especially if they use mobile communications equipment—have something to gain by replacing their d.c. generators. Any electronics technician should handle such a conversion easily.

THE CONCEPT of using an a.c. generator, or alternator, instead of the conventional d.c. generator in a vehicle is not new. Present availability of reliable, high-current silicon rectifiers at reasonable cost has pretty well removed all objections. Add to this the benefit of mass-produced, transistorized regulators. With the demand for increased power in many modern vehicles, it's often worthwhile to replace an existing d.c. generator.

The change is particularly advantageous for any user of mobile communications equipment—the ham, the cab driver, the policeman in a patrol car, and those involved in other emergency or commercial services relying on communication with a central point.

The greatest problems involve choosing the unit appropriate to a particular situation and installing it, but they are easily solved. Readers of this magazine, for example, should have little trouble making such conversions successfully. As for users who are not prepared to do the necessary work themselves, they represent a fruitful source of income for any service technician. His ability to evaluate the requirements for each case suits him very well for such work.

The user of mobile communications equipment needs a relatively high output of maximum current as compared to what is available from a d.c. generator and also relatively high output during idling of the engine. The alternator will provide both of these. It also offers the advantages of low maintenance requirements and compactness.

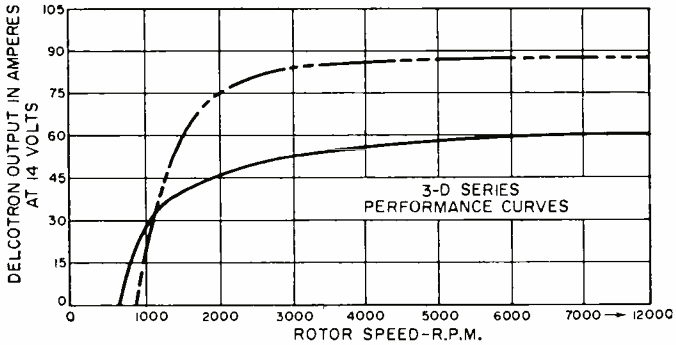


Fig. 2. Performance comparison between two models in the Delco-Remy 3-D series. Note that an alternator providing greater current output at engine idle sacrifices maximum capacity.

Many Models Available

A particular installation might need no more than 20 or 30 amperes at idle speed. On the other side of the fence, a large truck or bus may be able to use 135 amperes at idle and 200 amperes or so at maximum output. Choice of the alternator is obviously not an arbitrary matter. *Delco-Remy*, *Motorola*, *Leece-Neville*, and *Autolite* have spanned the needs of every user with complete lines of alternators. The most commonly used units in each line, along with minimum and maximum current capabilities, are listed in Table 1.

Table 1. Range of alternators made by four leading manufacturers, with minimum (idle) and maximum current ratings.

Mfr. & Models	Idle Current	Maximum Current
Delcotron 1-D, 2-D, 3-D	5-37 amps.	85 amps.
Leece-Neville 6000, 2074, 2002, 2000	5 amps. min.	60 amps.
Motorola A-30, A-45	8-15 amps.	45 amps.
Prestolite (Autolite) 51 Series	8-31 amps.	55 amps.

The table omits units for large vehicles with special equipment such as fire trucks and utility trucks, with systems that may involve 24, 32, or more volts, and with extra-heavy requirements that may vary considerably in each case. However the listed models account for units used in regular automobiles and more conventional trucks, which are involved in most installations. Although the information here pertains primarily to the latter, the principles are also applicable to the larger vehicles.

Output Requirements

There are factors other than current ratings that enter into the selection of an alternator. For example, the rated life span (stated in miles) and anticipated maintenance requirements are matters of concern. Consider the three basic series of *Delco-Remy* models (Fig. 3), for example, which range from light to heavy current output. Models in the 2-D, medium-output series can be obtained with life-expectancy ratings, before maintenance is required, of 100,000, 150,000, or 250,000 miles. The cost of additional, built-in quality obviously increases the initial cost of the device, but can be a worthwhile investment where long-term, long-mileage use in the vehicle is anticipated. More thought, however, has to be given to determining current ratings.

First determine how much may be required at maximum output. This assumes a situation in which all electrical equipment in the vehicle will be in simultaneous operation. A guide to the consumption of such devices is found in Table 2. For a more accurate statement of current consumed by communications and radio equipment, consult the manufacturers or their published data.

Next determine under what conditions the transmitter will be used most often. Some users will tend to operate when the vehicle is not in motion—during idle periods. Others will transmit while on the move—at speeds of 20 mph or more. If the former situation is the case, current output required during idle will go up. The idle charging rate on a particular basic alternator can be increased by using a smaller pulley. At the same time, however, the maximum current output available will drop.

If most transmission will occur during motion, the idle or low-speed current output will not be too important. This current depends on two factors: the amount of field current in the alternator and its speed of rotation. If rotational speed is excessive, it will cut down on the maximum output as well as the useful life of the generator.

Fig. 2 illustrates the relationship between maximum and minimum (idle speed) current output, by comparing two alternators in the *Delco-Remy* 3-D series. Assuming a rotor idle speed of about 1000 r.p.m., the unit represented by the solid curve would put out close to 30 amperes at this point but not more than 60 amperes at any condition. While the a.c. generator represented by the broken line would provide only 15 amperes during idle, it is capable of almost 90 amperes maximum. Another interesting point becomes clear from these performance curves: the alternator is self-limiting with respect to maximum current, removing the need for a current-limiting relay on the regulator. This enhances over-all system reliability.

The potential user does not always have a reliable estimate of the conditions of use at his fingertips. In such a case, the wisest course is to take an average over a few days of time before making a choice.

Since current consumption of most amateur and industrial transmitters (vacuum-tube type) is similar, a good estimate of idle-current requirement in daytime use, on the average, may be up to 20 to 30 amperes in a 12-volt system. Nighttime operation will add another 15 amperes or so. Double these figures for 6-volt systems. If a transistorized transmitter is used, current consumption may be cut in half, with an ensuing saving in the cost of the alternator.

Table 2. Current drain by electrically operated devices commonly found in automotive systems. Figures are on the high side and for heavy-duty equipment, to insure current reserve.

Equipment	Current Consumption (in amperes) 6-volt system	12-volt system
Headlights	34	17
Gauges, dash	7	3.5
Heater	30	15
Defroster	30	15
Radio, conventional	5-8	2.5-4
Wiper (electric)	8	4
Transmitter (standby)	16	8
Transmitter (in use)	40	20
Air conditioner	30	15

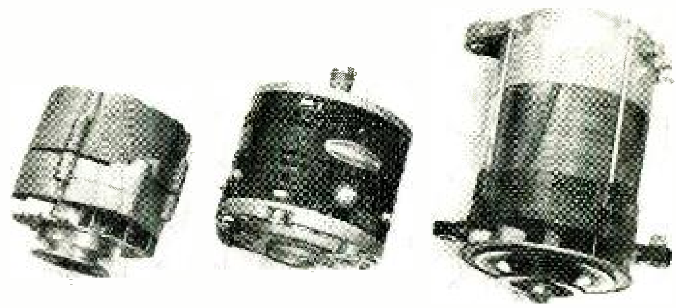


Fig. 3. The three basic Delcotron model series, 1-D, 2-D, and 3-D. They range from light to heavy-duty current output.

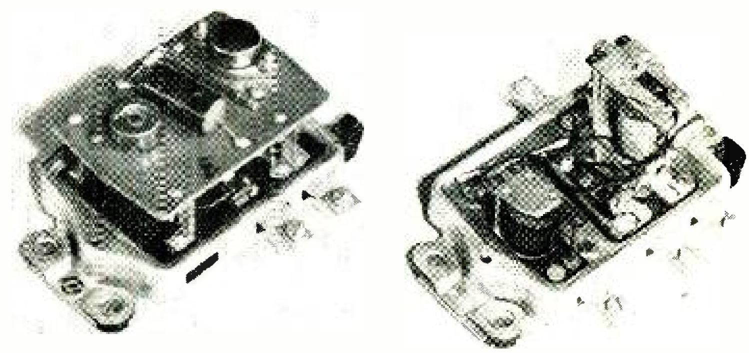


Fig. 4. A transistorized Delco regulator (left) compared to its conventional counterpart. Note adjustment atop former.

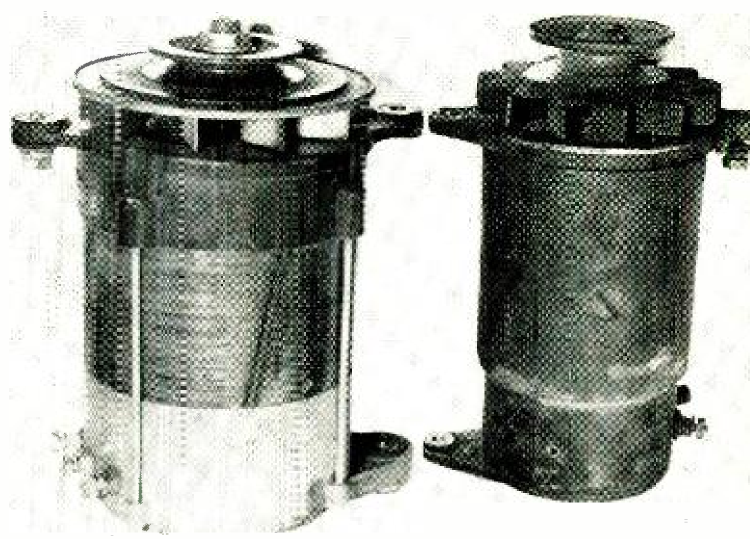
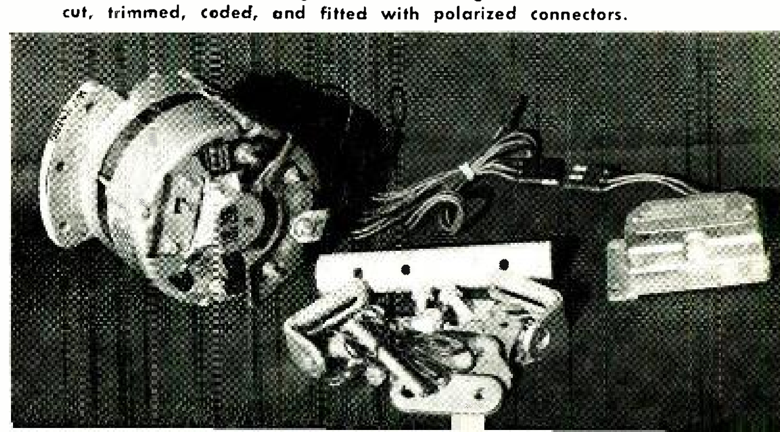


Fig. 5. Mounting slugs and general shape of the Delcotron alternator (left) conform to the d.c. generator being replaced, but the a.c. unit develops almost three times as much current.

Fig. 6. Contents of a Motorola complete-conversion kit: alternator, transistorized regulator, and wiring that has been cut, trimmed, coded, and fitted with polarized connectors.



It is desirable to have a direct-reading ammeter with an alternator installation. The so-called "idiot lights" often found on the instrument panel may tell you whether the generator is charging or discharging, but not how much. Such meters can be procured through automotive and many electronic suppliers.

Since conventional, vibrating-contact regulators are a source of r.f. interference, preference should be given to an all-transistor type. The two types are compared in Fig. 4. Note that the transistorized *Delco* unit on the left has only two tabs for external connections, as compared to three on the other. There is no connection for a current-limiting relay on the former, which, as already noted, is not needed.

Also note that placement of the transistor regulator is critical with respect to dissipation of developed heat, since transistors are temperature sensitive. Follow the manufacturer's instructions carefully. On the other hand, maintenance of this type is cut down to almost nothing.

Even after the decision has been made to add a transistor regulator, some thought must be given to the choice. *Motorola*, for example, does not incorporate a voltage-regulator adjustment on its devices, feeling the all-electronic unit to be so responsive to variations that "tailoring" to specific conditions is not required. A virtue not mentioned is the fact that misadjustment, so frequently encountered, cannot occur here.

Other manufacturers, however, feel that a setting suitable for operating conditions in one vehicle may not be as appropriate in a different situation. (Note the adjustment atop the *Delco* regulator to the left in Fig. 4.) Variations in under-the-hood temperatures, operating speeds, and the extent of nighttime service can all demand different voltage settings.

There is a factor, the author feels, that may balance out the need for an adjustment: choice of an alternator whose capabilities allow some margin of safety with respect to the original requirements, to begin with. If there is an adequate current reserve for idling requirements, "tailoring" is not likely to assume much importance later. If corners are cut close on an original daytime requirement and then there is a switch to a predominantly nighttime operation, there will probably be a need to adjust the regulator *only* if there has not been sufficient idling reserve. Play it safe.

The "problem" of physically mounting an alternator in the place of an existing d.c. generator is handled in various ways by different manufacturers. *Motorola*, for example, uses a round bar with sliding lugs that can be adjusted to fit most situations. An idea of the adjustment range can be obtained from Fig. 1. On its 3-D models, *Delco* is careful to match the mounting lugs of the standard, d.c. generator that is being replaced. The two units are compared in Fig. 5. What could be simpler?

Note, incidentally, that the a.c. generator in Fig. 5 has almost three times the capacity of its d.c. counterpart. In general, mounting problems are minimized by the fact that, ampere for ampere, alternators are always smaller than d.c. generators. There should be little difficulty in duplicating the spacing and mounting-adjustment requirements for the original unit.

Having chosen the size and type of alternator and regulator, all you have to do is install them. If you expect this to be a formidable task, you are wrong. At one time in the past, when the rectifiers were separate items and a special ammeter had to be added, a veritable jungle of new wiring was required. Today the rectifiers are incorporated inside the alternator housing.

Taking a tip from kit producers, alternator manufacturers have worked out ways of greatly simplifying installation. From *Motorola*, for example, you can obtain a kit that includes the a.c. generator, the transistorized regulator, and pre-assembled wiring with polarized connectors already in place (Fig. 6). You don't have to cut, trim, code, or observe polarity on the wiring between regulator and generator, and the rest of the job is not much more complicated. While other manufacturers don't go as far, confusion can be avoided with ordinary care.

About the only way in which you can go astray is by hooking up the wires wrong. This can be avoided with the same precaution that should be used in any bench job that calls for extensive re-wiring: simply attach identifying tags to all leads as they are disconnected from the original equipment, then follow manufacturers' instructions in connecting these leads in the new installation. If you know where a wire came from, there should be no trouble in finding out where it should go. A wrong connection, of course, may produce damage.

With good working methods, there should be success on the first try in almost every case. The small percentage of failures will probably be due to the fact that instructions have not been read and followed carefully. To avoid damage and correct mistakes without wasting too much time, there are some precautions that can be applied to all installations no matter whose equipment is being used. These are the ones that pertain to the installation procedure itself:

1. Be sure battery and alternator polarity agree. Both should be negative

ground or both should be positive ground. 2. Never ground or short any terminals on the regulator or alternator. 3. Never operate an alternator without a load on open circuit. 4. Do not try to polarize the a.c. generator. Polarization is characteristic of d.c. generators only. 5. On adjustable regulators, never short the adjusting tool to the regulator base. It helps to insulate the shaft of the adjusting tool with plastic tubing.

With respect to the cited precautions, an error can result in serious damage. Be careful. After the installation is completed, check for the following conditions if things don't work out just right:

1. The alternator doesn't charge: the fan belt may be loose; there may be an open circuit in the wiring. 2. The alternator is noisy: mounting may be loose; the fan belt may be frayed; the pulley may be loose; the rotor fan may be damaged. 3. The charging rate is unsteady: a connection at the battery or at some other wire may be poor; the fan belt may be loose; there may be a high-resistance ground connection. 4. The charging rate is excessive to a battery known to be fully charged: check for an inadequately grounded regulator base or open wiring to the regulator.

The conditions mentioned do not reflect possible defects in the regulators and alternators themselves. Since these units will obviously be in warranty at the time you install them, your best solution is to take a suspicious one, after system checks have been made, back to the particular manufacturer's nearest warranty station. Here they have facilities for checking the devices out in a hurry, and they can repair a defect or replace a faulty unit.

Servicing a defective alternator or a system using one, after warranty, is a study in itself, worth a separate article. For the present, we are less concerned with how the devices work and what can go wrong than in getting them into initial operation properly and quickly. ▲

Interference Stopper for AM Sets

By JOSEPH D. AMOROSE, K4I1W

INTERFERENCE from unwanted code transmissions on broadcast-band receivers is becoming an increasing problem. One reason is the fact that low-priced AM receivers are flooding the market again.

