Electronics World

MAC 1
JANUARY, 1963
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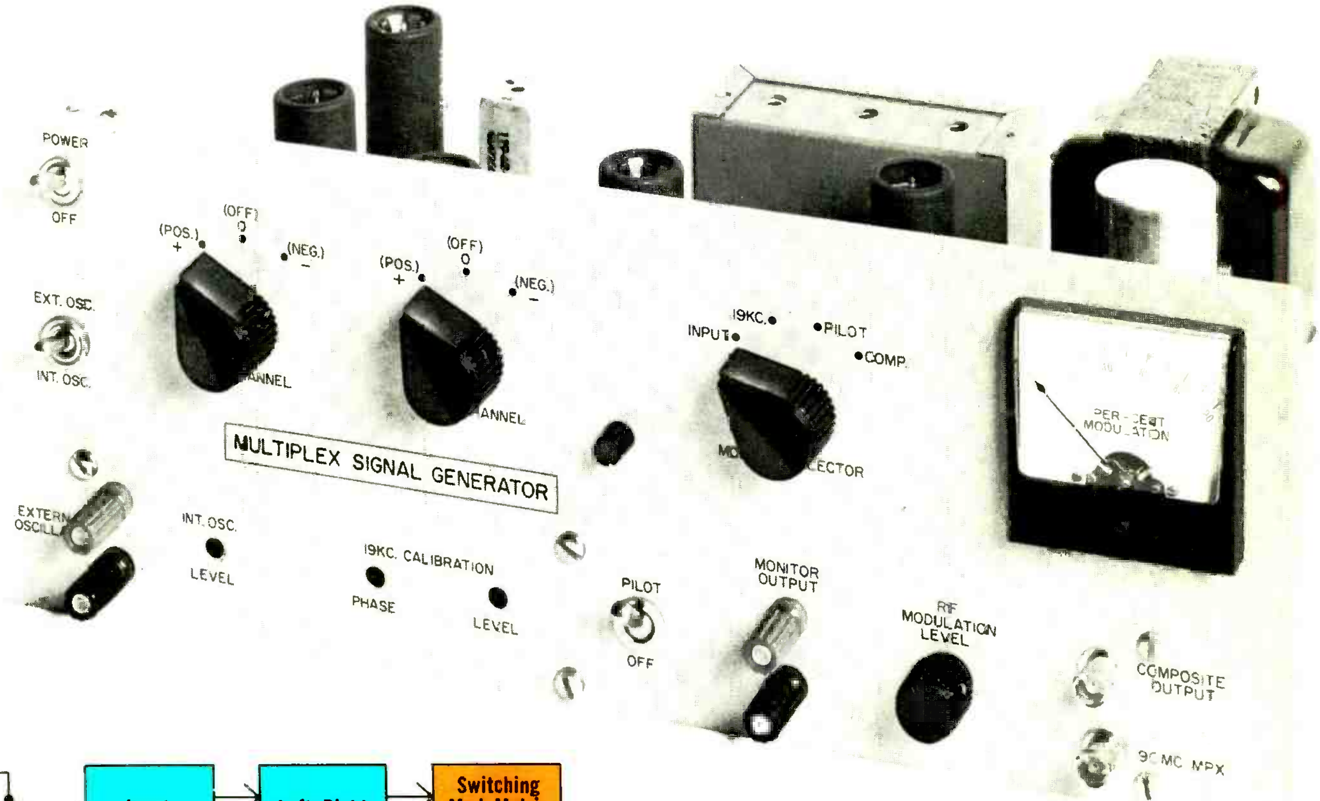
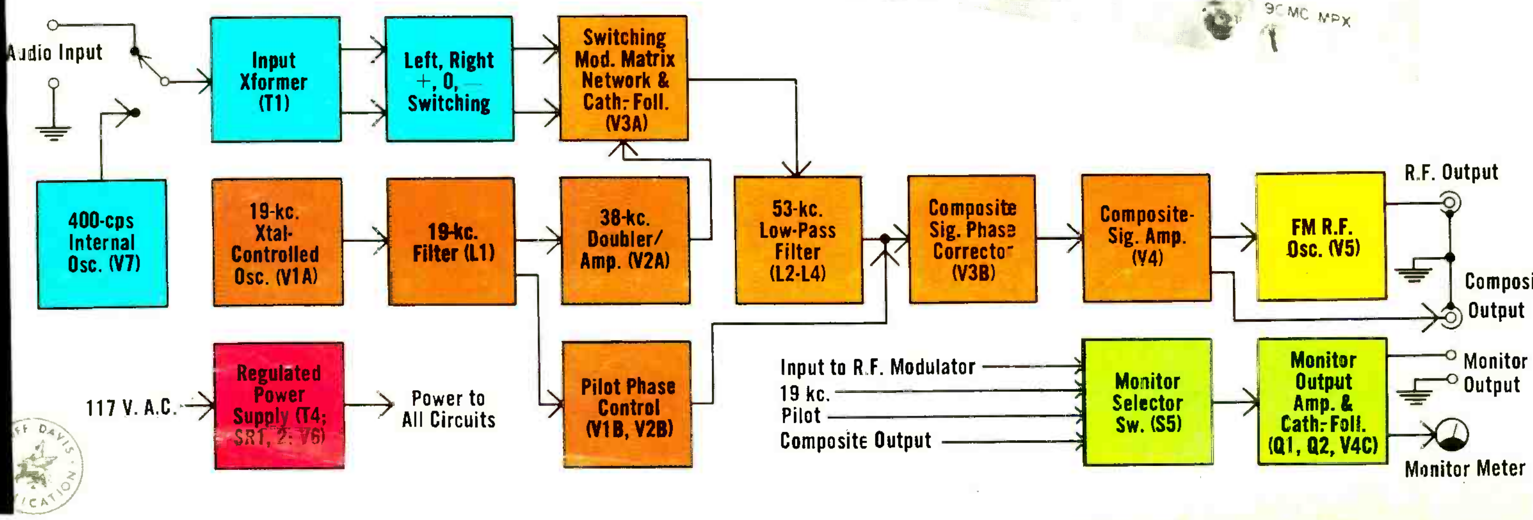
MICROELECTRONICS—*How integrated circuits are made and used.*

CHECKING SPEAKERS BY EAR

FCC ANSWERS QUESTIONS ON BUSINESS RADIO

Construction of FM MULTIPLEX SIGNAL GENERATOR





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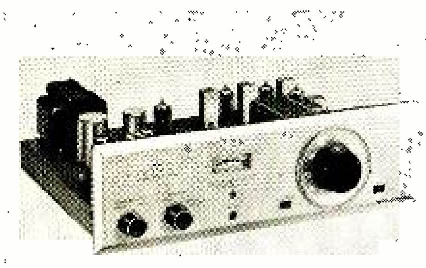
Scott Stereo Tuner Kit Wins Rave Reviews from every Leading Hi-Fi Expert!

Just one year ago Scott introduced the LT-110 FM Stereo Tuner Kit. High Fidelity Dealers built this superb kit themselves, examined its many features, and recommended it without reservation. Enthusiastic kit builders deluged us with mail. Now the verdict is in from all the leading technical experts. Never before in the history of the industry has a single kit received such unanimous praise. We reprint a few excerpts below.



from POPULAR ELECTRONICS

"No commentary on *Scott Kits* would be complete without first mentioning that this company pioneered new areas in the hi-fi kit market and brought forth several (then-radical) innovations. One of them continues to fascinate all purchasers of a *Scott Kit* — the full-color instruction manual. . . . Scott also pioneered the Kit-Pak — a shipping container which serves as a temporary workbench and storage box . . . a test model of the LT-110 was wired at POPULAR ELECTRONICS in just under five hours. Another 40 minutes was used for careful alignment and the tuner was "on the air." . . . The LT-110 met or exceeded all the manufacturer's detailed specifications on sensitivity, distortion, output level, a.c. hum, and capture ratio . . . the audio response is excellent, being within ± 1 db, from approximately 20 to 16,000 cycles. . . . Channel-to-channel crosstalk is particularly excellent both in terms of uniformity and the fact that it holds up well above 10,000 cycles. . . . Frequency drift of the LT-110 from a cold start is extraordinarily low — less than 5 kc. The a.c. hum level (referred to 100% modulation) is low and exceeds the manufacturer's rating by 5 db. . . . It's difficult to imagine a kit much simpler to assemble than the LT-110. The full-color instruction book eliminates just about the last possible chance of wiring errors. . . . From a plain and simple operational standpoint, the LT-110 *works well and sounds good*."

Popular Electronics, Oct. 1962

from ELECTRONICS WORLD

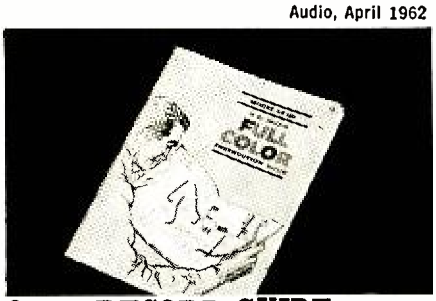
"Construction time for the unit we tested was 6½ hours, without alignment . . . in listening tests, the tuner showed its high useable sensitivity to good advantage. Using an in-door antenna which produced marginal signal to noise ratios on most other tuners we were able to get noise-free, undistorted stereo reception. It's quite non-critical to tune, hardly requiring the use of its tuning meter."

Electronics World, Nov. 1962

from AUDIO

"The LT-110 (is) so simple to build that we unhesitatingly recommend it for even the novice. . . . We found that the useable sensitivity (IHFM) was 2.1μv . . . a fine stereo tuner and an unusually easy kit to build."

Audio, April 1962



from RECORD GUIDE

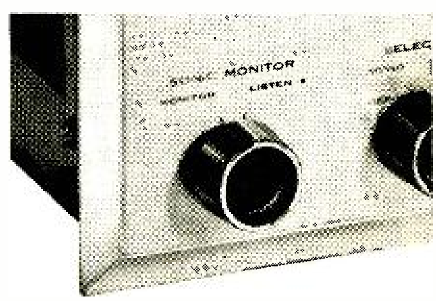
"It seems to me that every time I turn around I am building another of H. H. Scott's kits. And each time I end up praising the unit to the skies.

The Scott instruction books should be a model for the industry. They feature full-color, step-by-step, illustrated directions. Each resistor or other component is shown in the progressive phases in its color code and in its proper position. . . .

There is no audible drift in the LT-110 whatever. You can shut the tuner off on a station and pick it up the next day, perfectly tuned, without touching the tuning dial. No AFC circuits are included in this tuner and none are needed.

This tuner kit has to be ranked on the same plane as H. H. Scott's factory-wired units. It is an excellent product, and because of its conservative parts very likely to give long, trouble-free service."

American Record Guide, Sept. 1962



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*Patent Pending. (All prices slightly higher West of Rockies.)

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JANUARY 1963 / VOL. 69 NO. 1

Electronics World

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Editorial and Executive Offices
One Park Avenue
New York 16, New York
ORegon 9-7200

MIDWESTERN and CIRCULATION OFFICE
434 South Wabash Avenue
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COMING NEXT MONTH

Special Feature

Electric Shock—On Purpose—Carefully controlled shock can facilitate medical diagnosis, treat diseases, and save lives. Some of the techniques in use and the electronic circuitry required are described by Ed Bukstein, author of the authoritative text "Medical Electronics."

DIGITAL READOUTS
You can "see" a signal on an oscilloscope, but these optical, electro-mechanical, or mechanical/optical devices can convert a signal to a number or letter. Details on the various types of units available and how they work.

SINGLE SIDEBAND SIMPLIFIED
Even if you are operating SSB, it is a safe bet that you aren't absolutely sure what sideband is and how it works. W7CSD explains in non-mathematic terms, by means of text and vectors, the principles behind this mode of operation.

ELECTROMAGNETIC DELAY LINES
When pulse signals must have a precise, short time lag, artificial transmission lines or delay cables are used. Sidney L. Silver of B. Eichwald & Co. explains how these devices operate and their applications.

MODERN LOUDSPEAKER CONES
Cinaudagraph's Chief Engineer tells about the important role played by the material and design of paper cones and their effect on hi-fi sound. Practical requirements for high-compliance loudspeakers are covered, and some interesting cone break-up patterns are shown pointing out how a speaker behaves at various frequencies.

UPGRADE FROM CB TO BUSINESS RADIO
Many Citizens Banders have learned first hand about the usefulness of two-way radio but they would like to have more coverage and less interference. The Business Radio Service will answer these needs. This article compares the two services and indicates the advantages and disadvantages of each.

IS THE ELECTRONIC ANTENNA A MYTH? AN EW SYMPOSIUM
Is it better to treat antenna and preamplifier as an integrated design? Are there disadvantages? Will tubes or transistors do a better job? Spokesmen for six industry leaders consider these and other questions in an exclusive, open debate. Simon Holzman (JFD), John R. Winegard (Winegard), Harold Harris (Channel Master), Don Rogers (Jerrold), Ben Tongue (Blonder-Tongue), and L. H. Finneburgh (Finney) participate.

All these and many more interesting and informative articles will be yours in the February issue of ELECTRONICS WORLD . . . on sale January 22nd.

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...for the Record

By **W. A. STOCKLIN**
Editor

The Vanishing Circuit Designer

THE Edisons, Flemings, and de Forests, of course, are gone, but not many realize that the type of radio engineer of the early 40's is almost as extinct as the dinosaur. Those who are with us today have become specialists or have taken on new titles, such as Systems or Project Engineers. Even the IRE with its 29 professional groups, having a total membership of 81,600, could boast only 6800 members in its professional group on Circuit Theory in 1961.

During the last war, the military services recognized the desirability of using a minimum of different circuits and produced various handbooks of "preferred circuits." When digital computers came into being, it was apparent that a few basic circuits would be duplicated many times throughout the equipment and a strong design effort on those few "standard" circuits was warranted.

The introduction of printed wiring and plug-in boards further emphasized the need for extremely well-designed standard circuits. Miniaturization and the use of "potted" circuits hastened the trend and now that microminiaturization has brought a variety of circuit packages, the need for standard circuits is even greater.

Experimenting with a breadboard circuit is now considered wasteful. If a standard circuit does not yet exist for a particular application, the design of a special circuit or a new standard involves no experimenting. Precise calculations can be programmed on a computer and long before the circuit is actually built, all its characteristics are already known. Construction and extensive tests then merely verify the predicted data.

Many former radio engineers and circuit designers have gone into systems engineering, largely because they know what can be expected from all types of circuits, even though the details are not familiar to them. In systems engineering they deal with the proverbial "black box," for which they specify what it must do. Their work is generally limited to defining such basic system parameters as frequency, range, power, performance, size, weight, etc.

Another survivor of the old timers' group can be found with a title of "Project Engineer." His concern with technical details is limited to the cost and schedule problems posed by the technical aspects. He is expected to know what the systems engineers have come up with, and appreciate the problems of the various engineering specialists. His primary function, however, is to coordinate all of the various groups. While his technical knowledge is a prerequisite for the job, his real contribution lies in his managerial ability and over-all experience.

Fortunately, the basic fundamentals of electronic theory still remain valid, and it is not too difficult for an engineer or technician to change from one area of employment to another. As long as there remains a shortage of qualified personnel, there is no threat of unemployment.

To the alert individual these changes should be obvious, but it may come as a surprise that the future holds more drastic changes than the past. As a result of modular and integrated circuitry techniques, all future circuit design work, regardless of degree, will become the responsibility of the component manufacturer instead of the equipment producer.

This change is inevitable and the semiconductor manufacturers are in an almost ideal position to take on this extra function. Unfortunately, neither the present electronic circuit designer nor any of the specialists in the semiconductor field is qualified to handle such work. A new breed will eventually evolve—a man whose knowledge embraces electronic circuit design, semiconductor technology, plus manufacturing "know-how."

At the present time all of these changes are basically involved in the military and, to some degree, in the industrial areas of electronics. Rest assured, though, that in the not too distant future the techniques that are developing in these areas will influence the design of consumer products. Even now much work is being done in applying integrated circuit techniques to television receivers.

Engineers and technicians who could be affected by such a change should be alert to the effects this trend may have on their vocation. Even educators, those men who are involved not only in training our future engineers and technicians but those who plan and coordinate their programs, should base their curricula planning on these inevitable changes. ▲

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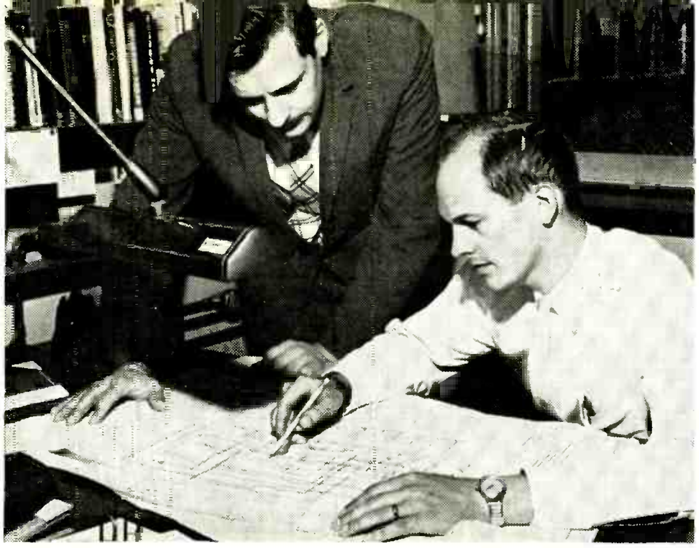
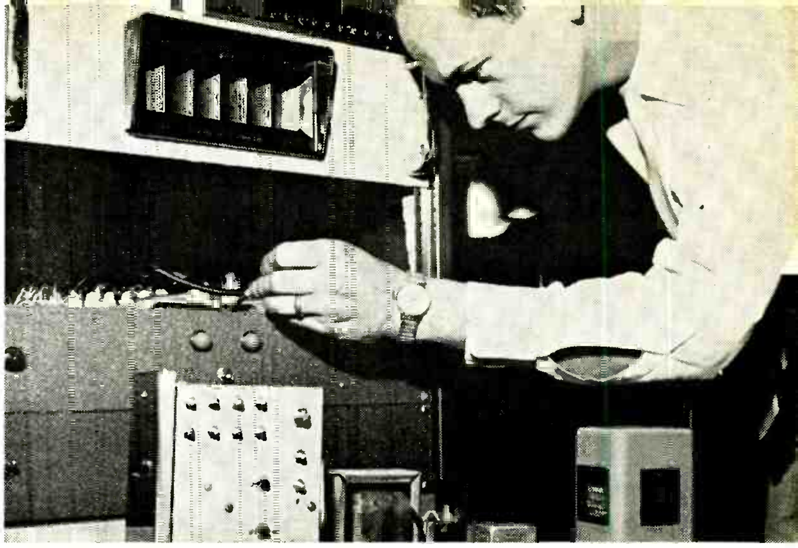
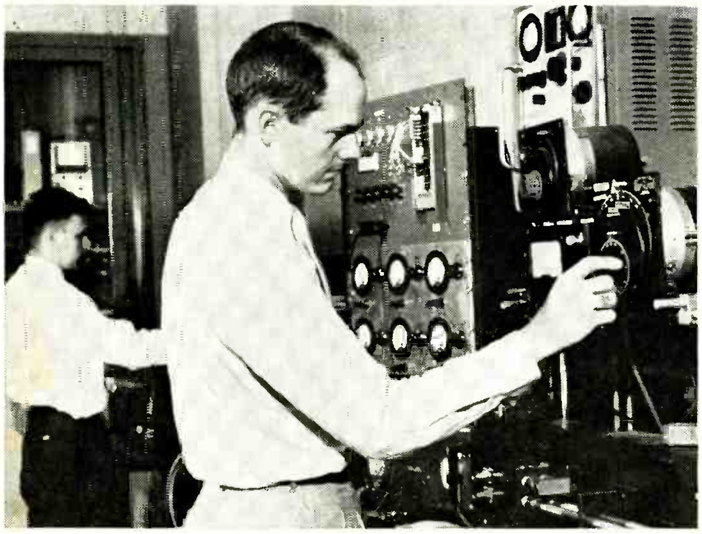


A CREI PROGRAM *has helped Reichert earn respect for his creative abilities. Here he discusses the design for an automatic transistor test set with John E. Iwersen, supervisor of the transistor development group of Bell Telephone Laboratories.*



THE HIGH LEVEL *of Reichert's knowledge of electronics is shown by his ability to contribute substantially to the design of, and to build the prototype of this automatic transistor test set, which measures the device characteristics of transistors under development.*



REICHERT ENJOYS *the satisfaction and rewards of contributing to the development of semiconductor devices at Bell Telephone Labs. He was doing routine electronic maintenance work at the time he enrolled in a CREI Home Study Program.*

PROMOTIONS MERITED *with the help of CREI Home Study have brought Reichert to an income where he is able to provide a comfortable, suburban way-of-life for his wife, Dawn, and his son, Alan. The motor scooter supplements the family car.*

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#35

LETTERS FROM OUR READERS

SOUND CHART

To the Editors:

The black and red fold-out page entitled "Sound" which you published recently in ELECTRONICS WORLD was certainly an attractive presentation. Apart from the usefulness of the facts themselves, the presentation was both pleasant to look at and easy to understand—an enviable combination in giving this sort of information.

As Training Officer of the Army's Human Engineering Laboratories at Aberdeen Proving Ground, I have been planning to lay out a similar presentation of these data to include in a training manual. This manual will be used as text in our orientation to human factors engineering course to train our own new employees as well as people from other installations. But your graphic art is much slicker than mine would be.

Would you give us permission to reprint your "Sound" spread in our manual? We might like to rearrange the graphs so each would appear by the portion of the text that it pertains to.

Incidentally, I have read your magazine for several years now and find it very helpful and informative.

WILLIAM WOKOUN, Ph.D.
Aberdeen, Maryland

The fold-out page referred to above appeared in our August issue. We are glad to grant permission to Dr. Wokoun to reprint the pages as requested.—Editors.

* * *

TRANSISTORS OR TUBES FOR HI-FI?

To the Editors:

The only conclusion I can draw from your transistor symposium (October, 1962 issue) is that the leading engineers of the hi-fi industry are failing to take the initiative in daring to produce the fully transistorized hi-fi set. They will be forced to do so by the Japanese, who will surpass them as they have done with portable and transistorized TV sets.

Certainly in the audio field, transistors can take the place of tubes. Years ago the hi-fi engineers were sighing if they could only rid themselves of the output transformer! The opportunity is here now.

DAVID POLLOCK
Little Silver, N. J.

The engineers in the hi-fi component field are pushing ahead on transistorized hi-fi. But this is being done only to improve the sound quality of the hi-fi amplifiers and not primarily to produce a smaller, more compact, and less expensive piece of equipment as is the case with the transistor portable pocket radio. For our views along these lines, see the editorial "Transistors For Hi-Fi?" in our December issue.—Editors.

* * *

THERMOCOUPLE MATERIALS

To the Editors:

Since I am an industrial instrument technician, I was quite interested in the discussion of thermocouples in "Mac's Electronics Service" in the September issue.

You might mention to your readers that rust is a problem with iron-constantan couples. Use of copper-constantan not only eliminates rusting out of measuring junctions, but also gives increased output because of higher millivoltage and decreased lead resistance.

Number 30 constantan, by the way, makes excellent meter shunts because of its high resistance and low temperature coefficient.

JAMES W. STUCKEY
Baton Rouge, La.

Thanks to Reader Stuckey for this bit of information on thermocouples and for the suggestion on constantan meter shunts.—Editors.

* * *

WIDE-BAND FM BOOSTER

To the Editors:

The article "Wide-Band FM Booster" in your November issue covers something I have been wanting to build for a long time. However, there seems to be a strange connection to the balun transformer T_1 on the schematic diagram and on the figure showing the construction of this transformer. It appears that you have one too many ground connections and that one of the secondaries of this transformer would be completely shorted out since it is grounded at both ends. I am interested in finding out whether this is a mistake or not so that I can proceed with the construction of the booster.

DEAN FORD
Iron River, Michigan

The balun-coil connections shown on the schematic and in the construction figure are both quite correct as drawn. Actually, the secondary has a fairly high impedance at FM frequencies so that the winding is not shorted out at all even

with the two ground connections. The tap at the antenna side of the secondary can be either grounded as shown or ungrounded. Such a transformer has been widely used in RCA, DuMont, *and* Emerson *TV sets to effect an impedance match between a balanced antenna and an unbalanced input or vice versa. In such receivers both ground connections are made to the chassis.*

When the booster was first built by the author, he used a commercial balun (Coleman *Part #1360) and he connected it just as shown in the schematic. Since this question arose, the author lifted the ground tap on the antenna side and did not notice any change in signal strength. Since this tap would be left hanging, the author preferred to reconnect it to ground.—Editors.*

° ° °

THE DIGITAL VOLTMETER

To the Editors:

I enjoyed John R. Collins' article entitled "The Digital Voltmeter" in the September issue, but was left with the feeling that the instrument is at best an example of engineering "gilding the lily" and at worst a great financial extravagance. To be able to produce a direct readout of voltage and polarity at, as was stated in the article, "over $1000, and many cost in excess of $10,000" is just a bit too much.

To my mind digital voltmeters are a close second to what was probably the greatest engineering absurdity a few years back—the "talking voltmeter." (It's exactly what the name implies.) This was demonstrated two or three years ago at the I.R.E. show in New York, and thank heaven hasn't turned up since.

The cost of such equipment, some of which was developed with government funds, is indeed difficult to justify.

PAUL MCELDRIDGE
Worcester, Mass.

° ° °

TV-FM ANTENNA DESIGN

To the Editors:

I have received quite a few inquiries concerning my article "Design for an All-Purpose TV-FM Antenna" (November, 1962).

There are several points which should be clarified; namely, α should have been 90° instead of 60° in Fig. 2, and the 1.85-foot dimension in Fig. 5 (page 86) should have been 2.85 feet to give $\psi = 45°$.

It should be noted further that the layouts given in Figs. 3 to 5 are correct and the design, as presented, will work. The noted discrepancy in $\alpha = 60°$ in Fig. 2 and the layout $\alpha = 90°$ (calculated) in Fig. 3 were apparently a source of confusion, particularly when trying to extend the design to lower frequencies.

In suggesting the other change from 1.85 feet to 2.85 feet, this would provide better performance. Unfortunately, my attic would not permit this height. However, if no restriction in height exists (on separation angle ψ), this increased height will provide slightly higher gain and better impedance match to 300-ohm line. Both are desirable.

Finally, some readers questioned whether larger gauge wire could be used in the construction. In reply, larger gauge wire (or aluminum rods) could be used. Slightly better antenna efficiency would result.

GEORGE J. MONSER
American Electronic Labs
Colmar, Pennsylvania

We have received many inquiries about this interesting antenna. We would like to emphasize that if the construction diagrams are followed, increasing the separation between triangular sections to 2.85 feet, then the antenna should operate properly. Incidentally, several TV antenna manufacturers are introducing all-channel antennas that operate on the log-periodic principles on which this design was based.—Editors. ▲

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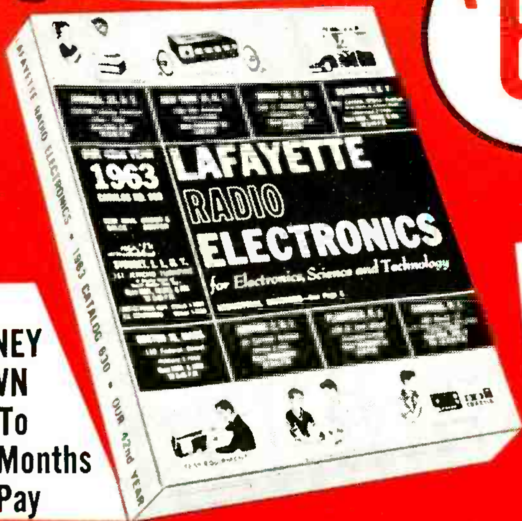

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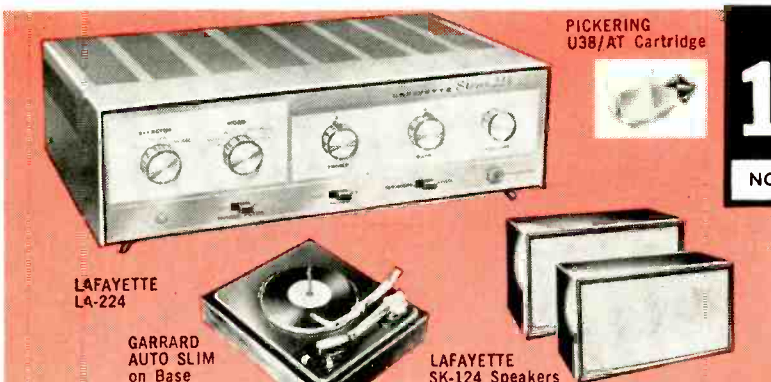

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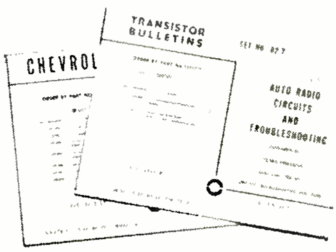

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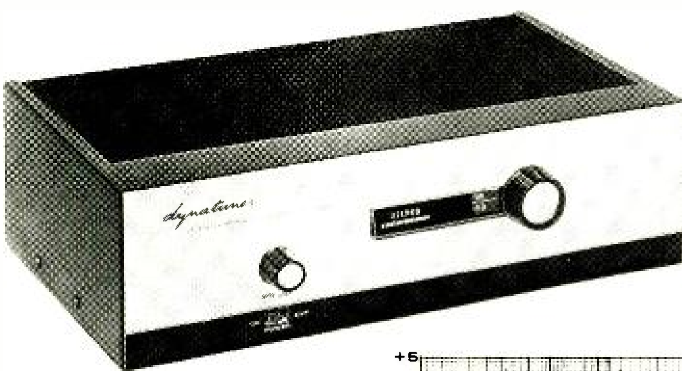
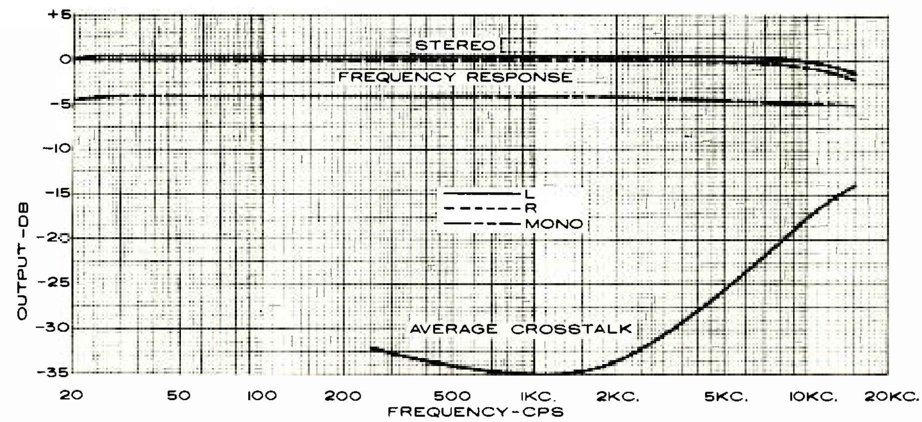
AUDIO PRODUCTS TESTED BY HIRSCH-HOUCK LABS

Dyna FM Tuner (FM-1) & Multiplex Adapter (FMX-3)
Leak "Sandwich" Speaker System (page 24)

Dyna FM Tuner (FM-1) & Multiplex Adapter (FMX-3)

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





THE Model FM-1 "Dynatuner" has earned a reputation for high performance. This FM tuner was fully described in the September, 1961 issue of this magazine. Now, a stereo conversion kit, the Model FMX-3 "Stereomatic Multiplex Integrator" is available for those wishing to adapt their FM-1 tuners for stereo or for those who have been waiting for such an adapter before buying the tuner kit. Like the tuner itself. the FMX-3 is simple to build and can be aligned using only the tuning eye tube, without external instruments.

The FMX-3 can be used only with the FM-1 tuner, for which it was specifically designed. It is constructed on a single etched circuit board, mounting in an area set aside for this purpose on the tuner chassis. Power comes from the tuner's power supply. In addition to mounting and soldering the components on the printed board, the builder is required to make two changes in the original tuner. The EM84 eye tube and the plastic dial cover are replaced by an EMM801 dual-eye tube and a new dial cover. The original volume control is replaced by a dual potentiometer, operating on both channels simultaneously.

The FMX-3 circuitry is remarkably simple, yet effective. This is an advantage of a multiplex adapter designed for a specific receiver, since its operating conditions are known and the various controls and compensating circuits found in "universal" adapters are not needed. The composite signal, before de-emphasis, is taken from a cathode-follower stage in the tuner, passed through a filter to reject SCA signals above 53 kc., to a four-diode switch. Monophonic signals pass through the diodes unmodified.

The 19-kc. pilot carrier in a stereo signal is amplified and doubled to develop a 38-kc. sub-carrier, in the proper phase relationship to the pilot carrier. The diode switch is gated by the 38-kc. signal, separating the composite signal into left- and right-channel outputs. These signals are separately de-emphasized and amplified by triode feedback amplifiers before going to the low-impedance output jacks.

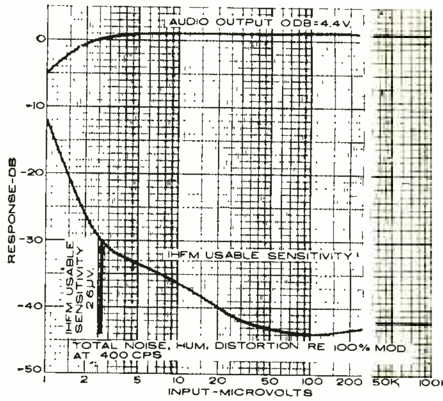
The EMM801 eye tube serves a dual function. The lower section is a horizontal bar of light which is closed by the voltage developed at the limiter grid. Never closed completely, it acts as a tuning indicator. The upper section, a similar bar of light, is actuated by the 38-kc. doubler circuit. In the absence of a pilot signal, it remains dark. During a stereo transmission, the bar closes fully. The special plastic dial cover has the word "Stereo" over the upper bar of the EMM801. When the stereo signal is received, the "Stereo" indication lights up brightly.

Operation of the FM-1 tuner with the FMX-3 "Multiplex Integrator" is fully automatic. Mono signals appear equally at both outputs. Separated stereo signals are developed without any action on the part of the listener, and with a clear indication of the "Stereocator," as the eye tube is called.

The unit we tested was factory-wired.

The FM tuner performance was excellent, with less than 0.75% distortion at 100% modulation for all signal strengths above 20 μv. The IHFM usable sensitivity was 5.7 μv. Capture ratio was 8.4 db, and the AM rejection was exceptionally good at 55 db. Total drift was about 60 kc. from a cold start. Although the sensitivity might not appear to be exceptional, this tuner has very little distortion at the lowest signal levels, and the subjective impression is of a very high effective sensitivity. In other words, even relatively weak signals can be received with enjoyable sound quality.

Frequency response and the average crosstalk are shown in the accompanying figure. *(Editor's Note: After these measurements were taken, we misaligned all tuned circuits in the adapter and we then realigned these circuits using the tuning eye as outlined in the instruction manual. When this was done, our separation figures were within 4 db of the original*



separation obtained with factory alignment.)

In use tests, the "Dynatuner" was very easy and non-critical to tune. Its listening quality left nothing to be desired. The automatic stereo feature, which works perfectly at signal levels down to 5 μv., nevertheless offers some problems. The user has no means of disabling the multiplex circuits. Weak signals may be marred by noise in stereo, yet be perfectly usable as mono signals. Unfortunately, the listener does not have the option of selecting his mode of operation.

The FMX-3 "Multiplex Integrator" sells for $29.95 in kit form, or $39.95 as a semi-kit, with all parts mounted and soldered on the etched circuit board. The complete factory-wired multiplex tuner, Model FM-3A, sells for $169.95. ▲

Leak "Sandwich" Speaker System

For copy of manufacturer's brochure, circle No. 59 on coupon (page 17).

ONE OF the recognized limitations of cone-type loudspeakers is the inability of a paper cone to move as a piston at all frequencies. At low frequencies the entire cone acts as a unit, which is the desirable form of piston motion. At higher frequencies, the phenomenon of cone break-up occurs, and different portions of the cone move in different phases. The effect of break-up is to cause a rough, irregular frequency response, as well as poor transient response.

Cone break-up results from insufficient rigidity in the conventional paper cone. Harold Leak's new "sandwich" speaker attacks this problem in a novel way, by constructing the cone of polyfoam and cementing an aluminum skin on each side to form a sandwich. The result is an extremely rigid, lightweight structure. The sandwich speaker, with an effective cone diameter of 10", is the woofer portion of *Leak's* new compact speaker system. The 2" diameter voice coil is capped by a polyfoam dome, and the impregnated cloth surround allows large linear cone excursions.

The walnut cabinet, measuring 15"

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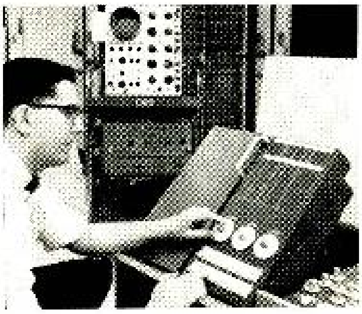

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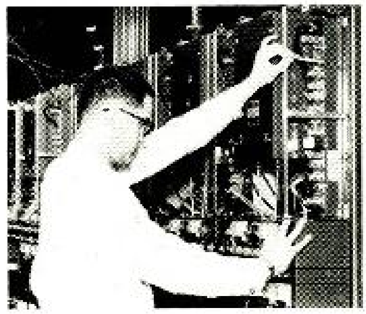

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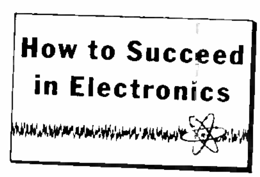

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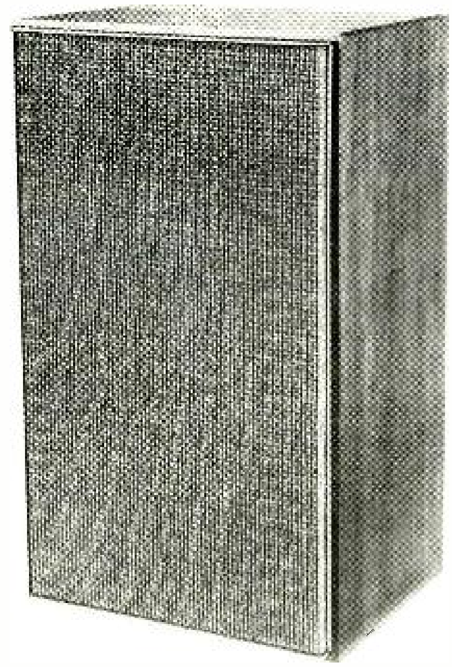


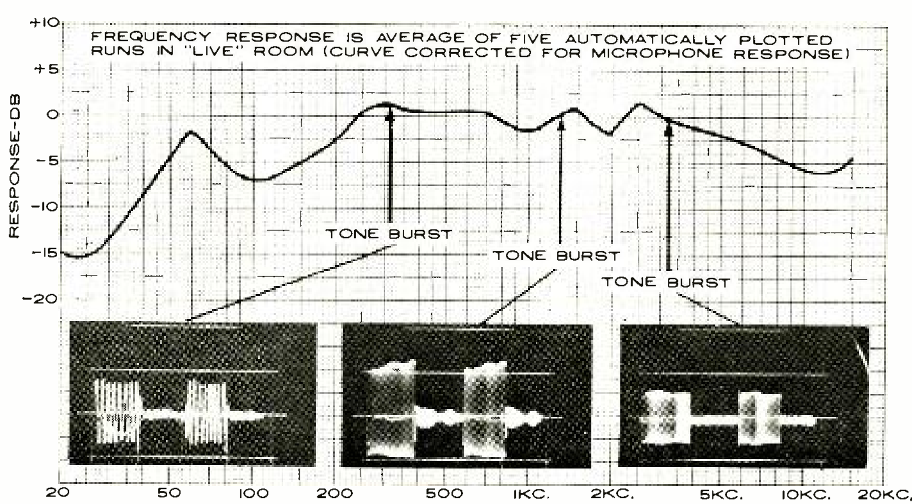
wide x 26" high x 12" deep, is fully enclosed and heavily damped internally with acoustic material. The high frequencies are handled by a 3" cone tweeter, with a 1" diameter voice coil and a massive magnet structure. The crossover network, which has no level adjustments, is built in. The system impedance is rated at 15 ohms by the manufacturer.

We measured the frequency response of the speaker system indoors, as usual, but used an automatic response plotting system. Five sets of curves were obtained, with various microphone positions, and averaged to obtain a single composite curve. This shows an exceptionally smooth response from 200 cps upward, to beyond 15 kc., with a drop-off of about 5 db at 10 kc. and above, relative to our calibrated microphone response. There appears to be a 5 or 6 db depression in the response in the region of 100 cps. The lower bass holds up well, with low distortion down to about 35 cps. Even in our indoor test room, the over-all response was ±4 db from 45 to 15,000 cps, which is excellent.

The success of the sandwich cone in preventing cone break-up is shown by the tone-burst photographs, which reveal practically no ringing or hangover. The worst ringing was found at 1.3 kc., and this would be considered quite good for most speakers.

Although the speaker system resembles most bookshelf systems physically, the manufacturer points out that it is designed for floor mounting, with the tweeter on top, and that wall mounting will result in a loss of bass response. This information was not available to us when the response curves were made, so the unit was mounted on a shelf at ear level, as we normally do with speakers of this type. When listening to music under these conditions, the sound is somewhat thin, although considerable amounts of bass boost can be applied in the amplifier without producing any muddiness or unpleasant sound from the speaker. When mounted upright on the floor, the bass comes up to a very satisfactory level. It is not as "heavy" in the lower bass as some of the American compact systems, but is nicely balanced over-all. In any position, the middles and highs are reproduced with superior definition, as good as we have heard from some of the finest and most expensive speaker systems. The sound of the speaker is tight, well controlled, and thoroughly musical. There is no trace of harshness, which is not surprising in view of the exceptional smoothness of its frequency response.

The *Leak* "sandwich" speaker system is imported from Great Britain by *Ercona Corporation*. The unit is available for $199.00. ▲



Response curve shown above is an average taken with the speaker system mounted on a shelf at ear level. When mounted upright on the floor, there was an increase in bass response. Tone bursts were taken at 310 cps, 1.3 kc., and 3.2 kc. Even at 1.3 kc., where there was some ringing, waveform is considered to be quite good.

