Electronics World

JANUARY, 1965
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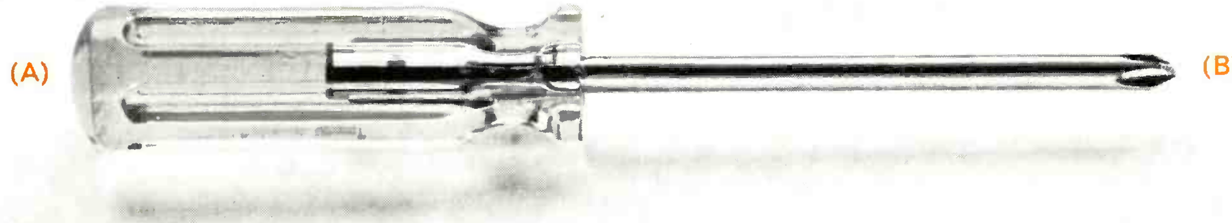

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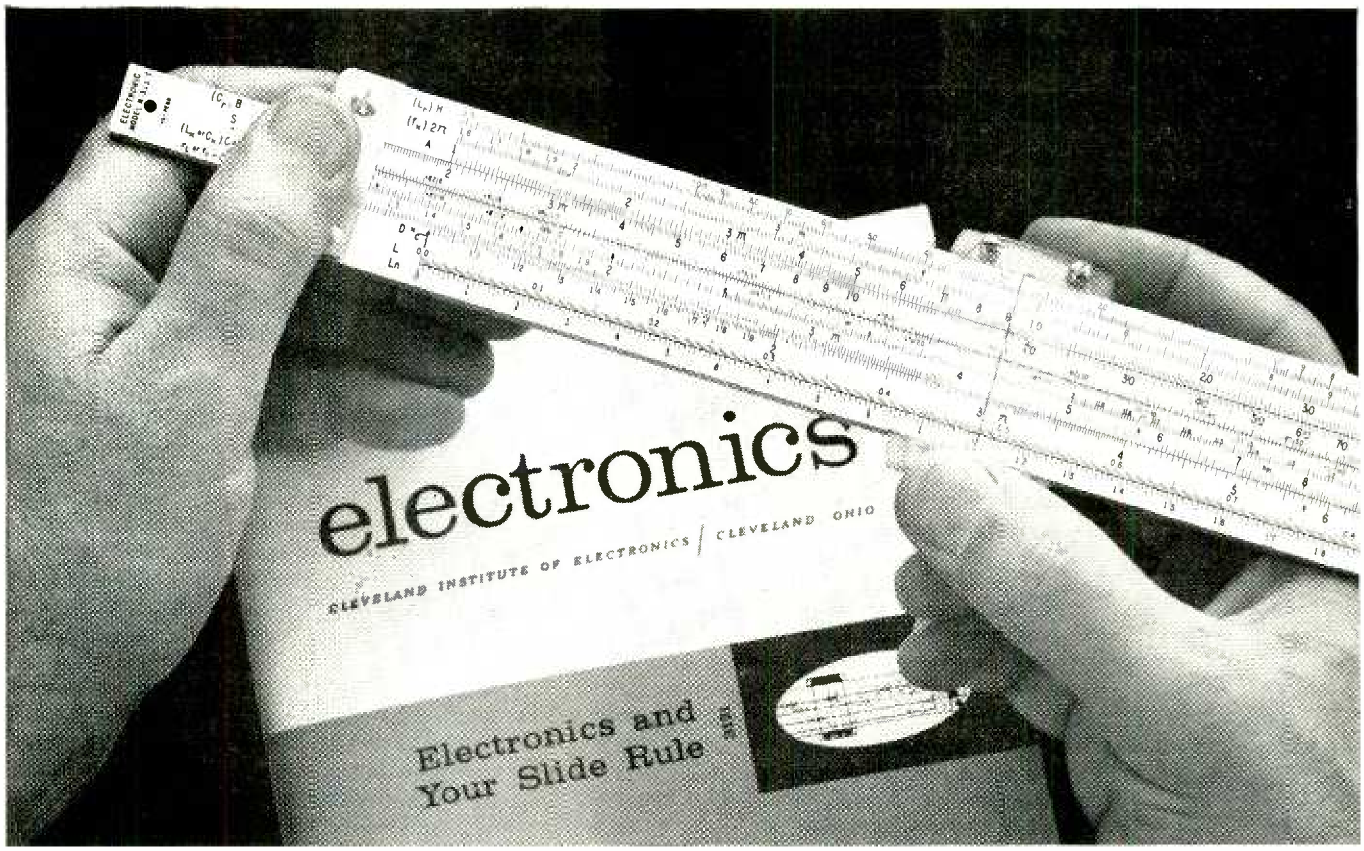
CIRCLE NO. 180 ON READER SERVICE PAGE

A New Electronics Slide Rule with Self-Training Course



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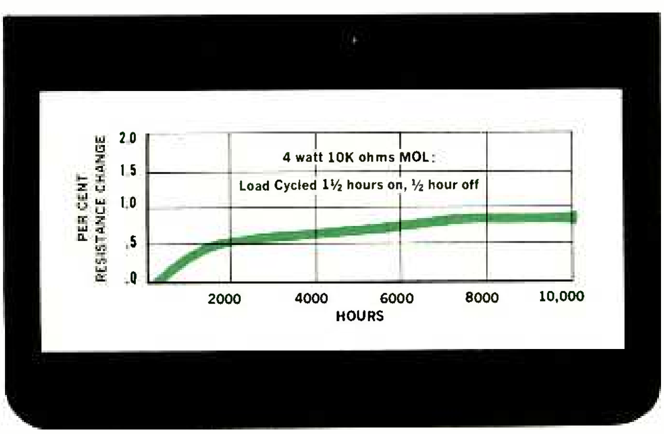
What you should know about film resistors



Typical stability test data: 10,000-hour load cycling test. Average resistance change is less than 1%!

If you've been looking inside some of the recent model television sets, chances are that you've noticed some unusual-looking resistors. Especially in the sizes readily identifiable as under 10 watts. You'll probably find them in spots where you're used to seeing small wirewounds.

There's a good reason. These are metal oxide film resistors. And the reason they're making such a hit is that they have as good stability and life as wire-wounds—but they cost only about half as much in most values.

What's different about them?

First, they're made differently. A thin layer of tin oxide is evaporated onto a high quality ceramic rod, at high temperatures. A spiral groove is then cut, by a highly precise automatic machine, to produce a resistance path with the desired ohmic value. Then the end connections are applied and the whole works gets a coating of silicone finish. You can get a lot higher resistance values, size for size, than with wirewounds, because you're not limited by the problems of winding hair-thin wires. Top resistance for the 4, 5 and 7 watt sizes is 120,000 ohms; for 2 and 3 watts, 56,000 ohms. Standard tolerance is 10%.

Second, they behave differently. Their stability is really terrific. We've run them with on-off load cycling for 10,000 hours and measured changes of less than 1%. They'll take heavy brief overloads without damage, aren't bothered by humidity or vibration. And they're noninductive up to 250 mc. The name to ask your Mallory Distributor for is the MOL film resistor. He has them in 2, 3, 4, 5, and 7 watt ratings, in popular resistance values. And when you need a higher wattage (up to 200 watts) ask him for Mallory vitreous enamel resistors—you can't beat them for cool operation and stable life.

Electronics World

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JANUARY 1965
VOL. 73, No. 1

MONTHLY FEATURES

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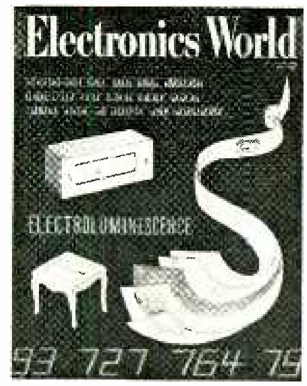

OUR COVER symbolizes the important subject "Electroluminescence" which is a large-area cold-light source that is produced by electric-field excitation of a phosphor. Electroluminescent (EL) devices are used for low-level lighting and in various types of display applications. One of the newest products in this field is a flexible EL light source introduced by Sylvania as "Tape-Lite." Our artist has taken a length of this tape and has split it into its five layers. When a.c. is applied to the two electrodes shown, the middle layer containing the phosphor glows. See page 23. . . . . (Illustration: Otto Markevics.)

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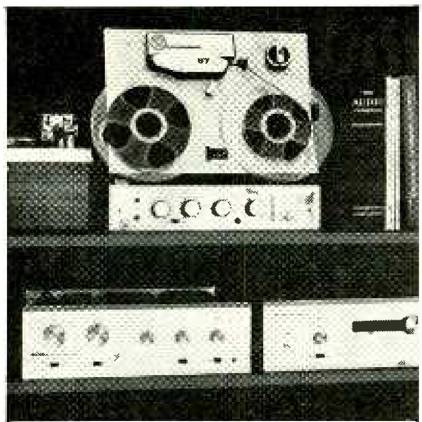

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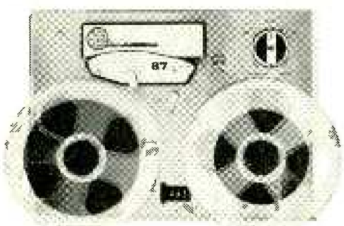

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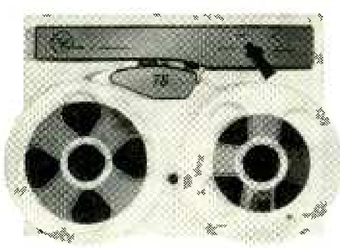

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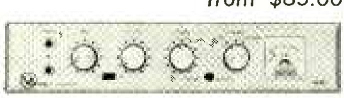

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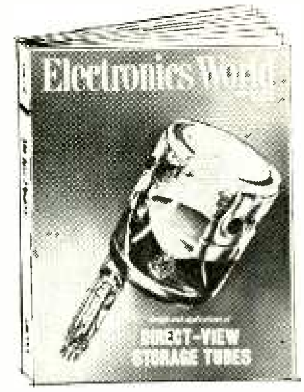
CIRCLE NO. 252 ON READER SERVICE PAGE

COMING NEXT MONTH



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

THE NEW LOOK IN RADARS
John F. Bachmann of Bendix Radio describes a new type of radar with an electronically steerable antenna array. It is being used to search for, track, catalogue, and store in computer memories information on satellites, missiles, and other space objects.

SOLDERING TOOLS & TECHNIQUES
The practical aspects of the new soldering techniques such as automatic wave soldering, ultrasonic, and micro-circuit assembly, plus some little known but helpful facts about ordinary soldering.

BASIC PRINCIPLES OF RELIABILITY
Once a piece of equipment is assembled, what are the chances that it will fail or stop working after some period of time? These questions are typical of those involved in the study of reliability.

COMPUTERS IN BUSINESS
Business applications for electronic data processing include payroll calculations, inventory recording and control, accounts payable and receivable. The techniques used in the computer to handle these basic operations are discussed by Ed Bukstein.

DIRECT-VIEW STORAGE TUBES
John B. Pegram of DuMont Laboratories covers the design and applications of special types of cathode-ray tubes that permit easy viewing in high ambient light areas.

DESIGN OF TRANSISTOR MULTIVIBRATORS
Simplified design techniques for transistor switches, inverters, astable, monostable, and bistable circuits are covered in this comprehensive article by Louis E. Frenzel, Jr.

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

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1583. Also: Funny, Forever And A Day, On Broadway, etc. *

1351. Also: Dream, This Is All I Ask, Noelle, 12 in all

1556. World's Fair, Unisphere, Iberia, Elementals, 2 more

1609. Also: Gotta Right to Cry, It's All Right, etc.

1459. The Academy Award Winning score by John Addison

1350. Also: Third Man Theme, Caravan, Solitude, etc.

1519. Also: Twist And Shout, Walkin' The Dog, etc.

1571. Also: School Day, Hey Little Freshman, Bucket "T", etc.

1593. Gordon Jenkins' musical poems in praise of Manhattan

1257. Also: Return to Paradise, Beyond The Reef, etc.

1263. "Magnificent performances!" — High Fidelity

1590. Also: Anything Love Can Buy, This Ol' Riverboat, etc.

1015. Also: Go Away Little Girl, Up on the Roof, etc.

1537. Also: Lost in The Stars, Too Close for Comfort, etc.

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1362. Also: Exodus, Irma La Douce, The Apartment, etc.

1013. Also: Twelfth of Never, No Love, Come to Me, etc. *

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1598. Also: Cup of Loneliness, Color of The Blues, etc.

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1600. Corcovado, Once upon A Summer Night, 7 in all

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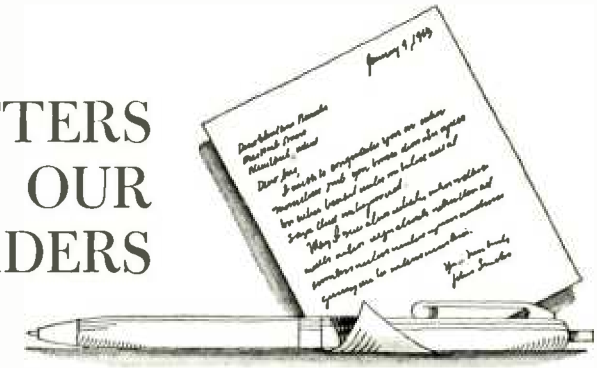
CIRCLE NO. 240 ON READER SERVICE PAGE

LETTERS FROM OUR READERS



TRANSISTOR IGNITION SYSTEM

To the Editors:

Just a comment about the letter from David H. McGoun in the August, 1964 issue.

Mr. McGoun is correct. The transistor ignition system by Mr. Mayfield described in the June, 1963 issue will give very difficult cold-weather starting, if not impossible. I experienced the same difficulties as Mr. McGoun, with the exception that it was 20° below zero when I installed the unit last January.

I made some voltage readings after the car refused to start and read approximately 7 volts across the two transistors (*i.e.*, from the emitter of Q1 to the collector of Q2) with the points closed. This indicated that the transistors were not "turned on" sufficiently with the battery voltage slightly low. I then adjusted *R6* until I obtained a minimum voltage drop across the two transistors. There was about 1 volt across each transistor. The slide on *R6* divided the 10 ohms, with 7 ohms to Q1 and 3 ohms to Q2.

I also increased the current to the ignition coil primary to 9 amps.

The system has started well in subzero weather and has given excellent performance and trouble-free driving for 9000 miles.

EUGENE T. WALDORF
St. Paul, Minn.

° ° °

ELECTRONIC PIANO TUNING

To the Editors:

As a piano technician, I would like to caution your readers about attempting to tune a piano as described in the article "Piano Tuning—The Electronic Way" by Frederick Van Veen, which appeared in the September issue. Mr. Van Veen has neglected to tell your readers that they could do irreparable damage to their pianos.

When a piano is in tune at A=440 cps, there is approximately 180 lbs. of pressure from each string bearing down on the soundboard and metal plate of the piano. Now, the piano is designed to take this tension as long as it is uniform throughout its entire length. But tighten the strings too much or unevenly and if you're lucky, you'll just break a string, a simple repair job to a competent piano technician. If you are not lucky, the soundboard could crack or warp, necessitating a costly major repair.

Mr. Van Veen also neglects to mention that it takes approximately two years to a lifetime to learn to tune a piano decently even with competent instruction and constant practice. This has no bearing on how accurately you can judge frequencies but depends on the ability to set the tuning pins properly. There are at least five pressure points or bearing surfaces which a piano string comes in contact with in the average piano. This is done to give the piano string rigidity and aid it in holding its tune. In order to get the string to hold, you must be able to pull the string sharply just the right amount, so that you overcome the tension placed on it by the bearing surfaces. Then the string must be settled by striking the key so that it drops into tune. The tension must be equal throughout the entire length of the string or it will not hold its tune.

CLIFFORD C. ROSE
Piano Technicians Guild
New York Chapter
New York, N.Y.

To the Editors:

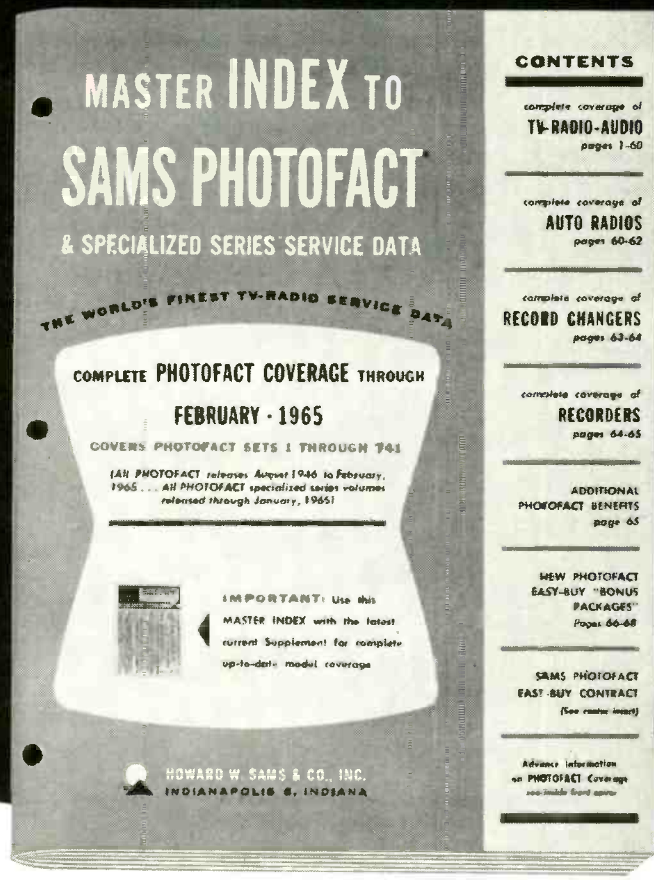
I suggest that any of your readers who are tempted to follow the advice of Mr. Frederick Van Veen in "Piano Tuning—The Electronic Way," and really want their piano to be in tune and stay in tune, call in an experienced piano tuner who understands hammer technique, who knows that piano tone partials are not harmonic, and who knows that pianos tuned to the frequencies listed in Table 2 will not sound in tune because pianos are not tuned to the equally tempered scale.

Some very good piano tuners use electronic instruments to guide them as well as using their ears, but there is very much more complexity to satisfactory piano tuning than this article would lead one to believe.

EARLE L. KENT, Ph.D.
Director of Research
C. G. Conn Ltd.
Elkhart, Ind.

Although the keys near the center of the keyboard are tuned to the equally tempered scale (12 exactly equal intervals between octaves), those at the ex-

need reliable service data?



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CIRCLE NO. 212 ON READER SERVICE PAGE

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tremes are not. The highest notes on the keyboard are usually tuned by ear to be a fraction of a semitone high (sharp), while the lowest notes are usually a fraction of a semitone low (flat). The precise tuning also varies depending on the type of piano being tuned. A reason for this is that the partials (harmonics) produced by the struck strings of a piano are not precise multiples of the fundamental but are very slightly off. This is because piano strings are not ideal but have stiffness, and there is some yielding of the bridge. As a result, undesired beats and dissonances would occur if the entire keyboard were tuned exactly to the equally tempered scale. For an excellent reference on this matter, see "Tuning: Pianoforte" in "Grove's Dictionary of Music and Musicians" (St. Martin's Press, New York).

A portion of Author Van Veen's letter replying to the above follows.—Editors.

To the Editors:

Dr. Kent's comments pertain to the last few paragraphs of my article, involving the use of a counter to tune a piano to the frequencies of the equally tempered scale. Because of the inharmony of piano tones, such "fundamental" tuning is inferior to aural harmonic tuning, especially at the ends of the keyboard. This, however, is not a consideration in the technique principally described, the use of a tuned audio filter. The method assumed inharmony and should therefore result in a properly "stretched" piano.

In piano tuning, as in so many other things, the professional practitioner generally offers the best job. Tuning your own piano, on the other hand, offers a great deal of satisfaction.

FREDERICK VAN VEEN
General Radio Company
West Concord, Mass.

* * *

AUDIO SWEEP GENERATOR

To the Editors:

You recently ran a construction story entitled "Transistorized Audio Sweep Generator" (August issue). I had trouble with the alignment of the transformers and found that by turning the sweep-width control to zero and feeding the output of the generator through an audio amplifier, the transformers could easily be tuned. In my circuit I used 2N336 transistors in the buffer and audio stages. If the 2N336's are used in place of $Q2$, $Q4$, $Q5$, and $Q6$, the following changes have to be made: $R6$ and $R13$ changed from 180k to 120k. Better stability was obtained by adding 220-ohm resistors in the emitters of $Q2$ and $Q4$.

To keep the display stable on the scope face, I connected a 9.1k resistor between sync and sweep output.

R. R. SHOEMAKER
East Syracuse, N. Y. ▲

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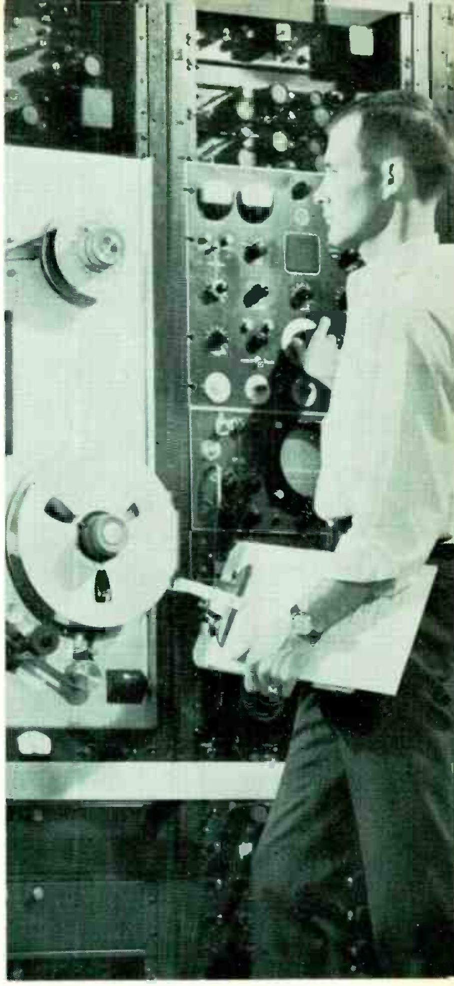

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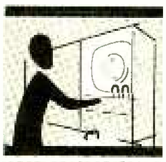

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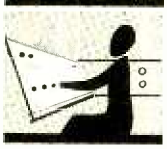

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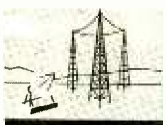

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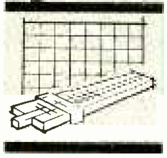

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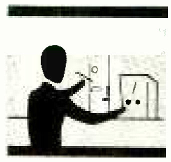

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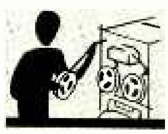

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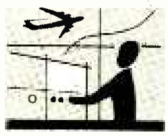

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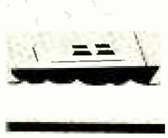

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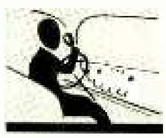

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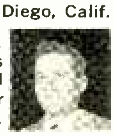

"I am a Senior Engineering Aide at Litton Systems, in charge of checkout of magnetic recording devices for our computers. Without the help of NRI I would probably still be working in a factory at a lower standard of living." **DAVID F. CONRAD,** Reseda, Calif.

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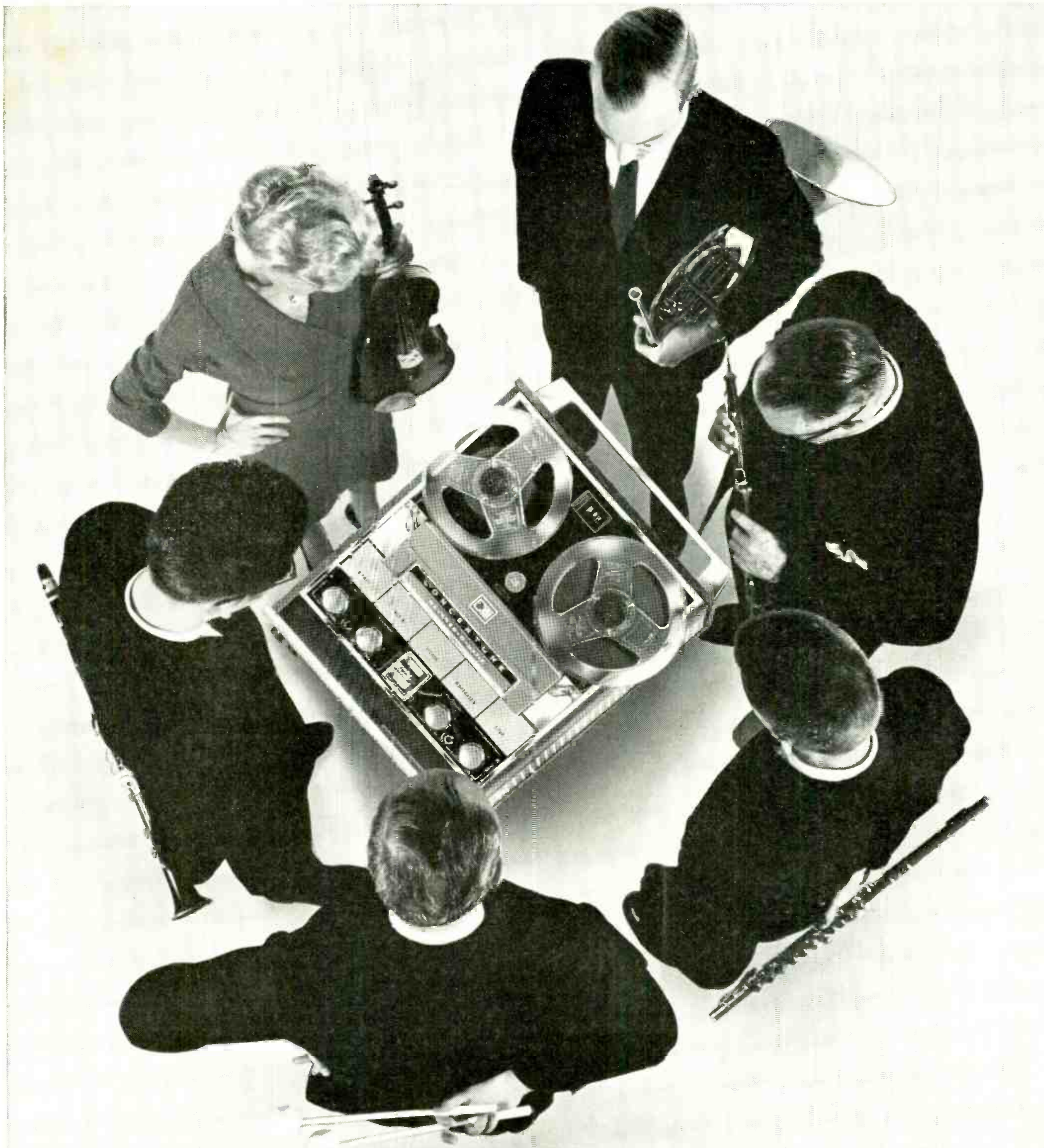

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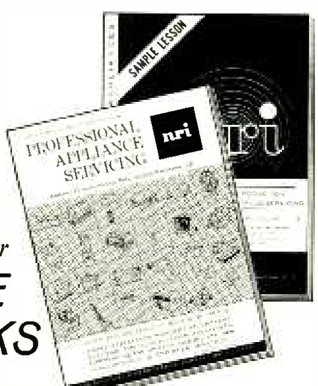

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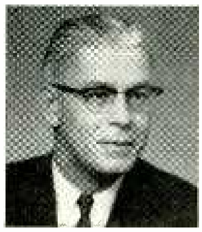

For the record

WM. A. STOCKLIN, EDITOR

CATV IN LOGANSPORT

OUR recent trip to the Midwest turned out to be an extremely interesting one. In addition to covering the National Electronics Conference (NEC), we were able to visit many outstanding electronics plants in the Chicago area, as well as in Kokomo, Frankfort, and Indianapolis, Indiana. As a result of these visits, there will be many useful and informative articles in forthcoming issues.

Since next month's issue will feature a full-length report on the community antenna TV system recently installed in Logansport, Indiana, we made every effort to learn more about its operation. It was the first cable system that we have seen and studied, and our reaction was highly favorable because of the outstanding performance of the *Jerrold*-designed system.

Logansport is a small, rural community near the center of Indiana, some 70 miles from its nearest TV station in Indianapolis. Previously, there were four v.h.f. and one u.h.f. channels available and these required fringe-area antenna installations. After the cable system was put in, ten v.h.f. channels were received, including stations from Chicago, South Bend, and Lafayette, Indiana.

Service technicians in the area were quite displeased with the idea of CATV prior to its installation. They feared the loss of business, since high-gain antennas, towers, and boosters would no longer be needed. However, their general reaction has changed considerably. The increased signal strength available with the cable system (about 1600 to 3700 μv. compared with 20 to 500 μv. formerly) has actually stimulated the sale of TV sets, particularly color-TV models, and has minimized difficult servicing problems.

Our first reaction was that CATV is an ideal method of distributing TV signals, particularly in remote areas. The question arises, however, as to whether or not CATV operators should be permitted to continue to install, without restrictions, new systems in any area they desire. We felt that since we have a free-enterprise system, normal economics should be allowed to determine whether or not the system would be financially successful. Obviously, where satisfactory TV reception is already available, people would not spend the extra money for any cable system.

We recently talked to Morton Leslie, Chairman of "TAME" (Television Accessory Manufacturers Institute). This organization opposes the indiscriminate franchising of cable systems. They do not object to systems which provide TV reception in areas that are unable to get good reception because of terrain or distance. They do, however, oppose the rather recent indiscriminate rush for franchises in hundreds of cities where good TV reception is possible and where there is a wide choice of programs.

The only present control of a CATV system is in obtaining a franchise from the local town or city government. The question arises whether these individuals are sufficiently knowledgeable in the technical developments and future plans of free TV, especially as they affect the country as a whole rather than an individual community. We know that they would not be as knowledgeable as individuals connected with the FCC.

We have heard of one incident—chances are there are more—where local government officials are actually part owners of the CATV system that they franchised. With lack of some control, what is to prevent one political party from monopolizing the CATV channels?

Also, what restrictions are there to prevent a CATV installation company from engaging in captive service? Although there is an honor system whereby independent service technicians will handle all TV-set service, there have, however, been instances where cable organizations have violated this rather nebulous agreement.

There is a general feeling that there should be federal regulation of all CATV systems, and that they should be made subject to the full provisions of the Communications Act, placing them under the jurisdiction of the FCC. In this way, the public can get the greatest measure of protection. Equally important is the continued growth of TV through new u.h.f. stations. There are today more than 1000 allocations that have not as yet been applied for. Since a new u.h.f. station would find it hard to compete with a CATV system, the public would thereafter be deprived of free TV through u.h.f.

We feel that all of our efforts should be devoted to fostering free TV wherever possible, without competitive restrictions. ▲

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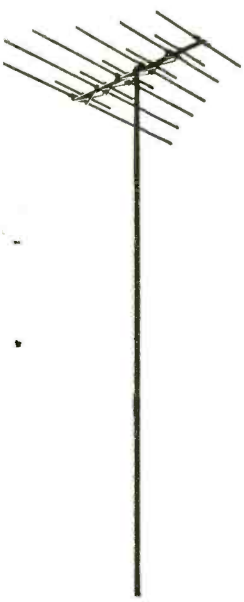

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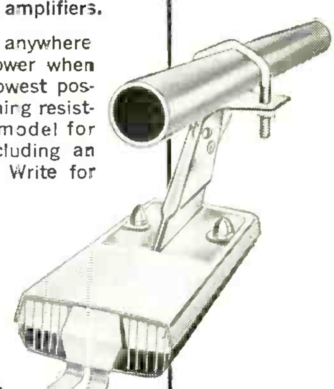

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HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS
Eico Model 2536 Stereo Receiver
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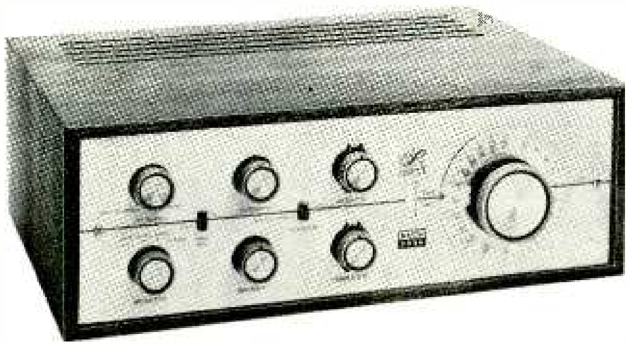
Eico Model 2536 Stereo Receiver

For copy of manufacturer's brochure, circle No. 55 on coupon (page 17).



THE new *Eico* "Classic Series" of high-fidelity components includes, in addition to the tuner and amplifier reviewed in earlier issues, a complete stereo receiver, the Model 2536. This is, essentially, a Model 2200 FM-stereo tuner and Model 2036 amplifier, on a single chassis measuring 15⅞" x 13⅜" x 5⅝".

The pre-aligned front end uses a single ECC85 dual triode as a neutralized r.f. amplifier and self-oscillating mixer. It has no a.f.c., but due to its excellent temperature compensation, warm-up drift is slight. The i.f. section is constructed on a printed board, with three stages of 6AU6 amplification and 6AL5 ratio detector. Like the front end, the i.f. amplifier is completely pre-aligned and tested at the factory. In mono FM reception, the detector output goes directly to the audio section of the receiver.

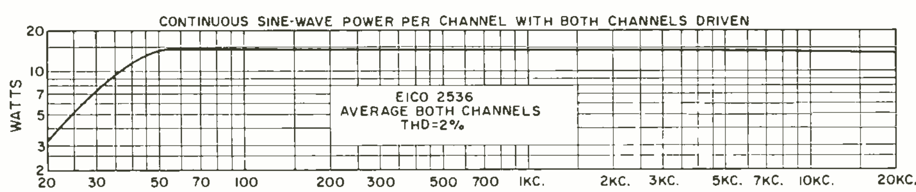
The pre-aligned multiplex board contains an amplifier with a 67-kc. trap to remove any SCA program material which might cause background whistles or noise. The 19-kc. subcarrier is separated in another stage, amplified, and doubled to synchronize a 38-kc. oscillator. A two-diode electronic switch is operated by the 38-kc. oscillator, separating the composite stereo signal into left and right components. After separate de-emphasis, these go to the amplifier channels.

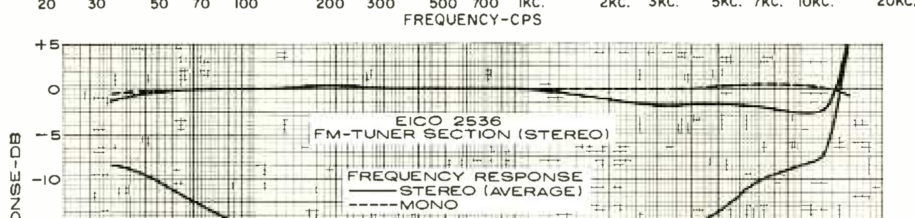
The amplifier, nominally rated at 14 watts steady-state power output per channel, or 36 watts total IHF music power, has push-pull EL84 tubes in each output stage. The input amplifier, to which negative feedback is applied from the speaker output, is direct coupled to a triode phase splitter. A 12DW7 twin triode serves both functions.

The tone controls are in a negative feedback path around a triode amplifier and are isolated from earlier circuits by another triode amplifier. These two stages are combined in a 12DW7 tube. The ganged level controls precede the tone-control section, which is followed by the balance control. A blend control across the two channels mixes the signals to "fill in the center" or reduce excessive stereo separation. When it is fully clockwise, the channels are blended to a mono signal, while in its counterclockwise position a switch is operated to completely separate the channels. This function is effective on all input signals.

A 6EU7 twin triode serves as a magnetic phono preamplifier. Negative feedback circuits around this stage provide RIAA equalization with low distortion. The two amplifier channels are identical, with 8- and 16-ohm outputs. The power supply for the entire receiver uses a GZ34 slow-heating rectifier, which prevents excessive surge voltages on the filter capacitors during warm-up.