Many high-powered c.w. transmitters operate in the vicinity of 455 kc., which is the i.f. in almost all superhet sets. Once a strong signal gets through the radio's converter, there is nothing to stop it from being amplified in the i.f. system, into whose passband it falls.

A well-made receiver may have an acceptor trap tuned to the i.f.—a series resonant circuit installed between the antenna connection and ground—which generally takes care of the problem. The inexpensive sets tend to omit this trap, which accounts for the problem, especially in areas where c.w. transmitters abound. An obvious and effective solution is to install the trap if none exists. In stubborn cases, however, some interference will persist even when the trap is installed or exists already. Another measure will usually take care of the problem.

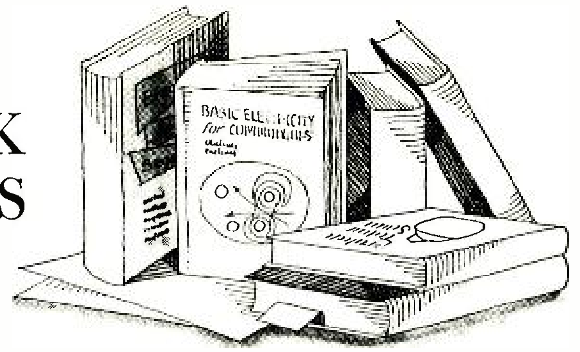
This is to lower the i.f. slightly—10 kc. is generally enough. The measure appears to work because the selectivity of the i.f. section is somewhat reduced and can thus discriminate better against nearby frequencies. Otherwise the radio's performance is not affected noticeably. The change in resonant frequency is only a difference of about 2 per-cent, so efficiency of the circuit is not changed significantly. The i.f. coils are first peaked to the new frequency, then the oscillator frequency is also lowered so that tuning tracking is restored.

In some severe cases, it has been necessary to lower the i.f. as much as 25 kc., but the method was still successful. In such instances, although not often, there may be some difficulty in getting the i.f. transformers to tune low enough. This is easily overcome by shunting a small capacitor (10 to 25 $\mu\mu$f.) across each winding. Use low-loss capacitors of good quality to avoid losses and drift.

Theoretically, tracking cannot be perfect with respect to dial calibration after oscillator frequency is reduced. Nevertheless, since calibration is seldom precise anyway, adjustment can be made so that the remaining difference in settings is not noticeable. Where there has been a considerable shift in intermediate frequency, repositioning of the dial pointer along with oscillator readjustment can produce a good compromise. To avoid extra work, lower frequency only as much as is necessary to eliminate the interference and no more.

Shifting the i.f. is also effective for another problem: when two locally received broadcast stations are close in frequency. For example, here in Richmond, WRNL is a very strong, nearby station on 910 kc. We also like to tune in WXGI on 950 kc., a weaker station only 40 kc. away, but heavy interference comes through due to beating with the stronger WRNL signal. Altering the i.f. only 10 kc. changed the selectivity curve enough to stop the annoying whistle. ▲

BOOK REVIEWS



"THE RADIO AMATEUR'S HANDBOOK" compiled by ARRL Staff. Published by *The American Radio Relay League*, West Hartford, Conn. 751 pages, including catalogue section and index. Price $3.50.

This is the Fortieth Edition of the ham's "bible" and it's a good one. Like earlier editions, this one has been revised and brought up-to-date to reflect the progress and changes taking place in radio communications, construction techniques, as well as the latest in receivers and transmitters.

Special communications methods, such as SSB and teletypewriter, are treated along with suitable equipment. The theory and practice of amateur mobile radio equipment is also covered with special emphasis on transistorized gear.

There are over 1300 illustrations, including almost 500 tube-base diagrams. A 14-page index facilitates location of needed material.

* * *

"SERVICING TRANSISTORIZED TWO-WAY RADIO" by Patrick M. Craney. Published by *Howard W. Sams & Co., Inc.* 126 pages. Price $2.95.

Since more and more two-way radio equipment is being transistorized to reduce the weight and power requirements of such gear, technicians in the field will find this manual invaluable in handling service work on such units. The author assumes a basic transistor background on the part of his readers hence merely reviews pertinent transistor fundamentals before getting down to the business of discussing specific circuitry.

The text is divided into six chapters dealing with transistors, the transistorized two-way radio receiver, receiver alignment and troubleshooting, the transistorized FM communications transmitter, transistorized mobile power supply, and tone-coded squelch systems. A schematic of the *Motorola* "Quick-Call" console and a transistorized power supply are included as a gatefold section in the back.

* * *

"PRACTICAL RADIO SERVICING" by William Marcus & Alex Levy. Published by *McGraw-Hill Book Company, Inc.* 617 pages. Price $11.95.

It has been over seven years since the authors' first edition appeared and during that time enough progress has been made in the field to warrant the publication of this revised and up-dated second edition.

This volume is actually a combination of the authors' "Practical Radio Servicing" and "Profitable Radio Troubleshooting" and incorporates the same thorough-going, basic treatment suitable for the beginner.

In addition to covering modern receiver servicing, including printed-circuit techniques, the volume covers phonographs which are often found in conjunction with receivers. The treatment is such that this could be used as a home-study text or as a classroom volume for beginning courses at the technical high school or trade-school level.

* * *

"MODERN COMMUNICATIONS COURSE" by Eward M. Noll. Published by *Howard W. Sams & Co., Inc.* Three volumes, $4.95 each, $12.95 the set.

This three-volume "course" is designed both as a classroom text and for home study and to that end is progressive in its treatment of techniques and equipment. The first volume deals with radio-frequency systems and includes practical projects on r.f. sections of transmitters, r.f. oscillators, r.f. amplifiers, multipliers, antennas, transmission lines, and matching sections.

The second volume covers the speech and modulation sections of AM transmitters, speech amplifiers, modulators, clipper-limiters, filters, SSB, and test procedures. The final volume is devoted to FM and multiplex modulation systems and covers FM principles and modulation methods, multiplex and pulse modulation, microwaves, radio relay systems, and tests and adjustments. Photographs and schematics of commercial units, line drawings, graphs, and tables are an important adjunct to the text material.

* * *

"TV TROUBLESHOOTING AND REPAIR" by Robert G. Middleton. Published by *John F. Rider Publisher Inc.* 206 pages. Price $3.95.

This is a second edition of the author's handy manual for the practicing service technician. It consists of basic techniques, shortcuts, and useful tips for successful troubleshooting. There are 9 chapters on visual-alignment procedures, troubleshooting sync circuits, locating sweep troubles, faults in video-amplifier circuits, high-voltage power supplies, receiver buzzes, and external interference. All this material is based on the service call completed at the customer's home. A final chapter on instrument differences and waveforms is intended for the benchman and discusses the strengths and weaknesses of various test instruments for specific troubleshooting chores.

* * *

"AN INTRODUCTION TO ELECTRONICS" by Dennis F. Shaw. Published by *John Wiley & Sons, Inc.* 326 pages. Price $6.25.

This text is designed for the physics major at the university level with special emphasis on the physical fundamentals of electronics. Like many British electronics texts the treatment is rigorous and mathematical.

The text is divided into fifteen chapters and two appendices and covers the field from circuit elements to the motion of electrons in electric and magnetic fields; thermionic diodes and triodes; semiconductor diodes and transistors; to cathode-ray tubes and oscilloscopes.

To adapt this volume as a classroom text, problems and a bibliography have been appended to each chapter. The author has adopted a special notation which may be a little confusing at first but becomes familiar as the subject progresses.

* * *

"SERVICING TRANSISTOR RADIOS" by Sams Staff. Published by *Howard W. Sams & Co., Inc.* Vols. 12 through 20. $2.95 each.

Just in time for the summer transistor radio season, this publisher has released seven new volumes in its series of service data on current-model sets. Each volume contains complete schematics, printed-board guides, component location photos, parts lists and replacement data, alignment information, and time-saving servicing hints. A cumulative index of material appearing in previous volumes is included in each book.

* * *

"BASIC ELECTRICITY" by Rufus P. Turner. Published by *Holt, Rinehart and Winston, Inc.* 395 pages. Price $6.00.

This is a revised and enlarged second edition of the author's 1957 text and reflects the changes which have taken place in the applications of the science since that date.

The text is written at a level suitable for beginners and technical-institute or junior-college students. With its use as a classroom text in mind, the author has included summaries of each chapter along with questions and exercises for assignment or self-testing.

The text is divided into 18 chapters and covers basic fundamentals, basic circuits and direct current, switches and controls, current flow in liquids and gases, magnetism and electromagnetism, a.c., capacitors and capacitance, inductors and inductance, phase relations and impedance, transformers, generators and motors, polyphase a.c. systems, rectifiers, electric wiring, electric illumination, telephone and telegraph fundamentals, and an introduction to electronics, and electrical instruments and measurements. The text is lavishly illustrated with line drawings, graphs, photographs, and schematics.

* * *

"BASIC OSCILLATORS" by Irving M. Gottlieb. Published by *John F. Rider Publisher, Inc.* 200 pages. $4.50.

This volume is designed to bridge the gap between oscillator theory and practice and, as such, is suitable for the technically minded whether engineer, technician, scientist, experimenter, or hobbyist.

The book first defines the basic principles and parameters involved in the subject of oscillators and then treats individual elements in which oscillation is induced or provoked, various devices that cause oscillations, and application data.

* * *

"PRINCIPLES OF APPLIED ELECTRONICS" by Ben Zeines. Published by *John Wiley & Sons, Inc.* 417 pages. Price $6.95.

This is a technical-school-level textbook covering basic material in the field of electronics. The early chapters deal briefly with the development of the physics of vacuum tubes and semiconductors, then the author takes up graphical and analytical methods employed in electronic and semiconductor circuits, finally devoting the balance of his book to various practical electronic circuits—and their operation. Self-checking problems and the correct answers are included in case this volume is to be used as a home-study text. The use of illustrative material of all types is generous and helps to clarify the text.

* * *

"UNDERSTANDING AMATEUR RADIO" by George Grammer. Published by *The American Radio Relay League*, West Hartford, Conn. 313 pages. Price $2.00.

To the thousands of youngsters interested in ham radio and those who have sampled radio communications as the operator of a CB station, the prospect of becoming a licensed radio amateur is often intimidating. This handy little volume covers the principles, construction, and operation of amateur radio equipment, including several "how-to-build" chapters on gear that is scaled to the technical and financial level of the beginner.

The theory sections have been written at the level of the tyro and cover receivers, transmitters, power supplies, and antennas as well as operating procedures and precedents.

* * *

"FUNDAMENTALS OF MAGNETIC AMPLIFIERS" by Barron Kemp. Published by *Howard W. Sams & Co., Inc.* 121 pages. Price $2.95.

Since magnetic amplifiers are now making their appearance in a variety of equipment ranging from missiles, computers, and industrial machinery to laboratory instruments, it is only a matter of time until those working in electronics will come face to face with such devices.

The book carries a comprehensive introductory section on saturable-core reactors and magnetic amplifiers, and continues with theory, reactor cores and rectifiers as used in magnetic amplification, and basic applications.

* * *

"HALL EFFECT INSTRUMENTATION" by Barron Kemp. Published by *Howard W. Sams & Co., Inc.* 126 pages. $4.95.

This is basically a primer covering the Hall effect in power measurement, multiplier applications, modulation techniques, and constant control-current applications. Since the treatment is non-mathematical, this book is suitable for the student as well as the instrumentation technician and engineer.

The author discusses application developments of the Hall effect and cites modern usage and future applications. ▲

Column Loudspeaker Systems

(*Continued from page 27*)

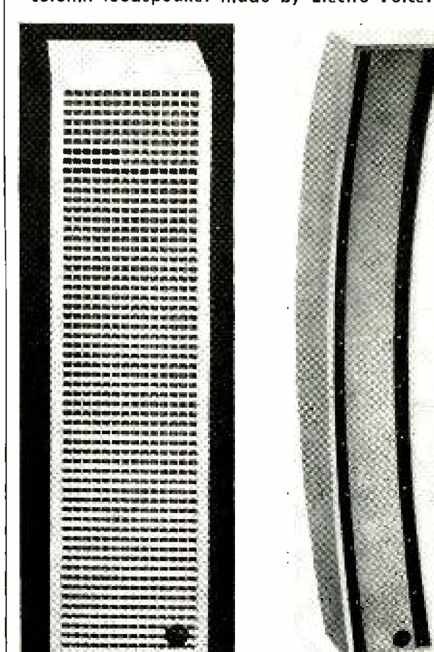
drastic physical changes were needed before anyone started worrying about the sound system.

Another point about sound columns is that while the concentration of sound energy into a restricted beam gives an apparent increase in efficiency, the dynamic range of these units is still a long way from that of high-quality horn/driver combinations. Sound columns are most often used for speech reinforcement indoors, so there will probably be no difficulty in getting enough intensity. But if one loudspeaker is four times as efficient as another (and this is a conservative ratio), it requires only one-quarter the amplifier power to produce the same loudness. When this means the difference between one 25-watt and two 50-watt amplifiers, the balance may be shifted back to the more expensive horns.

The third limitation results from the neat, diminutive size of the sound column. We pay for small size in the sacrifice of bass response—most commercial sound columns are designed to work above 100-200 cps. This is fine for speech reinforcement, but if the installation is also supposed to reproduce movie projector sound and an electronic organ, sound columns have their limitations.

If the sound installation expert will note the special features of the various commercial sound columns now available, and if he will keep their few limitations in mind, he will enjoy making use of this remarkable new tool in an effort to provide really natural sound reinforcement. ▲

Typical commercial column speakers. Unit at left is a University design. The speaker at the right is a curved-line type of column loudspeaker made by Electro-Voice.



ELECTRONIC CROSSWORDS

By DONALD W. MOFFAT

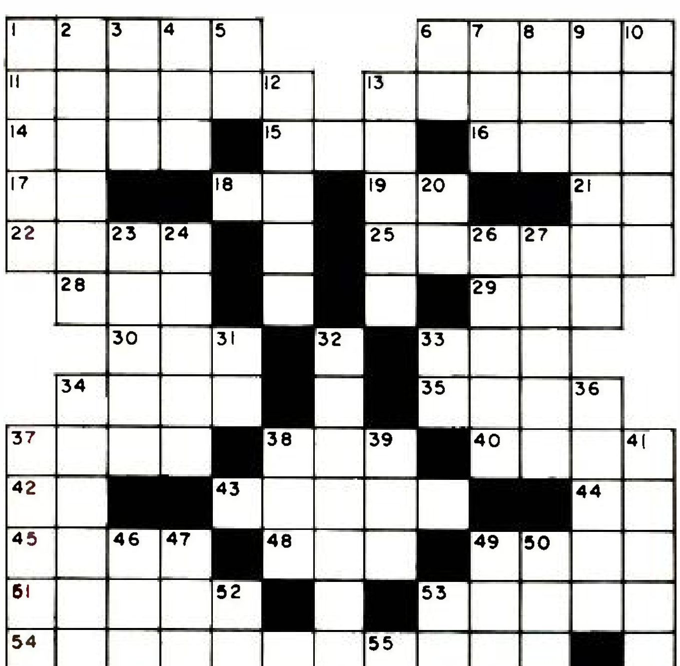
(*Answer on page 95*)

ACROSS

1. D'Arsonval is one type.
6. Modulation similar to FM.
11. Too much.
13. Part of tuning eye.
14. Rip.
15. Fuss.
16. Water vehicle.
17. If it's not off.
18. Large hatchet.
19. You and me.
21. College degree.
22. These numbers are not imaginary.
25. Bundles of wires.
28. Regret.
29. An untruth.
30. Unprocessed data is this.
33. Group led by emotion.
34. Type of rise time lost when h.f. response is poor.
35. Land measure.
37. The Van Allen is one.
38. Possessive pronoun.
40. Petruchio tamed her.
42. A3 modulation.
43. Half a frame.
44. "Fi's" twin.
45. Voltage across a capacitor ____ current.
48. "Slo-____" (type of fuse).
49. Drew blood.
51. Make happy.
53. Look unwaveringly.
54. Supervised discussion.
55. High volume.