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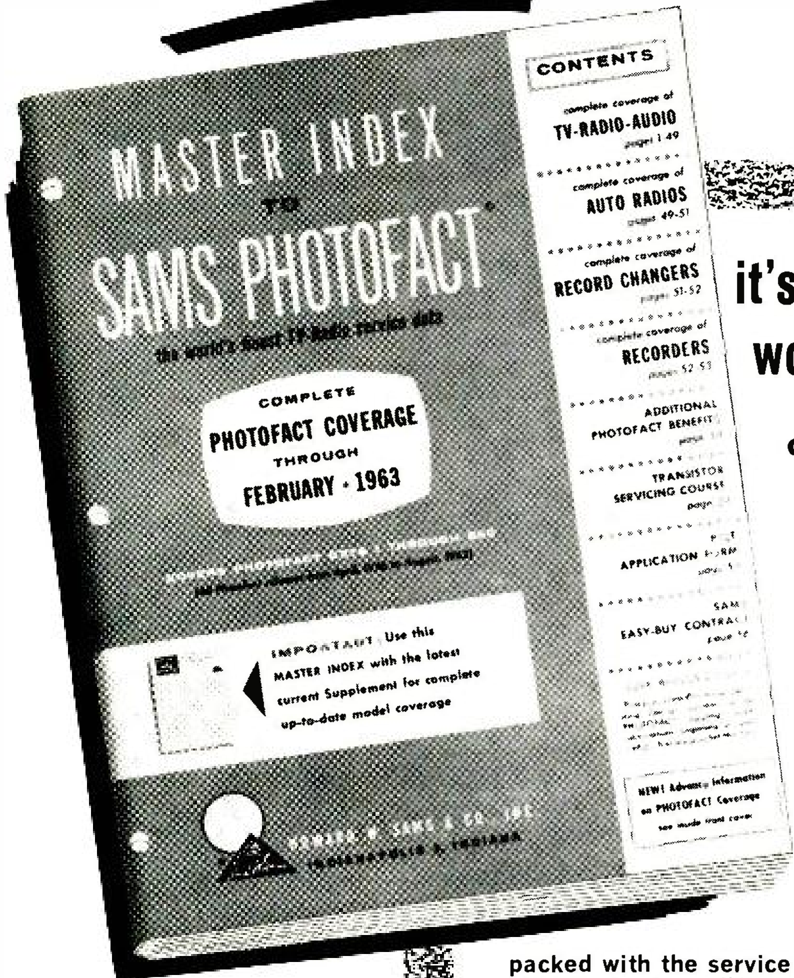

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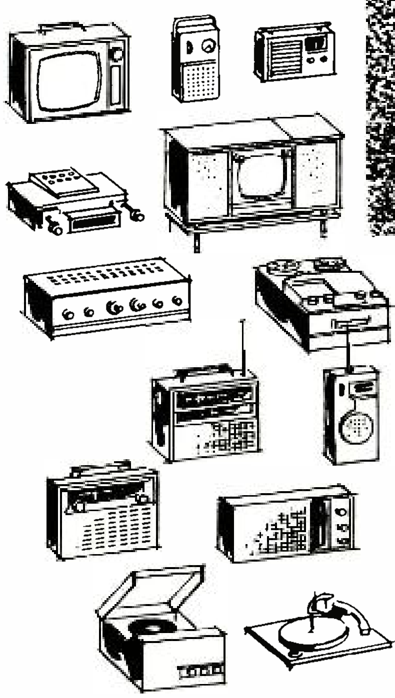

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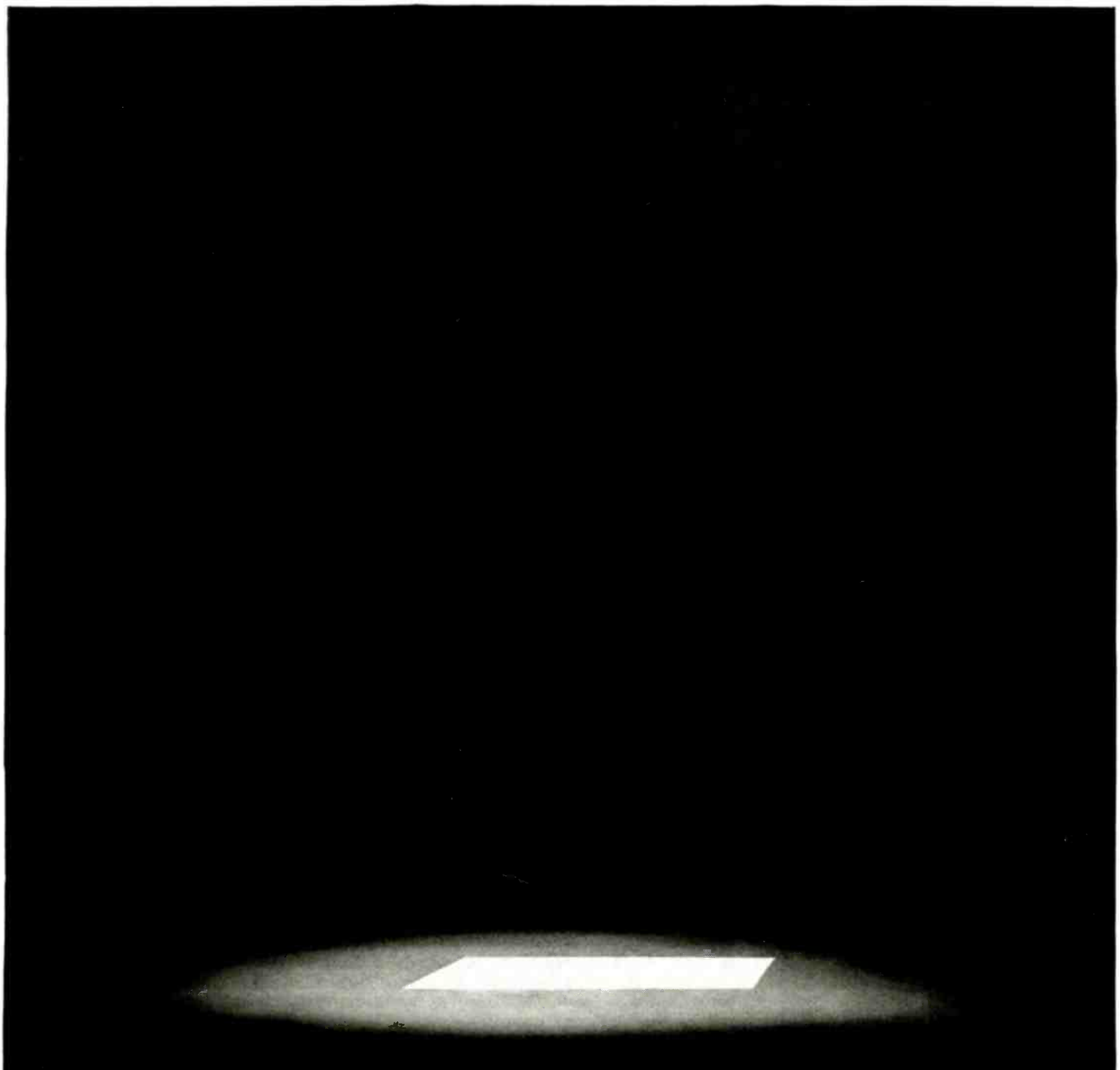

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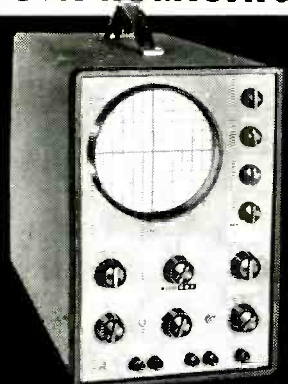

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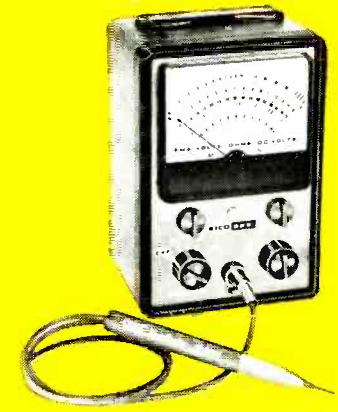

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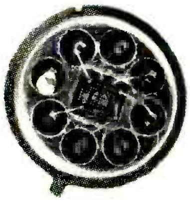
New integrated circuits being worked on in a score of laboratories promise fantastic size reduction of much equipment, more reliability, and, eventually, low cost.



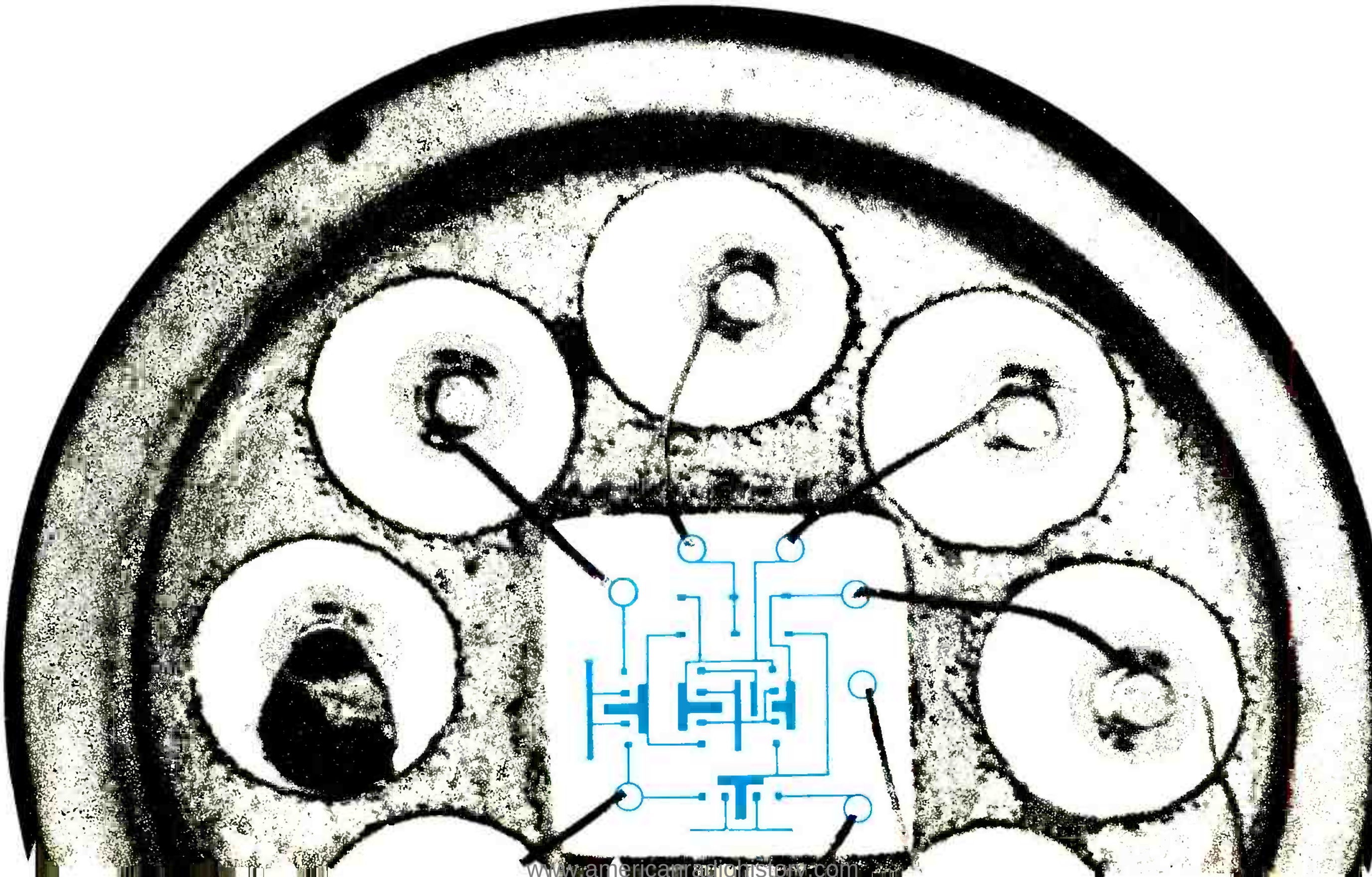
THE electronics industry is on the verge of a new era with the introduction of integrated microelectronic circuits. This new concept, now in active development by a score of laboratories, can pack over a million parts into a cubic foot of space and, at the same time, greatly increase reliability. Already circuits are available in quantity, in packages only 0.3 inch in diameter and 0.2 inch high, to build complete logic and arithmetic sections of computers.

The world's first integrated-circuit electronic control computer was announced last May. Called "Martac 420," the new computer was built by the *Martin Company* at Denver, Colorado. Designed primarily for ICBM pre-launch checkout and control, it tests and computes the readiness of all electronics in the missile. Within the electronic computing system, traditionally made up of transistors, diodes, and resistors, is logic circuitry comprising only plug-in integrated circuits. These reduced a conventional 20,000 parts to 5000 and cut over-all size to three-eighths that of previous construction. One part of this system, a decade counter with direct-coupled circuitry, is shown in Fig. 2. Here the integrated-circuit counter is compared to the number of conventional parts that might have been used.

Microelectronic development has been encouraged by the needs of military and space programs. Millions of dollars are now being spent for research and development. But, as in other areas of military research, benefits will eventually be passed on to the public. Military and space programs require smallness, reliability, and lightness; industry wants low cost and reliability; the public wants low cost. Microelectronic integrated circuits offer all these things. Their appearance in all types

By WILLIAM O. HAMLIN / Fairchild Semiconductor

MICROELECTRONICS



Steps in the manufacture of "Micrologic" circuitry

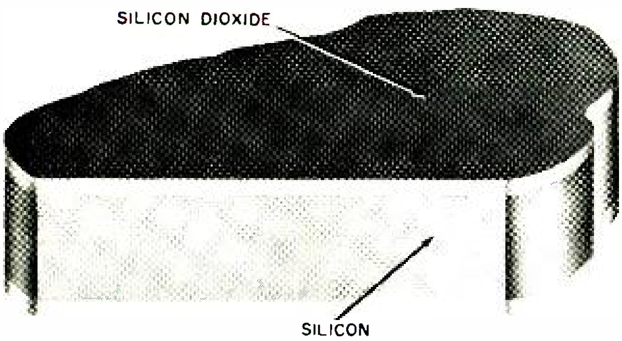


Fig. 1 **(A) Oxide Growth.** *Silicon wafer is placed into a furnace containing oxidizing atmosphere at 1200° C. Oxygen penetrates crystal surface to form inert, stable silicon dioxide.*

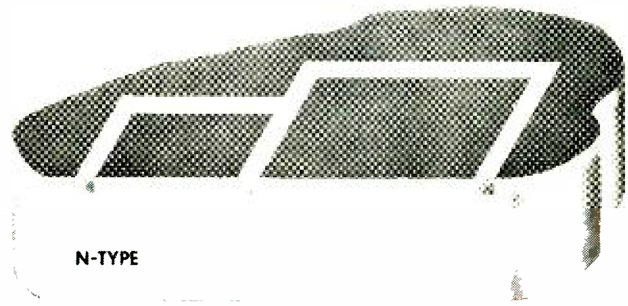


Fig. 1 **(B) Isolation Masking.** *Photo-etching technique is then used to remove surface coating in such a pattern as to produce separate areas for individual transistors and resistors.*

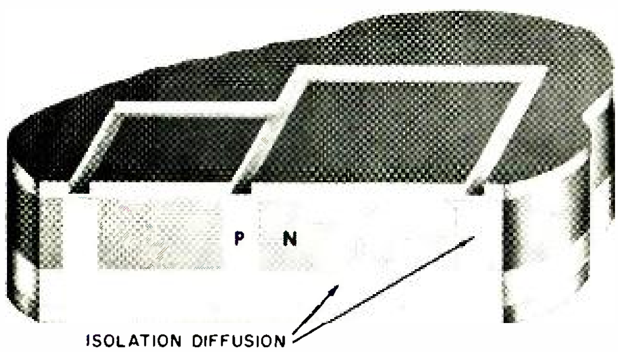


Fig. 1 **(C) Isolation Diffusion.** *Wafers are placed in high-temperature furnace with gaseous boron. Boron diffuses through the openings made by lines to produce "p" material.*

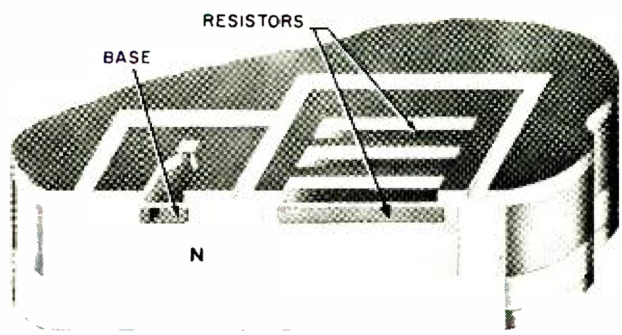


Fig. 1 **(D) Masking and Base Diffusion.** *Wafer is then photo-etched again to produce openings for transistor base and for resistors. Boron is again used at high temperatures to diffuse "p"-type material into "n"-type silicon, forming base, resistors.*

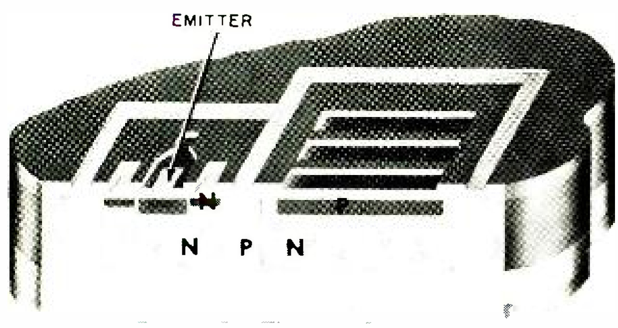


Fig. 1 **(E) Emitter Masking and Diffusion.** *Another photo-etch is used to locate the emitter area and collector contacts. In another high-temperature step, phosphorus is deposited and diffused to produce "n"-type areas employed for the emitter.*

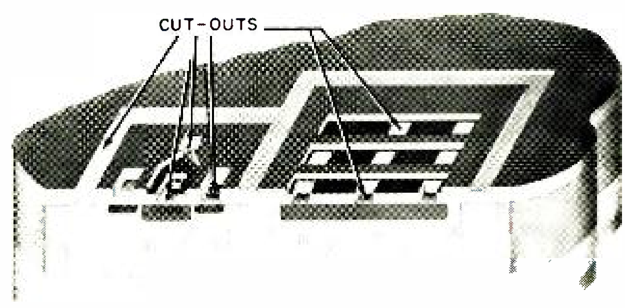


Fig. 1 **(F) Contact Areas for Interconnections.** *Next, photo-etching is used to produce cut-out areas that will be used for interconnection contacts. The wafers are then placed in a vacuum chamber where aluminum is evaporated from a hot filament to produce an even coating of the metal over the surface.*

Fig. 1 **(G) Metal Interconnections.** *In a final step the aluminum layer is masked and etched to form interconnections.*

of equipment, military and consumer, awaits only the ability to make the wide variety of circuits needed.

To visualize the future scale of sizes compared to present and past equipment, the graph of Fig. 3 shows theoretical parts per cubic foot, ranging from World War II electronic equipment to the human brain. It is difficult to conceive the ultimate theoretical smallness, but the human brain is probably close to this limit, having a density of over 100 billion parts per cubic foot.

Integrated circuits should perhaps more rightly be called functional blocks, because each is a single device performing a complete electronic operation. Such functions might include one or more stages of amplification, or several switching stages to perform a computer logic step, such as storing numbers or counting.

Various Design Techniques

One form of microelectronic circuit in common use today is made from a single silicon semiconductor crystal, with no external circuit wiring or components. Wiring is thus reduced to between-circuit interconnections, which may be printed boards. A typical integrated functional block is shown in Fig. 4. This is a half-shift register for computers, containing 9 transistors and 14 resistors all mounted within an 8-lead transistor-type can.

Intermediate approaches to microelectronics usually comprise the high-density packing of components, either on or in wafer substrates, or bunching components together like cordwood with welded connections.

Another technique, called "thin film," involves the evaporation of desired metals on the substrate. With suitable masks or stencils, and the right choice of metals, it is possible to form all of the passive components (resistors, capacitors, and inductors) plus interconnecting wires. But it is still necessary to insert individual transistors and diodes.

The most promising microelectronic concept at present, for versatility in serving both computer and communication needs and practical to construct with present scientific knowledge, seems to be the solid-state integrated functional block.

Maximum Reliability

For military and space electronics the reliability consideration is probably uppermost. Electronic systems used with weapons, aircraft, communications, and the control, launching, and tracking of orbiting or space vehicles, is fantastically complicated and will be more so in the future. For example, the over-all reliability of a system equals the product of the reliability of each of its parts. If the system has three parts, each with a 90 per-cent chance of success, then the chance of the system for successful operation is $(0.9 \times 0.9 \times 0.9 = 0.73)$ 73 per-cent. With perhaps billions of components involved in multi-million dollar space shots and with men's lives at stake, the expectation of success must be very much greater than that and the problem is infinitely more complex.

Experience has shown that deep inspection and extensive quality control are still not adequate to assure high reliability. Costs are too high and errors can be introduced into the controls themselves. Therefore, a reduction in the number of individual components, by making them part of an integrated circuit, is the only practical way to meet this urgent need. Putting it another way, *the more components, the greater the chance of failure.*

Fabricating the Circuit

To make an integrated functional circuit, which will provide the active functions of diodes and transistors as well as the passive components, one begins with a material having semiconductor potential, such as silicon. The properties necessary for semiconductor electrical characteristics then require the introduction of impurities into the silicon crystal. These impurities become the current carriers, since the pure

(*Continued on page* 86)

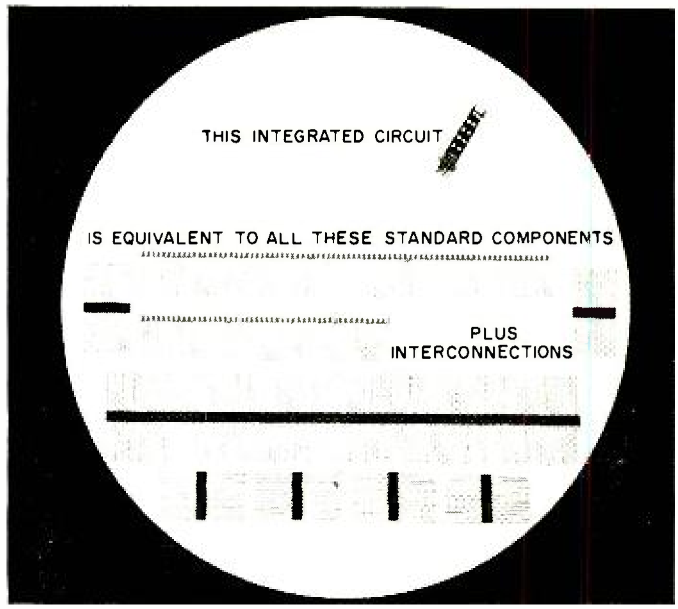


Fig. 2. Decade counter module and parts that it replaces.

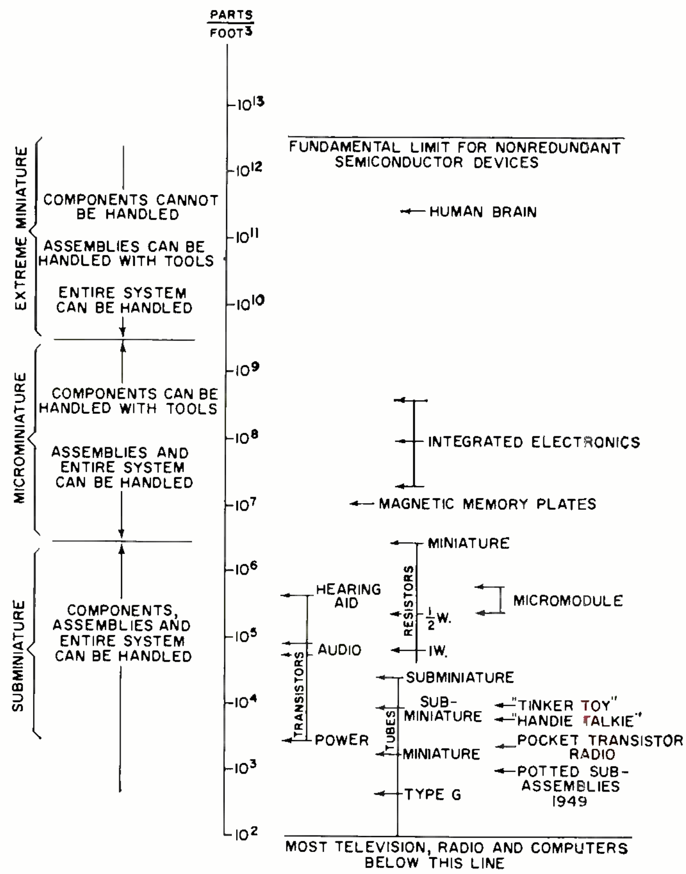
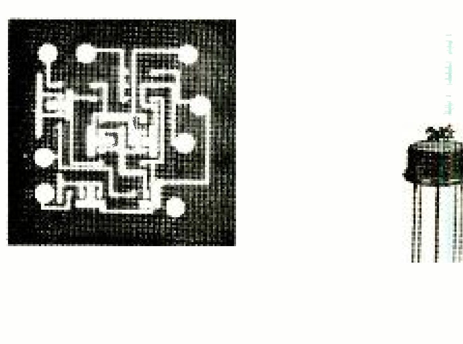


Fig. 3. Packing density for systems and components. (After Wallmark and Marcus, "Proceedings of IRE," March, 1962)

Fig. 4. "Micrologic" element containing 9 transistors and 14 resistors on base 70 mils square, which is then inserted into the 8-pin transistor case illustrated at the right.



FM MULTIPLEX SIGNAL GENERATOR

PART 1/Design & Construction

A precision test instrument that produces a composite stereo signal in accordance with FCC modulation specifications. The unit is professional in design and includes an r.f. generator and audio oscillator for checking and servicing multiplex adapters and multiplex circuitry in high-fidelity tuners and receivers.

By HARRY KOLBE, *Audio Workshop, Inc.*

EDITORS' NOTE

Realizing that FM stereo is going to create new service problems, the editors of ELECTRONICS WORLD *planned this article on a signal generator that will meet the highest professional standards of multiplex servicing. The generator provides all signals for the alignment of multiplex adapters and multiplex circuitry in FM tuners. Instead of having to make separation measurements and adjustments with off-the-air programs, you can use the 88-108 mc. signal from the built-in r.f. generator.*

In our February issue there will be an article on a multiplex signal generator of different design. It is less complex in that it does not include an r.f. generator.

THE advent of FM stereo has presented the service technician with both a potential boon and a rather severe financial problem. Sales of FM stereo equipment have grown constantly since the FCC decision last year. It goes without saying that the thousands of stereo receivers and tuners which have passed over the counters of the hi-fi dealers are, or eventually will be, candidates for service.

The majority of audio service technicians do not have the necessary test equipment to handle multiplex equipment. After investigating the special requirements, they will find that a stereo generator is a must for a proper job. Unfortunately the price tags on commercial generators start at $400 and go up to $1000. To this (with one or two exceptions) must be added an FM signal generator that has a wide-band modulation system capable of handling the composite signal from the stereo generator. The lowest priced FM signal generator of this quality is about $500. And if this isn't enough, some commercial stereo generators can only be used with an external, relatively expensive, balanced audio generator.

In view of the cost of stereo generators and the necessary accessory equipment, it is not hard to understand why so few service shops have FM-stereo service facilities. Only a few large service organizations can afford the severe financial beating the purchase of this equipment entails.

The stereo generator described here is a solution to the problem. The cost of parts is about $90. If the optional circuitry is not included, it is possible to keep the cost down to about $60. The optional features include an FM r.f. generator, an audio oscillator, and a monitor meter. If you own one of the better FM r.f. generators, such as the *Measurements Corp.* Model 210-A, you will not need the internal r.f. generator. The internal audio oscillator is a luxury since any service shop worth its salt will have an audio oscillator capable of driving the stereo generator. Convenience best describes the monitor meter. All or any of these three circuits may be eliminated with a corresponding reduction in the total cost.

This generator, if carefully built and aligned, is capable of holding its own with the more expensive commercial instruments. With an audio oscillator, a TV service scope, and an audio v.t.v.m. (which, by the way, are the only instruments required for the generator's alignment) it is all that is needed for complete servicing and alignment of any multiplex tuner or adapter. The right- and left-channel switching feature enables you to produce any of the monophonic and stereophonic components or a complete composite signal.

SPECIFICATIONS

This generator was sent to the Hirsch-Houck Lab for analysis and evaluation. The test results are detailed below.

SEPARATION: Between L and R = 0 (L only) or R and L = 0 (R only) is nominally 35 db from 50 cps to 10 kc. Mid-range it is in excess of 40 db. Residual subcarrier, hum, and noise is 55 db below 100% modulation.

INPUT: Unbalanced, 500-ohm impedance. Approx. 1.0 v. r.m.s. for 100% modulation. Response 50-15,000 cps.

INTERNAL OSCILLATOR: Approx. 400 cps. Harmonic distortion less than 0.5%.

OUTPUTS:

a) **Composite:** approx. 3.8 v. r.m.s. at 100% modulation level.

b) **R.f.:** 6000 μv. which when fed through a 300-ohm matching pad results in a 1000-μv. signal at the antenna terminals of the receiver under test. Frequency range 88-108 mc.

c) **19-kc. pilot:** 4-5 v. available at front-panel jacks.

NATURE OF MODULATION: Right- and left-channel switching permits the following signals to be derived:

L = R (L + R)
L, R = 0 (left only)
R, L = 0 (right only)
L = −R (L − R)
−L = R (L − R)

One mode of operation possible with this generator is the generation of only the stereo subcarrier, which makes life much simpler when servicing filter-type adapters. Some of the commercial generators do make provision for this type of modulation. For added convenience, a 4—5-volt, 19-kc. pilot signal is available at the "Monitor Output" jacks for use in servicing and aligning the 19-kc. circuitry of multiplex adapters.

All in all, the cost and time involved in the construction of this multiplex generator should be an investment with an incalculable return.

Circuit Description

The process that produces a composite stereo signal begins with a 19-kc. crystal-controlled Pierce oscillator, *V1A*. (See Fig. 3 and the block diagram on the cover.) The circuit was chosen because of its excellent stability and because it does not require an *LC* tuned circuit. Its accuracy of ± 2 cps conforms to the FCC multiplex broadcast specifications. The output of *V1A* is fed to the 19-kc. filter (*L1*, *C6*), which is a high "*Q*," sharply tuned, parallel-resonant trap that removes the 19-kc. harmonics at *V1A*'s output. The pure 19 kc. from the filter is fed to doubler/amplifier *V2A* and to the pilot control circuitry. *V2A* is a non-linear, pentode power amplifier with a 38-kc. resonant plate load (*T2*). The 19-kc. signal fed to this stage is doubled in frequency and amplified. The balanced secondary of *T2* feeds the relatively high level 38-kc. subcarrier to the suppressed-carrier balanced modulator.

The modulator consists of two diode bridges (*CR1-CR4* and *CR5-CR8*). If the diodes in each bridge are thought of as switches which are closed when they are forward-biased and open when reverse-biased, you can see that the 38-kc. subcarrier will forward-bias the diodes of one bridge during one-half of the cycle and reverse-bias them during the next half cycle. Since one bridge is connected across *T2* with the polarity of all its diodes in one direction and the other bridge is connected with all its diodes in the reverse direction, each bridge will be open or closed on alternate halves of a cycle; i.e. when one bridge is open the other is closed. One side of each bridge (junction of *CR1-CR3* and *CR6-CR8*) is connected to the audio path. When an audio signal is present at these points it will see a high impedance or open circuit to ground when the bridge is biased open. When the bridge is forward-biased (closed), the audio signal is shorted to ground. Put another way, any signal present at the input to the bridge will be turned off and then on 38,000 times a second. As in any modulation process, upper and lower sidebands are produced which in this case will be at frequencies that are the sum and difference of the audio modulating frequency and the 38-kc. carrier. The FCC standard for the audio response of the FM multiplex system is 50 cps to 15 kc. In terms of the 38-kc. carrier, sidebands will be produced in the modulation process that will extend from 23 kc. to 53 kc.

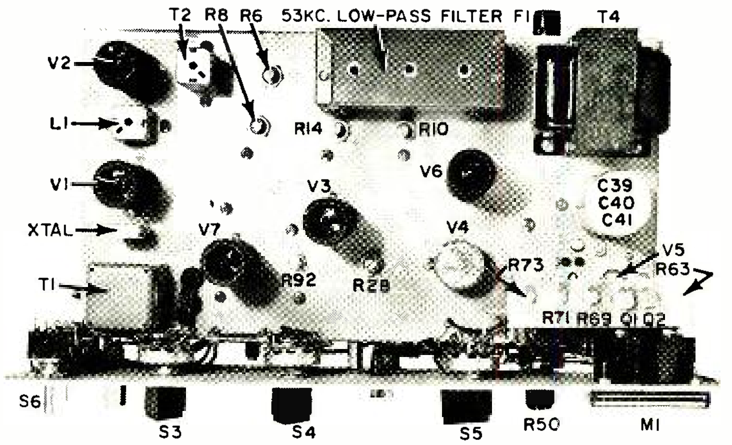
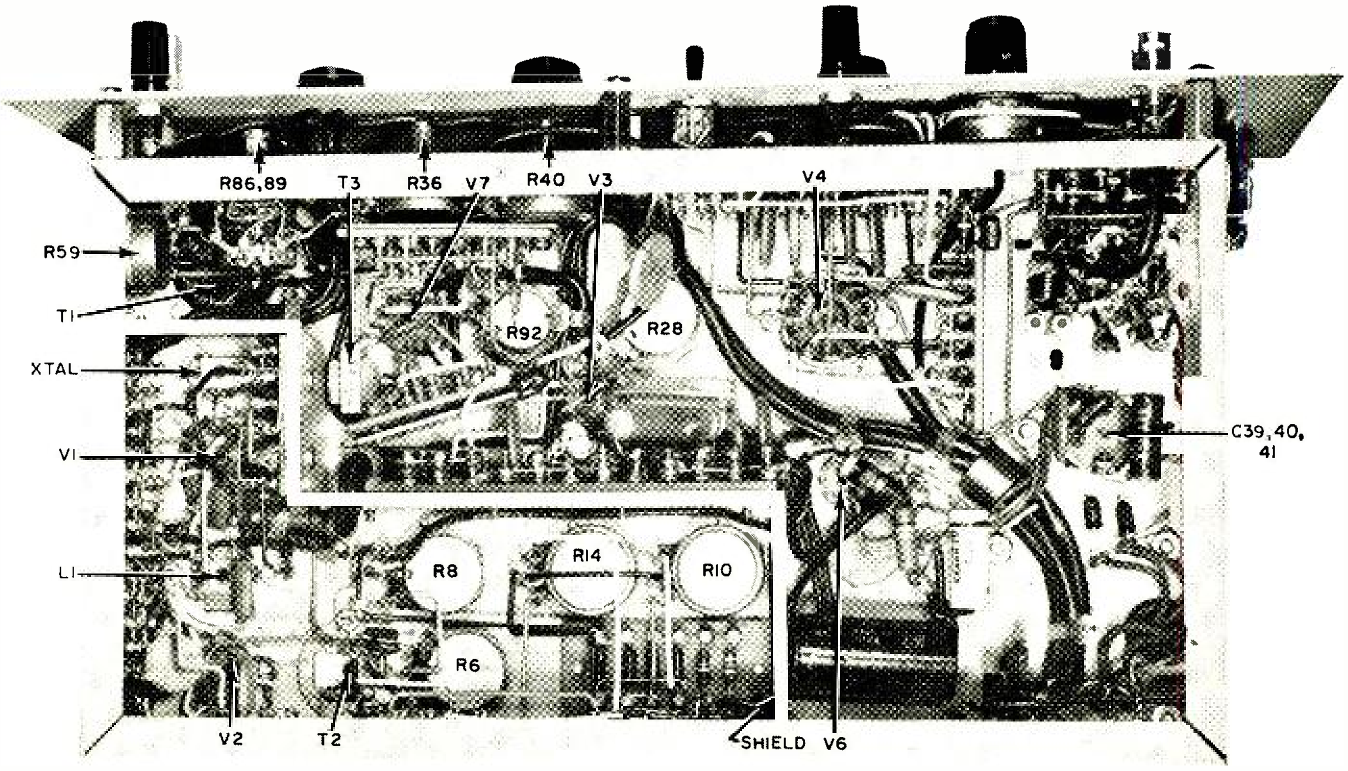
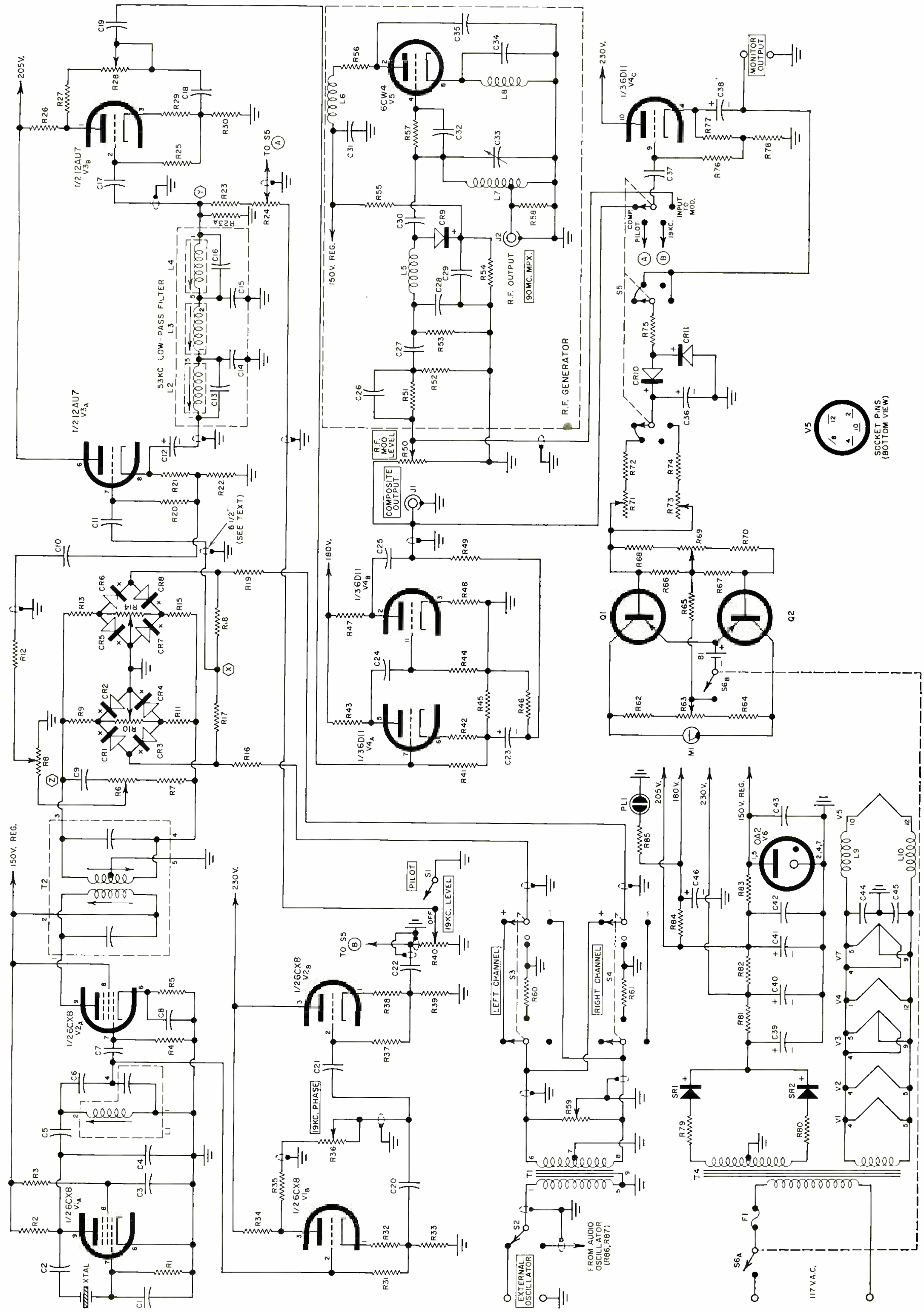


Fig. 1. Top view of the chassis showing the location of components.

In addition to producing sidebands of the 38-kc. carrier, the modulation system must suppress the carrier. The balanced bridges provide a high degree of carrier suppression. *R10* and *R14* permit precise modulator balance by correcting unbalances that may be caused by circuit components. The suppressed-carrier sideband output of the modulator is actually the subchannel ($L-R$) modulation. At point *X*, the output of the two diode modulators is summed. Depending on the audio modulation appearing at the inputs of the

Fig. 2. Underside of author's generator. The 19-kc. oscillator, doubler, and two diode-modulator bridges are located in the lower left corner and are separated from the rest of the unit by aluminum shield. Terminal boards were used extensively to mount small components.




R.F. GENERATOR
53KC LOW-PASS FILTER
R.F. OUTPUT
90MC. MPX.
R.F. MOD LEVEL
COMPOSITE OUTPUT
MONITOR OUTPUT
INPUT TO MOD.
PILOT
19KC. LEVEL
19KC. PHASE
LEFT CHANNEL
RIGHT CHANNEL
EXTERNAL OSCILLATOR
FROM AUDIO OSCILLATOR (R86, R87)
SOCKET PINS (BOTTOM VIEW)
117 V.A.C.
150V. REG.
205V.
180V.
230V.

bridges, any one of four possible signals may be present at X.

But before investigating the signals appearing at the output of the modulators, let's take a look at the nature of the audio modulation. The input transformer (T1) receives an audio signal from a single-ended source (internal or external oscillator). The secondary of T1 is balanced and has two outputs that differ in phase by 180°. Consider one output positive (terminal 6) and the other (terminal 8) negative. Also, consider the first bridge (CR1-CR4) as the left-channel modulator and the other bridge (CR5-CR8) as the right-channel modulator.

All signals derived by the left-channel modulator will be referred to as L signals and those derived by the right channel modulator as R signals. L and R signals are the same except that they are switched 180° apart as explained above. By considering the signal combinations made available by the left- and right-channel switches it is possible to visualize the output at point X. The following signals can be derived:

1. If S3 is in the "−" position and S4 is in the "0" position a + audio signal is sent to the L modulator and no signal is sent to the R modulator. At point X there will be a + signal (mono component) and L subchannel modulation (stereo component). The summation of these two quantities is called an L only or left-channel composite signal. If S3 and S4 are reversed (S4="+" and S3="0"), the output will be an R only or right-channel composite signal.

2. If both S3 and S4 are in the "+" position, a + signal is sent to both L and R modulators and +L and +R will appear at point X. However, no subchannel modulation will appear because both bridge modulators are switching in-phase signals 180° apart. More simply, the sidebands produced by one modulator will be 180° out-of-phase with the sidebands produced by the other modulator and they will cancel each other at point X. The only signal appearing at X is the +L and +R which is the mono signal.

3. If S3 is set to the "+" position and S4 is set to the "−" position, only an L−R signal or subchannel modulation will appear at X. The +L and −R mono components of the audio signal are of opposite phase and cancel each other. On the other hand, the two modulators are switching out-of-phase signals 180° apart which results in an in-phase relationship between the L and R modulator sidebands.

From the output of the modulator, the stereo composite signal is fed to modulator-output amplifier V3A. All of the functions of V3A may not be immediately obvious. As a cathode-follower its main function is to provide isolation and impedance transformation between the high output impedance of the modulator and the low input impedance of the 53-kc. low-pass filter. A second function of this stage is that of a mixer. Normally the modulation system suppresses the 38-kc. carrier. However, due to small unbalances and radiation leakage there may be considerable 38 kc. at the modu-

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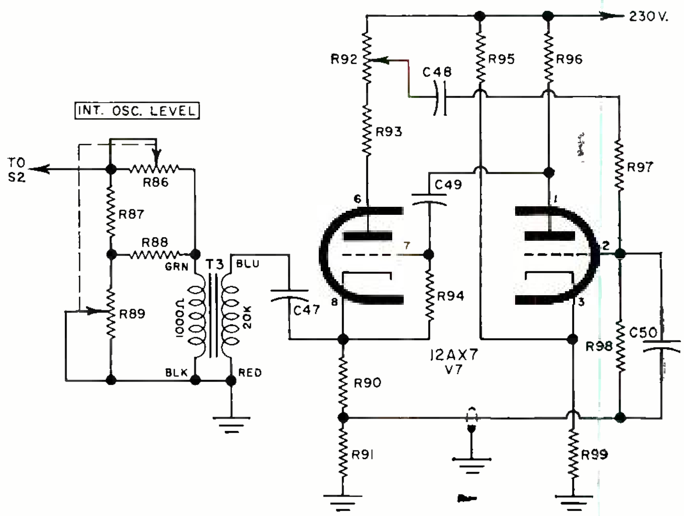


Fig. 4. Add this audio oscillator if external unit is not available.