The combination of the Model 2200 tuner and Model 2036 amplifier into a single unit has lost very little of the flexibility of the separate units. The only features omitted from the receiver are the front-panel headphone jack and speaker switch of the Model 2036 amplifier. As with the other "Classic" units, the Model 2536 receiver is very simple to build. Division of the assembly process into groups, with separately packaged components and a two-color illustrated manual, plus completely pre-aligned circuits, makes this kit quite suitable for the novice constructor.



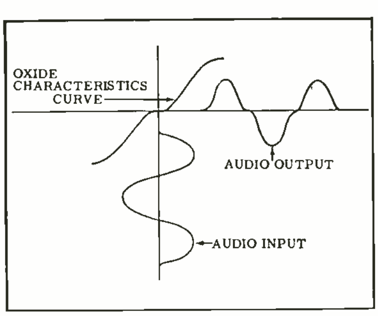


Some plain talk from Kodak about tape:

Bias transfer characteristics and dependent parameters

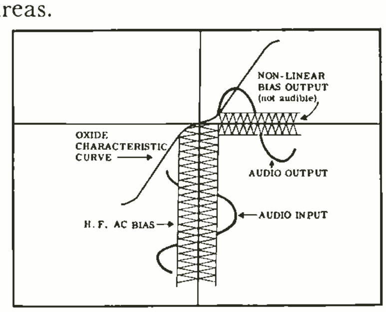
Ever heard the story about the pilot on his first solo flight? Unfortunately the engine failed. But fortunately he had a parachute. But unfortunately the chute failed to open. But fortunately he landed on a haystack. But unfortunately there was a pitchfork in the haystack. Except for the unhappy ending, this might be the story of how gamma ferric oxides respond to magnetic fields. Everything about it is fortunate with one exception. *Linearity*. The oxide needles used in the coatings have atrocious linearity characteristics. Feed in a clean, pure sine wave and out comes a non-sinusoidal complex waveform that looks something like a demented snake trying to bite its own head off. How does it sound? About as pleasant as Junior's first violin lesson.

How then is magnetic recording possible? Fret not—there's a way out. The entire problem is solved by one wonderful, mysterious phenomenon called bias. The transfer curves tell the story.

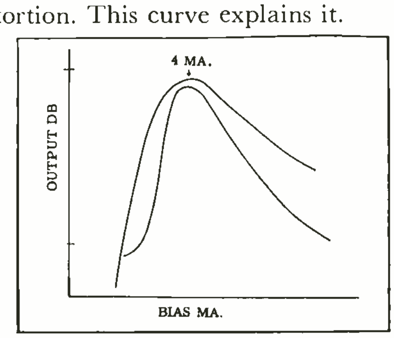


The slightly twisting curve at the upper left represents the oxide response. The lower curve is a pure, sine wave input. At the upper right we have the result of the response curve on the input . . . a mess.

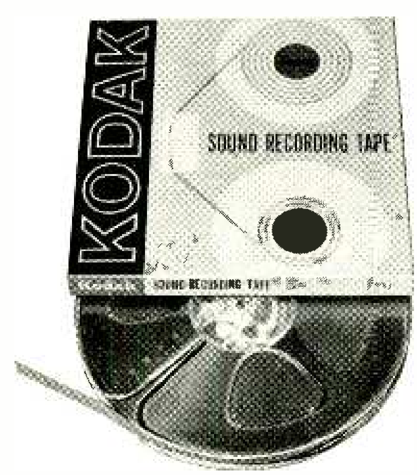
The reason it looks the way it does is because the sine wave input is affected by the non-linear characteristics of the gamma ferric oxides. But look closely. Note that while the oxide performance is non-linear when taken over its entire length, we can find linearity over selected sections. In other words, we can get rid of our distortion if we can put the signal on the linear section of the oxide's characteristic curve. And that is exactly what bias does. It "lifts" the signal away from the convoluted central area on the graph and moves it out to linear areas.



The amount of bias (that is the current in milliamperes) applied to the head is highly critical if top performance is to be achieved. Bias affects output, high and low frequency sensitivity, signal-to-noise ratio and distortion. This curve explains it.



The steep curve represents low frequency sensitivity (measured in db.) at varying bias levels for many tapes. Note that you get good performance providing you have a bias setting of about 4 milliamperes. (Curves for the other magnetic parameters are similar in shape and all peak at about the same bias level.) Vary one milliampere and you "fall off the curve" and suffer severe losses in sensitivity. Now look at the broader curve. You can vary a milliampere with hardly any change in performance at all. Here's the point. *Kodak tape has that broad curve.* It gives you top performance even though your bias settings aren't perfect. And if your tape recorder is more than a year old, then chances are enough shift has taken place to push you off the cliff. That's why we designed a broad bias curve. And that's why you need it. It's just one more way that Kodak tape gives you an extra bit of assurance of top performance.



KODAK Sound Recording Tapes are available at all normal tape outlets: electronic supply stores, specialty shops, department stores, camera stores . . . everywhere.

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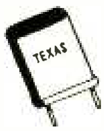

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CIRCLE NO. 229 ON READER SERVICE PAGE

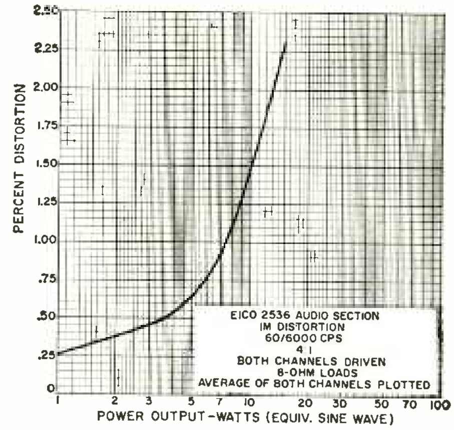
In our tests of the receiver, the audio section delivered slightly over 29 watts continuous power output over most of the audio range at 2% distortion. It exceeded its 28-watt rating between about 40 and 20,000 cps. At lower frequencies the power fell off, as is normal in moderate priced amplifiers. The frequency response was ±1.5 db from 20 to 20,000 cps, and the RIAA equalization was accurate within ± 2 db from 30 to 15,000 cps.

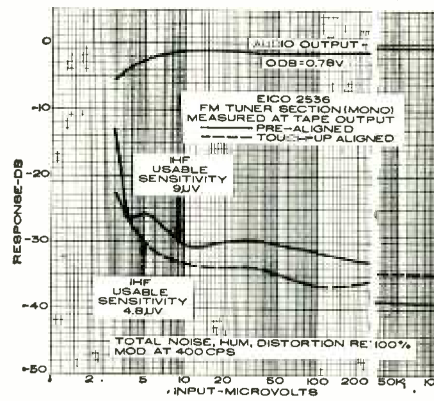
The IM distortion was about 0.3% at low levels, reaching 1% at a combined output of 15 watts and 2% at 26 watts total, with both channels driven. The amplifier was stable with capacitive loads. Its hum level was −52 db on phono, and −80 db on the "Aux." input, referred to 10 watts output.

The FM tuner, with no further alignment whatsoever, had an IHF usable sensitivity of 9 μv. Instrument alignment improved this to 4.8 μv. In most cases there would be no advantage in attempting an alignment, as the improvement would not be likely to be audible.

The FM-stereo channel separation was better than 20 db between 250 and 1500 cps, and 10 db between 45 and 7000 cps. The Model 2536 has a "push-to-check" slide switch for identifying stereo broadcasts. It requires considerable operating pressure, and momentarily interrupts the program, but gives a positive indication when a stereo broadcast is received, by closing the bar-type eye tube.

The tuning ease, general handling, and sound quality of the receiver leaves little to be desired. In most installations it should serve as well as many far more expensive receivers, although with some





sacrifice of operating conveniences. Its attractive price of $154.95 in kit form, or $209.95 factory wired and tested, should help to compensate for the slight reduction in sensitivity and power output and the omission of a few operating niceties found in other receivers at twice its price. The Model 2536 costs about 10% less than the individual units which it contains and is a little larger than either of them. ▲

PML EK-61 Capacitor Microphone

For copy of manufacturer's brochure, circle No. 56 on coupon (page 17).

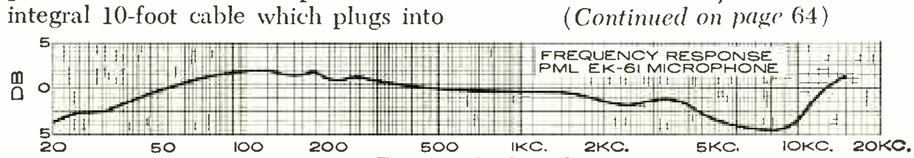
It is generally recognized that the widest, smoothest frequency response is usually obtained with capacitor microphones. They are used almost exclusively in high-quality recording and broadcast applications. Unfortunately, for the amateur recordist, capacitor microphones are frequently very expensive, costing from $250 to $600.

Basically, the Swedish *PML* capacitor microphones, distributed in the United States by *Ercona Corp.*, have all the performance of more costly microphones at an appreciably lower price. The *PML* is available in two models, the omnidirectional EK-61 and the cardioid model EC-61. Both are tiny cylindrical units, 11/16" in diameter and 2-11/16" long, weighing only 1¼ ounces. The microphone with its built-in amplifier has an integral 10-foot cable which plugs into a special power supply unit. This is also a cylinder, 2" in diameter and 4½" long, weighing 17 ounces.

The power supply furnishes a 67.5-volt polarizing voltage to the microphone and contains a subminiature tube which amplifies its very small output voltage to usable levels. A battery power supply is also available for use where a.c. power is not convenient. The a.c. supply has a 5-foot power cable and a socket for the 10-foot signal output cable. The normal output impedance is high, but other cables are available which connect to different taps on the built-in matching transformer to provide impedances of 50, 200, or 600 ohms.

The microphone comes in a fitted case, together with a microphone stand adapter. Other accessories, such as a wind-

(*Continued on page 64*)



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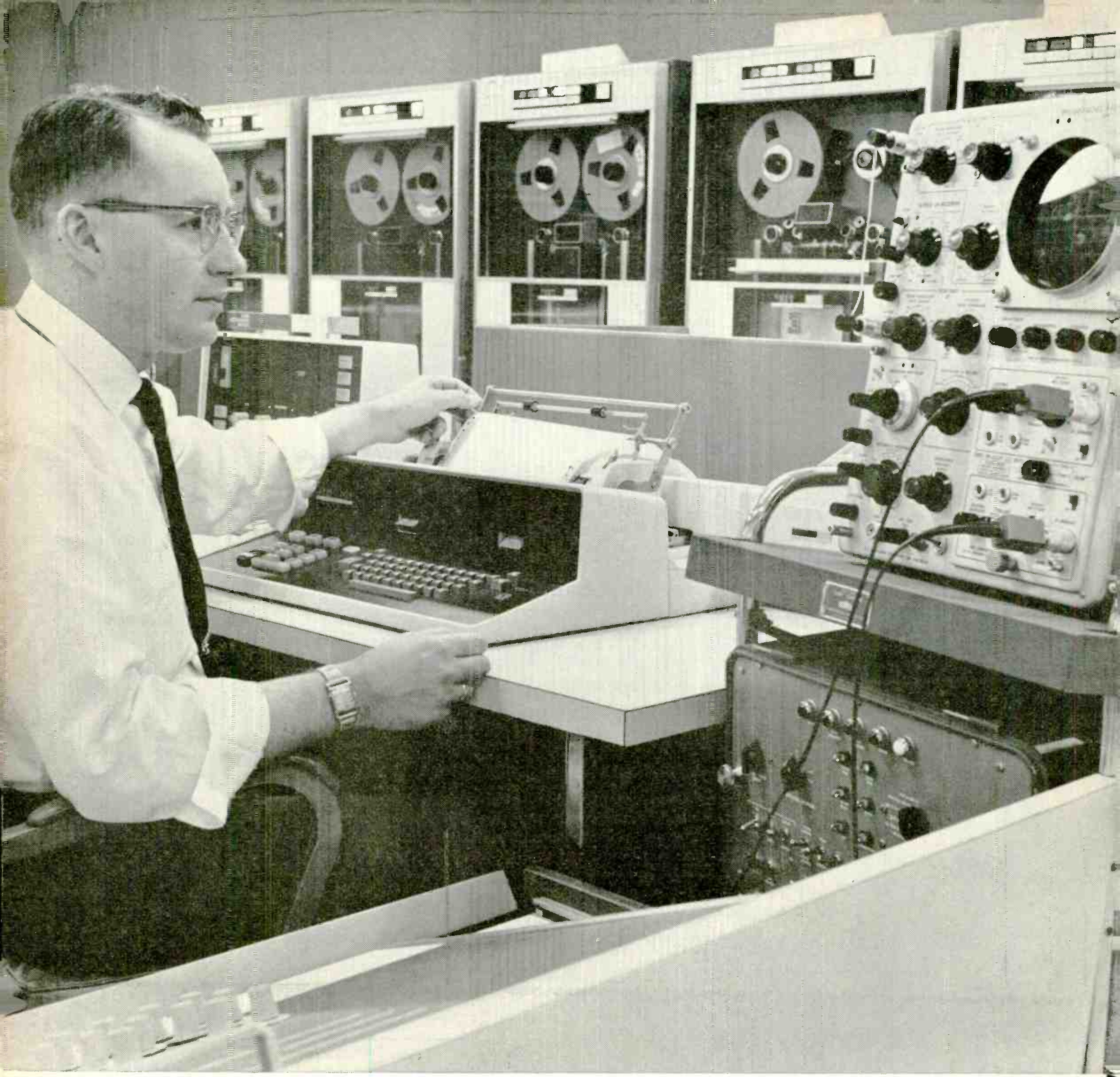

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I laughed when Fred Williams, my old high school buddy and fellow worker, told me he was taking a Cleveland Institute Home Study course in electronics. But when our boss made him Senior Electronic Technician, it made me stop and think. Sure I'm glad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

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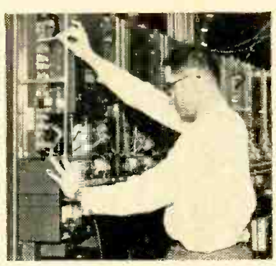

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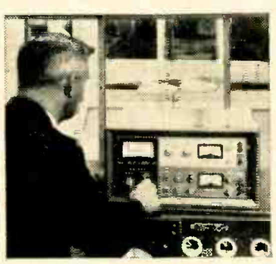

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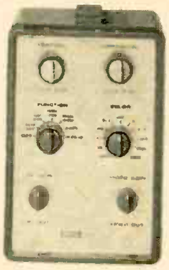

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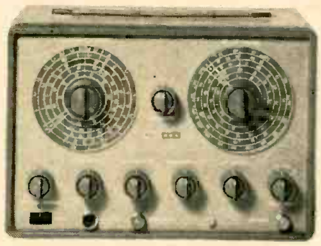

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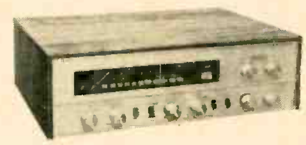

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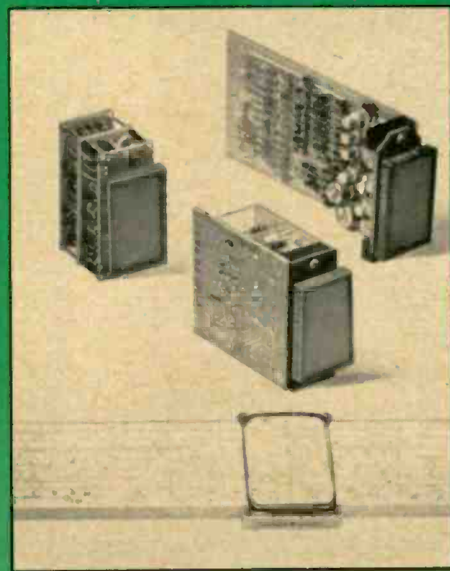
CIRCLE NO. 178 ON READER SERVICE PAGE

Decorative wall panel woven from colored strips of EL lighting tape.

Solid-state modules designed to translate a four-bit binary code to a numeric-type readout on the front-mounted EL panels.



ELECTROLUMINESCENCE: THEORY AND PRACTICE

By LESTER W. STROCK, Ph.D. / Sylvania Electric Products Inc

The cold light of electroluminescent devices is being put to ever increasing use in home and industry. Here is the theory behind them coupled with an explanation of how they are fabricated into various types of lamps and display systems.

THE phenomenon of electroluminescence (EL) has made possible the commercial development of a true area cold light source. This has been a significant technological advance—both in the lighting and display-device areas. In the lighting area, applications are presently confined to those requiring brightness in the 0.5- to 100-footlambert range. The impact of EL has been significant in the display-device field because of the wide variation in sizes and geometrical shapes possible with EL. Individual letters and numbers are available in sizes from ¼" up. Special units of segmented lamps, where the segments are combined at will by appropriate switching for forming any letter or number, are commercially available for incorporating into larger information display boards, such as in airline information areas, for flight position markers, and computer-fed displays, for example, in financial market centers.

Electroluminescence is the phenomenon whereby light is emitted from a crystalline phosphor (zinc sulfide in present lamps) placed as a thin layer between two closely spaced electrodes of an electrical capacitor. One of the electrodes must be transparent. The light output varies with voltage and occurs as light pulses more or less in phase with voltage pulses. They are thus operated on a.c. with light output strongly dependent on power frequency.

Since performance of the lamps is determined primarily by the characteristics of the phosphor, a detailed description of EL-phosphor properties and the electroluminescence mechanism is essential to an understanding of the unique character of various types of EL devices.

Photoluminescence in ZnS

The two chemical elements, zinc and sulfur, are familiar materials in science, industry, and the home. Sulfur was known to the ancients, while zinc was first prepared as a free

Flexible electroluminescent lighting tape can be made in lengths up to 150 feet. Strip is $\frac{1}{32}''$ thick with lighted width of $1\frac{1}{8}''$.

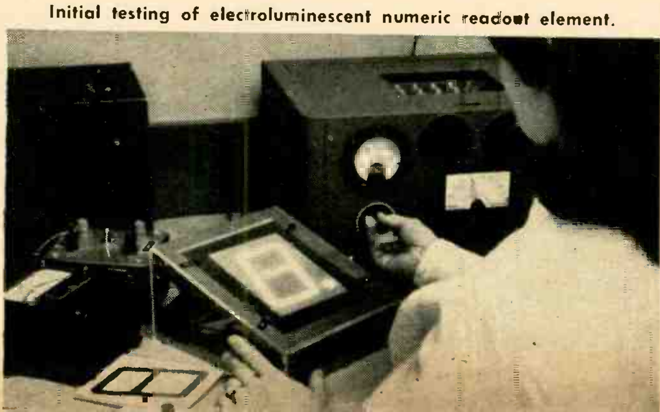
Electroluminescent numbers are used at O'Hare Field in Chicago in order to identify flight numbers and arrival of baggage.

metal in 1746. These elements readily combine to form a compound *ZnS* (zinc sulfide), which occurs naturally as the mineral zinc-blende or sphalerite—a major natural source of *Zn* (zinc) metal.

The addition of small amounts of certain metals to *ZnS*, as it is prepared in the laboratory, converts this compound into a very important electronic and luminescent material. *ZnS* is the host crystal for a large family of phosphors. When excited by electromagnetic radiation of energy ranging from near-infrared wavelengths (2 microns) down to *gamma* rays, these phosphors emit light which collectively covers the entire visible spectrum. Chemically, the color variations are achieved by progressive substitution of *Zn* by *Cd* (cadmium) and of S (sulphur) by *Se* (selenium).

Essential, however, is the addition of much smaller amounts (0.0001-0.1% range) of specific metals, of which *Cu* (copper) is a prominent and practical example, but also including *Ag* (silver) and *Au* (gold) as "activators." Likewise useful as "co-activator" is a halogen (prominently *Cl*, chlorine) or some normally tri-valent material like *Al* (aluminum), *Ga* (gallium), *In* (indium), or rare earths. Methods of preparation also greatly influence the characteristics of a particular phosphor.

Initial testing of electroluminescent numeric readout element.



ZnS phosphors have been known for a long time for their response to cathode rays as well as to 3650 Å ultraviolet excitation. An electron beam striking the face of a vacuum tube coated with *ZnS* phosphor generates the visual image of its path on oscilloscope, radar, and TV screens. Phosphate- and silicate-based phosphors are used on the inner walls of fluorescent lamps where the exciting radiation is of shorter wavelength (2536 angstroms in this particular case).

Electroluminescence in ZnS

G. Destriau reported excitation of zinc sulfide phosphors by an electric field as a scientific phenomenon in 1936, but the light emitted was so faint that some scientists cast doubt on the existence of the phenomenon. The first practical demonstration of electroluminescence was given by *Sylvania* at the I.E.S. technical conference in 1950. This clearly demonstrated that *ZnS* is a very important material having both interesting and practical electronic and luminescent properties. Thus it is that an increased knowledge of an old and previously used material like *ZnS* has become the essential component in new solid-state light sources and devices.

It has been amply demonstrated that electroluminescence, as a phenomenon distinct from photoluminescence, is dependent on some unique structural peculiarity of the *ZnS* crystal, as well as its specific activator composition. This becomes evident from the fact that the application of thermal and mechanical stresses can be quite important in converting photoluminescent to electroluminescent phosphors. These stresses produce strains within the crystal, forcing a rearrangement of its atoms. For a brief review of the present theories of electroluminescence, refer to the boxed copy on page 26.

Light Output of EL Phosphors

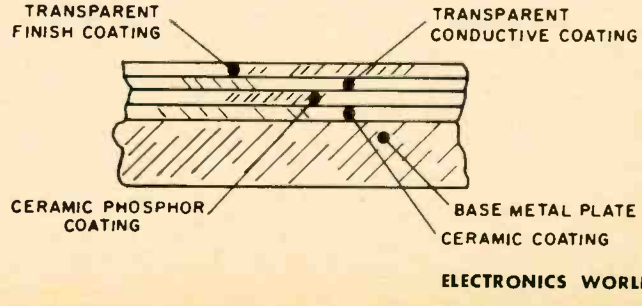
The characteristics of EL phosphors are evaluated in the laboratory in demountable cells. Such cells may present a square or circular lighted area of 2 to 3 square centimeters. The viewing side is made of conducting glass plate which serves as one electrode of the electric capacitor. The powdered phosphor (small crystals, 10- to 30-micron size) is suspended in some liquid dielectric, such as castor oil, in a ratio of 1 cc. oil to 1 or 2 grams phosphor. The bottom electrode is made of metal (brass or steel) in some convenient and substantial design so as to provide a 3- to 5-mil spacing for the oil/phosphor mixture. Both electrodes are connected to a variable frequency and voltage a.c. power supply. Voltages in the 50- to 500-volt and frequencies in the 60- to 6000-cps range permit a thorough evaluation of phosphors for both scientific and industrial purposes.

Light output can be measured with a photomultiplier detector and suitable current-reading instrument. Evaluation of the commercially significant parameter of life must be made on finished commercial products, as other factors also influence the life of the device using EL phosphors.

Design of EL Devices

Unique features of EL lamps include: (1) their being an area light source, and (2) their lack of catastrophic failure. Both features are responsible for their special applications

Fig. 1. Example of five-layer, metal-ceramic construction.



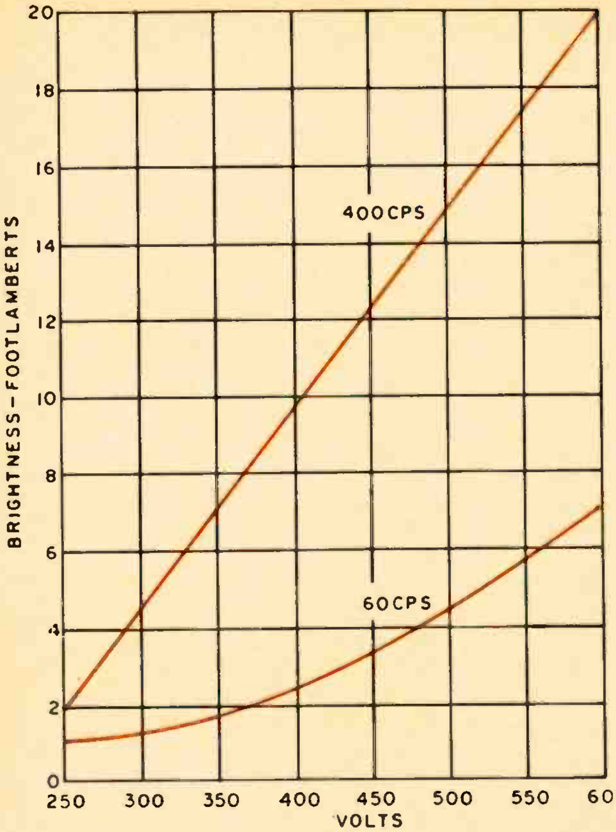


Fig. 2. Brightness versus lamp voltage for a 600-volt EL device. Note also how increasing excitation frequency raises brightness.

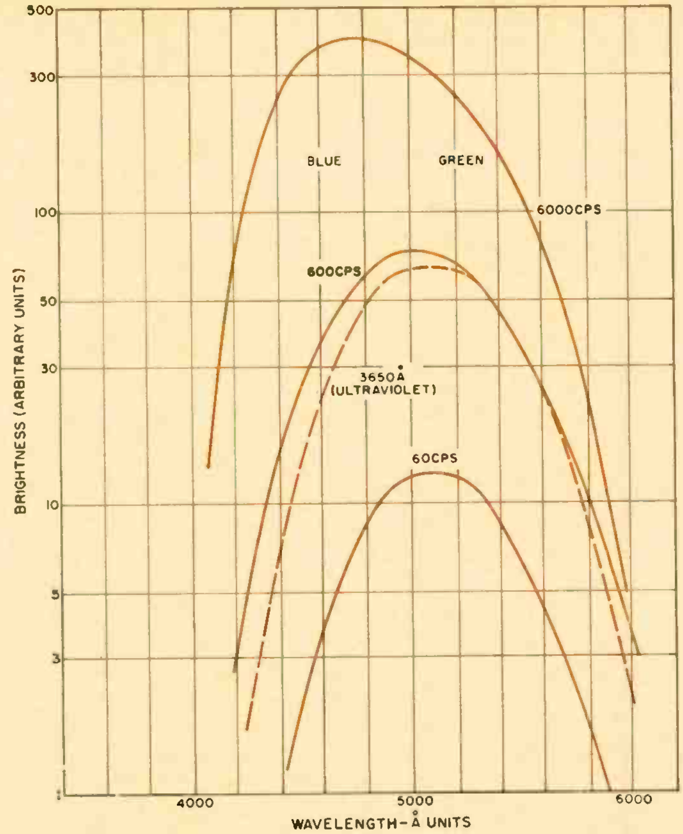


Fig. 3. Effect of frequency on wavelength distribution of the EL emission of a two-band phosphor peaking at 4600 and 5200 A.

in areas of novelty lighting, instrument lighting, and the broader field of display devices. Device applications make use of another feature of EL lamps, namely their versatility in matters of size and shape. Being light sources, their immediate function in whatever circumstances is to render something visible. This may be accomplished by reflected light, in creating a silhouette, or by its own luminosity. One thing is certain: an EL device is a solid-state light source and, as such, can be combined with other solid-state components to provide an all-solid-state system. The fact that EL light is available from luminous areas of a few square millimeters to a square meter or more, gives EL a broad application range from tiny readout lamps to very large information display boards.

The actual construction of the EL lamp is determined by its intended application. There are, at present, three types.

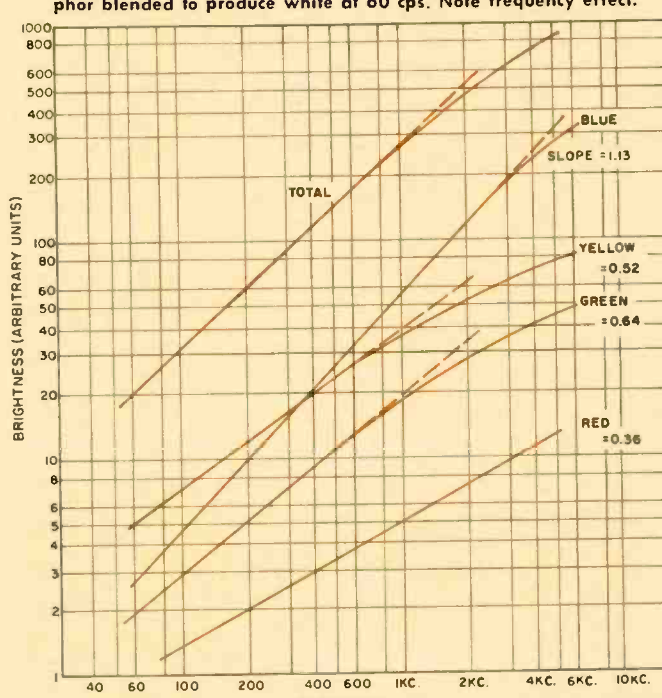
Metal-Ceramic & Glass-Ceramic Construction

The major application of the metal-ceramic construction is in lamps intended as low-level light sources. Their essential components are shown in Fig. 1. Present commercial products include: nighttime position markers (Nite Lites); switch plates; luminous background advertising items; clock faces; telephone, radio, and TV dials; automobile instrument panels; highway signs and markers; and decorative panels (in a variety of colors) for walls, ceiling, and space dividers. This lamp is of rugged construction and long life (in the neighborhood of 10,000 hours or more when operated at 60 cps). It can be made to operate in the range of 50 to 1000 volts to produce surface brightness from a few tenths to 100 footlamberts. Most current commercial units fall into these types: 120 volts, 60 cps yielding 1 to 1.5 footlamberts; 250 volts, 400 cps yielding 5 to 6 footlamberts; or 10- to 30-footlamberts range at 600 volts. By increasing voltage and frequency (*e.g.*, 600 volts, 2000 cps), brightness in the neighborhood of 100 footlamberts results. No lamp should be operated above manufacturer's ratings.

A typical brightness-voltage characteristic is shown in Fig. 2. Increasing the frequency will not harm the lamp, but unless rated for high-frequency operation, no spectacular increase in brightness may result. Fig. 3 illustrates, in the case of a particular EL phosphor, the brightness at three different operating frequencies, as well as the shift in color toward blue at higher frequencies. This is a result of the more rapid rise of output by the blue component in a two-band (blue-green) phosphor. Since phosphor life is closely proportional to operating frequency, obtaining high brightness in this manner is at the expense of life.

The designation *metal-ceramic* refers to the use of an iron

Fig. 4. Light emission in different color bands of an EL phosphor blended to produce white at 60 cps. Note frequency effect.



sheet as one electrode and the ceramic (low-melting-point glass) phosphor embedment material in its construction. A second ceramic layer can be placed between the iron plate and phosphor layer. The second electrode should be transparent. It is applied in the form of a conducting tin-oxide layer sprayed onto a thin glass layer over the phosphor layer, which is, in turn, usually covered by a second glass layer for moisture, mechanical, and electrical protection. Special spraying techniques for forming thin and uniform layers have had to be developed by manufacturers of EL units, and for sintering glass frits into transparent glass layers. The active phosphor layer of such lamps varies from about 2 to 8 mils depending on rated operating conditions.

For space lighting applications, special blends of blue, green, and yellow phosphors have been incorporated into lamps for producing various tones of white light. Fig. 4 shows the frequency response of such a white blend designed for 60-cps operations (voltage affects color in only a minor manner).

The various slopes for the different color components, as described previously, cause a decided color shift in emitted light when a lamp is operated at different frequencies.

Besides the metal-ceramic makeup, glass-ceramic construction is also employed.

This is the construction favored for lamps used in display applications, since it provides a flat surface for displaying information. In it, the active phosphor layer is placed directly on the conducting surface of the glass plate without an intermediate ceramic layer. This decreases the diffusion of light within the lamp and leads to sharper readout patterns. Finally, the back electrode is advantageously made of an evaporated metal film which adapts itself to segmentation for the purpose of applying voltage to selected localized areas of the lamp. This is done by vaporizing the back electrode through appropriate masks. These lamps are normally made to operate at 250 volts and 400 cps to produce an over-all brightness of approximately 10 footlamberts.

Flexible Plastic Construction

In this type of construction (see this month's cover), the initial electrode is again of metal; normally a thin aluminum foil. It is first coated with a thin uniform layer of white high-dielectric material, followed by a mixture of phosphor in a high-dielectric organic material (*Continued on page* 76)

REVIEW OF PRESENT THEORIES OF ELECTROLUMINESCENCE

A ZnS crystal consists of alternating layers of zinc and sulfur atoms. Much lower fields (factor 10 or more) are required to produce light when the field is applied parallel to these layers. Since high conductivity also exists parallel with the "easy" EL direction, light emission in this direction is evidently dependent on the flow of external electrons. In the perpendicular direction (called the **c-axis**) light emission involves displacement of electrons already present in the crystal. An EL crystal thus seems to emit light by two mechanisms: (1) low-field/high-current for a field parallel to atom layering or perpendicular to crystal c-axis, and (2) high-field when the field is perpendicular to the layering.

This directional dependence or anisotropy (different properties in different directions) has been explained by the author as resulting from an isolated atom displacement disorder. Such a disordering of the otherwise regular repetition pattern of Zn- and S-atoms of the ZnS crystal causes a sulfur atom to move under the influence of local strains into a nearby and alternate (but unoccupied) position of the crystal lattice. As a result, a covalent chemical bond (electron pair) by which this displaced sulfur atom was attached to one of its normal four Zn-atom neighbors has been broken. The geometry of the immediate site, after creation of this disorder, is such that a single charged copper ion (Cu^{+1}-ion) can be exactly fitted into the space next to the broken band on the displaced S-atom. This "quasi"-free Cu^{+1}-ion restores a more normal local energy situation.

This seemingly trivial matter of moving an isolated S-atom for a very short distance of about 4 A (angstroms) to a neighboring site, followed by entry of a Cu^{+1}-ion adjacent to it, provides a model useful for developing the details of a light-emission mechanism from an entirely different viewpoint than previously attempted.

Energy-Band Model

ZnS crystals are typical "wide-band-gap" semiconductors, and previously proposed theories have been based largely on energy-band-gap models. The band gap of ZnS is 3.76 electron volts (ev.). This means that energies of this amount are required to excite electrons associated with atoms on lattice sites of the crystal (**valence band**) to the **conduction band** where they may move for a very short time about the crystal as "conducting" electrons. Activators in a ZnS phosphor add new levels in the "forbidden" gap of ZnS at levels up to 1 ev. above the valence band. Since light absorbed by the activators is normally of shorter wavelength (higher photon energy) than that emitted, the phosphor has served as a wavelength or color converter. In the case of the ZnS:Cu-Cl EL phosphor most widely used, absorption of 3650 A leads to emission of two wide bands: the blue peaking at about 4600 A and the green peaking at about 5200 A. These represent electron transitions of 2.70 and 2.4 ev. between activator levels and trap levels a few tenths of an electron volt below the conduction band.

Collision-Ionization Theory

Although satisfactory for the description and calculation of photoluminescence phenomena, the energy-band model has not been able to treat all of the features of electroluminescence. Mainly there is the question of how the energy of the electric field, applied to lamps at levels of 50 to 100 volts per mil, is transferred to the phosphor to cause light emission. Even if the prime characteristic of electroluminescence is just a special mechanism for triggering off photoluminescence which then proceeds via the **collision-ionization** mechanism commonly accepted in electroluminescence theory, the question of the source for initial electrons remains. They do not seem likely to be created by **direct-field ionization** of luminescence centers because this will require fields acting on individual Cu activator atoms, e.g., to produce blue emission, in excess of that generally available by a factor 2280 in case of a 1-mil-thick device operated at 120 volts. To produce blue emission, energy in excess of 2.7 ev. must be applied across a Cu-atom of 2.7 A diameter representing a field of 1 volt/A or 10^8 volts/cm. The available field is actually only 4.4×10^{-4} volt/A. Concentrating the 120 volts available into a very small fraction of the active layer thickness; e.g., 120 A will produce a field adequate for direct ionization for purpose of supplying the initial electrons, which are then accelerated to velocities sufficient to collision-ionize other centers. The assumption of the existence of such barriers has been a prominent feature of previous EL theories. The field-release of electrons from donors or from traps a few tenths of a volt below the conduction band has been proposed in order to account for the release of electrons at low values of field intensity.