DOWN

1. Converts electrical energy to motion.
2. Less irregular (colloq.).
3. A beverage.
4. To make a mistake.
5. Schematic part designation.
6. System for distributing sound to a crowd.
7. Common-base reverse voltage amplification.
8. Days of yore.
9. Navy Construction Battalion.
10. Belonging to "Miss Kett."
12. Vertical values on a graph.
13. Handout (slang).
20. Symbol for atomic number 62.
23. Pertaining to hearing.
24. Smallest quantity.
26. What capacitors do to d.c.
27. Constellation.
31. Caused by gravity (abbr.)
32. Protect from undesired fields.
33. Unit of small current.
34. Type of connector.
36. Medium through which radio waves travel.
37. Prepared in large bundles.
38. Common-base input impedance.
39. Type of fuse that allows transient overload.
41. Large duck.
46. Talk a lot (slang).
47. Depot (abbr.).
49. Unit of heat energy.
50. Boy.
52. All the voltage in a circuit.
53. As stated or described.



U.H.F. TV Coverage

(Continued from page 24)

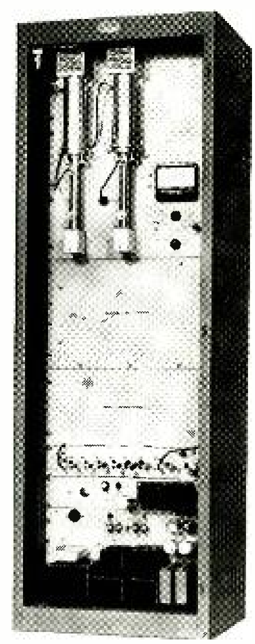


Fig. 10. Adler UST-20 (20-watt) translator. Add-on rack boosts to 100 watts.

possible in its translators, to help make maintenance easy by local service personnel. Maintenance checks every few months prevent on-the-air breakdowns from becoming a serious problem.

Limitations

FCC rules encourage the use of channels 70 to 83 for such service. Despite the roadblock presented by the scarcity of u.h.f. receivers, translators are already used in the hundreds, as noted earlier. They will multiply when all-channel sets are the rule. The only brake on the number of translators an area can have is the required frequency separation.

The FCC limits output capability in terms of transmitter power, not e.r.p., with 100 watts the top limit. Since normal restrictions on directivity do not apply here, the limitation is not serious. The 100-watt unit in New York, for example, has an e.r.p. of 1.65 kilowatts in the quadrant it covers. With the same transmitter power, sharper directivity can provide greater effective e.r.p. in a narrower antenna bandwidth, to cover considerable distances. One midwestern locale gets consistent reception from a 100-watt translator 70 miles away. Of course, this is not average; a more usual range would be about 35 miles.

Costs and Ownership

A complete single-channel translator installation can cost as little as $20,000. One for a typical town with a population of 10,000 would run to $50,000. Maintenance costs would run between $2000 and $3000 per year—less than the salary of one man in a satellite station. That comes to an initial investment of $5 and yearly maintenance of a few cents for each set owner. At these figures, expenditure to reach a larger audience with translators will be attractive to many broadcasters.

But interest is not limited to these groups. The translators for Grand Portage and Grand Marais mentioned earlier (Fig. 7) are owned by the Duluth stations that originate their signals. The translator farm in Blythe, California, however (Fig. 8), is community owned.

This is true of many such installations throughout the country, where impatient, TV-hungry residents do not wait for the broadcasters to act. Owners include individuals, voluntary community groups financed by public subscription, municipalities, counties, educational groups, and large companies who wish to provide viewing for employees in isolated areas. Costs can be low enough to make such local ownership attractive. In fact, there are many cases where translators have been chosen as more practical than wire-distributed CATV systems to provide locals signals.

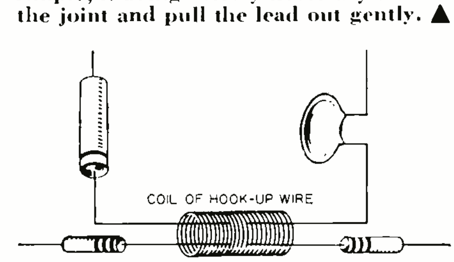
While all the techniques described will contribute to expanded TV coverage once u.h.f. gets under way, we feel the translator is likely to become the most important. No matter which system predominates, however, there will inevitably be more TV coverage rather than less, in general. As to those now enjoying abundance in areas that may become questionable if a u.h.f. switch comes, we doubt that they will suffer losses. Propagation techniques already tested should, in most cases, at least equate their present plenty. ▲

"MID-AIR" TIE POINT

By THOMAS R. HASKETT

SOMETIMES, when replacing "Couplates" or other component packages with individual parts, it becomes necessary to tie several leads together at a point where there is no available tie point. Wrapping three or four leads around one another makes subsequent testing very "sticky," but another method makes installation and removal easy.

Bare hook-up wire is formed into a small coil, by winding it around a thin-blade screwdriver shank. As the diagram indicates, the resistor and capacitor leads are then inserted into the coil, and the entire assembly heated while solder is flowed into it. Removing a lead is equally simple, it being merely necessary to heat the joint and pull the lead out gently. ▲



TECHNICAL MANUALS for SURPLUS EQUIPMENT

By EVERETT E. KELLEY

Helpful information in locating the instruction manuals for useful surplus electronic equipment.

SURPLUS electronic items are frequently bargains for the ham operator and experimenter—if you know what you are buying and can adapt it to your civilian needs.

The government went to great expense to provide technical manuals covering all of the equipment issued to the Armed Forces. This instruction material is clearly written and complete in its coverage of power requirements, operation, and maintenance for each specific piece of equipment. Unfortunately, with the passage of time since the equipment was removed from active service, the manuals, in most cases, have been separated from their associated equipment.

Locate the Nameplate

First, inspect your electronic item carefully to locate the nameplate which will have inscribed on it the equipment designation, with either the type or component number. Usually the contractor's name and address will be given but this is usually a less valuable item of information than you may think. Even if the contractor is still in business, he was only supplied with sufficient manuals for production purposes and he seldom has facilities for reproducing the material even if the manuals are still in his files. In some instances, the manufacturer may have produced a civilian version of the military gear in which case an instruction manual may be available. However, should yours be specialized military equipment, don't give up hope because there are still several other possible sources for you to try.

Which Manual?

The secondary problem, after determining the type or component number of the equipment, is to relate this information to the technical manual covering the equipment. This is necessary since most of the Armed Forces publication centers deal in the technical manual numbers only and these are not usually cross-referenced to equipment numbers.

If you will furnish the Office of Technical Services, Department of Commerce, Washington 25, D.C. with your equipment numbers, they will supply the number of the corresponding technical manual. In addition, they will quote the price of microfilming the corresponding technical manual—but with a manual of any length, this cost might be exorbitant.

Many local libraries, state archives, and university libraries are selective depositories for government publications and, if you prefer, you can search their card index until you locate a manual which includes your particular item of equipment. From Army Manual 21-6, "List and Index of Department of The Army Publications," you can determine the technical manual number even if the manual is not included in your library's collection.

Supply Sources

Once the pertinent technical manual number has been located, there are several potential sources of supply. On request, the Superintendent of Documents will furnish a copy of price list #19 covering Army Field and Technical Manuals. Depending on the service involved, you may write direct to The Department of the Army, Adjutant General's Office, The Pentagon, Washington 25, D.C.; The Department of the Air Force, Directorate of Administrative Services, Washington 25, D.C.; or to The Navy Department, Publications Section, Washington 25, D.C.

Many of the military reserve units, as well as the Army Corps of Engineers, keep files of instruction books and manuals and these are usually available for your inspection. Military training manuals for radiomen and electronics technicians frequently contain information on specific equipment which was used as a training example.

Many surplus radio dealers will sell technical manuals and there are several dealers who specialize in supplying such information. Any bookstore with an extensive technical book section should carry surplus handbooks and conversion manuals which contain technical information on all types of electronic equipment. Watch for magazine articles on military equipment and conversions, collect these, and begin a technical file of your own.

(Editor's Note: Although this publication does not have information available on surplus equipment, we refer our readers to such companies as Editors & Engineers, Summerland 2, Calif.; R. E. Goodheart, P.O. Box 1220-A, Beverly Hills, Calif.; G & G Radio Supply, 51 Vesey St., N. Y. 7, N. Y.; and others for this type of material.)

As a last resort, you can write to your Senator or Representative and have him forward your request to the Army, Navy, or Air Force liaison officer to Congress. This will always bring quick results from the appropriation-minded Armed Forces—but we suggest that you don't overdo it. ▲

What is "Skin Effect"?

By JOSEPH TUSINSKI
Senior Technical Instructor, The Technical Institute, Norfolk College of William and Mary

Review of important basic concept responsible for more circuit losses and resistance at higher frequencies.

A GREAT many of the phenomena associated with an alternating current flowing in a conductor are related to what is referred to as "skin effect." Factors such as r.f. resistance, proximity effect, variation of "Q," and high-frequency power losses can be explained by understanding skin effect.

The name itself suggests something dealing with a surface, and in this case the implication is the surface of a wire, although the effect is present throughout the entire cross-sectional area of a conductor.

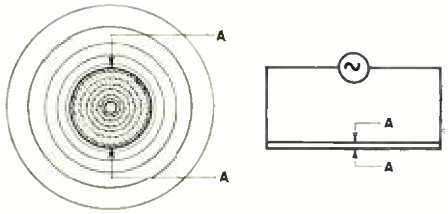


Fig. 1. Magnetic field distribution.

When a current is passing through a conductor, there is present a magnetic field and an electric field; one cannot be sustained without the other. By observing the action of either one the answer to "what is skin effect?" may be obtained. In this discussion the magnetic field will be used to analyze what happens when an alternating current is passing through a wire.

Effect of Magnetic Field

Outside of a conductor we can measure the relative strength of the magnetic field and we would find that the strength would diminish as we moved away from the conductor. The manner in which the field decays would follow a definite pattern, that is the field would decrease exponentially. The exponential decay means that the field follows the law of inverse squares, so that by doubling the distance from the wire the field is one-fourth as strong, and by tripling the distance the strength is one-ninth, and so on. The question might be asked, why worry about the field outside of a conductor? This outside field is most important when we consider its presence next to another current-carrying conductor.

If we could examine the field from the outside surface to the center of the conductor we would find that the number of flux lines actually follows the same law *inside* the conductor. This is shown in Fig. 1.

The relation that the flux has to the current flowing in a conductor is defined as the inductance of the conductor. The inductance is directly proportional to the number of flux linkages and inversely proportional to the current producing the flux. There are a greater number of magnetic lines at the center of the conductor, therefore a greater inductive effect must be present at the center of the wire.

The reactance that the inductance possesses is known to vary directly as the frequency varies. It can be seen then that there is a greater opposition to current flowing at the center of the wire, and that this opposition increases with frequency. The current actually distributes itself in the conductor as shown in Fig. 2.

A.C. Resistance and Skin Depth

How can we use this information to determine the a.c. resistance of a current-carrying conductor? The answer is to determine the *effective* current-carrying area, averaged over the entire cross-section. Then we may apply this effective area to the formula for the resistance of a conductor. The formula states that the resistance of a material varies directly as its length and the type of material and inversely as the cross-sectional area: $R = \rho L/A$, where R = resistance in ohms, ρ = specific resistivity of the wire (for copper, it is 10.37 ohms/mil-foot), A = circular-mil area, and L = length in feet.

The effective area may be determined from the point at the surface to where the current is attenuated 8.7 db, or one neper, where the attenuation of one neper is equal to $1/\epsilon$, or .368. Expressed as a percentage, the effective area around the conductor may be determined from the thickness of the conductor where the current diminishes to 36.8 per-cent of the current at the surface. This value defines skin thickness or "skin depth."

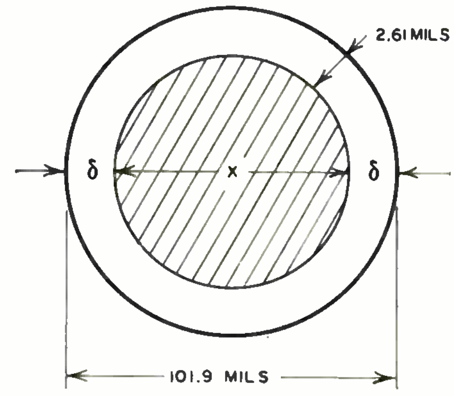


Fig. 3. Cross-section of conductor used in example. Dimensions are not shown to scale.

The skin-depth for copper may be determined with the expression: $\delta = 6.62/\sqrt{f}$, where δ is the skin depth in centimeters and f is the frequency of the alternating current.

From the formula it may be seen that the skin depth varies inversely as the square root of the frequency. This may also be seen in Fig. 2, where $\delta 2$ is less than $\delta 1$.

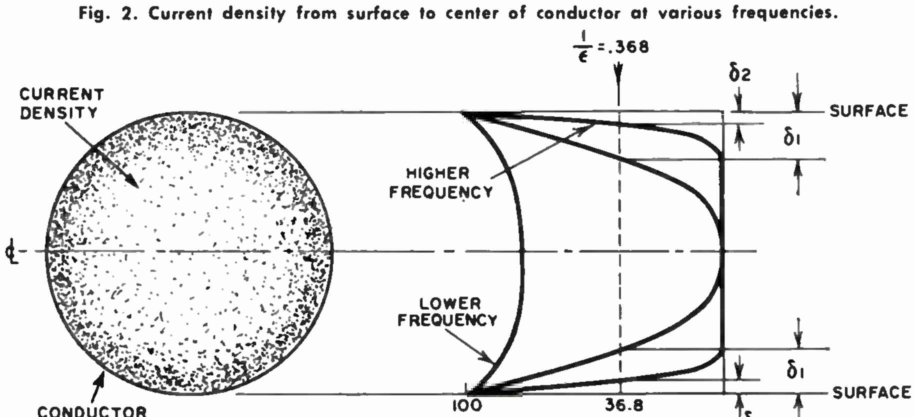
Some readers might observe that there is a magnetic field present even when direct current flows in a conductor, which is true. However, we have to remember in order to have an inductive effect the current has to change; the faster this change of current, the greater the inductive effect.

Practical Example

Combining all of the known factors thus far, let us take a 200-foot length of #10 copper wire into consideration at d.c., 1 mc., 10 mc., and 500 mc. and determine its effective (a.c.) resistance in each case.

From wire tables the diameter of #10 wire is given as .1019 inch or 101.9

Fig. 2. Current density from surface to center of conductor at various frequencies.



mils. The circular-mil area is the diameter in mils squared or 10,380 circular mils. The d.c. resistance is, $R = \rho L/A = 10.37 \times 200/10{,}380 = .199$ ohm.

To determine the resistance at 1 mc. it is first necessary to find the skin depth from $\delta = 6.62/\sqrt{f} = 6.62/\sqrt{10^6} = 6.62 \times 10^{-3} = .00662$ cm. Converting to inches, .00662 cm. $\times$ 1″/2.54 cm. = .00261 inch, or 2.61 mils. It can be seen that even at 1 mc. the effective current-carrying area has decreased considerably (Fig. 3).

If the diameter x is known, the circular-mil area may be subtracted from the total area to determine the effective area. $101.9 - (2 \times 2.61) = x = 96.7$ mils. Then squaring, d^2 = CMA = $(96.7)^2$ = 9350 CMA. Thus the effective area is 10,380 − 9350 = 1030 circular-mils.

Then we may use the resistance formula to determine the effective a.c. resistance. $R = 10.37 \times 200/1030 = 2074/1030 = 2.01$ ohms. It can be seen that from d.c. to 1 mc. the effective resistance has increased by approximately ten times.

For practice the reader is asked to try working with the other two frequencies mentioned, using the same size wire. It will be found that at 10 mc. the effective resistance is over 6 ohms and at 500 mc., it is in the order of 50 ohms.

Effects and Remedies

By knowing how the effective resistance varies as the applied frequency

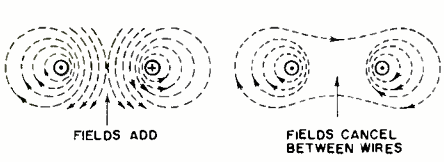


Fig. 4. Magnetic flux around two conductors carrying current in opposite, same directions.

changes, it can be seen and appreciated that the "Q" of a circuit will be influenced. The fact remains that in order to have a low-resistance conductor at high frequencies it is necessary to have a large surface area. The conductor does not have to be a solid conductor; a hollow tube or pipe may be used. The thickness of the wall should be at least five skin depths thick to be effective and for the calculated values of resistance to hold true.

It should be noted that the formulas given will hold for round conductors only. It would be difficult to develop a formula to hold true for any shaped conductor, that is rectangular, square, or elliptically shaped. The resistance of odd-shaped conductors is normally determined empirically.

The formula also assumes that the conductor is isolated from other current-carrying conductors or changing magnetic fields. This fact brings us to a brief discussion of what is termed the "proximity effect."