←— **Fig. 3. Schematic of generator less audio oscillator. R.f. section may be omitted if you intend to service only multiplex circuitry.**

R1, R20, R30, R41—2.2 megohm, ½ w. res.
R2—56,000 ohm, 1 w. res.
R3—100,000 ohm, 1 w. res.
R4—680,000 ohm, ½ w. res.
R5, R21, R29, R99—1000 ohm, ½ w. res.
R6, R10, R14—250,000 ohm, linear-taper pot.
R7, R56—20,000 ohm, ½ w. res. ±5%
R8, R28, R36, R50, R59—100,000 ohm, linear-taper pot.
R9, R11, R13, R15, R16, R19, R23—39,000 ohm, ½ w. res. ±5%
R12—22,000 ohm, ½ w. res.
R17, R18, R43, R47, R52, R65, R66, R67, R85, R96—100,000 ohm, ½ w. res.
R22, R27, R35, R45, R54, R57—10,000 ohm, ½ w. res.
R23A—2000 ohm, ½ w. res.
R24—10,000 ohm, linear-taper pot
R25, R31, R44, R53, R76, R94—1 megohm, ½ w. res.
R26, R75—4700 ohm, 1 w. res.
R32—1000 ohm, ½ w. res.
R33, R34, R78—10,000 ohm, 1 w. res.
R37, R74—1.2 megohm, ½ w. res.
R38, R42—690 ohm, ½ w. res.
R39—2700 ohm, ½ w. res.
R40, R86, R89, R92—5000 ohm, linear-taper pot.
R46—470,000 ohm, ½ w. res.
R48, R77—2200 ohm, ½ w. res.
R49—33,000 ohm, ½ w. res.
R51—160,000 ohm, ½ w. res.
R55—220,000 ohm, ½ w. res.
R58—50 ohm, ½ w. res.
R60, R61—68,000 ohm, ½ w. res. ±5%
R62, R64—3900 ohm, ½ w. res.
R63—1000 ohm, linear-taper pot
R68, R70—720,000 ohm, ½ w. res.
R69, R71, R73—1 megohm, linear-taper pot
R72—2 megohm, ½ w. res.
R79, R80—5 ohm, 1 w. res.
R81—1200 ohm, 5 w. res.
R82—1000 ohm, 5 w. res.
R83—3000 ohm, 2 w. res.
R84—10,000 ohm, 2 w. res.
R87, R88—510 ohm, ½ w. res. ±5%
R90—8200 ohm, ½ w. res. ±5%
R91—1800 ohm, ½ w. res. ±5%
R93—5100 ohm, ½ w. res. ±5%
R95—47,000 ohm, 2 w. res. ±5%
R97, R98—390,000 ohm, ½ w. res. ±5%
C1, C32—100 µµf., 500 v. N750 capacitor
C2, C9—30 µµf., 500 v. ±5% mica capacitor
C3, C7, C22, C47, C49—.02 µf., 500 v. capacitor
C4—4700 µµf., 500 v. ±5% mica capacitor
C5—82 µµf., 500 v. ±5 % mica capacitor
C6—2500 µµf., 500 v. ±5% mica capacitor
C8, C11, C17, C37, C42—.05 µf., 500 v. capacitor
C10, C31, C35, C44, C45—.001 µf., 500 v. capacitor
C12—100 µf., 50 v. elec. capacitor
C13, C16—1500 µµf., 500 v. ±5% mica capacitor
C14, C15—.002 µf., 500 v. ±5% mica capacitor
C18—10 µµf., 500 v., ±5% mica capacitor
C19, C20—220 µµf., 500 v., ±5% mica capacitor
C21—.005 µf., 500 v. capacitor
C23—2 µf., 50 v. elec. capacitor
C24, C25—.1 µf., 500 v. capacitor
C26—43 µµf., 500 v. ±5% mica capacitor
C27—.47 µf., 10 v. disc capacitor
C28—2 µµf., 500 v. ±5% mica capacitor
C29—500 µµf., 500 v. capacitor
C30—5 µµf., 500 v. capacitor
C33—3.5—12 µµf. ceramic trimmer capacitor (Centralab 827-B or equiv.)
C34—10 µµf., 500 v. type NPO capacitor
C36—40 µf., 10 v. elec. capacitor
C38—4 µf., 50 v. elec. capacitor
C39, C40, C41—40-40-40 µf., 450 v. elec. capacitor (Sprague TVL-3787 or equiv.)
C43—.22 µf., 500 v. capacitor
C46—50 µf., 250 v. elec. capacitor
C48, C50—1000 µµf., 500 v., ±5% mica capacitor
L1—Low-pass filter (Stancor RTC-9279 or equiv.)
L2, L3, L4—38-kc. output transformer (Stancor RTC-9283 or equiv.)
L5—330 µh. choke (J. W. Miller 70F334A1 or equiv.)
L6—82 µh. choke (National R-25-82 or equiv.)
L7—5½ turns No. 16 enamel wire closewound. I.d. .315". Tapped ¾ turn from end.
L8—24 turns No. 28 enamel wire wound on 1 megohm, ½ w. res.
L9, L10—3.3 µh. choke (J. W. Miller 70F-336A1 or equiv.)
T1—Audio trans. pri: 500 ohms, sec: 50,000 ohms, c.t. (UTC A-11 or equiv.)
T2—38-kc. trans. Available from Audio Workshop, Inc., 732 Broadway, N.Y. 3, N.Y. for $3.80. Part No. MX-2.
T3—Transistor audio trans. pri: 20,000 ohms. sec: 1000 ohms (Lafayette/Argonne AR-104 or equiv.)
T4—Power trans. pri: 117 v.; sec: 480 v., c.t. @ 70 ma., 6.3 v. @ 3 a. (Stancor PC8419 or equiv.)
S1—S.p.s.t. toggle switch
S2—S.p.d.t. toggle switch
S3, S4—2-P. 3-pos. rotary switch
S5—3-P. 4-pos. rotary switch
S6—D.p.s.t. toggle switch
CR1-CR3, CR2-CR4, CR5-CR7, CR6-CR8, CR10-CR11—1N542 diode (The 1N542 is a matched pair of Amperex 1N541 diodes. Diodes must be matched as shown above.)
CR9—24—120 µµf. (47 µµf. @ 4 v. d.c.) Varicap (Pacific Semiconductors, Inc., V-47 or equiv.)
SR1, SR2—Silicon diode, 500 ma., 800 p.i.v.
J1, J2—BNC coaxial panel connector
PL1—NE-2 neon lamp
M1—0-50 microammeter
B1—1.35-v. mercury battery
F1—1 amp. fuse
V1, V2—6CX8 tube, V3—12AU7 tube
V4—6D11 tube, V5—6CW4 tube
V6—OA2 tube, V7—12AX7 tube
Q1, Q2—"p-n-p" transistor (Philco 2N2376)
XTAL—19,000 ±2 cps crystal (Hill Electronics, Inc., 300 N. Chestnut St., Mechanicsburg, Pa.; Reeves-Hoffman Co., 145 Cherry St., Carlisle, Pa., and others.)

RC Charging Circuit Nomograms

By DONALD W. MOFFAT

Charts permit values of capacitor voltage to be found at various times in a wide range of RC circuit values.

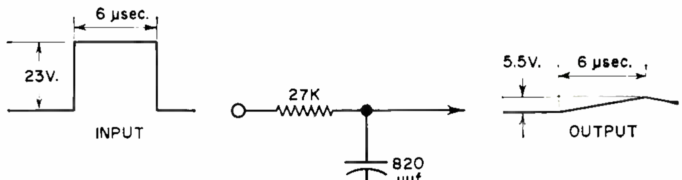


Fig. 1. Circuit example worked out on the two nomograms.

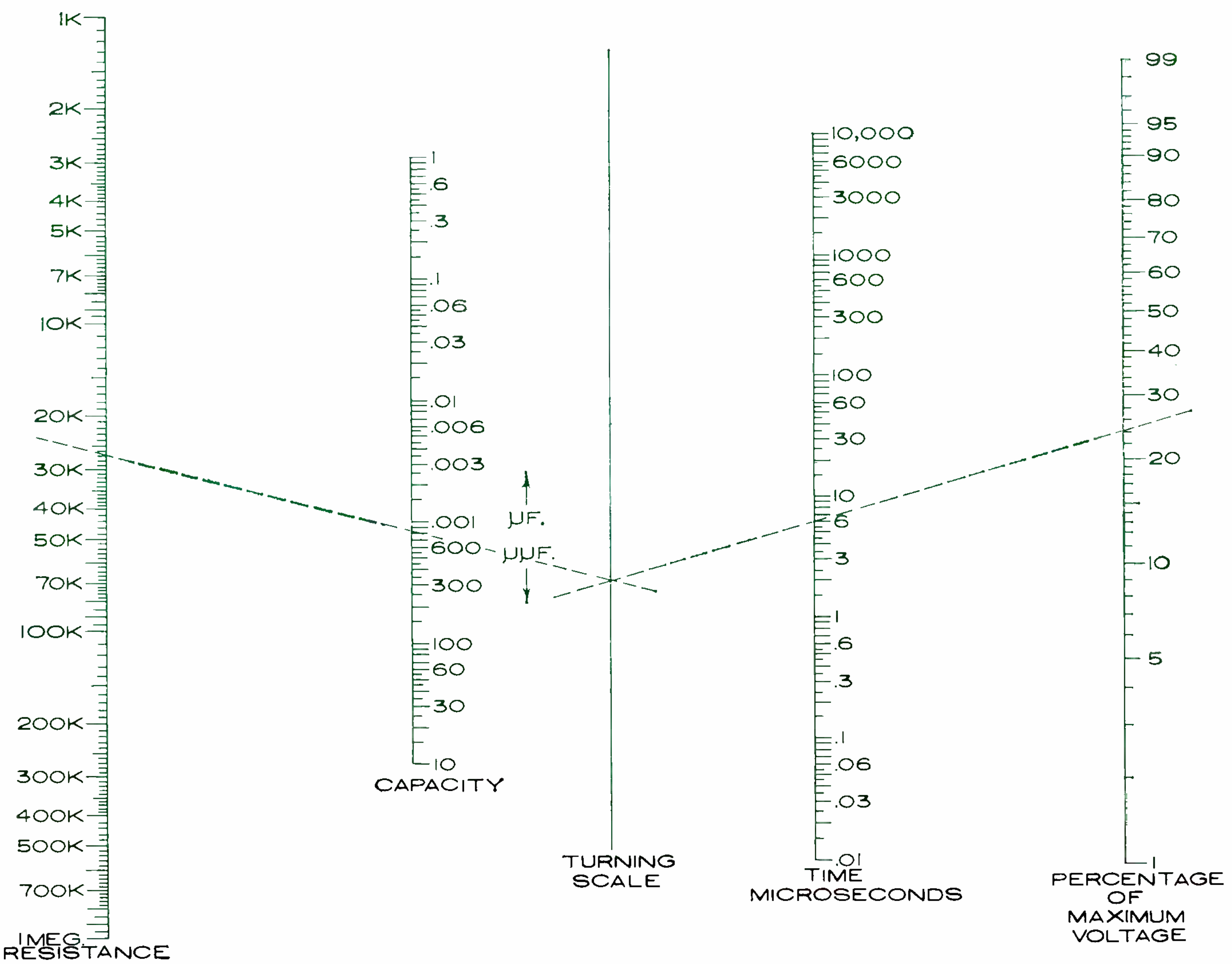
WHEN a d.c. voltage is suddenly impressed across a capacitor, through a resistor, the capacitor will charge up toward that voltage in an exponential manner. At any instant after the voltage is applied, the voltage to which the capacitor has charged is dependent on (1) the value of resistance in the circuit, (2) the value of the capacitor, (3) the magnitude of voltage which was applied, and (4) the length of time that the voltage has been applied. Although the governing equation is not difficult, solving it by conventional means requires a slide rule or tables and considerable time. The accompanying nomograms will permit the technician and experimenter to solve this problem in a matter of seconds.

For very short charging times, where the voltage is applied for a time much less than the product **RC**, it is sufficiently accurate to assume the capacitor charges at a linear rate. If the charging continued at its initial rate, the full amount of applied voltage would appear across the capacitor in one time-constant, that is, at a time **t** equal to the product **RC**. However, the error resulting from a linear approximation increases as charging continues, and at one time-constant the voltage actually has reached only about 63% of maximum. The nomograms are based on the full exponential equation, not on the linear approximation and therefore are correct over their entire range.

Fig. 2 is used to determine the percentage of applied voltage to which the capacitor will have to charge under any stated conditions. Then Fig. 3 is used to resolve the percentage figures into an actual voltage.

To use Fig. 2, locate the appropriate values of resistance and capacitance on the first two scales. Draw a line through these two points and extend the line to intersect the "Turning Scale." From that intersection on the center scale, a line drawn through the appropriate values on the "Time" scale will cross the last scale at the correct percentage of full charge. On Fig. 3, locate the percentage of full charge, just determined on Fig. 2, on the first scale and draw a line from there through the applied voltage on the last scale. The voltage appearing across the capacitor can then be read where the line crosses the center scale.

Fig. 2. Nomogram to determine the percentage of applied voltage to which capacitor will have charged under various conditions.



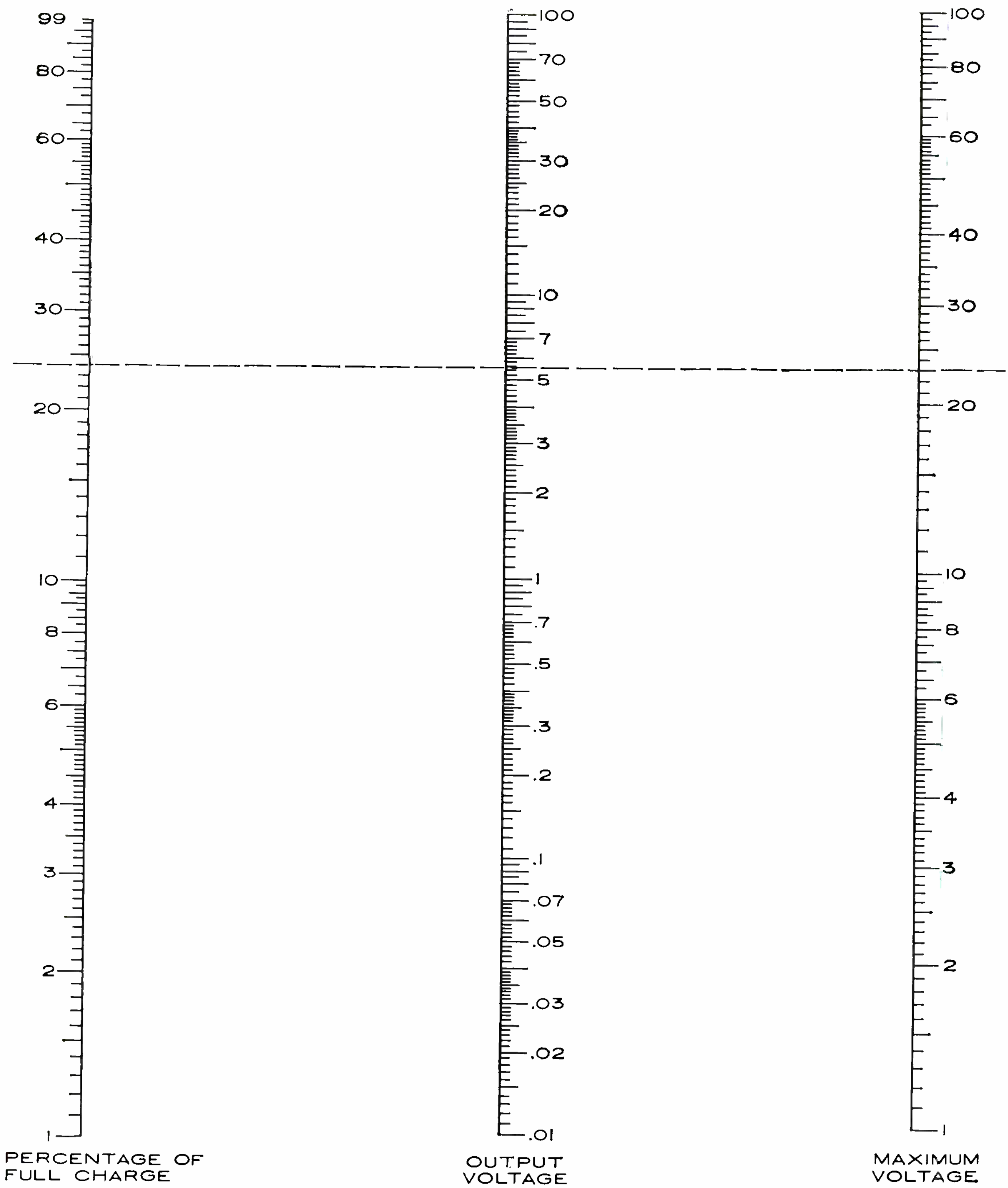


Fig. 3. Nomogram that may be employed to convert the percentages previously obtained from Fig. 2 into output voltages.

Example

A 23-volt pulse, 6 microseconds long, is applied across the circuit of Fig. 1. To what voltage will the capacitor have charged at the end of 6 microseconds? The first step is to locate the given values on the nomogram shown in Fig. 2.

Locate 27,000 ohms on the first scale, 820 $\mu\mu$f. on the second scale, and draw a line through these two points. From the point where that line crosses the "Turning Scale," draw a line through 6 microseconds on the "Time" scale. The answer, where the second line crosses the last scale, is 24 per-cent of the applied pulse voltage.

Now locate 24 per-cent and 23 volts on the first and last scales respectively of Fig. 3. Draw a straight line through the two points and where it crosses the middle scale, read the answer of 5.5 volts.

For applied voltage outside the range of 1 to 100 volts, the range of Fig. 3 can be extended. Move the decimal point any number of places on the last scale and then move the decimal point the **same** number **of** places, in the **same** direction, on the middle scale.

Fig. 2 can be used to determine points for plotting the entire charge cycle of the **RC** network. Rotate a straight-edge about any point on the "Turning Scale" and record various combinations of "Time" and "Percentage" that the straight-edge crosses. When these points are plotted on linear graph paper, they will then form the familiar logarithmic charging curve. ▲

SCALER MEASURES DISTANCES from AERIAL PHOTOS

Description of computer-type device that gives practical data for design of highways, dams, and other earthworks.

By WILLIAM R. HILIARD

AS THE hand mathematician is to the high-speed computer, so is the foot engineer with his transit level to the scaler or read-out device developed by *Auto-Trol* of Denver, Colorado. The fundamental purpose of the scaler is to measure scaled distances from aerial photographs. The advantage of this over the foot engineer is plain. It is estimated that 30 minutes of flying time will provide enough material to keep a computer busy for 100 hours. The whole system utilizes aerial photography, photogrammetry, and a tracing table to finally give the engineer a usable and practical data sheet for use in earthwork projects.

The scaler merely records horizontal readings and vertical elevations taken from topographical maps and then transmits them to the console. At the push of a digit button, the information is processed through the scaler and then punched upon cards. These, in turn, can be fed into a typing machine so the end result is usable, printed data which can be recorded up to 16 times faster than manual methods, with an accuracy of 1/10th of a foot. This is sufficiently accurate for any bulldozer or dragline.

The starting point at which the scaler comes into use is at the photogrammetry table. This is where the readings are taken from the topographical maps and are entered into the console by means of digital buttons provided for the purpose. One photo shows the operator looking at the white disc which serves as a projection screen. His left hand is turning the small wheel on a threaded rod which raises or lowers the disc. This same threaded rod is geared to a mechanical counter which is capable of giving visual elevation readings. However, the electrical encoder attached to it monitors the movements of the counter so that the readings can be transmitted to the console. At the same time, the horizontal readings are taken by another encoder driven by the horizontal rod passing through a circular base as shown. This operates on the rack-and-pinion mechanical principle. The accuracy of the rack is .001 inch, with a maximum of .002 inch.

In highway construction, all horizontal readings are taken at right angles from the centerline of the road in 25-foot segments until a maximum of 200 feet is reached. This process is repeated for the opposite side of the proposed road. Then 50 feet farther up the highway at the next "station," the whole process is repeated.

When the read-out button is pressed, the readings are automatically placed in a buffer memory until the operator sends it all through to the key punch. An automatic interlock system allows the operator to move to the next point without finding it necessary to wait for the completion of the cycle to make the next reading.

The scaler consists of three basic systems: the elevation counter, the horizontal counter, and the read-out control unit. The two encoders detect the motion, whether horizontal or vertical. The motion is changed to pulses which enter logic circuits in the counters. Other circuits within the scaler convert the information from its original binary coded form into decimal form. In this form, it is sent to the output circuits and to the *IBM* key punch. The readings can be used by the key-punch machine to produce cards at the rate of 10 characters per second. A computer can receive this information easily and at the same time type out a data sheet for the user.

One of a variety of forms produced by the punch, in conjunction with the scaler, is a Terrain Data Sheet. It names the job, gives the "station" number, distance, and elevation. The readings begin about 200 feet off to the right of the centerline and approach at approximately every 25 feet. Then the readings take off from the centerline working to the left for the same distance. Of course, physical characteristics in the terrain will dictate where the outside readings will begin and end.

The scaler has been put to use at the Denver Federal Center of the Bureau of Public Roads, as well as at the California State Highway Department in connection with various earthwork projects and construction jobs. ▲

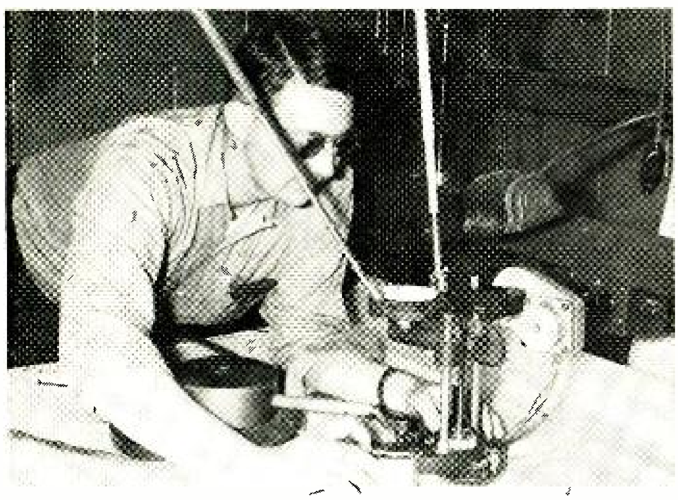
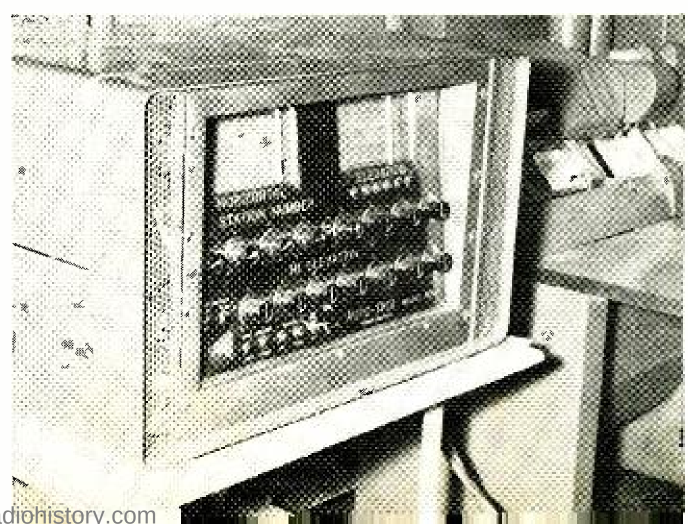


Photo of the stereoscopic plotting table in use. Two overhead projectors show the same scene, but from slightly different angles, on the small white disc which serves as a projection screen. The operator uses a pair of stereoscopic glasses to make the scene appear three-dimensional. The small circular screen is raised or lowered (along with the apparent rise and fall of the terrain being viewed) until two projected pinpoints of light are brought together at a single point of terrain being viewed. At this time, the elevation is recorded in the scaler.



The output of the console, shown here, is sent to the key-punch machine at the extreme right. This unit types out a complete listing of distances and elevations for a large number of closely spaced points surrounding the various stations.

Q&a

FCC answers our Questions on Business Radio

Here are the official answers to important questions about the Business Radio Service.

Editor's Note: Many of our readers are becoming increasingly interested in the Business Radio Service. This is especially true of those who are using Citizen's Radio equipment for routine business operations and who feel that they would like to have the increased coverage and reduced interference possible with Business Radio. We have submitted a list of some of the commonly asked questions about Business Radio to Mr. Curtis B. Plummer, Chief of the Safety and Special Radio Services Bureau of the FCC. Following are the answers to these important questions as obtained from the Federal Communications Commission.

QUESTION 1. *What is the purpose of the Business Radio Service and what does the FCC hope to accomplish in establishing the service?*
ANSWER: The purpose of the Business Radio Service is to provide two-way communications utilizing high-quality communications equipment in business activities which, by their nature, do not justify eligibility in the higher priority land-mobile services.

QUESTION 2. *How does the Business Radio Service compare with other two-way radio services?*
ANSWER: The Business Radio Service compares directly with many higher priority services in terms of equipment used and frequency bands in which the service may be authorized. It is distinctly different from many of the other services in regard to the amount of sharing which must be tolerated and the fact that frequency coordination is not required.

QUESTION 3. *Who is eligible to operate in the Business Radio Service?*
ANSWER: The following persons when engaged in lawful activities are eligible for authorization in the Business Radio Service:

a. Any person engaged in a commercial activity.
b. Educational or philanthropic institutions.
c. Clergymen or ecclesiastical institutions.
d. Hospitals, clinics, and medical associations.
e. A subsidiary corporation proposing to furnish a nonprofit radiocommunication service to its parent corporation or to another subsidiary of the same parent where the party to be served is engaged in one of the activities as set forth above.

QUESTION 4. *What licenses are required for station? for operator? for service personnel?*
ANSWER: Each base or fixed station in the Business Service requires a station license; a single mobile station license may authorize as many mobile units as are required. If only one base station is employed in a system, the associated mobile units and the base station may be authorized on one license. No operator's license is required for routine operation of type-accepted equipment. Service or maintenance work may be performed on Business equipment only by personnel holding a second class or higher grade commercial radio operator's license.

QUESTION 5. *How does one obtain a Business Radio Service license and how long does it take?*
ANSWER: A Business Service license is obtained by filing FCC Form 400 in accordance with the associated instructions and Part 11 of the Commission's Rules. The processing time for such application generally varies between 3 to 6 weeks, depending on work-load.

QUESTION 6. *How many licenses have been issued so far? At what rate are license applications being processed?*
ANSWER: At the present time there are some 40,000 outstanding licenses in the Business Radio Service. This figure has been reached since the fall of 1958 and applications are being processed at the rate of approximately 1000 per month.

QUESTION 7. *Are specific frequencies assigned and who decides what these frequency assignments should be?*
ANSWER: Specific frequencies are assigned as requested in the application made, providing the selection is in accordance with the Rules.

QUESTION 8. *How crowded are the various channels?*
ANSWER: The degree of sharing varies quite closely with the distribution of population in most frequency bands, and ranges from quite heavy in some metropolitan areas to very light in the more isolated areas. However, considerable freedom from interference is still possible in many metropolitan areas in the available frequency range between 460 and 470 mc.

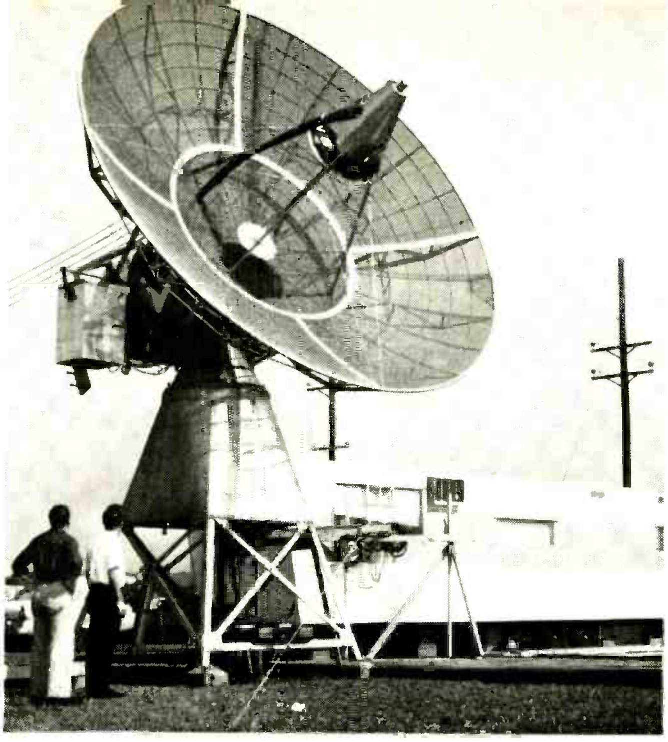
QUESTION 9. *What are the limits on power? frequencies? types of modulation? frequency stability?*
ANSWER: *a.* Power limitations in the Business Radio Service are associated with the frequencies assigned. Some seven frequencies between 27 and 36 mc. may be used with 500-watt input power. Also, two frequencies in the 150-mc. band are available for use with a maximum plate input power to the final radio-frequency stage of 600 watts. The greater bulk of the available frequencies may be authorized a maximum power input not to exceed 180 watts. Some five channels in the 27-mc. band are restricted to 30 watts maximum input power. Several other frequencies scattered through the bands 27-36 mc., 151-158 mc. and 460-470 mc. are restricted to a maximum input power of 3 watts.

b. In general the Business Radio Service is restricted to Type F3 (FM or PM) or Type A3 (AM) modulation, however, the five 10-kc., 30-watt frequencies 27.235, 27.245, 27.255, 27.265, and 27.275 mc. may be utilized for intermittent transmissions employing any type of emission which does not exceed an occupied bandwidth of 8 kc. The bandwidth authorized on all other frequencies in the Business Radio Service for frequency modulation is 20 kc. and for amplitude modulation the bandwidth is 8 kc.

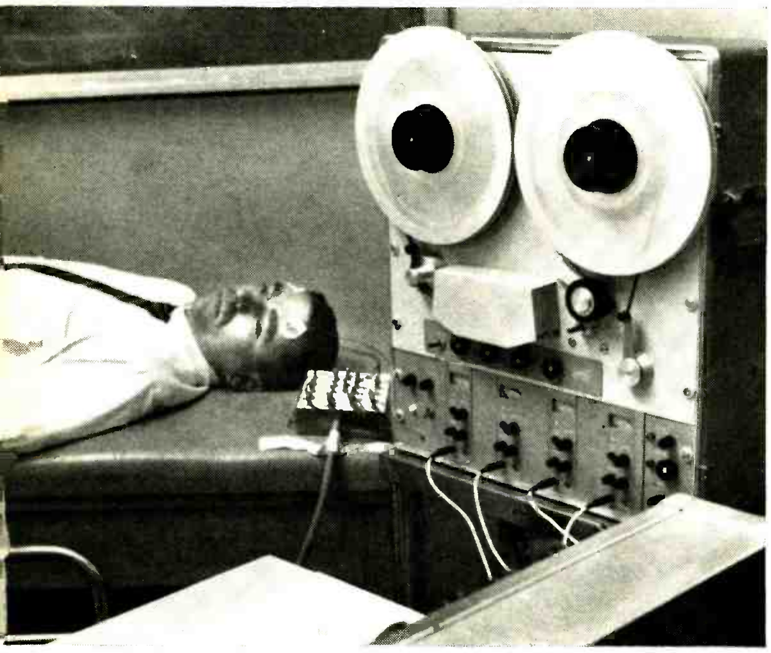
c. The frequency stability required in the Business Radio

(*Continued on page* 76)

RECENT DEVELOPMENTS IN ELECTRONICS



→
Simple Station Contacts "Telstar"
This is the compact ground station used by Bell Laboratories recently to demonstrate single two-way voice communications via the satellite "Telstar" using simple, relatively inexpensive ground equipment. The 18-foot dish antenna is used for both sending and receiving. Control equipment is housed in the trailer.



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Portable Medical Recorder
A new instrumentation recorder, designed specifically for medical use, is shown recording encephalogram signals for future playback and analysis. One-sixth the size and half the cost of previous precision instrumentation recorders with comparable performance, the unit may be operated without advanced technical skills. The four-track recorder-reproducer, demonstrated recently by Ampex, can simultaneously monitor a patient's blood flow and pressure, respiration, body temperature, and other physiological phenomena.

Sun-Pumped Laser
A laser, pumped by concentrated sunlight, has been developed by RCA Laboratories. A 12" reflector focuses sunlight on a rod-shaped crystal of calcium fluoride that converts the energy directly into continuous, coherent infrared radiation. The assembly is cooled by means of liquid neon.
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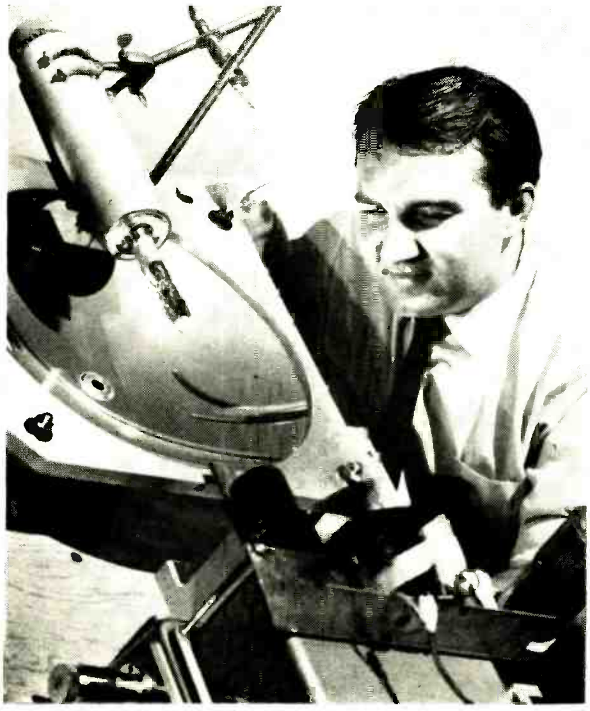

Integrated Microcircuit
This integrated "nor" gate microcircuit, developed in the Sprague Research Center recently opened in North Adams, Mass., is intended for use in electronic computers of the future. On a silicon substrate only .08" square are 8 diodes, 1 transistor, 4 resistors, and 1 capacitor. The actual diameter of the semiconductor header in which the circuit is housed is .290".
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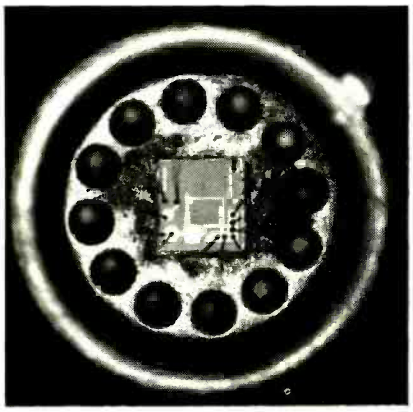
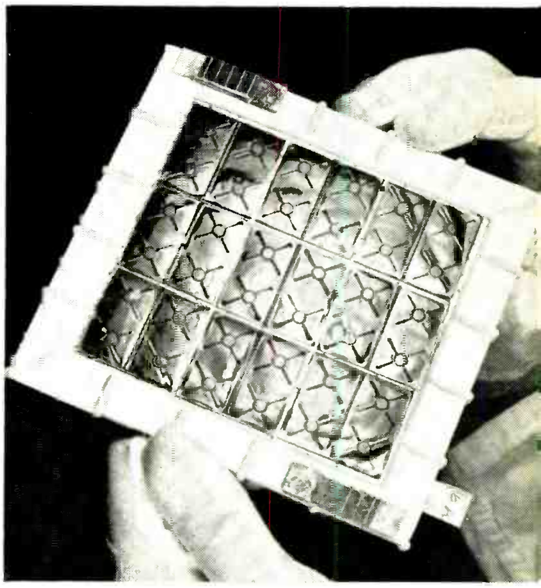


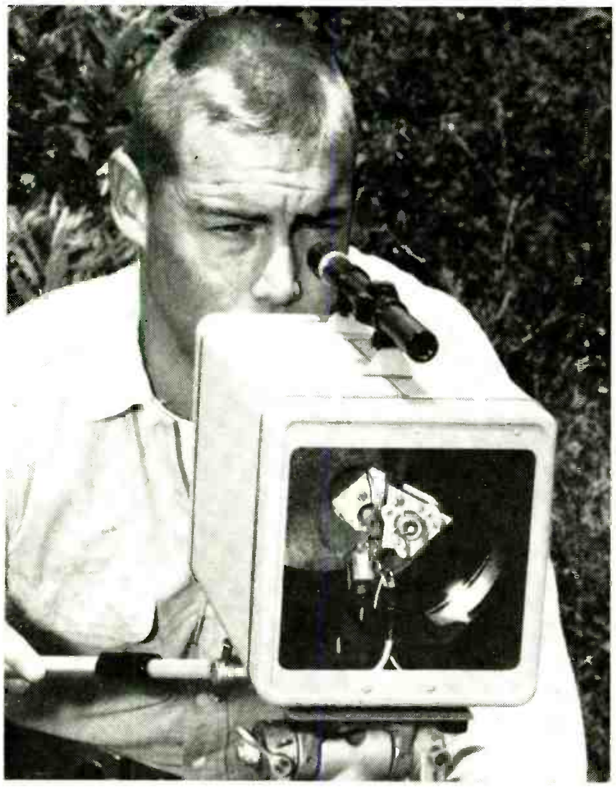
Flight-Position Indicator →

A flight-navigation device that gives pilots of small planes a continuous picture of their flight position by means of a small red dot that moves in synchronization with the plane is shown at the right. The instrument, developed by ACF Industries, is completely transistorized and operates from ground radio signals. The unit is designed to allow pilots to fly routes that reduce flight time and increase air safety.

Solar Thermoelectric Panel →

Sun-operated thermoelectric panels, using a new concept for converting the sun's energy into auxiliary electrical power for space vehicles, are part of an experimental package to be sent into orbit soon. The converters, built by General Dynamics, differ from silicon solar cells because they are relatively insensitive to radiation. Unlike photoelectric solar cells that convert sunlight directly to electricity, the panels first convert the sun's energy to heat and then to electricity, operating on the principle that a temperature difference across a thermoelectric material causes electric current to flow.





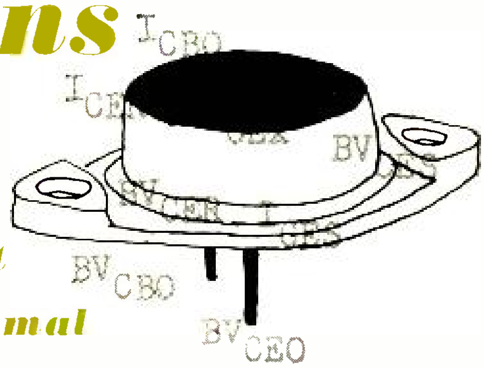
Infrared Communicator ↑

Invisible light rays generated by portable infrared communicator make it possible to carry on two-way confidential conversations between stations up to 10 miles apart. Communicator, developed by Raytheon, produces pencil-thin beam so narrow that it is virtually impossible to tap.

Subminiature Semiconductor Mike →

A pinhead-sized microphone has been developed in which changes of pressure on a tiny junction transistor result in an amplified output signal. The mike employs a diaphragm assembly that resembles a miniature thumbtack whose point bears directly on the semiconductor. The Raytheon unit has responded to a vibration range extending from subsonic, through audio, and into the ultrasonic frequencies.

Power Transistor Specifications



By JOHN R. GYORKI / Burroughs Corporation

Discussion of important mechanical, electrical, and thermal characteristics to familiarize the technician with several basic transistor limits.

ALTHOUGH a great number of power transistor specifications can be devised (and the number seems endless), a few of the more common and important mechanical, electrical, and thermal characteristics will be discussed. Without a doubt, the sophisticated power transistor as we know it today would not exist if it were not for the absolute control of a myriad of fine characteristics during manufacturing and sorting. However, we are concerned only with the ratings that decide how we can best keep a device operating at its highest efficiency.

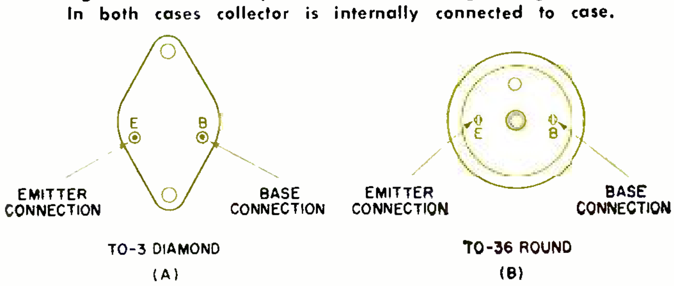
Mechanical Characteristics

One of the industry's most common power transistor package styles is the diamond base, also commonly known as the "TO-3." It has straight pins that can be plugged into a suitable socket (through a heat sink or radiator) and is usable with emitter currents of ten amperes or less. Socket connections, however, are not satisfactory connections and develop voltage drops; just as voltage drops across a resistance. Also, excessive heating losses occur when currents above the ten-ampere rating are used. Therefore, we must utilize a more substantial type of transistor.

Another equally popular style is the round type, "TO-36." It is generally used for emitter currents of 15 amperes and above. Two straight pins are used for the base and emitter connections with holes in them for soldering or they are available with tinned leads welded directly to short emitter and base studs.

In both types, the collector is mechanically and electrically fastened to the transistor case. The case serves as the collector terminal and thermal radiator connection. This is done since the collector junction becomes very warm during operation. The emitter and base leads usually can be identified by observing an "E" and a "B" stamped on the transistor case near the respective leads. However, this is not always the situation, so a basing diagram for the particular transistor being used should be consulted. Fig. 1 shows the typical lead arrangement for both styles.

Fig. 1. Two common power transistor basing arrangements. In both cases collector is internally connected to case.



The diamond package is held in place by a 6-32 screw inserted through each hole in the opposite corners of the heavy mounting base. The round style is mounted by a single threaded stud projecting outward from the bottom. A 10-32 nut and lockwasher terminal is used to secure it in place. The recommended torque on the TO-36 mounting stud is 12 inch-pounds; no more should be used. Appropriate insulating washers are often used at this time to electrically insulate the transistor from the heat sink. This will be discussed more fully under thermal conditions.

Transistors are not mechanically shockproof in themselves. However, their rigid construction makes them suitable for use in rugged type equipment. They are hermetically sealed with a metal cap, either hot or cold welded to the mounting base. This excludes moisture and light, both of which can degrade the quality of the device.

Electrical Characteristics

Leakage Current: Collector cut-off currents are simply other words used for discussing inherent leakage currents associated with the collector while the base and emitter are held to pre-determined conditions.

One of the most important collector leakage currents is I_{cbo} or more commonly, I_{co}. See Fig 2A. It is a leakage current from collector to base with the emitter open-circuited and is critical because it is most susceptible to temperature variations. Since power transistors operate with high junction temperatures, changes in I_{co} could greatly affect the stability of the transistor and circuit. I_{co} can easily be demonstrated by constructing the circuit of Fig. 2A. Heat from your hand or a lighted match brought near the transistor will change the indicated leakage current enough to be quite obvious.

Leakage current from collector to emitter with the base circuit open is termed I_{CEO}. This is a condition that could be expected in switching applications; the base open and the collector supply voltage present across the collector and emitter. In better switching circuits, however, the base circuit is not entirely open. It is usually reverse-biased or connected to the emitter by a low value resistor.

Two other collector leakage currents are I_{CER}, with a specified resistor from base to emitter, and I_{CES}, with the base shorted to the emitter. They, as well as I_{CBO}, are measured with the conventional reverse-bias voltage from collector to base. See Figs. 2B and 2C.

These leakage currents vary from a few microamperes to a few milliamperes, depending on the specific transistor type. They are among the most critical power transistor ratings and should be kept as low as possible. Increased leakage current causes a rise in junction temperature; a rise in temperature creates more leakage current. This condition is called thermal runaway and, if not controlled, could end in the destruction of the transistor. Outside factors which generally determine the over-all stability are controlled by the circuit designer.

Voltage Breakdown: Collector breakdown voltage is that reverse voltage applied between collector and emitter where the collector current begins to avalanche and the collector current becomes independent of collector voltage. This constitutes a group of breakdown voltages where the base and emitter are held to various constants. One such voltage is BV_{CBO}, the reverse breakdown voltage between collector and base with the emitter open. See Fig. 3A.

Two other breakdown voltages are BV_{CES}, base shorted to emitter, and BV_{CEO}, the base open-circuited. Refer to Figs. 3B and 3C. These are important considerations when circuits with inductive loads are used. During transient voltage peaks the actual instantaneous voltage present between collector and emitter may be very much higher than the supply. It is at this time especially we do not want the collector-to-emitter voltage rating exceeded.

Another breakdown voltage is BV_{CER}. This arrangement has a specified resistor between base and emitter (usually around 10 ohms). See Fig. 3D.

BV_{CEX} is the reverse breakdown voltage between collector and emitter with a small reverse bias between the base and emitter of 0.1 volt or more. This constitutes the absolute maximum surge voltage limit that the transistor can tolerate.

Steady-state voltages are not used to measure these breakdown voltages (as may be implied from the diagrams) because of the excessive junction heating which could destroy the transistor before final results were tabulated. Rather, a sweep method is used, employing an oscilloscope and a sine-wave generator where collector voltage *versus* collector current can be observed and the breakdown curve clearly indicated without undue junction heating. (See "*Motorola* Power Transistor Handbook," First Edition, Chapter VIII "Transistor Testing," page 159.)

Collector saturation voltage, $V_{CE(sat)}$, is that small voltage appearing between collector and emitter with such large base drive applied (forward bias) that any further increase in base current will not change the collector current appreciably. In other words, this is where further collector injection (by the base) brings to a halt the further increase of collector current. Current gain is no longer considered existent at these high current levels. Saturation voltage ratings of most transistors are measured with a specified value of collector and base current.

Current Gain: Transistor current gain, *beta*, is the ratio of a change in collector current to a change in base current. This is the actual usable current amplification rating of a particular transistor. Current gain specifications in power transistors are generally given a range of values for a specific transistor. These values are known as "large-signal current gain" and are primarily used over the mean values of maximum collector currents. "Small-signal current gains" are sometimes specified for medium- and high-power transistors, but more generally are considered a special case, since only a very small portion of the allowable collector current is actually used. That is, the current gain of a power transistor is much higher at low collector current levels than at high collector currents.

Cut-Off Frequency: Current gain frequency cut-off, f_{ae} (common emitter), is that frequency where the small-signal current gain of the transistor is 3-db down from some pre-determined value specified at a particular frequency. This means that the current gain at f_{ae} is 0.707 of the value specified at some reference frequency (usually 1 kc.). The actual cut-off frequency is usually 10 kc. for most common power transistors.

Other Characteristics: There are a few other normal operating characteristics concerning voltage and current that are important and should be considered.