Atom-Ion Pair Model

It is also possible to explain the above-mentioned anisotropy of EL emission by the isolated atom displacement model. Its essential feature is that in the EL center there exists an atom-ion pair oriented with its join line perpendicular to crystal c-axis. EL emission results when an electron oscillates between the atom and ion in phase with an a.c. field.

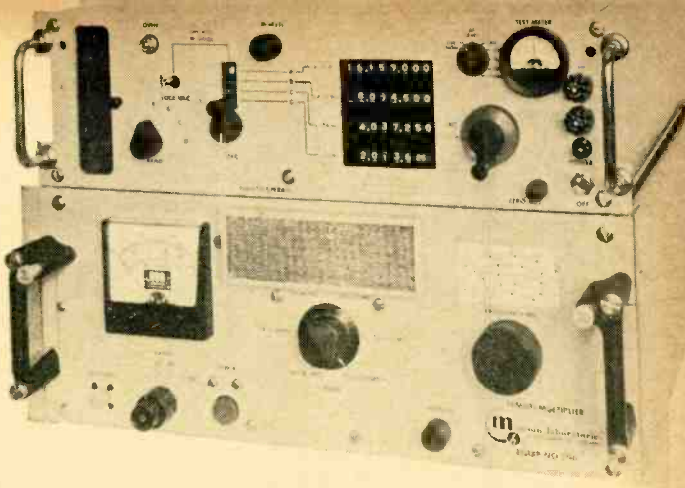
The extent to which this electron exchange process produces light directly by optical transitions and indirectly by virtue of furnishing electrons which escape the center into the surrounding host crystal, where on acceleration they ionize normal photoluminescence centers, is still unknown. Assuming the essential correctness of the EL-center model, the chemical entity of the atom-ion pair will determine the color of EL emission. If some electrons escape from the center to trigger off the characteristic photoluminescence of the host crystal, the light emitted will be a composite of the output of the two mechanisms involved.

EL and Photoluminescence

The close similarity of some bands of light emitted by an EL phosphor under ultraviolet light and field excitation has long been a point of interest which, on the basis of the model, indicates that a substantial portion of electrons from the center do escape to the surrounding crystal, especially at low frequencies. However, as frequency increases, the number of electrons escaping the center will decrease, confining light emission more and more to the primary EL mechanism, with less from the host crystal. That this does happen receives support from the known frequency characteristics of the widely used blue-green ZnS:Cu-Cl EL phosphor. Here, the blue component emission increases steadily with frequency and at a much faster rate than does the green component. Further, green emission soon reaches a plateau. In line with the theory, the blue component is the prime EL emission generated by the EL center; while green is photoluminescence originating at luminescence centers of the surrounding crystal.

Attempts to convert yellow photoluminescent phosphors to EL phosphors have revealed that frequently any EL emission created is blue. Most EL yellow phosphors contain a blue component. In this case, electrons do not escape to yellow centers in the surrounding crystal. The study of EL phosphors in the laboratory is thus a very essential step in the development of commercial EL lamps.

Frequency Synthesizers



Commercial frequency synthesizer (top) is often used with an external frequency multiplier (bottom) to increase range.

By IRWIN MATH / Engineer, Manson Labs. Inc.

Using a highly stable crystal oscillator with a harmonic generator and phase detectors, it is possible to create a very large number of frequencies with extreme accuracy.

IN highly precise communications systems, astro-navigational systems, and various types of research and development projects, the generation of wide ranges of accurate, stable frequencies is an absolute necessity. To produce such frequencies, with stabilities of 0.01 cycle drift per day at 1 mc., for example, requires the use of special equipment known as frequency synthesizers. Basically, these devices combine the excellent stability of fixed crystal oscillators with the flexibility of variable frequency oscillators (v.f.o.'s) to produce a highly stable, accurate, wide range of frequencies.

At the present time there are two major ways to synthesize or generate highly stable frequencies. One of these, the direct method, is to add or subtract frequencies obtained from a standard oscillator. Fig. 1 shows such a system. A highly stable crystal-controlled oscillator produces some standard frequency, let us say 100 kc. This signal is fed to a harmonic generator such as a class C amplifier, where 100-kc. multiples of the original signal are produced. By simple switching techniques, various harmonics are made to mix with themselves and the original 100 kc. with the resulting sum-difference furnishing the desired frequency. For example, suppose that 600 kc. is desired. The 900-kc. and 300-kc. signals are mixed and the difference frequency, 600 kc., is taken from the mixer. This system is quite simple. However, to obtain wide frequency coverage in small increments, many circuits are required and the equipment becomes quite bulky.

Although direct frequency synthesizers are produced today, the more commonly used technique is the indirect one. In this system, a wide-range v.f.o. is phase-locked to the standard oscillator over its (*Continued on page* 56)

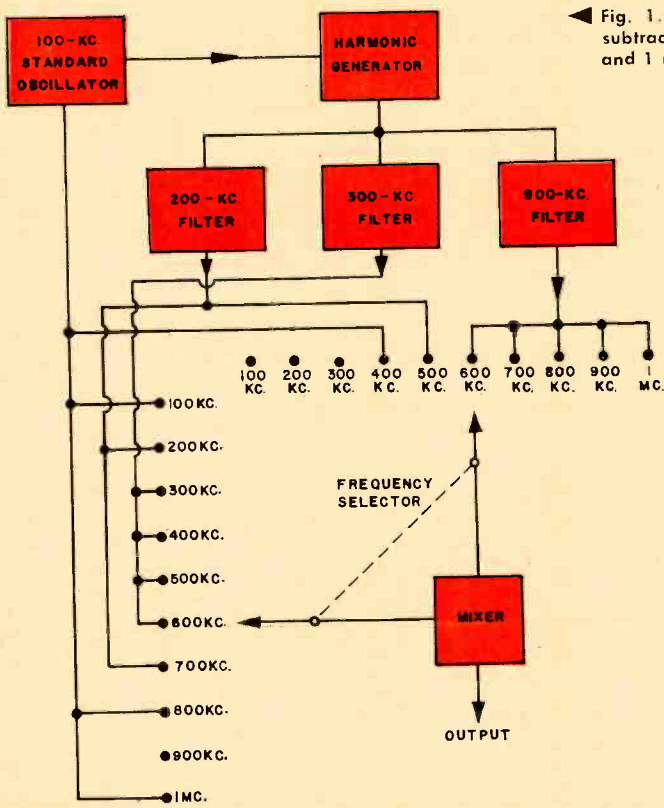


Fig. 1. Simple, direct frequency synthesizer. By adding or subtracting various frequencies, the range between 100 kc. and 1 mc. can be covered in 100-kc. crystal-controlled steps.

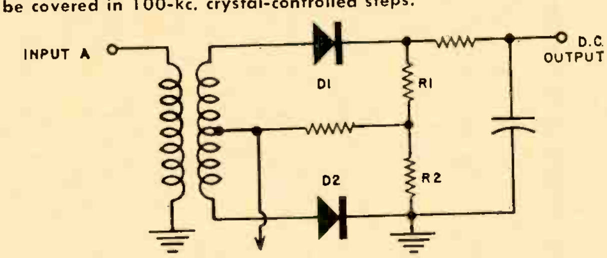
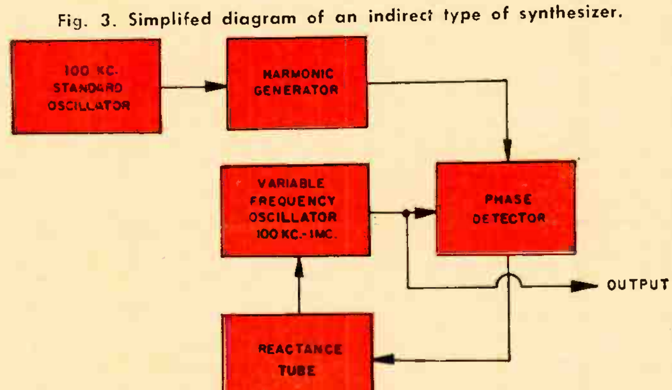
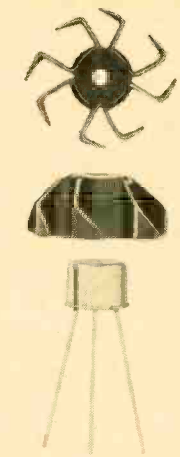


Fig. 2. Simple type of frequency discriminator as used in TV.

Fig. 3. Simplifed diagram of an indirect type of synthesizer.

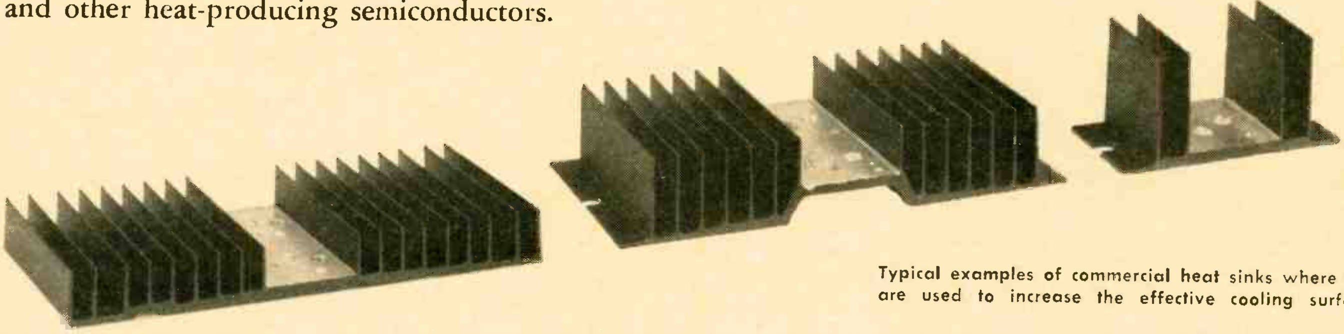


SEMICONDUCTOR HEAT SINK DESIGN CHART



By FRANK D. GROSS

Simple method of determining how large a heat sink area is required for SCR's and other heat-producing semiconductors.



Typical examples of commercial heat sinks where fins are used to increase the effective cooling surface.

HEAT sink information seems to be rarely, if ever, in a usable form, particularly for SCR and other switching circuits. This nomogram directly relates the load an SCR is controlling to the required heat sink area. The nomogram may be extended to apply to any semiconductor.

The heat produced in an SCR is caused by two factors; namely, a brief power pulse during turn on, and the continuous power loss due to the forward drop of the *p-n-p-n* junction. In all power frequency circuits (1 kc. or less), the turn on of the SCR is so fast that only the forward drop need be considered. Put another way, the duty cycle of the turn-on power pulses is very low. The heat produced by the SCR due to forward drop loss is given by $P_{loss} = V_f \times I_{load}$ where V_f is the forward drop which varies with the load current but never exceeds 1.1 volts when the SCR is run within its continuous power rating. Let us make the conservative assumption that the forward drop is always exactly 1.15 volts and that the SCR is on all the time (or half the time in a half-wave circuit). This means we can assume that the power loss in an SCR is equal to 1% of the maximum load power since the load power is given by 115 I_{load} and the forward loss is assumed to be 1.15 I_{load}. This is strictly a worst-case assumption as the power loss will be considerably less when lower conduction angles (less load power due to speed or brightness setting) are chosen.

Heat transfer is accomplished in two ways by the heat sink: convection and radiation. Convection is almost always the stronger of the two transfer mechanisms. Radiation is very much a function of the color and roughness of the heat sink surface and can approach zero for a smooth, highly polished surface. Convection is independent of these parameters. Let us make a second assumption that all of the heat transfer is provided by convection. Again, this is a worst-case assumption.

The physics book says that $Q = H_c \times A \times \Delta T$ where Q is watts of heat transferred by convection, H_c is convection transfer constant, A is surface area, and ΔT is temperature difference between ambient and heat sink.

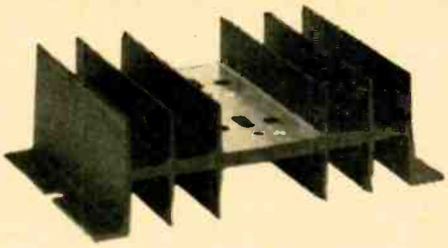
H_c is a constant of heat transfer which is given by $H_c = .0022(L/\Delta T)^{1/4}$ where L is the vertical length of a square metal plate in inches and T is the temperature difference in degrees centigrade between the plate and the ambient air.

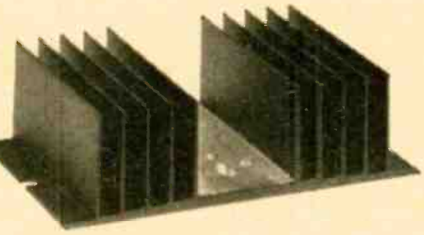
An SCR is capable of safely operating at case temperatures that can cause serious burns to humans. In any SCR control, consideration should be given to what the operator or user of the equipment can stand and not to the ultimate temperature damaging to the SCR. This is especially true in small dimmers and power-tool controls where the case doubles as a heat sink. Operation at heat sink temperatures safe to humans allows the SCR to run well within its ratings, enhancing circuit life and reliability.

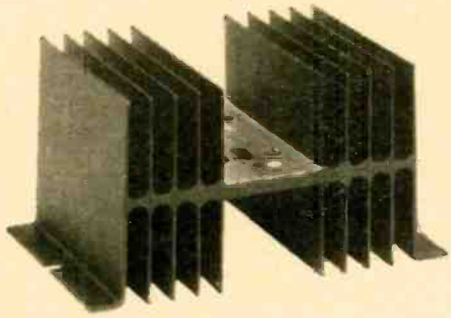
A metal plate at 140°F (60°C) may be described as alarmingly hot. No burn damage will occur, but substantial will power is required to hold onto a metal plate at this temperature. Above this temperature, the probability of a burn rapidly increases. A choice of 55°F (13°C) of allowable temperature rise permits the heat sink to stay below the critical temperature for any ambient temperature below 85°F. This is quite reasonable for most SCR applications. The heat sink is normally well below this design temperature except during full-on operation.

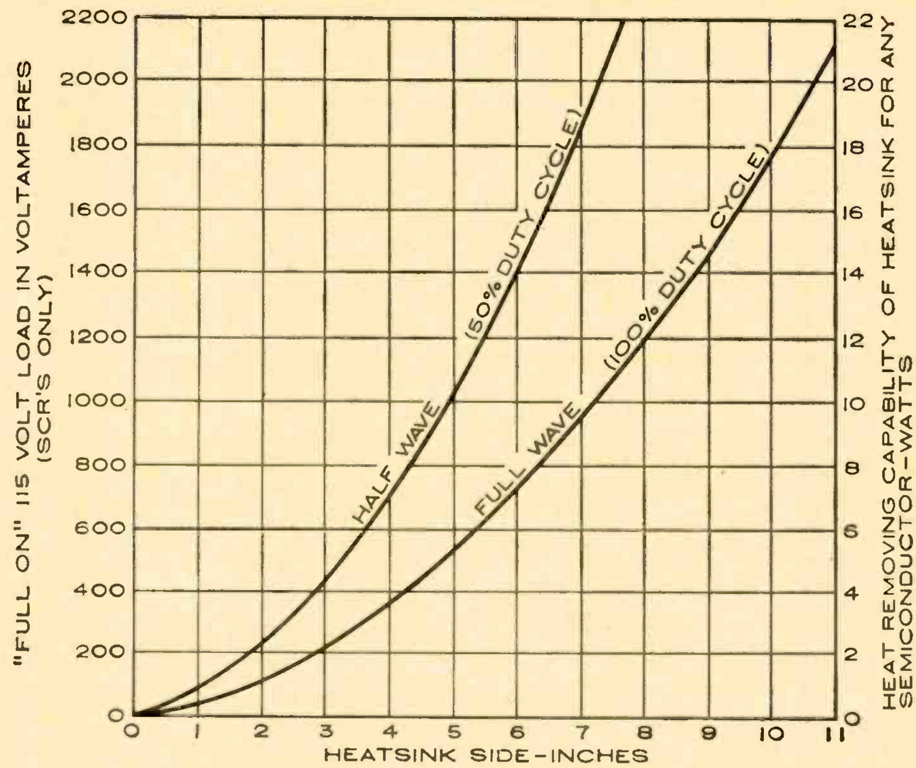
The geometry assumed for the nomogram is a vertical, square, ⅛-inch thick piece of aluminum with both sides exposed to the cooling air. A minimum clearance of 1½ inches on either side is assumed. It is also assumed that there is no obstruction to ambient air either above or below the heat sink. A bit of thought will allow this geometry to be distorted into any heat sink geometry required for a specific application.

Generally, the nomogram will give quite conservative re-









These curves will give a 55° F. (13° C) temperature rise of the heat sink above room temperature when using a square, vertical 1/8-inch aluminum plate with a minimum of 1 1/2 inches of side clearance and unobstructed top and bottom access to ambient air. The heat sink may be any color as long as any coatings used on the aluminum are as thin as possible.

sults, *e.g.*, the heat sink temperatures will be less than predicted.

If the SCR is used in a half-wave circuit (or a full-wave circuit in which the alternate half cycles are conducted by a diode or other SCR), only half the normal SCR power is produced since the SCR is only on half the time. Because of this, a heat sink of one-half the area (or a square of .707 *L*) is required.

If only one side of the heat sink is available to the cooling air, then twice the required area (or 1.41 times each side) must be used.

Actually, the nomogram is simply a plot of how many watts a heat sink can transfer and is by no means limited to SCR's. Any semiconductor or, for that matter, any heat producer will provide the same results.

If higher heat sink temperatures are permitted, the reduction in area is proportional to the allowable temperature rise. For instance, if a 110°F rise is permitted, only half the required area for the 55°F case is needed. If higher temperature operation is used, the SCR *must* have a very low thermal resistance to the heat sink. This means that at most a thin mica or anodized-aluminum insulating washer may be placed between SCR and heat sink. The use of silicone grease is mandatory in this case.

Here are some examples that show nomogram use.

1. How large a two-sided heat sink is required for a 1-kw., 115-v.a.c. light dimmer using an SCR in a half-wave circuit?

Answer: The 1000-va. line is followed horizontally across the nomogram till it intersects the half-wave curve. The required size is read vertically downward. The answer is five inches square.

If only one side of the heat sink has access to cooling air, the same area is still required. The area is $2 \times 5 \times 5 = 50$ in.^{2} This is equal to a one-sided square slightly over seven inches on a side. The area need not be calculated if you are using a square geometry. Simply multiply the original side by 1.41, or in this case $5 \times 1.41 = 7$ inches.

2. How large a heat sink is required for a bilateral SCR operating a 2.2-amp. electric drill as a power-tool control?

Answer: The drill voltampere rating is given by $115 \times I$ or $115 \times 2.2 = 253$ va. Following the value horizontally to the full-wave curve and reading downward gives 3½ inches square.

3. Two SCR's are used as a contactor for a 115-v.a.c., 1-h.p. induction motor, both mounted on the same heat sink. What size is required?

Answer: Two half-wave SCR's are the same as one full-wave one, so the full-wave curve must be used. The voltampere load of the motor must be found. One horsepower equals 746 watts. The efficiency of the motor at full load is probably above 90%, and the power factor is most likely to be .8 or better. The voltamperes drawn are then equal to $746/(.8)(.9) = 1036$ va. An 8-inch heat sink is required.

4. A germanium transistor is used in a 400-cps static inverter that draws five amperes from a 28-volt d.c. line. As the circuit is push-pull, the transistor is only on half the time. What size heat sink is required?

Answer: The low frequency of the inverter allows us to assume that most of the heat produced is during the conduction or on time and that we may neglect switching-power losses during on time. The saturation voltage may be found on the transistor data sheet, or it may be assumed to be less than .3 volt. The heat produced is then equal to 5 amps × 3 volt = 1.5 watts. Since the transistor operates on a 50% duty cycle, .75 watt of heat must be continuously removed by the heat sink. The right ordinate of the nomogram and the full-wave curve are used to give an answer of one inch. As this is quite small, it might be better to consider a larger value to account for turn-on losses and starting transients. Three inches would be a good choice. ▲

LOSS FIGURES FOR 300-OHM TWIN-LEAD

By MARK L. NELSON

Catalogues usually give the characteristics of 300-ohm transmission lines in free space. These figures will change considerably when used in actual installations.

ALMOST every TV antenna in the country uses 300-ohm twin-lead for the transmission line. These transmission lines are installed with procedures that time and experience have shown to be best. Other than experience, however, what do we really know about 300-ohm lines? What effect do water, metal, or close proximity to wood or the earth itself have on 300-ohm transmission lines?

The only published figure the author found stated that the 300-ohm flat transmission line has a loss of 1.7 db per 100 feet at 200 mc. (Ch. 11 = 198-204 mc.). Taken quite literally, this means that a 200-mc. signal would travel through 353 feet of 300-ohm twin-lead before losing 6 db, or ½ of its original voltage. This is quite an achievement for such a low-cost transmission line. For all practical purposes, though, this figure is useless because it is a computed, free-space loss that is not valid in actual practice.

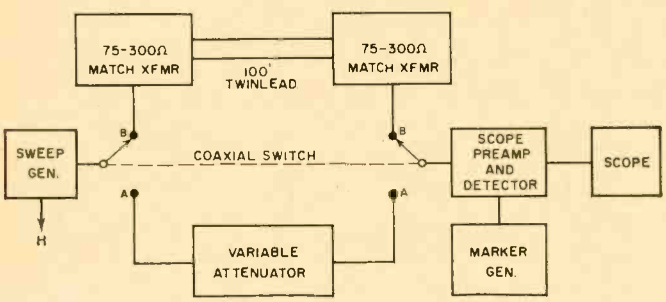


Fig. 1. Test setup for determining the characteristics of typical 300-ohm transmission line under various conditions. Sweep generator "H" output drives scope horizontal circuit.

Lacking any further information, it was decided to find out exactly how good 300-ohm twin-lead is and the extent to which various practices affect its transmission qualities.

Fig. 1 shows the test setup used to sweep the twin-lead over the TV frequencies of interest (54-216 mc.)

The loss of the line at different frequencies, and under different conditions, is determined by adjusting the variable attenuator until the detected outputs of path *A* and *B* are equal as observed on the scope.

Using the test setup shown, a group of tests was made to determine loss *vs* frequency. The 300-ohm transmission line used in these tests was 100 feet of *Belden* No. 8225.

Test 1. 100 feet of twin-lead was routed along a wooden wall, simulating a normal installation with 3½" screw insulators every ten feet.

Test 2. 50 feet of twin-lead was supported with insulators and 50 feet of twin-lead was stapled with Romex staples across the line. Staples were placed five feet apart.

Test 3. 100 feet of twin-lead supported by wooden blocks was placed just above ground level. Distance above ground was three feet at wooden supports and two feet at mid-span between blocks.

Test 4. 100 feet of twin-lead was lying on the ground.

Test 5. 100 feet of twin-lead was installed as in Test 1 with the twin-lead running through a three-foot section of aluminum weather stripping.

Test 6. 20 feet of twin-lead was soaked in water for two hours. The results were multiplied by five to obtain the figures for 100 feet of line.

From the preceding experiments, the results shown in Fig. 2 were obtained. (The figures take into consideration the matching losses from the matching transformers.) ▲

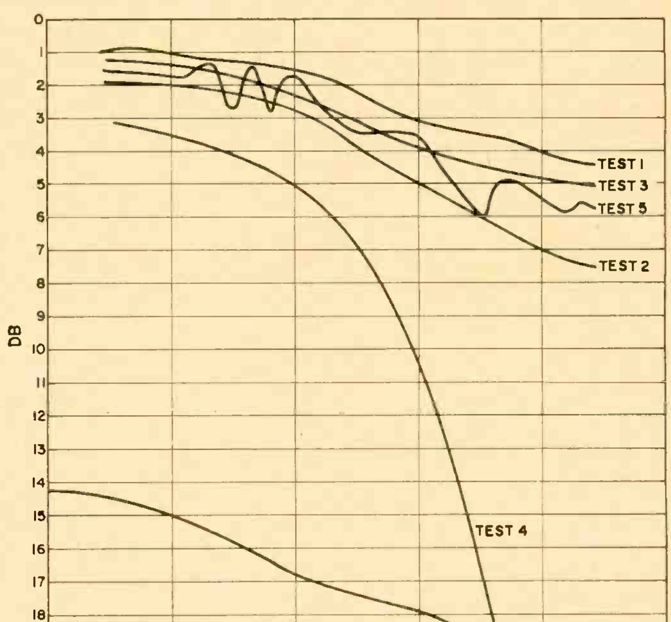


Fig. 2. Results of six tests made on typical 300-ohm twin-lead.

Test No.	54 mc.	108 mc.	162 mc.	216 mc.
1	1.0 db	1.5 db	3.0 db	4.0 db
2	2.0 db	2.75 db	5.0 db	7.0 db
3	1.3 db	2.3 db	4.0 db	4.9 db
4	3.5 db	5.0 db	10.5 db	>20 db
5	See graphical representation of scope response			
6	15 db	17 db	18 db	21 db

6 db = 2x or ½; 12 db = 4x or ¼; 20 db = 10x or 1/10 voltage

NOISE PERFORMANCE OF TRANSISTORS IN AUDIO CIRCUITS

By W. A. RHEINFELDER / Director, Research & Development, Ameco, Inc.

Results of testing a large number of different transistor types show that germanium-alloy transistors are quieter than tubes. Included is design of low-noise phono preamp.

THERE are various methods of specifying transistor noise but for audio applications, these tests are often meaningless. For this reason, a more suitable testing method was developed and used on various transistor types, specifically on germanium alloy, germanium mesa, and silicon mesa transistors. The tests clearly indicated the superiority of germanium alloy for low-noise audio applications.

In conjunction with these noise tests, a high-quality phono preamplifier was developed. Complete performance data on this unit will be given in this article.

Methods of Testing Audio Noise

In order to evaluate transistors for noise performance in the audio-frequency range, various methods have been used. A simple test would be to determine the spot noise figure at 1 kc. This procedure may be extended to other frequencies in order to find a possible rise toward lower frequencies due to low-frequency noise (flicker effect). It is in this fashion possible to obtain noise-figure readings over much of the audio range. However, noise figure is rather meaningless at audio frequencies because of the irregular spectral density of signals as well as noise in the audio-frequency range.[1] Since the noise figure is very much a function of the complete circuit, including input matching, the reading must of necessity change with emitter current and frequency even though the noise generated in the transistor might be constant. Noise figure does not become a useful tool except at frequencies of about 100 mc. and higher.

An alternate procedure determines the equivalent voltage and current noise generators for both open- and short-circuited input at one particular frequency and d.c. condition. While this is a rather useful approach, being independent of the circuit, theory shows that a total of four noise parameters is needed to specify a noisy four-pole network. With transistors, an approximation using two parameters (two noise generators) would be permissible at audio frequencies. However, this data must be made available in the form of curves for different d.c. conditions and frequencies in order to be of use to the designer.

Even if graphs of this sort were made available by the transistor manufacturer, these curves would be of small advantage because of the limited number of noise specialists familiar with their use. There is another reason why spot noise data is of limited value. This is because of the rather non-uniform noise distribution, particularly at low frequencies. One might also think that measurements taken with a bandwidth equal to the complete audio range, rather than spot frequency measurements, might lead to useful data. While such information is more meaningful, it still leaves something to be desired because of the very nature of audio signals as well as the different applications of the audio preamplifiers.

For example, since the peak power of music occurs at 300 to 1000 cps, with the power level down to approximately one-hundredth at frequencies of 10 kc., it is obvious that the limits of signal-to-noise ratio vary considerably. In order to improve conditions in recording and other transmission systems, it is desirable to pre-equalize sound so that a nearly constant power level is recorded or transmitted. This is called constant-amplitude or flux recording or transmission. It is also called pre-emphasis when used in FM broadcasting. In playback or reception, an inverse characteristic is used to restore natural tonal balance. This, of course, greatly affects the noise characteristics of playback equipment. In the best circuits this equalization is achieved by negative feedback which takes place after the noise producing stages (input stage), thereby affecting noise simultaneously with the signal and leading to a reasonably constant signal-to-noise ratio throughout the audio range. It is therefore possible to measure directly, with a wideband meter, the noise level of such a correctly equalized preamplifier. A reading thus obtained is called "weighted noise," weighted according to the particular equalization used.

Major audio applications where low noise is important include: phonograph and magnetic tape preamplifiers and microphone and instrumentation amplifiers. The responses of the first two circuits are very similar and, since all equalization is in a single feedback network, it is an easy matter to change from one response to the other. Because it is of greater general interest, the circuit with the standard RIAA phonograph equalization was used to test transistors for low audio noise.

The other circuits have a flat or other undefined response and can be represented by changing the feedback network to a flat characteristic. Therefore, measurements taken for these responses should suffice to fully characterize a transistor as to noise performance. The great advantage of this direct method of testing arises from the fact that the available figures are immediately meaningful to the designer of low-noise transistorized audio circuits.

Other forms of weighting such as for loudness, de-hissing, etc. are sometimes used. However, these weighting methods are not useful for low-noise design or measurements since they affect the signal simultaneously, therefore leaving the signal-to-noise ratio unchanged.

Test Circuits & Performance Data

As was to be expected, preliminary tests indicated that the second stage of the two-stage circuit used (Fig. 1A) has little influence on the noise output of the whole amplifier.

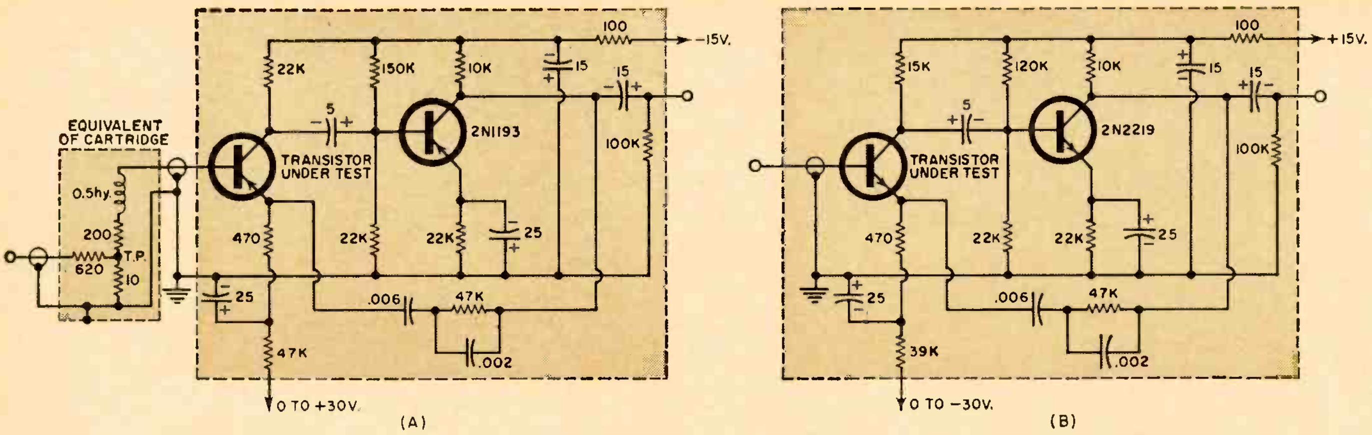


Fig. 1. Audio noise test circuits used for (A) "p-n-p" and (B) "n-p-n" transistors. The second transistor has little effect on noise.

Therefore, this transistor was permanently installed and uses fixed bias which was optimized for lowest distortion. Due to the large amount of negative feedback, no critical transistor selection is needed in this stage.

The first stage uses adjustable bias with a separate emitter supply. The input is simply shorted for noise measurements. There is virtually no difference in noise when a phonograph cartridge or its electrical equivalent is substituted in this circuit, except for magnetic hum pickup which would have to be carefully removed. After a current adjustment the circuit should be allowed to recover for a while before noise is read. This time is needed to stabilize all voltage levels in the circuit and permit the capacitors to accept full charge.

Equalization is accomplished by feedback from the second collector into the first emitter. The loop factor has been optimized throughout the circuit. This also results in the least noise. Only the three components of the feedback network need to be changed for the different characteristics. The components might be assembled in the form of a plug-in network if desired. All resistors are low-noise, deposited-carbon types and all electrolytics should be selected for low leakage current (tantalum types).

A separate circuit (Fig. 1B) was constructed for *n-p-n* transistors. A few changes were made for optimum loop factor and optimum bias for the second stage. The response is identical because of the unchanged feedback network.

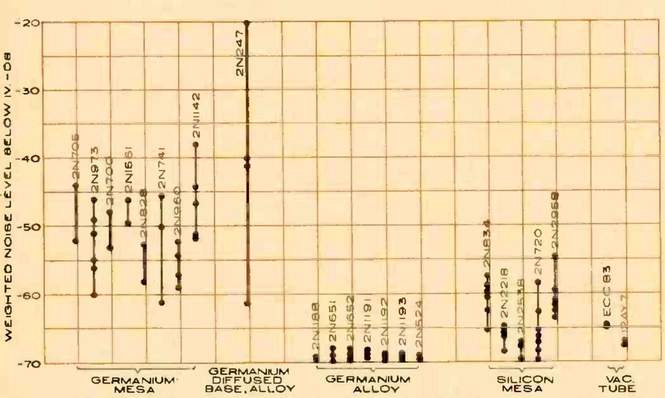
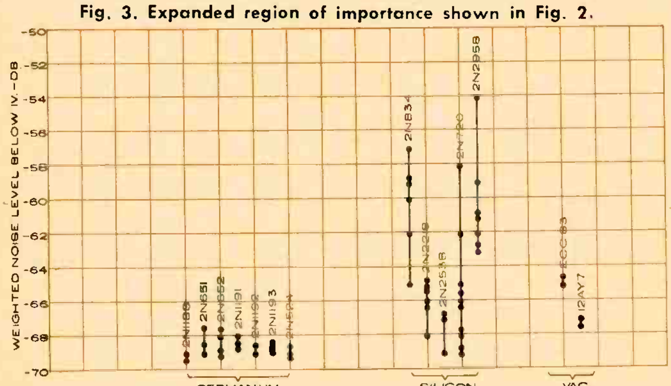


Fig. 2. Audio noise of transistors and tubes as measured.

Fig. 3. Expanded region of importance shown in Fig. 2.



In testing transistors or tubes for audio noise, it is important to distinguish between the two different types of noise, as indicated by the output meter. One reading concerns the average value of noise. This reading is obtained by averaging the readings of peak-to-peak excursions. This reading can be obtained easily by using a meter with a long-discharge time constant. The other important audio noise property involves specifying a typical maximum peak-to-peak excursion which should occur in a given time interval. Obviously a unit with low average noise may still be objectionable if it has a high peak-to-peak noise value. Peak-to-peak ratio can be read with an oscilloscope or a short-time-constant meter (fast attack and release). A *Ballantine* Model 310A was used since it presents a reasonable compromise among these conflicting requirements and approaches the damping characteristics of a vu meter, making it suitable for noise measurements in the audio range.

Performance

Performance of typical transistors tested is shown graphically in Fig. 2 and expanded for the better transistors in Fig. 3. The number of dots indicates the number of devices tested, except for vacuum tubes where a typical spread is plotted. Because of the limited number of transistors tested, these results should be used with care. Of the transistors tested, the best were germanium-alloy transistors followed by silicon mesas. The least suitable were germanium mesas or diffused-base types. Germanium-alloy transistors excelled on these three points: average noise, peak-to-peak noise, and spread between units. Hence chances are best for obtaining a low noise unit with a germanium-alloy transistor.

In the next best device, the silicon mesa (see Fig. 3), a wide variation exists among units. Peak-to-peak excursion was also higher on most silicon mesas. They were decidedly inferior in this application to germanium-alloy transistors. However, with careful selection it is possible to pick some silicon mesas that will perform as well or nearly as well as germanium-alloy transistors. Such "hand picking" is important in applications where silicon must be used. Because of the large spread, future production technology may improve such noise characteristics. Only 16.5% of the silicon units tested had a noise level better than −67 db below 1 volt, compared to 100% of the germanium-alloy units. For better than −68 dbv, the figures were 8% for silicon and 85% for germanium. The optimum emitter current for all transistors tested was from 300 to 600 microamps and is not critical.