If we consider the fields around two conductors that are assumed to be close together, the fields distribute themselves as shown in Fig. 4.

The effect is such that the flux density is greater near the surfaces between the two conductors depending on which direction the current is flowing and the distance between the two wires. The effective current-carrying area is reduced considerably in Fig. 4A and slightly in Fig. 4B, and as a consequence the a.c. resistance is increased.

At microwave frequencies the effective current-carrying area might be only in the silver plating of a waveguide. This is why guides are plated on the inside.

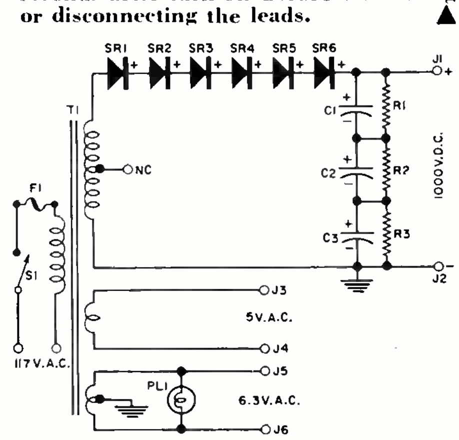
To combat the skin effect, Litz wire (made up of a number of fine strands, insulated from each other) is effective up to frequencies in the order of a megacycle, however the difficulty in proper manufacture and capacity between conductors at higher frequencies cancel the merits that can be enjoyed at the lower frequencies. ▲

1000-Volt Power Supply

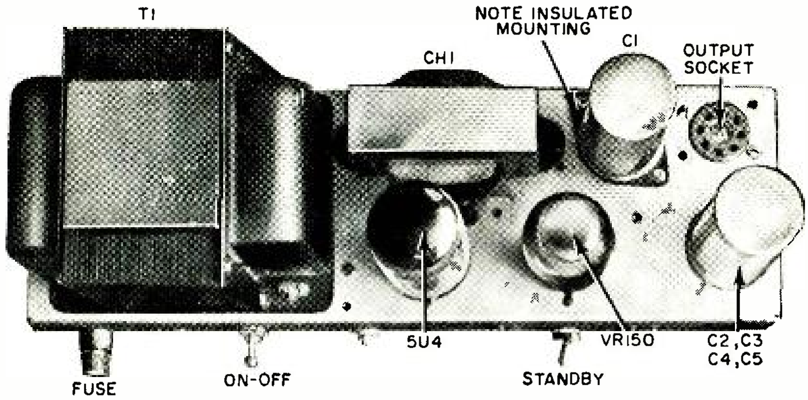
By WALTER TEMCOR

THIS power supply provides 1000 volts d.c. to a load requiring only a few milliamperes and 900 v. to a 100-ma. load; it can deliver a maximum of 200 ma. and, in addition, supplies 6.3 v. and 5 v. at 3 and 5 a. respectively. The ripple is 2 v. r.m.s. for light loads, increasing to about 8 v. at 100 ma.

The circuit is a half-wave rectifier with capacitor-input filter. The full secondary voltage of T_1 is applied to six, series-connected silicon rectifiers that operate well under their rated peak-inverse voltage. Bleeder resistors R_1, R_2, R_3 distribute the d.c. equally across C_1, C_2, C_3 and reduce the output to 350 v. five seconds after S_1 is opened. However, wait at least 30 seconds after turn-off before connecting or disconnecting the leads. ▲



R_1,R_2,R_3—75,000 ohm, 2 w. res.
C_1,C_2,C_3—40 µf., 450 v. elec. capacitor
SR_1-SR_6—Silicon rectifier, 500 ma., 400 p.i.v.
T_1—Power trans., 800 v. center tapped @ 200 ma., 5 v. @ 3 a., 6.3 v. @ 5 a. (Stancor PC-8412 or equiv.)
S_1—S.p.s.t. toggle switch
F_1—3 a. fuse
PL_1—6.3 v. pilot lamp
J_1,J_2—Five-way binding post



Top view of author's home-built high- and low-voltage supply.

HYBRID BRIDGE POWER SUPPLIES

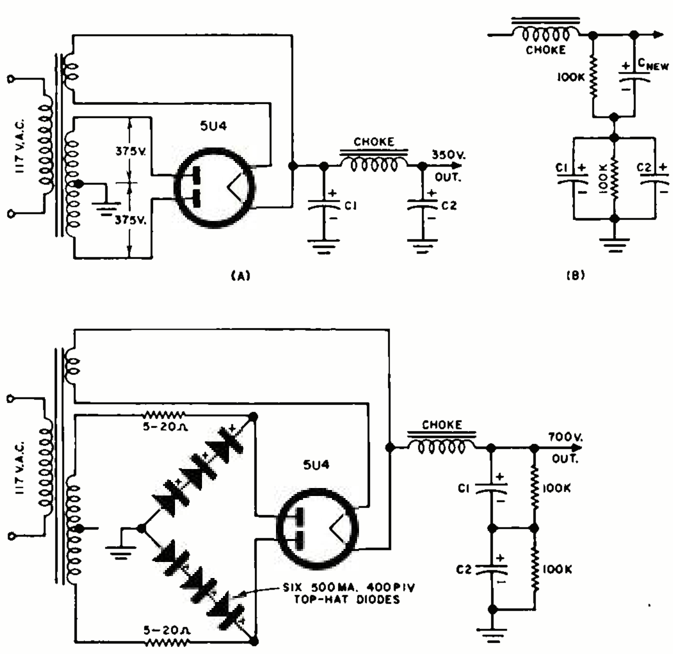
By JOSEPH MARSHALL, WA4EPY

DO YOU need 600 to 700 volts at 150 to 200 ma. to power a new transmitter? Somewhere you no doubt have a power supply which delivers 300 to 350 volts at the requisite current so it is just a matter of a simple and inexpensive modification to double its voltage or to obtain both the present and a new doubled voltage.

Fig. 1A is a diagram of a typical low-voltage power supply using a vacuum-tube rectifier. Fig. 1C is a diagram of the same supply modified to deliver twice the voltage. The modification consists of two steps: First, turn the present full-wave rectifier into a bridge rectifier by addition of two legs composed of silicon diodes. For the typical 350-volt supply, three of the "top-hat" diodes, rated at 400 p.i.v. each, are connected in series for each of the two legs. These are available for as little as 50 cents each.

The second step is to change the filter from capacitor to choke input and to wire the present capacitors in series. This is easy to do if the capacitors are individual cardboard units. If the capacitors are in a single multiple-section can or case with a common negative, it is not possible to series them. In that event, obtain another, cardboard-cased capacitor with a total capacitance equal to the sum of the capacitances of the present one. In other words, if the present capacitor has two 20-μf. sections, obtain another with either one 40-μf. or two 20-μf. sections. The voltage rating should be equal to that of the present capacitors. Parallel the two sections of the present capacitor and wire it in series with the new one, as indicated in Fig. 1B. Add 100,000-ohm, 1-watt resistors across each bank of the capacitors. These will serve as voltage equalizers and, at the same time, as a bleeder to discharge the capacitors. It is a good idea, too, to put 1- or 2-watt resistors (from 5 to 20 ohms) in series with each lead from the transformer secondary to the rectifiers to protect them against current surges.

Fig. 1. Modifying a low-voltage power supply for high voltage.



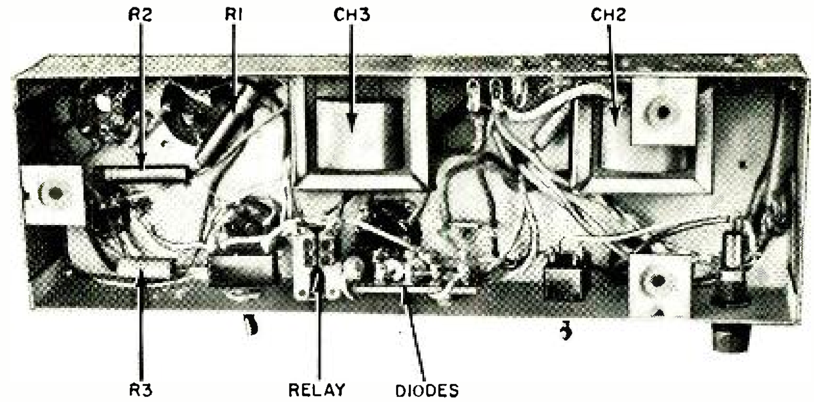
Supply for Transmitter Use

In a typical transmitter you need both a high voltage for the final and a lower voltage for the exciters. You can obtain both, as shown in Fig. 2. The high voltage is obtained from the output of the vacuum-tube rectifier while the low voltage comes from the transformer center-tap. The simplest way to handle the problem of filtering is to move the present filter down to the center-tap and add another filter for the high voltage, using another choke and capacitor. Thus you can obtain a high voltage, in addition to the present low voltage, for the price of six diodes, a choke, and a filter capacitor.

The first hybrid supply built by the author was modified in this way and, with VR tube regulation at the end of the center-tap filter, provides 700 volts at 200 ma. for the final and 125 ma. at 350 volts for the exciter and screen modulator. It has been operating for months without trouble and is still operating well below maximum possibilities because the transformer is scarcely warm to the touch. Several other supplies using hybrid rectifiers are in use by hams in this area.

The power supply, diagrammed in Fig. 2 and shown in the photographs, was made from old TV-type transformers, chokes, and commonly available can-type electrolytics—at a total cost of less than $10. It supplies 700 volts at up to 150 ma., 350 volts at up to 150 ma., 150 volts regulated at up to 20 ma., and filament current for 6-volt tubes. A 6-volt relay breaks the rectifier ground for removing the voltage from the transmitter during reception. It is actuated by a double-pole, double-throw switch on the receiver, one section of which simply grounds the lead from the relay coil, permitting current to flow through it and actuate it. (The other section disables the receiver during transmitting periods.) A s.p.s.t. switch is included on the power-supply chassis for convenience so that the power supply can be used or tested when the relay is not actuated. The parts were easily placed on and inside a 4" x 13" x 2" chassis which happened to be around. The supply furnishes all operating voltages for the r.f. portion of a 100-watt transmitter and a screen modulator.

Simple modification of a power supply in order to obtain double the output voltage for use with ham type radio transmitters.



Under-chassis view of the combination power supply is shown.

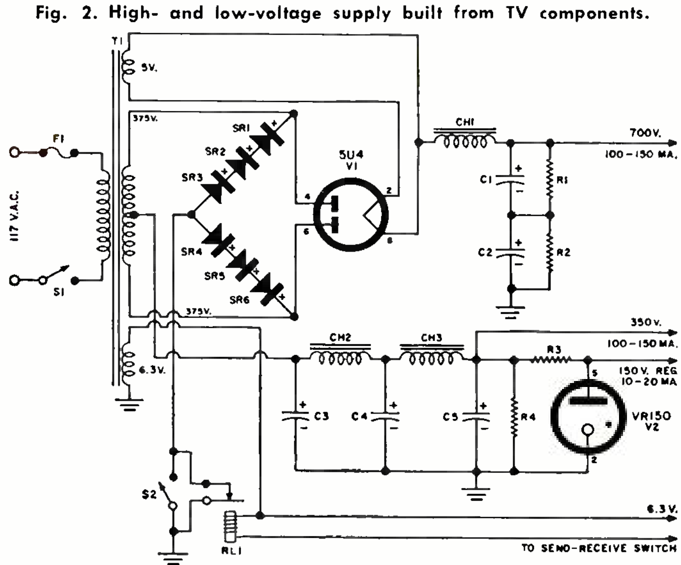
Of course, higher voltage can be obtained with capacitor input. However, with capacitor input the diodes should be derated about 25%. In other words, the total p.i.v. of each leg should be increased by about 25%. Three 400 p.i.v. diodes should handle outputs up to 750 volts but for higher voltage it is safer to use four. It is probably a good idea to parallel each diode with a resistor of several hundred thousand ohms, particularly with capacitor input. There seems to be a difference of opinion on this point since some manufacturers of diodes recommend this and others say it is not necessary.

Circuit Performance

How much current can you draw from a hybridized bridge power supply? The ham handbooks say that a bridge rectifier can deliver about twice the voltage but the current should be held down to half. In other words, the permissible kva. output of the power supply is the same for bridge and full-wave service. This is not quite accurate and over-conservative for ham service.

As a matter of fact, when changed to bridge service from full-wave service, a transformer *designed for full-wave service* can deliver continuously between 125 and 150% more output with about the same heating and in ICAS service it is quite safe to draw a total current in one or both legs equal to the current drawn in full-wave service. In other words, if a transformer is rated to deliver 350 volts at 300 ma. in full-wave service, it will deliver 200 to 225 ma. in bridge service without additional heating in continuous service and can be expected to deliver the full 300 ma. in intermittent service.

Fig. 2. High- and low-voltage supply built from TV components.



R_1, R_2, R_4—100,000 ohm, 2 w. res.
R_3—10,000 ohm, 10 w. wirewound res.
C_1— 40 µf., 450 v. can-type capacitor (insulated from chassis)
C_2,C_3,C_4,C_5—40/40/40/40 µf., 450 v. elec. capacitor
CH_1—8 to 12 hy., 120-150 ma. TV choke
CH_2, CH_3—2-3 hy., 200 ma. TV choke
SR_1, SR_2, SR_3, SR_4, SR_5, SR_6,—500 ma., 400 p.i.v. top-hat diode
S_1—S.p.s.t. switch ("On-Off")
S_2—S.p.s.t. switch ("Standby")
RL_1—S.p.s.t. 6.3 v. relay
F_1—3 amp. fuse
T_1—TV trans. 375-0-375 v. @ 200-300 ma.; 5 v. @ 3 amps; 6.3 v. @ 3-5 amps

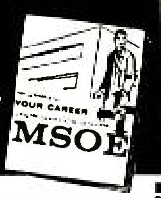
The efficiency of a bridge rectifier in terms of output power is roughly 40% higher than that of a full-wave rectifier. A transformer designed for full-wave service must be able to handle 1.57 times the output power in its secondary, and 1.34 times the output power for the whole transformer. On the other hand, in bridge service a transformer need handle only 1.11 times the output power. Hence with the same d.c. output power, a full-wave transformer converted to bridge service will heat only 75% as much. Therefore, the power output can be increased by from 25 to 40% in bridge service without exceeding the transformer dissipation rating.

However, most full-wave transformers are rated for continuous service whereas a power supply in an amateur or commercial communications transmitter has a duty cycle of 50% or less. Hence the transformer will be cooling at least 50% of the time. Under these circumstances, it can be asked to deliver more power during its duty cycle and increasing the power output to some point between 150 and 200% of the output in full-wave service is not likely to cause dangerous overheating in ham service.

Mixing Rectifiers

Does mixing vacuum tubes and solid-state rectifiers pose any problems? Apparently not. We have found no problems in several applications—both in our own and other shacks. Since a 5U4 or a GZ34 is cheaper than six diodes, it is more economical to use for one pair of legs in a bridge rectifier even in a brand-new power supply. The p.i.v. rating is no problem since these tubes and others of similar capabilities, are rated for 1400 p.i.v. or more. On the other hand, at today's prices, six diodes are cheaper than the additional tube plus the additional filament transformers which would be needed for an all-tube bridge rectifier.

Hybrid operation of silicon diodes with tube rectifiers in bridge power supplies offers an economical and convenient means of obtaining high voltage or both low and high voltage for amateur and commercial transmitters. When transformers designed for full-wave service are used in amateur and intermittent commercial operation, the power output with bridge rectifiers can be increased to between 150 and 200% of the output with full-wave rectification without excessive transformer heating. ▲



CONTROLLED-RECTIFIER GATE CIRCUITS

Design considerations for gating circuits that are to be employed with semiconductor controlled-rectifiers.

When designing gate circuits for controlled-rectifiers, it is necessary that the gate signal be of sufficient voltage and current to positively fire any individual controlled-rectifier of the type being used. But, at the same time, the power delivered to the gate must not exceed its specified power-handling capability. Since there is a considerable range of gate volt-ampere characteristics for a given type of controlled-rectifier, a graphical construction is helpful in establishing circuit parameters which will satisfy all the requirements listed above.