Maximum emitter current is a common rating and means just that; the maximum emitter current that can flow before permanently damaging the device. This is probably one of

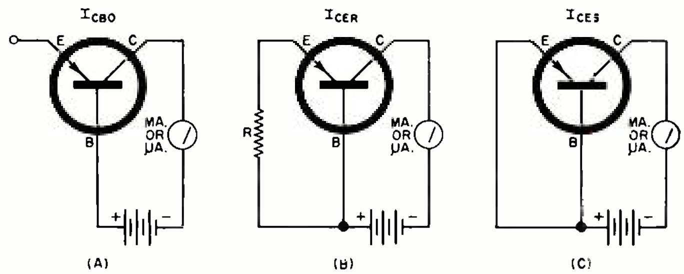


Fig. 2. Circuits for measuring leakage currents of transistors.

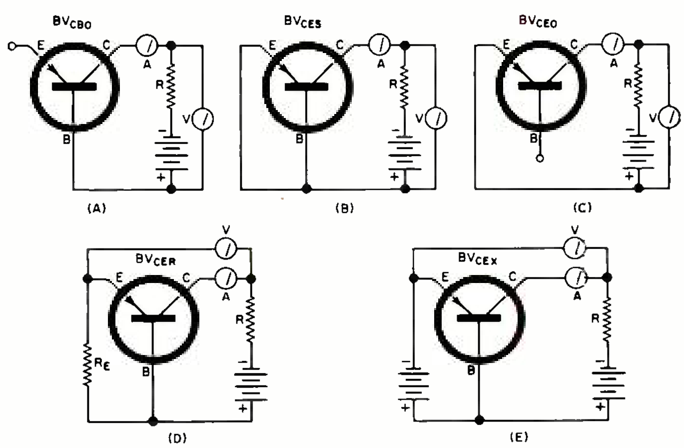


Fig. 3. The various breakdown-voltage measurements are depicted.

the first practical operating ratings considered for either replacement or new design purposes.

Collector-to-emitter voltage is usually specified with the base shorted to the emitter or with the base open-circuited. In either case, the rating is specified with a certain value of collector current.

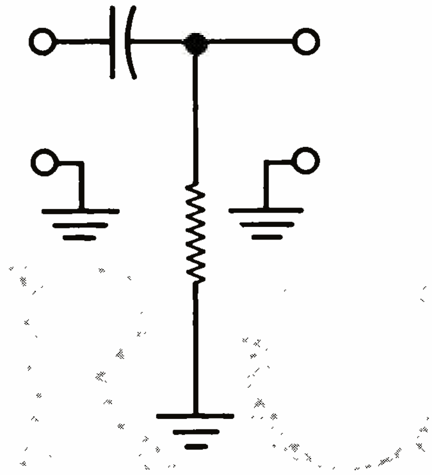
Collector diode voltage, V_{CB} (voltage, collector-to-base) is indicated with a value of emitter-to-base voltage. The actual circuit supply voltage should be less than the collector diode or collector-to-emitter voltage ratings.

Base current is usually given as a continuous value or a maximum value. This base current rating should not be exceeded or the junction will overheat and destroy the transistor.

Power and Thermal Ratings

Power dissipation and junction temperature rise are directly related since the rise in junction temperature is caused by power being dissipated in the junction. The maximum allowable junction temperature of germanium power tran-

(*Continued on page* 90)



COUPLING NETWORKS:
A PRACTICAL VIEWPOINT

By SOL HELLER / Instructor in Electronics, Voorhees Technical Inst.

What could be simpler than this two-component configuration? It is the root of many poorly understood, practical problems.

AT FIRST glance, an *RC* network looks too simple to be the exclusive subject of an article. Yet there are many facts about this configuration that are not too well understood, and they have important bearing on circuit trouble. There is so much information, in fact, that only one aspect will be dealt with here: the proper sizes of resistor and capacitor in the simplest and commonest *RC*-coupling network (Fig. 1A).

This information can help speed recognition of trouble in such practical situations as when (1) coupling capacitor C_c or grid resistor R_g has changed value; (2) an improper substitution has been made for one of them; (3) the value of either or both can not be read or otherwise determined; and (4) the values used by the equipment designer or manufacturer are less than ideal.

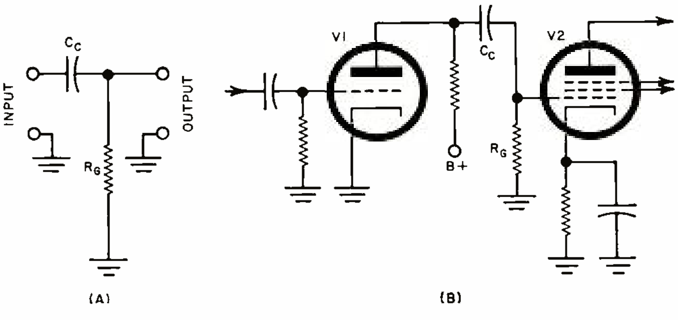
Before effects are discussed, function should be reviewed. C_c couples a.c. signal from the output of one stage (*V1* in Fig. 1B) to the input of the following stage, *V2*; but it blocks the d.c. voltage at the *V1* output so that this voltage will not be applied to the input of *V2*.

R_g serves to provide input signal for *V2*: the input signal must be developed across some resistance or impedance. R_g also returns the *V2* grid to the same point as the cathode return, which is ground in this case. Without such a return, there would be no *V2* bias and no signal input.

R_g also forms a voltage divider for the applied signal, in conjunction with the reactance, X_c, of series capacitor C_c. The larger the reactance at the signal frequency, the more signal voltage will be developed across C_c, and thus the smaller will be the useful signal voltage developed across R_g. In effect, the *V2* input signal is reduced.

Thus it is generally desirable to make X_c very small in relation to R_g (by making C_c large) to minimize signal losses across the capacitor. Another way of looking at this is to state that the value of C_c is selected to help provide the desired low-frequency cut-off of an audio or video amplifier or other circuit.

Fig. 1. A basic RC coupling network (A). As widely used to join two stages (B), it enters into a variety of relationships.



Capacitor-Related Effects

The graph in Fig. 2 illustrates the effect of different values of C_c on the low-frequency end of the response curve for a particular audio amplifier. Either flat response or controlled roll-off at a desired point can be obtained by manipulating the value of the single component.

To help extend low-frequency response, the values of C_c thus are commonly larger in high-fidelity amplifiers than in other audio amplifiers. The larger value also assists reproduction of transients.

A transient is a complex waveform that does not have a regularly repeated pattern, like the sound generated, for example, when cymbals are struck. Since a transient generally consists of a fundamental with a large number of harmonics covering a considerable frequency range. Wide bandwidth, including extended low-frequency response, is thus needed for realistic reproduction of transients.

It would then seem that increasing a low value of C_c in the audio section of an ordinary radio receiver is a good idea, since there will theoretically be an improvement of bass response. This may not turn out, however, to be a wise change in practice. The receiver may not otherwise have been designed to handle such response properly. As a result of cabinet and speaker resonances or other factors, performance may be worse instead of better. In fact, a smaller value than normal for C_c is sometimes used for deliberate bass attenuation.

The case just cited bears directly on a popular belief concerning coupling capacitors: that, although one should be careful about reducing the value during a replacement, it is always safe to use a larger capacitance than that originally found. Service technicians may follow this practice in trying to squeeze the last ounce of signal out of one stage in coupling to the next. More than one drawback, however, is possible.

The Leakage Problem

Consider capacitor C_g in Fig. 3. In practice, there is always a certain amount of d.c. leakage through it, due to shunt leakage resistance R_{cg}. This current develops a positive, d.c. grid-to-ground voltage (E_g) across R_g, which is imposed on the input of V2. The larger the coupling capacitor, the greater will be the leakage current through it, and thus the d.c. voltage across R_g will also be greater.

This positive voltage reduces the bias of the stage, and can therefore cause overloading and grid limiting at normal levels of input signal. When the stage is used to process sync signal, operation may be sufficiently impaired to change the critical timing of the sync pulse, possibly resulting in sync or interlace problems. In the case of a horizontal sweep circuit, a larger value of coupling capacitor may overdrive the output tube to produce drive bars and/or nonlinearity that may not be easy to eliminate with ordinary drive-control readjustment.

Furthermore, consider what happens if C_g were carefully chosen to attenuate certain signals. Video signals formerly kept out of a sync or sweep stage, for example, may enter when the capacitor value is increased. Hum formerly kept out of a critical circuit may be able to enter; a smaller than normal value of C_g may be used specifically to reduce hum originating in preceding stages. And yet, although this is true, the opposite can also be true. Sometimes a smaller than normal value of C_g can *increase* hum level.

Referring to Fig. 1B, this reverse phenomenon will tend to occur when grid resistor R_g is 500,000 ohms or larger. To understand this phenomenon, see Fig. 4. The a.c. voltage across the V2 heater is coupled to the grid through inter-electrode capacitance C_{gh}. The hum signal is then developed across R_g in parallel with the series combination of C_c and R_L. (The plate resistance of V1, R_p, is also in parallel with R_L.)

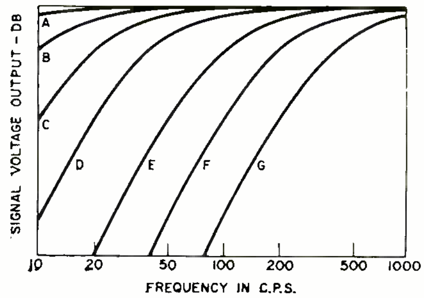
If C_c is made smaller, its X_c goes up, and the net impedance between the V2 grid and ground consequently rises. The grid-to-ground impedance is in series with the heater-to-ground capacitance. If the former rises while the latter remains the same, a larger percentage of the a.c. heater voltage is developed between grid and ground—increasing hum input.

Video Circuits

Too small a value of C_c in a video-amplifier coupling circuit can cause picture smear. C_c introduces an appreciable angle of lead into low-frequency signal voltages developed across R_g. This phase shift tends to displace picture information to the left on the picture screen. When C_c and R_g have the proper value, and a suitable low-frequency compensation circuit is employed, the phase shift is minimized and made uniform for all frequencies. When C_c is too small, however, the phase shift becomes non-uniform, and displacements of large picture areas with respect to the rest of the picture occur that produce a smear effect.

Assume a picture background that is black on the left side, white on the right. The picture signal representing this background may be considered to have the shape of a square wave. If such a video signal is applied to the input of the video amplifier coupling network, it should emerge at the output with the same shape.

The larger the product of R_g and C_c, the more closely will the output waveform approximate a square wave. If $R_g \times C_c$—*i.e.*, the time constant—is too small, the top of the wave will



CURVE DESIGNATION	COUPLING CAPACITOR VALUE IN µfd.
A	.05
B	.02
C	.01
D	.005
E	.002
F	.001
G	.0005

WITH A CAPACITOR OF .1µfd. (NOT REPRESENTED ON GRAPH) RESPONSE WAS PRACTICALLY FLAT BETWEEN 10 AND 1000 C.P.S.

Fig. 2. The effects of different values of C_c on the response of a circuit. In this case, R_g is held constant at 1 megohm whereas, compared to it, the plate resistance and plate load resistance of the stage preceding the network are very small.

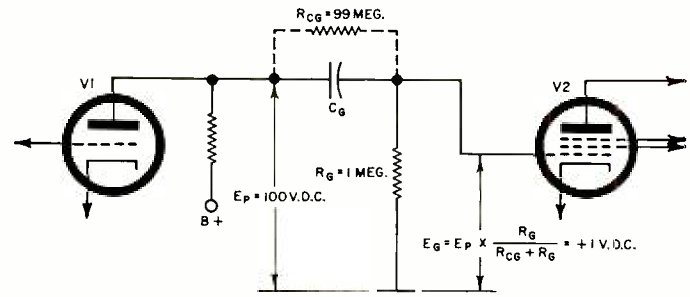


Fig. 3. How the leakage resistance of a coupling capacitor (C_g) acts as a d.c. voltage divider in conjunction with the grid resistor (R_g). The degree of leakage affects V2 bias.

slant. The smaller $R_g \times C_c$ is, the greater will be the amount of slant. Such a distortion of the square wave means that the background illumination, as well as large masses in the picture, will be improperly reproduced.

If C_c in a video amplifier is made too large, excessive d.c. current leakage through the capacitor is likely to become a problem. Also, the shunting of high-frequency signals to ground *via* the increased capacitance-to-ground of the larger capacitor will reduce the high-frequency response and impair picture detail.

Resistor-Related Effects

And now, what about the size of R_g in various circuits? In the case of triodes or pentodes using resistive plate loads, the maximum value of R_g that can safely be used depends chiefly on the reverse grid current that can be tolerated. This current flows *up* through R_g, producing a positive grid-to-ground voltage that bucks the bias present.

Reverse grid current is due chiefly to gas (assuming grid emission is negligible). Positive gas ions that are present in every tube drift to the grid, which is relatively negative and thus attracts them. (See Fig. 5A.) The larger the value of R_g, the greater is the positive voltage developed between grid and ground as a result of this reverse grid current, and the greater the effect on the bias.

Since gas current fluctuates in amplitude and tends to be erratic, bias variations are introduced that impair the stability of the tube's performance. The larger R_g is, the larger will be the voltage developed by reverse grid current, and the greater will be the undesired bias variations.

When a tube has a high transconductance (G_m), a small gas-caused voltage variation at the grid will produce a relatively large change in plate current. It should be evident, then, that a relatively large value of R_g is particularly undesirable in the case of high G_m tubes. A similar line of reasoning applies to power output tubes, since these are high current tubes providing relatively large power gains; a small change in grid voltage will produce a large change in power output. Not only will circuit performance be unstable in such cases—

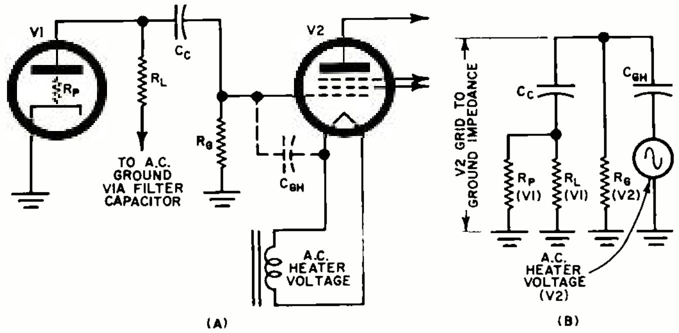


Fig. 4. Hum voltage coupled from heater to grid via interelectrode capacitance appears across the V2 grid resistor. The simplified circuit (B) shows effects of preceding stage.

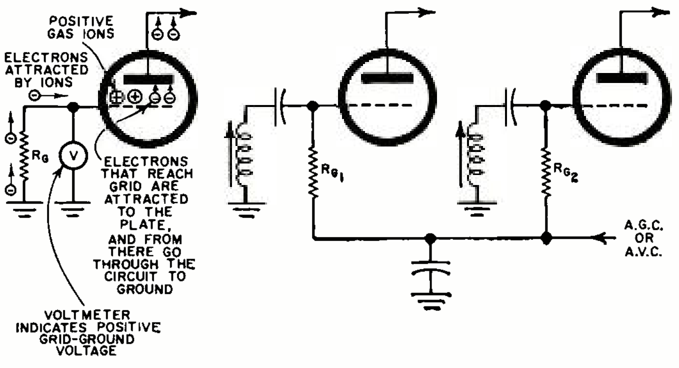


Fig. 5. How reverse grid current (A), due to gas in this case, is developed. Values of grid resistors in such tuned circuits as i.f. stages (B) influence gain and bandwidth.

excessive plate and/or screen currents may be produced as a result of the reductions in bias. Tube electrodes will be called on to dissipate more heat than they can safely tolerate, and tube damage also becomes possible.

Still another undesired risk in power output tubes, when R_g is too large, is a runaway effect that can destroy the tube. Gas current tends to make the grid-to-ground voltage positive, which reduces the bias, which increases the space current flowing through the tube, which heats the tube up more and causes a still greater amount of gas to be released, which further reduces the bias, and so on—until the tube is destroyed.

The condition just described is particularly likely to occur if grid emission is present in significant amounts. Grid emission can occur if cathode-coating material has been deposited on the grid. Heating will then cause the grid to emit electrons just like the cathode. The resultant current will be in the same direction as the gas current previously described. The greater the heating of the tube, the larger the grid emission.

Secondary grid emission can also cause trouble in a power output tube. This type of emission takes place when electrons from the cathode strike the grid with sufficient force to knock other electrons out of the grid. The loss of electrons tends to make the grid positive to ground, and has the same general effect as a primary grid emission.

In the case of power output receiving tubes, a maximum R_g value of 500,000 ohms is ordinarily safe when the tube is self-biased. If fixed bias is employed, the safe R_g maximum may be only 100,000 ohms. The reason the larger resistor can be tolerated when self-bias is used is this: When a gas effect produces a positive grid-to-ground voltage that tends to *lower* the bias, the resultant increase in cathode current produces a larger voltage drop across the cathode resistor that tends to *increase* the bias. The initial effect is thus counteracted to a considerable extent.

Tuned Circuits

In r.f. and i.f. circuits using grid resistors in a parallel-feed arrangement, *i.e.*, grid resistors in parallel with tuned circuits (see Fig. 5B)—too small a value of R_g will damp the tuned circuit with which it is in parallel excessively, reducing the signal voltage produced across that circuit. Too large an R_g value is undesired for reasons previously given. It is also undesired, in this particular application, because bandpass may be reduced, and the tuned-circuit gain increased to a point where regeneration or oscillation occurs.

Very large values of grid resistance—as high as 10 megohms—may be found in stages where grid-leak bias is present. Positive grid current flow is used in these stages to develop the bias. (It is current that flows from cathode to grid when the grid is positive with respect to, or less negative than, the cathode. It occurs during positive swings of the input signal voltage.)

R_g is made large to limit grid current to a very small value. A large value of grid current is undesired, not only because it would damage the tube, but because the grid-cathode circuit is effectively in parallel with the plate circuit of the preceding stage (see Fig. 6), and a large grid current in V2 will load the V1 plate circuit excessively. The V1 gain will be correspondingly lowered. (The grid-cathode resistance, when grid current flows, is only several thousand ohms or less; the larger the amount of grid current, the lower does this resistance effectively become.)

Why isn't a large value of R_g harmful in a grid-leak biased stage, as it would be in a stage biased in some other way? Because the negative grid-to-ground voltage discourages the kind of reverse grid current (*up* through R_g) that makes a large value of R_g detrimental.

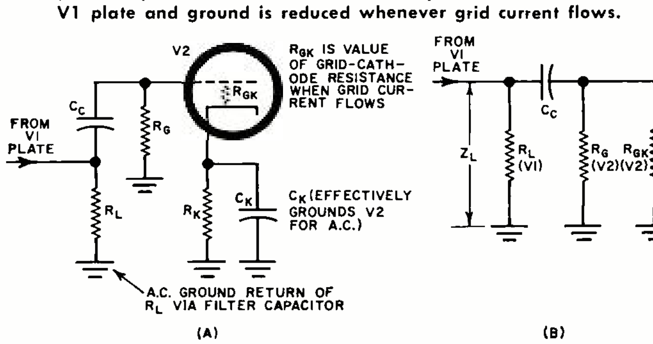
While a large value of R_g (in stages other than grid-leak biased ones) is undesirable, as we have seen, it is nevertheless often necessary to make R_g as large as it can safely be. This is so because R_g is effectively in parallel with the plate circuit of the preceding stage. (See Fig. 6.) If R_g is not made considerably larger than R_L, it will reduce the effective plate load impedance of V1, thus reducing the V1 gain.

The author remembers cases where insufficient gain from an *RC*-coupled stage baffled the technician working on a receiver for quite some time, because he didn't realize that the grid resistor of the next stage (or grid current in that stage) could be responsible.

There is an interesting relationship between heater voltage variations and the permissible size of R_g. If heater voltage variations are in excess of 10%, due to relatively wide line-voltage fluctuations (or battery voltage variations in an automobile receiver), maximum permissible values of R_g will be less. The reason is that the range of bias voltage variations due to gas current will be extended by the heater voltage variations. A smaller value of R_g narrows the bias voltage variations to tolerable limits.

The chain of rarely considered relationships and interactions relating to the simple two-component coupling network is certainly intriguing, but it is more than that. An understanding of the possibilities can be of great practical value in many service-type defects that are otherwise quite baffling. ▲

Fig. 6. The effective circuit (A) when grid current occurs in the second of two stages joined by RC coupling. The simplified equivalent circuit (B). The net impedance between the V1 plate and ground is reduced whenever grid current flows.



V.L.F. LOOP ANTENNA

Construction of a simple, low-cost sensitive loop ideally suited for good low-frequency reception.

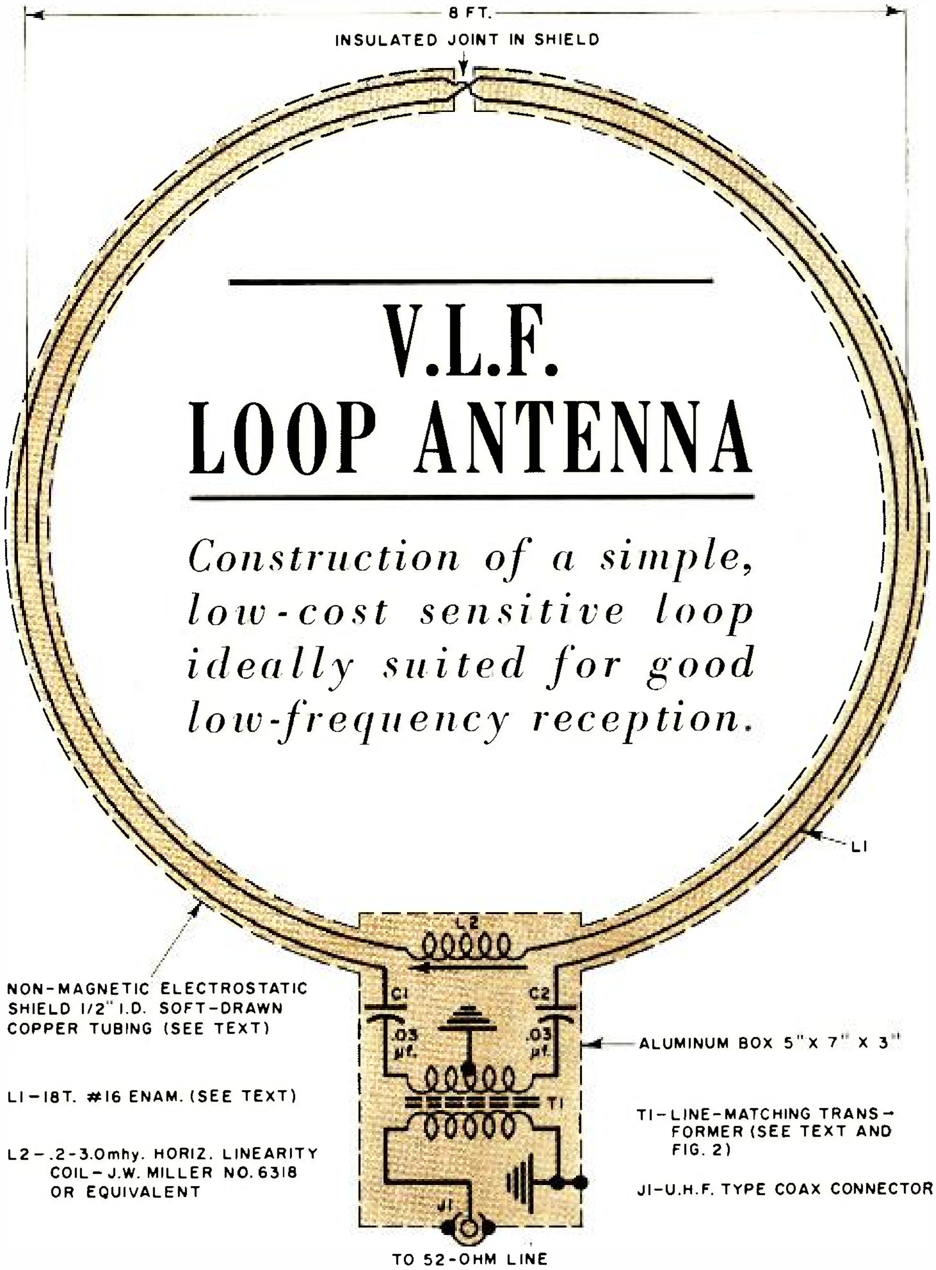


Fig. 1. Schematic of loop with its tuning and matching network.

By RICHARD A. GENAILLE

THE very-low frequencies from 3 to 30 kilocycles have experienced a resurgence of use and interest about which many persons engaged in electronics are not aware. The September, 1961 issue of this magazine carried an article ("Below the Broadcast Band") in which the author described some of the activities which are taking place in the very-low and low-frequency bands and also a simple low-frequency converter which could be constructed for the reception of these frequencies. Briefly, the very-low frequencies are providing a means of high-accuracy frequency determination in much shorter periods of time than is normally possible on the higher frequencies, and also the means by which the U. S. Navy transmits messages to submerged submarines which are scattered throughout the oceans of the world. Present and proposed activities relative to the v.l.f. region will be discussed later in this article.

So fascinating and useful have the very-low frequencies become that the author decided to upgrade his receiving antenna system for v.l.f. by constructing a loop antenna which would greatly improve signal-to-noise ratio and would discriminate against adjacent-channel interference. A considerable amount of experimentation produced a v.l.f. loop antenna that, you will discover, is simple to construct, efficient and inexpensive, and which has all of the desirable electrical features that a loop antenna should have. While the loop to be described was constructed for use in conjunction with the low-frequency converter featured in the aforementioned article, it has been designed with a feed-point impedance of 52 ohms to accommodate standard 52-ohm coaxial transmission line and the input impedance of some receivers. It may be used on other very-low frequency converters or receivers having other than a 52-ohm input impedance by the simple expedient of impedance matching. Since receiver input impedances can vary considerably, the author will describe the method used to impedance-match to his converter as well as several simple methods of matching to other input impedances.

The decision to construct a loop antenna for v.l.f. in preference to using a random length long wire or a simple half-wave dipole was made after realizing that such antennas have several undesirable characteristics. Providing that the long wire was made long enough to have definite directional characteristics, it would be quite difficult to make use of the directional features because of the problem of positioning the antenna. The long wire is inferior to a loop antenna for minimizing noise pickup. A *simple* half-wave dipole at 20 kilocycles would be approximately 4 miles long. To keep the v.l.f. antenna to a reasonable size and to provide directional

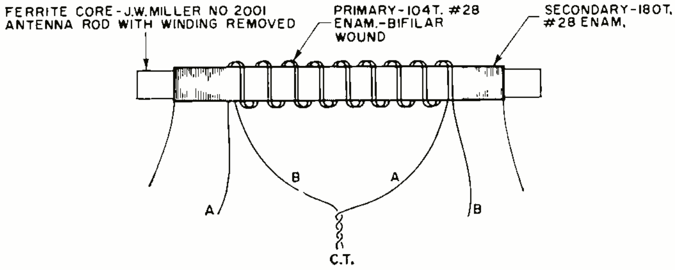
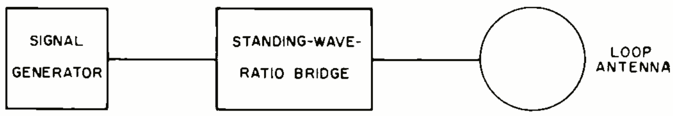


Fig. 2. Construction of the bifilar-wound balanced transformer.



SEE TEXT FOR ADJUSTMENT PROCEDURE
Fig. 3. Bridge method of measuring s.w.r. when tuning antenna.

selectivity and noise reduction were factors which led to the choice of the loop antenna as the most satisfactory solution to the antenna problem.

Since loop antennas are not as commonplace as the "garden variety" of directional antennas, such as multi-element directive arrays for amateur radio and TV use, a few words regarding loop antenna operation may be in order for a better understanding of the constructional details to follow.

Loop-Antenna Operation

Loop antennas have been widely used for many years in direction finding systems particularly aboard aircraft and vessels. The function of the loop is to sense the direction of the arrival of radio signals emanating from a transmitter at a fixed location. The basic loop antenna is simply a coil of wire whose diameter is small in comparison to the wavelength to which the coil is tuned. The ground-wave transmission from the very-low frequency station causes vertically polarized waves to induce voltages in the loop wire as these waves pass by the loop. The induced voltages in the loop wire produce a loop current which depends upon the positioning of the loop antenna with respect to the wavefront.

Almost any convenient shape can be used for a loop antenna, such as a square, triangle, octagon, or diamond. But regardless of which shape the loop assumes, the maximum directivity is along the plane of the loop with a distinct minimum or null at right angles to the plane. The directive pattern of a loop whose diameter is small with respect to the wavelength to which the loop is tuned is similar to that of a doublet antenna, that is, a figure-8 field pattern. The minimum or null, which is broadside to the plane, is extremely sharp in a well-designed loop antenna and is normally capable of giving bearing information better than one degree in low-frequency direction finding work.

While the purpose of constructing the loop antenna, in this case, is not that of direction finding, the presence of a sharp null at zero and 180 degrees with respect to a fixed v.l.f. signal source a reasonable distance away indicates that the loop is functioning properly. This will make it possible for us to eliminate undesirable adjacent-channel interference. The abscence of this sharp null broadside to the plane of the loop antenna can be caused by locating the antenna too close to power wires, other antennas, gutters and downspouts, or other metallic objects and, in general, by poor symmetry of the entire loop antenna circuit including the transmission line and receiver input. The use of a balanced feedline arrangement and a push-pull r.f. stage for the receiver input or a suitable matching transformer to match between a balanced feedpoint and an unbalanced line can be accomplished to improve loop circuit symmetry.

Static electricity in the air is a source of much noise in low-frequency reception and very often causes complete masking of desired signals. Enclosing the receiving loop wires in a non-magnetic metallic shield will greatly reduce noise pickup thereby enhancing the over-all signal-to-noise ratio of the receiving system. The loop wires are completely surrounded by the shield except for a narrow transverse gap or break at the apex of the loop electrostatic shield.

Circuit Arrangement

The v.l.f. loop antenna shown in the photograph can be resonated from approximately 14 kc. to 25 kc. with the components specified in the schematic diagram. In this range the feedpoint impedance will be 52 ohms. The construction of this antenna is quite simple and straightforward and the cost of the materials used represents a very small investment for the performance obtained. All of the component parts of the loop antenna circuit are readily available.

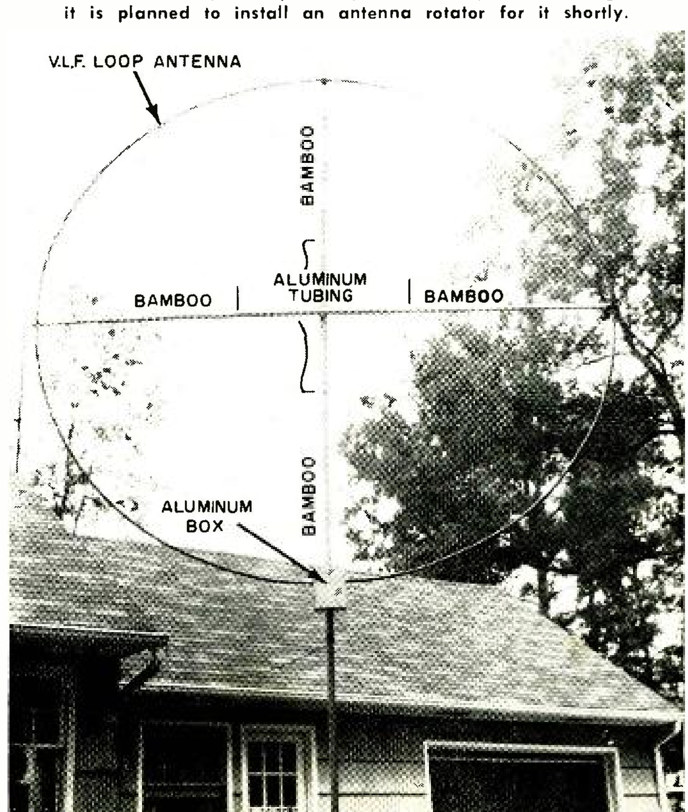
The schematic of the v.l.f. loop is shown in Fig 1. *L1* is a continuous loop made up of 18 turns of #16 enameled or formvar-insulated wire. *L2*, which is adjustable from .2 to 3 mhy., is used to resonate the loop circuit to the desired frequency. *T1* is a matching transformer wound so that loop balance is maintained while providing a match to a 52-ohm unbalanced line. Capacitors *C1* and *C2* are good quality micas used to bring the over-all loop tuning into the range of tuning coil *L2*. The tuning coil, capacitors, and matching transformer are housed in an aluminum box with dimensions of suitable size to permit freedom in making the necessary connections.

The electrostatic shield for the loop wires is made from a twenty-five foot length of soft-drawn copper tubing with a ½-inch inside diameter. This tubing is available from *Sears, Roebuck* or any plumbing supply house. In many cases 25 feet of tubing represents a standard length coil and was chosen so as to avoid wasted tubing due to cutting. A length of cheap plastic hose with a ⅜-inch i.d. and slightly less than a ½-inch o.d. was used inside the copper tubing to protect the loop wires during the pulling operation. The author felt that the small extra cost of the plastic hose would be worth it to prevent possible abrasion of the wire insulation and subsequent operational troubles. The plastic hose also provides additional loop rigidity lost by the necessity for a gap in the copper tubing at the apex of the loop.

Construction Details

The first step in the construction of the loop proper is to uncoil and stretch out the 25 feet of copper tubing on a level

The author's loop must presently be turned by hand although it is planned to install an antenna rotator for it shortly.



floor. The straighter the tubing the easier it will be to pull through the plastic hose and wires in the following steps. After the tubing has been straightened, solder a ½-inch copper tubing-to-outside thread adapter to each end of the tubing. Conduit nuts of suitable size may be used to secure the copper tubing to the metal box which houses the smaller circuit components. Next, measure to the exact center of the length of tubing and, using a tubing cutter, cut the tubing in half. Keeping the tubing sections together, insert a 27-foot length of plastic hose into one end of the tubing and, by working it slowly, pass the hose through both sections of the tubing so that approximately one foot of hose remains outside each end of the copper tubing.

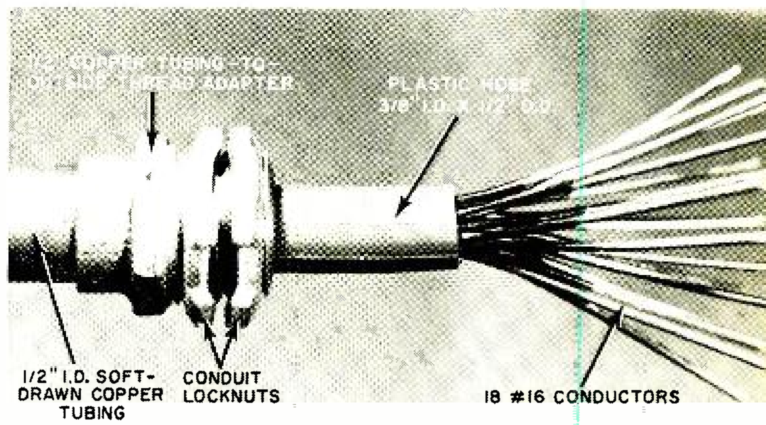
At this point a single #16 wire should be worked through the tubing-hose combination to facilitate pulling through the bundle of 18 #16 loop wires. The loop wires should be cut to a length of 27 feet and each wire tinned on one end. The bundle of eighteen wires should then be soldered to the pulling wire and the bundle carefully pulled through the entire length of the loop tube. Incidentally, the tedious job of removing the insulation from the wire ends can be simplified by using some *Sears, Roebuck* No. 2779 Paint and Varnish Remover. The simplest way to form the loop is to lay out a circle 8 feet in diameter on your basement or garage floor. Use a heavy marking pencil so the outline may be easily seen. A word of caution, don't construct the loop in the basement if you can't get it out of the basement doorway.

In bending the tubing the author found that the 100 or so pounds of his 13-year-old son standing on the tubing prevented the tubing from moving as the circle was being formed. After the circle has been formed the plastic hose and wire should be cut back as shown in the photograph. Suitable holes may now be drilled in the metal box and the tubing ends fastened to the box with the conduit nuts.

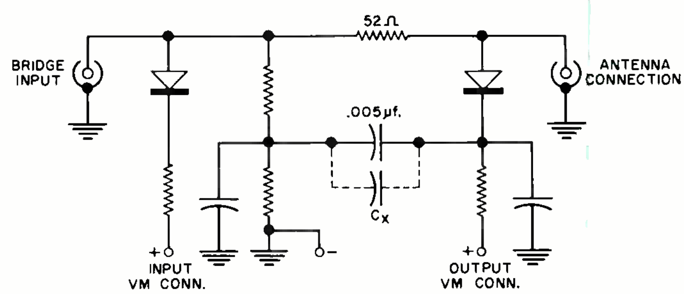
A terminal board was installed in the metal box in order to facilitate connecting the 36 wire ends into a continuous loop of 18 turns. Connecting the wires properly can be accomplished by using an ohmmeter or they can be "buzzed out" by use of a dry cell and buzzer or pilot light bulb. If care is exercised the center turn of the multi-turn loop can be identified and marked at the time that the loop wires are being soldered together to form the continuous coil thus avoiding the trouble of trying to determine the loop center by electrical measurement. The loop wire resistance is quite low, approximately 1¾ ohms, and it is quite difficult to make accurate measurements in the low resistance range of the ordinary ohmmeter. After the loop wires are all connected, except for the two ends, tuning coil *L2* can be mounted and connected in series with the loop wires at the midpoint. Capacitors *C1* and *C2* can be mounted and wired except for the connection to be made to the matching transformer *T1*. A suggested layout for the various components that are installed within the metal box is shown in the photograph.

Line-matching transformer *T1* is an important part of the loop circuit in that it provides the impedance transformation required while maintaining loop balance. Reasonable care should be exercised in winding *T1*. The ferrite rod from a transistor-radio loopstick was used as the core for this transformer. The original windings were removed and 180 turns of #28 enameled wire closewound on the core. This winding will be the secondary and will connect to the coaxial output connector *J1*. To determine how much wire will be required for the primary and how much space will be taken, wind 104 turns of #28 enameled wire over the secondary. Remove the 104 turns of wire and after finding the center of this length of wire, fold the length of wire in half so that the wire is doubled. Now take the doubled wire and wind 52 turns over the 180-turn secondary. Care should be taken to center the primary winding over the secondary in order to maintain balance. By connecting the wires of the primary as shown in Fig. 2 we will have a bifilar primary which will have equal capacities from its ends to ground. Some coil dope can be applied to the windings of *T1* to keep the wires in place. When the line-matching transformer has been completely fabricated it should be installed in the metal box and wired into the loop circuit.

The loop antenna proper is now electrically complete and should be mounted in a manner convenient to the builder. The author used a combination of aluminum tubing, bamboo, and TV-type antenna clamps to construct the supporting cross members. Be careful not to use a solid metallic framework to support the loop since the electrical operation of the loop may be seriously affected by shorting across the electrostatic shield. A piece of steel tubing was used for the lower part of the mast and this piece of tubing was inserted



One end of the loop just prior to its being tied into the box.



Cx-.05μf. (ADDITIONAL CAPACITANCE REQUIRED FOR SATISFACTORY VERY-LOW-FREQUENCY OPERATION)

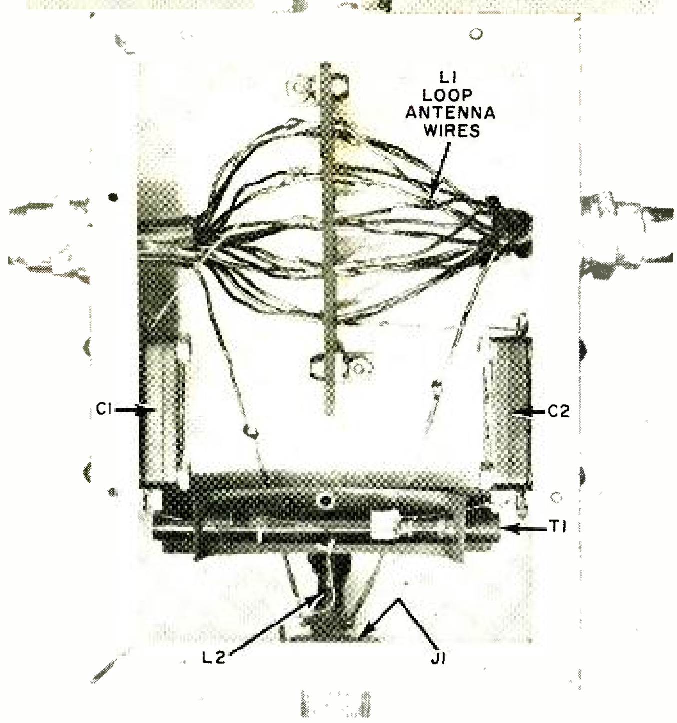
Fig. 4. An s.w.r. bridge modification for improved v.l.f. use.

into a slightly larger piece of tubing which had been driven in the ground. As shown in the photograph of the loop, the "Armstrong" method of rotating the loop was used; however, the author plans to install a TV antenna-type rotator in the near future.

Tuning and Impedance Matching

Tuning the loop to resonate at a particular frequency in the 14 kc. to 25 kc. range is not much of a problem. It is accomplished in the same manner as tuning and impedance matching of higher frequency antenna systems. A simple block diagram of the set-up used by the author is shown in Fig. 3. The standing-wave-ratio bridge used for adjustments is a home constructed bridge typical of those described in any of the popular radio handbooks. The audio signal generator used was a *Heathkit* AG-9 with a range of up to approximately 100 kc.

Before starting the adjustment procedure it would be wise to check the bridge to be used for satisfactory operation on the very-low frequencies. If the bridge is to be used to check a 52-ohm termination, connect a 52-ohm resistor to the output



Inside view of the aluminum box. A terminal board or a piece of insulating material with holes drilled into it can be used to support the connected ends of the No. 16 loop antenna wires.

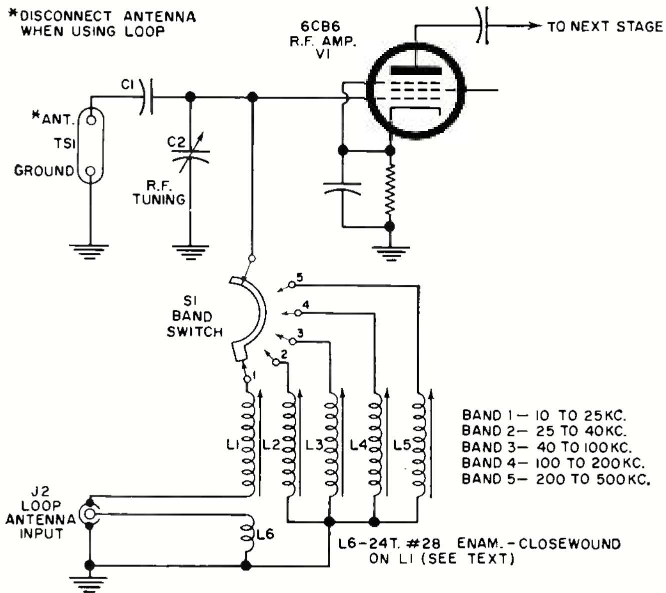


Fig. 5. Circuit modification to the author's v.l.f. converter.

or line side of the bridge and feed a signal of about 20 kc. into the bridge. If, with the correct load, the bridge indicates reflected signal, make the modification to your bridge as shown in Fig. 4. The bridge should then operate satisfactorily on the v.l.f. band.

With the bridge and signal generator connected to the antenna, as shown in Fig. 3, set the generator to deliver output at the frequency to which the loop antenna is to be resonated. Adjust the loop tuning coil $L2$ until the reflected power reading on the bridge reads a minimum. On the author's installation it was possible to obtain a zero reading of reflected power on the bridge at all frequencies between 14 and 25 kc.

Impedance matching to the converter or receiver with which the loop antenna is to be used can be accomplished in a number of ways. A satisfactory match to the author's converter was made by winding 24 turns of #28 enameled wire on the converter v.l.f. coil $L1$, as shown in Fig. 5. The coupling loop is wound as close as possible to the original winding and on the slug adjustment side of the coil. The converter v.l.f. coil was remounted on the upper side of the chassis since it was found that a noticeable amount of signal strength was lost by under-the-chassis mounting. The same mounting hole was used and several smaller holes were drilled in the chassis to accommodate the grid and coupling coil connections which were run under the chassis. In addition, a u.h.f.-type coaxial connector was installed on the chassis to connect to the loop antenna transmission line.

For the different input impedances which may be encountered one may find it convenient to use one of the ultra-compact high-fidelity audio transformers manufactured by *UTC*. The *UTC* type A-24 or A-26 has a response of from 20 to 40,000 cycles with a primary impedance of 15,000 ohms and 30,000 ohms respectively. The secondary impedance for both of these transformers is 50, 125-150, 200-250, 333, and 500-600 ohms as required. By using either one of these transformers in reverse it is possible to make a transformation between the low impedance 52-ohm line and the high-input impedance of a converter or receiver.