For comparison, figures for vacuum tubes are also shown. Because of their extremely high input resistance (5000 megohms), vacuum tubes have a high noise figure with normal source impedances. For inductive sources the inductance is limited to approximately 0.5 henry in high-quality applications for reasons of frequency response. This results in a far from optimum mismatch with tubes. In transistor circuits with feedback, optimum mismatch is more nearly achieved.

Low-Noise Phonograph Preamp

Fig. 4 shows a low-noise transistorized phono amplifier. Two common-emitter stages are used with feedback from the output (collector of second stage) to the emitter of the first stage. The feedback network is designed to provide the necessary equalization. In this particular example RIAA equalization was chosen, but other equalizations may be obtained by changing the feedback network. All bias values were optimized for least noise and the output stage for lowest distortion.

Generally, it is advisable to keep local feedback down and the over-all feedback up. This results in lowest noise and distortion. Local feedback is still present in the first stage due to the unbypassed 470-ohm emitter resistor, which is used for connecting the over-all feedback loop. A smaller emitter resistor may be used; however, care must be taken that the feedback network (which is then also smaller) does not produce excessive parallel loading of the output stage. The circuit is such that maximum feedback is obtained at high frequencies, thereby reducing the output impedance and increasing the input resistance. At 10 kc. the feedback is about 30 db, which gives an input resistance of about 350,000 ohms and input capacitance of less than 10 pf. Although the output impedance is low, most amplifiers with voltage feedback have a Nyquist point[2] with capacitive loading. A Bode[3] step network ($R2$ and $C3$) in the output corrects this deficiency. It is one of many possible correction networks.

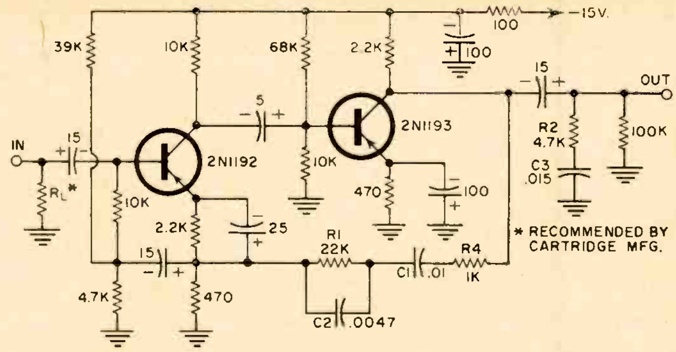
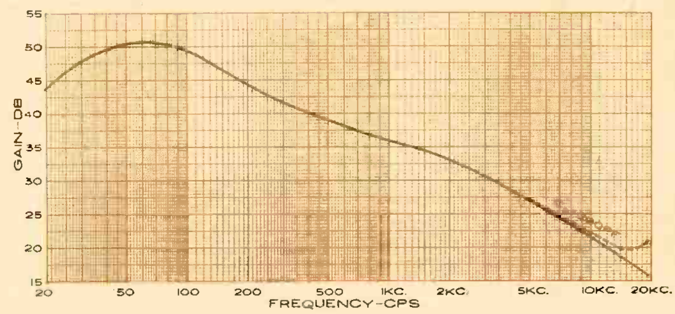


Fig. 4. Low-noise phono preamplifier employing RIAA equalization. All capacitance values are in μf. Electrolytic types are shown with polarity signs; voltage ratings need not exceed 15 volts.

Fig. 5. Response of phono equalizer is within 0.5 db of RIAA curve. Circuit is unaffected by source inductances up to 1 hy. and only slightly affected at high end by high shunt capacitance.



While it is possible to achieve a lower noise level with certain transistors than with vacuum tubes, a serious problem with transistors is their much smaller output capability. It has been demonstrated that the peak power of certain percussion instruments (including piano) reaches 30 db above the average level. For high-fidelity application these peaks must be preserved. With a normal preamp output of about 0.5 volt, this calls for an overload level above 16 volts (24 dbv).

Feedback cannot cure overload because feedback ceases when overload occurs. Local feedback of the second stage caused poorer over-all performance. It seems that the only way to get larger overload levels is to use a higher supply voltage. In the amplifier of Fig. 4, this was not done so the circuit could operate from a single 15-volt battery. The overload level occurs at +13 db above 1 volt, compared to +26 dbv for a high-performance tube circuit. The noise level for the transistor amplifier is −76.5 db below 1 volt (against −70 db for the tube version). Both amplifiers had identical gain (about 36 db).

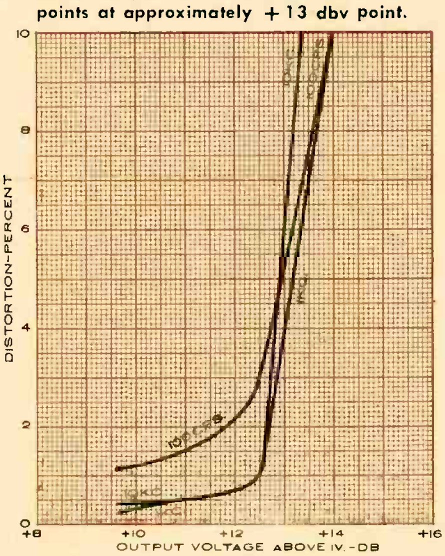
In order to obtain a better overload-to-noise ratio the gain of the transistor amplifier might be reduced by increasing the feedback. A greater amount of feedback is desirable for lower distortion, but must be limited at the high-frequency end by $R4$ to keep the number of Bode networks required within reason. Optimum gain for each cartridge and sound system is different so individually designed networks are needed. Typical values are given in Table 1.

The optimum values for $R2$, $C3$, and $R4$ are best determined by a square-

Table 1. Values of equalization networks for different gains.

R1	C1	C2	GAIN	R2	C3
22k	.01 μf.	4700 pf.	36.6 db	4.7k	.015
12k	.02 μf.	8200 pf.	32 db	——	——
6.2k	.047 μf.	.017 μf.	27 db	——	——

Fig. 6. Harmonic distortion of preamp at three frequencies. Note the overload points at approximately +13 dbv point.



wave test. Typically, a 3-kc. square wave is applied to the input and the output is loaded with a .01-μf. capacitor and applied to a scope. The added capacitance simulates output cable capacitance and throws in a safety factor. The values of $R2$, $C3$, and $R4$ are then adjusted for the smallest amount of ringing. No attention should be paid to the distortion of the basic square wave, since this is not a flat amplifier and, due to the equalization, the sharp edges will be rounded off. If picked correctly, $R2$, $C3$, and $R4$ will have no effect on the frequency response.

With the values shown in Fig. 4, the response curve of Fig. 5 was obtained. The overload characteristic is plotted in Fig. 6. With a 1-kc. gain of about 36 db and a noise level better than −76 db below 1 volt, an overload-to-noise ratio of 89 db occurs. If a gain of 29 db is acceptable, the same overload-to-noise ratio as previously obtained with tubes (96 db) is achieved if the cartridge output is reduced by 6 db. This "bonus" is added to the many other advantages inherent in transistor circuitry. Thus the design objectives of a preamplifier of wide dynamic range, correct equalization, and low noise are fully met. In addition, output cable capacitance in excess of .01 μf. are permissible with no degradation in performance. These results are considerably better than those obtained with conventional tube circuitry.

This circuit may be installed directly on the turntable board or mounted remotely. A 6-foot input cable, C_S in Fig. 5, causes a response increase of only 1 db at 10 kc. The preamp should need no attention except for occasional replacement of the battery. ▲

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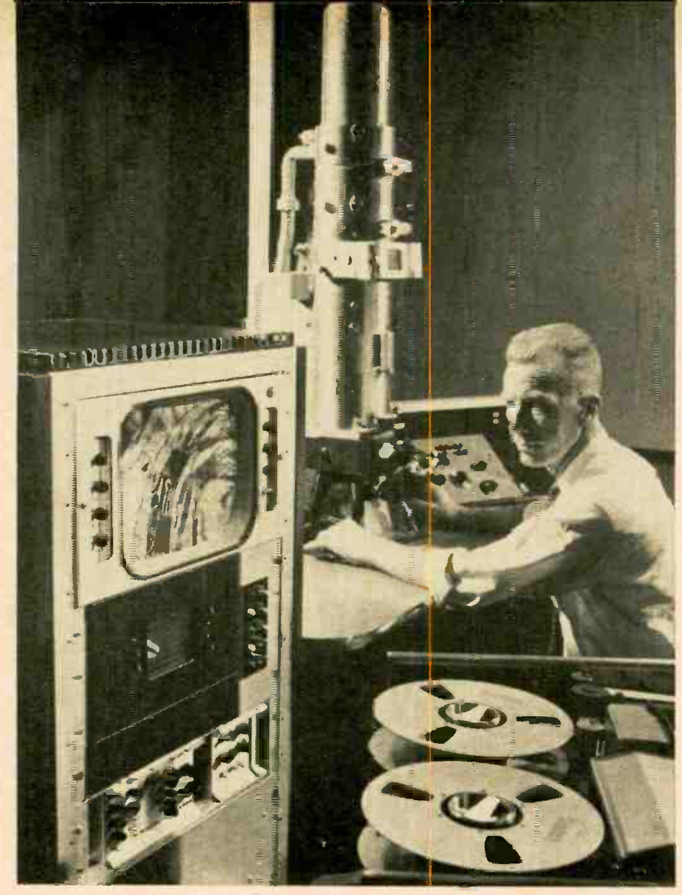
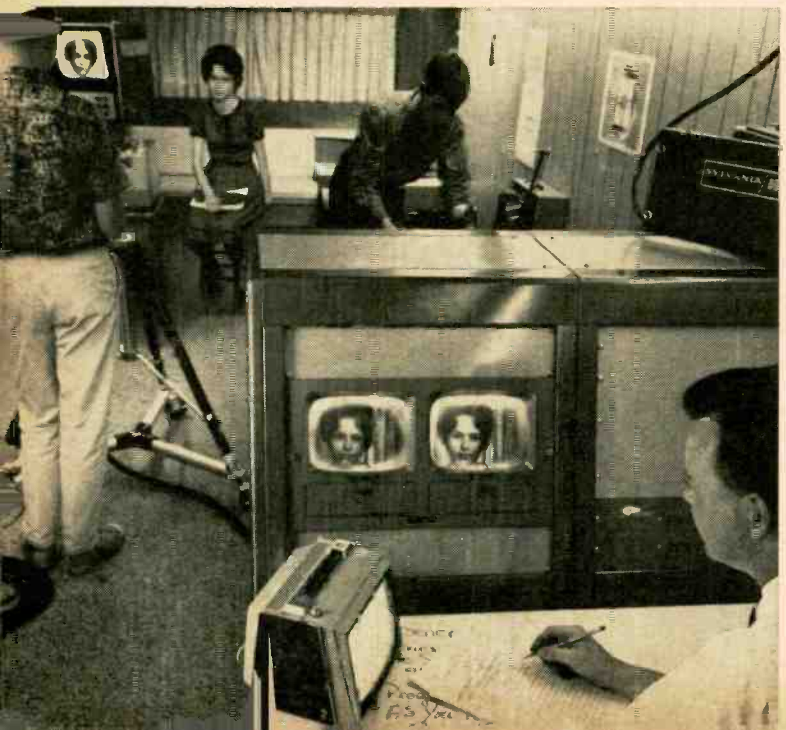


RECENT DEVELOPMENTS in ELECTRONICS

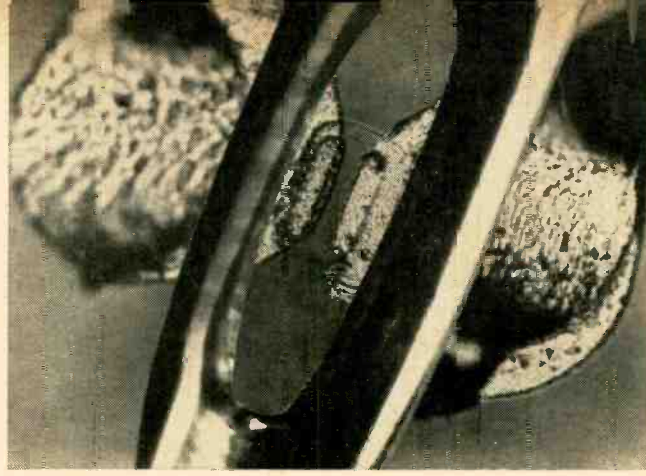
TV Electron Microscope. (Left) A new system combining television image intensification and pickup with the electron microscope is shown being demonstrated in the photo. The addition of TV boosts the microscope's visible magnification potential tenfold to 2 million times. Specimen images appearing on the instrument's fluorescent screen are brightened by an image intensifier and the resulting brighter image is picked up by a highly sensitive TV camera. The pictures can be displayed on a monitor —as in this study of an oak leaf cell structure—and piped into a closed-circuit system for viewing at many locations, and simultaneously recorded and video taped for later playback. The new system, developed at RCA Laboratories, uses an all-transistorized TV camera with a 3-inch image orthicon as the camera tube.

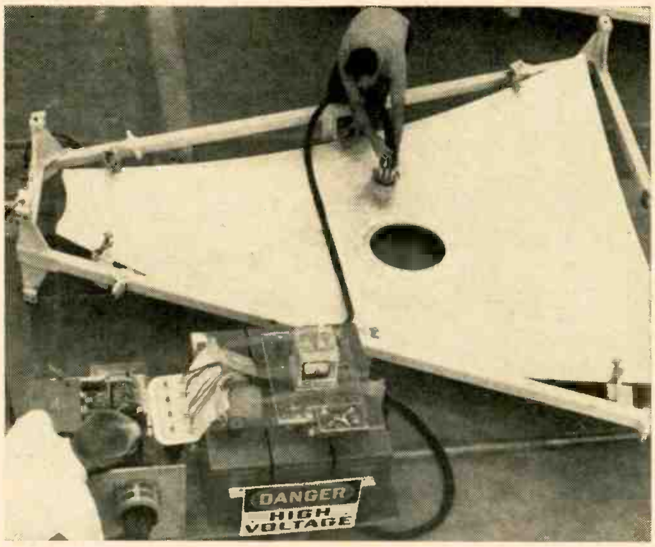
Filing by Television. (Right) A new system, called "Videofile," that replaces file folders with TV recordings that may be viewed and kept up-to-date electronically has been developed by Ampex. The first of the new systems will be delivered to NASA under an $875,000 contract. It will be used to file and automatically retrieve technical reports of components tests and reliability data. The system will permit storage of more than 250,000 document pages per 14-in. reel of standard video tape. Reports can be viewed on a monitor or an electrostatic printer can be used for printed copies. Incidentally, a close look at the original photo shown here discloses that the page being viewed is from the August, 1962 issue of Electronics World. It is page 52 from our article "Transistorized Ignition System" by B. Saatjian.



Mobile TV Studio. (Left) A library of filmed and taped educational TV programs has been prepared by students and faculty members of the Darien, Conn. public school system in a mobile TV studio recently delivered by Sylvania. Shown during a taping rehearsal is a student (left) operating the company's new closed-circuit viewfinder TV camera. A faculty member in the foreground follows camera action on the monitors installed in the director's console. The studio on wheels will be driven throughout the state to record educational television programs. These programs are fed from the studio van over coaxial cables to all classrooms in the town's seven elementary schools, junior and senior high school auditoriums, and administration offices.

Micro-power Switching Transistor. (Right) This is the 2N3493 micro-power switching transistor as seen through the eye of a needle. The new transistor is so small that it has practically zero input and output capacitance. The two large circles on each side of the device are bonding islands for making connections to the transistor's base and emitter. These bonding islands are only 2½ mils in diameter, while the active area of the Motorola transistor is less than 0.8 mil.² Applications include micro-power logic circuits in which the switching circuits operate at collector currents in the microamp range. Because of the minute currents, extremely long times are required to remove the charge from transistor capacitances which, with conventional devices, are relatively large. This limited switching speeds to 10 to 20 kc. With the new 2N3493, the switching circuits can now be operated at 1 mc.

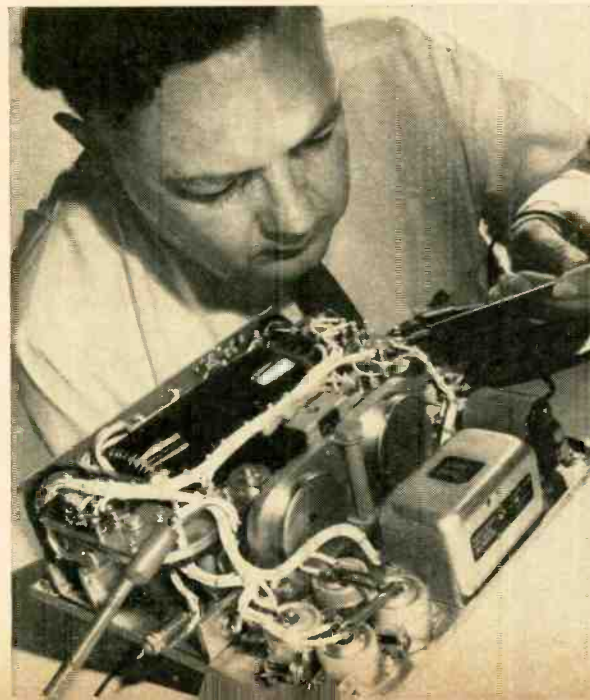




Magnetic Hammer. (Above) A magnetic hammer is being used at NASA's Marshall Space Flight Center at Huntsville, Ala. to smooth out distortions in segments of the Saturn V fuel tank. Eight of the segments are joined to form the dome-shaped end of the tank. The hammer's force results from a strong magnetic field set up for about 500 microseconds from the high-voltage power supply. The segments, costing about $30,000 each, are made to such close tolerances that distortion from welding fittings into them, such as the one in the center, makes them useless. The hammer has salvaged 8 segments.

Slow-speed Home TV Recorder. (Above) A new portable video tape recorder was demonstrated recently by the Video-Medical Electronics Corp. of New York. Excellent quality TV pictures which had been recorded off the air and from a CCTV camera were played back through a conventional TV set to which the recorder was wired. The pictures had good stability and were free from interference. Unlike some other recorders designed for home use which we have seen, this recorder operates at the slow speed of only 6 ips. This speed is possible because of the use of a single rotating head which scans the 1-inch video tape in a helical manner. The machine, manufactured by Loewe-Opta A.G. of West Germany, is expected to be on the U.S. market near the end of this year at under $3000.

Low Input Voltage Converter. (Right) A solid-state converter designed especially for testing fuel cells or other low-voltage devices is shown here. In a reverse twist on the general trend toward ever-smaller electronic components, the converter uses the world's largest transistors—germanium units almost 2½ inches in diameter and ¾ inch thick. Operating from an input as low as 0.5 volt, the Honeywell-designed system efficiently chops large currents to produce a stepped up voltage at regulated power levels of more than 150 watts. This single-cell converter system, capable of putting out either a.c. or d.c., can condition the power to specific requirements. The unit was described as being ideal for many outer space applications and for unattended terrestrial, sea, and under-sea uses.



Besides acting as a full-range light dimmer, this versatile device can be remotely operated by any audio signal for many control functions.

MULTIPURPOSE ELECTRONIC CONTROL

By DONALD LANCASTER

THE compact, multipurpose electronic control described in this article is essentially a 200-watt, full-range lamp dimmer with the added provision that a low-level audio-control signal can also proportionately control the lamp brilliance. In this latter mode, less than 50 mw. of input signal can directly control 200 watts of lamp, giving a gain of 4000. Fig. 1 illustrates some of the many operations that can be performed with this unit. Package and component modifications can give a one-kilowatt control capability at the expense of size.

By connecting the audio input of the control to the speaker terminals of a public address system (Fig. 1C), display-lamp brightness will smoothly follow music.

If two controls are used, one on the left channel of a stereo speaker system and the other on the right (Fig. 1D), an interesting test instrument results. The control can provide a dynamic and vivid indication of the balance and separation of the two stereo channels. This is done by placing the controls in proximity to each other and terminating one in a red lamp and the other in a yellow one. The state of the two stereo channels can then be continuously monitored.

Extension of these "stereo lamps" yields a color-organ type of device with a different twist—the colors produced correspond to the *position* of a particular solo instrument, not the pitch. One method (Fig. 1E) is to use red bulbs for the left channel, blue bulbs for the right channel, and green bulbs for *both* channels. (Half the green bulbs are tied to each side.) When this is done in a suitable reflective display, you can watch as well as hear music. Actually, a two-tone display works just as well as the three and can produce much deeper colors.

If the input sensitivity is set quite low, the light output will follow the input intensity variations, giving a fairly linear indication of the input signal strength. If the input is overdriven, the control will provide a discrete on-off type of indication that depends only upon the presence of an input signal and not its amplitude. (See Fig. 1F.) The control can then be used as a telemetry indicator or a visual alarm in high-noise areas.

A new, low-cost ($1.60) SCR together with a low-cost ($2.40) miniature, molded, full-wave bridge rectifier assembly make the circuit possible. The compact package is obtained by using a large SCR and operating it without a heat sink. The power levels inside this control are well within the manufacturer's specifications for no heat sink operation, even at moderately high temperature.

The schematic is shown in Fig. 2 and the circuit is best explained by breaking down the control into two parts—the dimmer portion and the audio-control portion.

Full-wave proportional control of a load by using SCR's can only be obtained by using two SCR's, or else by inverting the alternate a.c. half cycles with a bridge rectifier. The latter method is chosen since only one SCR and no gate transformers are required. This method also guarantees that reverse breakdown of the SCR cannot occur; there is never anything but forward voltage applied to the SCR.

Pulse the gate of an SCR, and it turns on and stays on until the voltage across it drops to zero (as happens every a.c. "zero"). If the SCR is turned on late in each half cycle, very little power gets to the load. Pulsing the SCR gate in the middle of each a.c. half cycle allows about half the available power to reach the load. Pulsing the gate early in each half cycle allows nearly full power to reach the load. By controlling when in each half cycle a gate pulse is produced, the load power can be directly and proportionately regulated. In this control, load power is variable from a minimum of 5% to a maximum of 95% of the available load power.

The required gate pulses are produced by a resistor, a capacitor, and an avalanche diode. In operation, *R*3 charges *C*3 until *C*3 reaches the breakdown voltage of avalanche diode *D*4. The avalanche diode then snaps on and empties the capacitor into the gate of the SCR, turning it on. Increasing the value of *R*3 causes the capacitor to charge slowly. The SCR turn-on is later in each half cycle and very little power gets to the load. This gives a low lamp brilliance. A lower-valued *R*3 will result in a fast capacitor charge and early turn-on, giving high load power and high brilliance. *R*3 is made variable to vary the output power.

As the SCR turns on, it eliminates the voltage supply for the *RC* network and discharges the capacitor ($C3$) completely *via* diode $D2$. This insures zero capacitor charge at the beginning of each half cycle and locks the capacitor's timing to the line frequency.

The circuit shows the parts used. *Rect.*1 is a 1.5-amp., full-wave bridge rectifier the size of a mica capacitor, which inverts the alternate line half cycles. *SCR*1 is a 5-amp. (if heat-sinked) device in a power-transistor type of case. The load terminals are in series with the SCR which is powered by *Rect.*1. The combination of $R3$, $C3$, and avalanche diode $D4$ provides the SCR gate turn-on pulses. $D4$ breaks down whenever the voltage across its terminals exceeds 30 volts. Varying $R3$ controls the lamp brilliance from a dull orange glow to full on. ($D3$ is always forward-biased during dimmer-only operation and does not affect the circuit performance.)

Capacitor $C1$ prevents the fast turn-on transient of the SCR from traveling back into the power line to become radio noise. Resistor $R1$ forms a permanent load for *Rect.*1, preventing stray capacitance and long cables from affecting performance.

The audio circuitry consists of an input-sensitivity control $R4$ and a high-ratio, step-up transformer $T1$. The secondary voltage of $T1$ is rectified by $D1$ to provide a continuously varying d.c. voltage of 0-40 volts magnitude in proportion to the input audio. This voltage is filtered by capacitor $C2$. This capacitor determines the time constant of the audio control and may be varied to suit individual taste. The larger $C2$ becomes, the more gradual the attack and decay of the output.

The rectified and filtered audio voltage is used to forward-bias avalanche diode $D4$, causing it to turn on earlier than normal, in direct proportion to the audio voltage present. This earlier turn-on causes the load lamp to brighten, again in proportion to the audio input. Diode $D3$ blocks the reverse audio bias from SCR gate. Capacitor $C4$ is a commutating capacitor required to start SCR turn-on in lieu of a momentarily reverse-biased $D3$. This completes the circuit.

If *Rect.*1 is changed to a 6-amp unit (*Motorola* MDA-952-3), and a 3-inch square aluminum heat sink is added to *SCR*1, then 600 watts of load power are permissible. For 1-kw. control, use a MDA-962-3 unit and add a 5-inch square heat sink to an 8 amp. SCR. Remember that the SCR case is electrically hot.

Operation depends upon the application. Some connection possibilities are shown in Fig. 1. The "Brightness" control should smoothly vary the light output from a dull orange glow to full brilliance, increasing in a clockwise direction. Likewise, the "Sensitivity" control increases audio sensitivity in the same manner. Since the audio is used only to bias a diode and not to provide gate current for the SCR, sensitivity is quite good. Whisper-level audio from a 16-ohm source will be enough to excite the control.

The control will only operate on 100- to 125-volt, 60-cycle a.c. lines. (For 50-cps operation, change $C3$ to .12 μf. The circuit will not function at 400 cps.) The circuit will not operate most motors due to the inverted waveform, although some small universal motors will work. Fluorescent lamps will *not work* with this control and permanent damage to both the control and the lamp may occur if this is tried. Do not exceed more than 200 watts of load, unless the control has been modified as previously described.

The choice of lamp load depends upon application. Conventional light bulbs, up to 200 watts, work fine. All three-way bulbs whose top rating is 200 watts or less also work equally well. The control will not excite a neon lamp or an electroluminescent panel because they draw too little current (if they are connected in parallel with a 10-watt conventional bulb, they will operate properly).

For audio control of lamps, a good choice is a 25-watt bulb. This size combines a large amount of light output with a minimum of thermal inertia (reluctance to turn off).

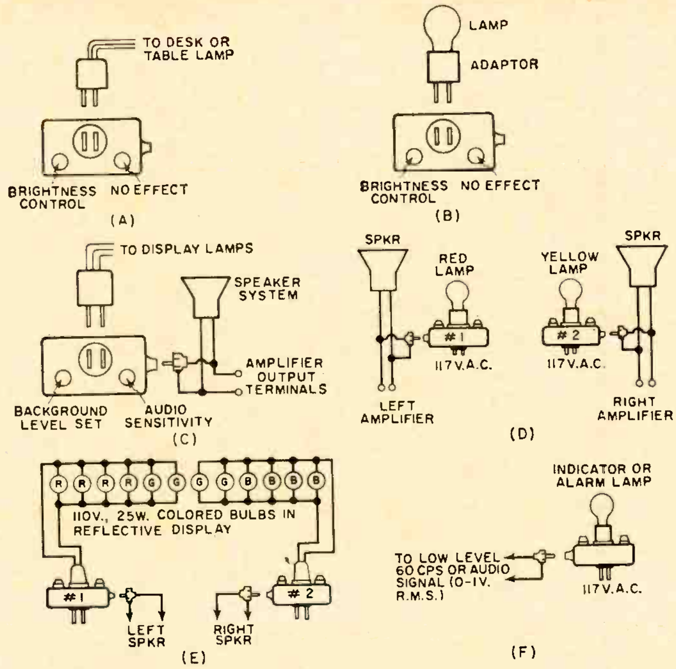


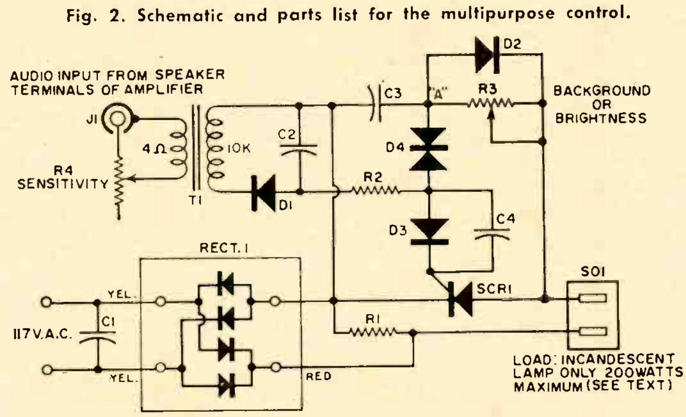
Fig. 1. (A) Conventional dimmer. (B) Variable brightness aisle marker. (C) Lamp brightness varies in proportion to audio volume. (D) Stereo test set. (E) Stereo color display where color varies with instrument position. (F) A telemetry indicator or an annunciator for high-noise areas may be made either proportional or on-off depending on sensitivity control setting.

There may be some variation in the exact value of $C3$ and $C4$ required due to slight manufacturing differences in trigger diode $D4$. In addition, the tolerances in some diodes are rather wide, varying from as low as 20 volts to as high as 40 volts. $C3$ should be a value that allows the load to just extinguish completely at the minimum brightness setting of $R3$. The change in capacitance might be $\pm$.02 μf. A disc ceramic capacitor of low value could be used to trim $C3$.

$C4$ should be the minimum capacitance that reliably allows audio control of the lamp brightness. Certain trigger diodes might require a value of $C4$ as high as .002 μf.

Frequency-sensitive filters can be added to the audio input to make the control sensitive only to some desired portion of the audio spectrum. ▲

Fig. 2. Schematic and parts list for the multipurpose control.



R1,R2—39,000 ohm, 1/2 w. res.
R3—250,000 ohm potentiometer
R4—250 ohm potentiometer
C1—.02 μf., 600 v. paper cap.
C2—.04 μf., 600 v. disc cap. (two .02 μf. in parallel)
C3—.1 μf., 400 v. paper cap.
C4—100 pf., 600 v. disc cap.
T1—Audio output trans: pri; 4 ohms; sec; 10,000 ohms or higher. (Stancor TA-33 or equiv.)
SO1—Type "S" power socket (Amphenol 61-S or equiv.)
D1,D2,D3—100 ma., 200 p.i.v. diode. (Motorola 1N4003 or equiv.)
D4—30 v. trigger diode (Transitron ER-900, TI TI-43, or G-E ZJ-238)
SCR1—Silicon controlled rectifier 2N3228 or 2N3528
Rect.1—1.5 amp, full-wave rectifier (Motorola MDA-942-3)

DISTRIBUTED-AMPLIFIER *techniques*

By SIDNEY L. SILVER

Applying traveling-wave concepts to video frequencies, these circuits provide very high gain at extremely large bandwidths. Circuits are used in laboratory instruments and communications systems that handle very short pulses.

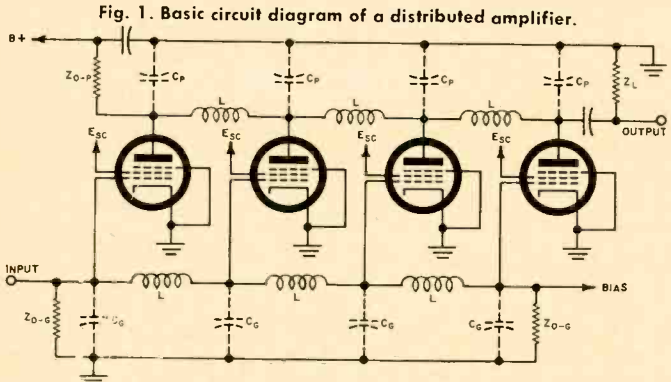
WITH the rapid expansion of the electronic art, there has been a steadily increasing demand for amplifiers with large bandwidths. The problem of amplifying pulses without distorting the waveform is a fundamental one in nearly every branch of electronics.

A common method of obtaining the very wide bandwidth and extremely fast pulse response required for video amplifiers, is the application of distributed-amplifier techniques. With these techniques, undesirable changes in tube parameters are cancelled or minimized. Consequently, far greater bandwidths are obtainable, extending from the low audio frequencies to several hundred megacycles. The limitation of the gain-bandwidth product can be overcome by paralleling the tubes in a special way, so that the mutual conductances effectively add but the tube capacities do not. Individual tubes in the stage can, therefore, be operated at unity gain and a stage gain greater than unity can be obtained. If the bandwidth requirement is so large that the gain per tube is much less than unity, the output voltage can be made to exceed the input voltage if a sufficient number of tubes is employed.

Distributed amplifiers find many applications in wide-range antenna measurements, nuclear instrumentation, u.h.f. communications systems, and general laboratory measurements. As preamplifiers for pulse generators, scintillation counters, wide-band oscillators, photo-multiplier tubes, and delay lines, they provide the broad passband that no tuned amplifier can offer. Extensive use is also found in high-speed oscillography to make possible the accurate reproduction of short pulses and transients.

Unlike distributed amplifiers, ordinary video amplifiers require corrective methods to give flat gain *vs* frequency response. Such circuit configurations as series and shunt peaking, feedback, and *RC* compensation are widely employed to obtain uniform amplification over a larger frequency band. Regardless of the complexity of the coupling system, there is an upper limit to the gain-bandwidth product per stage of amplification for a given tube type. The optimum gain-bandwidth product of a conventional video amplifier is determined

Fig. 1. Basic circuit diagram of a distributed amplifier.



by a factor which is proportional to the ratio of mutual conductance (G_m) to the sum of input and output tube capacities. This is expressed by the equation: *Gain* × *Bandwidth* $= G_m/2\pi\ (C_G + C_P)$, where C_G = tube input capacity, and C_P = tube output capacity.

The maximum bandwidth that can be obtained with a video amplifier is limited by the fact that the gain per tube must exceed unity. If the gain were allowed to fall below unity, it would be futile to connect stages in cascade, since the over-all gain of a multi-stage amplifier is equal to the products of the gains of the individual stages. Parallel operation of tubes does not help, inasmuch as the resultant increase in G_m is compensated for by the corresponding increase in the combined tube capacities. These limitations in the ordinary video amplifier led to the development of distributed-amplifier techniques to handle the job.

Basic Circuitry

The distributed amplifier is composed of two artificial transmission lines of identical characteristics, called the grid line and the plate line, with a number of amplifier tubes arranged between the lines. The lumped transmission lines consist of low-pass filter sections properly terminated at each end, to provide a desired line cut-off frequency. Fig. 1 shows the basic circuit of a distributed amplifier using a single stage consisting of four tubes. The grids and plates of each tube are connected at regular intervals along the low-impedance delay lines, with the stray capacities of the tubes (C_G and C_P) forming the shunt capacities of the lines. Effectively, the tubes act in parallel as far as plate current is concerned, while the shunt capacities are separated. The grid and plate lines, with identical velocities of propagation, are so proportioned as to have the same phase shift between adjacent tubes.

The signal voltage produces a wave that travels down the grid line, exciting successive grids with a progressive phase difference determined by the phase shift per section of line. As each grid is energized, the resultant plate current produced in each tube divides, half flowing backward toward the terminating impedance (Z_{O-P}) and half flowing forward toward the load impedance (Z_L). Inasmuch as the time delay per section of the grid and plate lines is the same, the plate currents from successive tubes add in the forward direction to give an amplified output voltage at the load. The backward component waves largely cancel each other and whatever is not cancelled is absorbed by the terminating impedance.

The maximum number of tubes that can successfully be employed in a single stage is limited by high-frequency losses in the transmission networks. A critical point is reached where the increase in amplification due to the added tubes is offset by the attenuation of added sections of line. Optimum gain per stage is achieved at this point when there are enough tubes to obtain an amplification of 2.72 (8.7 db).

Although individual distributed amplifier stages inherently have low gain, stages may be cascaded to obtain an over-all gain of any desired amount. As shown in Fig. 2, the output from the plate line of the first stage supplies the voltage that is applied to the grid line of the second stage. Since the gain of cascaded stages is multiplicative, the over-all gain (A) of a distributed amplifier is expressed by the formula: $A = (\frac{1}{2} E_G G_m Z_{O-P} N)^m$, where m is the number of stages, and N is the number of tubes per stage.

Any number of distributed amplifiers can be cascaded with negligible change in bandwidth or rise time, provided the flat transmission characteristic of each stage is maintained.