One such construction (taken from a recent issue of the *Westinghouse* Semiconductor Department publication "Tech Tips") is a gate circuit volt-ampere diagram on which is superimposed a rectangle of maximum gate voltage-current requirements and a hyperbola

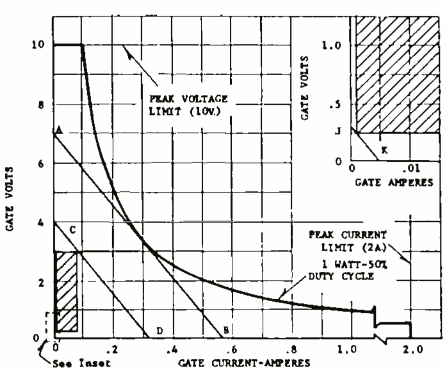


Fig. 1. Gate characteristics of the 2N681.

of maximum gate-power dissipation for the duty cycle used. This type of diagram may be readily constructed from tabular data as shown in Fig. 1. In this diagram, any condition of gate voltage or current which lies above or to the right of the shaded area in the lower left-hand corner will operate the controlled-rectifier, provided sufficient anode-cathode voltage exists. The shaded area is bounded by the gate current and voltage specified as the maximum required to fire the unit at the maximum operating temperature. The small unshaded areas below and to the left of the rectangle indicate the maximum values of gate current or voltage for non-operation.

For the type 2N681, a positive voltage of three volts or more applied to the gate or a positive current of 0.080 ampere or more into the gate will turn all units on. No units of this type will turn on with gate voltages or currents equal to or less than 0.25 volt or .001 ampere respectively. The input resistance of an individual gate at the turn-on point will be between 3 and 3000 ohms.

Due to this variability in gate input resistance, gate behavior can best be predicted by assuming the energizing source to be a constant-voltage generator in series with a resistance composed of its own internal resistance and an external limiting resistance. A load line can then be constructed on the diagram by using the source for a point on the voltage scale, and this voltage divided by the total series resistance for a point on the current scale. To insure operation of all gates, all points on this line must lie above or to the right of the shaded rectangle. Also, to avoid overloading the gate, all points on this line must lie below the appropriate gate power dissipation curve. After the total resistance has been determined, the slope of the load line will be fixed and construction of a line of this slope through any value of driving e.m.f. will indicate whether this e.m.f. is sufficient to operate the controlled-rectifier.

For example, consider a 2N681 controlled-rectifier operating in half-wave service with the gate driven by an inphase sinusoidal signal as shown in Fig. 2. The negative half-cycle of gate signal is blocked by silicon diode (*CR*) so that

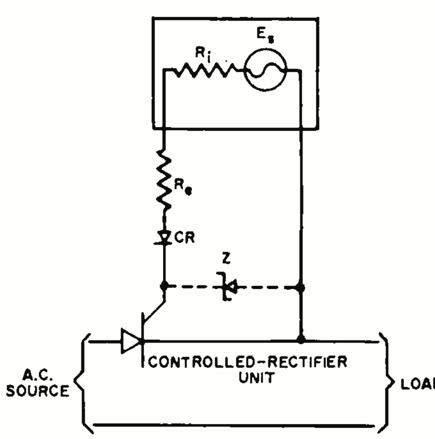


Fig. 2. Schematic showing equivalent circuit.

the gate operates on a 50% duty cycle. The diode also functions as a threshold device by inserting about 0.5-volt drop in any signal applied to the gate. This drop absorbs small random noise impulses and prevents spurious operation of the controlled-rectifier. In the following discussion this voltage drop has been neglected for simplicity.

To avoid exceeding the 10 volts peak gate voltage limit, the r.m.s. voltage of the gate drive source must be no more than 7 volts. Load line *AB* can be drawn from the 7-volt point on the vertical axis tangent to the 50% duty cycle power curve. The slope of this line (7 volts/.56 ampere) indicates a minimum circuit resistance of 12.5 ohms. All load lines for this resistance will be parallel to line AB. Thus, as the instantaneous source voltage rises from zero toward its maximum value, a succession of load lines, parallel to line AB, rise from the base line—reaching a maximum voltage of 9.9 volts at the peak of the sine wave. All units of this type will have been fired when the line no longer passes through the shaded rectangle. Thus, line CD, parallel to AB and tangent to the shaded rectangle, indicates that all units must have operated when the instantaneous source e.m.f. reached 4 volts. Some units, on the other hand, may fire when the source e.m.f. reaches about 0.30 volt (see line JK). The firing angle with sine-wave drive will thus be between 1.5 degrees and 24 degrees depending on the characteristics of the particular unit.

The minimum firing angle can be reduced by increasing the rate of rise of the signal voltage. A higher signal e.m.f., clipped to 10 volts or less with a zener diode, can be used. If a magnetic amplifier is used as the signal source, it can be supplied with square-wave voltage rather than sinusoidal. The minimum firing angle which can be attained will depend on the source voltage and the resultant degree of clipping. A pure square-wave source will allow the angle to be reduced to zero.

Use of this particular construction with other types of driving signals will be similar. ▲

NOVEL "FILTER CAPACITOR"

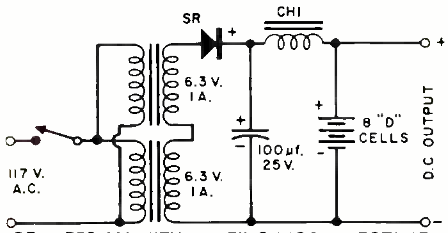
By JOHN POTTER SHIELDS

RECENTLY the author had occasion to build up a small low-voltage, low-ripple supply to power some experimental transistor equipment. After a luckless search of the "junk box" for a low-voltage, high-capacitance filter capacitor, it was decided to try the old trick of "floating" a battery across the power-supply output terminals.

Not having a 12-volt storage battery handy, eight size "D" flashlight cells were substituted and gave excellent results. The flashlight cells, having low internal impedance, neatly bypassed the supply's ripple to ground, as well as stabilizing the output voltage with respect to line voltage variation.

Fig. 1 is a self-explanatory schematic of the "junk box" power supply for those who might want to duplicate it. About the only things to watch are: the flashlight cells must be reasonably fresh otherwise their internal impedance may be too high to be effective, and the battery voltages must be equal to the power-supply output voltage.

The cells will last just about their normal life as essentially zero current is drawn from them. ▲



SR = 750 MA. "TV TYPE" SILICON RECTIFIER
CHI = 6 OR 12 V. FIL. TRANS. SECONDARY

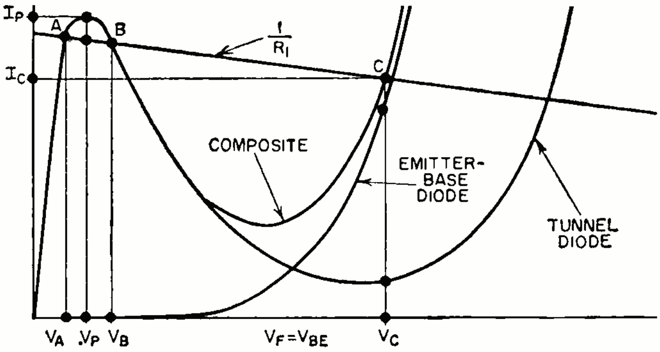


Fig. 1. Composite characteristic curve of tunnel diode along with transistor emitter-base junction.

Application of a tunnel diode in a circuit that measures leakage resistance up to 10^{12} ohms, current as low as 10^{-12} ampere.

TUNNEL DIODE HIGH-RESISTANCE CHECKER

By CARL DAVID TODD / Hughes Aircraft Co.

HOW many times have you wanted to measure the leakage resistance of a switch, printed circuit, or a capacitor but could not because of the cost of a commercial high-resistance test set? This tester, which can be built for $10, uses a tunnel diode and one transistor, subjects the test sample to only 1.35 volts, and can be carried in your pocket.

Tunnel Diode as a Bistable Switch

A plot of the voltage as a function of the applied current of a tunnel diode biased in the forward direction (Fig. 3A) is shown in Fig. 2. Notice that there are two positive-resistance regions separated by a region in which an increase in the forward voltage, V_F, will result from a decrease in the current, I_F. This middle region is said to exhibit negative resistance.

Fig. 2 also illustrates some of the important tunnel diode parameters. Of major concern are the peak current, I_P; the valley current, I_V; the ratio of these two currents, H; the valley voltage, V_V; the peak voltage, V_P; and the magnitude ($-1/r_d$) of the negative resistance (which may be approximated by the reciprocal of the slope of the curve in region 2). By careful selection of the supply voltage (V_S) and the load resistance, R_L, (Fig. 3A) we can position the load line so that the operating conditions are approximately like those shown in Fig. 2. Note that the load line crosses the characteristic curve in three places. Points A and C are stable bias points and operation may be at either depending on the "history" of the circuit. However, point B, where the load line intersects the negative resistance region, is not a stable operating point and if we attempt to bias here, the tunnel diode will tend to switch to point A or to point C.

Assume that we are biased at point A on the curve of Fig. 2. If we now apply a positive d.c. trigger to the circuit shown in Fig. 3A, we will shift the load line upward as the current is increased to the highest value (I_P) shown. The tunnel diode current will increase up to the peak current at I_P and, if the input current is increased still more, the load line will intersect the characteristic curve in only one place, D; the operating point will then shift to point D. If the input signal is now removed, the operating point will move back along the curve until point C is reached. The bias point will remain at C until a negative trigger is applied or until the supply voltage V_S, is removed.

When the input trigger is negative, the load line will move toward the origin (down), as shown by the dotted lines, until a condition is reached where the only possible operating point is at E where switching action again takes place. When the input signal is removed, the bias point moves back to point A where it will remain until the next input signal. The tunnel diode, therefore, acts as a switch with two stable conditions: at point A, with a very low voltage (typically 30 mv.) and at point C, where the voltage is considerably higher (450 mv.). The tunnel diode can be switched from one state to the other by the input signal. Less input power is required to move the bias point from A to C than from C to A.

Adding a Power Amplifier

The voltage swing of a tunnel diode used as a bistable switch is quite small and the current (I_F) is limited to the peak current of the tunnel diode. By adding a transistor amplifier we can get both a current and a voltage gain. The added amplifier is shown in Fig. 3B. The maximum current which may be taken from the tunnel diode circuit of Fig. 3A without causing switching to the low-voltage state is determined by the difference between the current at operating point C (I_C) and the valley current I_V. For the maximum

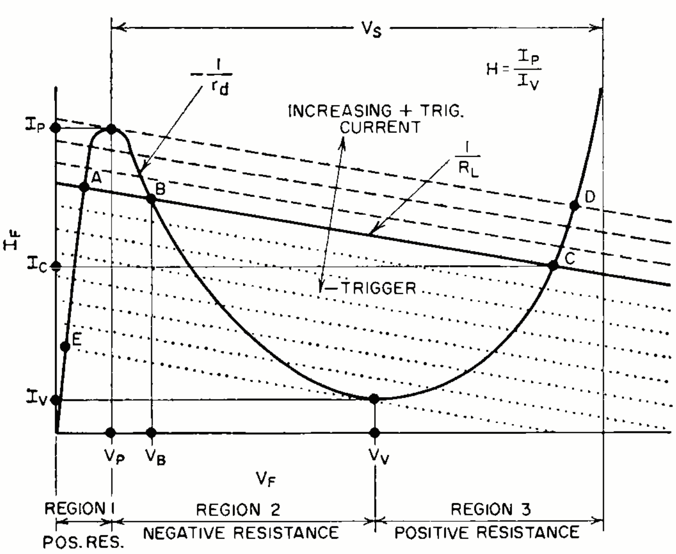
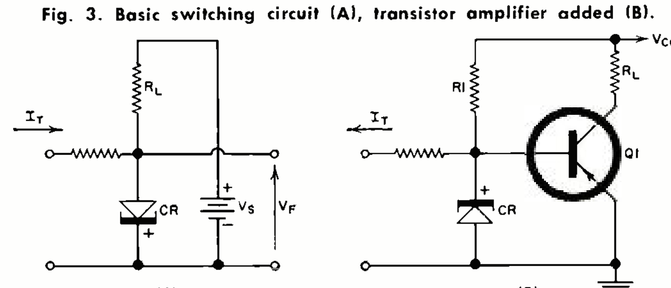


Fig. 2. Tunnel diode characteristic curve shows operating regions.

Fig. 3. Basic switching circuit (A), transistor amplifier added (B).



output current, operating point C should be at a current level almost equal to the peak current I_P. This can be achieved by using a high-resistance load (to produce a flatter load line).

Since the emitter-base diode of transistor $Q1$ is in parallel with the tunnel diode, a composite-characteristic curve, as shown in Fig. 1, will result. Since the diodes are in parallel, we can add the currents corresponding to several fixed voltages to establish the stable operating points A and C as before. When the operating point is at A on the composite curve, practically all of the current flows into the tunnel diode and very little current flows through the emitter-base junction of $Q1$. $Q1$'s collector current will therefore be very small. When the operating point is at C, that is, after the tunnel diode switches to the high-voltage state, $Q1$ is turned on. The individual operating points of the tunnel diode and the emitter-base diode of $Q1$ will almost be superimposed at C. The highest base current for $Q1$, operating in conjunction with a tunnel diode with a specific peak current, will occur when $Q1$'s emitter-base characteristic curve intersects the tunnel diode characteristic curve in the valley region. Therefore, if a tunnel diode with a high *II* is used and the operating point C occurs at a voltage almost equal to V_1 (Fig. 1), practically all the current will be available to drive the transistor. With the amplifier added, it is possible to switch a larger current and at a higher voltage level which is limited only by the transistor used. A slight improvement in the switching action was obtained by inserting a small resistor in series between the tunnel diode and the base of $Q1$ to reduce ringing.

The tunnel diode switch, transistor amplifier, and additional circuitry are shown in Fig. 4. Assume that the tunnel diode is in the low-voltage region (region 1, Fig. 2). Capacitor $C1$ will be charged by battery $B1$ through the resistance path R_X under test. If, after $C1$ has been adequately charged, S1 is momentarily closed, the tunnel diode will be switched from a stable operating point in region 1 (A, Figs. 1 and 3) to point C on the composite characteristic curve (Fig. 1) by the accumulated charge on $C1$. That is, when the current I_F increases beyond I_P, the current through the tunnel diode will fall, and at the point $V_F = V_{BE}$ (Fig. 1) the current will flow through the emitter-base diode of $Q1$. This causes an increase in $Q1$'s collector current and $PL1$ will light. The tunnel diode can be reset to its original condition by momentarily depressing S2.

$PL1$, therefore, will be lighted by the momentary closing of S1 provided there was an adequate leakage path (R_X) to assure a long enough time for $C1$ to charge. $C1$'s voltage must be in excess of the voltage corresponding to point B (V_B on the curve of Fig. 1) or the tunnel diode will not be switched when S1 is closed.

Construction

The author's tester was built in a 3" x 2" x 1" plastic box. While a metal box could be used, it may introduce some leakage paths which will affect accuracy. Large mercury batteries were used to insure long battery life. If you want to decrease the size, smaller mercury cells, such as *Mallory* type RM-1R may be substituted. The light should not be left on for long periods. If low cost is the primary objective, two standard 1.5-v. penlight cells may be used for the lamp supply. ($B2$ as shown is two 1.35-v. mercury batteries in series.) A 1.35-v. mercury cell should be used for $B1$ to maintain accuracy. The most important thing to remember during construction is to prevent the formation of leakage paths. It was for this reason that switch S1 was built rather than purchased. Although it isn't necessary, S2 may also be built. Construction details of S1 and S2 are shown in Fig. 5. Two phosphor-bronze strips should be cut and formed as shown. One is the ground connection and one end serves as the arm of S1; the other is the arm of S2. The terminal end of test jack $J1$ is the other part of S1. A small plastic or wood pin is used to close the switches. The sharp edge of S1 bites into the terminal end of $J1$ as the button is depressed to overcome poor contact that might be caused by oxidation. For best performance, $J1$ should be made of low-loss insulating material; the surfaces around it on both sides of the box should be free from dirt. The remaining construction details are not critical and may be modified at will. For reasons to be discussed later, $C1$ should be installed temporarily.