Another alternative in obtaining a higher feedpoint impedance for the loop antenna is to replace capacitors $C1$ and $C2$ and line-matching transformer $T1$ with a single .015-μf. capacitor to close the loop coil. When the loop is resonated by the use of tuning coil $L2$ one may tap at two points, one on either side of the loop electrical center and each equidistant from the center, and obtain a balanced feedpoint that is higher in impedance than 52 ohms. On the author's loop, tapping on the first two loop turns on either side of center gave a feedpoint impedance of 150 ohms. This impedance could be conveniently fed by the use of two 75-ohm coaxial cables with the shields tied together and the inner conductors connected —one each to each loop tap. Since the loop turns are accessible in the miscellaneous components box it is quite convenient to tap in this manner to find a satisfactory feedpoint.

Operation and Results

Operation of the v.l.f. loop antenna needs very little comment. You will notice, after a trial "spin," that the loop exhibits two very sharp nulls broadside to the plane of the loop and that you have a much improved signal-to-noise ratio. Comparative checks can be made which will vividly demonstrate the superiority of the loop over that random long wire that you may now be using.

Stations now being heard by the author on the v.l.f. band include the U. S. Navy's precise frequency-controlled transmitters such as NAA at Cutler, Maine on 14.7 kc., NBA (Summit, Canal Zone) 18 kc., NPG/NLK (Jim Creek, Washington) 18.6 kc. and others. WWVL, the National Bureau of Standards' frequency-standard station, which operates on 20 kc. from Sunset, Colorado can be heard but not nearly as loud as the Navy "giants" which run in the neighborhood of two million watts of power to their antennas. Several foreign stations, such as GBR in Rugby, England on 16 kc. and FUB near Paris, France on approximately 17 kc., are being heard consistently. Future plans for the very-low frequencies include the construction of a new Navy transmitter to be located in Australia which will undoubtedly be in the multi-megawatt class and a proposed NATO station which will operate on 19 kc. Recent tests using satellites have disproven the belief that the ionosphere was a shield for the very-low frequencies with the result that consideration is now being given to the use of these frequencies for communicating between the earth and outer space. The ultra-low frequencies recently produced some astounding results when a 400 cycle-per-second signal was transmitted a distance of approximately 750 miles from Boron, California to El Paso, Texas in tests conducted by the Air Force.

The very-low and low frequencies are, to be sure, more fascinating than ever before. Constructing the novel v.l.f. loop antenna described in this article will assure you of greater success and listening pleasure while exploring the very-low frequencies. ▲

WIRELESS STEREO CONVERTER

The stereo system is shown here in use. The small table radio at the left picks up the left channel from the wireless oscillator built into the phonograph. The phono plays back the right channel through its own built-in amplifier and speaker. Total cost for the conversion shown was about $10. To convert to stereo by making a duplicate of the existing amplifier and providing an inexpensive baffle for the extension loudspeaker would have cost something on the order of $16.00.

By JAMES E. PUGH, JR.

Construction of phono oscillator that transmits one stereo channel and allows an inexpensive monophonic phonograph to be converted into a stereo unit.

ALTHOUGH not hi-fi, nearly any existing monophonic phonograph can be easily converted to stereo with a definite improvement in listening pleasure. Even the cheaper units sound much better after this simple change is made, and the cost of such a conversion will usually be quite low.

Two approaches to the conversion are possible. The more obvious way is to simply build an exact copy of the existing phono amplifier and add an external speaker. However, a wireless system for the second channel (see Fig. 1) has some advantages that may make it even more attractive. For example, it will generally be less expensive since a part of the system will be a radio that you already have, extra shelf space will not be required for the second speaker as it is already contained in your radio, all interconnecting wires between the phono and the second channel speaker are eliminated, and the added circuitry uses so little power that it can be connected right to the existing amplifier's power supply in nearly every case.

Cartridge and Tone Arm

The three main requirements in making such a conversion are: a stereo cartridge to replace the mono unit, turntable speeds of 33⅓ and 45 rpm must be available, and an amplifier and speaker for the second channel must be provided.

The first step is to obtain a stereo phono cartridge having approximately the same electrical and mechanical characteristics as the mono unit which it replaces. The first (output voltage and frequency response) can usually be duplicated close enough by selecting a cartridge of the same type (ceramic, crystal, etc.) with approximately the same output voltage. The mechanical features such as size, shape, and weight should be duplicated if possible but, if the unit will fit, any difference in weight and height can be compensated for easily.

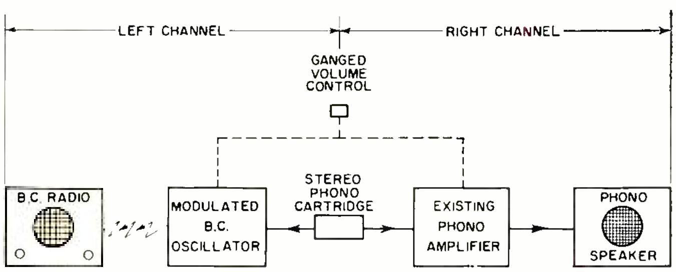
The phonograph shown is an inexpensive one and is typical of the thousands of similar units that are in need of conversion to stereo. The original cartridge was a *Vaco* type TO-45 crystal turnover unit with an output of about 3 volts. Had a stereo unit by the same manufacturer and with the same characteristics been available it would have been used. However, the cartridge was an import and stereo replacements of the same make were not available from the usual source of supply.

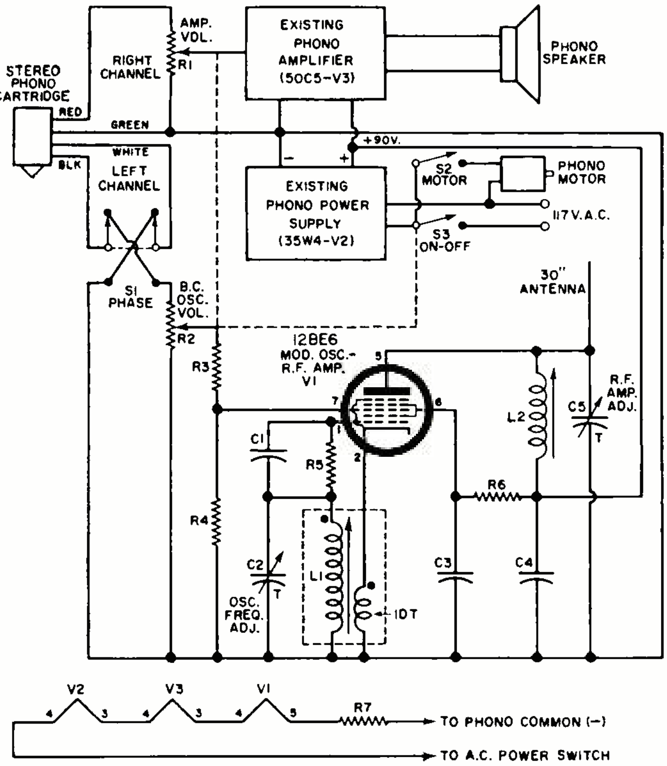
A little investigation showed that the *Sonotone* 12THA would do the job very nicely. It was a crystal unit with an output of 2.5 volts and essentially the same frequency response. Although it was different mechanically it did fit in the available space, the needle could be positioned exactly the same as the original, and the total weight of cartridge and mounting hardware brought the stylus pressure so close to the recommended value that no adjustment was made. Also, the height was satisfactory. After mounting to make sure that everything fits, remove the cartridge to avoid damage while making the other modifications.

Motor and Turntable

Most phonographs sold today are multispeed types and will need no consideration here other than possibly installing a motor switch if yours doesn't have one. Some of the cheaper phonographs of more "modern" construction often don't have such a switch, so now is the time to put one in if you would like to reduce strain on the filaments of your tubes. In the

Fig. 1. Block diagram of the complete stereophonic system.





R1, R2—Two-gang pot with switch (S3), 2-meg. log taper (see text)
R3—.68 meg., ½-w. res. (see text)
R4—.15 meg., ½-w. res.
R5—22,000 ohm, ½-w. res.
R6—10,000 ohm, ½-w. res.
R7—150 ohm, 5-w. res. (see text)
C1—33 μμf. ceramic capacitor
C2, C5—80-480 μμf. trimmer capacitor
C3—.05 μf., 200 v. paper capacitor
C4—.25 μf., 200 v. paper capacitor
L1,L2—Adj. ferrite-core r.f. coil, for use with 10-365 μμf. tuning capacitor. (Superex "Vari-Loopstick" or equiv. Close wind 10 t. #30 en. at cold end of L1.)
S1—D.p.d.t. switch
S2—S.p.s.t. slide switch
V1—12BE6 tube
1—Stereo phono cartridge (Sonotone 12THA, see text)
1—1¼" dia. x 1" high metal shield for L1

Fig. 2. Complete schematic of phono-powered stereo converter.

model shown an inexpensive slide switch was used to keep costs low. Since the motorboard was made of compressed fiber a pencil outline of the back of this and the phase switch was drawn in the desired location and cut out with a sharp knife. Use a small file for smoothing rough edges, and touch up with paint to match the original.

If yours happens to be one of the older phonographs that plays only 78-rpm records, it too can be modernized. Simply install an inexpensive 4-speed motor and turntable assembly and you can enjoy any 33⅓ and 45-rpm stereo and mono records, the new 16-rpm talking books, and your old 78-rpm favorites. To do it, locate accurately the centerpost position of the original unit and install the new one in its place. Use a new motorboard if needed for a good fit and accurate centering.

The B. C. Oscillator

The remaining part of the conversion project consists of adding a good quality broadcast oscillator that will be modulated by the audio signal from one channel (left, in the model shown) of the stereo phono cartridge. The r. f. signal, adjustable to any place in the broadcast band, is picked up with a radio placed about four feet away and the demodulated audio signal is amplified and sent on its way to the listener's ears *via* the radio's speaker. A d.p.d.t. switch between the cartridge and oscillator input is used to reverse the phrase relationship between the two channels so as to obtain proper stereo reproduction.

As seen in Fig. 2, the two volume controls (*R*1 and *R*2) are ganged to vary the output from both channels simultaneously. If available, use an attachable rear control with the same characteristics as the one in your amplifier. otherwise buy the complete 2-gang control with switch. The control shown is a pair of ganged *Mallory* U-55's and mating switch.

The voltage divider, *R*3 and *R*4, is proportioned to prevent overmodulation when the volume control is full on. Also, *R*4 must be kept below a certain critical value to prevent distortion. Anything below 150,000 ohms will be satisfactory. If the cartridge has an output of less than 2.5 volts reduce *R*3 to obtain full modulation. With *R*3 removed satisfactory results can be obtained with a cartridge output of about .1 volt. If less than this a stage of audio amplification may be needed between *R*2 and *V*1.

*V*1 is a 12BE6 pentagrid converter tube connected as a type of modulated electron-coupled oscillator. The oscillator section is similar to the local oscillator part of the converter circuit used in most AM radios, but instead of feeding the usual r. f. signal in at grid #3 for mixing with the oscillator signal we will feed in the audio signal from the phono cartridge. This a. f. signal amplitude-modulates the r. f. signal that appears at the plate by varying the electron stream, thus there is but little frequency modulation, and a very clean signal is obtained at the output (the plate) of *V*1.

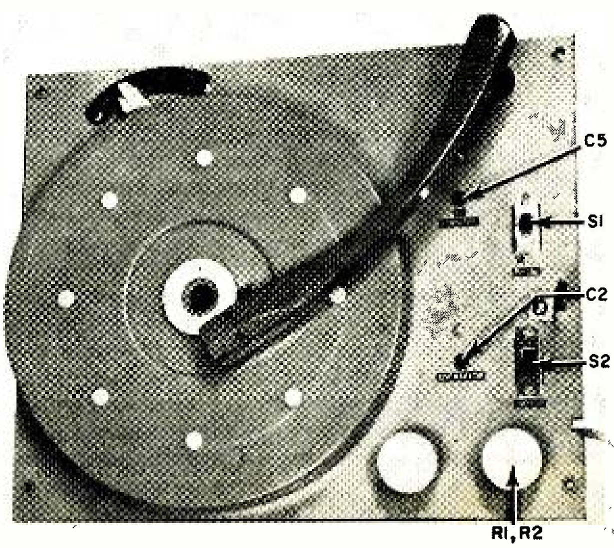
A tuned circuit (*L*2 and *C*5) for the plate load provides a maximum output at the oscillator frequency and minimizes harmonics. The oscillator inductance, *L*1, is modified slightly by adding 10 turns of thin wire (about #30) for the cathode winding. No change is required in *L*2. Both oscillator and r. f. amplifier tuned circuits use adjustable mica trimmer capacitors since they will need to be adjusted only occasionally. However, if you would like to simplify tuning somewhat, replace *C*2 and *C*5 with a standard two-gang 10-365 μμf. tuning capacitor. The antenna consists of the unshielded *L*2 plus a 30-inch length of wire taped to the underside of the phonograph motorboard.

The oscillator section of *V*1 requires about 3.5 ma. at 50 volts, and the plate draws less than 1 ma. at 90 volts. If your supply is greater than 90 volts reduce it with a resistor between the power supply and the oscillator.

The new tube, *V*1, must have the same filament current rating as the other tubes already in the phonograph, and a new series resistor must be installed to provide for the new tube. The author used a 50C5, a 35W4, and a 230-ohm, 5-watt series resistor. The added 12BE6 requires 12.6 volts at .15 ampere, which means that the 230-ohm resistor must be reduced 84 ohms to maintain the desired voltage across the three tubes. The nearest 5-watt resistor above the resultant 146 is 150 ohms. Other phonographs may use other tubes and therefore a different value resistor, but the value of the new resistor can be found this same way.

If space is available, mount the socket for *V*1 on the chassis, or if necessary add a small metal bracket. The phonograph shown here already had a spare tube socket hole punched out—probably for a different model by the same

Top side of the converted phono showing switches and oscillator adjustments. Labels with adhesive backing mark adjustments.



manufacturer—which made this part of the project easy. A metal shield, about 1¼" diameter by 1" high, is mounted over *L1* to eliminate radiation from this coil. The signal from this part is unmodulated and is therefore of no value in the receiver, whereas that radiated by *L2* is modulated and is the one we want to use. This also eliminates feedback from *L2* to *L1* and thus prevents any oscillation from this source so as to insure stable operation of the circuit.

Adjustment and Use

After all parts are assembled and wired, re-install the cartridge. Then check that *V1* oscillates by searching for the signal with your b. c. receiver. Tighten both *C2* and *C5* to maximum capacitance and adjust the core of *L1* until the signal is heard at the low end of the broadcast band. Now play a record and adjust *L2* for the loudest signal from your radio. Next, check that the upper end of the band can be reached when *C2* is opened to near its minimum capacitance. Also, the *L2-C5* circuit should resonate at the high end (1600 kc.) when *C5* is nearly open. If you want to check the 12BE6 plate current now, it should be about .8 ma. at the low end of the band and about .5 ma. at the high end when the *L2-C5* circuit is tuned to the oscillator frequency. The meter should be inserted in the lead between *L2* and the 90-volt supply with a small capacitor (about .01 μf.) between these two points. Note that the plate current will drop rapidly to its minimum value when this circuit is tuned to the oscillator frequency.

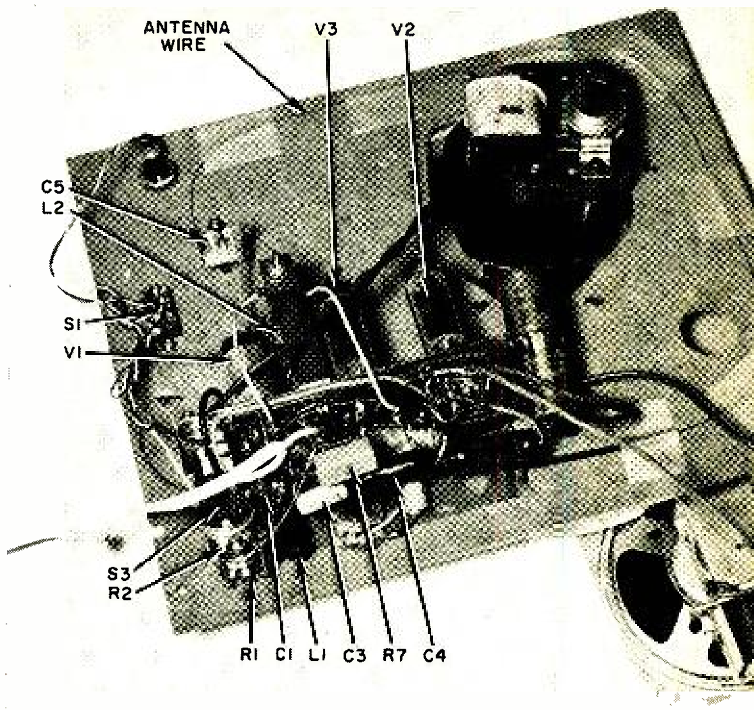
If everything is satisfactory set the radio to some spot in the band where no station is heard, and adjust *C2* and *C5* for maximum output. Now, with the phonograph and radio speakers about 4 feet apart, adjust the volume control for a comfortable level from the phonograph, and then set the radio volume control for approximately the same output. Throw the phase switch to both positions and note in which one the music seems to come from some location between the two speakers. This, and a pronounced improvement in bass, is a sure indication that the phase is correct for stereo. The opposite phase setting will cause the apparent bass to decrease, and the music will seem to come from two widely separated sources.

When the phase is correct note how adjusting the balance control (the receiver volume control) causes the apparent source of the music to move between the two speakers. It will seem to be centered when the two have equal outputs. Try a monophonic record when making this check so as to get a good idea of the effect both phase and balance have on the music reaching the ears. After this it will be an easy matter to recognize correct stereo phase and balance, and you will enjoy this 3-dimensional music more than you ever did with the old mono phonograph. Even mono records sound much better when played on a stereo system.

While a license is not needed for a low-power communication device such as the b. c. oscillator described here, the

Low Power Microphone & Phonograph Oscillator

1. Operating Conditions:
   Oscillator tube—12BE6
   Frequency—510 to 1600 kc.
   Plate input power—No more than 100 mw.
   Plate voltage—90 volts normal, 110 v. maximum
   Plate current—.8 ma. normal, .9 ma. maximum
   Plate load—tuned to oscillator frequency
2. Antenna—Built-in, about 30 inches long
3. This device was built according to published plans of a tested model, and will meet FCC requirements when using components having the normally expected tolerance.
4. Date built: Month______________ Year____
5. Signature ____________________



Underside of motorboard showing how new parts were added to the existing chassis. Note how the antenna is taped around the edge of motorboard. After all the wiring has been completed, the metal shield can is then fastened over coil L1.

Federal Communications Commission does specify that certain requirements *must* be complied with. Full details can be found in Part 15, Subpart E, of the FCC regulations on Incidental and Restricted Radiation Devices. Measurements made on this oscillator when operating up to the limits that would be encountered due to the maximum variation in component values showed that if the unit is built and operated according to the instructions given it will meet such regulations.

The applicable requirements and related compliance of the b.c. oscillator are as follows:

1. The operating frequency must be confined to the 510- to 1600-kc. band. Alignment by reference to stations in the band will keep it within these limits.

2. Power input to the final stage must not exceed 100 milliwatts. With a 20% change in voltage and component values, the highest input power at the plate of *V1* was less than 95 mw.

3. Harmonics must be at least 20 db below the unmodulated carrier. Better than 40-db harmonic suppression was obtained when using the oscillator at any frequency.

4. Total length of the transmission line plus antenna must not be greater than 10 feet. The 30" built-in antenna is all that is required for this application.

5. The r. f. voltage on the power line to which the device is connected must be no more than 200 microvolts at any frequency from 510 to 1600 kc. The maximum measured was less than 50 microvolts.

6. The FCC Information Bulletin NO. 17-G notes that the maximum coverage must be less than 300 feet. The greatest distance at which the minimum detectable signal could be picked up with a sensitive receiver was about 60 feet.

7. A certificate must be permanently attached to *all* such devices, whether assembled by a manufacturer, as a kit, or as a do-it-yourself project.

This certificate must be reproduced or copied as shown above. Sign it and attach to your phonograph in some convenient place. ▲

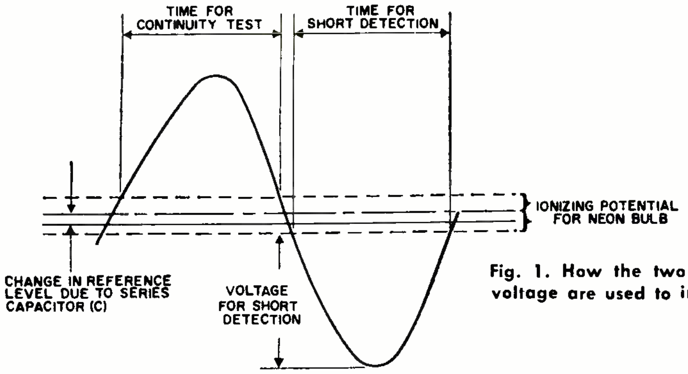


Fig. 1. How the two half cycles of an applied a.c. test voltage are used to indicate continuity and then shorting.

the Problems of Tube Short Testing

A. OVERSTROM / Westinghouse Electric Corp.

There are different types of shorts, methods for detecting them, and sensitivity figures for the check. Some common understanding on these points is important to all tube users.

WHAT IS a tube tester actually checking when it indicates a short? What is meant when the sensitivity of this test is mentioned? These questions are of concern to anyone who has ever had occasion to test tubes. Furthermore, although it is important that both the manufacturers and users of tubes have a common understanding of the nature of tube faults, particularly shorts, there is confusion concerning terms.

Let's start by considering the meaning of sensitivity in a short check. Sensitivity is the maximum value of resistance the test device can detect, which corresponds to the smallest amount of leakage. The definition can be expanded to include, not only the resistance of the short, but its duration in time. This can be as brief as a few microseconds. Such time durations are difficult to detect. Yet duration is directly related to the effective severity of the short.

Consider, for example, the continuous short, which is called a solid short because there is positive contact between the elements involved. The condition could burn out associated circuit components, causing costly repairs. On the other hand, the "flicker" or "temporary" short causes trouble only when the tube or equipment is jarred. But the temporary short may become a solid one if, for example, the tube is tapped.

The sensitivity required to detect a short generally increases as the time duration gets smaller. In other words, the resistance of a solid short would be very close to zero; that of a short of long time duration would be rather small; and resistance of a momentary short would be greater. It is well to remember, however, that any type of short is a potential source of trouble.

Most short detectors use small neon bulbs as indicators. One bulb may be used for each element of the tube under test. Sometimes various combinations of lights are used. If you have a tester and you want to know exactly where it is indicating shorts, you can try a shorting bar between various combinations of pins in its tube sockets. By making a notation of the light arrangements used, you can subsequently identify shorts at a glance.

Although there are various kinds of short detectors, only the commonly used a.c. and d.c. types will be discussed here.

A.C. Short Detectors

In one popular method, alternating voltages are applied to the tube elements through a neon lamp, as in Fig. 3. In addition to indicating shorted elements, this has the advantage of providing a continuity test that reveals whether an element is properly connected or open. (Although not shown in the simplified circuit, heater voltage is also applied.) Each element is tested with respect to the cathode. In this case, the test is between grid and cathode.

When a.c. applied to the electrode is going positive (Fig. 1), there will normally be conduction due to rectifier action and one side of the neon lamp will glow. If the bulb does not ignite at all, the grid or other element under test is open. Thus continuity or its absence is established.

If the tube is good, it will not conduct on the negative half-cycle of applied a.c., and the other side of the neon lamp thus will not glow. The indication for a good tube will then be as shown in the lower left-hand corner of Fig. 2. (The white area indicates glow.) With an open electrode, as discussed in the last paragraph, both sides of the bulb would remain dark. This condition is not shown.

(*Continued on page* 91)

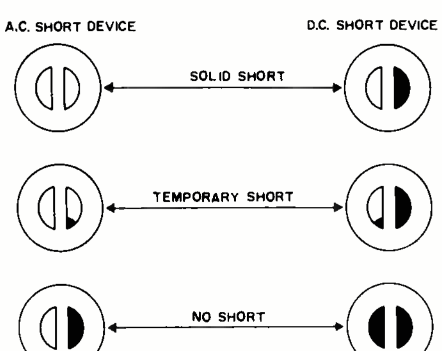


Fig. 2. How various conditions are indicated in the two most common systems used for detecting interelectrode shorts.

Fig. 3. An a.c. short detection circuit.

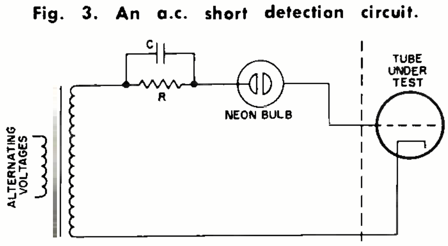
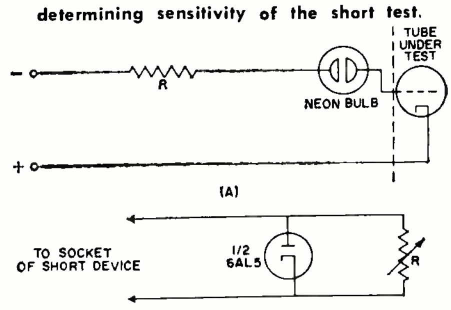
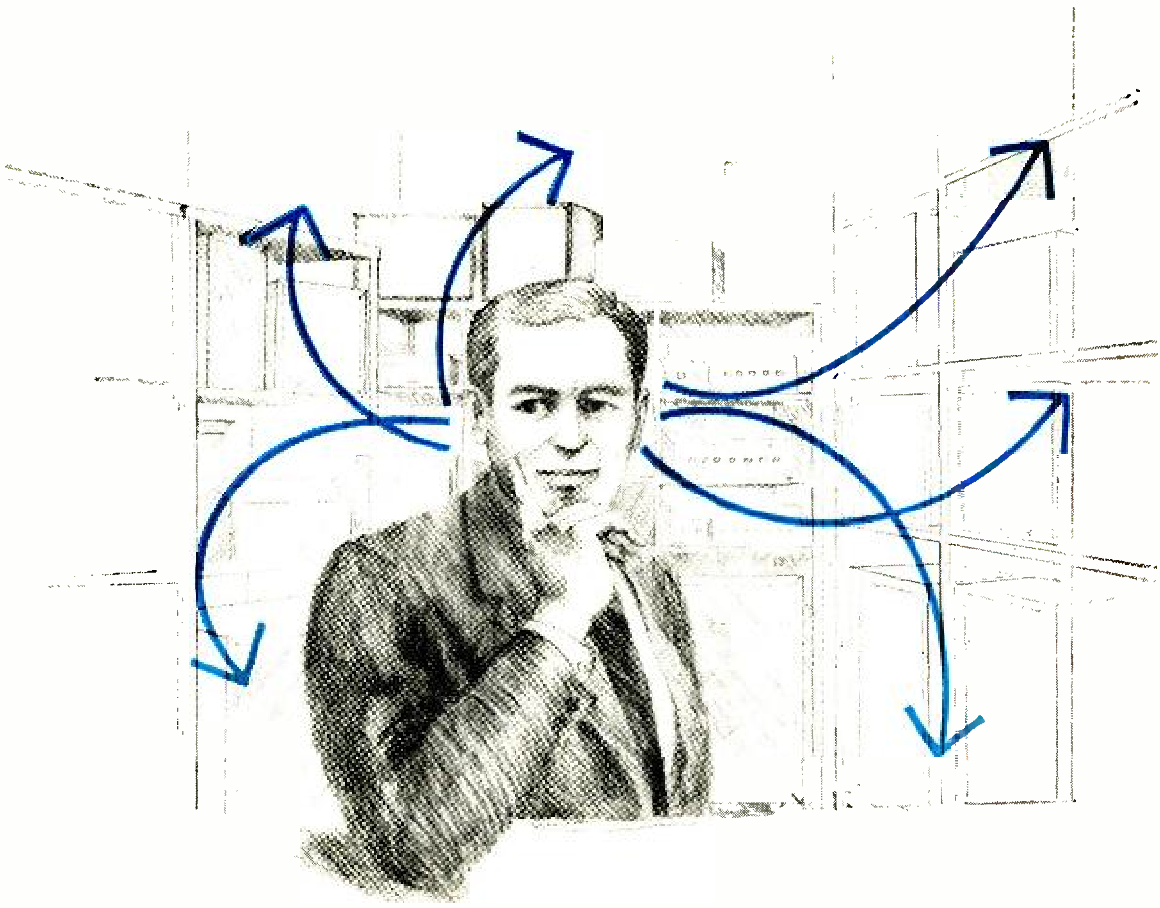


Fig. 4. (A) A d.c. short detection system in basic form. (B) A simple circuit for determining sensitivity of the short test.





CHECKING SPEAKERS BY EAR

By ABRAHAM B. COHEN / Author, "Hi-Fi Loudspeakers and Enclosures"

Some practical advice on how to judge the quality and the performance of a hi-fi speaker system by objective listening.

SELECTING a loudspeaker system for a component high-fidelity installation is one of the toughest problems facing the audiophile. What makes it difficult is that there are so many quality systems available—yet no two systems may sound the same *to him*.

The purchaser will naturally prefer what he thinks sounds best but how is he to know that the system he has chosen is really the best? Of course, he may take an expert with him to help in the selection but the expert may be biased in favor of a particular type of system, which would affect his judgement even before a single speaker was turned on. We won't say that his opinions aren't valid, but the fact remains that there are many experts—and even they can't agree!

The reader may find it an amazing experience to go into a modern, well-stocked high-fidelity showroom and listen first to one speaker, then another, and still another. No two speakers will sound exactly the same despite the fact that they both have been designed and manufactured by reputable firms. Notwithstanding objectively measured characteristics obtained in their laboratories, the "ears" and tastes of the chief engineer and sales manager of one firm may be quite different from those of another company. Basically, it is these differences that are being offered to the public since one pair of ears may be just as "right" as the next pair, and conceivably, neither may be as good as those attached to your own head.

Since preferences in loudspeakers are personal and subjective, we advise the reader to make full use of his ears, *aided* if he wishes (but not pushed) by a more experienced and knowledgeable listener and *guided* by specification sheets which detail the speakers as supplied by various manufacturers. Our aim is, then, to examine these properties of loudspeakers so that we can recognize them when we hear them and to suggest some method whereby we may correlate what we hear with the printed specifications.

Control of Listening Facilities

First we should select a dealer who has a wide variety of loudspeakers to demonstrate. Preferably he should be able to demonstrate a number of such speaker systems by merely flicking a switch. This will enable the listener to "A-B" speakers quickly without any pauses during switching.

Having selected your hi-fi shop, pay the dealer a visit during the beginning or middle of the week when one of the regular, experienced salesmen has time to help you.

In making any listening test, it is important that the speakers to be compared are adjusted for the *same volume level to the ear* and not to the same volume setting on the amplifier. Any switching board worth its salt will have volume controls on each test channel, by means of which the various loudspeakers can be adjusted for the same *audible* level. It is also important that the listening test be made using only one amplifier and that it is capable of good, clean power output of at least 20 watts. Some of the systems you "audit" will, in all probability, fall into the "low-efficiency" category. Such speakers require a good reservoir of driving power even for moderate volumes. If this power is not available from the amplifier when it is turned up to drive such low-efficiency systems, the amplifier will overload and distort.

The first "listening-go-round" is designed to quickly weed out those systems which are palpably unsuitable. These may include systems which are consistently "boomy" or those which are so excessively peaked in the high end that they cause physical pain. Obviously systems exhibiting either of these extremes should be avoided at any cost. Neither system will, in the long run, give lasting satisfaction. They may, in fact, quickly become "earsores."

When making these listening tests it is wise to have a few "tricks" up your sleeve—such as taking along your own favorite and familiar records. If possible, this miniature record "library" should include not only musical selections but one or two with spoken words (especially by a male voice) and a commercial test record on which various frequency bands are impressed. (This last item will not make you wildly popular with the salesman, but it is your money you are spending for the speaker system!)

If you do take along your own program material, select it carefully. A musical number in fast tempo may show up one type of faulty response in the speaker that a low, sustained note will not, and *vice versa*. For instance, a plucked bass in a jazz combo will pinpoint bad system resonance (boominess) at the low end. If there is any tendency for the system to be boomy or resonant in one area, that phrase will literally jump out at you with considerably increased volume and, probably, a "tubby" sound. Once evidence of boominess has been pinpointed in musical passages you will probably find that a recording of a male speaking voice will exhibit a "bottom of the barrel" quality as well.

Another victim of critical listening, and one which may be eliminated quickly by means of this preliminary trial run, is the system which is "sway backed" in its response. It has good lows, it has good highs, but the middles may be lost. Such a situation may be readily recognized on musical passages where there is a solo voice. If you get the impression that the singer is behind a curtain or not in the same room with the orchestra, then the system most likely has this sway-back characteristic. The human voice is centered in the middle frequencies and if the voice appears weaker than it should for normal musical balance with the accompanying orchestra, then very possibly the system is deficient in the middle frequencies—or lacks the so-called "presence" of a good system.

If, during this preliminary run, any one system seems to be consistently harsh in a complex orchestral performance or if a female member of your buying expedition remarks "That sounds horrible! It screeches something awful!," then, sir, you may as well put that system aside. Women have very sensitive upper-frequency hearing acuity. They will frequently hear things at high frequencies that we unfortunate (?) men cannot hear. In general, however, when the system is reproducing fully orchestrated highs and, irrespective of selection, the system makes them all sound as if someone were scraping a piece of sandpaper and/or crumpling a piece of aluminum foil close to your ear while the music is playing, then the upper regions of the system are poor in performance and these systems will probably not prove satisfactory over a long period of time.

All Systems Have "Coloration"

One of the most popularly applied, yet most widely misunderstood, characteristics of a speaker is "coloration." Coloration is a descriptive term to which the acoustic design engineer cannot even begin to apply figures of measurement. We know how to measure frequency response, amplitude distortion, intermodulation distortion, transient distortion, tone bursts, electro-acoustic efficiency, angular radiation . . . but how do we measure coloration? Perhaps it is the sum total of these many performance factors that makes it possible for the loudspeaker to reproduce a clarinet tone cleanly or, at some fugitive instant, add to it some "reediness" that may give it an oboe characteristic.

Coloration makes one loudspeaker sound different from another. Coloration, good or bad, exists in the best of speakers and arises from many sources. Some persons believe that coloration stems from the type of material used for the vibrating diaphragm. These people are, by and large, correct. In fact, the loudspeaker designer has available to him a tremendous variety of cone pulps, materials, and compounds which will produce, *as he deems fit*, characteristics from soft "wooly" tones, through medium hard tones, to sharp strident tones. He has available to him paper compound cones, impregnated phenolic linen diaphragms, metal diaphragms, and Mylar diaphragms. Even expanded polystyrene sheets are being used as diaphragm material. But one should use "coloration" cautiously.

The author spent a worthwhile hour with a visitor at an audio fair some years ago when this visitor latched on to the word "coloration" as the prime devil of poor loudspeaker performance. "How can the metal diaphragm (of a horn-loaded tweeter) reproduce faithfully the top sounds of a *violin*? It will give the violin a metallic sound." Having somewhat of a New England background, the author horse-traded a few questions with him, such as: "How can we expect a *paper* diaphragm of a direct-radiator tweeter to reproduce a violin tone faithfully? Won't it have a paper sound? What about the electrostatic loudspeaker with its aluminum foil diaphragm which was hailed as producing 'transparent' sound, as if the sound were coming through the instrument, not from it? Is a violin made of such insubstantial, ethereal substance as air or is it made of wood of the forest, the gut of an animal, energized by the hair of a horse's tail, and controlled by the flesh and bones of human fingers?" In a loudspeaker we want to reproduce this color exactly but we try to do it with steel, magnets, phenolic paper, and copper or aluminum. All things considered, we do remarkably well.

Perhaps what the gentleman really meant to say was that he didn't like horn-type tweeters (which was the type we were discussing in this instance) because he came back to the subject in terms of horn tweeters *versus* direct-radiator types on the basis that "how can we expect a horn-type reproducer to reproduce a violin-type instrument?" The answer must be quite obvious at this point for we may counter with the corollary question, "How may we expect a direct-radiator tweeter to reproduce a horn-type instrument such as a trumpet or French horn?" The complete answer is that we may expect true reproduction of all instruments from either type of tweeter if the *air* pulsations produced by them faithfully follow those produced by the instruments themselves.

Faithfulness of reproduction (fidelity) bears little or no relation to whether the diaphragm is made of paper, plastic, wood, or aluminum or whether it pulses the air around it directly or by means of an acoustic transformer such as a horn. The desired *end effect*, whatever the means used to achieve it, is naturalness of reproduction in the form which most closely simulates the original instrument.

Wide Frequency Response

It is generally agreed that the wider the frequency response, the better the system. Actually, though, a loudspeaker system with an extremely wide frequency range and capable of actually reproducing that range may not perform nearly as well as another system of more restricted range.

The frequency response of a system is usually stated in terms of some low- and some high-frequency limit, with the tacit assumption that all frequencies in between these limits are faithfully reproduced. Thus a typical specification may read "30 cps to beyond audibility." Now, believe it or not, there is hardly any hi-fi or even pseudo hi-fi speaker system that will not reproduce this range *if we do not take into account the variations in output level at these extremes and even in the mid portions*. One well-known and widely accepted loudspeaker system lists its frequency response as: 38-1000 cps ± 1½ db, 1000-13,000 cps ± 5 db, 15 db down at 20 cps and at 17,000 cps. Now this is as straightforward a statement as one is ever likely to encounter and, if we believe in the integrity of the manufacturer, we will accept it.

But, we will as readily accept the statement of an equally reputable manufacturer who says his speaker system is "extremely smooth from 32 to 16,000 cps." The basic fact that we may extract from both sets of specifications is that the systems are designed for and are intended to reproduce the very lowest of the audible frequencies.

By contrast another manufacturer, also of good repute, lists two loudspeaker systems, one whose low end is stated as going down to 30 cps while the second one goes down to only 70 cps. Since, in this case, the manufacturer himself considers his second speaker to be limited at the low end, we would probably skip this one in our listening tests if we were looking for the very best in low-frequency extension.

We might ask why the manufacturer puts such a limited low-end reproducer up for sale. The answer is that it costs approximately $80 less than his better system and, to many people, a saving of $80 per speaker for a stereo system requiring two such units would amount to enough to buy an amplifier, turntable, and cartridge of low to moderate cost. In justice to the manufacturer, one might even be pleasantly surprised by such a "70-cps" system when compared to less well-known brands that stretch their low-end specs to the snapping point.

Bass Response

In checking bass response, we must first set some reference for initial comparison. As a reference we would use a musical selection which fully covers the entire listening spectrum yet features passages and instruments in the low register.

For an initial high-level comparison, set the volume or level control on the amplifier so that the loudspeakers are playing somewhat louder than you would normally tolerate in your living room. Under this condition the ear will be equally sensitive to all frequencies, including the low ones.

When we have satisfied ourselves that the several systems to which we are listening have good response under louder-than-normal conditions, we may proceed with the "contour" test. Turn the amplifier level down in small increments and at each level change listen to the various speakers for any significant dropping off of the low frequencies in relation to the middles. There may be no apparent change until the over-all volume gets very low, but this point must be approached slowly. Soon the loudspeaker systems will be playing at a low enough level so that you may really have to strain to hear the low frequencies. However, if you have the volume turned down to the point where you still hear the low bass notes on one system and not on the other (even if you are playing them softer than you would normally), then the former has more bass response than the latter.

At this stage we may turn up the amplifier volume control. This should immediately boost the low frequencies of the system to the point where you will not have to strain to hear the bass. You may now verify the difference in bass level response between systems by comparing them at the same loudness level.

Low-Distortion Bass

Bass response, in terms of frequency extension, is only really half a specification. Bass reproduction must be clean and undistorted and here again we may use our ears to determine, qualitatively, the difference in distortion between speaker systems.

Distortion is generally related to the frequency being reproduced, to the power with which the system is being driven, and the type and degree of loading. If figures for distortion are given in a specification sheet, they should be stated in these terms. Naturally, if we are talking about a fully assembled, complete system, then the baffling (or loading) is a fixed quantity and the given figures would then take into account only frequency and power. What these figures represent will be the ratio of (new) harmonics generated to the original fundamental tone which gives rise to them—expressed in per-cent.

A simple test for audible detection of harmonic distortion is to choose one good low frequency—such as 30 or 40 cps—and reproduce it first at a rather low output level, but not so low that you have to strain to hear it. Listen to this tone carefully, especially for its *musical pitch* (a musically trained ear would be helpful here). Now make a *sudden* jump to a much higher volume level. If there is no harmonic distortion, then the pitch of the note will be practically unchanged, as will the character of the tone. However, if there is any appreciable degree of distortion, then the pitch will apparently be raised, not fundamentally, but harmonically. There will be new upper harmonics (octaves) of the fundamental and as the strength of these harmonics increases, there will be an audible

change where you will still hear the fundamental note but now you will hear a blending of a tone of at least an octave higher, which gives the impression that the original pitch is being raised.

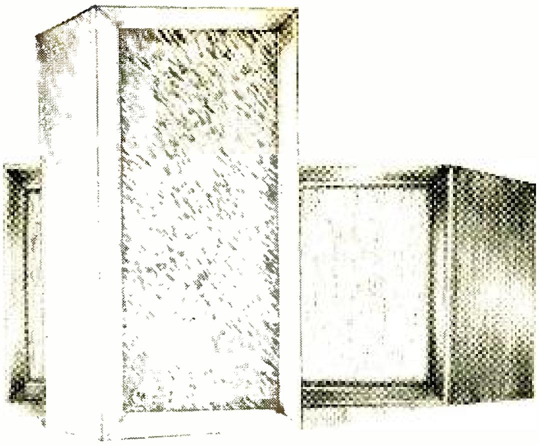
This same effect may be observed in improperly baffled speakers which produce a phenomenon usually referred to as "doubling." This is a very serious low-frequency defect where, due to improper baffling and insufficient loading and damping, the speaker motion is excessive for its limits of linearity and it begins to distort—producing a strong second or higher order harmonic (which is why it is called "doubling").

After tests have been made for low-frequency harmonic distortion (using a few low-frequency tones, as from a test record), it would be a good idea to double-check with some judiciously selected program material. When listening for harmonic distortion, low, sustained musical phrases, such as deep organ passages may be used. Such passages (preferably not embellished with too complex chordal material—but simple elemental low-frequency melodic strains), when first played at low level and then at progressively higher levels will bring to light such non-linear distortion, if it exists. As the sustained musical phrases are played and volume is increased, sounds that were not present when the system was operated at low level may creep in. If they do, it is evidence of some type of distortion—most likely harmonic distortion.

The importance of using different types of test material cannot be overemphasized. Use selections with which you are familiar so that you can judge the components rather than the musical content—but use your familiar material with caution. Be sure you have good, clean, and reasonably new playing surfaces.

Cone Break-Up

A sustained low-frequency tone, or series of tones, is also very valuable in checking a system for mechanical imperfec-



tions such as buzzes, rattles, and noises arising from poor workmanship. Furthermore, the availability of a good many frequencies—especially around the *middle* frequency region—will prove valuable in checking for any break-up characteristics of the woofer section—if its range normally extends into the middle frequencies.

Break-up is an odd form of distortion that is only *generally* related to the original driving frequency and is not a nice easy numerical multiple of it. Cone break-up is generally characterized by a very harsh tone—easily audible in the mid-frequency range and often higher than the driving frequency—but within the general limits of an octave. Cone break-up distortion may occur at two, three, or more discrete frequencies with, strangely enough, no distortion at all between these discrete points. Be assured that if break-up distortion is present, you will recognize it. You will hear, in addition to the original tone, a sound similar to that made by a youngster taking his first violin lesson—all horsehair and catgut.

The interesting thing about this type of break-up is that its coming and going is sharply defined and the very narrow bands of frequencies causing this distortion are almost totally unpredictable. The most prevalent frequency spread, within which such cone break-up may occur for a 12" speaker, may be between 800 and 1500 cps—with no way of telling at how many points within this range break-up will occur. You just have to explore this region very carefully with as many frequency values as possible. If the system being tested has cone break-up possibilities, they will show up. You will surely detect such cone break-up if you make use of the type of test record that has a constant glide tone that starts at one end of the spectrum and slowly progresses to the other.

Intermodulation Distortion

Intermodulation (IM) distortion may be produced when a single speaker diaphragm is called upon to reproduce very low and very high notes at the same time—but only when there is, initially, non-linear motion of the cone at low frequencies. These non-linearities of the cone, when producing low frequencies, are impressed on the high-frequency vibrations of the cone and the high frequencies are modulated by the low frequencies. Thus there is intermodulation of the frequencies. Strangely enough, the wider the frequency range of a single speaker, the greater the possibility of intermodulation, if there are non-linear tendencies in the low-frequency region.