Complex Circuitry

The over-all gain characteristic within the passband of a distributed amplifier is governed by the extent to which the characteristic impedance of the plate line is constant with variations in frequency. Since the Z_0 of lumped lines consisting of series L and shunt C elements increases as the cut-off frequency is approached, distributed amplifiers show a peak in the gain characteristic below cut-off. In addition, the phase-shift characteristic of low-pass filter sections deviates from linearity at frequencies near cut-off, to give rise to periodic fluctuations at the terminations of the networks. In practical distributed amplifiers, therefore, it is necessary to employ more elaborate circuit configurations to flatten out the peak and to linearize the phase shift.

An arrangement that provides both the plate and grid lines with a flat delay characteristic is the bridged-T network. This network has the advantage of allowing a constant impedance within the passband, independent of frequency. As shown in Fig. 3, each coil section forming the successive series line inductances is mutually coupled together and bridged by capacitors (C). The line shunt capacitors (C_G and C_P) are supplied by the stray wiring and tube capacities. By proper adjustment of the LC line elements, it is possible to achieve a linear time delay and a transient response that is free from overshoot.

The choice of pentode tubes in distributed-amplifier systems is governed by the very small interelectrode capacity between plate and grid. However, when the amplification of frequencies above 400 mc. is required, pentodes are no longer suitable due to the adverse effects of grid loading and transit time. To minimize these effects, u.h.f. triodes must be employed in order to avoid a serious reduction in bandwidth. Triodes, however, cannot be incorporated directly in a distributed amplifier owing to feedback from the plate line to the grid line *via* the grid-plate capacity of the tube (Miller effect).

This effect may be avoided by employing cathode-coupled pairs of triodes to obtain the required degree of isolation. As shown in Fig. 4, the tube pairs form a paraphase circuit consisting of a cathode follower (V1) driving a grounded-grid amplifier (V2). When a number of these tubes are spaced equidistantly along grid and plate lines having an equal velocity of propagation, amplification is obtained in a manner similar to that in a conventional distributed amplifier. Since no over-all phase inversion occurs in the amplifier, the problem of instability is thereby eliminated.

The equality of line impedances must be maintained between cascaded stages to avoid adverse effects on frequency response. Mismatching would result in standing waves, the amplitudes of which are proportional to the products of the reflection coefficients from the two ends of the mismatched lines. For the purpose of obtaining signals of large amplitude with minimum tube current, it is desirable to employ delay lines with the highest possible characteristic impedance (Z_0), yet low enough to satisfy the attenuation criteria. Practical impedance values of 50 ohms to 200 ohms are satisfactory for the transmission of pulses of very short rise time. Hence, the distributed capacity of the coaxial cables, even at considerable distance from the amplifier, will not be sufficient to seriously distort the high-frequency response.

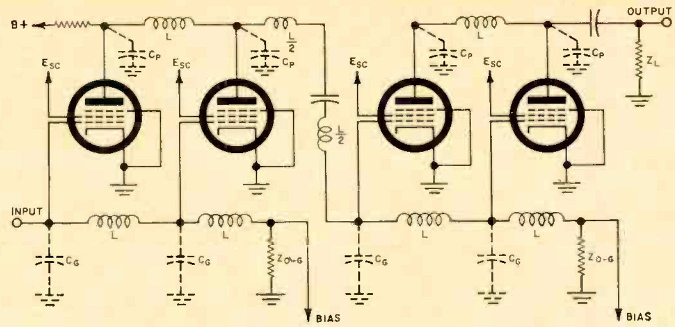


Fig. 2. Two cascaded stages are shown here. Note that each stage of amplification consists of two pentodes.

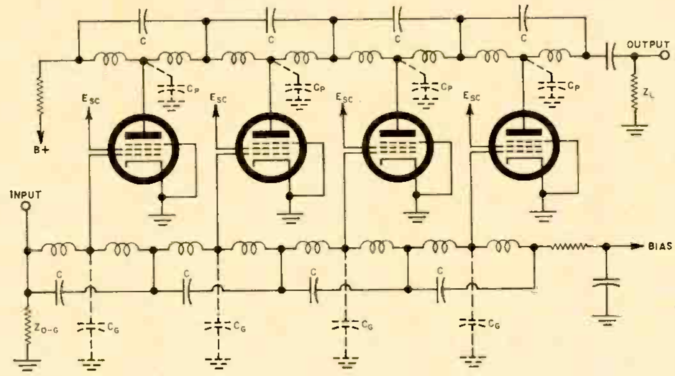


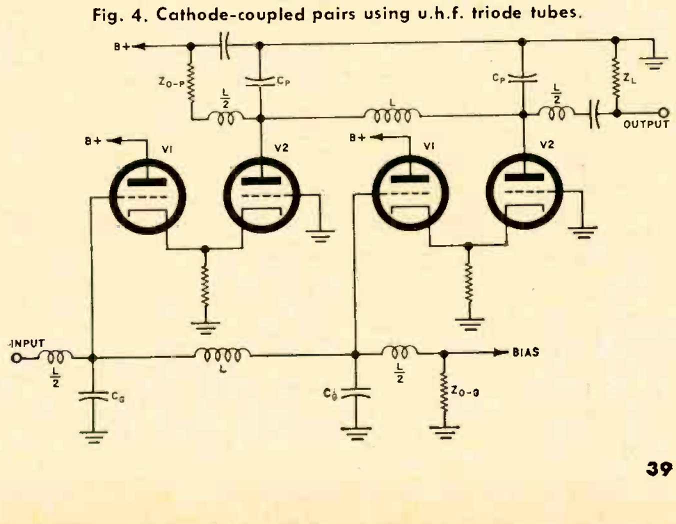
Fig. 3. Distributed amplifier employing bridged-T networks.

If the required output impedance is considerably lower than the plate-line impedance, a tapering arrangement may be employed to minimize reflections. The plate line sections are tapered in harmonic progression so that if the impedance of the plate section of the first tube is called Z, the impedance of the next section is made equal to Z/2, the next equal to Z/3, etc. The portion of the forward traveling wave reflected at each change in impedance is cancelled by the backward component wave generated at the plate of the tube involved, and there is no resultant wave in the reverse direction. Since all the power reaches the load, the terminating resistor at the reverse end of the plate line may be omitted. The impedance of the load should have the value Z/N if there are N number of individual tubes in the stage.

Transistor Version

Transistors can be used successfully as wide-band distributed amplifiers to produce a relatively constant gain over a very wide range of frequencies. The design problems consist of maintaining fixed input impedances over a broad frequency range by the use of compensating networks. Fig. 5 shows a simple distributed amplifier stage consisting of three transistors with a base delay line and a collector delay line of identical Z_0's. Since the common emitter current gain of each

Fig. 4. Cathode-coupled pairs using u.h.f. triode tubes.



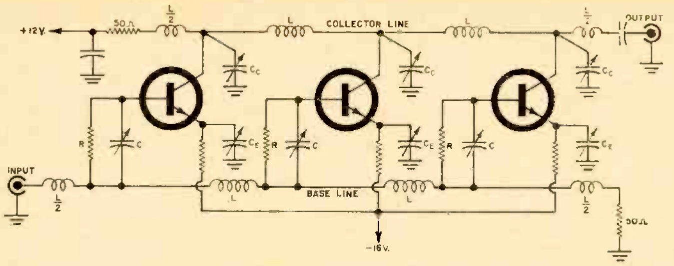


Fig. 5. Three-section stage transistor distributed amplifier.

transistor rolls off at the *beta* cut-off frequency, a compensating network consisting of R and C is employed to cause a complementary rise in base current. If the input impedance of the transistor is much lower than that of the parallel RC network, a constant collector current independent of frequency will be obtained. Further, it is possible to extend the frequency range with emitter compensation by adjusting trimming capacitors (C_E). Additional trimmers (C_C) are employed to balance the parallel capacity of the collector line with that of the base line and thus determine the flatness of response.

The expression for voltage gain (V.G.) is: $V.G. = (NB_0E_G R_L)/2R$, where N is the number of transistors per stage, B_0 is the low-frequency current gain, E_G is the input voltage, R_L is the load resistor, and R is the base resistor.

As the number of sections per stage is increased, a higher line cut-off frequency must be calculated for an amplifier of a given bandwidth. With present-day high-frequency transistors, it is possible to obtain bandwidths up to 250 megacycles with reasonable gain.

Practical Applications

Distributed amplifiers have a most important application in conjunction with oscilloscopes, for the recording of high-speed transients on photographic film. Fig. 6 shows a wide-band amplifier designed to increase the amplitude of low-level transient waveforms too small to be applied directly to the deflection plates of the oscilloscope.

The signal leaving the probe enters the grid line of the first distributed preamplifier stage ($V1$ to $V4$). The plate line is coupled to a buffer amplifier ($V5$) which effectively provides an open circuit termination to the plate line, thus giving a factor of two improvement in gain. This is followed by an identical preamplifier stage (not shown in the illustration) which feeds the main amplifier through a specific length of delay cable. An output is also provided for the signal to feed a synchronizing amplifier which triggers the cathode-ray tube time-base circuit. The main amplifier is designed to match the passband characteristic of the preamplifier and should be properly terminated at the input.

A phase inverter feeds the signal to the drivers which provide sufficient excitation for the grid lines of the push-pull output stages ($V6$ to $V13$). The choice of tubes for the output stages should be governed by a consideration of the total plate current change over the linear region, rather than by mutual conductance alone. The plate lines are connected to the CRT deflection plates without the addition of a resistive termination, resulting once more in a factor of two improvement in gain. Lack of a terminating resistor may cause some fluctuations at the edge of the passband but in applications where the leading edge of a fast pulse is of primary interest, any reflections would arrive too late to have any adverse effect. Since the load to be driven is capacitive, the CRT deflection plate capacitance should be arranged to form the shunt element of a further section; in effect, an extension of the plate line.

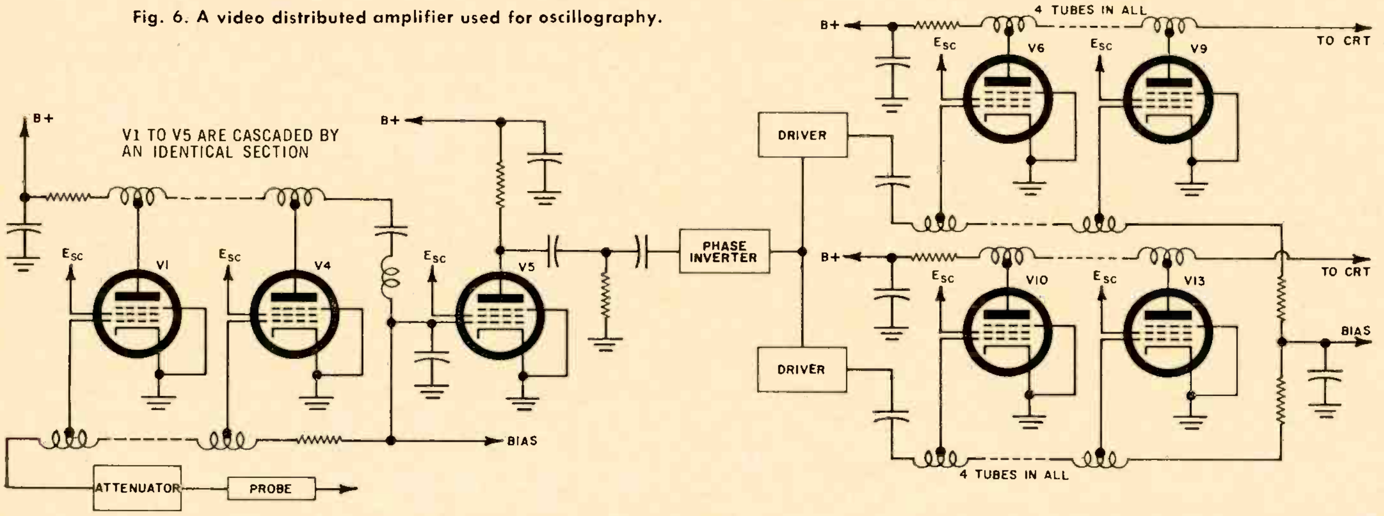
One of the most important advantages of a distributed amplifier is the capability of producing much higher undistorted power outputs than are obtainable with conventional video amplifiers. The requirements for power amplifiers differ from those of low-level amplifiers, since high efficiency and maximum power output are desired, rather than maximum gain. Where large power output is required, enough tubes are added to a stage until the optimum load resistance is approximately equal to the effective plate resistance for a desired bandwidth.

A typical high-power distributed amplifier system employing power tetrodes is capable of 100 watts output into a matched load, when suitable driving power is provided to the input. The frequency of operation ranges from 200 kc. to 275 mc. with no tuning required. Since the amplifier is operated class A, it can be used for many types of r.f. signals where large amounts of power are required over a wide band of frequencies.

As an r.f. amplifier, it provides a broadband transmitter capability for wide-range antenna measurements to plot patterns, determine efficiency, directivity, etc. In millimicrosecond pulse applications, video signals with a rise time of 1.5 nanoseconds or greater may be amplified with no appreciable distortion. If desired, an increase in the output pulse level may be obtained by adjusting the bias level to a higher negative value so that the amplifier approaches class B operation.

The distributed amplifier, by applying traveling-wave concepts to video frequencies, offers a real gain-bandwidth product advantage for very large bandwidths. A further advantage is the comparative freedom from any tendency to self-oscillation. As far as frequency range is concerned, there is reason to believe that bandwidths over 1000 mc. could be obtained in the future with the introduction of new and more adaptable tubes and transistors. ▲

Fig. 6. A video distributed amplifier used for oscillography.



EXTREME RELIABILITY VACUUM TUBES

Trans-ocean telephone cables use vacuum-tube repeaters about every 400 miles. The tubes used in these units must, of necessity, have a very high order of reliability. Each tube is individually made under exacting conditions.

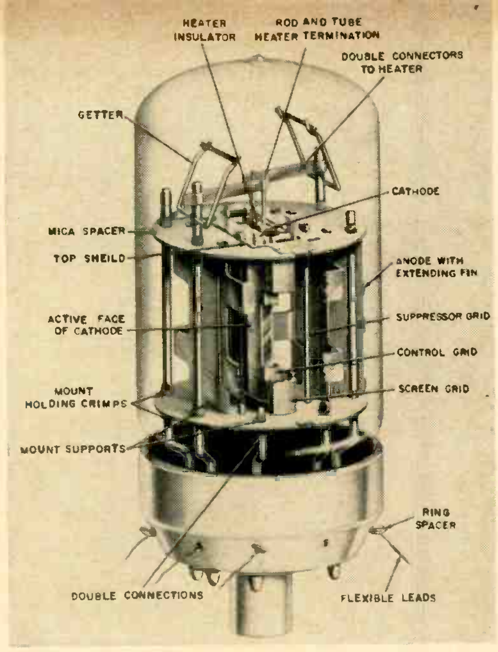


Fig. 1. Cutaway view of the 455A-F telephone cable amplifier tube.

WHEN a vacuum tube fails in a conventional amplifier, it is an easy matter for a technician to test and replace it. However, when that tube is part of an amplifier located somewhere in mid-ocean and at great depths, service can become quite a problem. Such is the case with the broadband amplifier tubes used in submarine cable systems.

High reliability for these tubes is necessary because of the relatively heavy expense of replacing faulty repeaters and the resultant loss in revenue during any out-of-service periods. The reliability objective is ". . . no tube failures in 20 years." More specifically, the probability of a 3000-mile system breakdown due to a tube failure should not exceed 50% for a 20-year service period. This corresponds to about 0.7 tube failure among 900 tubes for a 20-year period, or to 29 years operating time between failures.

To achieve desired system reliability, which depends principally on amplifier performance, the underwater amplifier includes two parallel circuits of three tubes each, with the circuit arranged so that the most probable kinds of tube failure will cause a system failure only if both strings are involved.

The basic amplifier tube used is the 455A-F pentode as shown in Fig. 1. This is an indirectly heated cathode type in which the cathode is made of rectangular tubing and is coated only on the two broad external faces. The control grid and screen grid are frame type. Both grids employ relatively fine lateral wires wound under high mechanical tension at moderately fine pitches. This results in a double planar structure. The suppressor grid consists of four vertical rods strategically located.

Completing the tube is the anode or plate which is made open to permit intensive inspection of the tube for workmanship and for entrapped particulate matter. The particle problem has strongly influenced the design and fabrication of the tubes since a foreign particle lodged in a critical area might cause a short circuit, or become a noise generator.

An example of designing for minimization of particles is the substitution of lead crimping for eyelets as a means of supporting the metallic parts to the mica insulators. This was done without materially weakening the structure. The tubes can safely withstand 10 times the shock levels expected in cable handling and laying. While eyelets provide excellent structural support, they are subject to weld splash, generate mica particles, and also catch and retain particulate matter, often concealing it until late in the tube processing. The tubes are fabricated in extremely clean rooms, using the highest practicable degree of housecleaning measures.

The reliability required for this type of service is designed and built into the tubes. This includes special selection and procurement of all raw materials, followed by complete knowledge and control of all processing and fabrication operations. Every part—metal, glass, mica, insulating oxide compounds, active oxide coatings, or other chemical formulations—is identified by lot numbers and must meet rigid raw material acceptance criteria.

Two examples of rigid selection of raw materials are the heaters and cathodes. The heater of the 455A-F tube is a coiled tungsten wire formed into a precisely dimensioned "M" shape, spray coated with aluminum oxide, and slipped into a formed block of aluminum oxide. To insure a large supply of uniform quality tungsten, a program was worked out with the materials supplier whereby special ingots of tungsten were specifically made for the 455A-F. These ingots are reduced to wire form and wound on many small spools. The spools are sampled in a statistical manner by making sample heaters and running regular and accelerated life tests on them. Use of any spool of wire is contingent on a perfect record of these tests.

To insure a supply of cathodes that would be free as possible from the formation of interface impedance, a special series of high-purity nickel alloys was developed. One of these—nickel plus 2% tungsten plus .02% magnesium—was ultimately selected as best suited for the tubes. Billets of this material are processed down to round seamless tubing and then formed into rectangular seamless tubing of the desired dimensions. Special measures are taken to avoid pickup of contaminants. Each individual cathode sleeve is identified as to its starting billet.

Another phase of operations is the cleaning of all parts. Basic cleaning steps include removal of grease by solvents, removal of physical contaminants by ultrasonic agitation, cascade rinsing in de-ionized water, oxidation to remove residual organic materials, reduction in hydrogen to outgas the parts, atomizer testing for surface contaminants, storage in atomizer-clean containers with strict limitations on duration of storage.

The 455A-F are pentodes with somewhat conventional performance characteristics. Maximum power output available from the tube is 50 mw. In the interests of achieving long life, cathode current density is 10 ma. per cm.^{2}.

Use of vacuum tubes in submarine cable systems appear justified in light of their better than 80-million amplifier tube hours on the sea bottom with no failures.

This article is based on a paper "New Electron Tubes For SD Submarine Cable Systems," by V. L. Holdaway, W. Van Haste, and E. J. Walsh, which appeared in the *Bell Labs* "Record." ▲

"CHIRP" A NEW RADAR TECHNIQUE

By DONALD LANCASTER

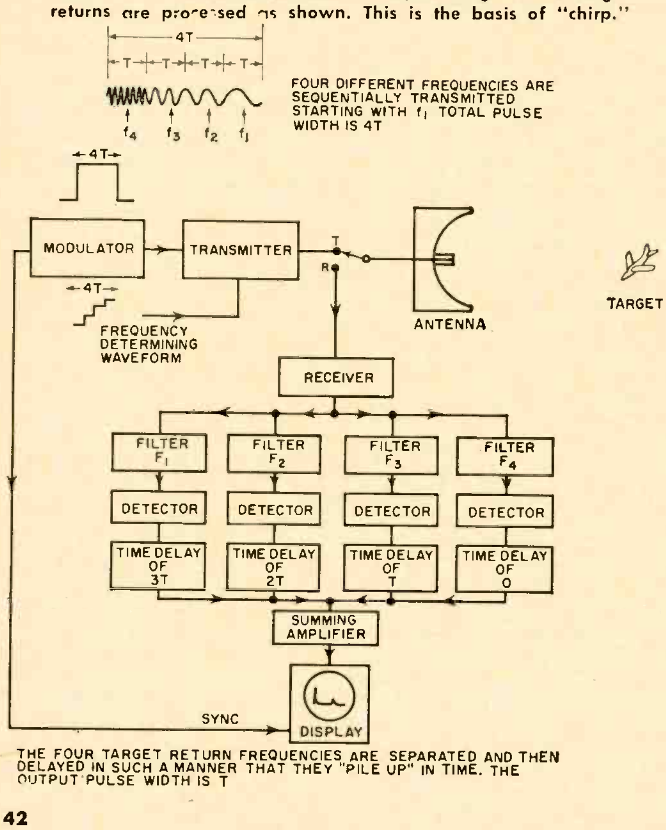
Using a swept-frequency approach, this new radar has greatly improved range and target resolution over conventional pulse methods and is also less susceptible to present-day jamming techniques.

THE dark veil of military secrecy has been lifted on a most amazing and powerful radar technique called pulse compression—nicknamed "chirp." By applying mathematical techniques to a conventional pulsed radar, range and resolution can *simultaneously* be increased while at the same time using less peak input power. The radar also becomes significantly harder to jam, and much more immune to certain forms of noise. Further, the requirements for very high power-supply voltages can be reduced.

Chirp is perhaps the most significant radar advance of recent years. Its improvement upon radar performance can be as high as several hundred times the capability of conventional techniques. There is no apparent limit to the ultimate attainable improvement.

The majority of presently used radars are of the pulse type, *i.e.*, systems that transmit a very large burst of radio frequency energy for a very brief interval and then wait for echo returns from any targets within range. From these echoes, the position, size, type, and movement of a target may be determined. Pulse radar uses extend from weather observation, airport flight control, travel aids for the blind, and vehicle collision devices, to the military long-range mapping radars, battlefield radars, and other detection systems.

Fig. 1. A four-frequency radar will have four times the resolution of a conventional radar of equal range if the target returns are processed as shown. This is the basis of "chirp."



THE FOUR TARGET RETURN FREQUENCIES ARE SEPARATED AND THEN DELAYED IN SUCH A MANNER THAT THEY "PILE UP" IN TIME. THE OUTPUT PULSE WIDTH IS T

In a conventional pulsed radar, a narrow, high-voltage pulse is applied to an r.f. tube such as a magnetron which briefly oscillates at a fixed microwave frequency. (Microwaves are used for radar because physically small antennas with good directional properties can be obtained only at very high frequencies.) This microwave pulse is first transmitted. A receiving antenna and detector then monitor for target echoes, and these returns are displayed on a cathode-ray tube whose sweep is synchronized with the transmitted pulse. The *time* it takes an echo to get back to the receiver is directly related to the *distance* between radar and target. The radar burst travels at the speed of light, or roughly 1000 feet in a microsecond. Since the transmitted signal has to make a round trip, each microsecond of delay accounts for a target-to-radar distance of 500 feet. Another pulse is transmitted after all the initial echoes have had a chance to return. This process is repeated again and again, thus producing a continuous plot of targets.

The bigger a target is, the more energy it will return and the brighter it will appear on the display. Further signal processing, based upon the Doppler effect, can determine whether the target is moving or stationary, and if moving, in what direction and how fast.

Chirp becomes valuable only when the ultimate limits of the conventional pulse radar fall short of the required performance in range and resolution. Range of a radar is the maximum target distance at which reliable echo returns can be expected, while resolution is its ultimate ability to discriminate between two closely spaced targets while still giving two distinct return echoes.

Range is determined by the amount of r.f. energy being transmitted. This is equal to the pulse height (power) multiplied by the pulse width (time). (*Power* $\times$ *time* = *energy*.) This is equal to the *area* of the transmitted pulse. The range of a radar is proportional to the *fourth* root of the transmitted energy because both radar and target transmit energy in a square-law manner. To double the range of a radar, the transmitted energy must be increased by a factor of 2^4 or 16 times.

Resolution of a radar is determined solely by transmitted pulse width. Two targets separated by less than the pulse width will give a single echo return because the end of the transmitted pulse will be reflected by the near target at the same time the beginning of the transmitted pulse is being reflected from the far target.

Range and resolution, therefore, are two radar system requirements in opposition to each other. To obtain resolution, the transmitted pulse must be as narrow as possible; to obtain range, the area of the transmitted pulse must be as large as possible. These two taken together result in a very narrow, extremely high-power r.f. pulse. System and component capabilities then enter the picture. The transmitter tubes are asked to provide very brief pulses of extreme power, sometimes as high as several megawatts. The narrow duty cycles used in very brief pulses are inefficient. There is also an upper limit to the maximum voltage power supply that is practical in an airborne application, due to arcing problems. Voltages in excess of 40 kv. become quite troublesome. Higher-current transmitting tubes can be used, but there is a limitation here also. The resonant cavities of the tubes must be of a small size if they are to produce microwaves; there is also a limit to the maximum current-produced heat that will not melt the tube structure.

This was the problem before chirp. What was needed was a method of increasing the transmitted pulse length, thus increasing power, yet not degrading the resolution.

How Chirp Works

To explain chirp, consider the imaginary system of Fig. 1. Instead of transmitting a single frequency pulse, the radar now transmits, in turn, four discrete frequencies forming the over-all transmitted pulse. The first frequency (f_1) is transmitted for a time T, then frequency f_2 for a time T, then f_3 for time T, and finally f_4 for time T. The time length T (in microseconds) of each frequency of transmission is identical. The receiver uses four separate filters and detectors for the target-returned frequencies f_1, f_2, f_3, and f_4. *The outputs of the four detectors are then time-delayed in such a manner that the outputs all "pile up" or coincide in time.* Thus, f_1 is delayed for $3T$ seconds, f_2 for $2T$ seconds, f_3 for T seconds, and f_4 is not delayed. The summed output pulse width is T seconds. However, the original transmitted pulse was $4T$ seconds long; therefore, the resolution has been increased by a factor of four with no decrease in transmitted energy.

Resolution is determined by what each individual detector receives, which is a pulse only T microseconds wide. With a conventional radar, the return pulse would have to be $4T$ microseconds wide.

This 4:1 improvement does not have to mean heightened resolution. It can just as well be a 4:1 increase in transmitted energy resulting in increased range with no change in resolution. By the fourth-root law, this would extend radar range by a factor of 1.20. Or, if both the conventional range and resolution were satisfactory, the four-frequency modulation technique reduces the peak power required by a factor of four, thus greatly simplifying system power supplies.

The *more* frequencies that are used and the *less* time spent at each frequency, the better will be the result. The limit of more and more frequencies is a *linearly swept* signal. The delay required at the receiver would then be a linearly increasing delay *vs* frequency device. This is the foundation of chirp.

A chirp radar is one that transmits a swept-frequency signal, receives it from a target, and then delays the signal in such a manner that the return signal is *compressed* in time to give a short, intense return signal. The swept signal is called the chirp signal. The final narrow pulse is called the dechirped, collapsed, or compressed signal.

When a linearly swept or chirp signal is run through a linear delay *vs* frequency network, as in Fig. 2, the various frequencies are delayed so that they pile up in time at the output. This piling up does not result in a perfectly rectangular pulse, but instead the signal assumes the shape of the pulse shown in Fig. 2. This pulse is called a ($\sin x/x$) pulse because this is its mathematical shape. (A mathematician at this point might correctly point out that chirp radar signal processing is nothing but a means of taking the Fourier transform of the rectangular energy spectrum of the transmitted signal. This is where the ($\sin x/x$) pulse comes from.) If the sidelobes of this waveform are eliminated, a very good approximation to a conventional rectangular pulse results.

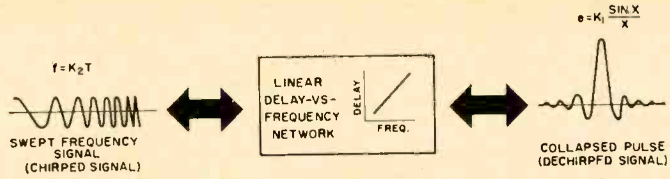


Fig. 2. If a linearly swept frequency is fed to a linear display vs frequency network, the different portions of the signal will be delayed long enough so that all frequencies will pile up into a narrow output pulse. This network can also be used in reverse.

A linear delay *vs* frequency network is a reciprocal device. This means that a ($\sin x/x$) pulse can be fed through the network to produce a swept-frequency signal or a linearly swept signal can produce a ($\sin x/x$) pulse.

In a chirp radar, a ($\sin x/x$) pulse of the desired resolution is generated and passed through the network to produce a swept-frequency signal. This signal is then transmitted at microwave frequency at the required high-power level. The echo returns are then received and passed through a second delay network to obtain return echoes the same shape and resolution as the initial ($\sin x/x$) pulse. In the process, a significant improvement in range, resolution, and peak-power requirement is obtained.

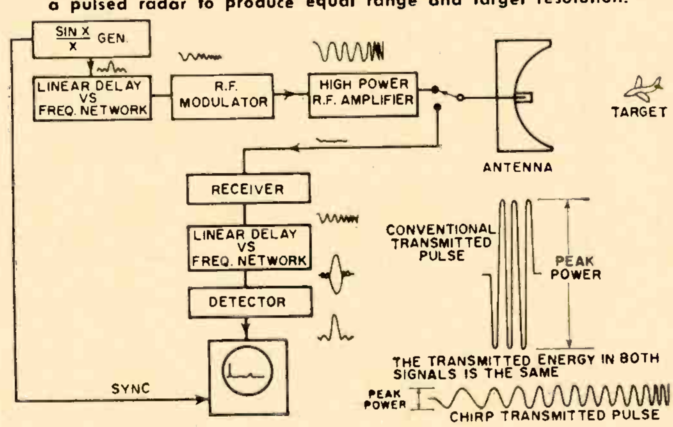
The ratio of lengths between the swept signal and the ($\sin x/x$) pulse is called the chirp ratio and is a figure of merit of the expected improvement of a chirp system over a conventional system. The chirp ratio can be as high as several hundred although the minimum chirp ratio meeting system requirements is always chosen, since the wide receiver bandwidths needed add greatly to system cost and complexity.

A chirped radar is compared to a conventional radar in Fig. 3. Here the chirp ratio is about five. Although both radars have equal range and resolution, only ⅕ the peak power is required using the chirp system.

There are a number of ways of generating the swept signal. There is a distinct advantage to the method of starting with a ($\sin x/x$) pulse and passing it through a delay network. If the *same* network is used for both chirping and dechirping, any system non-linearities or distortions *cancel*, giving a cleaner signal than would otherwise be possible. This is called a matched-filter technique, a tremendously significant radar tool. It is possible also to actively generate a linearly swept frequency without using a delay network. This method is simpler but requires very careful control of system linearity and sweep rate.

There are likewise a number of dechirp, or pulse compression, methods. Certain ultrasonic aluminum delay lines, as well as special quartz delay lines, can directly produce the required delay *vs* frequency characteristic. A delay line that delays various frequencies different lengths of time is called a *dispersive* line. A second method uses a bridged-T network. By carefully "stacking" the right number of bridged-T's, with properly chosen delay (*Continued on page* 59)

Fig. 3. A "chirp" radar system requires much less power than a pulsed radar to produce equal range and target resolution.



ELECTRONIC PUMPS:

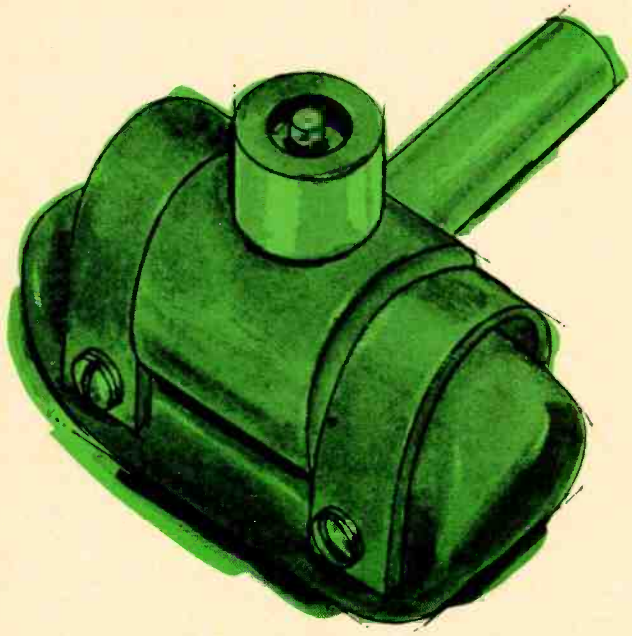


Fig. 1. A miniature ion pump with magnet in place. Insulator at top is a vacuum-tight, high-voltage feedthrough.

A NEW APPROACH TO VACUUM GENERATION

By T. C. SINCLAIR

Containing no fluids and with no moving parts, the electronic ion pump can remove all gas from many different types of high-vacuum tubes and chambers.

THERE is a new kind of all-electronic vacuum pump that is finding more and more applications in the mushrooming field of vacuum technology. This device, unlike most conventional vacuum pumps, contains no fluids and has no moving parts. The titanium getter-ion pump, or ion pump as it is usually called, operates by taking gas molecules and atoms out of the system being evacuated and then permanently trapping them in continually forming deposits of metal.

The choice of an ion pump for any given application can usually be traced to certain advantages over the more conventional methods of vacuum pumping. As an example, small ion pumps similar to the one shown in Fig. 1 are often permanently attached to large microwave or sealed-off power tubes. The pump is then activated periodically to prevent the tube from becoming "gassy." A small ion pump that requires only a simple source of electricity and operates silently in any position is ideal for this application. In addition, the power supply meter can be used as a pressure indicator and a separate vacuum gauge is not required.

The demand for contamination-free vacuum systems is increasing. One important use for clean, oil-free pumping systems is in the vacuum deposition of thin-film electronic circuits. Results obtained with evaporated semiconductor devices have shown that much more reproducible voltage-current characteristics can be obtained if the circuits are deposited in an ultra-clean, ultra-high vacuum. A vacuum evaporator using ion pumping provides this environment.

Fig. 2. Ion pumps are located around this circular electron accelerator to provide the necessary high vacuum required.

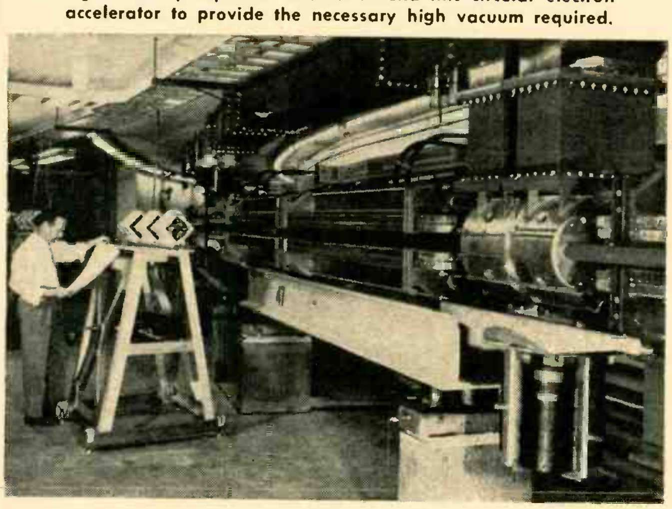


Fig. 2 shows one of a total of 48 triode ion pumps installed around a 750-foot-long circular electron accelerator. These pumps were chosen to maintain a continuous, clean, high vacuum in the orbit chamber of the accelerator. The vacuum is necessary to prevent the loss of electrons due to gas scattering during their 10,000 accelerating orbits.

Vacuum pumps operate in many different ways. Some pumps use mechanically driven vanes or impellers to push gas out of the pump and into the atmosphere. In others, high-speed vapor jets of oil or mercury sweep gas molecules through the pump. The vapor-jet pumps usually empty into the suction side of a mechanical pump which then pushes the gas out into the atmosphere.

The ion pump is somewhat unique because it is a sealed-system device. That is, all the gas that is removed from a system by the ion pump is permanently trapped inside the pump itself. Once it has started to operate, the ion pump combines the methods of ionization and ion bombardment to take gas molecules out of circulation.

This type of pump is a relative newcomer to the field of vacuum technology and has progressed from a laboratory curiosity to an important industrial tool in the past five years. The acceptance of these devices is indicated by the wide range of sizes in which the pumps can be obtained. Besides the extremely small units that can be permanently attached to sealed-off electron tubes, there are moderate-sized pumps used to put the vacuum into television picture tubes before sealing and massive multiple-element pumps large enough to evacuate huge space simulation chambers.