Calibration

Since R_X forms the charging path for $C1$, and we know that the voltage to which $C1$ is allowed to charge must be greater than the voltage V_B (Fig. 1) it is possible to calculate the time required to charge $C1$. If this initial charge on $C1$ is zero, the time $T1$ required for $C1$ to charge to V_B is:

$$T_1 = R_XC1 \times \log_e (V'1/[V'1 - V_B])$$

$V'1$, the supply ($B1$) voltage for charging, is the sum of voltages $B1$ and V_A (Fig. 1), across the tunnel diode. Since $B1$ and V_A, hence $V'1$ and V_B are fixed for a given tunnel diode/load-line combination, the required charging time is a linear function of R_X and $C1$. For a given value of $C1$ you can plot a graph which will represent the calibration curve

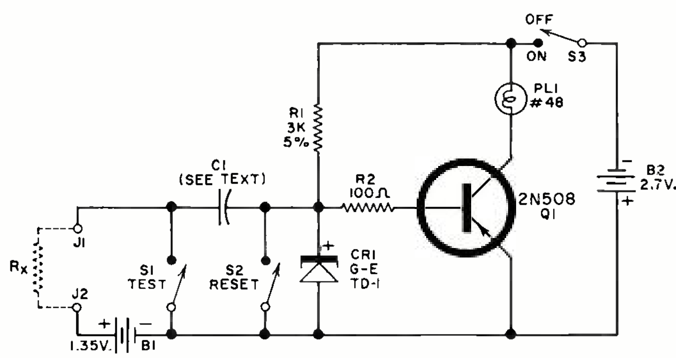


Fig. 4. Schematic of tester. Tunnel diode is G-E type TD-1 (1N3712).

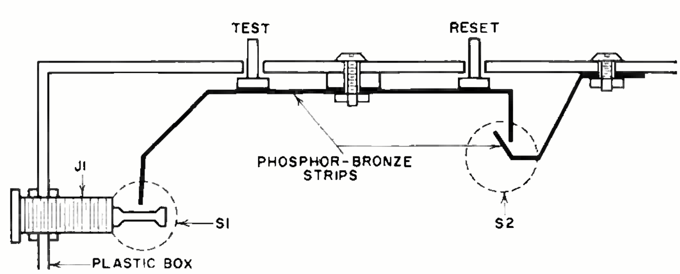
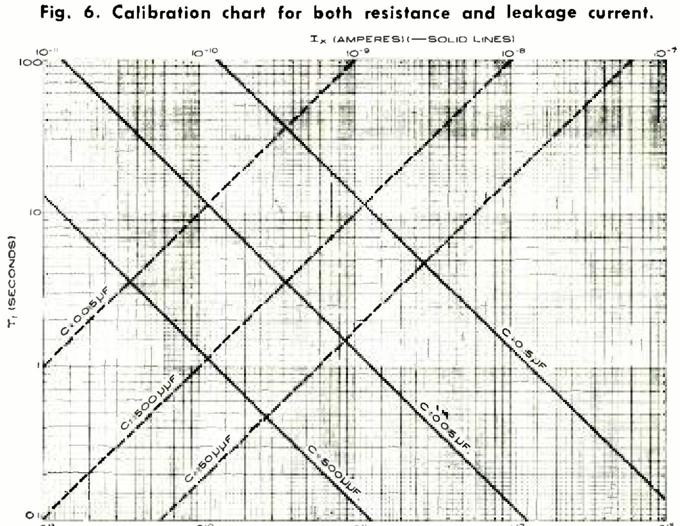


Fig. 5. Construction of S1 and S2 assures low leakage resistance.

Fig. 6. Calibration chart for both resistance and leakage current.



for the test set. In the author's test set, $B1$ was 1.35 v., V_1 = 0.035 v., V_B = 0.85 v., and C_1 = 1500 $\mu\mu$f. Charging time T_1 worked out to be:

$$T_1 = (R_X)(1500 \times 10^{-12}) \times \log_e \left(\frac{1.345 + 0.035}{1.345 - 0.035 - 0.085} \right) = (R_X)(10^{-10})$$

This means that if R_X is 10^{10} ohms the charging time will be 1 second. If R_X is 10^{11} ohms, the charging time will be 10 seconds. This relationship is shown graphically in Fig. 6. If $C1$ is changed to .015 μf., the top dashed line should be used. By using different values for $C1$, the test set range can be changed. It would seem that a reduction in the value of $C1$ by a factor of 10 would change the range in the other direction; while it is true that the calibration curve will change, it will not be a linear relation as held true for the higher values of $C1$. This is because the input capacitance of $Q1$, which was negligible for high values of $C1$, is now important. A typical calibration curve for $C1$ equal to 150 $\mu\mu$f. is also shown in Fig. 6.

For most applications of resistance measurement an accuracy of 10 to 25 per-cent is adequate. When built as described, you can get this without special calibration techniques. If greater accuracy is required, high-value precision resistors should be used by measuring them and noting the difference between the measured and the known value.

In any case, the relationship between the required charging time and leakage resistance will be linear and hence only two or three points are necessary to determine the position of the line.

Operation

Operation of the test set is simple; a watch with a second hand is the only extra equipment you'll need. There are two procedures to be followed depending on the information desired. You can use the test set to determine if an unknown leakage resistance exceeds a certain value or you can use it to determine the actual leakage resistance. For the first application, refer to Fig. 6 to determine the required charging time for $C1$, then close $S3$. Depress both $S1$ and $S2$ to reset $CR1$ and to discharge $C1$. Release $S1$, and then release $S2$. (This sequence must be followed or the measurement will be in error.) Timing begins the instant $S1$ is released. At the end of the time limit determined from Fig. 6, $S1$ should be depressed again. If R_X is lower or equal to the limit-resistance value, the charge on $C1$ will switch the tunnel diode and turn on $PL1$. If $PL1$ remains off at the end of the specified time, then $C1$ was not adequately charged and R_X was higher than the limit value. To determine the actual value of R_X, you must make a series of such measurements.

Capacitor Leakage Resistance

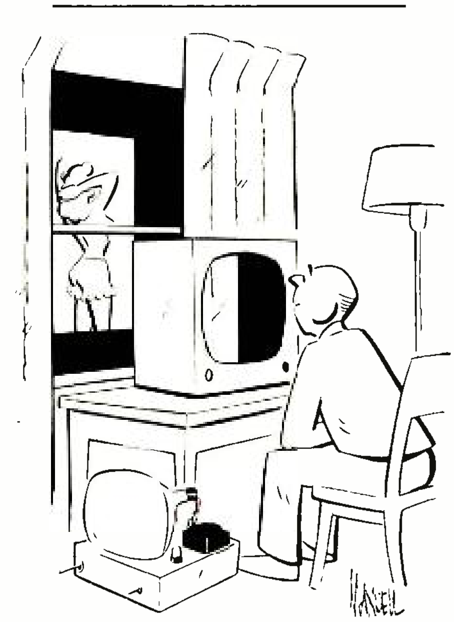
The leakage resistance of a capacitor connected to $J1$ and $J2$ may be measured in the same manner as any other leakage resistance. When $S1$ is depressed, the capacitor under test will charge to the voltage $B1$. If additional current flows after $S1$ is released, it must be due to leakage of the capacitor under test. To make an accurate measurement, it will be necessary to clean the surface of the capacitor to remove dirt.

Leakage-Current Measurement

The test set can be used to measure the leakage current of silicon diodes and transistors. Since we are dealing with current instead of resistance, the calibration is somewhat different. If you assume that the current is a constant value, then the time required for $C1$ to charge to the required voltage, V_B, is $T_1 = (C1 \times V_B)/I_X$. Thus, when $C1$ is 1500 $\mu\mu$f., a charging time of 10 seconds means a current of 0.013 nanoampere (13 millionths of a microampere). This is much lower than the current level for most silicon devices and hence it will be necessary to use a higher value for $C1$. Fig. 6 (solid lines) should again be referred to for the different values for $C1$.

The leakage current measured in this manner is that which flows at 1.35 v., reverse bias. An additional voltage may be applied by adding another battery, in series with $B1$, to $J1$. The calibration curve will not be affected for current measurements.

Note that the maximum voltage applied to the test sample is only 1.35 volts—a much lower value than is normally applied by conventional high-resistance test sets. ▲



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 15.

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

SECONDARY FREQUENCY STANDARD

1 **Hammarlund Manufacturing Company, Inc.** has announced the availability of its new secondary frequency standard, Model TM500-A.

The new instrument is designed to measure transmitter frequencies, calibrating frequency

and deviation meters, as well as for setting FM transmitter deviation with precision.

The unit measures frequencies to an accuracy of 0.00003%, far in excess of FCC requirements, at frequencies from 5 kc. to 500 mc. It is furnished with a calibration book containing dial settings for all of the radio channels in the 25-50 mc., 72-76 mc., 108-135 mc., 150-174 mc., and 450-470 mc. bands. It will operate from 95-130 volts, 190-240 volts, 50-60 cps a.c., at ambient temperatures from −10 to +120 degrees F at rated accuracy.

MOTOR-SPEED CONTROL

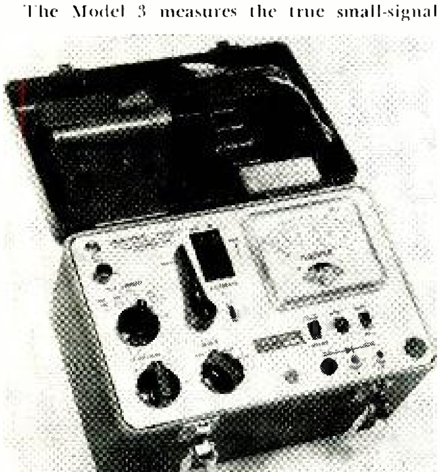
2 **Seco Electronics, Inc.** is now offering a new "Vari-Volt" which controls the voltage to an a.c.-d.c. motor or incandescent light bulbs to give an infinite range of speed or brightness.

The complete and compact self-contained unit operates on a silicon controlled rectifier rather than from a transformer. The unit measures 6¼"x 3¾"x 2" including separate "on-off" switch, fuse, control dial, and receptacle. It will handle up to 1000 watts.

TRANSISTOR & DIODE TESTER

3 **Test Equipment Corporation** has recently introduced a new portable instrument which balances effects of circuit impedances to accurately measure parameters of semiconductor devices installed in such circuits.

The Model 3 measures the true small-signal



a.c. current gain at a frequency of 1 kc. The a.c. beta range is 3 to 1000. The d.c. operating current is continuously variable to 1000 ma. The instrument also performs in-circuit measurements of the saturation voltage of transistors and the forward voltage drop of diodes and rectifiers. Accuracy is 3% out-of-circuit and 5% in any circuit of 20 ohms or more.

PACKAGED RECTIFIERS

4 **Mallory Semiconductor Company** is now in production on a new type of encapsulated semiconductor circuit which results in a substantial reduction in price.

The new technique is being applied to packaged voltage doubler circuits and center-tap silicon rectifier circuits. The three-terminal device contains two series-connected rectifier cells and has a current rating of 350 ma. at 85° C. It is available in p.r.v. values of 50 to 600 volts.

IGNITION SYSTEM

5 **Electrotone Laboratories, Inc.** is now offering a transistorized ignition system which is being marketed as the "Trigniter Model SS-1." Designed for all negative-ground 6- and 12-volt

automotive systems, the unit can be quickly and easily installed in cars, boats, and trucks.

The system utilizes a special high-ratio coil with the transistorized circuit completely encapsulated in a patented heat sink. The circuit uses a single high-voltage transistor and a heavy-duty zener diode for protection.

POWER CONTROLS

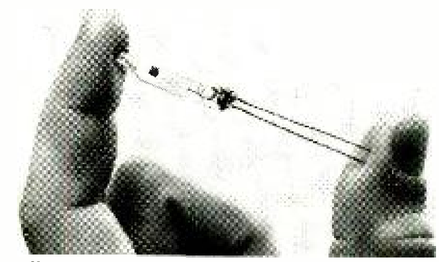
6 **Waber Electronics Inc.** has added two new units to its "Powerline" series of master power controls and outlet boxes, Models 25 and 35.

The Model 25 has seven color-coded "U" ground outlets, each individually controlled by its own color-coded switch. All seven outlets are, in turn, controlled by a master switch with a neon indicator to show when power is on. This unit is available with either a 6- or 15-foot safety cord set and with either a panel-mounted fuse or circuit breaker.

The Model 35 has the same features except that it is fitted with two-wire components. The cord set is 10 feet long and is made of heater cord. Both units are rated at 15 amperes, 130 volts.

MINIATURE CIRCUIT BREAKER

7 **Sylvania Electric Products Inc.** has announced the development of a low-cost, snap-action miniature circuit breaker for regulating temperature and current flow in electric motors and electronic circuitry.



Known as the "Thermo-Snap," the new unit provides fast, positive thermal response and long contact life. The glass-encapsulated, hermetically sealed breaker contains an inert gas that provides faster heat conduction and prolongs the life of the contacts by reducing oxidation.

The unit is electrically rated for 5-ampere, 115/240-volt continuous duty. The breakers cover a temperature range from 80 to 180 degrees C and can be specified in tolerances of ±5, ±7, or ±10 degrees C. The breaker is approximately 1⅜" long and 9/32" in diameter.

SNAP-OFF DIODE

8 **General Electric Company** has developed a new type of silicon diode which turns off in the time it takes light to travel 1½ inches. Called a "snap-off" diode, the new device is expected to find wide application in electronic circuits for anti-missile missiles, space-probe vehicles, and other space-age machinery which require the extreme in speed for reaction capability.

The new unit is similar in most respects to the standard high-speed planar epitaxial passivated diodes made by the firm, except for a modification in the processing. As a result, the stored charge, developed when the diode is in the conducting state, is constrained close to the junction. This makes the charge available at a high current level when a reverse voltage is applied so that the diode then switches rapidly to the blocking state. In addition, the range and minimum and maximum points of the stored charge are controlled.

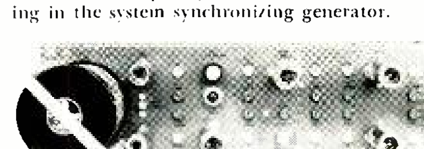
SHRINKABLE TUBING KIT

9 **Alpha Wire Corporation** is now marketing an assortment of its "Alphex FIT" shrinkable tubing in a compartmented plastic kit. The kit contains five types of shrinkable tubing in six-inch lengths and in various colors and sizes, including a complete selection of markers and caps.

The kit is designed for laboratory, prototype, and experimental use.

COLOR STANDARD

10 **Telemet Company** has recently introduced its "Telechrome" Model 605E color standard which generates a 3.58-mc. color subcarrier for encoding and transmitting color information in a standard NTSC color-TV system. It also provides, simultaneously, a synchronous 31.5-kc. double-line frequency reference signal for locking in the system synchronizing generator.



These signals are both derived from a single crystal-controlled oscillator stage that employs an oven to stabilize crystal temperature. Since both signals are derived from a single source, the phase and timing relationship is preserved.

A pair of 75-Ω source-terminated isolated jacks supply 2 volts peak-to-peak of color subcarrier output while the 0-80 volt peak-to-peak adjustable reference signal is supplied through an unterminated jack.

SOLID-STATE COUNTER

11 **Northeastern Engineering, Inc.** has made available the Model 10-81, a fully solid-state counter of low panel height and 8-digit in-line presentation.

Nine standard output frequencies are available in decade steps from 0.1 cps to 10 mc.

from a source impedance of 1000 ohms. Of these nine frequencies 1 and 10 mc. are sine wave, while the balance are rectangular pulses.

The basic 12" model is supplied with 14" rack panel mounts.

X-Y RECORDERS

12 **F. L. Moseley Co.** has developed two low-cost X-Y recorders, designed to plot a great many functions in industrial production, research, and testing.

The recorders, called Models 135C and 2D4,

will draw cartesian coordinate curves from two related sources of d.c. electrical information on standard graph paper. The Model 135C has a writing area of 7"x10", while the Model 2D4 has a 10"x 15" writing area.

Ten calibrated input ranges from 0.6 millivolt per division to 10 volts per division may be selected from the front panel. One per-cent resistors are used in the attenuator. Any one range may be calibrated to 0.1% of full scale by easily accessible controls. A variable range control allows any arbitrary voltage, within recorder limits, to be set to full scale.

PC-BOARD HEAT SINKS

13 **Accel Electronics Products Company** is introducing its Series E circuit-board-mounting transistor heat dissipators.

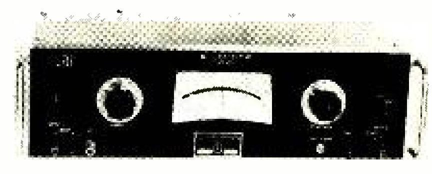
The expanded surface provides over 40% more cooling area, where serrations are used, and provides up to 20 watts dissipation in free air. The high thermal conductivity aluminum extrusion is basically 2½" wide x 5/8" high and comes in three standard lengths, 1.5", 2.5", and 3.5".

The series is available in standard or foot lengths, punched, blank, anodized, or unfinished.

GALVANOMETER-NULL DETECTOR

14 **Julie Research Laboratories, Inc.** is now marketing a new solid-state electronic galvanometer-null detector as the Model ND 106.