There are test records available which have IM grooves for the purpose of checking system distortion. If such a record is available, by all means use it. If we remember that IM results from non-linearities in the system which show up more predominantly when the system is being driven near its maximum, then when making tests for IM we will have to drive the system at a higher-than-normal listening level if such distortion is to be pinpointed.

Applying the test signal from the record to a truly hi-fi speaker system we should hear two clean notes—a low-frequency tone and a high-frequency tone. As we increase the power into the speaker, both tones will get louder and both will stay clean until the system is driven to a point where non-linearity in the low-frequency excursion of the diaphragm mechanism begins to intrude. If such a point is reached, then the high-frequency note will begin to sound garbled and fuzzy.

If we want to make this test, using musical material instead of a special test record, then we must choose some type of selection where there are sustained low-frequency notes—like the pedal notes of the organ, combined with a slow series of upper-register notes of simple and relatively pure tone—like those of the flute. If played at low level, the flute sounds clean and natural but when the volume is turned up high, the flute begins to sound harsh and rough—then in all likelihood there is considerable IM distortion present in the system.

Multi-Speaker Systems

At this point, readers familiar with loudspeakers may suggest that perhaps this harshness might be attributable to the tweeter being overdriven—and they may well be right. This brings us to a very important reason why so many *full-range speaker systems are of the multi-component type, i.e.*, woofer-tweeter or woofer-midrange-tweeter, rather than a simple wide-range unit in a housing. There is one obvious advantage to a system where the audible band is broken up, with its various portions reproduced by separate components, and that is that it gives the user an opportunity to balance the level of the various speaker components to suit either his ear or the acoustic environment of his listening room. But, in addition, there are other and more important advantages to multi-component systems.

These attributes lie in the area of reduced distortion. Intermodulation distortion will be greatly reduced because the high frequencies—having their own reproducer—will no longer be physically or electrically dependent upon the action of the woofer diaphragm. The independence of the tweeter from the woofer will literally cut the tie that creates the *inter*modulation of one by the other. Cone break-up may also be eliminated or greatly reduced, especially in a woofer-midrange-tweeter combination, if the *input* is rolled off sufficiently by means of a crossover network before the break-up frequency area is reached—an area which will now be covered by the separate midrange unit.

Specifications that include references to a tweeter or midrange unit can, of course, be readily checked. There are usually level controls for the midrange and tweeter and their presence, usually in the back of the enclosure, is a pretty sure sign that the unit is a multi-speaker system. If reference is made to separate *electrical* components and *electrical* crossover networks, then it is a true multi-speaker system.

If, however, there are no controls and the spec sheet calls it a "multi-range" system, we have to interpret carefully for there is another type of wide-range speaker which employs a dual cone arrangement, using what is called *mechanical* crossover. This structure is simply a unit where *one* voice coil drives a main woofer diaphragm and a small diaphragm simultaneously. This small diaphragm, usually called a "whizzer," is fastened to the apex of the large diaphragm and is helpful in giving a boost to the high end—but this is all that it does. It does not reduce the prevalence of intermodulation, it does not eliminate cone "cry," nor is its performance adjustable. Despite these shortcomings the two-way mechanical-crossover type speaker, when properly designed and built and installed in an enclosure to match it, may give a reasonably good account of itself.

In conclusion, perhaps the day will come when we will see the emergence of more meaningful specifications on loudspeaker performance which will enable the purchaser to make his selection almost on the basis of catalogue inspection. Since such a day is probably somewhat distant, in the meantime the audiophile's ear must be the final judge of speaker system quality. Be sure to use yours to the fullest! ▲

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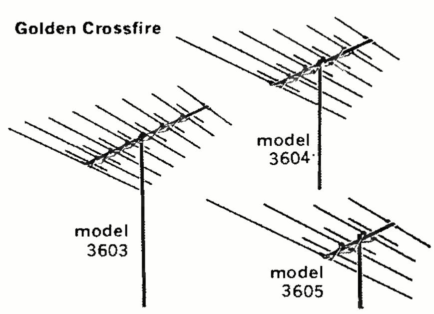

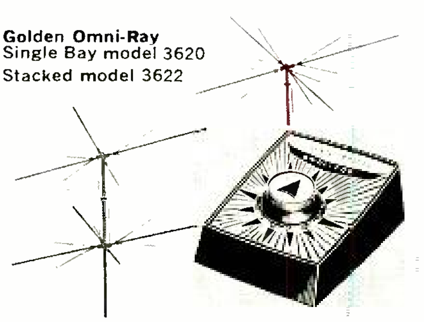

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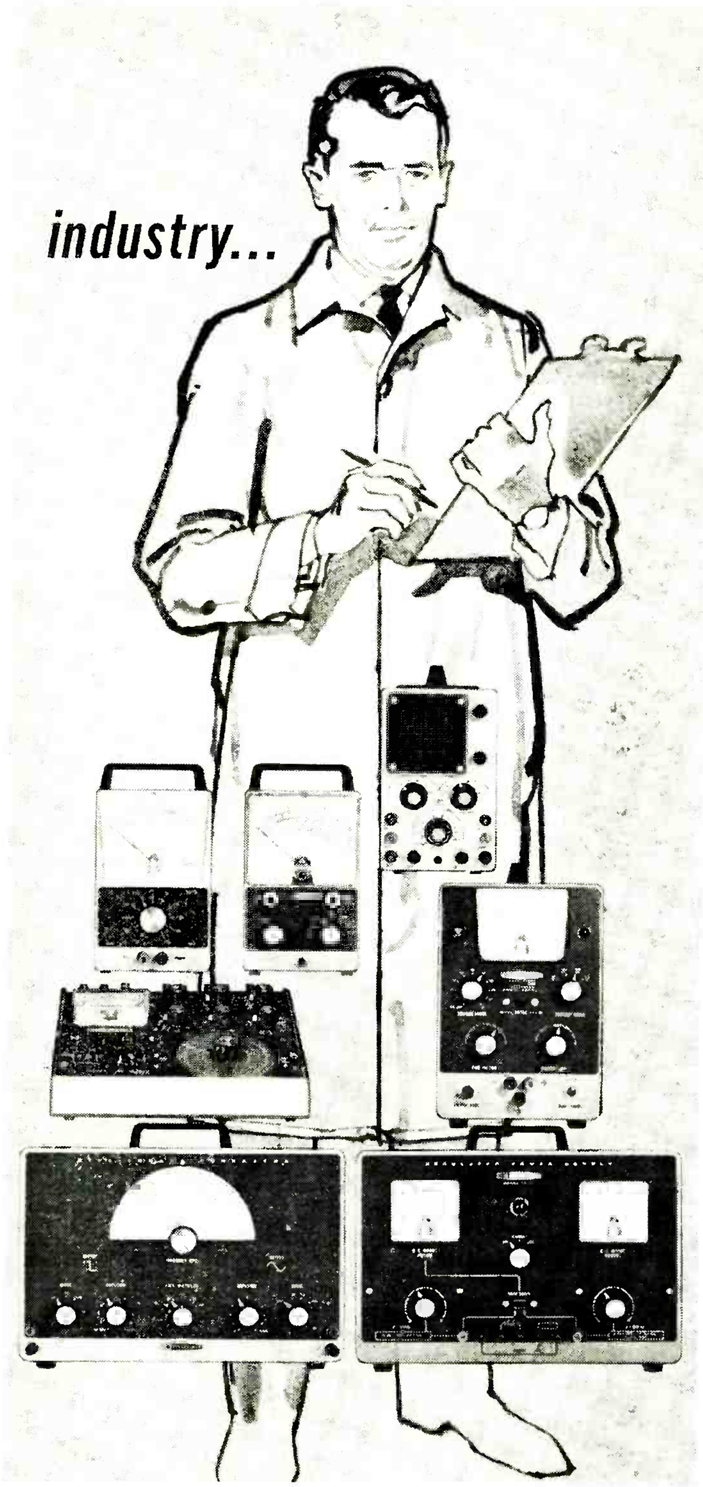

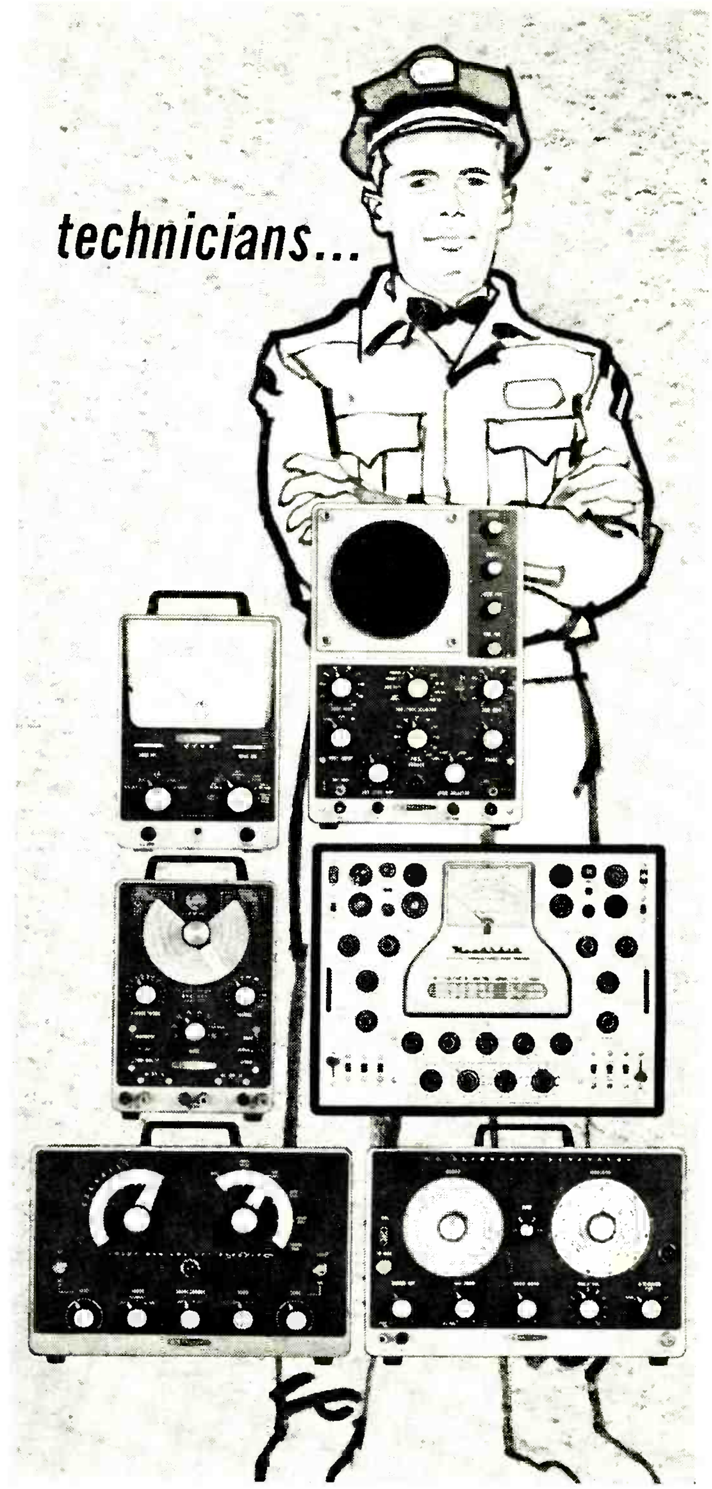

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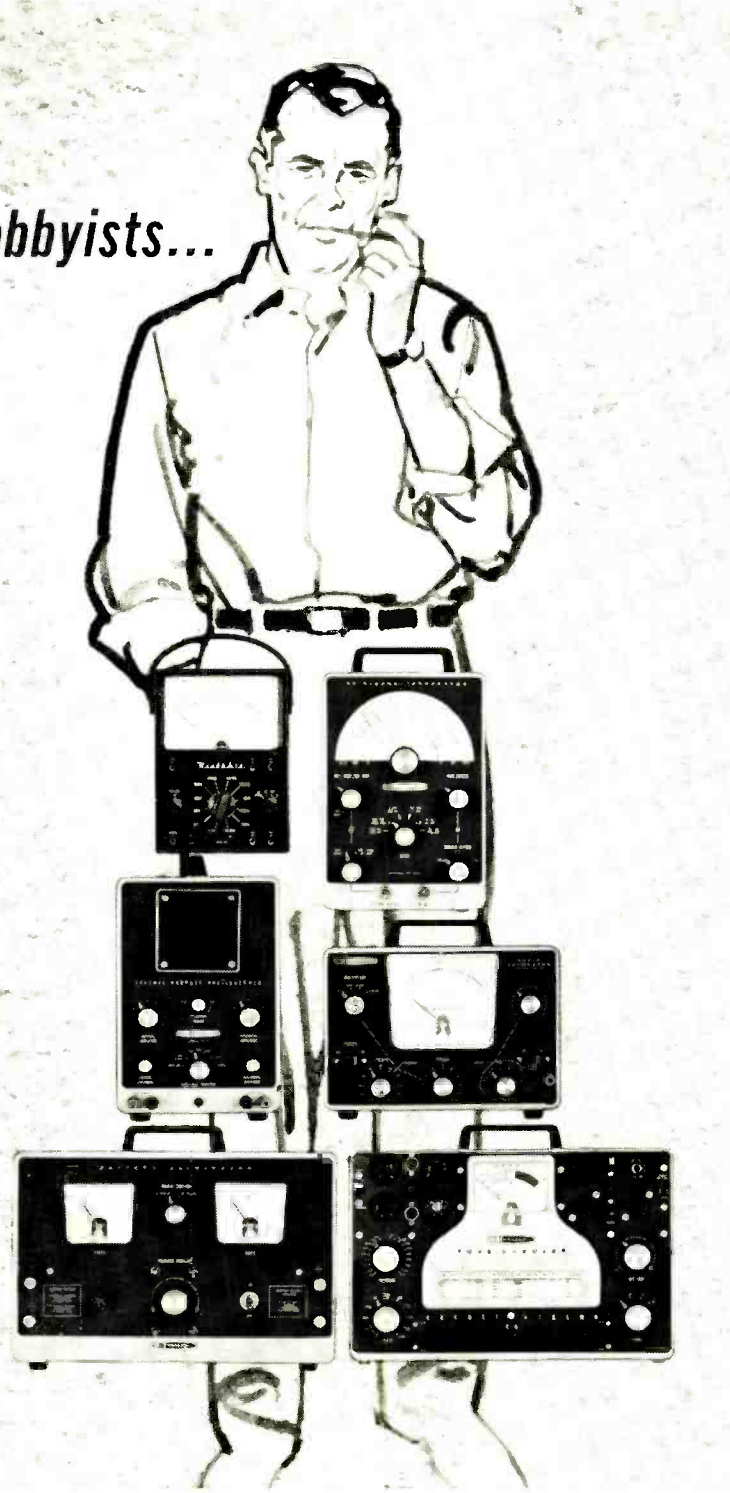

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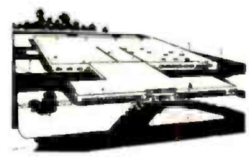

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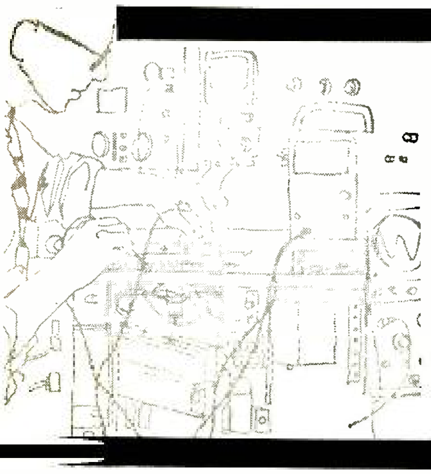

MAC'S ELECTRONICS SERVICE

By JOHN T. FRYE

Brain Vacations

IT was a dreary part of the year. Thanksgiving had crowded past with unseemly haste. The season had already revealed its whole bag of weather novelties: snow, sleet, freezing rain, and bitter cold; so now all it could do was repeat these monotonously for three more months.

Barney, Number Two Man at Mac's Electronics Service, usually generated his own sunny emotional climate; but apparently the letdown had reached even him. Anyway, he wasn't whistling or humming as he frowned at a little a.c.-d.c. radio chassis on the bench before him.

Additional years had taken from Mac, working beside him, the ability to zoom into the stratosphere of joy at the slightest provocation; but, in compensation, these same extra years had toughened the older man's spirit so that it was much harder to depress. Mac, therefore, was feeling about as usual as he glanced sideways at his morose assistant and asked:

"What's the matter, Buster? You got problems?"

"Just a teensy-weensy one," Barney replied sarcastically. "Either I need a vacation, or I'm losing my mind. The customer complained this little radio had no pep, and he was right. Only the local station could be received with good volume. It didn't take long to discover the d.c. voltage was down to about fifty volts; so I replaced the 35W4. That apparently solved the difficulty, for when I turned the radio on, it played loud and clear all the way across the dial. Just to be *sure*, though—the result of the both-belt-and-suspenders training you have drilled into me—I let the set play for a while on an out-of-town station. After four or five minutes, the volume began to go down very, very gradually. At the end of fifteen minutes, reception was almost as poor as when the radio came into the shop; and the d.c. voltage was down to fifty-five volts.

"The first thing I did was try another 35W4. Same difference. I reasoned something must be pulling the voltage down as the set warmed up. It could be a defective filter or other capacitor that became increasingly leaky after voltage was applied or perhaps a tube that gradually lost its bias and drew increasingly excessive current. To check on my theory, I lifted the lead from the cathode of the rectifier and inserted a milliammeter in series with it. That blew my theory all to heck: the current went *down* with the dropping voltage instead of up. See why I say I need a vacation, maybe in a laughing academy?"

Instead of replying, Mac pursed his lips thoughtfully while he glanced over the little radio and then picked up the cabinet and looked at the bottom of it. His mouth relaxed into an amused smile. He took a new tube from stock and substituted it for the 35W4 in the set. The radio soon began to play much louder than before. Barney waited expectantly for a drop in volume, but the minutes ticked by without the least faltering in performance.

"Now wouldn't that clam your chowder?" Barney asked disgustedly. "I had to get two bad 35W4's in a row. The chances of that happening must be about one in a million at least."

"It didn't happen now, either," Mac said softly. "Take a look at the number on that tube I put in."

Barney took a quick glance at the type number on the tube and then snatched up the cabinet and stared at the tube diagram pasted to the bottom while a flush of embarrassment spread over his face.

"A 36AM3!" he exclaimed; "and all the other tubes are 100-ma. filament types, too. How stupid can you get! But a 35W4 *was* in that socket when the set came in. See; right here it is."

"I don't doubt it. A vacation is your trouble, all right; but it's not that you need one; your brain took one. You made the common technician error of believing the tube you found in a socket was the one that belonged there. This has always been a dangerous assumption, and it's doubly so during these days of drug store do-it-yourself tube checkers."

"I should have been suspicious," Barney castigated himself. "Now I recall the customer's mumbling something about hoping we did a better job on the little radio than the last shop that had it. But we hear that so often I just dismissed it from my mind. Why do you suppose that other joker switched rectifiers?"

"He may not have had a 36AM3 and sloppily decided he could 'get by' with a 35W4, or he may have been ignorant enough to believe the tubes directly interchangeable because they have the same base diagram and roughly approximate characteristics, except for filament current. With all filaments cold, the resistance of the 35W4 filament was fairly close to that of the 100-ma. filaments in series with it. When voltage was applied across the cold string, it divided up among the filaments in about the proper ratio.

"That's why the 35W4 cathode got hot enough to do a fair job of emitting right at first. Once the filaments were thoroughly heated, however, the resistance of the 100-ma. jobs increased considerably beyond that of the 150-ma. 35W4 filament, and more and more of the total line voltage was distributed across the high resistance filaments while less and less of it appeared across the 35W4. The rectifier filament began to cool down, and this aggravated the condition still more. That's why the radio was a good starter but a poor finisher. The other technician may never have let the set play long enough to find this out."

"I'm pretty dumb, all right," Barney admitted with a rueful grin.

"Not necessarily," Mac said quickly. "All of us appear quite stupid at these times when our brains seem to take a vacation, but none are immune to the experience. Sometimes we are blinded by a preconceived notion; again we let our limited experience overwhelm the evidence of direct observation; more often than not we simply neglect to consider *all* the possibilities. The end result, especially when illuminated with hindsight, is that we seem—and temporarily are—very foolish. We can't hope to avoid this trap altogether, but the trick is not to fall into it too often.

"Let me give you a little ferinstance from my own recent experience. A couple of days ago while replacing the filters in an a.c.-d.c. set I noticed the #47 pilot lamp was out. I put in a new one but it didn't light. It's not too unusual to find a new lamp with a broken filament, but a simple continuity check revealed this filament wasn't open. Next I examined the socket very carefully. It was okay. The spring was good; the contacts were not corroded; the leads from the rectifier socket to the lamp socket weren't broken or shorted together, and they did connect to pins 2 and 3 of the 35Z5GT socket. I replaced the lamp and turned the set on. A voltage check between pins 2 and 3 of the rectifier revealed no voltage.

"'Aha!' I said to myself; 'something is wrong with the 35Z5GT.' But changing rectifiers made no difference. Leaving

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WILLIAM A. STOCKLIN
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the a.c. voltmeter attached to the rectifier socket, I removed the lamp to examine the bayonet socket once more. As I did so, out of the corner of my eye I saw the meter pointer swing up to a reading between 7 and 8 volts. 'Obviously,' I thought to myself, 'the socket is shorting internally when the bulb is in place.' I wasted the next fifteen minutes trying to prove this, but could not make the short reappear without the dial lamp in place.

"Finally I did what I should have done in the beginning: I tried another dial lamp. It burned perfectly normally. I checked the resistance of the bulb I had first—not just the filament continuity as before. It was zero. Simply because I had never run across a short-circuited dial lamp in a third of a century of servicing, I wasted a good half hour on a difficulty that could have been solved in ten seconds just by trying another dial bulb.

"I suppose the manufacturer in attaching the bulb to the base had somehow crossed the filament leads or shorted them out with a drop of solder."

"Boy oh boy!" Barney ejaculated, brightening visibly; "you certainly make me feel better. I'm encouraged to tell you now something I've been ashamed to admit before. Last week I turned on our TV at home to see the *Bonanza* show, and about all I got from the speaker was a roaring hum that chopped up the audio and persisted in spite of any setting of the volume control. For a month I had been noticing some vertical bending on the screen; so I didn't even bother to take the back off the receiver. Very obviously the filter capacitors that had been on their way out had opened up altogether. Feeling very disgruntled, I switched off the set and spent the rest of the evening reading magazines.

"The next morning I pulled the chassis and lugged it down here to the shop bright and early before you came to work. I decided to turn on the set and bridge the filter capacitors with a good unit one at a time to see if they were all *kaput* or not. As soon as I flipped that switch, I was willing to sell myself very cheap. One of the output tubes lit up like a neon sign with a flickering violet-colored light. I don't think I ever saw a more gassy tube. Replacing it took away every trace of hum. And the vertical bending was quickly traced to a tube with heater-to-cathode leakage. There had been no connection between the two symptoms in spite of my best effort to marry them. Since I have a complete set of replacement tubes at home, I could easily have had that set going before Hoss finished his welcoming grin."

There was silence in the shop for a few minutes while Barney and Mac smiled at each other sympathetically. Finally the older man summed things up:

"I guess you might say experience got into our way in all three of these cases. Experience is an indispensable aid to a service technician, but it can play tricks on him if he considers it complete and infallible. Nobody has enough experience to merit those two adjectives. The best experience is the kind that keeps saying to you: 'Usually—but not always!' " ▲

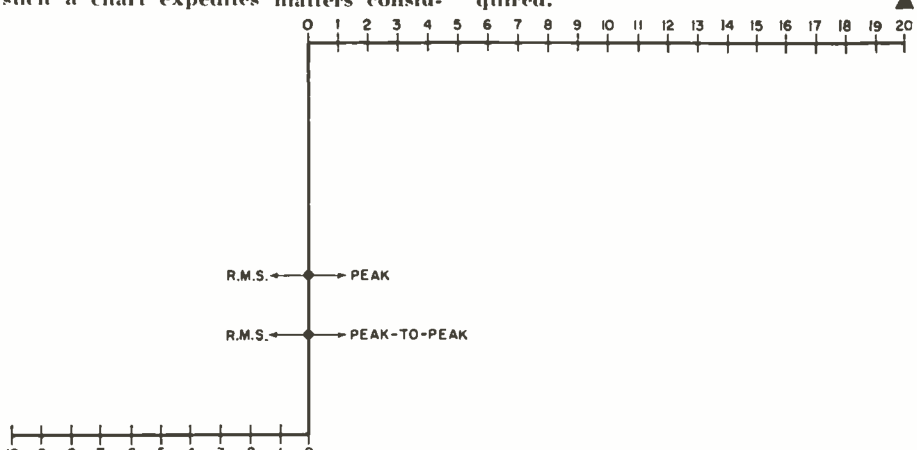
A.C. VOLTAGE-CONVERSION CHART

FREQUENTLY, the technician, experimenter, or serviceman must convert the value of an a.c. voltage from its usual r.m.s. figure to either a peak or a peak-to-peak value. This is especially true when substituting silicon rectifiers and when choosing capacitor voltage ratings.

While the conversion can be made by multiplying the r.m.s. value by the appropriate conversion factor, it is often handy to be able to determine the voltage by means of a nomogram. When only an approximate value is required, use of such a chart expedites matters considerably for the busy service technician.

The chart below makes the conversion to or from either value. To use it, simply draw a straight line from the known voltage through the desired conversion point to the other voltage scale and read the equivalent voltage from that scale. The r.m.s. values are on the lower scale and peak and peak-to-peak values are on the upper scale.

In using the chart, note that values have been normalized. Divide or multiply actual voltage by 10, 100, or 1000 as required. ▲



EMERGENCY CALL SYSTEM for HIGHWAYS

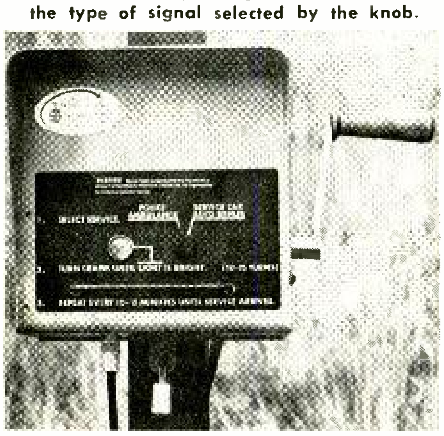
Hand-cranked radio xmtr sends coded signals to summon police or service.

AN EMERGENCY call system for use along the nation's highways and toll roads is now undergoing field tests on a 5-mile section of the Garden State Parkway in New Jersey. The signalling system, known as "Turn Call," consists of a number of roadside transmitter units by which motorists may institute calls for police or service trucks. Receiving equipment is located at 15-20 mile intervals to relay or directly connect the coded information to the communications center where the call is decoded, displayed, and used to send appropriate help on its way.

The call boxes, located on poles alongside the road, use a hand-crank generator to supply electrical power to the transmitter and activate the code wheels. Each transmitter operates on about 160 mc. and delivers around 2 watts of r.f. to a yagi antenna that is located atop the mounting pole. The code wheels produce frequency-shift keying of the FM transmitter. One coded signal is used to summon police and ambulance; another is used for an auto repair service truck.

FM receivers pick up, detect, and pass the message on to a decoder-display unit using either existing communications or direct connection into the decoder-display unit. The message is retained on a visual display at the receiver until reset by the operator. The system was developed by the *ITT Kellogg Communications Systems Division.* ▲

"Turn-Call" transmitter is attached to an antenna pole alongside a remote highway. When crank is turned, an automatic radio signal is sent out calling for police or service trucks depending on the need and the type of signal selected by the knob.



Radio & TV News

Events in the Service Industry

PUTTING THE service technician in a test tube and analyzing him must hold a special fascination: it is probably the industry's favorite pastime. One reason is the fact that there is less undeniably reliable information than is available for similar studies in other fields. This gives the mind more speculative room over which to range.

For example, we have seen reports on the number of service shops in this country that range from 30,000 to 70,000. Each comes from an intelligent and responsible source that is trying to do the best with whatever evidence is available. Accuracy aside, however, each interpretation manages to turn up its own points of interest and value.

Certainly there will be interest in the opinion of the executive director of the National Alliance of Television & Electronic Service Associations, Frank J. Moch. He sets the figure of "legitimate, properly equipped places of business" at 52,000. The terminology is significant. What do you count as a service shop? Perhaps some of the estimates of 70,000 (and higher) confer the designation on anyone who earns some part of his income from service and has set up a bench in his basement. On the other hand, the low figure of 30,000 comes from an individual who believes that anyone with less than $10,000 invested in stock and equipment cannot be enough of a factor to be counted. Perhaps his definition is more restrictive than Moch's.

Be that as it may, the NATESA spokesman goes on to state that these shops account for a technical work force of 83,000 men, and that the total hours devoted exclusively to service work come to 5,976,000. If he is correct and means hours per week, as seems to be the case, the average man puts in a 72-hour stint. That seems rather unlikely. Perhaps he means some of these hours to include the group next mentioned, the "50,000 individuals who do some service work on a catch-as-catch-can basis working an indeterminate amount of time." Altogether, then, there would be 133,000 men involved to some degree and at some level of competence.

Further, more than 68 per-cent of the businesses are one-man (or "papa and mama") affairs, which means that service facilities are broadly distributed. In fact, Moch judges, almost 98 per-cent of all service establishments involve fewer than four men. An exact statement on this point is made difficult, however, because of his belief that most shops do use the services of part-time men who have regular jobs elsewhere in electronics. But this practice does reflect the need for more trained people in the field, a need that has come about because qualified people have had to leave service for more rewarding pastures. In this connection, he finds that the average earnings of a service technician come to less than $82.00 per week.

There is quite a bit to think about here.

Assembly Reliability

The feeling of distrust that has accompanied the use of printed boards, at least at the outset, as compared to hand wiring was often based on the belief that a hand-wired chassis was more reliable. Looking back after a few years of experience, *RCA* indicates that the opposite may be true. Accumulated data on receivers using the boards show that —wiring aside—the individual *components* used in printed sets seem to hold up better. How so, since they are basically the same components used in hand wiring? It seems that the stress to which components are subjected when first soldered into the circuit has bearing on their ultimate life. They appear to take less of a beating from the dip-soldering methods used where boards are involved than from hand soldering.

Shoe on the Other Foot

According to the "Newsletter" of TSA of northeastern New York, pharmacists and drug stores in that area are actively promoting a new slogan: "Buy Drugs in Drug Stores." It seems they are being hurt by the fact that aspirins, toothpaste, vitamins, *et al.* are available from supermarkets, notions counters, mail-order firms, *et al.* What makes this so ironic is that, in the modern drug store, one has to duck around displays of toys, books, records, foodstuffs, hardware, *et al.* in search of the prescription counter. Drug stores have taken the lead in this sort of "diversification." In fact, as any irate service dealer can tell you, the first thing you will trip over is the do-it-yourself tube tester near the door. *Et al.*

"Stamping" Out Competition

One of the real hot-under-the-collar items for service people during the past year was the rash of merchandising schemes for giving away "free" TV sets, *via* "instant dividend" plans, food-store stamps, and the like. Bidding for increased tube sales, *Sylvania* is now offering dealers green stamps through participating distributors. Oh well, a gimmick itself is neither good nor bad. It's the way it's used that counts. ▲

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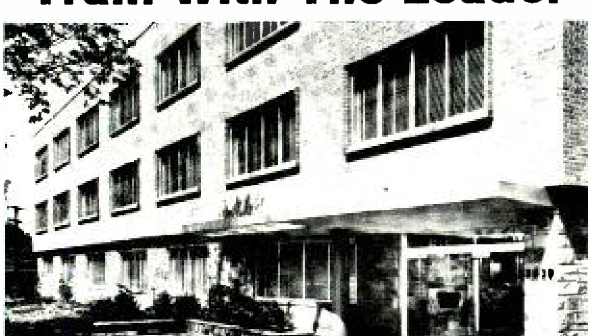

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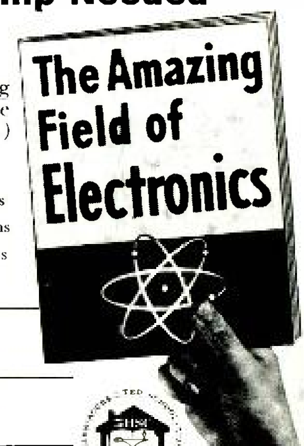

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ELECTRONIC CROSSWORDS

By LUTHER A. GOTWALD, JR.

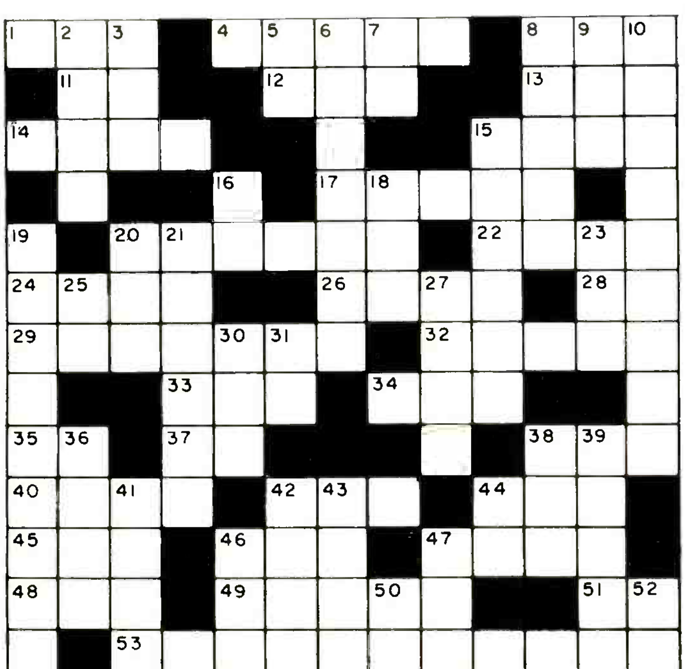
(*Answer on page* 103)

ACROSS

1. Attenuator circuit.
4. Device used to detect unseen objects.
8. TV frequencies (abbr.).
11. Rare silver-white element (abbr.).
12. Likely to use radar.
13. Malayan ape.
14. Used in calibrating in the field.
15. Circuit employed in most computers.
17. Sacred song.
20. Many radar units are this.
22. Southernmost U.S. land mass.
24. Unit of time.
26. What radar senses.
28. English dipthong.
29. Tube that reduces the effect of amplitude modulation.
32. At full speed.
33. A grain of cereal grass.
34. Young fish.
35. Local official servant (abbr.).
37. An officer (abbr.).
38. One of the "Little Women."
40. To sleep fitfully.
42. Woman's name.
44. Order of animals (suffix).
45. To contrive by various make-shifts.
46. Hawaiian baking pit.
47. River in Hades.
48. Capek's play about robots.
49. Circuit which blocks low-level extraneous signals.
51. Good (prefix).
53. Circuits where lighthouse tubes are used.

DOWN

2. Particle.
3. German article.
5. Transformer output.
6. Effect utilized by radar.
7. One of the press associations (abbr.).
8. Body of Moslem scholars (Arabic spelling).
9. Chapeau.
10. It's usually given in cycles-per-second.
15. Melancholy.
16. One of the backfield (abbr.).
18. Unit of time (abbr.).
19. Grid mounting on lighthouse tubes.
20. Indian of the Mayan tribe.
21. Colorful songbird.
23. Fencer's cry.
25. Region in Southeast Asia (abbr.).
27. The male red deer.
30. Make edging.
31. And (Latin).
36. African antelope.
38. Unlimited.
39. Combines oscillator and echo signals.
41. Nought.
42. East Indian tanning tree.
43. Consisting of two parts.
44. Pronoun.
46. A Federal agency (abbr.).
47. Mineral spring.
50. Unit of measure (abbr.).
52. You and me.



Calendar of Events

JANUARY 8-10, 1963
Millimeter and Submillimeter Conference. Sponsored by the Orlando section of IRE and PGMTT-IRE. Cherry Plaza Hotel, Orlando, Florida. Program information from J. W. Dees, Martin Co., P.O. Box 5837, MP-172, Orlando, Florida.

JANUARY 21-24
Ninth National Symposium on Reliability and Quality Control. Sponsored by PGRQC, Los Angeles Section of IRE. Program information from L. W. Ball, Boeing Co., P.O. Box 3707, Seattle 24, Washington.

JANUARY 21-31
The 1963 Engineering and Management Course. Sponsored by University of California. Los Angeles Campus. Intensified 10-day short course, 8 a.m.-5 p.m. daily (excluding Sunday). Brochure on course available from Reno R. Cole, Coordinator, Room 6288, Engineering Unit II, University of California, Los Angeles 24.

JANUARY 22-26
Fourth Annual ERA National Convention. Sponsored by Electronic Representatives Association. Mark Hopkins Hotel, San Francisco. Details from ERA Headquarters, 600 South Michigan Ave., Chicago 5.

JANUARY 30-FEBRUARY 1
Fourth Winter Convention on Military Electronics. Sponsored by PGMIL and Los Angeles Section of IRE. Ambassador Hotel, Los Angeles, Calif. Program information from IRE Los Angeles Office, 1435 La Cienega Blvd.

FEBRUARY 8-10
1963 Pacific Electronic Trade Show (PETS). Sponsored by Association of Electronic Distributors. Shrine Exposition Hall, Los Angeles. Details from Association, 10480 National Blvd., Los Angeles 34. Att: Charlie Silvey, executive vice-president.

FEBRUARY 11-15
Third International Symposium on Quantum Electronics. Sponsored by IRE, SFER, ONR. Unesco Building & Parc de Exposition, Paris, France. Program details from Madame Cauchy, Secretaire, 7 rue de Madrid, Paris 8me, France.

FEBRUARY 20-22
International Solid State Circuits Conference. Sponsored by PGCT, AIEE, Philadelphia Section of IRE, University of Pennsylvania. Sheraton Hotel and University of Pennsylvania, Philadelphia. Program information from S. K. Ghandi, Philco Scientific Lab, Blue Bell, Pa.

MARCH 25-27
Convention on H.F. Communication. Sponsored by the Electronics Division of the Institution of Electrical Engineers. Program information from Secretary, IEE, Savoy Place, London, W.C. 2, England.

MARCH 25-28
IEEE International Convention. Sponsored by all Professional Groups of the IRE. Coliseum and Waldorf-Astoria Hotel, New York. Details from Dr. D. B. Sinclair, IRE Headquarters, 1 E. 79th St., New York 21, N.Y.

APRIL 10-11
Fourth Symposium on Engineering Aspects of Magnetohydrodynamics. Sponsored by PGNS, AIEE, IAS, University of California. Details from Julian L. Dunlap, Thermonuclear Exp. Div., Oak Ridge National Lab., Oak Ridge, Tenn.

APRIL 16-18
Cleveland Electronics Conference. Sponsored by IEEE, ISA, Cleveland Physics Society, Case Institute, and Western Reserve University. Hotel Sheraton, Cleveland. Details from Lapine Enterprises, 310 Hotel Manger, Cleveland 14, Ohio.

Symposium on Optical Masers. Sponsored by IRE, AIEE, Optical Society of America, U.S. Defense Research Agencies. Polytechnic Institute of Brooklyn, N.Y. Details from Jerome Fox, Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.

APRIL 16-20
1963 British I.R.E. Convention. Sponsored by British Institution of Radio Engineers. University of Southampton. Information from I.R.E., 9 Bedford Square, London, W.C. 1, England.

APRIL 17-19
Southwestern IRE Conference and Show. Sponsored by Region 6 of IRE. Dallas Memorial Auditorium, Dallas, Texas. Details from Prof. A. E. Salis, EE Dept., Arlington State College, Arlington, Texas.

International Conference on Nonlinear Magnetics. Sponsored by IRE and AIEE (IEEE). Shoreham Hotel, Washington, D.C. Program information from J. J. Suozzi, Bell Telephone Labs., Whippany, New Jersey.

APRIL 23-MAY 2
London International Engineering Exhibition. Sponsored by Industrial & Trade Fairs Ltd., Earls Court and Olympia, London. Details from Press Office, Commonwealth House, New Oxford Street, London, W.C. 1, England.

APRIL 24-26
Seventh Region Technical Conference. Sponsored by Region 7 of IRE. San Diego, Calif. Details from George C. Tweed, Jr., 8080 Pasadena Ave., La Mesa, Calif.

MAY 2-3
Fourth National Symposium on Human Factors in Electronics. Sponsored by PGHFE of IRE. Marriott Twin Bridges Hotel, Washington, D.C. Details from IRE Headquarters, 1 E. 79th St., New York 21, N.Y.

MAY 7-9
1963 Electronic Components Conference. Sponsored by AIEE, EIA, IRE, with American Society for Quality Control. International Inn, Washington, D.C. Program information from Edward J. Kaputa, BuShips, Code 681A2, Dept. of Navy, Washington 25, D.C.

Multiplex Signal Generator

(*Continued from page 37*)

lator output. The network consisting of *C*9, *R*6, *R*7, *R*8, and *R*12 derives a 38-kc. signal whose phase and amplitude may be varied over a relatively wide range. This signal is adjusted so that it is of equal amplitude and of opposite phase to any 38-kc. leakage from the modulator. Mixing at *V*3*A* results in virtually complete elimination of 38-kc. carrier that may have gotten through.

The 53-kc. low-pass filter (*L*2-*L*4, *C*13-*C*16) is an M-derived filter which provides more than 60 db of attenuation at 76 kc. and a minimum of 35 db attenuation at frequencies higher than 76 kc. The filter is adjusted so as not to affect the amplitude or phase linearity of the passband below 53 kc. Filtering of the composite signal is necessary because the switching action of the modulator produces harmonics of the switching frequency; 76 kc., the second harmonic, is most prominent.

The filtered composite is fed to composite phase corrector *V*3*B*, which is a high-frequency phase shifter. *R*28 compensates for any phase error that might be caused by the 53-kc. low-pass filter or in the following composite-signal amplifier stage.

The composite-signal amplifier (*V*4*A*,

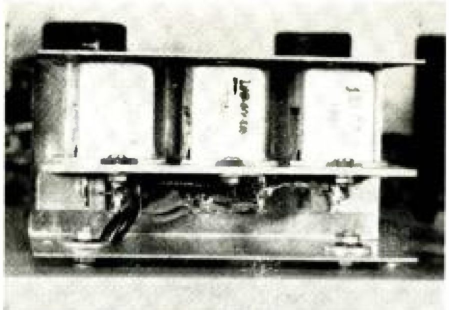


Fig. 5. Inside view of 53-kc. low-pass filter shows mounting of L2, L3, L4 on bracket.

B) is a wide-band feed back pair that brings the composite signal up to a more useful level and provides a relatively low-output impedance at "Composite Output" jack *J*1.

The 19-kc. pilot signal is derived from the 19-kc. filter (*L*1,*C*6) and is then fed to the pilot phase control triode *V*1*B*. *R*36 permits the pilot phase to be adjusted over a range somewhat greater than 90° with respect to the composite signal at point *Y*. Cathode-follower *V*2*B* provides the low driving impedance necessary for the insertion of the pilot at point *Y*. *R*40 controls the level of the pilot and *S*1 turns the pilot off by grounding it.

The FM r.f. generator, which consists most importantly of *V*5 and *CR*9, pro-

(*Continued on page 74*)

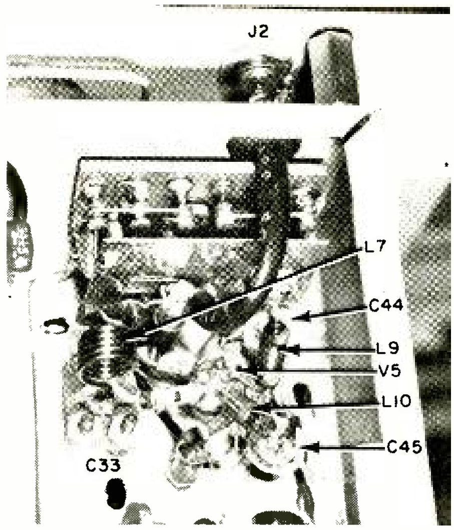


Fig. 6. R.f. generator (upper right corner, Fig. 2) should be covered with chassis box.

duces an r.f. carrier to simulate an FM stereo broadcast. *V5*, a nuvistor triode, is used as a Colpitts oscillator with a range of 88-108 mc. The modulator, *CR9*, is a voltage-variable, silicon-diode capacitor (Varicap) that has an extremely wide-band characteristic. The bandwidth of the Varicap is such that as an FM modulator, it does not cause phase or amplitude distortion of a stereo composite signal. The oscillator produces approximately 6000 μv. of signal across 50 ohms at the output. Use of the proper impedance-matching pad will result in a 1000-μv. signal at the 300-ohm antenna terminals of an FM receiver.

Audio oscillator *V7* (Fig. 4) is an unusual variation of a Wien-bridge oscillator. The left half of *V7* is a split-load phase inverter and the right is a gain stage. The positive feedback path is *via* *R97* and *C48*, and the negative feedback path is from the cathode of the phase inverter to the input grid of the gain stage *via* *R98* and *C50*. Frequency of oscillation is controlled by *R97*, *R98*, *C48*, and *C50*.