How It Works

The arrangement of electrodes found in a typical ion pump is shown schematically in Fig. 3 and pictorially in Fig. 4. The anode, an open, cell-like structure, is sandwiched between two flat cathode plates made of titanium. A vacuum-tight metal envelope encloses the electrodes and is connected to the system to be evacuated. The entire pump assembly is positioned between the poles of a powerful permanent magnet.

Pumping is started by first applying a high d.c. voltage between the anode and the cathode plates. Electrons present in the space between the electrodes are accelerated toward the positively charged anode. The electrons start to move directly to the anode but the strong magnet field forces them to travel in a spiral path. The electrons are also repelled by the two cathodes and they oscillate back and forth between the open cells of the anode before eventually reaching it. The long path length that an electron travels means that it will have a good chance of hitting a gas molecule before reaching the anode.

If this happens, the energy of the impact may cause the gas molecule to release one of its own electrons. The released electron also travels toward the anode, and it too may collide with gas molecules, releasing still more electrons. This process is called *ionization* and the molecule stripped of its electron is termed a *positive ion*.

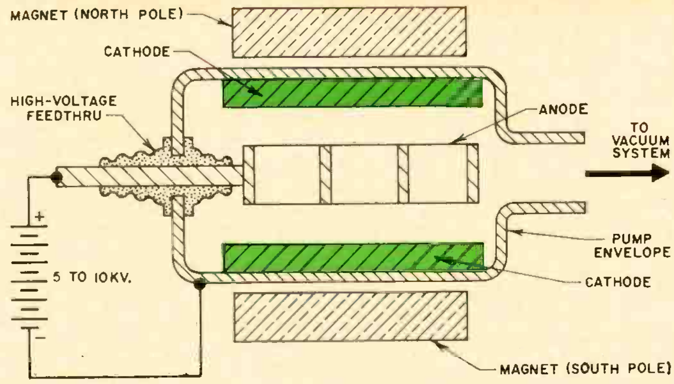
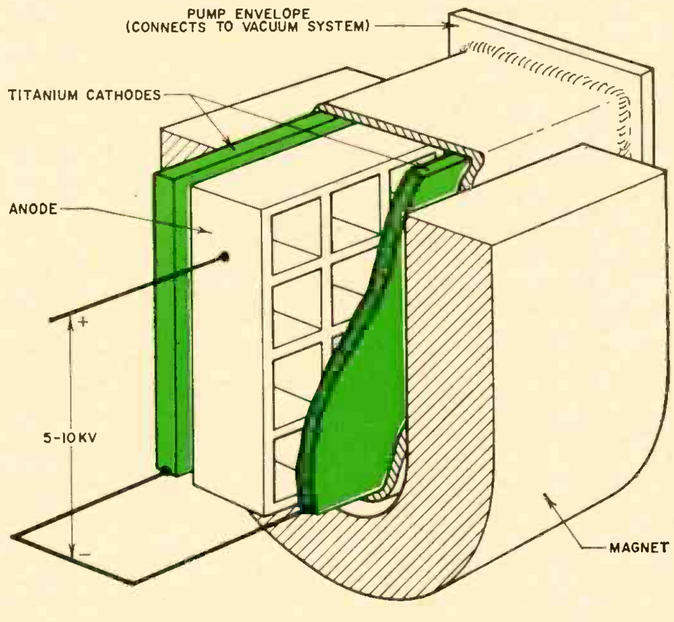


Fig. 3. Arrangement of electrodes in a two-element ion pump.

Fig. 4. Cutaway view of a two-element ion pump and magnet.



Pumping Ions

Positive ions, not affected by the magnetic field, are accelerated toward the negatively charged cathode where they are collected. When a positive ion strikes the cathode, the impact speed drives the ion deep into the metal surface where it is buried. In this way, some of the gas molecules are removed from inside the unit and pumping has begun.

The force of the positive ions bombarding the cathode causes atoms of titanium to be knocked off, or "sputtered," from the cathode surface. Cathode-sputtering causes a thin film of titanium to be continually deposited inside the pump. The freshly formed deposit is chemically active and combines with many of the gas molecules to form stable chemical compounds. This process, known as "gettering," is another method by which gas is removed from inside the ion pump.

When starting an ion pump, it is first necessary to reduce the number of gas molecules in the pump so that the accelerating electrons can travel fast enough to begin the ionization process. A small mechanical pump is sufficient to lower the pressure to this level. Following the initial evacuation, the mechanical pump is sealed off from the system and voltage can then be applied to the ion pump.

Triode Ion Pumps

There are a few molecules of gas that do not combine with the titanium deposit. These inert gas molecules are mostly removed by ionization and burial at the cathode. Unfortunately, buried ions are not permanently removed from the system. Continual bombardment of the cathode releases some of the buried gas and it must be pumped again and again. One solution to this problem requires the addition of a third electrode to the pump.

In the triode ion pump (shown in Fig. 5), the titanium cathodes are made in the form of an open grid and are relocated between the anode and the pump wall. A third electrode, the collector, is placed outside the cathode grid and is maintained at a potential that is positive with respect to the cathode. Ions passing through the cathode grid are driven into the collector surface. The energy of impact buries the ions but is not sufficient to blast out gas or metal atoms that are already there. Other ions strike the cathodes at high speed and cause sputtering. The sputtered metal covers the buried ions and reacts with gas molecules as before and pumping proceeds minus the danger of gas re-emission.

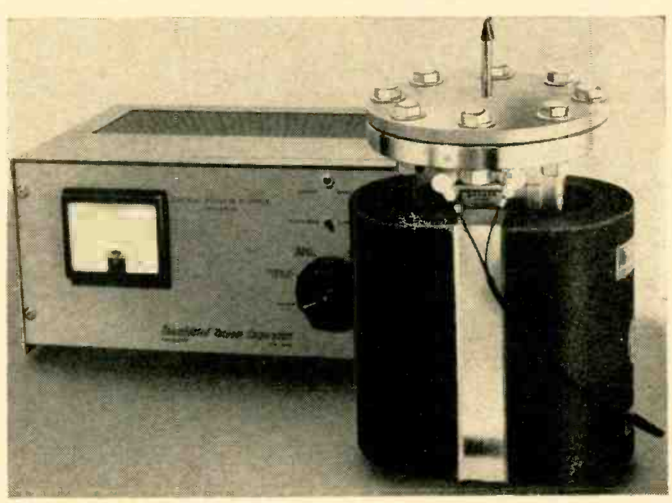
Ion Pump Controls

Ion pump control circuits are designed to provide sufficient power to start and operate the pumps under all normal conditions. In most cases this requires a power supply capable of delivering from 5 to 10 kv. d.c.

The current flowing between the electrodes of an ion pump will be dependent on the number of positive ions collected at the cathode. The formation of ions, however, is directly proportional to the pressure of gas in the pump. An ammeter placed in the circuit to measure ion current will also, when properly calibrated, indicate the gas pressure in the pump.

The control unit can supply all normal loads from short to open circuit without damage to the equipment. In some cases, such as a sudden leak in the pump, the abrupt change from open to relatively short circuit would cause a damagingly high current. In this event, a protection relay is activated and primary power is removed from the supply. ▲

Fig. 5. A triode ion pump and control unit. The large flange connects the ion pump to the system undergoing evacuation.



AUTOMATIC WIRING CHECKOUTS

By SELAH BOND/Technical Writer, Brooks Research, Inc.

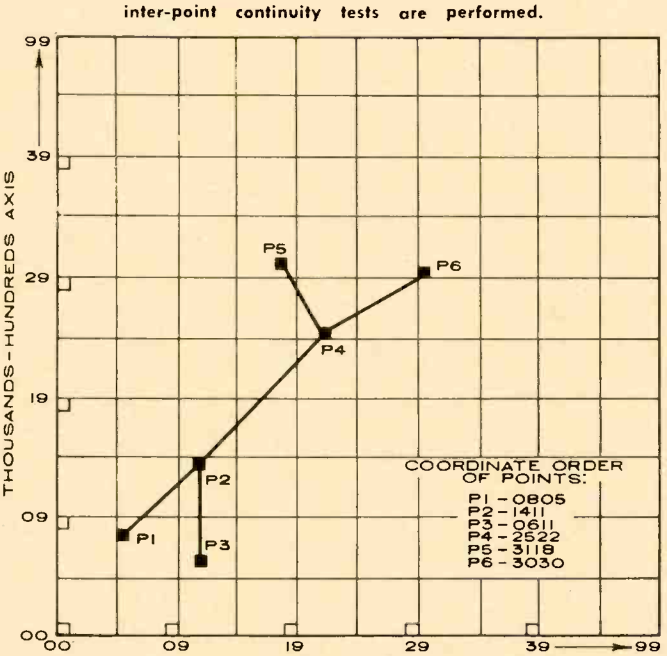
High-speed scanning techniques permit analysis of up to 100,000 terminations of a complex wiring assembly. During these tests, device points out wiring errors.

SEVERAL years ago, wiring assemblies were relatively simple and verifying the electrical paths was a tiresome but manageable task. Present-day assemblies, however, present a growing challenge to electronic manufacturers. These assemblies are complex and the required terminal capacities are large—up to 100,000 terminations are often used. The manufacturer also has the problem of setting up a test program with equipment that is reliable, flexible, and adaptable to in-line inspection.

Verifying wire paths in today's complex circuitry calls for unique, automatic, computer-type analyzers. Basically, automatic checkout equipment is designed to test circuits containing any component or device that can be evaluated by resistive measurements. The equipment then makes decisions on the basis of pulse responses and transfers the decision to an output device. Common tests include the detection of missing, extra, or crossed wires; open circuits; and missing, extra, or reversed diodes. Some analyzers, however, are sophisticated to the extent that they can measure resistance, voltage, time delay, or dwell-time circuitry.

Other requirements for advanced checkout equipment have called for increased accuracy and greater ranges for test values. For example, leakage tests by some systems are performed at voltages ranging from 12 to 1500 v.d.c. with the acceptance limits of such tests as high as 1000 megohms. Dwell time is measured between .1 and 300 seconds, continuity is measured between one ohm and one megohm, while current is measured between .1 and 4 amperes.

Fig. 1. Mathematical model of test shows how inter-point continuity tests are performed.



Another requirement for checkout equipment is flexibility. While automatic checkout equipment is heavily oriented to military operation, an equally important application for the smaller commercial checkout units is directed toward computer wiring backboards, harnesses, and patchboards. When the design of the analyzer provides modular flexibility, the same reliable test system can be applied to these smaller units.

Scanning

High-speed scanning is the basic principle of operation in most automatic checkout equipment. Several types of scan design can be used, each having certain advantages and disadvantages. None, however, is superior in any significant respect to the scanning system in which every point is checked against every other point within a given wiring assembly. In this scan system, the term "point" means any terminal or connection to which a wire is taken or could be taken.

This system is in direct contrast, for example, to the "end-to-end" method of scanning in which a branch circuit, however complex, is checked at two points only. Such systems make no pretense at locating misplaced wires, although they sometimes check for error connections between the branch circuits themselves.

A simple mathematical model such as shown in Fig. 1 helps to understand the "each point against every other point" scan system. Here, a test field, or matrix, represents all wiring connections in a system to be tested. Actual wiring configurations are represented by points on such a matrix. These points are located with vertical and horizontal axes identifying all terminations by coordinates. By constructing all types of branch circuits within this framework, all possible interrelationships of points, wired and unwired, can be seen.

Leakage Test

Part of a leakage test is a leakage scan which compares a preselected termination with all other terminations. Scanning in this case requires that the numerical value of the coordinates for each termination relates to other coordinates as "higher" or "lower." In Fig. 1, for example, *P*3 is the "lowest" point. *P*1 is "lower" than *P*2. Scanning is always performed unilaterally to the "lowest" termination. Thus a typical scan is from the tens-units axis up to *P*3. Another scan is performed from *P*3 to *P*1.

If a continuity test is associated with the test point (as *P*3 to *P*2), this will be done after completion of the scan.

Because of the "downward" look, any shorts, leakages, or extra wires between a given branch circuit and points above the reference point will not necessarily be detected during the scan. Such faults are detected under the program requirement that a leakage scan must be conducted against all supposedly spare or unwired points.

Faults between one branch circuit and another will always be indicated because one lowest point must always be below the other, and the fault will be detected in the normal scan of one of the circuits concerned.

In conjunction with scanning, a self-programming function provides the ultimate automatic checkout. Self-programming completely describes the terminations of the unit under test. Having no prior information about the unit under test, the checkout equipment automatically compares and describes the relationship of each termination with all other terminations. Circuitry design in self-programming enables the output circuitry to produce error-free tapes that can be used immediately to recheck the same unit or to check similar units, and no reprocessing or editing is necessary.

Continuity Testing

In continuity testing there is no scan, insulation, or extra wire test. Referring to Fig. 1, note that the branch circuit consists of six interconnected points $P1$ through $P6$. Each point is connected to the analyzer.

To perform continuity tests on the circuit shown, five separate tests are made: $P1$–$P2$, $P2$–$P3$, $P2$–$P4$, $P4$–$P5$, and $P4$–$P6$. If any of these tests fail (open, or high resistance), the faulty path or connection is immediately identified and printed at the output.

Among the merits of continuity testing performed by this method is the fact that any of the preceding five tests may be made at any time, independently of the others, and the tests may be carried out in any order. This is true randomization. Also, using the existing program tape, any test may be added to or deleted from the program without major program change. In addition, an exact connection path is followed, providing a simple evaluation of component (as in a resistor network) and the isolated fault is indicated in the event of a failure. Finally, each test is self-contained, calling for a "From" and a "To" terminal. This is compatible with computer-produced wiring documents and it is also compatible with the wiring data on a single card that is commonly utilized with automated wiring devices.

Reliability

Since automatic checkout equipment performs an inspection function, one essential characteristic of the test equipment is reliability. Solid-state photo-diode reader inputs, for example, provide a reliability not exceeding one lost bit in 10^{12}. Precision calibration standards are also built into the leakage and continuity bridges.

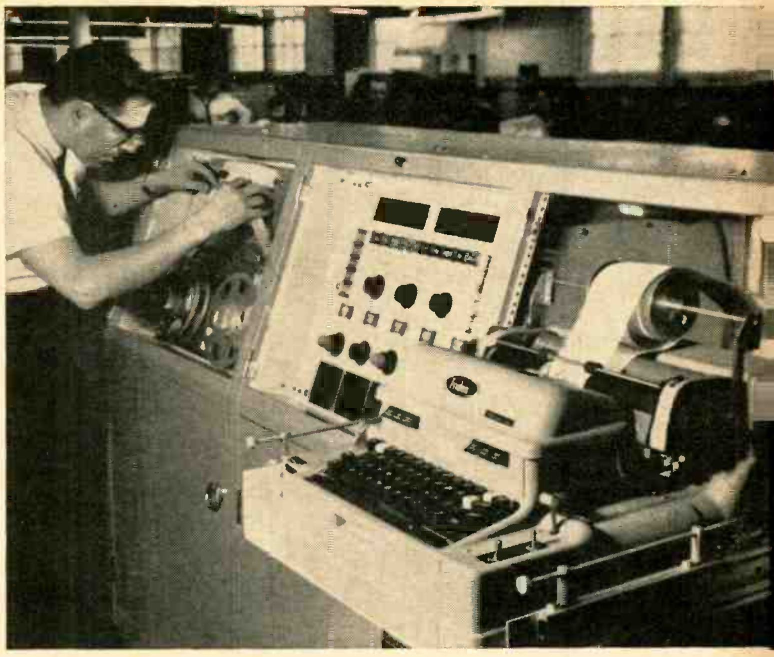
All printed wiring assemblies, designed to meet "worst-case" conditions, are tested to determine the effects of voltage variations, parameter drift, and transient and r.f. interference.

Other standard design factors contributing to reliable electronic performance include matched impedances, high-stability precision resistors, solid-state amplifiers having ultra-high input impedance, and shielded leads in the test-measurement circuits.

Still another kind of reliability necessary for checkout equipment is the fail-safe concept. Should a malfunction occur in the checkout equipment, the problem area is immediately isolated. Testing then stops and will not resume until the faulty area is cleared.

The time required to test a typical 1000-point assembly of 500 one-to-one wires using the high-voltage scan is 5 minutes and 30 seconds. This includes both leakage and continuity testing.

However, evaluation time varies with the particular circuit configuration undergoing the test procedure.



Automatic wiring checkout starts with a programmed punched tape (left). The control panel is in the center, while the printer-readout (right) records any and all wiring errors.

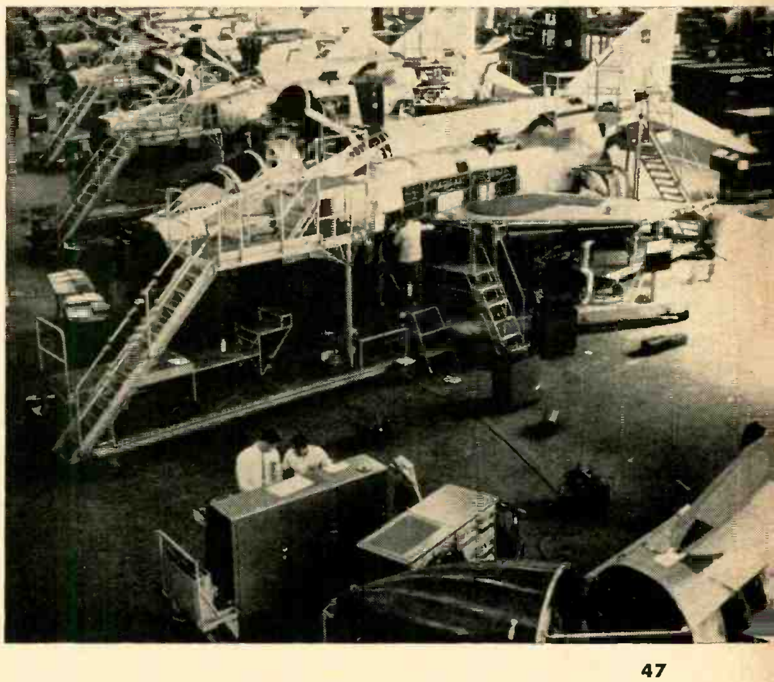
When a continuity test is to be performed on the same 1000-point assembly of 500 one-to-one wires, then only 2 minutes and 45 seconds are required to make this version of the over-all test.

For a typical wiring assembly consisting of 2000 points, the test time would be doubled; for an assembly of 3000 points, the time would be tripled; etc.

Conclusion

Automatic wiring checkout is no longer considered a luxury but an essential tool. Reliability, time, and the need for accuracy dictate the use of such equipment in a growing number of electronic production applications. Units available today are keeping pace with industry's needs, and the outlook for even more progress is promising. A growing market is demanding more development and engineering work in this area. ▲

The automatic wiring checkout console (foreground) speeds up production and increases the reliability of wiring analysis of modern, complex jet aircraft like the F-4 Phantom II here.



METER PROTECTION CIRCUIT

Expensive current meters can be ruined by accidental overload. This one-transistor circuit can prevent such damage by limiting the current flow through the meter.

By A. A. MANGIERI

DELICATE milliammeters, microammeters, and volt-ohm-milliammeters are easily destroyed by short-circuit currents. A short circuit caused by a component failure, a wrong connection, or even the slip of a test prod on a printed-circuit board can result in meter burnout or damage. Such accidents can be quite costly.

Designed for use on transistorized and other low-voltage circuits, this limiter protects the meter from damage by limiting the short-circuit currents to safe values. In addition, the limiter does not seriously alter the normal voltages and currents in the circuit under test as would be the case when a series resistor is used as a current limiter.

Shown in Fig. 1, and having eight current ranges from .5 to 500 milliamperes, the limiter is a handy accessory for use with either single-range or multi-range milliammeters. Using an inexpensive 2N176 transistor, costs are quite low.

Fig. 1. Demonstrating limiter action, intentional short circuiting of the resistive load on the battery has pinned the meter. However, no damage results. Without the limiter, the meter would have been destroyed by excessive current flow.

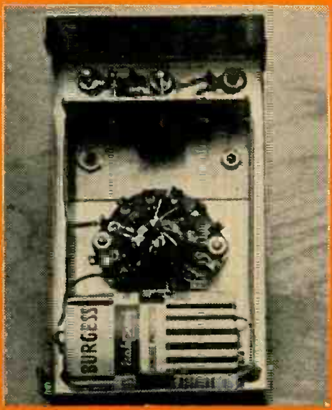


Fig. 2. Rear view of the limiter. Resistors are clustered on S3. The transistor is mounted on 1/16" copper shelf.

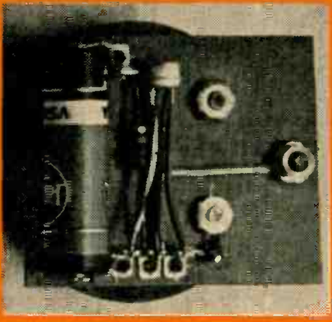


Fig. 3. Meter-mounted limiter uses a low-power transistor. On-off switch is omitted and common-base configuration used.

Circuit Operation

Transistor $Q1$ (Fig. 4) is biased by battery $B1$. Range switch S3 switches the bias current as determined by resistors $R1$ through $R8$. Jacks $J1$ and $J2$ are used for the low current ranges up to 10 milliamperes while operating the transistor in the common-base circuit connection. Jacks $J1$ and $J3$ are used for the higher current ranges while operating the transistor in the common-emitter circuit connection. Diode $D1$, in series with the collector, insures that the current limiter is properly connected to the circuit under test when switch S2 is open. Since the 2N176 is a *p-n-p* type, the collector must be negative, or reverse biased, for operation.

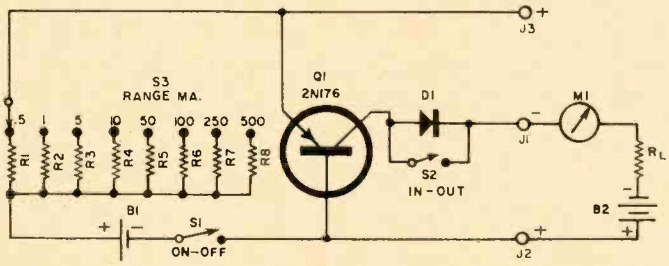
Battery $B2$ represents the battery or other low-voltage source in the circuit under test, such as the battery in a transistor radio. Resistor R_L represents the load on the battery, such as the transistor radio circuit itself. In effect, $B2$ and R_L function as the collector voltage source and load resistor for transistor $Q1$.

Current limiting action of $Q1$, when using jacks $J1$ and $J2$, is easily understood by examining the common base V_c-I_c curve shown in Fig. 5. Assume that meter $M1$ reads 10 milliamperes at full scale. The emitter bias current I_e is set by S3 to a fixed value of 15 milliamperes. Because the common-base d.c. current amplification of a junction transistor is close to but never greater than one, the maximum collector current is almost equal to the emitter current as shown.

As an illustration of the limiting action with $B2$ equal to 20 volts and R_L equal to zero (as by a short circuit), the loadline will be vertical at V_c equal to 20 volts as shown in Fig. 5. The current determined by the point of intersection at point "A" is only 15 milliamperes. The meter is overloaded by 50%, which is not harmful. When R_L is high enough to result in on-scale indications of meter $M1$, the loadline will intersect the steep vertical portion of the V_c-I_c curve at a point such as "B."

Because the common-base circuit requires emitter currents equal to the limiting short-circuit currents, battery life would

Fig. 4. Schematic and parts list for the meter protector.



R1*—2200 ohm, 1 w. res.
R2*—1000 ohm, 1 w. res.
R3*—200 ohm, 1 w. res.
R4*,R8*—100 ohm, 1 w. res.
R5*—1500 ohm, 1 w. res.
R6*—700 ohm, 1 w. res.
R7*—250 ohm, 1 w. res.
D1—1N4004 diode
M1—See text
R_L—See text

J1,J2,J3—Banana jack
B1—1.5-v. dry cell
B2—See text
S1,S2—S.p.s.t. slide switch
S3—S.p. 8-pos. switch (Mallory 31112J or equiv.)
TO-3—Transistor mounting kit
Q1—2N176 transistor

*See text for exact value

be reduced on the higher current ranges. To avoid this, the transistor is operated in the common-emitter connection by using jacks *J*1 and *J*3. In this case, we take advantage of the high common-emitter current gain of the transistor. Load-lines drawn on a common-emitter V_c-I_c curve will illustrate similar current limiting action of the transistor.

Construction

Figs. 1 and 2 show construction details of the current limiter. A 5¼" x 3" x 2⅛" chassis box was used. Support the transistor, using a TO-3 transistor mounting kit, on a copper or aluminum bracket as shown. Remove the transistor when soldering wires to the socket. The transistor is insulated from the heat sink by the mica washer supplied with the mounting kit, and silicone heat sink compound is used to improve thermal conductance. When soldering diode *D*1, grip the lead being soldered with long-nose pliers serving as a heat sink. Mount the diode on switch *S*2. Solder leads directly to the battery and insulate each end with tape. Provide a mounting clip or bracket for the battery. Insulate the jacks from the case. Label and mark the panel as shown using decals or otherwise.

Resistors *R*1 through *R*8 are determined by test because transistor gains and leakage currents vary widely. The lowest possible current limiting range for a transistor is determined by its open emitter leakage current, I_{cbo}, between the base and collector terminals. To measure I_{cbo} for your particular transistor, proceed as follows. Open S1 and S2. Using a 9-volt transistor radio battery for *B*2, a 10,000-ohm pot set to maximum resistance for R_L, and a low-range meter *M*1, connect them in series between jacks *J*1 and *J*2. Gradually reduce the resistance of R_L to zero and read I_{cbo} on the meter. Because I_{cbo} was 0.2 milliampere for the unit on hand, the lowest range was adjusted for 0.5 ma. If a choice is available, use the transistor with the lowest leakage current.

If I_{cbo} is equal to or less than .2 milliampere, use the specified values for *R*1 through *R*4. For higher leakage transistors, use the hookup as above to determine the value of the bias resistor. With S1 open, connect a 5000-ohm pot *set to maximum resistance* in place of the unknown bias resistor. Then, close S1, reduce R_L to zero, and adjust the pot downwards until *M*1 indicates 50% above the range indicated on the panel. Open S1, remove the pot, and measure its adjusted value with an ohmmeter. The short-circuit currents are set to values 50% above the indicated range to allow for eventual aging of battery *B*1.

For tests on ranges from 50 to 500 milliamperes, use a 6-volt battery for *B*2. Connect the positive terminal of *B*2 to jack *J*3. Use a 10-ohm, 10-watt pot for R_L, or omit entirely. Proceed as before with a 5000-ohm pot in place of *R*5 through *R*8, setting the short-circuit currents 50% above the range indicated. On all tests, *do not accidentally short* the pot as this will damage the meter and probably the transistor. Resistance values will be near the values specified for a typical 2N176 transistor having a d.c. current gain of 63.

Applications

For current ranges up to and including 100 milliamperes, use the limiter in circuits with voltages up to 25 volts. At 250 and 500 milliamperes, limit the voltages to 20 and 12 volts respectively. These voltage limitations insure transistor operation well within rated transistor dissipation of 10 watts. Except during a short circuit, the transistor dissipates little power and will run cool.

Do not use the limiter in high-voltage power supplies found in tube transmitters, radio and television receivers, and similar apparatus. Apart from a shock hazard, the transistor will fail immediately due to excess collector voltage if a short circuit takes place. Do not use the limiter in highly inductive circuits where inductive voltage surges can damage the transistor.

To use the limiter, set S3 as required for the meter. Before making connections to the circuit under test, open switch S2 (diode *D*1 in). If S2 is on while making connections, incorrect connections with respect to meter and battery polarities can be made while obtaining up-scale readings on *M*1 but the current limiting action is lost. After making correct connections, switch the diode out (S2 closed). With jack *J*1 as common, use *J*2 only on the low ranges and *J*3 only on the high ranges. When inserting a meter into a circuit for test, a suitable bypass capacitor may be required at the point of insertion as usual.

Meter failures occur by either extremely high current pulses of short duration or by continuous high overloads. In the first case, the moving-coil assembly is rotated with such violence that the assembly or pointer is damaged. In the second case, heating takes place until a restoring spring or fine coil wire melts and opens up much like a fuse. Usually, repair costs cannot be justified except for expensive laboratory grade meters.

Typical high-grade domestic meters meet ASA C39.1 specifications. A two-percent panel meter which meets this specification can withstand a continuous overload of twice its full-scale rating and a momentary pulse of current ten times full-scale rating. The current limiter protects the meter from both momentary and continuous overload by limiting the current to well within twice its full-scale rating.

Although the limiter provides complete protection for a .5-milliampere meter on the .5-milliampere range, this range also provides partial protection for a 100- or 250-microampere meter by limiting momentary surges to safe values.

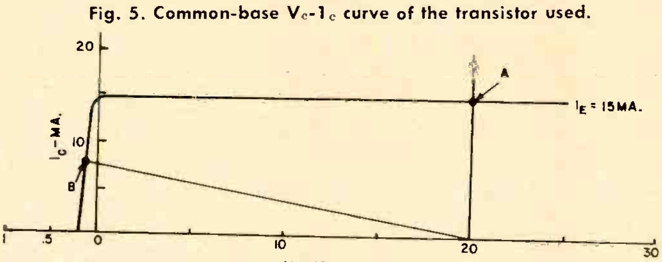
Complete protection of 50- and 100-microampere meters is best accomplished by use of a meter-mounted limiter using milliwatt transistors connected for common-base operation. Fig. 3 shows an arrangement using a 2N169 transistor. A penlite Z-cell or a type-1 flashlight cell may be used to provide bias current. The circuit of Fig. 4 is used and the diode and switches are eliminated. One bias resistor is selected as previously detailed to set the short-circuit current to the desired level. An on-off switch is not required when using a type-1 cell.

It is worth pointing out that if the common-emitter connection is used, transistor leakage alone may be equal to the desired limiting current, thereby eliminating the battery and bias resistor. However, this connection is quite temperature-sensitive but nevertheless useful in some cases. Transistor selection is required, and it is best to check the limiting currents at various voltages, particularly when using bargain transistors.

Except for infrequent battery replacement, the limiter requires little servicing. A *Burgess* 210 cell will provide 500 to 1000 hours service depending on the range in use. Replace the battery when the limiting currents drop below the range values marked on the panel. Check the limiter from time to time to make sure that the transistor has not shorted due to accidental abuse.

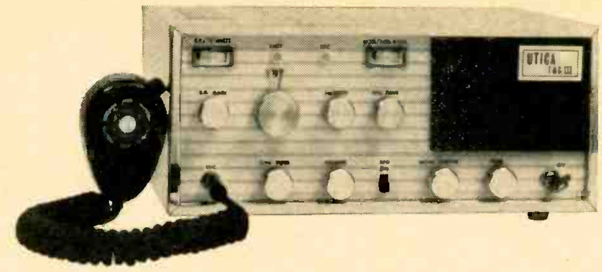
Because construction costs are low, it is a good idea to make two limiters for simultaneous use in experimental circuits. Although costly at present, high-voltage power transistors can be used in this limiter. Use the limiter at every opportunity to avoid a costly meter replacement. ▲

Fig. 5. Common-base V_c-I_c curve of the transistor used.



A

B



NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

C

Description of an automatic noise limiter, a b.f.o. for SSB signals, and a novel squelch arrangement.

IN a typical AM receiver, the connection between second detector and first audio stage is direct. Basically, it couples detected audio to subsequent stages for amplification. In CB receivers, however, the second detector is usually the site of elaborate signal-processing circuitry required for communications work. Each of the following three circuits is an example of such specialization. All are positioned between detector and audio stages. The first is the automatic limiter of *GC*'s recent *Globe* "President VIII." This is followed by a circuit newly introduced to CB radio: a b.f.o. to enable a conventional second detector to demodulate single-sideband signals. It is found in the *Utica* "Town & Country III." The last circuit is the squelch circuit that is employed in the *Allied Radio* "Knight" KN-2550 transceiver.

Globe "President VIII" Noise Limiter

Given ample signal strength, pulse-type noise interference is the next significant factor which determines whether a received signal will be heard and understood. A principal noise source, the automobile ignition system, may be treated effectively with suppression techniques; suppressors, r.f. bypassing, shielding, and grounding. But such measures work only for the operator's own car. They do nothing to suppress the noise generated by other autos in the immediate vicinity. Thus, nearly every current CB transceiver includes some kind of noise-limiter circuit. It attempts to remove sharply peaked, short-duration pulses from the audio signal while introducing the least distortion.

The simplest noise-limiting device is a diode shunted across some section of the audio circuit. Biased to a preset level, the diode can be made to conduct and short-circuit only strong voltages developed during noise spikes, leaving the desired signal relatively unaffected. It works, but is subject to a major fault which reduces effectiveness; namely, that the percentage of noise clipping varies with incoming signal strength. Not so with the circuit designed into *GC*'s[1] "President VIII" (see photo A). The new transceiver features an "automatic series-gated full-wave" noise limiter. The "automatic" refers to the circuit's ability to continuously adjust itself to the incoming signal. This eliminates the need for manual readjustment. The same relative limiting level occurs for both weak and strong signals. The "series-gated" term refers to the circuit's position, in series with the audio signal traveling from second detector to the first audio amplifier. As we will see, the limiter is made to conduct during normal audio reception, but opens for noise pulses. Finally, the "full-wave" feature refers to the circuit's clipping of both positive and negative noise peaks of incoming interference.

Shown in Fig. 1 is a partial schematic of the transceiver indicating the noise-limiter circuitry of *V2B*. It will be seen that the cathode of the tube ties to the a.v.c. through resistors *R*1 and *R*2. (These resistors and capacitor *C*1 create the a.v.c. time-constant; short enough to respond to shifts in carrier strength, yet long enough to keep audio from feeding back to earlier, controlled stages.) Thus, a.v.c. biases the noise-limiter cathode with negative voltage proportional to incoming carrier strength. This is the basis of automatic operation. Incoming audio tapped from the second detector is applied to the diode plate, pin 7. Note that the second detector load is split between two resistors, *R*3 and *R*4. Dividing the load in this fashion permits the relative clipping level to be fixed. Given this arrangement, a noise-free audio signal can transfer through the limiter diode due to the relative potentials. Audio is negative-going at the diode plate, but less negative than cathode bias developed by a.v.c. The diode plate (pin 7), therefore, appears positive and signal current may flow.

With the arrival of a noise pulse, negative voltage applied to the plate increases sharply. Since the plate is now driven more negative than the cathode, no signal conduction occurs during the pulse period. It should be noted that the cut-off condition of the diode is not apparent to the listener as a "dead" spot. Noise pulses are of extremely short duration. They tend to sound much longer in non-limited receivers due to mechanical inertia of the loudspeaker cone or "ringing" in i.f. stages.