The instrument has a sensitivity of 0.2μv. and an input impedance of better than 100,000 ohms. The unit incorporates a high gain, chopper-stabilized d.c. amplifier, a calibrated attenuator,



and a differential d.c. output amplifier. The instrument has provisions for zeroing the meter for both short-circuit and open-circuit conditions.

Output may be selected to be: calibrated, variable, or logarithmic. The input circuit is completely isolated from ground. A guard terminal permits the instrument to read voltages above 100 volts off ground. Output terminals provide approximately ± 2 volts for full-scale meter deflection.

SERVICE DATA PACKS

15 **Colorgrams Inc.** has recently introduced a series of "Service-Paks" consisting of color-coded charts covering various circuits in the TV receiver, a master schematic, and a manual incorporating the original manufacturer's service notes plus special hints, instructions, and parts numbers.

Developed by Paul B. Zbar and Robert Cornell, both with extensive servicing backgrounds, the use of individual "Colorgram" charts facilitates troubleshooting key circuits with the signal flow paths in color. These partial schematics are color-keyed to the master schematic which is designed to be hung over the bench as an over-all plan.

At the present time the service includes the most popular TV chassis of **RCA**, **G-E**, **Motorola**, **Admiral**, **Westinghouse**, **Philco**, **Emerson**, and **Magnavox**, numbering 50 "Service-Paks," covering approximately 1400 models.

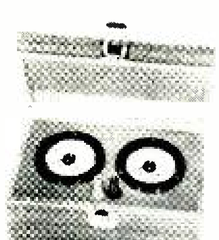
SILICON POWER RECTIFIERS

16 **International Rectifier Corporation** is now in production on a new series of 70- to 250-amp rated silicon rectifiers designed to meet NEMA standards and operate with high-reliability in electromechanical processing and general industrial service.

The new units are capable of withstanding voltages having a value 2.5 times the working peak reverse voltage without a permanent change in diode characteristics. The new devices have voltage ratings of 900 volts repetitive p.r.v., 1200 volts transient p.r.v., current ratings of 250 amperes continuous, and 1500 amps peak 1-cycle surge current capability.

400-CYCLE TEST SET

17 **AMF Instrument Division** has developed a new 400-cycle test set, Model PTS-12C, which is designed to meet the need for an instrument to provide laboratory-standard accuracy for frequency and voltage measurements in the field.



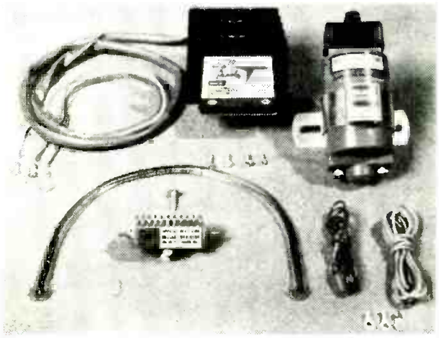
The instrument consists of two of the company's precision meters, each with 250-degree expanded-scale dials, mounted in a durable formica case with detachable hinged cover and handle. Both voltmeter and frequency meter are temperature compensated to maintain accuracy over the range of −30° to +50° C and are ruggedized to assure reliability despite shock and vibration encountered in field use.

Information on available ranges and accuracies will be supplied on request.

TRANSISTORIZED IGNITION SYSTEM

18 **Slep Electronic Company** is now offering a moderately priced transistorized ignition system which is available in 6- and 12-volt models, positive- or negative-ground.

The Model TS-30 system can be installed in all types of automobiles, foreign and sports cars; freight and fire trucks; police cars; speed, pleasure, and fishing boats; tractors and other farm equipment. The negative-ground system comes



complete with 250:1 turns ratio coil while the positive-ground system has a 500:1 coil.

HI-FI—AUDIO PRODUCTS

ELECTRONIC ORGAN KIT

19 Artisan Organ Company is now offering a new compact organ in kit form as the "York."

The new instrument has a "theater-type" horseshoe console and is designed for areas where space

is limited. The circuit incorporates two full-size 61-note manuals, 25-note pedal keyboard, dual expression pedals, and 40 multi-colored stop tabs.

The organ is designed to be played through the customer's hi-fi mono or stereo audio system. Optional audio components are available if required.

INTEGRATED STEREO UNIT

20 Fisher Radio Corporation is now offering a 75-watt integrated FM/stereo/multiplex unit as its Model 500-C. The new instrument incorporates the firm's "Stereo Beacon" for signalling

and switching to stereo or mono, four i.f. stages, a d'Arsonval tuning meter, time-division multiplex section, 1.8 μv. sensitivity (IHF), and the company's "Golden Synchrode" front-end.

The unit measures 17½" wide x 5¾" high x 13½" deep. It weighs 36½ pounds.

LIGHTWEIGHT MONO RECORDER

21 Concord Electronics Corporation has added a new lightweight mono tape recorder to its line which is being marketed as the Model 104 "Compact."

The new unit offers two speeds (3.75 and 7.5 ips), 7" reel capacity, magic-eye record level indicator, and mixing facilities. Separate jacks allow monitoring during recording, private listening through an earphone, and connection to an external speaker. Frequency response is 50-12,000 cps at 7.5 ips; signal-to-noise ratio is better than 35 db; wow and flutter is less than .25% at 7.5 ips. The instrument measures 5½"x 12½"x 10½" and weighs 10½ pounds.

POLE-MOUNTED SPEAKER

22 **Wald, Inc.** has added a unique hi-fi speaker system to its line of wood enclosures.

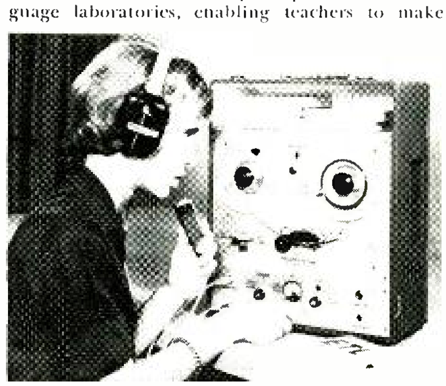
The "Stereo Master" is pole-mounted with a spring-loaded top section enabling it to fit all standard ceiling heights. Enclosures are finished on all four sides for placement anywhere in a room or for use as a room divider.

Internal capacity is in excess of 4620 cubic inches and acoustic lining is used to prevent bass reverberation. The enclosures are supplied with a **Jensen** 8" extended-range woofer, 3½" tweeter, and crossover network. The cabinet dimensions are 40" high x 11" wide x 10¼" deep.

CLASSROOM TAPE RECORDER

23 **Electronic Teaching Laboratories** has recently introduced a multi-purpose, dual-channel tape recorder which combines five different study and teaching features for language training, speech therapy work, public speaking training, and other educational purposes.

The "Monitor II" features individual-study tape recorder for use with dual-track language tapes, permitting students to record language response, erase, and re-record without erasing master lesson material; tape duplication for language laboratories, enabling teachers to make



new master tapes; master tape recording from live voices; provision for student monitoring by teacher; loudspeaker for class language drills, recorded readings, and music.

The unit operates at 3.75 and 7.5 ips speeds and measures 17"x 14"x 9".

OUTDOOR SPEAKER SYSTEM

24 **University Loudspeakers** has recently introduced a new weatherproof speaker system engineered for outdoor and indoor public-address applications requiring high-fidelity reproduction.

The Model CLC is equipped with a "U" bracket permitting either vertical or horizontal mounting. Frequency response is 55-14,000 cps, dispersion is 90 degrees, and impedance is 8 ohms. The system will handle 30 watts. Over-all diameter is 22¾" while the housing is 12$^{11}/_{16}$" deep.

RECORD EQUALIZER

25 **Gray Research and Development Co., Inc.** is in production on a new passive record equalizer for stereo and mono discs, designed to permit broadcast stations to install new stereo facilities, to convert existing mono facilities to stereo, or to simply improve mono performance.

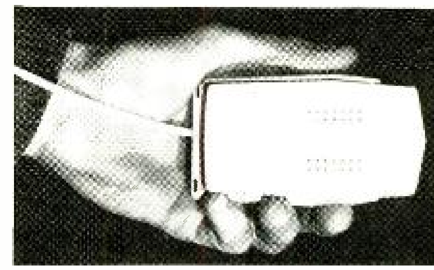
The Model 601-M/S equalizer takes the constant velocity output of either stereo or mono magnetic cartridges and feeds their signal into the low-impedance microphone channels on a stereo mixing console, automatically compensating for both cartridge output and recording characteristics.

The unit can be used with either high-imped-

ance magnetic stereo cartridges or low-impedance mono cartridges.

TAPE-RECORDER MICROPHONES

26 **Sonotone Corporation** has added two new microphones to its line of ceramic units designed especially for use with tape recorders. The



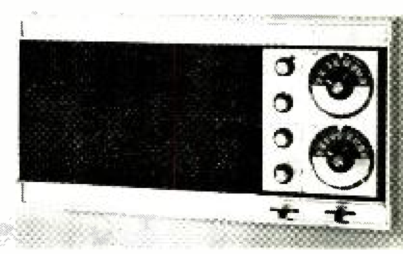
Models CM-40 and CM-41 are slim, light, and styled in an ivory high-impact plastic case. Both models feature a swing-type stand for table use. Both are equipped with five feet of shielded cable with phone plug.

Frequency response of both models is 40-8000 cps with −50 db sensitivity. The CM-41 is identical to the CM-40 except that it is equipped with a push-to-talk d.p.d.t. switch.

TRANSISTORIZED INTERCOM/RADIO

27 **NuTone, Incorporated** is marketing a fully transistorized intercom-radio system which has been especially designed for built-in installation in homes.

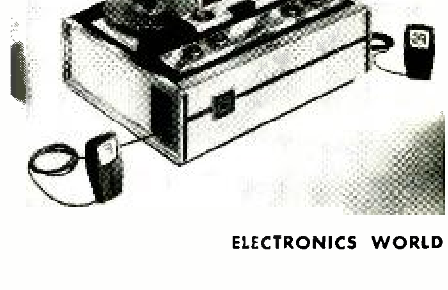
The system features an 8-wire cable hookup that makes independent intercom possible. The 8-wire cable is wired station to station, not back to the master, for ease of installation. The master unit, with 9"x 6" speaker, is available in silver



or copper finish. Special remotes for the system include 5" speaker, 8" hi-fi speaker with detachable remote control, door speaker, and 8" outside patio speaker.

STEREO RECORDER

28 **Argus Incorporated** has entered the recorder field with its Model 800, a full stereo unit featuring four-track stereo and mono recording.



According to the company, the unit has less than .2 of 1% wow and flutter at the 7.5 ips speed. A special "Simul Sound" circuit permits the user to listen to what has been previously recorded while simultaneously recording on another channel.

The recorder operates at 7.5, 3.75, and 1⅞ ips; will handle 7" reels with the cover closed; operates vertically or horizontally; has a frequency response of 10-15,000 cps at 7.5 ips, 60-kc. bias frequency, calibrated electronic level control, digital counter, input or output jacks, and two 6"x 4" speakers.

CB-HAM-COMMUNICATIONS

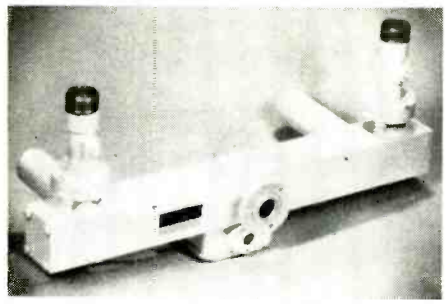
MARINE RADIOTELEPHONE

29 Bendix Marine is currently introducing a new model radiotelephone which meets the need for a 70-watt unit of compact size and low current drain. The "Skipper 372" is the same physical size as the firm's "Skipper 242," has six channels in the 2- to 4.5-mc. frequency range, and features a tunable broadcast band. Rated output is 41 watts to a 50-ohm antenna load or 37½ watts to a 10-ohm load. Features include a built-in noise limiter, squelch control, radiation indicator lamp, and sensitivity of 3-5 µv.

The unit is 5⅜" high x 10" wide x 13¼" long. It weighs 15.5 pounds and comes complete with microphone, universal mounting bracket, built-in speaker, and two sets of crystals.

HIGH-POWER COAX SWITCHES

30 Mark Products is now offering high-power coaxial switches, using transmission line principles, for 200 to 2500 mc. The switch shown is rated for 2000 watts c.w. for 425 mc. with 10% bandwidth (v.s.w.r. less than 1.15). The switch operates at 117 volts, 50 watts. The switches come equipped with EIA flange input connector and type LC output connectors.



Details on the entire line are available from the manufacturer.

GROUND RADIAL SYSTEM KITS

31 Ready-Radials is now offering ground radial systems in kit form for improved performance from long-wire, vertical, and other ham and SWL antennas which operate against ground.

The radial systems are being marketed in two sizes to meet most ham and SWL requirements. The No. 14 solid copper radial wires are electrically and mechanically bonded to a center hub. Drive pegs are provided for securing radial wire ends. The radials can be buried.

The 1000-foot kit includes ten 60-foot, eight 33-foot, and eight 17-foot radials while the 2000-foot kit has twenty 60-foot, sixteen 33-foot, and sixteen 17-foot radials.

U.H.F. BEAM-POWER TUBE

32 RCA Electron Tube Division has developed a new forced-air-cooled u.h.f. beam-power tube for use in pulsed r.f. amplifier service in compact aircraft, mobile, and stationary equipment.

Designated the RCA-8184, this cermolox tube is rated for a maximum peak power input of 2 megawatts as a plate-pulsed r.f. amplifier at the following conditions: for a maximum "on" time of 10 µsec. in any 2000-µsec. interval, and for frequencies up to 500 mc.

The design includes an integral louvered-fin radiator for efficient axial forced air cooling.

OPTICAL COMMUNICATIONS SYSTEM

33 Westinghouse Electric Corporation has developed a frequency-modulated optical communications system which ultimately could be used for spacecraft communication, particularly during rendezvous.

The system uses the input signal to vary the wavelength or frequency of the transmitted optical beam. Special features of the new system, in addition to frequency modulation, are increased information security, relatively high

bandwidth which permits multiplexing of audio channels, high anti-jam characteristics, and simplicity of operation.

TUNABLE CB FILTER

34 **Gavin Instruments, Inc.** is now marketing a tunable Citizens Band filter, the Model CB-F. Utilizing a multi-section filter circuit, the unit provides more than 30 db attenuation of signals above 28 mc. Insertion loss is less than 1 db. This means a maximum bandpass of CB signal and efficient suppression of unwanted signals and harmonics which disturb normal TV reception.

Special input and output tuning trimmers are

included and, once adjusted, they permit exact matching of the transmitter to the antenna. Easily installed between the transmitter and the antenna, the device weighs only 1 pound and measures 4" x 2¼".

TRANSISTORIZED V.L.F. RADIO

35 **Western Geophysical Company of America** has developed a v.l.f. radio receiver operating in the 12-kc. to 25-kc. range which is designed for field use anywhere in the world.

The instrument is completely transistorized and weighs 2½ pounds in the a.c. model or 3½ pounds in the battery-powered d.c. version. Sensitivity is such that ¼-μv. input will give full audio output to the headphones. The unit is temperature-stable from −40 to +140 degrees F. Power drain is under ½ watt on the d.c. model and under 2 watts on the a.c. It measures 3⅛" x 3¾" x 9½".

HELICAL ANTENNAS

36 **Technical Appliance Corporation** is now marketing two six-turn helical antennas operating in the frequency band from 300 to 520 mc. The Types G-1215 and G-1257 are identical except for the input connector assembly. The G-1215 is a transmitting antenna with an LC connector for power ratings of 1-kw. average while the G-1257 uses an N connector.

Both antennas operate in the axial mode with a circularity of 1.5 db or better.

MANUFACTURERS' LITERATURE

TRIMMING POTS

37 **Weston Instruments & Electronics Division** has issued a technical data sheet on the Daystrom 316 Series "Squaretrim" subminiature trimming pots which provides complete specifications covering this ½"-square adjustable potentiometer.

In addition to actual-size photographs, the technical data sheet contains detailed electrical, mechanical, and environmental specifications. Modification possibilities are also shown. Complete engineering drawings, power rating curves, and circuit diagram round out the presentation.

TV DISTRIBUTION SYSTEMS

38 **Jerrold Electronics Corporation** is now offering literature covering a completely new line of television distribution equipment for homes, motels, apartment buildings, and hospitals.