Construction

The stereo generator shown on the cover was built on a standard 7"x13"x2" aluminum chassis and a 13¼"x5¾"x⅛"-thick aluminum panel. Construction may be simplified by using a larger chassis and panel; the layout of the unit shown need not be followed. If the builder elects not to include one or more of the optional circuits, the layout can certainly be redistributed to reduce component crowding. However, there are several points you should keep in mind if the layout is to be changed. The most critical area in the generator is the 19-kc. oscillator and the doubler/amplifier. The 19-kc. and 38-kc. signals in these stages are at relatively high levels and radiation can become a problem. It is imperative that this circuitry be kept as far as possible from the rest of the generator circuits. The danger of radiating the 19-kc. and 38-kc. signals and their harmonics can be substantially reduced by locating the 19-kc. oscillator, doubler, and modulators in a separate compartment. In the author's generator, an aluminum wall (see Fig. 2) compartmentalizes these circuits. In general, keep all leads short.

The 53-kc. low-pass filter, which is particularly susceptible to radiation pickup, is built in a 1⅝"x2⅛"x4" aluminum chassis box as shown in Fig. 5. *L2*, *L3*, and *L4* are mounted on an aluminum shelf which is attached by an aluminum bracket to the inside wall of the box. The r.f. oscillator and modulator are completely contained in one corner of the generator and are enclosed by an aluminum chassis box (not shown) as in Fig. 6.

The front panel is mounted away from the chassis on six ⅝"-long standoffs (see Figs. 2 and 6). All of the switches, input and output jacks, "R.f. Modulation Level," *R50*, the meter and meter amplifier are mounted on the front panel. The "19-kc. Phase," "19-kc. Level," and the "Internal Oscillator Level" controls are screwdriver-adjust controls and are accessible through holes on the front panel.

Since the multiplex system is extremely sensitive to phase and frequency-re-

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Plan to use the signal generator for:
Laboratory work ☐ *Professional servicing* ☐ *Hobby* ☐

sponse variations, great care must be taken regarding stray-wiring capacity. Use shielded cable *only* where indicated on the schematic. Under no circumstances use standard shielded audio cable. All of the shielded cable shown on the schematic is low-capacity r.f. coaxial type. The author used type *RG-174/U* (30.4 $\mu\mu$f./foot). The shielded cable between point *X* and *C11* *must be exactly* 6½" long as its capacity is taken into account in the circuit design.

In the author's generator, almost all small components are mounted on terminal boards. This construction is not absolutely necessary, but is desirable for a neat, professional appearance.

Meter calibration pots *R63*, *R69*, *R71*, and *R73* and the meter amplifier are mounted on an aluminum *L*-bracket attached to the back of monitor meter *M1*. The meter amplifier, except for the transistors, is built on a piece of perforated phenolic board using "flea" clips. The transistor sockets are mounted on the aluminum bracket. The transistor heat sink (not shown) is a ⅜"x1½"x⅜" piece of aluminum drilled and reamed to fit snugly over the transistors.

Because the alignment and checkout procedure would take up considerable extra space in this issue, we decided to make it available separately. You can obtain it free of charge by simply filling out and returning the coupon. ▲

METER BATTERY TROUBLE

By RICHARD A. GENAILLE

MANY items of test equipment use standard flashlight batteries for one purpose or another. A number of popular volt-ohm-milliammeters, like our Simpson 260, use a few penlight cells plus one "D" size battery, the latter being used on the lowest or two lowest ohmmeter ranges.

Trouble was recently encountered on the RX1 and RX100 resistance ranges. At times, the ohmmeter could not be zeroed properly. At other times, the same fixed resistor would yield a different reading each time it was measured.

Investigation of the "D" cell (an Eveready 950) disclosed that it was manufactured with a small depression centered in the negative (bottom) end that approximately matched the head of a 6-32 screw. The depression is about 9/32 of an inch in diameter and 1/16 of an inch deep. The meter's contact terminal for the negative end of the battery is approximately 7/32 of an inch in diameter. This spring-loaded contact fits into the battery depression, but without sufficient pressure to maintain good electrical contact. The result is erratic or intermittent operation on low-resistance ranges.

The battery and contact arrangement is not an unusual one, nor is the dimple at the bottom of the "D" cell exclusive with one manufacturer. The difficulty would not therefore be unique. In fact, there is no way of knowing how many batteries, otherwise good, have been discarded because of this symptom. A simple cure is to fill the depression with solder, clean off excess rosin with steel wool or sandpaper, and then re-insert the battery. ▲

Q & A on Business Radio

(*Continued from page 41*)

Service is related to the band in which operation takes place and the amount of power employed. Specifically, any operation between 25 and 50 mc. utilizing power in excess of 3-watts input is required to maintain a tolerance of .002%; operations in this band with a power input of 3 watts or less may utilize a tolerance of .005%. Operations in the band 50-1000 mc. with power in excess of 3 watts requires a frequency tolerance of .0005%; operations in this band with a power input of 3 watts or less may utilize .005% tolerance.

QUESTION 10. *Can home-built or kit-type equipment be used?*

ANSWER: Home-built or kit-type equipment *may not be employed* in the Business Service. Equipment used in this service must be on the Commission's List of Radio Equipment Acceptable for Licensing in Part 11 of the Rules.

QUESTION 11. *What maintenance measures are required and how often must they be made?*

ANSWER: Maintenance measures required in the Business Radio Service are similar to those required in all other industrial services and, in general, constitute determinations by the licensee that the carrier frequency, plate power input to the final stage, and degree of modulation does not exceed the limitations established by the rules and by his station authorization. Such determinations must be made under three conditions:

a. When the transmitter is initially installed.

b. When any change is made which may affect the frequency, power, or modulation values of the transmitter.

c. At regular time intervals not to exceed one year. (In the case of a non-crystal-controlled transmitter, however, the frequency determinations must be made at intervals not to exceed one month.) Station records (maintenance logs) must reflect the dates and results of such measurements and by whom made.

QUESTION 12. *May the 10-kc., 30-watt Business Service frequencies in the 27-mc. band be utilized in the Citizens Radio Service or with Citizens Radio equipment in the Business Radio Service?*

ANSWER: These frequencies may not be used in the Citizens Radio Service and, in general, most Citizens Band equipment is not licensable for use on these frequencies. As covered above, equipment utilized in the Business Radio Service must appear on the Commission's List of Equipment Acceptable for

Licensing under Part 11 of the Rules. The technical requirements for Business Radio are somewhat more stringent. Business Radio equipment requires a modulation limiter and low-pass audio filter, while Citizens Radio does not. The frequency tolerance of Business Radio is .002%, while Citizens Radio is .005%.

QUESTION 13. *Since Business Service eligibility is extended to anyone engaged in a commercial activity, does this mean that a Business Service licensee could utilize his system for the purpose of handling message for other parties, either on a charge or no-charge basis?*

ANSWER: Licensees in the Business Radio Service, like those in all of the other Industrial Radio Services, may not use their radio system to render a communications common-carrier service or to carry program material of any kind for use in connection with radio broadcasting. Further, as a general premise, a licensee in the Business Service may not utilize his radio system to handle message traffic between two other parties unless specific authorization for such operation has been obtained. ▲

PATCH PILOT

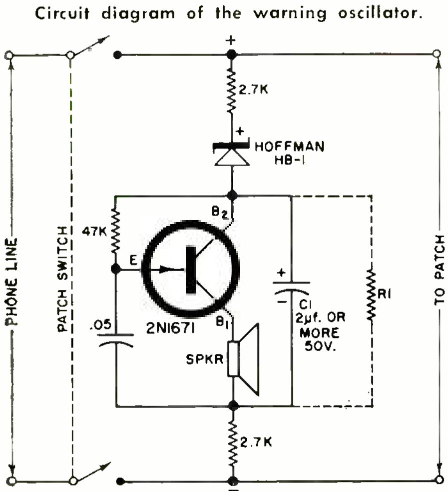
By TOM LAMB, K8ERV

LEAVING a phone patch connected after hanging up is about the surest way to incur the wrath of the phone people. The "patch pilot" is a line-operated audible oscillator that squawks if the phone is hung up but the patch is left on.

An open phone line carries about 40 volts. This drops to a few volts when the telephone hook switch is closed. A unijunction relaxation oscillator is connected to the 40-volt line through isolating resistors and a very inexpensive 10-volt zener diode. As long as the phone is in use, the line voltage is below 10 volts and the diode disconnects the oscillator. But if the phone is hung up with the patch on, 30 volts is applied to the pilot giving a warning tone. C_1 prevents the tone from going back onto the line.

Should the voltage across C_1 be greater than 30 volts, load the circuit with a resistor, R_1, until 25-30 volts is obtained. The speaker may be almost anything, from a miniature transistor set speaker to a telephone receiver. ▲

Circuit diagram of the warning oscillator.



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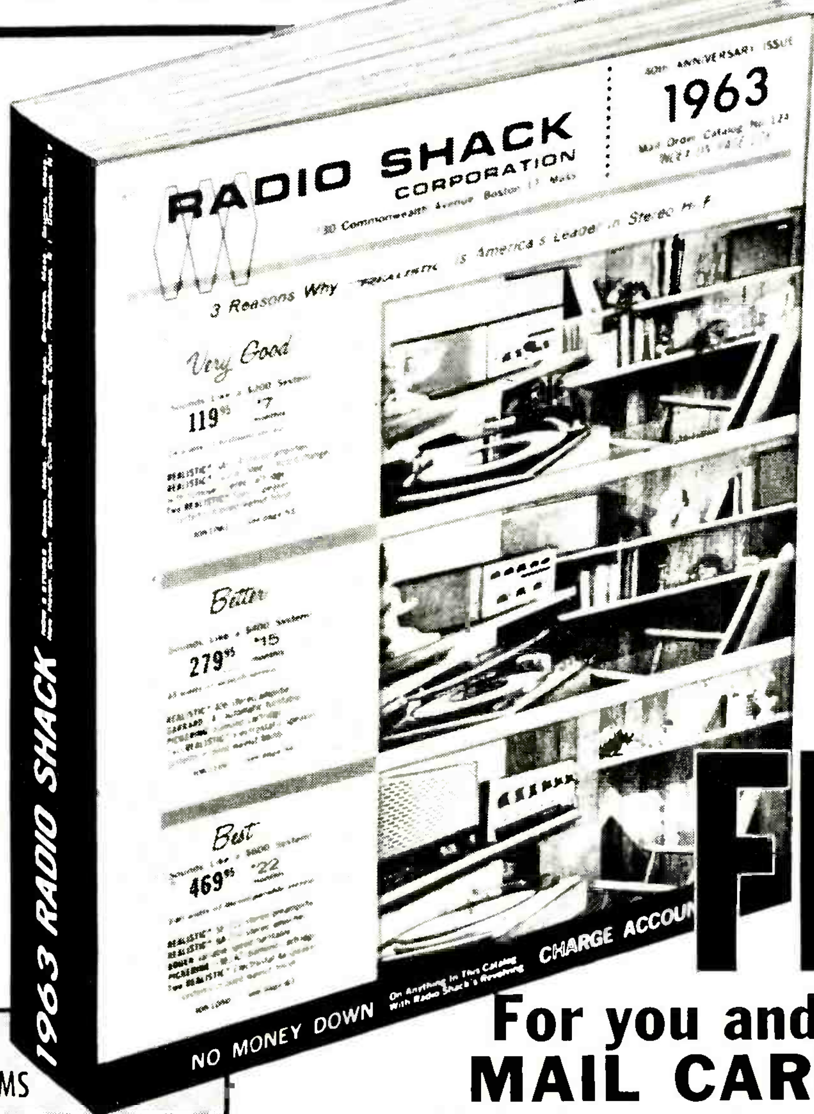

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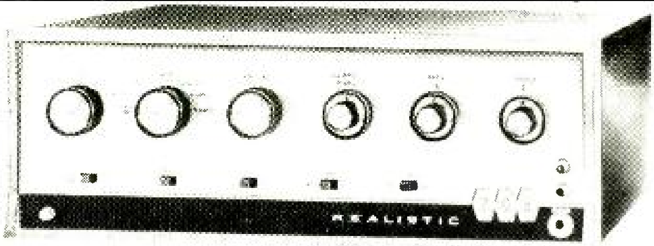

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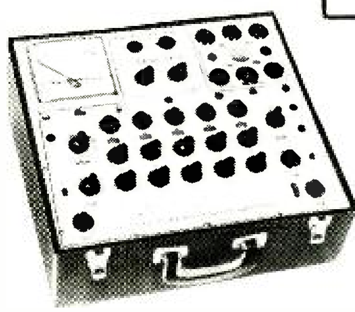

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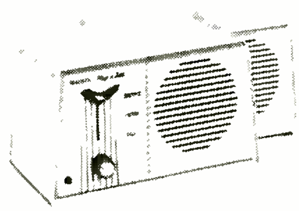

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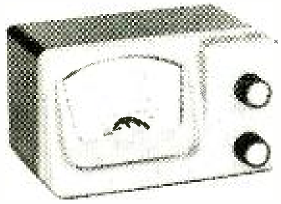

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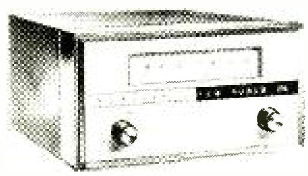

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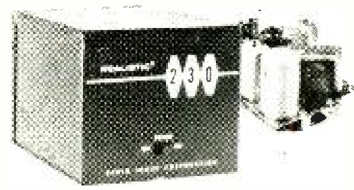

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Technical Books

"A PRIMER OF LINEAR PROGRAMMING" by Kurt Meisels. Published by *New York University Press*, New York. 103 pages. Price $4.50.

An introduction for non-mathematicians, this is a carefully developed exposition of a mathematical technique useful in the analysis and solution of industrial production, scheduling, and distribution problems.

An allocation problem that can be solved by linear programming is this: How should a manufacturer of two test instruments with similar specifications, differing only in the number of components and selling at slightly different retail prices, but with identical labor and overhead expenses schedule his production for maximum gross profit and limited component inventory?

Intended for middle-management men, this book is also useful to the newcomer with no previous exposure to the field and to engineering and production personnel.

° ° °

"AMATEUR RADIO ANTENNA HANDBOOK" by Harry D. Hooton, W6TYH. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 157 pages. Price $2.95. Soft cover.

This handy manual provides complete coverage of antenna systems for the amateur radio operator. The author discusses the design and construction of systems, including information on transmission lines, impedance matching, coupling, towers, and arrays.

The text is divided into eight chapters covering radio wave propagation, antenna fundamentals, high-frequency antennas, transmission lines, impedance matching systems, antenna coupling systems, antenna construction, and towers and supporting structures. Polar patterns, line drawings, schematics, and photographs amplify the text material for maximum usefulness to the active ham.

° ° °

"IT'S EASY TO USE ELECTRONIC TEST EQUIPMENT" by Larry Klein & Ken Gilmore. Published by *John F. Rider Publisher, Inc.*, New York. 183 pages. Price $4.00. Soft cover.

This is a basic book for those working as service technicians and lab technicians, or those who have an interest in electronic experimenting or ham radio. The authors devote a chapter each to 14 different test instruments: v.o.m., v.t.v.m., oscilloscope, voltage calibrators, tube tester, transistor tester, test-bench bridges, r.f. signal generator, r.f. sweep generator, audio generator, square-wave generator, a.c. v.t.v.m., harmonic distortion analyzer, and IM distortion analyzer, along with chapters on applications of some of the instruments.

Basic circuitry, test setups, application data, how to hook up the equipment, calibration, and troubleshooting the instruments are all covered in this well illustrated text.

° ° °

"abc's OF RADIO NAVIGATION" by Allan Lytel. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 94 pages. Price $1.95. Soft cover.

The boom in boating and recreational flying has made it almost imperative that participants navigate with the aid of electronic units of various types. This book discusses the use and operation of electronic radio navigation equipment designed for small planes and boats as well as for larger commercial craft.

The author covers two-way radio, radar, radio direction finders, radio ranges, d.m.e., instrument landing systems, marine radio, loran, Consolan, Decca, and Gee. Not only will the owner learn how to use his equipment but the technician will find this book helpful in gaining an understanding of basic circuit principles.

° ° °

"ADDITIONAL 1962 TELEVISION SERVICING INFORMATION" compiled by M. N. Beitman. Published by *Supreme Publica-*

tions, Highland Park, Ill. 192 pages. Price $3.00. Soft cover.

This is volume TV-20 in this publisher's series of service manuals. It covers TV models, from seventeen well-known manufacturers, released after the original offerings in their 1962 lines.

As is the case with all of these service books, this volume includes a schematic of the set, alignment and service hints, parts list, tube/adjustment location guides, and information on printed-circuit-board servicing.

* * *

"CB RADIO ANTENNA GUIDEBOOK" by David E. Hicks. Published by *Howard W. Sams & Co., Inc.,* Indianapolis. 133 pages. Price $2.50. Soft cover.

This manual is designed not only for those who install CB equipment but for owner-operators as well. In easy-to-understand language, the author explains the principles of the various types of antennas, ranges to be expected under various conditions and the servicing and testing of antenna systems.

Details for improving existing systems are included along with information on selecting and installing new equipment.

* * *

"CITIZENS BAND RADIO MANUAL" compiled by Sams Staff. Published by *Howard W. Sams & Co., Inc.,* Indianapolis. 160 pages. Price $1.60. Soft cover.

This is the second volume in a series for users and service technicians and covers 30 recent CB transceivers made by some 19 firms. Each unit is represented by a schematic, chassis photo, parts list, replacement data, alignment information, and maintenance data.

A special editorial section covers classes of equipment, receiver and transmitter circuits, transceiver designs, kits, converters, transverters, and tone-coded squelch. There is a cumulative index covering both volumes in the series.

* * *

"HIGH FIDELITY SYSTEMS" by Roy F. Allison. Published by *Acoustic Research, Inc.*, 24 Thorndike St., Cambridge 41, Mass. $1.00 postage paid from publisher.

This 70-page book is designed as a user's guide and covers the installation and care of sound systems in the home. Divided into 8 chapters plus two appendices, the text covers mono and stereo, stereo components, cables and plugs, physical installation, system adjustments, troubleshooting, and operation and maintenance. The appendices deal with mounting a tonearm and cartridge, and setting the controls for dual mono preamps with stereo adapter.

The text is written in easy-to-understand, non-technical language and is illustrated with cartoons, line drawings, and lavish photographs of hi-fi installations and equipment.

* * *

"HOW TO MAKE MORE MONEY IN YOUR TV SERVICING BUSINESS" by John Markus. Published by *McGraw-Hill Book Company, Inc.*, New York. 340 pages. Price $7.95.

Many talented and dedicated service technicians are constantly flirting with failure because, although they know their jobs, they are woefully lacking in business know-how. This volume is designed to remedy that lack.

The author emphasizes the importance of charging enough in an ethical manner to justify the operation of a service business and then tells how to collect these charges as painlessly as possible, how to keep simple but completely efficient business records, how to cut income taxes legally, and how to manage profits.

There are a number of check lists, summaries, and tabulations for ready reference, including a table suggesting realistic service charges for various types of repair work.

Details on a simple, single-entry bookkeeping system are included to enable the beginning businessman to cope with all of his problems single-handedly until success warrants staff expansion. ▲

TECHNICAL MAGAZINE "COMPRESSOR"

By RUSSELL D. SHATTUCK

One solution to the space problem in holding on to back issues of technical magazines.

OCCASIONALLY the subscriber to a technical magazine has to make a decision whether to move out, sacrifice his allotment of storage space, or throw out the back issues. An alternative to this latter choice is the author's magazine "compressor."

The technique involves the use of judicious (called "heartless" by editors) culling of unusable material. Here is how the author decides what to save. ELECTRONICS WORLD consists of articles on construction, technical topics, servicing, general-interest subjects, amateur, industry news, high-fidelity topics, and ads.

One year is about the maximum for an ad to remain in force. Industry news is about the same. General-interest articles on subjects such as radio astronomy or ion propulsion may be perused in detail in their own specialized magazines so the reference value of such material is short unless the subject is of special interest to the reader. In the author's case, not being in the service business, the articles dealing with servicing are not of lasting interest. As a result, once an issue is over a year old I can dispose of quite a few pages. Readers with other fields of interest will have their own preferences as to what they want to keep and what they can discard.

The author has found that the best way to compress ELECTRONICS WORLD is to start by removing the cover. The complete procedure is as follows:

1. The cover is glued on. Fold it back and pull gently, first on the front cover, then on the rear cover. About 98% of the covers come off intact this way.

2. The pages are glued and stapled. The neatest pages result if the glued edge is sawed off on a bandsaw. Then remove the staples. For this size staple, a screwdriver and pliers are the only solution.

3. This leaves separate loose pages. Save the title page and be sure to save the continuation pages in the back for the articles you want to keep. Scrap the rest.

4. The final bundle is again stapled together. ▲

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CIRCLE NO. 125 ON READER SERVICE PAGE

Microelectronics

(*Continued from page 33*)

crystal is not a good conductor. The atoms of the impurity must be able to combine with the crystal structure in such a way that an electron is either added or taken away. The first impurity type is called *n* and the latter *p*, for negative and positive.

If *p* and *n* characteristics are formed alternately in the same material, then an electrical barrier is formed. This barrier will allow current to flow readily when a battery is placed across it with the negative terminal to the *n* type and positive to the *p* type. But on reversing the battery a high resistance is presented to current flow.

With present technology, one efficient way of making integrated circuits with silicon is to introduce a small amount of *n* impurity into the entire ingot. Then the *n* polarity is either counteracted as required by the addition of *p* impurity, or the *n* characteristic is strengthened by increasing its concentration.

In the manufacture of integrated circuits these impurities are added to the circuit substrates by diffusion. The units are placed in a high-vacuum furnace and, at an elevated temperature, a gas containing the desired impurity is introduced so that the impurity comes in contact with the substrate and penetrates its surface. Other methods of adding impurities to semiconductors, such as alloying, are not suitable for integrated circuits. The diffusion method is the same as used for the manufacture of modern high-frequency silicon transistors.

The great advantage of the diffusion method is that many units can be placed simultaneously in the furnace to make thousands of devices. With all being exposed to the same conditions, their uniformity is high, and production yields are high, because once the process is perfected each individual device tends to be as good as the whole.

The patterns of diffusion on the substrates are formed by a photolithographic process similar to that used for etching plates in printing. Very fine details are possible, limited only to the degree of control over the precision camera work, the making of masks for the patterns, and the alignment of the masks in successive manufacturing steps.

Both active and passive components are made into the silicon substrate material by the same diffusion processes. The methods employed for the several types of components follows:

1. Resistance is controlled by varying the amount of diffusion of impurities. More impurity lowers resistance. The photolithography pattern determines length and width.

2. Capacitors are formed in two ways.

Fig. 5. "Micrologic" element shown mounted in transistor case (enlarged 6 times).

In one method, *p-n* junctions (barriers) are used, which inherently exhibit capacitance when reverse biased. In the second method, capacitors are formed on the surface, with silicon dioxide acting as the dielectric.

3. Inductors of limited value can be formed by diffusing-in a heavy concentration of an impurity in a spiral pattern. Considerable development is still required in this area, however.

4. Transistors and diodes are made by successive diffusion of their parts. These can be made at the same time as the passive parts, if the impurity concentrations are the same.

"Micrologic" Manufacturing

Typical microelectronic integrated circuits, known as "Micrologic" by *Fairchild Semiconductor*, are made by means very similar to those used for diffused "planar" transistors. This is a device whose surface is in one plane, with the base and emitter contacts on the upper surface, and the collector integral with the substrate material. The previous generation of transistors was the "mesa" type, which involved etching away of the surface to control and reduce the size of the base area. True planar transistors have a hard protecting surface of silicon dioxide, formed by an oxidizing atmosphere introduced with the diffusions.

The "Micrologic" manufacturing steps, from the preparation of the ultrapure silicon crystals to final inspection and capping, are shown in Figs. 1 and 5. Some 60 to 100 circuits are formed simultaneously in one wafer, and dozens of wafers can be diffused at one time. This batch processing leads to lower and lower costs.

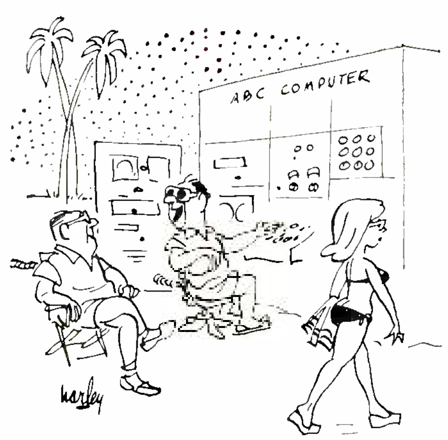
The completed unit with leads attached is evaluated for reliability and electrical performance, by a unique method of testing. Since individual components cannot be tested, the entire function is checked for performance over the specified voltage and temperature ranges.

Of the several approaches to microelectronics now under investigation, the integrated circuit seems to have an excellent chance of long-range and universal use. Reasoning behind this statement is the integrated circuit advantages of inherently high reliability, the ingredients required for mass production, and consequently, low cost.

Other types will have varying degrees of popularity. The microsized discrete component may lose favor when integrated circuit development permits all desired functions to be served by them. The drawbacks of the discrete microcomponent approach are failure to reduce the number of interconnections and high cost.

Thin-film circuits will logically be used with integrated circuits to give greater flexibility and a wider range of circuit values than possible with diffusion alone. But with advanced integrated circuit technology, the thin-film circuit with individual transistors and diodes will no longer be required. Admittedly, however, the transistor was announced only 14 years ago and we have probably only scratched the surface of the potential capability, materials, and technologies. Already gallium arsenide is being investigated for its higher frequency potentiality. Cryotrons, which switch at zero resistance with very low temperatures, have been found adaptable to thin-film production. And the field-effect transistor is coming into its own as a high-impedance amplifier, competing with vacuum tubes.

The success of the integrated circuit principle, however, whether in the form described here or in some form yet to be discovered, seems to be assured, because of the needs of our modern electronic world. It is not too farfetched to visualize them in all types of industrial and consumer equipment in the next five years or so. They will probably be seen in broadcast and communications equipment, in hi-fi gear, in household electronic controls, and in small business computers. ▲



"For some reason the boss thinks I rigged the computer's analysis of its own best operating location."

CIRCLE NO. 159 ON READER SERVICE PAGE

BRITISH ELECTRONICS RESEARCH

By PATRICK HALLIDAY

New devices and techniques seen recently by the author at the Mullard Laboratories, near London.

ONE OF the major commercial electronics research centers in Britain is that of the *Mullard* firm, located some 20 miles south of London. At the center, a staff of over 750 is exclusively concerned with research and development over a wide field of materials and systems for electronics. The center is closely linked with the large *Philips* organization in the Netherlands, and much of the present long-term work is aimed at smoothing out the steady transition of electronics from an industry for mass production for entertainment applications toward more complex and specialized applications in industry and communications.

Recently the writer was fortunate in seeing something of the work now going on at this research center which covers a floor space of over 160,000 square feet. Current projects range from low-noise masers to color television; from cold-cathode field-emission devices to linear motors and automobile electronics; from military infrared image converters for seeing in the dark to the elimination of friction by ultrasonic waves and automatic inspection devices for industry. Many of the materials and components now being processed at this center are likely to find world-wide application in the next decade.

It has been shown that a dramatic speed-up in computers is possible by the use of magnetic thin films in place of the conventional magnetic cores now widely used in computer memory systems. While the magnetic core—fast though it acts—is inherently limited in speed, thin magnetic film can change its state of magnetization in about one billionth of a second or roughly the time taken for light reflected from this page to reach your eye. These magnetic thin films are being produced as tiny discs only four-millionths of an inch thick, yet like magnetic cores can be magnetized in either of two directions, the two states corresponding to the "0" and "1" notations of the binary scale. Yet another method of speeding up computers now under investigation depends upon extremely low-temperature superconductivity.

The coming utilization of u.h.f. television bands in Britain is reflected in the development of transistorized u.h.f. tuners. Mass-produced alloy-diffusion transistors—already widely used in AM and FM radio receivers—have been improved for use up to 1000 mc. The r.f. amplifiers at this frequency give gains of between 10 and 15 db and have a noise figure of only 6 db. We saw TV tuners adapted from two beam-triodes to transistors which show an improvement of at least 4 db in noise figure.

Engineers at the center believe that the automobile will soon include a far greater amount of electronics, with utilization of transistors, semiconductor rectifiers, ferrite magnets, and printed-circuit techniques. Under development is an improved alternator using ferrite magnets, intended for use in conjunction with semiconductor rectifiers. Also seen was a cheap form of compact electric motor suitable for air conditioners, window openers, etc. with the usual windings replaced by printed-circuit discs. Work is also going on toward electronic control of automatic transmission systems. Here the aim is to control a normal mechanical gearbox by means of a small computer unit which will make the necessary decisions and initiate a fully automatic mechanical gear change.

Among the many industrial control projects is an automatic "inspector" to detect flaws in paper passing a line of photocells at speeds up to 2000 feet a minute. The photocells are placed ten to the inch across the paper and can readily detect blemishes, discoloration, holes, creases, or changes in thickness.

A new small square-loop ferrite device which is likely to have a big future in "fail-safe" switching and signaling systems is the "laddic"—so called because the ferrite material looks like a tiny half-inch-long *ladder* and can perform *logical* operations, as an *and* and *or* gate. Because of its size and "fail-safe" feature, the laddic has many applications formerly requiring electromagnetic relays.

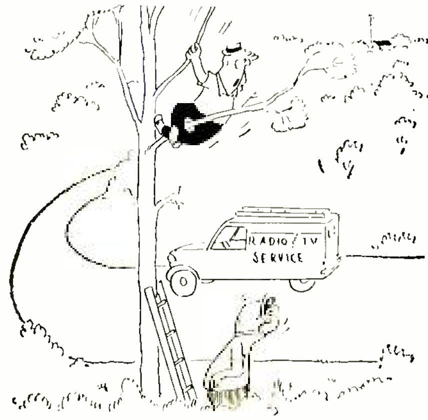
We also saw an effective demonstration of the ability of ultrasonic waves—or "ultrasound" as it is termed—virtually to eliminate friction. Several pounds of nickel-iron were made to float on a film of water covering a sheet of metal. This was done by energizing, with high-frequency current, coils around the nickel-iron. The current causes minute but rapid changes in the length of the metal: these fluctuations cause energy to be radiated into the water, producing the force which supports the metal.

Work is also going on in connection with small "linear" electric motors in which great interest has been revived recently by work carried out at Manchester University. The linear motor follows the general principle of the induction motor but has the poles of its stator magnet arranged in-line. Unidirectional or reciprocating linear motion can be imparted without any mechanical conversion, thus eliminating overheating. In traction applications, the rotor is formed by the rail on which the vehicle travels, and the writer was shown a small model monorail car running on an aluminum track.

New techniques are being developed for possible use in transistor television receivers and battery-operated radar displays. One of these is "scan magnification" in which a great amount of power is saved in cathode-ray tube deflection circuits by means of focusing quadrupole magnet lenses placed along the neck of the tube. A power saving on the order of 40:1 can be obtained in television time bases provided that these are not also required to furnish a high-voltage supply.

Improved high-vacuum techniques have revived interest in field-emission tubes, in which a tiny unheated point of tungsten replaces the conventional hot cathode. This type of emission will not work with the degree of vacuum in an ordinary tube, but when really low pressures can be achieved a great number of electrons will leave the tungsten point under the influence of a positively charged plate.

Much work has been carried out on low-noise traveling-wave masers which give considerably higher gain and bandwidth than the earlier cavity devices. One of these masers is now installed at the British ground station (Goonhilly Downs) for satellite communications, working at 4170 mc. ▲



"This is the road all right, I can see it."

Power Transistor Specs

(*Continued from page 45*)

sistors is 100°C (212°F). Any higher temperatures will soften and finally melt the germanium. The average power dissipation is equal to the emitter current multiplied by the collector-to-emitter voltage. This will yield a hyperbolic curve that can be found on typical output characteristics curves. The transistor circuit load line, incidentally, must stay under this curve to insure reliable operation of the transistor and keep excessive power dissipation in the junction down to a safe level.

Thermal conductivity is the ability of a material to transmit heat along or through itself. The heat conductivity path from the transistor collector junction to the ambient air must have as little heat resistance as possible. Since the junction of an operating transistor heats and the temperature of the ambient is normally less than the transistor junction temperature, it is desirable to have the junction heat radiating into the surrounding air and allow the junction to approach the temperature of the ambient. If the heat transfer path from the transistor junction to the air were 100% efficient, the junction temperature would be the ambient temperature. However, this is not practically possible. Between the transistor junction and the ambient air we find the connection between the junction and the case, case and insulator, insulator and heat sink, heat sink and air; all of which total up to an opposition in the path from junction to air. These obstacles are known separately as thermal resistance. Each different thermal resistance has a unique coefficient number. The coefficient of thermal resistance is expressed as a temperature in degrees centigrade per watt of dissipation. Due to these resistances, there will always appear a temperature differential between transistor junction and ambient. This temperature differential must be reduced to as low a value as possible.

The actual amount of temperature difference depends upon the amount of power the transistor junction is dissipating. We add up the individual thermal resistances, multiply the total thermal resistance by the power being dissipated by the transistor junction ($P = E_C \times I_C$) and add the results to the ambient temperature. This gives us the transistor junction temperature. If the junction temperature just calculated is over the maximum allowable rating for the transistor, one or more factors will have to be reconsidered. We can lower the collector current and voltage to reduce power dissipation (and consequently the stage output power) or, perhaps, we might lower the ambient temperature. This could be done by adding a fan for air circulation or by relocating the assembly in a cooler environment. Any one of the thermal resistances may be lowered to accomplish the same end, but this may be a little more difficult to do. With the new values determined, the junction temperature must be re-calculated. A useful formula for this is

$$T_J = P_D(\theta_{JC} + \theta_{CS} + \theta_{SA}) + T_A$$

where: T_J = junction temperature in degrees C, P_D = power dissipation in watts (collector current × collector voltage), θ_{JC} = transistor thermal resistance in degrees C/watt (junction to case), θ_{CS} = insulator thermal resistance in degrees C/watt (case to heat sink), θ_{SA} = heat sink thermal resistance in degrees C/watt (heat sink to ambient), and T_A = ambient temperature in degrees centigrade.

Insulators used are mica, Teflon, or anodized aluminum. They are used only where the collector must be electrically insulated from the heat sink, but not thermally. Silicone grease applied in small amounts between the transistor and heat sink (and insulator when used) can reduce thermal resistance even more, enhancing total heat dissipation. Teflon has the highest thermal resistance with mica second and anodized aluminum the lowest. Teflon and mica are not as mechanically durable as anodized aluminum, but scratches through the anodized coat on both sides of the aluminum can electrically short the transistor to the heat sink. Silicone-coated mica insulators seem to be the most popular choice at the present time in the industry at large. However, no insulator at all, with silicone grease between the transistor and heat sink, is the best possible situation.

The maximum amount of heat transfer takes place in the immediate vicinity of the mounting studs on the TO-36 package and around the holding screws on the TO-3 package. The mounting surface is smooth and made of copper or is plated with another metal, such as nickel, to enhance thermal conductivity. In general, securing a heat radiator to the cap of the transistor affords little or no heat dissipation. The transistor mounting base surface is the only reliable area for connection to a heat sink.

Conclusion

The many power transistor specifications that are required in the manufacture of transistors are not necessarily the same specifications required for field technicians. Once the transistorized equipment is designed and used, the technician need only be aware of certain practical and general precautions in the replacement of transistors, that is, if he does not have a direct replacement, a substitute may be used. In such a case, a knowledge of a few transistor characteristics will assist him in making an intelligent guess as to a proper replacement and insure operation of equipment. ▲

Tube Short Testing

(*Continued from page 56*)

If the electrode under test is shorted solidly to the cathode, the continuity during the negative half-cycle will permit ignition and both sides of the lamp will light. See the upper left-hand portion of Fig. 2. A continuous glow on one side with intermittent or partial glow on the other indicates a flicker short.

D.C. Short Detectors

The use of direct voltage is most common in service-type testers. The typical configuration is simplified in Fig. 4A. Only one side of the neon bulb can glow under any condition. That will occur when a short exists. Indications for this and other conditions are shown to the right in Fig. 2. Note that, for an open element (no continuity), the indication is the same as for the normal indication of no short.

Determining Sensitivity

How reliable is a given tester in revealing shorting and leakage? This depends on its sensitivity, *i.e.*, on the maximum resistance up to which it will give indication. The circuit of Fig. 4B can be used to determine that resistance on a tube tester. Variable resistor *R* must be a calibrated unit whose maximum value should be at least several megohms. The leads from the 6AL5 and the variable resistor are connected to two appropriate points in the socket of the tube tester, depending on which short test (between which two electrodes) one wishes to check sensitivity. Starting with maximum value, *R* is then adjusted until the same indication is obtained on the neon lamp that occurs with a typical tube short. The calibrated value noted on *R* is the value of the resistance sensitivity.

If a d.c. short test is employed, the 6AL5 diode may be omitted. Its purpose is to provide clear-cut comparison of indications where an a.c. short test is used. With the diode passing current on one half of each cycle, one side of the neon bulb will be permitted to glow (no short) before the value of *R* is reduced; then both sides will glow when the value of *R* is equal to the resistance sensitivity.

Excessive Sensitivity

Does higher sensitivity mean a more reliable short test? Not necessarily. If it is too high, it may indicate a short when there is a slight leakage path that will not cause trouble in normal use, misleading the user as to the tube's actual condition. On the other hand, too low a resistance sensitivity is not likely to expose such significant conditions as flicker shorts.

There is a problem here, and it is made particularly significant by the fact that there is no standardization on sensitivity. It may vary from .5 to 5 megohms from one tester to another depending on manufacturer and model. As for the tube manufacturer, sensitivity is usually held to 1 megohm. The important consideration is to keep the tube user happy. A carefully chosen average sensitivity will detect bad tubes without causing others to be replaced.

Another factor is involved in sensitivity. The latter is a function of the test voltage applied to the tube. The higher the voltage used, the greater the sensitivity. However, not all electrodes in all tubes are made to withstand great stress. Consider a test for shorting or leakage with voltage applied between grid and cathode. The grid will act as a rectifier plate, drawing considerable current. It was never designed for such duty. The higher the voltage applied (or the longer the duration of the test period), the more likely is a tube that was good to begin with to arc over and become damaged.

In addition, as the bulbs age, more voltage will be dropped across each, leaving less for the tube electrodes. In other words, the test becomes less responsive with time. A periodic recheck of sensitivity is enlightening.

In fact, such recalibration is recommended from time to time. Accurate knowledge of sensitivity is a distinct advantage if one is to evaluate test results properly.

Such knowledge is also important to establish a common ground of understanding between tube manufacturer and user. Only in this way can the former serve the latter. ▲

PROTECT THOSE DESIGN CHARTS

By ROBERT K. RE

FROM time to time charts and graphs will appear in electronics magazines for the benefit of technicians in solving electronic design problems. These handy items soon become torn, marked up, and soiled. To protect them from damage, place them in an 8½"x 11" plastic protector and store them in a standard three-hole binder.

The plastic protectors used by the author are designated V.P.D. Sheet Protector NF-100-.003. These have black paper backing sheets and each will hold two 8½"x 11" pages back-to-back. The protectors can be purchased in most stationery stores for a few pennies. Once inserted in the plastic protector, the charts and nomograms can be used over and over again without fear of damage.

Tracing paper can be placed over the chart and the desired values found in the normal manner, or you can write directly on the plastic with a ball-point pen. (Some pens will not write on plastic, but most will work all right.)

After the chart has been marked, simply use a rubber eraser, tissue paper, or rag to remove the ink from the plastic. Storage of the protected charts in a binder will keep them from getting lost or damaged and the binder can also serve as a handy design manual for the home or shop. ▲

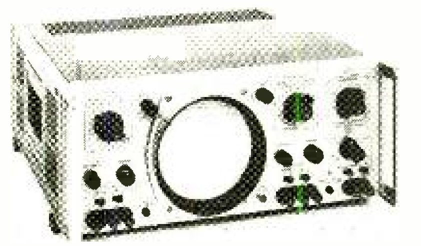
New Products and Literature

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 17.

GENERAL-PURPOSE SCOPE

1 **Hewlett-Packard Company** has recently introduced a new general-purpose d.c.-to-500 kc. oscilloscope, the Model 130C.

The new instrument provides up to 200 μv. per centimeter sensitivity with either of its identical



horizontal or vertical amplifiers. This high sensitivity means that output signals from low-level transducers can be measured directly without external preamplification.

The sweep circuit provides a magnification factor of from 2 to 50 times so that any portion of the sweep may be examined in detail. In addition, the sweep circuit may be disabled after a single sweep, permitting observation of single-shot phenomena or random events.

MOTORIZED CONTROLS

2 **The Lionel Corporation** is now in production on an a.c. hysteresis motor, a.c. hysteresis motor and gear train, and a.c. motorized potentiometer controls developed especially for remote control applications in stereo, TV, and radio, in industrial controls, instrumentation, and displays.

The new units are available with operating voltages of 6, 12, 24, or 117 volts a.c. or to the customer's order. (An external capacitor must be used for operation and reversing.) Maximum power input is 7.5 volt-amperes.

Motor output is 1800 rpm at 0.1 inch-ounce torque, the motor gear train operates at 6 rpm with 14 inch-ounce torque while the motorized

controls are at 6 rpm. Output speed and torque can be changed to meet specialized requirements.

BREADBOARDING MODULES

3 **Vari-L Company, Inc.** is marketing a new line of semiconductor-circuit breadboarding modules as "Develoboard."

The unit features 35 solderless connectors which accept up to four leads, making 140 noise-free junctions—ample for most circuits employing 3 or 4 transistors. All wiring is on the surface in plain sight and jumpers are not needed. Each board includes an accessory panel for controls and all connectors are pre-inserted so that there are no loose parts to misplace. The modules are 3¾" x 5" and several can be interconnected to form larger circuits.

SOLID-STATE RELAY

4 **Weston Instruments Division** is now offering a solid-state relay which combines ruggedness with extreme sensitivity to low-level signals.

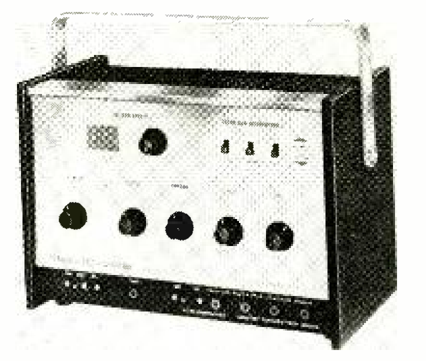
The Model 82 "Magsense" is an adjustable set-point control relay suitable for industrial and military use as a control relay, proportional controller, comparator, on-off controller, and for alarming and "go-no-go" logic.

Epoxy-cased, the unit weighs 4.5 ounces and measures 1.8 x 1.8 x 1.2 inches. The relay is designed to withstand severe environmental conditions and meets MIL Spec requirements for temperature, humidity, altitude, salt spray, vibration, fungus, corrosion, rain test, sand and dust tests, immersion tests, and shock.

COLOR-CIRCUIT ANALYZER

5 **Sencore, Inc.** has added a color circuit analyzer, the Model CA122, to its line of service test equipment.

The new unit provides all required test patterns and signals for testing from the TV tuner



to the tri-color tube. In addition, the unit provides analyzing signals for injection at each stage, including audio, video, and sync. The instrument provides ten standard color bars, white dots, crosshatch pattern, vertical and horizontal bars, shading bars, plus r.f. and i.f. analyzing signals.

50-WATT ZENER DIODES

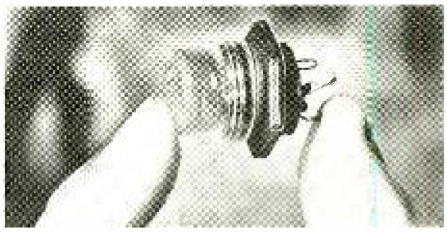
6 **Fansteel Metallurgical Corporation** has introduced two new 50-watt silicon zener voltage-regulator diodes for electronic and electrical power systems.

The units are available in a stud-mounted package (JEDEC DO-5 case) or diamond-shaped transistor package (JEDEC TO-3 case). Stud-mounted units are about 1.2 inches long while the transistor-cased units are about 1.5 inches long. They are hermetically sealed for full protection against any environment.

TRANSISTOR PROTECTOR

7 **Littelfuse, Inc.** has developed a new protective device for use in transistor circuits where a single accidental misapplication of voltage or damaging current surges could destroy expensive components.

The "Transistor Protector" is a three-terminal device suitable for mounting in printed-circuit boards or with standard wire connections. Cylindrical in shape, the unit measures 1-3/16" long, is .687 ± .005" in diameter, and is internally threaded with a straight knurled plastic protec-



tive cap. There is a 35/64" front-panel projection. The unit comes complete with a 15/16" hex mounting nut for 3/16" maximum panel thickness.