The action just described clips only the negative-going part of the noise pulse. The second section of the limiter diode, pin 6, suppresses the positive component. Note that the audio signal, already clipped for negative pulses, also reaches pin 6 of the limiter diode. This is due to the com-

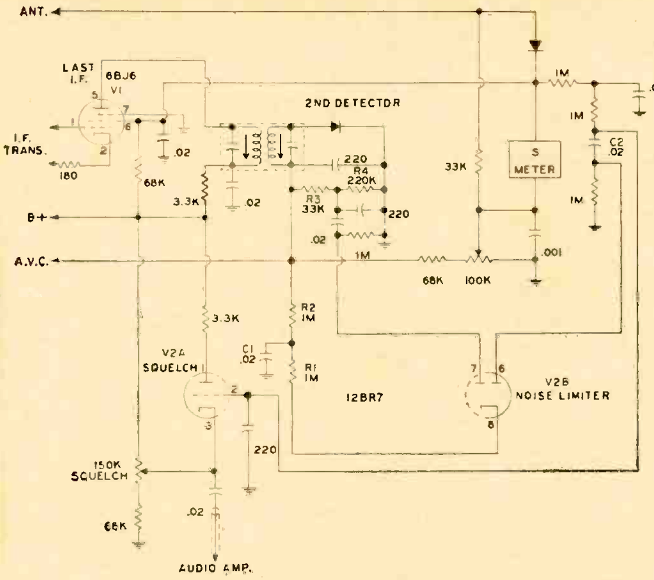


Fig. 1. Noise-limiter circuit employed in Globe "President VIII"

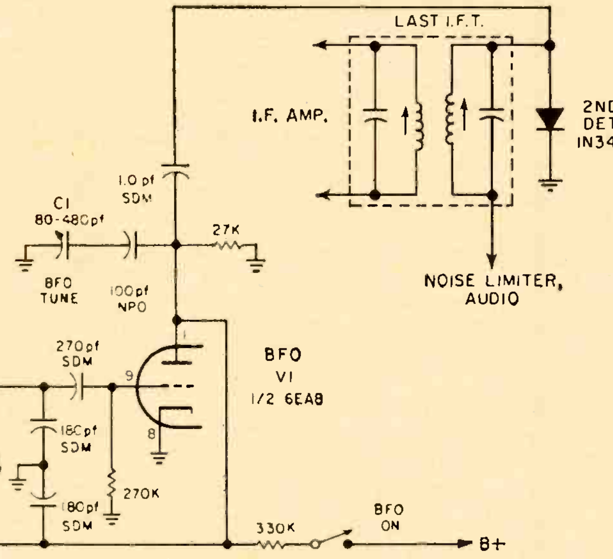


Fig. 2. The Utica "T & C III" unit uses the b.f.o. stage as shown.

mon cathode between diode halves, which causes electron coupling. If a strong positive noise spike, occurring faster than the a.v.c. time constant, reaches the limiter cathode (pin 8), again the diode will be cut off. At the end of the spike period, the diode conducts again, and the normal audio signal may proceed to pin 6, then through capacitor *C*2, the squelch stage, and to the audio amplifier.

Utica "T&C III" B.F.O.

Single-sideband equipment, now being offered on the CB market, is not compatible with conventional transceivers. Lacking a carrier, the SSB signal produces unintelligible garble in a conventional AM receiver. The second detector stage must be provided with carrier energy to heterodyne against an incoming sideband for producing the difference frequency, *i.e.*, audio. Anticipating possible widespread usage of sideband, *Utica*[2] equips its new "Town & Country III" (see photo B) with a method for sideband detection in their CB-AM receiver. The circuit is a beat-frequency oscillator—the familiar b.f.o. found on communications receivers, but notably absent from CB gear until now.

The b.f.o. stage is shown in Fig. 2. It is a self-excited oscillator of the Colpitts type whose operating values place the output frequency nominally on 266 kc. This matches the receiver's i.f. at the second detector. When the operator wishes to detect sideband, he closes the switch to energize the oscillator stage with "B+." He then adjusts variable capacitor *C*1 for small changes in frequency.

Oscillator r.f. output is coupled into the receiver's second detector where heterodyne action occurs. If the incoming sideband signal contains 1-kc. audio, for example, it could appear at the second detector as 267 kc. In manipulating the front-panel tuning control, the operator varies the b.f.o. for precisely 266 kc. The resulting mixture—b.f.o. and sideband signals—re-creates 1-kc. audio, or different frequency. In the case of a voice transmission, the operator tunes the b.f.o. to "clear up" the audio. The b.f.o. oscillator has an approximately ±15-kc. tuning range to accommodate normal frequency tolerance.

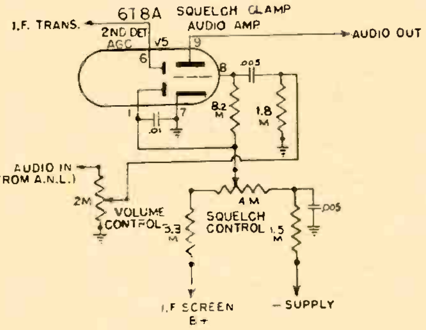
"Knight" KN-2550 Squelch

Another circuit associated with CB second detectors is the squelch; the muting feature which completely quiets the receiver between incoming calls. Our example occurs in the "Knight"[3] Model KN-2550 transceiver (see photo C). The circuit represents one of several popular techniques for developing squelch action. In effect, it utilizes changing screen-grid voltage of an i.f. stage to clamp, or render inoperative, one of the receiver's audio amplifier tubes. The operation of this particular circuit is discussed below.

The schematic section devoted to squelch is shown in Fig. 3. During signal reception, audio is recovered from the i.f. signal by the second detector diode (pin 6). After passing through noise-limiter circuitry (not shown), audio appears across the volume control. This energy is fed to the triode section for amplification. Squelch control of the triode grid is achieved in the following manner: It will be seen that the grid (pin 8) not only picks up audio from the volume control, but is also tapped into the squelch-control potentiometer. Voltages applied to the ends of the squelch pot are available from two sources: a fixed negative potential derived from the transceiver power supply (approximately −50 v.) and from the screen of an i.f. stage (about 80 v.). Assuming that no signal is being received, the operator adjusts the squelch pot so loudspeaker noise just disappears. This is equivalent to sliding the squelch-control arm to some negative point along the pot's resistance element—just enough so the audio amplifier triode section is biased to the cut-off point.

Now assume that a signal is received. Since a.v.c. is being developed, which controls the i.f. stage, screen voltage of the i.f. tube swings increasingly positive. (Decreasing screen current produces a voltage rise in a positive direction.) This upsets the potential balance across the squelch control. The squelch arm will now "see" a more positive point and the triode tube is unclamped. It commences to conduct the audio signal. For correct operation of the triode tube, its grid should not, under any circumstances, be permitted to enter an absolutely positive region. An additional diode, seen at pin 1, prevents an absolutely positive condition no matter how high the i.f. screen swings. Also tied to the amplifier grid, the diode's conduction produces the necessary voltage drop to prevent the triode grid from ever reaching the positive condition. ▲

Fig. 3. Squelch circuit that is used in Allied's "Knight" KN-2550 transceiver.



REFERENCES

1. GC Electronics Co., 400 S. Wyman St., Rockford, Illinois
2. Utica Communications Corp., 2917 W. Irving Park Road, Chicago 18, Illinois
3. Allied Radio Corp., 100 N. Western Ave., Chicago 80, Illinois

JOHN FRYE

TV interference is appearing in new forms, as the result of improper use of Citizens Band units and CATV equipment.

NEW VARIETIES OF TVI

MAC was alone at the service bench, and his mind was obviously not on his work. Every few minutes his eyes strayed to the clock on the wall and then anxiously to the sleet and freezing rain scratching against a rear window. Barney had left to make a couple of service calls right after lunch, and the foul weather had started about an hour later. Finally, though, there came the sound of the service truck being parked behind the shop, and Barney soon came through the rear door.

"Man, it's so slick out there a rooster couldn't stand up to crow!" the youth exclaimed as he shrugged his way out of his heavy coat. "The street department hasn't gotten around with the salt and cinders yet, and I slid right on through a couple of intersections. I don't mind admitting I'm glad to be inside. Did you worry about me?"

"Why should I worry? I've got plenty of insurance on my truck," Mac answered with just a trace of a grin. "Did you make the calls?"

"Yo," Barney replied, "and the funny thing is both turned out to be TVI complaints. At the first place, the owner really came on like Tarzan. He was trying to watch a basketball game, and every few seconds the picture went every which way and a gal's voice cut in complaining how tough it was to be cooped up with a couple of kids with the mumps, especially when she hadn't had 'em—I mean the mumps, not the kids!

"The fellow was convinced something was wrong with his set until I lugged in our portable and showed him the same thing was happening to channel 6 on ours that was happening on his set. I explained we were picking up interference that very likely came from some radio station right in the neighborhood. That did it. The guy was immediately ready to grab his ax and run down the block to where he said a ham lived and chop down the pole supporting the ham's beam antenna. By this time, though, I had caught the call of the interfering station; and I explained the interference was coming from a CB rather than an amateur radio station. I called a CB friend of mine and asked who belonged to the call. He promptly supplied the information, and it turned out the station was in a house just across the alley.

"About all I could think of to do was to go across the alley and take a look at the CB station. Persuading our hot-headed customer to stay home took a little doing, but I managed it by saying I needed someone to watch his TV set while I was checking. A rather attractive redhead let me in, and she was not too surprised when I explained why I was there. She said the same thing happened to her own TV set when she operated the CB rig but this didn't bother her much because she never wanted to talk and watch TV at the same time anyway!

"She readily agreed to let me look at the set—actually I think she was glad to have someone to talk to besides those lumpy-faced kids that kept hopping out of bed and running into the room every few minutes. There was nothing unusual about the transceiver, but a short piece of coax went from its output to a metal box with some tubes in it, and then another piece of coax led from the box up to a ground-plane on the roof. When I asked about this box, she said it was an 'amplifier' a friend had built for her husband to help him get out better. The box had no meters on it, but I noticed it used a pair of 6146's, and I'll bet that linear amplifier was inputting at least 150 watts.

"When I asked permission to take the amplifier out of the feedline temporarily, she said to go right ahead. With the linear out of action, I suggested she contact someone while I called our customer on the telephone to see how the interference was doing. She picked up the mike and said her station was 'ten-eight on eleven,' whatever that means. A fellow called her immediately, and while they were chatting our customer reported no interference with his ball game; furthermore, her own TV set showed no sign of interference. The other CB station reported she was not 'as many S-units' as usual, but she was just as readable.

"Before leaving, I asked if she wanted me to reconnect the amplifier, and she said not to bother. Her husband was the DX hound. I told her very gently that I didn't think the FCC wanted CB stations to use that kind of 'amplifier' and that maybe her husband had better check into it. She said she'd tell him."

"Is this sort of thing common?" Mac asked.

"I don't think so, but sometimes I wonder. A CB'er asked me to build him a linear amplifier a few months back. I refused, explaining a legally operated class AB linear would deliver less signal to the antenna than his present class C final because of the lower efficiency of the linear. He replied with a perfectly straight face it didn't matter how much power he ran into the linear. All that was required was that he didn't run more than five watts into the 'final,' which, of course, was in the transceiver! I tried to tell him any stage feeding the antenna *became* the final and was limited to five watts input, but I don't think he read me. Even if he'd been right, any ham could tell him operating a linear is tricky and you don't attempt it without meters. Grid drive, neutralization, and antenna loading must all be carefully adjusted to keep the amplifier 'linear'; and if it's not linear, you can get all sorts of weird results, including juicy TVI.

"Modern CB equipment has built-in TVI-preventing measures, and I'm confident it will not cause trouble if properly operated under ordinary circumstances. Of course, a non-linear device, such as an oxidized joint in downspouting or a TV antenna, can always rectify the signal and radiate harmonics; or grids in unshielded audio amplifiers can pick up enough r.f. to make their tubes act like detectors instead of amplifiers and change hi-fi, radio, or TV sets into temporary CB receivers."

"This is probably a silly question to you, but how can a technician tell a CB call from a ham call?"

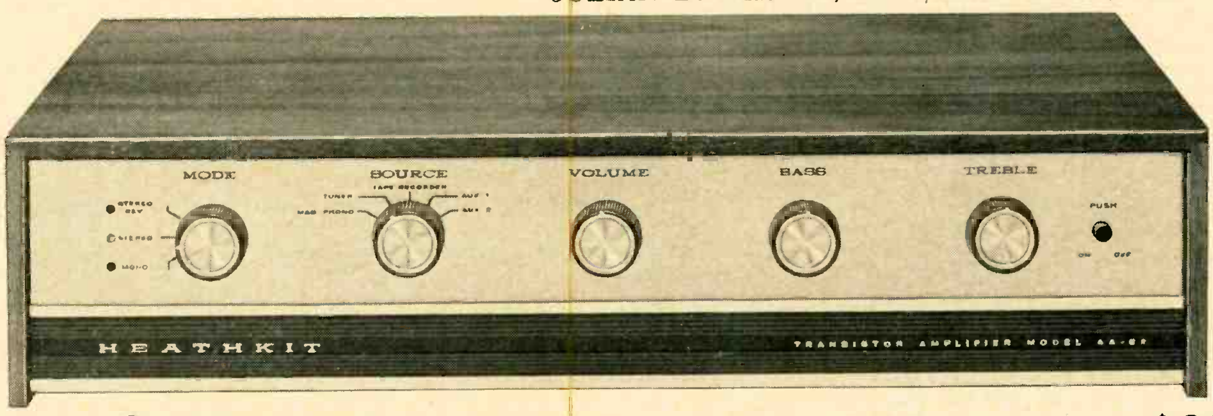
"That's easy. If the call has only one digit, as W9EGV, it's a ham call. If it contains more than one digit, as KHD4167, it's a CB call."

"By 'properly operated' do you mean just not using a linear?"

"Not necessarily. Every group has a few jokers who think

"Until just recently, I have been somewhat skeptical about low priced transistor amplifiers. However, after testing and listening to the Heath AA-22, I feel it is time to revise my opinion. This remarkable amplifier can easily hold its own against any amplifier—tube or transistor—anywhere near its price range."

JULIAN D. HIRSCH, Hi Fi/Stereo Review, Nov. '64



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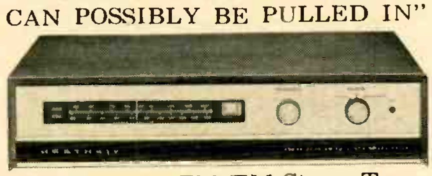

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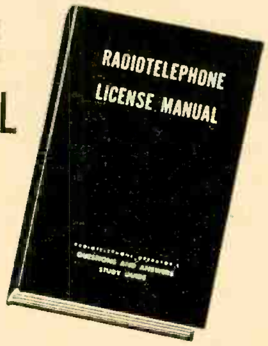

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rules are just for other people, and they ruin things for everyone. I doubt many fellows use linears, but a lot of CB operators use a transistorized amplifier between the mike and the mike jack and literally drive the pants off the audio stages and the modulator and 'bleed' across all 23 channels. They can't understand overmodulation only makes a signal wider without making it stronger. You'd think they'd realize that if those transceivers needed more audio amplification the manufacturer would certainly have built it in."

"You said you had two TVI complaints. Was the other caused by a CB station?"

"No, but it was just as puzzling. In this case the sound was OK but the picture had a vertical bar down the center and it looked as though a weak duplicate picture was in behind the main one. This weak picture, though, was cut in half by the bar so that the left side of it was faintly seen on the right side of the screen and *vice versa.* I could bring up the weak picture by rotating the antenna, but then the picture started to roll. And at the station break I saw both pictures were coming from the same station. It was not, as I had begun to suspect, a case of co-channel interference.

"Checking with our portable fastened to the customer's antenna proved the trouble was not in his receiver. I plugged the portable into an extension cord so I could lug it around while I used its built-in antenna. With this setup I could get a snowy picture without the bar on the west side of the house, but when I went back to the east side where his set was, I got a stronger picture but the bar had returned. At this point I noticed something funny: the weak picture on the customer's set was the strong picture on the portable!

"This gave me a clue. Even though it was just starting to sleet, I plugged the extension into a porch outlet and carried the portable across the yard toward the neighbor's house on the east. The farther I went the better my picture became, and when I stood right next to the neighbor's TV tower I had a beautiful picture with no bar. A very strong signal was being radiated from the feedline. Then I noticed that while the feedline from the tower went through the wall, so did a CATV line from the alley.

"I knocked at the neighbor's door and asked the elderly lady who answered it if I could check her reception with that next door. She obligingly turned on her receiver to reveal excellent CATV reception with no bar, but while she was doing this I managed to get a glimpse behind the receiver. Both the lead from the CATV impedance-matching transformer and the tower lead were connected to the set's input terminals. When I called this to her attention, she said her husband had been 'experimenting' the night before to see if using both antennas made any difference in reception. It didn't, but he didn't bother to disconnect the tower lead. She didn't object to my doing so, and a check by telephone revealed the bar had disappeared from our customer's receiver.

"Of course the 2000-microvolts-plus signal from the cable was feeding up to the TV antenna and being radiated and picked up by our customer's antenna next door. The cable acted as a delay line so that the picture it delivered—the faint picture—was displaced on the screen enough that the horizontal blanking bar came squarely in the middle of the picture being received directly. Hey, what are you grinning about?"

"At a thought that just crossed my mind. Have you ever had the mumps?"

A look of growing horror spread across Barney's face as his hand involuntarily stroked his jowls. "Holy cow, no!" he groaned. "I was so busy chasing Tennessee Valley Indians—that's what we hams call TVI—that I never once thought about it!" ▲

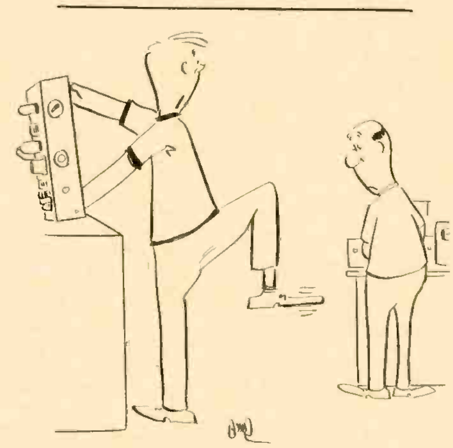
GROMMET REJUVENATION

By RONALD L. IVES

Many varieties of soft rubber grommets, intended for electronic work, lose their resilience in a few months, becoming so hard and brittle that they cannot be inserted into the intended holes.

These can be softened, temporarily, so that they can be pushed through chassis holes without disintegrating, by soaking them in any one of a variety of rubber softeners. Most of these are medium to high volatility benzenes and petroleum ethers, somewhat hard to get as such in small quantities (less than a 55 gallon drum). However, suitable compounds are available "over the counter" in stationery stores, where they are sold as "Platen Softener" for use with office machines.

Rubber grommets are effectively softened by soaking them for about 15 minutes in this compound. They become hard again in a few weeks. Use any and all of the compounds in an adequately ventilated area and keep away from open flames, as they have toxic fumes and are at least as flammable as lighter fluid. ▲



"Hey, Dad, cut me a piece of wire about that long."

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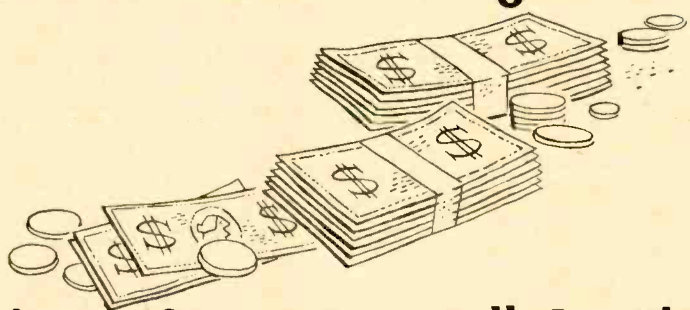

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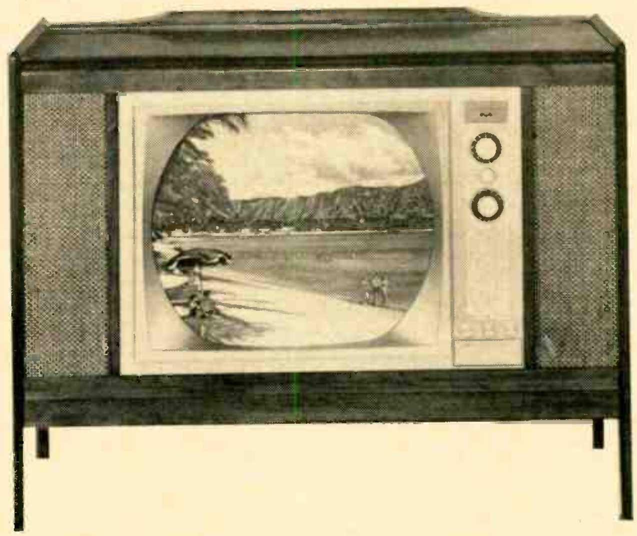

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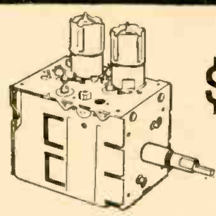

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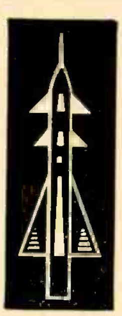

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Frequency Synthesizers

(*Continued from page 27*)

entire range, thus producing a whole band of frequencies, each fully as stable as the standard employed. Before any further discussion of this type of synthesizer is attempted, it would be wise to briefly investigate the operation of phase locking one oscillator to another.

Fig. 2 is a schematic diagram of a simple phase comparator. This circuit is often used as a horizontal sync discriminator in TV sets. The signal from the harmonic generator is applied to input "A" while the v.f.o. signal is applied to "B." The diodes act as rectifiers so that when the input frequencies are *exactly* the same (in phase), equal but out-of-phase voltages appear across $R1$ and $R2$. The net result is zero output voltage. If the v.f.o. is higher in frequency than the reference, one diode will conduct more heavily than the other and a d.c. control voltage will be produced. If the v.f.o. is lower in frequency than the standard, again an output voltage is produced but this time of the opposite polarity. This control voltage is fed to a reactance tube which in turn changes the frequency of the v.f.o. so that it is the same as the harmonic of the reference. The v.f.o. is now said to be locked to the standard. Fig. 3 is a simplified diagram of an indirect type of frequency synthesizer. This device, as the one in Fig. 1, will produce signals from 100 kc. to 1 mc. in steps of 100 kc., but its operation is much simpler and the circuitry far less complex. It can now be seen that large frequency ranges can easily be covered without circuitry becoming unwieldy.

Fig. 4 is a simplified block diagram of a commercial synthesizer which covers a range of 2-34 mc. in steps of 100 cps at a guaranteed stability of 1 part in 10^8 per day. The output of the 10-kc. minor loop is now added to the main loop in the second mixer and locks the frequency range at 10-kc. intervals. In a similar manner, the 1-kc. and 100-cps loops are injected into the main loop, resulting in the v.f.o. producing 16-34 mc. completely locked in 100-cps steps. A divider on the output of the v.f.o. now divides the output signal by 1, 2, 4, or 8 to give the proper coverage. Because the master v.f.o. is essentially locked at 100-kc., 10-kc., 1-kc., and 100-cps intervals by signals all initially derived from the standard, the stability of the output is that of the standard. For maximum stability, then, the oscillator used as a standard is usually one designed for extreme stability. The photograph shows a commercial frequency synthesizer (top) and an external multiplier (bottom) for increased range. These two pieces of equipment provide ultra-stable signals over the range of 2 to 500 mc.

As the need increases, other standards with stabilities of .001 and even .0001 cycle per day can be incorporated into these synthesizers, and wide ranges of frequencies with the utmost in stability can be produced. ▲

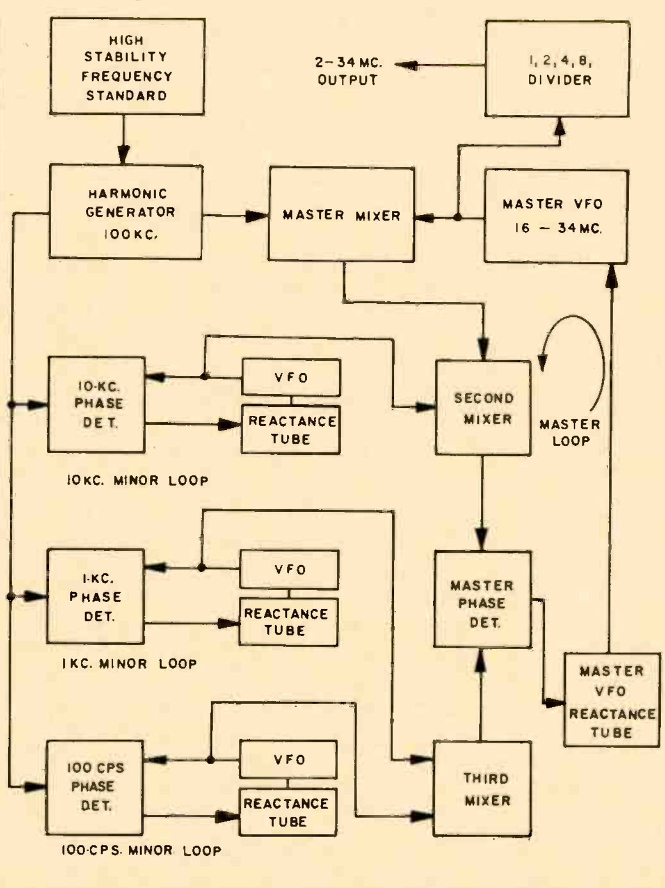

Fig. 4. Operating diagram of modern frequency synthesizer.

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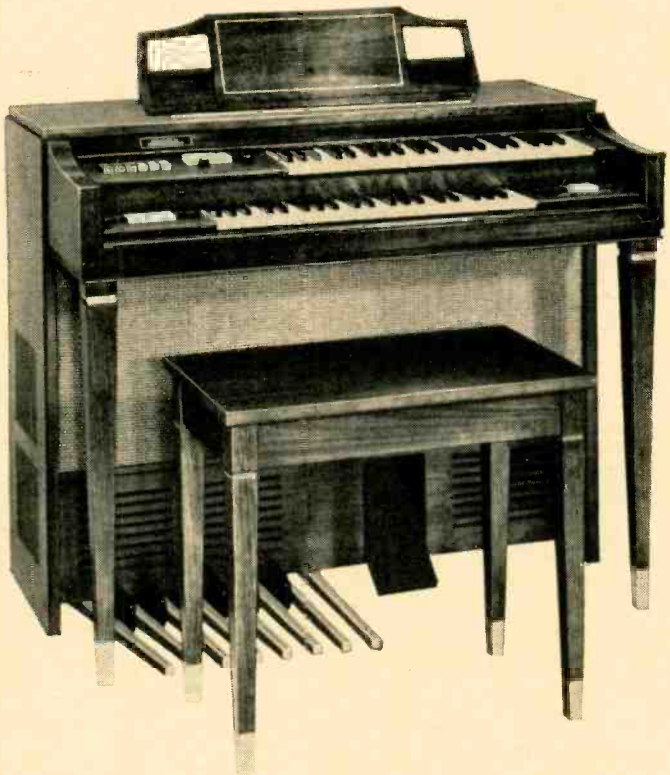

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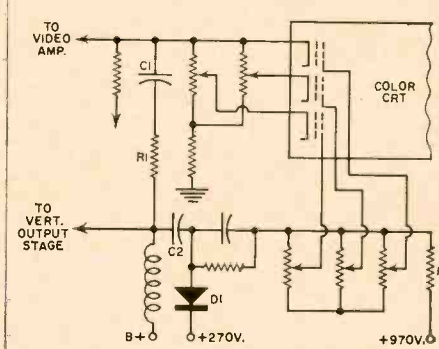
COLOR-TV RETRACE BLANKING

THE automatic vertical retrace blanking circuit used by *Motorola* in its new color-TV sets is shown in the diagram. In this circuit, voltage from the vertical output stage is fed to both the CRT cathodes and screen grids to turn the brightness off during the vertical retrace period. This will prevent the retrace lines from appearing in the picture thus eliminating this cause as a possible source of picture degradation that might otherwise spoil a well-received color picture.

The voltage at the plate of the vertical output tube has a large positive-going component during the vertical retrace period. This is caused by the discharging yoke inductance. The pulse portion of this waveform is made up of high-frequency components and is passed to the CRT cathodes through *R*1 and *C*1. The time constant of this network is short enough to prevent the remainder of the sawtooth from passing. This positive pulse applied to the cathode will cut the CRT off. However, this spike pulse is not long enough to keep the CRT turned off for the entire duration of the retrace.

The additional circuit components between the vertical output stage and the CRT screen grids are used to keep the CRT blanked for the remainder of the retrace period. The blanking voltage applied to the grids must be negative going.



Automatic vertical retrace blanking circuit as used in Motorola color-TV sets.

This is accomplished by differentiating the positive-going pulse present at the vertical output by *C*2 and *R*2. After differentiation, the negative-going portion will be slightly delayed in time with respect to the positive portion. Diode *D*1 is connected as shown to limit the positive excursion of the differentiated voltage allowing only the negative portion to pass. This negative voltage is passed to the CRT grids to keep the tubes cut off until the vertical retrace is complete. ▲

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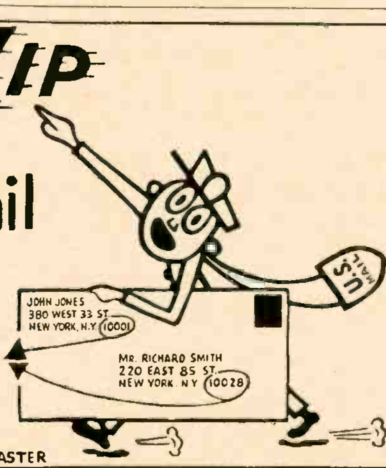

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"Chirp" Radar

(Continued from page 43)

widths and center frequencies, a linear delay *vs* frequency can be very closely approximated. The complexity of this method is offset by the wide bandwidth and adjustability attainable.

There are some more subtle but equally significant advantages of chirp. Note that a chirp system has to have a much wider receiver bandwidth than a conventional pulsed radar of equal peak power. Also note that the energy transmitted is distributed over a much wider range of frequencies. This makes the radar relatively immune to jamming.

There is another significant advantage of chirp. The delay network will only pile up, or compress, one particular swept frequency whose slope and bandwidth exactly match the network. Random signals fed into the delay network will not pile up and will come out of the network with the same amplitude they had when they went in (assuming a lossless network). However, the real signal will pile up by the chirp ratio and *increase in amplitude by the same factor*. This means that the signal-to-noise ratio of the radar echo returns is considerably improved going through the delay network.

One thing remains—the sidelobes on the ($\sin x/x$) pulse. By controlling, or shaping the amplitude of the swept-frequency signal before or after it is transmitted, the sidelobes can be very greatly reduced in magnitude (Fig. 4). This increases the radar dynamic range.

For further reading in chirp and chirped radars, the references listed below might be of interest. Most of the references assume an extensive knowledge of advanced mathematics and, with the exception of reference 1, might make fairly difficult reading. Sources 1 and 2 are excellent general radar texts, while the others deal specifically with chirp and pulse compression. ▲

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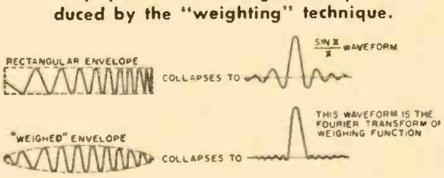
4. "IRE Transactions on Military Electronics," Vol MIL-6, April 1962. Special issue on signal processing radar.
5. Omeara, T. R.: "The Synthesis of Band-Pass All-Pass Time-Delay Networks Using Graphical Approximation Techniques," Hughes Research Report No. 114, Hughes Research Labs., Malibu, California.

Fig. 4. The sidelobes of the collapsed chirp pulse can be significantly reduced by the "weighting" technique.



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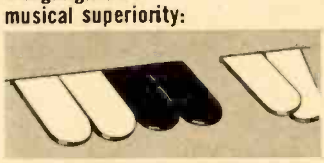

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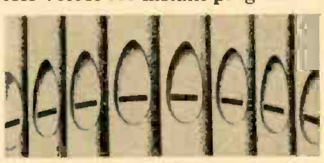

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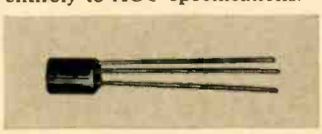

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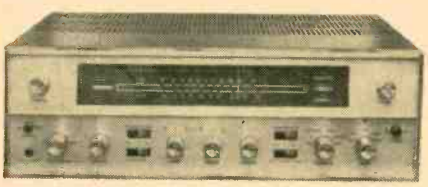

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New LR-800 70-Watt Complete AM-FM Stereo Multiplex Receiver features a tuned nuvistor "front-end" and an FM "Stereo-Search" multiplex indicator. Excellent sensitivity, frequency response, and low distortion specs. Imported, **99-0005WX.**

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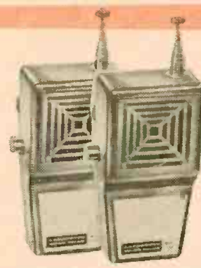

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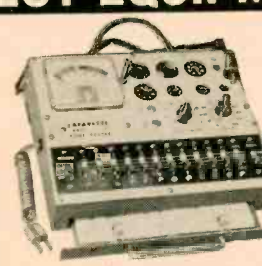

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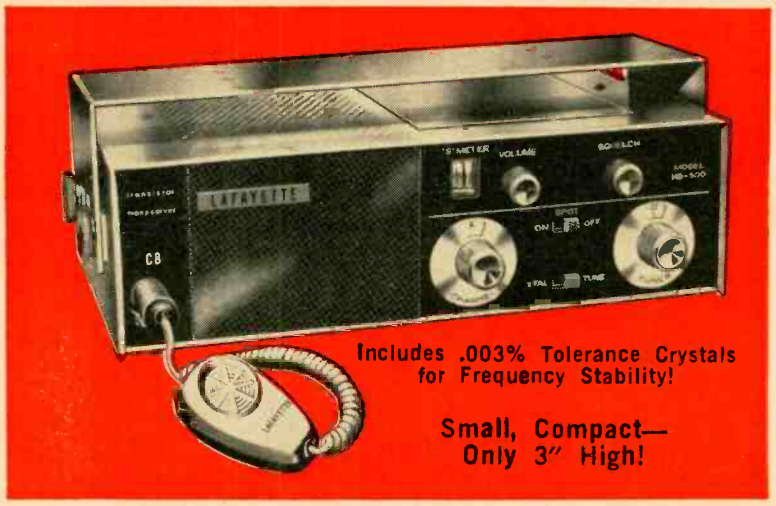

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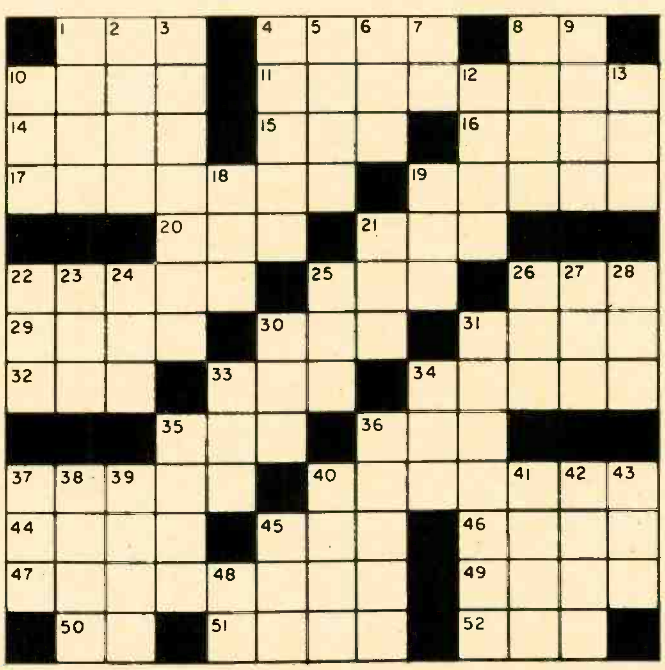
ELECTRONIC CROSSWORDS

By JAMES R. KIMSEY

(*Answer on page* 98)

ACROSS
1. Decay.
4. Jezebel's husband.
8. Type of current (abbr.).
10. Strong wind.
11. Commonly, the stage or circuit in a radio set that demodulates the r.f. signal into its audio or video component.
14. Dill seed.
15. Part of "to be."
16. Ore deposit.
17. "_____ tube," special CRT.
19. Made to occur at or during a set period.
20. Poem.
21. "_______switch," a multi-contact switch, usually rotary.
22. Component having two electrodes; one a cathode and the other a plate or anode.
25. Atom or molecule which has fewer or more electrons than normal.
26. Possessive pronoun.
29. Sea eagle.
30. "Swinging ____," a type of mounting and feed used to move cutting head at uniform rate across the recording disc in some sound recorders.
31. "____troposphere"; that portion of the atmosphere located about 40-60 miles above earth's surface.
32. Very small.
33. Noah's boat.
34. Finished.
35. Tube circuit in color-TV receivers which keeps both frequency and phase of 3.58-mc. color oscillator synchronized with burst signal (abbr.).
36. Quantity (abbr.).
37. Fall into disuse.
40. Electron gun in three-gun color CRT which provide beam striking the blue-emitting phosphor dots of screen mosaic (two words).
44. On the sheltered side.
45. Delay in the recording or display of any device with respect to the conditions being measured or reproduced.
46. Not any.
47. Type of curve formed by intersection of cone and plane; the plane being parallel to edge of cone.
49. Any point, line, or surface in stationary-wave system at which amplitude of wave-shaping variable is zero.
50. City map abbreviation.
51. Coil assembly used to produce electromagnetic deflection of electron beam in CRT television tube.
52. Fuss.