The information, including photographs, charts, block diagrams, and specifications, covers a wide range of newly developed systems and components. Data is provided on master antenna system yagis; high-output, broadband amplifiers; and the new "Ultra-Tap," an all-purpose tap-off unit meeting all architect and installer design requirements.

PERMANENT MAGNET MANUAL

39 **General Electric Company** has available a 40-page illustrated brochure, No. PM-200, on the theory, characteristics, design, and application of permanent magnets.

The two-color publication contains sections on the theory of magnetism, characteristics of magnetic materials, energy and permanent magnets, magnet stability, as well as a discussion of the various types of magnetic materials—"Alnico," "Lodex," platinum-cobalt, and hysteresis alloys.

CURRENT REGULATOR

40 **Regulus Inc.** has issued a four-page illustrated data sheet covering its Model I d.c. current regulator which is designed to deliver pre-set current by programming at the unit or from a remote location.

The brochure outlines the important features of this solid-state device, covers applications, provides a circuit diagram of the unit, and lists complete electrical and mechanical specifications.

MOLDED WIREWOUNDS

41 **Ohmite Manufacturing Company** has issued a four-page catalogue sheet, Bulletin 153E, covering its "Riteohm 88" line of molded wire-wound resistors.

The data sheet provides general information, MIL standard values, derating graphs, application details, and a listing of available ohmages and wattages.

MEMORY TEST SYSTEMS

42 **Digital Equipment Corporation** has issued a 20-page report covering memory core testers for research and product applications, memory testers for coincident current and word address planes and stacks, and memory exercisers for testing complete memory systems.

The brochure is lavishly illustrated with photographs, block diagrams, and tables along with complete electrical and mechanical specifications and performance features.

TECHNICAL BOOK LIST

43 **John F. Rider Publisher, Inc.** is now offering a 64-page catalogue covering a complete line of technical books and servicing manuals issue by the firm. Included are books on basic electricity and electronics, radio, television, audio, industrial electronics, and computers.

INTERCHANGEABILITY GUIDE

44 **Semitronics Corp.** is offering a wall chart covering replacement and interchangeable transistors. American-made replacements are listed, along with foreign substitutes for a wide range of power, high-wattage, high-current, audio, r.f., and "n-p-n" transistors. Basing diagrams are also included on this handy chart.

MICROWAVE ANTENNAS

45 **Technical Appliance Corporation** has issued a 20-page, two-color catalogue, No. 100, covering its greatly expanded line of microwave antennas and accessories. Antennas operating from 806 mc. to 12 gc., microwave antennas for special applications, as well as a complete line of feeds, mounts, radomes, and control and thermostat kits are included.

TEST & MEASURING EQUIPMENT

46 **Kay Electric Company** has issued a 100-page, 2-color catalogue covering its line of precision test and measuring instruments.

Complete data on the firm's lines of sweeping oscillators, audio spectrum analyzers, noise generators, attenuators and oscillators is included, along with photographs, special features, and detailed specifications—both mechanical and electrical.

The catalogue is cross-indexed for rapid product identification according to product name, category, and page number.

PRODUCT CATALOGUE

47 **Mallory Controls Company** is now offering a new 92-page product catalogue covering its line of wirewound resistors, film resistors, power rheostats, variable wirewound controls, switches, jacks, plugs, and accessory items.

The catalogue contains hundreds of photographs and drawings which assist in the specification of stock or customized components. Technical data pertaining to performance characteristics is also included.

SOLID-STATE POWER SUPPLIES

48 **Advanced Electronics Corp.** has published a data sheet covering a new series of low-power-output subminiature solid-state d.c.-to-d.c. power converters with wide applications in airborne telemetry systems and in missile, radar, beacon, and other electronic equipment.

The catalogue sheet illustrates and describes sample versions of the power supplies with inputs of 24 or 30 volts and outputs of from 30 to 180 volts.

CRYSTAL SPECIFICATIONS

49 **Reeves-Hoffman** is offering copies of its four-page letterhead-size bulletin which gives detailed technical specifications on three ultra-precision crystals at frequencies of 1000 kc., 2500 kc., and 5 mc.

Frequency tolerance, holder types, temperature range, temperature coefficient, anti-resonant effective resistance, aging, vibration and shock permitted, and typical electrical equivalent parameters are given for these three crystals.

TRANSFORMER-RECTIFIERS

50 **Tung-Sol Electric, Inc.** has issued a short-form catalogue listing specifications on 22 different models of transformer-rectifiers. These units convert 400-cps, 200-volt a.c. to 28-volt d.c. to supply airborne equipment in missiles, aircraft, helicopters, and accessory pods. Output currents range from 5 amps to 200 amps.

The six-page brochure shows illustrations of each of the 22 models and lists electrical and physical specifications on each unit.

ALUMINUM SOLDERING

51 **Paraco Metals, Inc.** is offering two catalogue sheets, one covering techniques for soldering aluminum with "Paraco-Bond 61" and the other a price list for the product in rod, bar, powder, and foil forms.

The product itself permits aluminum soldering without flux and the catalogue sheet details the process from method for heating to applications procedure and uses.

VOLTAGE SURGE PROTECTION

52 **International Rectifier Corporation** has published a 20-page manual containing complete data on the protection of silicon rectifier diodes, transistors, silicon controlled rectifiers, and other semiconductors through the use of selenium transient voltage suppressors.

Included in the five chapters of the manual are sources and types of voltage transients, selecting the proper voltage suppressor, suppressor advantages, and suppressor characteristics.

ZENER REFERENCE DIODES

53 **Lafayette Industrial Electronics Division** has issued a four-page data sheet covering **Dickson** temperature-compensated zener reference diodes which it is prepared to supply from stock.

The data sheet provides complete electrical and mechanical specifications on the line along with information on MIL-S and tolerance.

GAS LASERS

54 **Sylvania Electric Products Inc.'s** Microwave Device Division is now offering a free brochure describing its line of continuous-wave gas lasers. The new brochure features a new mirror-mounted laser with a base usable as a perot interferometer. Included are a component list of each laser and photographs of mode patterns. Image converters and power supplies are also described.

CAPACITOR CROSS REFERENCE

55 **Electra Manufacturing Company** is now offering an easy-to-use cross reference guide to MIL-C-26655/2B. The guide outlines dimensions, type, case size, voltage, capacitance, and tolerance for both insulated and uninsulated solid tantalum capacitors.

CAPACITOR SELECTOR

56 **Cornell-Dubilier Electronics Division** is now offering two 17" x 22" wall charts which have been compiled to aid circuit designers select electrolytic capacitors for commercial, industrial, and military applications. One chart covers aluminum electrolytics while the second deals with niobium and tantalum types. ▲

REAL "COOL" CHASSIS

By THOMAS R. HASKETT

IF YOU assemble circuits with any regularity, either on your own or in a shop, save the ice-cube trays from that old refrigerator or pick some up at a junkyard. They are made of aluminum and are easy to work. Their shape tends to be very similar to the expensive, military-type, plug-in chassis that are widely used. In fact, many of them come with handles in the front, so that you can install Jones, Amphenol, or other types of connectors on the rear apron and turn them into plug-in units, if you desire. ▲

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Answer to Electronic Crosswords

(Appearing on page 77)

M	E	T	E	R				P	H	A	S	E
O	V	E	R	L	Y	■	T	A	R	G	E	T
T	E	A	R	■	A	D	O	■	B	O	A	T
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E	L	A	T	E	■	D	■	S	T	A	R	E
D	E	B	A	T	E	■	L	O	U	D	■	R

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ELECTRONICS ENGINEERING AND INSTRUCTION

USED Correspondence Courses and Books sold and rented. Money back guarantee. Catalog Free. (Courses Bought.) Lee Mountain, Pisgah, Alabama.

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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"DRAFTING, Reading Blueprints, Schematics. Send $2.00 first lesson, complete home course $25.00. Prior, Inc., 23-09 169 Street, Whitestone 57, New York."

ELECTRONIC Explanations Superheterodyne Converter Description, Components Function, Servicing Procedure. $1.00. AJAN, Box 4154, Hamden 14, Conn.

HIGHLY-effective home study review for FCC commercial phone exams. Free literature! Wallace Cook, Box 10634, Jackson 9, Miss.

FOR SALE

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.

MAILORDER courses. Fantastic discounts. Selmar Scientific, 14808 N 30th Drive, Phoenix 23, Arizona.

COLOR television, black-white television converts to color, easily installed. Send size of screen and $2.98. Delecto Electronics, 4725-45th N.E., Seattle, Wash.

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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.

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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.

CB transmitters $6.00. Other bargains, send 10¢ for list. Vanguard, 190-48 99th Ave., Hollis 23, N.Y.

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

TEST Equipment. Techtronics 511AD—$225.00; 512—$225.00; 513—$425.00; 514—$450.00: Measurements Model 80—$300.00. Equipment bulletin on request. Rex, 84 Cortlandt St., New York 7.

CLOSED circuit RCA camera with lens and 6944 vidicon, new, $350.00. Colonial Plaza Motel, Berwyn, Md.

TUBES

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.

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FREE Catalog—name brand tubes 65% discount, phono needles 80% or more discount, phono cartridges, picture tubes 75¢ inch, parts, parts kits, silicon and selenium rectifiers, transmitting tubes, 7" T.V. test tube $6.99, imported batteries, tube testers etc. Want to swap or sell tube inventory? Send us your offering. Arcturus Electronics Corp., Dept. Z.D., 502 22nd St., Union City, N.J.

WANTED

CASH Paid! Sell your surplus electronic tubes. Want unused, Clean radio and TV receiving, transmitting special purpose, Magnetrons, Klystrons, broadcast types. Want military and commercial lab/test equipment such as G.R.H.P., AN/UPM prefix. Also want commercial Ham Receivers and Transmitters. For a Fair Deal write: Barry Electronics Corp., 512 Broadway, New York 12, N. Y. (Walker 5-7000).

QUICKSILVER, Platinum, Silver, Gold. Ores Analyzed. Free Circular. Mercury Terminal, Norwood, Massachusetts.

ARMY Sets or Parts—GRC—PRC—FRR/URR—TCC—SB—SCR—Send Listings—Quick Cash. Anker Electronics, 1617 So. Main St., Box 26, Wilkes-Barre, Pa.

TAPE AND RECORDERS

TAPE Recorders, HI-FI Components. Sleep Learning Equipment, Tapes. Unusual Values. Free Catalog. Dressner, 1523 EW Jericho Turnpike, New Hyde Park 10, N.Y.

RENT Stereo Tapes—over 2,500 Different—all major labels—free catalog. Stereo-Parti, 811-G, Centinela Ave., Inglewood 3, California.

SELF-Hypnosis. New concept teaches you quickly by tape or LP-record. Free literature. McKinley Publishers, Dept. T6, Box 3038, San Bernardino, California.

SAVE 30% Stereo music on tape. Free bargain catalog/blank tape/recorders/norelco speakers. Saxitone, 1776 Columbia Road, Washington, D.C.

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RECORDERS, Components! Free wholesale catalogue! Carston, 125-R, East 88, N.Y.C. 28.

LOW, LOW quotes: all components and recorders. Hi-Fi, Roslyn 9, Penna.

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WANT to sell good equipment and accessories? Place a low-cost classified ad in this space. For information, write: Martin Lincoln, Electronics World, One Park Avenue, New York 16, N.Y.

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TV Tuners rebuilt and aligned per manufacturer's specifications. Only $8.50. Guaranteed. We ship cod. Valley Tuners, 5641-B Cahuenga, North Hollywood, Calif.

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GOVERNMENT Surplus Direct From Government. Jeeps $264.00. Radios $2.53, Typical Prices. Guns, Typewriters, Cameras, Tools, Thousands More. Amazing Low Prices. How, Where To Purchase, Merchandise Available, Etc., Only $1.00 To: Surplus, P.O. Box 50512, Dept. R, New Orleans 50, Louisiana.

BUSINESS OPPORTUNITIES

EARN extra money! No investment required. Part-time selling; brand name hi-fi components at discount prices. Exclusive territories. To qualify you must be a hi-fi enthusiast or knowledgeable in field. Give full info. by letter including 3 business refs. & bank. Greatest opportunity for extra earnings ever offered. Write: I F A Electronics, P. O. Box 559, Encino, Calif.

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A HANDY GUIDE TO PRODUCTS, NOT NECESSARILY ELECTRONIC, BUT OF WIDE GENERAL INTEREST.

PHOTOGRAPHY — FILM, EQUIPMENT, SERVICES

MEDICAL FILM—Adults only—"Childbirth," one reel, 8mm $7.50; 16mm $14.95. International W, Greenvale, L.I., New York

SCIENCE Bargains—Request Free Giant Catalog "CJ"—144 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts. War surplus bargains. Edmund Scientific Co., Barrington, New Jersey.

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LEARN while asleep. Remarkable, scientific. 92% effective. Details free. ASR Foundation, Box 7021, Dept. e.g., Lexington, Kentucky.

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Your classified ad in this space will be read by more than 200,000 buyers. It costs only 60¢ per word. For information, write: Martin Lincoln, Electronics World, One Park Avenue, New York 16, N.Y.

BUSINESS OPPORTUNITIES

MISCELLANEOUS

ELECTRONICS WORLD JUNE 1963

ADVERTISERS INDEX

Printed in U.S.A.

Beauty
TO UHF CONVERTERS

The Model "A", the only UHF converter you can show and sell with pride. Designer styled in beige and tan to blend with today's decor . . . to harmonize with modern TV cabinet design. Standard waited . . . and tested, analyzed, and re-tested until they could bring you the quality instrument you and your customers have a right to expect from the leading manufacturer of tuners. As a result, you now have a converter which is beautiful, *profitable, and dependable.*

PERFORMANCE YOU CAN SEE

New low-noise, shielded tuner permits fine tuning for all 70 UHF channels. Functions perfectly with color or black and white sets. Two simple controls: one for VHF, UHF, and "off" . . . the other for channel selection and fine tuning. The "SK" installs in about a minute with just a screw-driver.

POWER IN PROMOTIONAL SUPPORT

With a first order of 12 units or more, Standard supplies 3 newspaper ad mats . . . 3 radio spot scripts . . . materials for a powerful TV spot . . . 2-color catalog sheets . . . a giant (3′ x 6′) 2-color window banner . . . a counter card . . . as many pre-printed jumbo post cards as you can use PLUS hard hitting ads in TV Guide.

Feature this exciting counter-top display carton

Contact your Standard representative . . . or write

standard kollsman INDUSTRIES, INC.

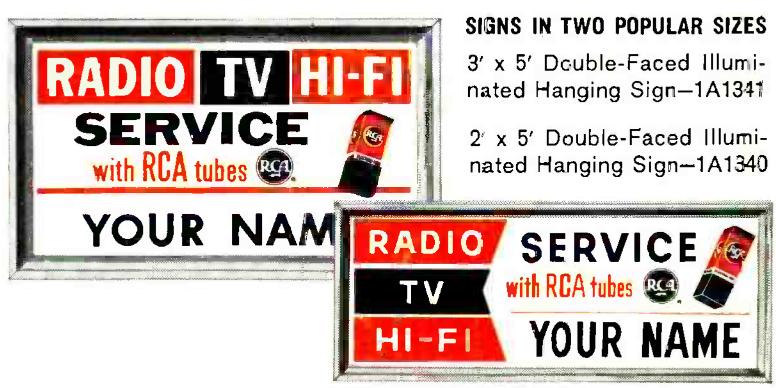
Formerly Standard Coil Products Co., Inc., Melrose Park, Illinois / WORLD'S LARGEST MANUFACTURER OF TELEVISION TUNERS

CIRCLE NO. 142 ON READER SERVICE CARD

Let RCA put your name in lights

Put a bright new face on your store front with a striking illuminated outdoor hanging RCA business sign. Through Authorized RCA Tube Distributors, RCA offers you a choice of two new double-faced illuminated shop signs imprinted with your business name. Made of weather-proof translucent plastic, RCA business signs:

- Brighten your entire shop front
- Give your business a smart, modern, efficient appearance
- Focus attention on your services
- Fix your shop location in the minds of potential customers
- Associate your business with the prestige and customer acceptance of RCA—the most trusted name in electronics



SIGNS IN TWO POPULAR SIZES

3′ x 5′ Double-Faced Illuminated Hanging Sign—1A1341

2′ x 5′ Double-Faced Illuminated Hanging Sign—1A1340

Find out now how you can get yours. Your participating Authorized RCA Electron Tube Distributor has all the facts. Call him today.

RCA ELECTRON TUBE DIVISION, HARRISON, N. J.

The Most Trusted Name in Electronics