H.V. POWER SUPPLY

8 **Kepco, Inc.** has started delivery of its new d.c. regulated power supply, the Model ABC 2500M.

The supply is continuously adjustable over its full range of 0 to 2500 volts at up to 2 ma. and has better than 0.05% regulation and stability. A ten-position step range selector and a ten-turn fine control voltage adjustment permits resolution of not more than 25 millivolts. Ripple is less than 0.5 millivolts r.m.s. Recovery time for abrupt line and load variations is less than 50 microseconds.

The instrument is housed in a cabinet measuring 1¾" x 8-5/32" x 9⅝" which is adaptable for rack mounting.

MAGNETIC OPERATIONAL AMP

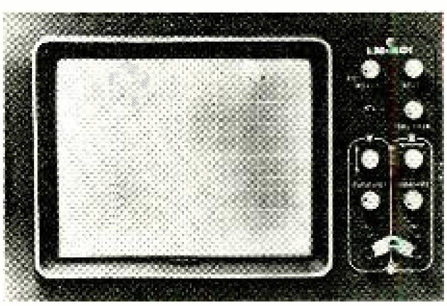
9 **Electronic Control Systems, Inc.** has announced the availability of a new magnetic operational amplifier designed for analog computation and control.

The Series 100 operates on 60 cycles a.c. and does not require additional power supplies or drift stabilization. It performs all the functions commonly associated with vacuum-tube operational amplifiers as well as several added functions.

Magnetic reliability and input current of less than 1 μa. makes it suitable for analog computation, industrial control, and low-level amplification.

MONITOR SCOPE

10 **ITT Industrial Products Division** has announced availability of the Model 401 moni-



tor oscilloscope, a precision instrument for the visual presentation of low-frequency electrical data.

The 14" rectangular-screen scope uses magnetic deflection and electrostatic focusing to provide a resolution of 25 lines per centimeter. Deflection linearity is 1% of full scale along the major axes while plotting accuracy is 0.6 centimeter maximum error anywhere on the screen. Drift is less than 0.5 cm. per hour after warmup.

SCR FIRING MODULE

11 **Electrologic Corporation** is now marketing a new silicon controlled rectifier firing module designed for industrial application. This unit, in conjunction with silicon controlled rectifier power units, can continuously proportion a.c. and d.c. power and may be used as the final control element in an industrial control system.

The outputs of the unit are pulses which vary approximately 180 degrees in phase with respect to the power line as the input current varies over its 5 to 1 operating range. Two output signals are available for firing full-wave SCR power systems.

50-MA. POWER SUPPLY

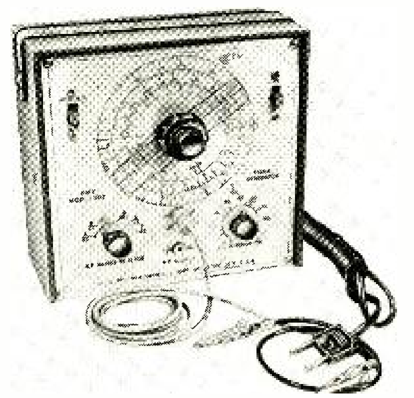
12 **Trans Electronics Division, Burton Manufacturing Co.** has developed a precision power supply, Model 450, which provides dual-tracking output voltages for automatic cancellation of power supply common mode effects in dual-polarity amplifiers and bridge circuits.

With continuously variable dual outputs of +300 to +400 volts d.c. and −300 to −400 volts d.c., the unit can be used as a power source in balanced-input d.c. amplifiers, null-sensing circuits, and dual-polarity control circuits.

R.F. SIGNAL GENERATOR

13 **Electronic Measurements Corporation** is offering a low-cost signal generator, the Model 502, which is available in kit or wired versions.

The instrument has six bands from 115 kc. to 110 mc. on fundamentals and up to 220 mc. on



second harmonic. There are individual slug-tuned coils for each band. A Colpitts r.f. oscillator is incorporated for high stability.

The unit in its two-color etched panel cabinet measures 6⅝" x 6⅝" x 4". It comes complete with an r.f. output lead.

SOLID-STATE D.C. AMPLIFIER

14 **Astrodata, Inc.** is offering a new potentiometric d.c. amplifier as the Model 140.

This all-solid-state unit is designed to be used as a line driver for coupling high-impedance single-ended voltage sources into cables for driving distant recording equipment. It provides a voltage gain of unity to signals which range from 0 to ± 5 volts d.c. and will withstand input signals as large as ± 28 volts d.c. without damage to the amplifier.

The instrument measures 2.8" wide x 6.5" long x 0.5" thick.

SQUARE PANEL METERS

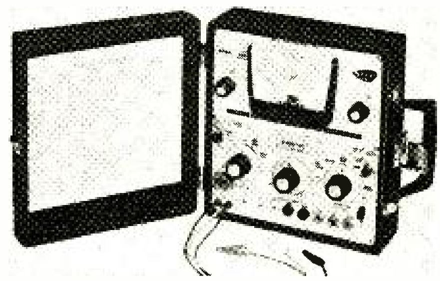
15 **WacLine Meters** is now offering a wide selection of 1½" square, ruggedized, and sealed panel meters for standard and custom applications.

Manufactured in conformance with MIL-M-10304, all meters are available for commercial as well as military applications. The line includes a variety of custom movements, special resistances, custom scaleplates and markings, shunts, resistors, and a full line of other accessories.

TRANSISTOR/DIODE ANALYZER

16 **Seco Electronics, Inc.** has developed a moderately priced transistor and tunnel diode analyzer which is being marketed as the Model 250.

The instrument reads both collector-to-base and collector-to-emitter leakage currents. It oper-



ates as a comprehensive transistor circuit analyzer and tests both tunnel and zener diodes.

With the Model 250 transistors can be tested in or out of the circuit. The company is offering it in a.c. or battery powered versions. A wood or heavy plastic cover is optional at no additional cost.

LOW-PASS FILTERS

17 **Triad Transformer Corp.** is now marketing a new series of low-frequency, low-pass filters for any application in the frequency range from 7.5 to 150 cps.

The three new models are the Type GF-600 (7.5 cps, 5¼ ounces), GF-601 (14.5 cps, 5¼ ounces), and GF-602 (150 cps, 3.4 ounces). All have input impedance of 0 to 100 ohms, output impedance of 10 megohms, and maximum input of 3.5 volts.

NUVISTORS FOR U.H.F. TUNERS

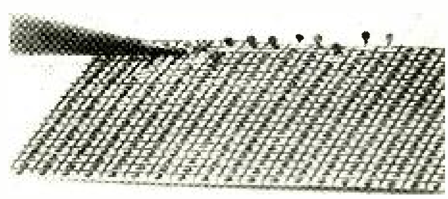
18 **RCA Electron Tube Division** has announced the availability of two new nuvistors which were developed specifically for u.h.f. television tuners.

The new nuvistor triodes have been designated 2DV4 and 6DV4. They are designed for oscillator service in u.h.f. TV receivers and other equipment operating at frequencies up to 1000 mc. Both units have gold-plated envelopes and gold-plated pin terminals.

PRE-FABRICATED CONNECTORS

19 **Amphenol-Borg Electronics Corporation** has developed a pre-fabricated interconnecting system which is being marketed as "Intercon" circuitry.

The grids are 3" x 6" sheets of circuit patterns with welding tabs on 0.100" centers. The weld-



able tabs may be lifted where desired by a bent open paper clip or other simple tool. A hand punch can be used to interrupt conductors. In this way a wide variety of prototypes can be created for immediate production of modules or interconnecting, multi-layer wiring harnesses.

HI-FI—AUDIO PRODUCTS

ANTENNA FOR FM

20 **The Winegard Company** has recently introduced the "Stereotron," an 8-element antenna designed especially for FM applications.

The new antenna features a built-in nuvistor amplifier which takes up to 200,000 µv. of signal.

The antenna has a minimum gain of 26 db over a folded dipole and a flat frequency response of better than ± 1/4 db from 88 to 108 mc.

The unit is being offered with either 300-ohm twin-lead or 75-ohm coaxial cable facilities. It is permanently gold anodized for corrosion protection. It is also available either with or without the nuvistor amplifier.

STEREO EARPHONES

21 **E. J. Sharpe Instruments, Inc.** has just released a moderately priced stereo earphone, the Model HA-8.

Frequency response is 20-15,000 cps and maximum input power 2 watts. Impedance is 8 ohms per phone and attenuation of ambient noise is 20 db at 1000 cps. Other impedances are available on request.

The phones are shockproof and shatterproof and made of plated steel and plastic. The phones come with a six-foot conductor cord with strain relief and 1/4" diameter three-circuit phone plug.

CARTRIDGE/TONEARM

22 **Gotham Audio Corporation** is handling the U.S. and Canadian distribution of the **Neumann** professional dynamic stereo cartridge (DST-62) with its matching stereo tonearm (STA-12).

The cartridge incorporates an improved metal underside in place of the rubber of the previous model. It is sealed against dust and dirt and is permanently aligned for maximum separation. The tonearm keeps extraneous resonances at an inaudible level through an improved, special rubber damping which separates the arm from the counterweight. An integral calibrated gauge permits adjustment of the tracking force from 0 to 7 grams.

FM STEREO ANTENNA AMP

23 **JFD Electronics Corporation** is now marketing a new transistorized FM stereo and mono signal amplifier. The TNT106FM amplifier is attached directly to the terminals of any FM antenna to add up to 25 db gain to that of the antenna with uniform frequency response across the FM band.

The electronically amplified antenna system is capable of operating two, three, or four FM sets with fully balanced and separated high-fidelity stereo.

The amplifier includes a 117-volt a.c. power supply and distribution system with 300-ohm jack-type outlets.

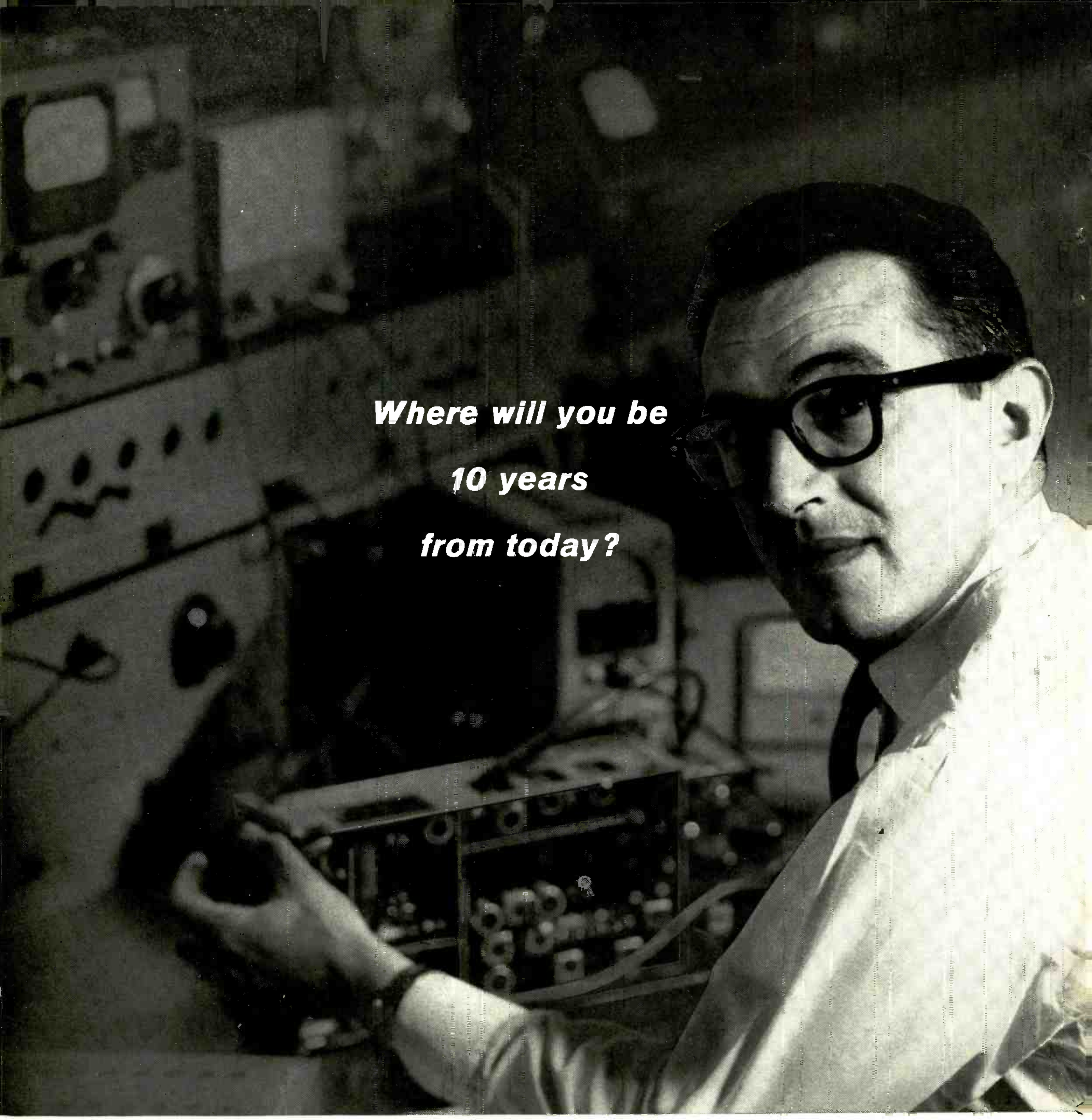
CONDENSER MICROPHONE

24 **Superscope, Inc.** is now shipping the new miniature **Sony** condenser microphone, the C-17B, designed for the broadcast, recording, and entertainment fields.

The microphone is 5/8" diameter by 3 3/4" long and provides a cardioid pattern with 25-db front-to-back sensitivity. The diaphragm is constructed of a special plastic material that is processed to a thickness of only 0.006 mm. and coated on one side with pure gold to a thickness of 0.0003 mm. Frequency response is 20-15,000 cps ± 2 db.

The power supply included with the micro-

(*Continued on page 100*)



Let RCA help you find the answer with a profitable career in electronics

Now, you can put your finger on the electronics career of your choice, and RCA Institutes will help you train for it—right in your own home! RCA Institutes Home Training Courses can lead you directly to the kind of job you want! If you are looking for a career in electronics, here is your chance to plan a successful future for yourself—the RCA way—right down the line!

RCA Institutes, one of the largest technical schools in the United States (devoted exclusively to electronics), offers the finest facilities for home training. A service of the Radio Corporation of America, RCA Institutes gives you the technical instruction you need to plan, build, and realize a lifetime career in today's fastest growing field.

RCA Institutes offers both home training and classroom training—whichever best fits your needs. See the adjoining page for a dramatic example of how RCA can help you plan for the future you want! Licensed by the New York State Department of Education. Approved for Veterans.

RCA CLASSROOM TRAINING
IN NEW YORK CITY AND LOS ANGELES

INDUSTRIAL TITLE	THIS IS THE RCA TRAINING THAT WILL HELP YOU GET IT!	QUALIFICATION
Engineering Aide, Lab Technician, Field Service Engineer, Test Engineer, Technical Instructor	Electronics Technology (T-3)	High School Grad with Algebra, Physics or Science
Electronic Technician, Field Technician, Computer Technician, Broadcasting Technician, Customer Service Engineer, Instrument Technician	Industrial and Communications Electronics (V-7)	2 yrs. High School with Algebra, Physics or Science
TV Serviceman, Electronic Tester	Electronics and Television Receivers (V-3)	2 yrs. High School with Algebra, Physics or Science
Transistor Circuits Specialist	Transistors	Radio background
Junior & Senior Detail Draftsman	Electronic Drafting (V-11, V-12)	2 yrs. High School with Algebra, Physics or Science
Color TV Service Technician	Color Television (V-14)	Television background
Industrial Electronic Technician V-14	Audio Hi-Fidelity	Radio background
Technical Writer	Technical Writing	Electronics background
Computer Service Technician V-15	TV Studio Production(S-1) (V-15)	High School Grad
Console Operator, Junior Programmer	Computer Programming (C-1)	College Grad or Industry sponsored
Radio Code Technician	Radio Code	8th Grade
Preparatory	Preparatory Math & Physics (P-1)	1 yr. High School
Preparatory	Preparatory Mathematics (P-OA)	1 yr. High School

• **Free Placement Service.** RCA Institutes graduates are now employed in important jobs at military installations such as Cape Canaveral, with important companies such as IBM, Bell Telephone Labs, General Electric, RCA, and in radio and TV stations all over the country. Many have opened their own businesses. A recent New York Resident School class had 93% of the graduates who used the FREE placement service accepted by important electronics companies, and had their jobs waiting for them on the day they graduated!

Note: 3 additional locations. RCA Technical Institutes offers a limited selection of basic resident school courses in Electronics in Chicago, Philadelphia, and Cherry Hill, N. J. (near Camden). For complete information write the name of the city of your choice on the attached postcard.

RCA HOME TRAINING

INDUSTRY DESIGNATED JOB TITLES	THIS IS THE RCA TRAINING THAT WILL HELP YOU GET IT!	QUALIFICATION
Radio aligner, Repairman, Tester	Radio-Electronic Fundamentals	8th Grade
Black & White TV Service Technician	Television Servicing	Radio Background
Color TV Service Technician	Color Television	Black & White Television
Automation Technician	Automation Electronics	Radio or Electronics Fundamentals
Transistor Circuits Specialist	Transistors	Radio or Electronics Fundamentals
Transmitter Technician, Communications Specialist	Communications Electronics	Radio or Electronics Fundamentals
Junior Draftsman	Electronic Drafting	8th Grade
Coder, Programmer, Analyst	Computer Programming	High School Grad plus 1-year business experience

• **Voluntary Tuition Plan for Home Training Courses.** This plan affords you the most economical possible method of home study training. You pay for lessons only as you order them. If, for any reason, you wish to interrupt your training, you can do so and not owe one cent. No other obligations! No installment payments required!

• **You get Prime Quality Equipment.** All kits furnished with home-training courses are complete in every respect and the equipment is top grade. You keep all the equipment furnished to you for actual use on the job, and you never have to take apart one piece to build another!

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A Service of the Radio Corporation of America,
350 West 4th St., New York 14, N. Y.
Pacific Electric Bldg., 610 S. Main St., Los Angeles 14, Calif.

The Most Trusted Name In Electronics

(Continued from page 95)

phone provides both low-frequency four-position step attenuation and high-frequency cut-off.

TRANSISTORIZED CARTRIDGE

25 **Fairchild Recording Equipment Corporation** has developed a low-mass, transistorized cartridge system for stereo applications.

The new "F-7" has a frequency response of 20-20,000 cps ± 1 db and 20-db separation throughout the audible range. The system incorporates a transistorized pre-preamp which generates sufficient noise-free, distortion-free voltage for the preamp. The pre-preamp is compatible and a switch on the unit permits it to be used with conventional cartridges.

STEREO TAPE DECK

26 **Benjamin Electronic Sound Corp.** is handling the U.S. distribution of the British-built "Truvox PD-96" stereo tape deck.

The new unit is a four-track deck with three heads, three motors, and self-contained record

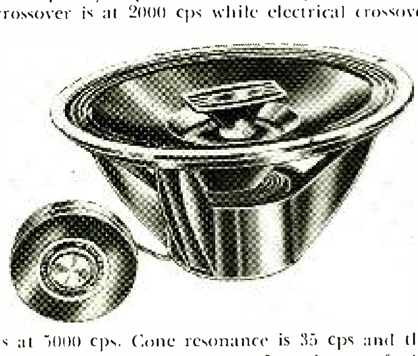
and playback preamps. It will handle 7" reels and operates at 7.5, 3.75, and 1⅞ ips. Frequency response is 30-20,000 cps ± 3 db at 7.5 ips. The instrument also features individual vu meters for each channel, a digital tape counter, automatic shut-off, and sound-on-sound facilities.

THREE-WAY SPEAKER

27 **Lafayette Radio Electronics Corporation** is currently marketing a new three-way hi-fi speaker, the "Cavalier 12 Mark II."

Made in England, the speaker features a 1¾ lb. high-efficiency ceramic magnet. The woofer, mid-range radiator, and tweeter are axially mounted within a unitized die-cast frame. Virtually free-edged cone suspension is achieved by an exclusive cone-bonding and cone-edge treatment construction process.

Frequency response is 30-20,000 cps, mechanical crossover is at 2000 cps while electrical crossover



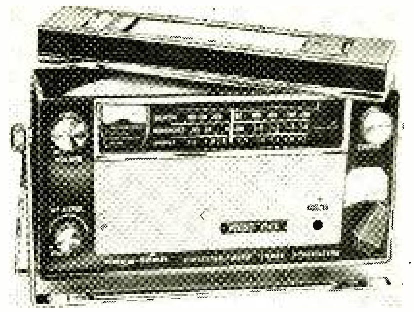
is at 5000 cps. Cone resonance is 35 cps and the unit will handle 25 watts. Impedance of the speaker system is 16 ohms.

CB-HAM-COMMUNICATIONS

PORTABLE RDF

28 **Nova-Tech, Inc.** has developed a three-band all-transistor portable marine radio direction finder that is being marketed as the "Pilot Pal RDF."

The 8-transistor receiver provides fast and accurate position fix or homing direction to any station on any of the three bands. Band one is



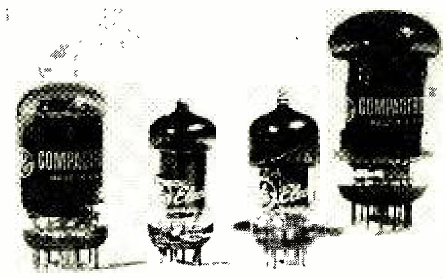
190-400 kc. and monitors marine navigation beacons and U.S. Weather Bureau continuous weather reports. Band two covers standard broadcast and Conelrad 440-1600 kc. Band three, 1.5-4.5 mc., covers all marine communications, radiotelephone, ship-to-ship, ship-to-shore, Coast Guard, police calls, and radio amateur frequencies.

The unit measures 8" x 2½" x 5" and weighs 2 pounds.

TUBES FOR MOBILE USE

29 **General Electric Receiving Tube Department** has announced the availability of one new compactron and two 9-pin miniature transmitting tubes which have been specifically designed for mobile communications in the high bands.

The compactron, Type 8156, is a medium power transmitting tube with 15 watts plate dissipation at 175 mc. The multiplier-driver tube, Type 8106, is rated at 6 watts plate dissipation. The 8106 can double and drive the 7984, can drive two 7984's in push-pull, or can double and



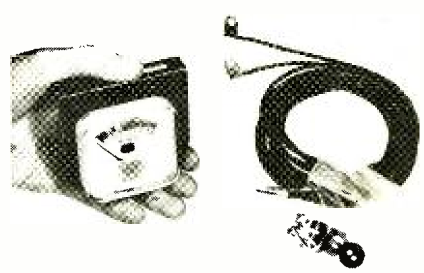
drive a pair of 8156's. For frequency tripling and FM modulator, a triode-pentode type, 8102, is now available. All of the new tubes employ 13.5-volt heaters.

BATTERY CONDITION MONITOR

30 **The Leece-Neville Company** is now offering a low-cost instrument which shows actual battery voltage and percentage of charge as well as output of the voltage regulator, generator, or alternator.

Designed to mount on the dashboard or instrument panel of any car, truck, boat, bus, or off-the-road equipment, the "Volt-I-Cator" will replace the "tell-tale" light. The unit may be specified for 6, 12, 24, or 32 volt ignition systems.

The instrument attaches directly to the battery. Two scales are provided on the meter face



—the quick-reading top scale indicates in different colors the battery discharge range, the state of the battery charge, regulator opeating range, and overcharge range. The bottom scale indicates actual voltage values.

CB TRANSCEIVER

31 The E. F. Johnson Company is now in production on the "Messenger Two," a 10-tube CB transceiver designed to cover any 10 channels in the 23-channel band.

The unit is housed in a modern chrome and black cabinet and features an illuminated channel indicator. A channel selector switch permits easy choice of channel. The receiver section contains a new noise limiter circuit and a.v.c.

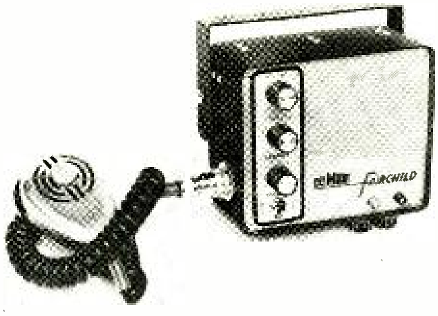
The transceiver measures 5⅝" high x 7" wide x 11⅜" deep. It is being offered in 117-volt a.c. and 6-volt d.c. or 117 volt a.c. and 12-volt d.c.

models. It comes complete with push-to-talk microphone, coiled cord, and crystals for one channel.

MOBILE TRANSCEIVERS

32 Allen B. Du Mont Laboratories Communications Department has announced the immediate availability of a new series of Fairchild/Du Mont mobile two-way radios which have been designated the "800."

The new units deliver full 100-watt output in the low band and 75 watts in the high band. The

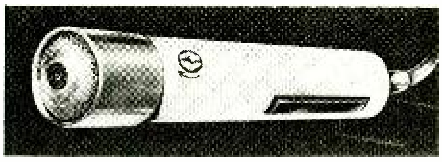


Type MCA 825-A is designed for the 25-54 mc. range with a rated output of 100 watts. Type MCA 875-A for the 144-174 mc. range has an output of 75 watts. Both models feature a remote control head with completely transistorized power supply.

COMMUNICATIONS MIKE

33 Instruments & Communications, Inc. has introduced a new high-output, transistorized variable microphone designed for mobile or base-station CB and ham use.

Tradenamed "Big Mike," the unit features a built-in transistor amplifier with adjustable controls for varying output level and tone, a "squeeze-to-talk" bar, and hang up. The miniature, mercury-cell battery pack is located inside



the handle and is good for many months of normal operation. The microphone measures 8¼" long x 1⅜" in diameter.

MANUFACTURERS' LITERATURE

CERAMIC CAPACITORS

34 Erie Resistor Corporation has issued a two-color data sheet covering its "Transcap" line of ceramic capacitors.

Bulletin NP-120-2 tabulates mechanical and electrical characteristics of the units along with the results obtained on these capacitors with life and humidity tests.

SEMICONDUCTOR PRODUCTS

35 Tung-Sol Electric Inc. has available a four-page "Quick Reference Guide" covering its complete line of silicon rectifiers as well as power and switching transistors.

Included are electrical specifications on all the different types along with other pertinent details of interest to design engineers.

ZENER DIODE LOCATOR

36 International Rectifier Corp. has issued a 24-page guidebook which lists all known zener devices by EIA and manufacturers' part numbers. All listings are in numerical sequence for quick reference and include case type, power rating, nominal voltage rating, and specified test current on each type.

Also included are detailed specifications for all of the firm's zener devices including 270, 400, 750 mw. and 1, 3½, 10 watt power dissipation ratings.

TRANSFORMER APPLICATIONS

37 Acme Electric Corp. is offering copies of its new catalogue which discusses in detail the applications for boost and buck transformers in the correction of undervoltages or overvoltages.

The catalogue explains why a relatively small transformer of this type is capable of handling loads as much as 20 times the insulated rating of the tranformer, how to determine transformer size, how to figure output volues in proportion

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, JULY 2, 1946 AND JUNE 11, 1960 (74 STAT. 208) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF ELECTRONICS WORLD published Monthly at Chicago, Illinois for October 1, 1962.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Ziff-Davis Publishing Company, 434 S. Wabash Ave., Chicago 5, Ill.; Editor, William A. Stocklin, 1 Park Avenue, New York 16, N.Y.; Business manager, M. T. Birmingham, Jr., 1 Park Avenue, New York 16, N.Y.

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4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: 204,152.

M. T. BIRMINGHAM, JR., business manager.

Sworn to and subscribed before me this 19th day of September, 1962.

(SEAL) MICHAEL A. LALLI, Notary Public
(My commission expires March 30, 1964)

to input voltage, and how to use two or more transformers in a cascade series.

LOSSY DIELECTRIC

38 **National Beryllia Corporation** is now offering a 4-page technical data sheet covering a new lossy dielectric ceramic "CarBerlox."

The data sheet includes a product description and graphs of attenuation factor, loss tangent at various frequencies, and dielectric constant at various frequencies, for a range of percentage of lossy phase content.

ANTENNA SYSTEMS

39 **Advanced Structures Division** has issued an illustrated brochure on advanced antenna systems which it is offering without charge.

Included are photographs and editorial information on large precision antennas for satellite communications, target tracking, decoy discrimination, radio astronomy, telemetry, and space communications research.

MEMORY SYSTEMS

40 **RCA Semiconductor and Materials Division** has prepared an 8-page brochure describing its MS Series memory system in detail.

The brochure also explains selection of operating modes, options and system capacities as well as showing how custom flexibility can be incorporated in the firm's standardized line.

PANEL METER BOOKLET

41 **Weston Instrument Division** is offering copies of its new handbook entitled "The Panel Meter as a Design Element" which covers human engineering considerations in panel meter layouts.

The booklet presents a simplified approach to the design considerations which each engineer faces as he sets out to design a front panel which requires the use of indicating instruments. It covers selection of meter size, mounting methods, cover styles, use of color inserts, and multiple meter applications.

LEVER-TYPE SWITCHES

42 **Switchcraft, Inc.** has issued a 6-page, two-color catalogue covering engineering drawings, specifications, and operating features of lever-type switches.

Catalogue S-302 includes detailed specifications on the new "Lever-Lock" communications lever switch as well as full details on other models in the company's line, their applications and features.

METAL SEARCH COILS

43 **Gardiner Electronics Co.** has issued a 20-page booklet which describes in considerable detail the firm's line of metal detectors, featuring metal search coils.

The publication lists the various types of units available plus information on detection range, operation, special features, and specialized applications.

RECTIFIER INTERCHANGEABILITY

44 **Semicon, Inc.** has issued an interchangeability guide covering over 150 types of silicon controlled rectifiers.

The bulletin serves as a cross reference to the leading SCR producers' internal numbers with the firm's direct replacements.

TRIMMERS AND INDUCTORS

45 **Corning Electronic Components** has issued a new 16-page illustrated booklet which describes its line of metallized glass trimmer capacitors and inductors with high "Q" and low temperature coefficients.

The publication discusses special glass dielectrics and details of design, construction, and performance of individual standard trimmer and inductor models.

INDICATOR-LIGHT DATA

46 **Dialight Corporation** has just issued a 12-page cross-reference guide designed to help the engineer translate military code numbers into commercial designations for indicator lights, lamp holders, and panel lights.

Covered by the listings are ungrounded assemblies that accommodate midget flanged base single contact, miniature bayonet single contact, and candelabra bayonet double contact lamps. Bracket-mounted sockets, indicator light housings, and indicator light lenses are also included.

BASE-STATION ANTENNAS

47 **Mark Products Division** has issued a two-page, two-color data sheet covering its line of high-gain colinear array omnidirectional base station antennas for two-way service in the 150 and 450 mc. ranges.

The publication contains charts with typical v.s.w.r. curves and gain of colinear arrays for the antennas, along with diagrams of mounting details. A selection chart includes list prices for all models.

AUTOTRANSFORMER CATALOGUE

48 **General Radio Company** has just issued a 28-page technical bulletin covering over 200 different models of "Variac" autotransformers.

Bulletin P covers motor speed controls, voltage regulators, and motor-driven autotransformers in addition to the "Variac" line.

Complete technical specifications and over 100 illustrations are included.

REED RELAYS

49 **Struthers-Dunn, Inc.** is now offering copies of its new 12-page reed relay catalogue A which provides full information on the "Dunco" line of encapsulated and magnetically shielded basic reed relays, pulse reed relays, cross-point reed relays, magnetic latch relays, infinite margin types, and crystal can reed relays.

Much of the information is presented in tabular and graph form for easy reference.

INSTRUMENT ENCLOSURES

50 **TA Mfg. Corp.** has issued a single-page data sheet covering its new "Panaliner" series of electronic instrument enclosures.

The brochure, No. 407G, provides details on special features and a tabulation of the various sizes and types of units currently available in the line. A line drawing shows the salient mechanical features of the enclosures.

CAPACITOR CHART

51 **Cornell-Dubilir Electronics Division** has issued a handy 21¾" x 16¾" wall chart which provides information on its "Demicon" capacitors for designers and engineers.

The chart's main table cross-references types of dielectrics with important capacitor characteristics. Four smaller tables on the chart provide capacitor users with comprehensive data on other operational features. The chart has an adhesive backing for easy mounting.

COMPONENTS CATALOGUE

52 **Centralab** has just published its component catalogue #200, a 16-page book which gives full price and product information on the firm's distributor line of controls, switches, ceramic capacitors, and "PEC" packaged circuits.

In addition to detailed replacement data on over 1815 components, the catalogue includes full descriptions of the contents of 15 of the company's kits, including the new FRK-100 kit of "Fastatch II" controls.

The publication is completely indexed for easy use.

SURGE IMPEDANCE EXPLAINED

53 **Cleveland Institute of Electronics** is offering copies of its Electron Bulletin Vol. 17, No. 8 which explains and discusses characteristic impedance for the benefit of technicians.

The relationship of input impedance, terminating impedance, frequency, and transmission line wavelength to characteristic impedance is explored at some length. The bulletin also touches on oscilloscope photography, an electronic device for pacing heart patients, and the development of extremely minute hearing-aid type transistors.

COLOR BAR GENERATOR

54 **The Hickok Electrical Instrument Company** has issued a four-page brochure describing its Model 661 "Chrom-Aligner" NTSC standard color bar generator in detail.

The brochure defines and illustrates an NTSC standard signal as well as standards for white dot and crosshatch patterns and describes the simplified set up procedure to operate the new instrument.

HAM AND S.W. GEAR

55 **National Radio Co., Inc.** is now offering a new 12-page catalogue covering a complete line of amateur and short-wave receivers.

The 8½" x 11" brochure includes a description of each receiver plus complete specifications on the individual unit.

WELDING EQUIPMENT

56 **Raytheon Company** has issued an 18-page handbook covering complete precision welding systems and accessories. Photographs, drawings, and charts illustrate a full line of d.c. and a.c. equipment, along with data on miniature welding heads and information on resistance welding. A fold-out page summarizes complete systems.

COMPRESSION TERMINALS

57 **Electrical Industries** has issued a six-page, four-color bulletin covering its line of single lead compression terminals for a variety of electronic applications.

The publication includes ferrule details, terminal details, electrical specifications, installation data, and a selection chart based on the projected application. ▲

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Answer to Electronic Crosswords

(Appearing on page 71)

P	A	D		R	A	D	A	R		U	H	F
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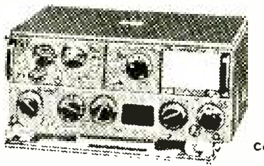
AN/ART-13 100-WATT XMTR



11 CHANNELS
200-1500 Kc
2 to 18.1 Mc

$69.50 exc. used

Complete with Tubes

Famous Collins Autotune Aircraft Transmitter. AM, CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PP811s modulate 813 in final up to 90%, class "B". A Real "HOT" Ham buy at our low price! Orig. cost $1800.

AN/ART-13 XMTR as above, Like New .. $79.50
0-16 Low Freq Osc. Coil for ART-13 .... 7.95
24V Dynamotor for ART-13 .... 11.95
Same as above less meter 39.50
We carry a complete line of spare parts for above.

APR-1 Navy VHF-UHF radar search Receiver, 80 Mc to 950 Mc in 2 bands. **BRAND NEW** $79.50
TUNING UNITS for above: TN1, TN2, TN3. **BRAND NEW**, each $39.50

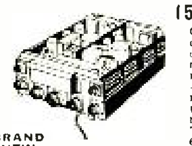
AN/APR-4 RECEIVER only, 38 to 4000 Mc in 5 tuning unit ranges. High precision lab instrument. Input 115 V60 cy. **Like New** $79.50
Tuning Units TN16, 17, 18 each $39.50
Tuning Unit TN19. **Brand New** $89.50
Tuning Unit TU54 ....$149.50

LIMITED QUANTITY SPECIALS!

BC-312 MOBILE RECEIVER 6 bands, 1500 Kc to 18 Mc. With Tubes and 14 V Dynamotor, Like New $79.50
BC-312 for AC operation $89.50
AN APT-5 AIRBORNE RADAR SET, with tubes, Like New $49.50
AN/APT-5 BRAND NEW $69.50
POWER SUPPLY for AN APT-5, complete, Brand New, for 80/115 V 400 to 2600 cycles..........$14.95

FAMOUS BC-645 TRANSCEIVER

15 Tubes 435 to 500 MC



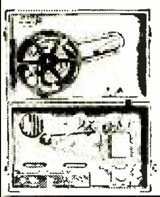
BRAND NEW

Can be modified for 2-way communication, voice or code, on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!); 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.
Shipping weight 25 lbs. **SPECIAL!**.... **$19.50**

PE-101C Dynamotor, 12/24V input..........$7.95
UHF Antenna Assembly 2.45
Complete Set of 10 Plugs 5.50
Control Box 2.25

SPECIAL "PACKAGE" OFFER:
BC-645 Transceiver, Dynamotor and all accessories above COMPLETE, BRAND NEW, While Stocks Last............ **$29.50**

TG-34A CODE KEYER



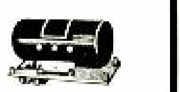
Self-contained automatic unit, reproduces code practice signals recorded on paper tape. By use of built-in speaker, provides code-practice signals to one or more persons at speeds from 5 to 25 WPM.

Like New, Tested **$26.50**

Set of 11 Reels, Army Code Practice Lessons, BRAND NEW, original packing ............P.U.R.

MOBILE-MARINE DYNAMOTOR

Model DM35



Input 12V DC. Output: 625 V DC @ 225 Ma. for press-to-talk intermittent operation. Shpg. wt. 14 lbs.
BRAND NEW.. **$14.95**

OTHER DYNAMOTOR VALUES:

Type	Input	Output	Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V .05A	2.45	4.45
DM-33A	28V 5A	575V .16A		
	28V 7A	540V .25A	1.95	3.75
DM-34D	12V 2A	220V .080A	4.15	5.50
DM-53A	28V 1.4A	220V .080A	3.75	5.45
PE-73C	28V 20A	1000V .350A	8.95	14.95
PE-86	28V 1.25A	250V .050A	2.75	3.85

DM-42A DYNAMOTOR. Input 12 V DC @ 39 Amps. Output 515 V DC @ 215 Ma. and 1030 V DC @ 260 Ma. Wt. 38 lbs. BRAND NEW, each $6.95
DM-37 DYNAMOTOR. Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each $3.25

CARTER GENEMOTOR

INPUT: 5.9 V DC @ 32 Amps.
OUTPUT: 405 V DC @ .270 Amps.
BRAND NEW, special.................. $8.95

MICROPHONES

Model	Description	EXC. USED	BRAND NEW
T-17D	Carton Hand Mike	$4.45	$7.95
RS-38	Navy Type Carbon Hand Mike	3.95	5.75

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Model	Description	Excellent Used	BRAND NEW
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HS-33	Low Impedance	2.69	4.95
HS-30	Low Imp. (featherwt.)	.90	1.65
H-16 U	High Imp. (2 units)	3.75	7.95

TELEPHONICS—600 ohm Low Impedance HEADSETS, BRAND NEW, PER PAIR $3.25
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Earphone Cushions for above—pair.......... .50

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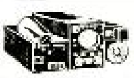
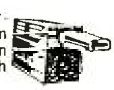


Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes. Exc. used $49.50
Receiver-Indicator as above, BRAND NEW $88.50
Shock Mount for above $2.95

INVERTER POWER SUPPLY for Loran. Made by Eclipse—Pioneer Div. INPUT: 24 V DC @ 75 A. OUTPUT: 115 V AC @ 10.5 Amps, 800 cycles. Complete with two connecting plugs BRAND NEW $49.50

12-Volt Inverter Power Supply, Like New. P.U.R.
We carry a complete line of spare parts for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR



Used in ships and aircraft. Determines position by radio signals from known xmitters Accurate to within 1% of distance. Complete with tubes and crystal. Exc. used.
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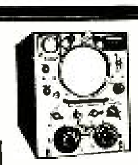
12-Volt Inverter Power Supply, Like New P.U.R.
Shock Mount for above $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of spare parts for above.

LORAN APN/4 OSCILLOSCOPE



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BC-455	Receiver 6-9 Mc	11.50	13.95
1.5 to 3 Mc. Receiver Brand New			$17.95

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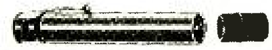

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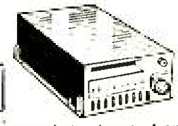
ARC-3 RECEIVER!



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APN-1 Exc. used, like new....... $8.95

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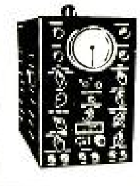

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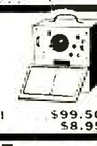

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PRICE $79⁵⁰

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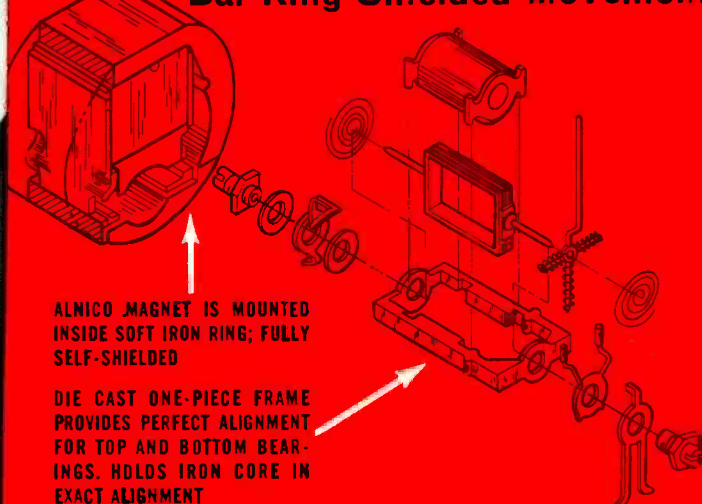
Bar-Ring Shielded Movements



ALNICO MAGNET IS MOUNTED INSIDE SOFT IRON RING; FULLY SELF-SHIELDED

DIE CAST ONE-PIECE FRAME PROVIDES PERFECT ALIGNMENT FOR TOP AND BOTTOM BEARINGS. HOLDS IRON CORE IN EXACT ALIGNMENT

FACTS MAKE FEATURES:

1. **70 RANGES**—nearly double those of conventional testers. Unbreakable window. Mirror Scale.
2. **HIGHEST ACCURACY**—1½% DC to 1200 volts, 3% AC to 1200 volts; mirror scale and knife-edge pointer to eliminate parallax.
3. **FREQUENCY COMPENSATED**—Flat from 20 CPS to 100,000 CPS; varies from ¾ to 1¼ DB at 500,000 CPS. Temperature compensated. Meter protection against overloads.

THE TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

Uses Unlimited:

FIELD ENGINEERS ■ APPLICATION ENGINEERS ■ ELECTRICAL, RADIO, TV, AND APPLIANCE SERVICEMEN ■ ELECTRICAL CONTRACTORS ■ FACTORY MAINTENANCE MEN ■ INDUSTRIAL ELECTRONIC MAINTENANCE TECHNICIANS ■ HOME OWNERS, HOBBYISTS

MODEL 630-NA-RM RACK MOUNTED VOM

Same ranges as Model 630-NA, except for 3000 and 6000 AC and DC volts. Heavy etched aluminum panel 19″ x 5¼″. Standard test leads come out the front. $109.50.

630 630-A 630-PL 630-APL 630-NA 630-NS 630-T 631 310 310C 666-HH 800 666-R

FOR EVERY PURPOSE—THE WORLD'S MOST COMPLETE LINE OF VOM's / AVAILABLE FOR IMMEDIATE DELIVERY FROM YOUR TRIPLETT DISTRIBUTOR'S STOCK

An important message to electronic technicians . . .

RCA invites you to

PUT YOURSELF IN THE COLOR PICTURE

Color television today is a 300-million-dollar-a-year business—and the fastest growing segment of the home entertainment industry.

Color TV programming is at an all-time high. If you still limit yourself to black-and-white servicing, you put yourself in the same position as the village blacksmith who considered automobiles a fad.

Leading manufacturers are now turning out color TV sets with the color picture tube developed by RCA. Servicing these sets means big and highly profitable business, but it requires special skills, knowledge, equipment and parts. What are you doing to take advantage of this great new business opportunity?

To the public, *color TV means RCA!* It was RCA who conceived and pioneered the compatible color system in universal use.

How can you climb on the color bandwagon? Associate your business strongly with the prestige and customer acceptance of the recognized pioneer of color TV. See your authorized RCA distributor; stock and advertise RCA tubes and associated products for color. Isn't it time you started seeing yourself in color?

RCA ELECTRON TUBE DIVISION, HARRISON, N.J.

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