DOWN
1. Rave.
2. Substitute for "the more expensive spread."
3. Four-electrode vacuum tube.
4. Metaphorical saying.
5. In this place.
6. Consumed.
7. Is.
8. Smallest unit of any chemical element.
9. One type of communication.
10. Substance with a boiling point below normal ambient temperatures and pressures.
12. Small, spring-type clamp.
13. "Hot-line" color.
18. Fruit drink.
19. Light brown.
21. Male cat.
22. Night moisture.
23. Former name of the industry's engineering society (abbr.).
24. Single unit.
25. Anger.
26. Antiquated.
27. American Indian.
28. Round metal bar.
30. Intense luminous discharge between electrodes and conductors.
31. Aerial.
33. Mimic.
34. Australian bird.
35. Perplexed.
36. Seaweed.
37. "Over_______," the amount by which effective height of scanning facsimile spot exceeds nominal width of scanning line.
38. Exclamation of sorrow.
39. Saucily free and forward.
40. Stop short and refuse to go.
41. Righteous.
42. Reverse.
43. Born.
45. Old card game.
48. Near.



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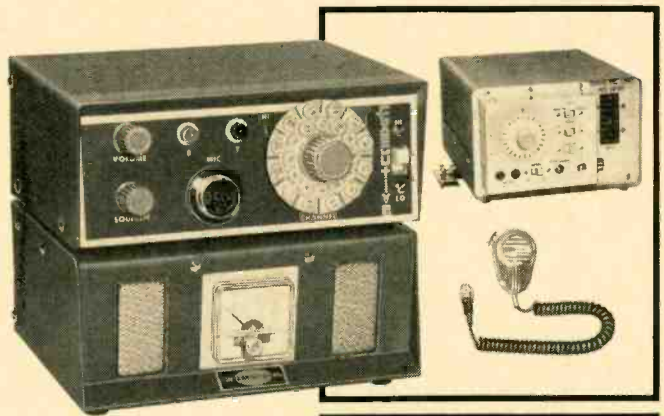
CB TRANSCEIVER WITH 24 BUILT-IN TEST CIRCUITS



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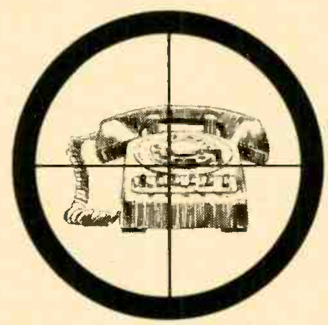

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CIRCLE NO. 192 ON READER SERVICE PAGE

EW Lab Tested

(*Continued from page* 16)

screen and boom or lavalier mounts, are available.

We tested an EK-61 omnidirectional model. Being similar in size and shape to our calibrated laboratory microphone, we tested it by measuring the output of a loudspeaker with each microphone, taking care to place each one in the same position relative to the speaker. Both curves were automatically plotted on a single sheet of paper. The difference between them, corrected for the known response of the reference microphone, is plotted as the frequency response shown.

It is evident that its response is very smooth and within ± 3 db from 20 to 15,000 cps, the calibration limits of the reference microphone. *PML* rates it at ± 3 db from 30 to 18,000 cps, and there is no doubt that it meets that specification handily. Its output level was almost identical to that of the reference microphone and is sufficient to drive almost any tape recorder microphone input.

We made recordings with this mike, with uniformly excellent results. Its sound is indistinguishable from that of the much more expensive reference microphone, without background noise, hum, or any detectable coloration. There can be no doubt that the unit brings fully professional performance within the reach of the serious audio hobbyist.

The price of the EK-61 is $99.50. The cardioid EC-61 is $109.50. The a.c. power supply is $49.50 while the battery supply is $39.95. ▲

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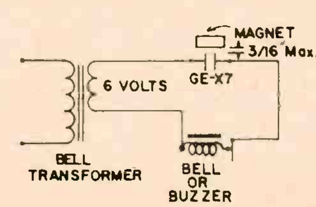
The circuit used is shown in the sketch. One way of using it is to mount the reed switch and magnet on a window or door sill to be protected. A magnetic shield is mounted to the door or window so that when the door or window is closed the magnetic shield will be inserted between the magnet and the reed switch. This will keep the switch open. When the door or window is opened, the shield will be removed, the magnet will close the reed switch, and the alarm will sound. ▲



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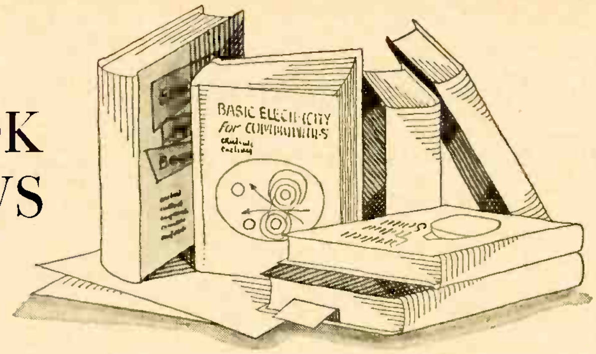
BOOK REVIEWS



"ELPHYMA TABLES" by Erik Ingelstam & Stig Sjoberg. Published by *John Wiley & Sons, Inc.* 99 pages. Price $3.50.

This fourth edition is an updated, all-inclusive handbook of tables, formulas, and nomograms covering just about all phases of physics, electricity, and mathematics. It is an excellent collection of reference material for use by the engineer and advanced technician.

The authors have tried to make the information useful to readers accustomed to various systems of units and have given a considerable amount of guidance for conversion between systems. Many of the tables and nomograms are in two colors to simplify reading.

If the title bothers you, it is an acronym for *EL*ectricity, *PHY*sics, *MA*thematics.

* * *

"ENCYCLOPEDIA OF HIGH FIDELITY," John Borwick, general editor. Published by *Focal Press, Inc.*, New York. Six volumes, 1500 pages. Price $49.00 the set, $9.50 each volume.

The publishers of this "encyclopedia" have called upon six audio experts to treat six individual subjects: acoustics, amplifiers, radio reception, disc recording and reproduction, tape recording and reproduction, and loudspeakers. Each book is complete in itself and is written at a level suitable for the technician and/or serious amateur. Each volume covers both theory and practice and the text material is filled out with hundreds of diagrams and illustrations.

Since all of the authors and the general editor are British experts, the terminology, circuitry, and standards are British and/or European. This in no way lessens the value of the series, but the reader should be alerted to this matter. Mathematics are used where required for the subject under discussion but in most cases appendices providing the necessary math review material are included.

* * *

"PULSE TECHNOLOGY" by William A. Stanton. Published by *John Wiley & Sons, Inc.*, New York. 251 pages. Price $7.00.

This text has been written at the technician's level but is equally useful to mathematicians working with digital electronic devices. Mathematics, where used, are at a level below calculus. Since the author feels that the technician should use basic laws rather than formulas and the oscilloscope rather than the slide-rule, those with minimum mathematical background shouldn't be deterred.

The book is divided into eight chapters and three appendices. Since the book is written in lesson style, answers to problems and quizzes are also given. The first chapter is a review of fundamental concepts and the author then goes on to waveshaping circuitry, multivibrators, pulse generation, switching and counting, numbers and codes, logic fundamentals, and programming fundamentals.

A glossary of terms and a fairly extensive bibliography complete the book.

* * *

"MODERN ELECTRONIC VOLTMETERS" by Sol C. Prensky. Published by *John F. Rider Publisher, Inc.*, New York. 219 pages. Price $4.95. Soft cover.

With the proliferation of new and more sophisticated vacuum-tube voltmeters, the electronics technician is in need of a book such as this to provide practical experience and increasing competence in his field.

In order to provide a background for modern electronic voltmeters, the author reviews the fundamental principles of the standard service v.t.v.m. Then he discusses diode voltmeters (vacuum-tube and semiconductor), elementary d.c. v.t.v.m. (triode v.t.v.m.), the general-purpose a.c.-d.c. v.t.v.m., using the v.t.v.m., transistor voltmeters, d.c. testing, a.c. testing, r.f. testing, high-sensitivity a.c. voltmeters, high-sensitivity d.c. voltmeters, electronic microammeters and galvanometers, potentiometric voltmeters and recorders, digital voltmeters, and specialized applications.

The text is copiously illustrated with photographs of commercial instruments in each category, schematics, graphs, tables, and a directory of manufacturers.

* * *

"RCA RECEIVING TUBE MANUAL" compiled and published by Electronic Components and Devices, *Radio Corporation of America*, Harrison, N.J. 608 pages. Price $1.25. Soft cover.

This is a newly expanded and redesigned handbook which carries over 400 pages of technical data covering active *RCA* receiving tubes, a 50-page section on renewal and discontinued types, as well as chapters on popular circuits, tube applications, and installation.

The technical data section has been restyled, has a new format, and a new and larger typeface for easy readability—a welcome feature for those using the manual on the bench.

* * *

"TRANSISTOR SELECT-A-SPEC" compiled and published by *TechPress Publications*, Brownsburg, Indiana. 135 pages. Price $3.95. Soft cover.

This is a handy reference volume for all who work with transistors. In addition to listing specifications for over 5000 transistors representing 60 manufacturers both domestic and foreign, the manual offers a unique "programmed" feature which permits the selection of the correct transistor when its parameters are known. This is an especially valuable feature for circuit designers and those experimenting with new types of transistorized equipment.

* * *

"HOW TO SERVICE U.H.F. TV" by Allan Lytel. Published by *John F. Rider Publisher, Inc.*, New York. 124 pages. Price $3.50. Soft cover.

This volume is written for the practicing service technician and provides, in addition to circuit and servicing data, background information on u.h.f. television, the conversion of u.h.f. signals, and u.h.f. installations.

The remaining six chapters cover transmission lines, antennas, converter and tuner circuits, u.h.f. tuner servicing (7 commercial models), u.h.f. converter servicing (7 commercial units), and tuner strips and single-channel converters (six models). Schematics, partial schematics, graphs, tables, and photographs of commercial units are used to amplify the text material.

* * *

"WRITING TECHNICAL REPORTS" by Bruce M. Cooper. Published by *Penguin Books Inc.*, Baltimore, Md. 183 pages. Price 95 cents. Soft cover.

While the author is mainly concerned with the problems faced by engineers and technical personnel when it comes to writing industrial reports, most of his points are pertinent to all forms of technical writing. He stresses intelligibility and the elimination of "meaningless" words and phrases. He also points out the importance of writing "to your audience" and avoiding esoteric terminology the reader can't understand.

In addition to outlining the "dos" and "don'ts" of technical report writing, he covers matters of style, technical illustrating, and grammatical correctness (British version).

This little book is well written in a lively style and should be of interest to anyone whose vocation or avocation requires a lucid exposition of his work.

° ° °

"ELECTRONIC PRECISION MEASUREMENT TECHNIQUES AND EXPERIMENTS" by Philco Technological Center Staff. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 331 pages. Price $13.00.

This volume is addressed to all whose work involves precision measurements. Increasingly stringent measuring accuracies needed to test and calibrate the new electronic equipment has made such precision necessary.

The book provides information on precision measurement techniques with special emphasis on electrical and electronic equipment. Those who use the book are assumed to have a practical background in the use of field test instruments. A large part of the book is devoted to the technique involved in the calibration of precision test equipment. The equipment covered is most commonly found in precision equipment laboratories.

The 13 chapters cover all phases of measurement and calibration for a wide variety of test instruments. Since each chapter concludes with "questions" whose answers are provided, this text can be used by the student working alone as well as in the classroom.

Numerous items of commercial test equipment are pictured and described in some detail, along with pertinent schematics, block diagrams, and performance graphs.

° ° °

"SERVOMECHANISM FUNDAMENTALS AND EXPERIMENTS" by Philco Technological Center Staff. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 243 pages. Price $10.60.

This volume has been prepared for a wide and diversified group of readers, including college graduates or undergraduates, technical students, and engineers. It is a general introduction to the concepts, operation, and maintenance of synchro and servomechanism systems.

The material is presented in step-by-step order, with the first three chapters devoted to the areas of components, systems, and troubleshooting. The remaining seven chapters deal with fundamental servo principles, position servo performance considerations, servo transducers and error detectors, servo control amplifiers, servomotors and rate generators, representative servomechanisms, and measurement and maintenance techniques.

There is a self-testing quiz at the end of each chapter with the correct answers provided in the back of the book. This should do much to increase the usefulness of the volume for those who are interested in furthering their knowledge of servos through self-study. ▲

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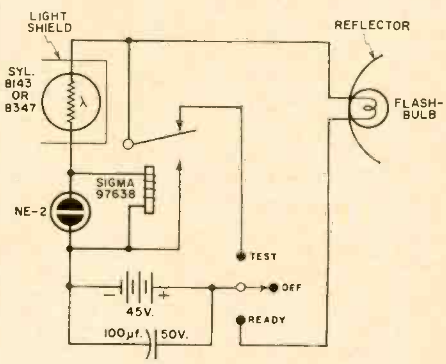
SLAVE PHOTOFLASH

THE slave flash shown in the diagram is suggested by *Sylvania* for shutter speeds no faster than 1/25 sec.

The flashbulb is fired by closure of the normally open (*NO*) relay contact. With the switch at "Ready," a small current flows through the series circuit of flashbulb, photoconductor, and relay coil. Because of the high resistance of the photoconductor when not exposed to light, this current will be less than that required to operate the relay. When excited by light from the master flash, photoconductor resistance drops to a low value. The resulting increase in relay coil current causes the armature to pull in, closing the *NO* contact, firing the flashbulb.

The "Test" position and neon lamp are provided to assure that ambient light will not prematurely fire the flashbulb. In this position, the 45-v. battery is connected in series with the photoconductor and relay coil through the normally closed (*NC*) relay contact. If the ambient light is sufficient to cause prefiring,



Both simple and economical to construct, this slave photoflash unit suggested by Sylvania can be a boon to photographers.

the relay armature will start to pull in. As it does, the circuit is broken and the armature springs back (before it reaches the *NO* contact). The cycle repeats like a buzzer. Each time the *NC* contact opens, the collapsing relay coil field produces a voltage sufficient to strike the neon lamp.

The photoconductor should be recessed about one-inch in a tubular light shield. This assembly should be swivel-mounted so that the photoconductor can be adjusted to face the master flash regardless of how slave flash is positioned.

With the switch off, insert a flashbulb, and position the unit as desired with the photoconductor facing the master flash. Set the switch to "Test." If the neon lamp lights, ambient illumination is too bright and must be reduced. If the indicator does not light, place the switch at "Ready" and all is set.

Maximum distance from the master flash for reliable operation must be determined experimentally. ▲

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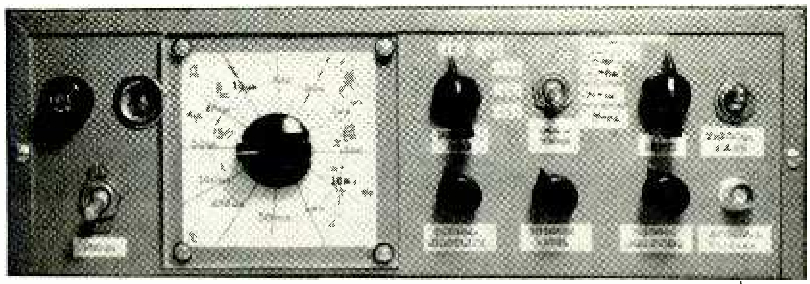
TRIGGERED SWEEP FOR IMPROVING SCOPES



Any low-priced oscilloscope will benefit by using this accurately calibrated, linear sweep system.

By MERLYN W. BARTH / Senior Staff Eng., Missouri Research Lab.

ANYONE who has had a chance to use a high-quality oscilloscope which has triggered sweep and an accurate time base knows the convenience such features provide. Some of the advantages of such scopes are: excellent sync stability which can be maintained even while changing the frequency of the input signal, absence of jitter, and no readjustment of the internal sweep rate to a multiple of the input signal frequency. In addition, the period of a waveform, rise time, or time between two points on a display, can be read directly from the face of the scope if the time base is calibrated accurately. In fact, if one is to work with digital equipment, the calibrated time base and triggered sweep are necessary to check division ratios, timing, etc. with speed and accuracy.

Although many scopes are available with triggered sweeps, most are somewhat expensive. Because of the cost of such a feature, some of the less expensive, kit-type scopes can be greatly improved by the addition of the triggered sweep circuit described in this article.

The original unit was operated with an *Eico* Model 460 and calibrated sweep ranges from .5 μsec./in. to 1 sec./in. were obtained. However, any scope can be converted as only three connections to the scope are required and, on some models, all connections can be made externally.

The basic concept of the triggered sweep is not difficult to understand, as can be seen from the block diagram of Fig. 1. The desired trigger input signal is fed to the trigger amplifier. Either a.c., d.c., or an internal trigger can be used and, if desired, 60-cycle line position could be added. The adjustment of the "Trigger Level" allows the sweep to start at a point corresponding to any desired voltage level of the waveform. The output of the amplifier is shaped to provide a clean, accurate edge with which to initiate the sweep. The "Slope" switch will allow the sweep to be initiated by either a positive or a negative slope. The sloped output triggers a gate which, with the aid of the gate amplifier, allows the generator to initiate sweep. Sweep time is determined by the *RC* network of the sweep generator circuit, so that as much or as little of a given waveform as desired can be displayed. While the sweep is in progress, other edges from a changing input can do nothing since the trigger gate is open.

The sweep is stopped at a precise voltage amplitude by the comparator. The comparator triggers the one-shot holdoff monostable. This, in turn, resets the trigger gate and sweep generator. The trigger gate cannot be opened by an incoming trigger edge until the holdoff monostable has reset to its stable state. The time period of the holdoff monostable is called the "holdoff time." This time is necessary to allow the sweep generator to retrace to the starting point. When the holdoff monostable releases the trigger gate, it is ready to receive the next trigger edge and the cycle is repeated. The output of the sweep generator is applied to the horizontal amplifier in the scope, and an unblanking pulse is applied to the CRT grid to allow the waveform to be brightened and displayed.

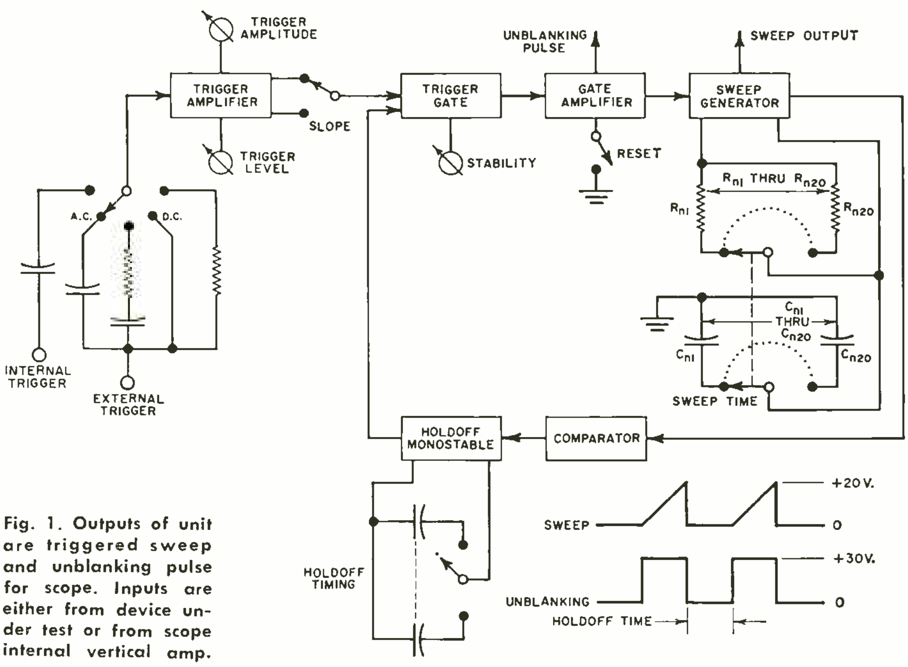


Fig. 1. Outputs of unit are triggered sweep and unblanking pulse for scope. Inputs are either from device under test or from scope internal vertical amp.

Circuit Description

The complete circuit is shown in Fig. 2. The input signal selected is applied to control *R*3 and is attenuated to a level just sufficient to trigger *Q*1. The direct (d.c.) input connection can be used to trigger on very slowly changing waveforms, but they must swing to within about 6 volts of ground. The "D.C. (Low)" input should be used with peak-to-peak signals of 50 volts or less, and the "D.C. (High)" level input with signals greater than 50 volts. Normally, for digital and repetitive waveforms, the a.c. inputs can be used. The low-level inputs have an input impedance of somewhat less than 100,000 ohms which is adequate for most digital or analog work. However, if the sweep input does load a particular circuit, the "Int. Trig." position should be used. This position picks up the vertical signal after it has been isolated by the vertical amplifier

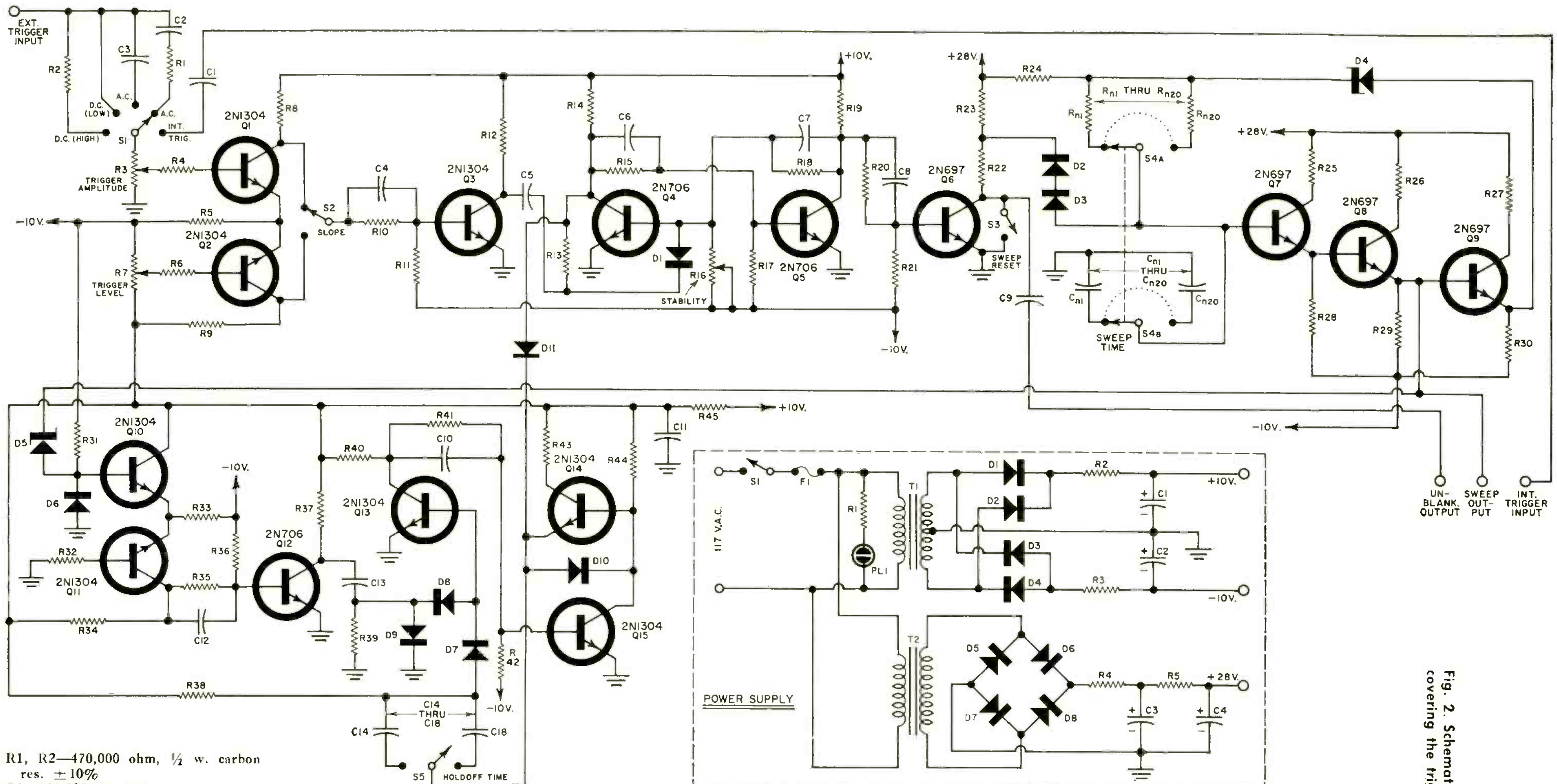


Fig. 2. Schematic diagram and parts list covering the triggered sweep generator.

R1, R2—470,000 ohm, ½ w. carbon res. ±10%
R3—100,000 ohm pot
R4, R6, R20, R29, R32, R33, R34, R41—4700 ohm, ½ w. carbon res. ±10%
R5, R8, R9, R10, R23, R35—5600 ohm, ½ w. carbon res. ±10%
R7—20,000 ohm pot
R11, R17, R21, R31, R36, R38, R42—22,000 ohm, ½ w. carbon res. ±10%
R12, R37—2700 ohm, ½ w. carbon res. ±10%
R13, R39—10,000 ohm, ½ w. carbon res. ±10%
R14, R19, R40, R44—2200 ohm, ½ w. carbon res. ±10%
R15, R18—8200 ohm, ½ w. carbon res. ±10%
R16—50,000 ohm pot
R22—47 ohm, ½ w. carbon res. ±10%
R24—3300 ohm, ½ w. carbon res. ±10%
R25, R26, R27, R43—100 ohm, ½ w. carbon res. ±10%
R28—120,000 ohm, ½ w. carbon res. ±10%
R30—1000 ohm, ½ w. res. ±10%
Rn1 through Rn20—See Table 1
R45—10 ohm, ½ w. carbon res. ±10%
C1, C2—.22 µf., 600 v. capacitor
C3—.22 µf., 100 v. capacitor
C4—470 pf. capacitor
C5, C8, C12—1000 pf. capacitor
C6, C7, C10—270 pf. capacitor
C9—.05 µf., 1000 v. capacitor
C11—100 µf., 15 v. elec. capacitor
C13—.002 µf., 100 v. capacitor
C14—1200 pf. capacitor
C15—.01 µf. capacitor
C16—.05 µf. capacitor
C17—.2 µf. capacitor
C18—1 µf. capacitor
Cn1 through Cn20—See Table 1
S1, S5—S.p. 5-pos. non-shorting rotary sw.
S2—S.p.d.t. switch
S3—S.p.s.t. n.o. sw. (momentary contact)
S4—Two-section d.p. 23-pos. non-shorting rotary switch.
D1, D6, D7, D8, D9, D10—1N456 diode
D2, D3, D11—1N625 diode
D4—6-v. zener diode (1N709)
D5—18-v. zener diode (1N720)
D12, R46—not shown (see text)
Q1, Q2, Q3, Q10, Q11, Q13, Q14, Q15—2N1304
Q4, Q5, Q12—2N706
Q6, Q7, Q8, Q9—2N697

POWER SUPPLY

R1—100,000 ohm, ½ w. res.
R2, R3, R4—1 ohm, ½ w. res.
R5—150 ohm, 2 w. res.
C1, C2—1000 µf., 15 v. elec. capacitor
C3, C4—500 µf., 50 v. elec. capacitor
S1—S.p.s.t. switch
F1—1 amp. fuse
PL1—NE-51 pilot light
T1—Fil. trans. 12.6 v. c.t.
T2—Fil. trans. 25.2 v.
D1, D2, D3, D4, D5, D6, D7, D8—1N2069

of the scope. $R3$ provides control over the amplitude of the signal supplied to the trigger amplifier and $R7$ ("Trigger Level") adjusts the level of sensitivity of the amplifier primarily for low-level d.c. inputs. The output is taken from the collector of either $Q1$ or $Q2$ depending on whether it is desired to trigger from a positive or negative slope.

$Q3$ is normally not conducting. As the collector voltage of $Q1$ or $Q2$ rises, $Q3$ turns on, producing a fast falling edge with which to trigger gate $Q4$ and $Q5$. This gate is a conventional flip-flop, triggered at the base of $Q4$ with the negative edge from $Q3$. $D11$ resets the gate at the end of the sweep. Before a trigger pulse arrives, $Q4$ is conducting; the trigger pulse turns $Q4$ off and forces $Q5$ to conduct. The function of $R16$ ("Stability") is to provide sync stability. If $R16$ is adjusted so that the gate circuit is bistable, a sweep will start only when a trigger pulse sets $Q4$. However, if $R16$ is adjusted so that the gate has only one stable stage ($Q4$ off), the sweep will repeat at a rate determined by the sweep time plus the holdoff time and will not be triggered. This allows either free-running or triggered operation.

With the collector voltage of $Q5$ low, $Q6$ turns off, allowing its collector to swing to 28 volts. This voltage pulse is used as an unblanking signal applied to the grid of the CRT. With $Q6$ conducting, the base of $Q7$ is held at ground by $D2$-$D3$. As the collector voltage of $Q6$ rises to 28 volts, the two diodes are back biased. The selected capacitor ($Cn1$ through $Cn20$—"Sweep Time") is then allowed to charge through the selected resistor ($Rn1$ through $Rn20$) producing a linear ramp.

Transistors $Q7$, $Q8$, and $Q9$, together with $D4$, form a constant-current source for linear charging of the selected Cn capacitor. Switch $S3$ ("Sweep Reset"), located at the collector of $Q6$, is momentarily depressed to start the sweep action when power is first applied.

The function of the comparator, $Q10$, $Q11$, and $Q12$, is to stop the ramp at an accurately determined voltage each sweep time. $Q11$ is normally conducting with its base set at a voltage corresponding to the maximum desired ramp voltage. $Q12$ is then not conducting since the collector voltage of $Q11$ does not exceed the zener voltage of $D5$. As the ramp applied to the base of $Q10$ exceeds the base voltage of $Q11$, $Q11$ turns off, causing $Q12$ to conduct. The pulse at the collector of $Q12$ is used to trigger the holdoff monostable to inhibit the trigger gate for a time sufficient to allow the sweep capacitor (Cn) to discharge. It is evident that for slower sweeps, when the value of Cn is large, the holdoff time must be longer. Therefore, several holdoff times are provided by capacitors $C14$ through $C18$ to allow a long holdoff for slow sweeps and a short holdoff for fast sweeps so maximum brightness can be maintained for the fast sweeps.

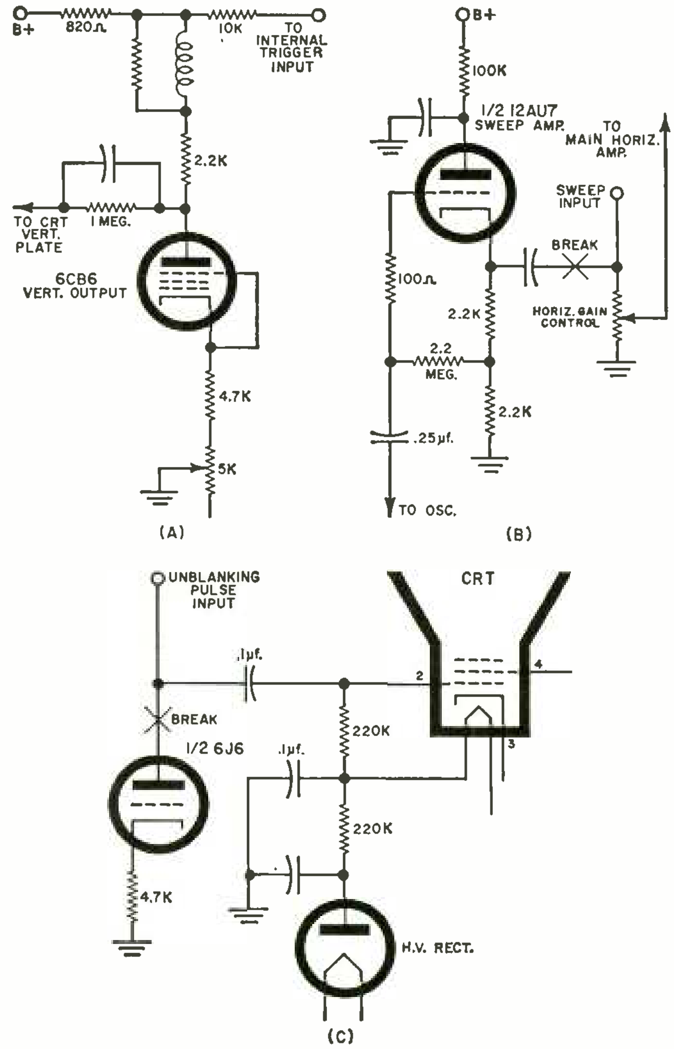


Fig. 3. (A) Method of picking up internal trigger pulse. (B) How triggered sweep is hooked into circuit. (C) Method of injecting unblanking pulse. These circuits from Eico Model 460.

The actual construction of the sweep circuit is not at all critical and the physical arrangement is left to the ingenuity of the builder. The original unit was constructed on a *Vector* pre-punched terminal board mounted close to the metal panel containing the necessary controls. As with all high-speed circuitry, wire length should be kept short and the controls should be located as an integral part of, or close to, the rest of the circuit. The transistors listed in the parts list

Fig. 4. (A) Output of the transistorized sweep. (B) Comparison between transistorized sweep and commercial unit. (C) Both sweeps superimposed to show similarity.

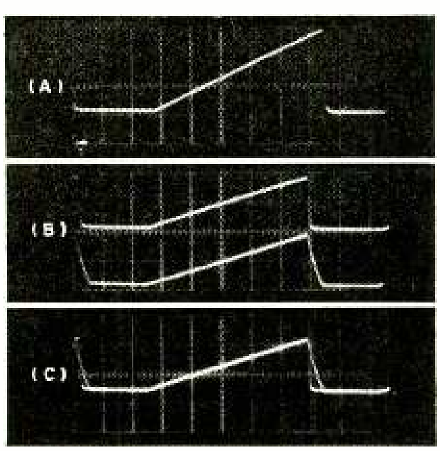


Fig. 5. (A) Sweep output (top) with associated holdoff monostable pulse (bottom). (B) Sweep (top) and Q5 gating waveform. (C) 10-kc. sine-wave input and Q3 output.

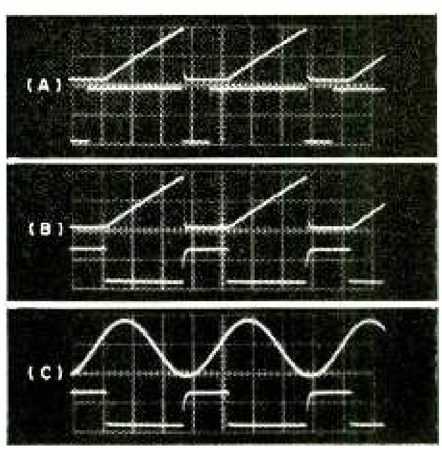
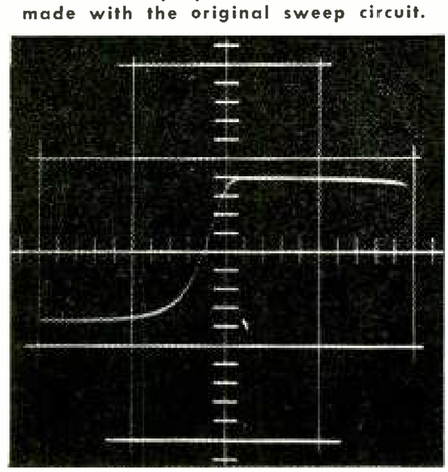


Fig. 6. Rise time of flip-flop running at 200 kc. Horizontal calibration is 1 µsec./inch. This display could not have been made with the original sweep circuit.



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should be used as a guide. If other types are available, it would pay the builder to consider using them. For Q1, Q2, Q3, Q10, Q11, Q13, Q14, and Q15 it is suggested that the 2N1304 be used as it is a reasonably fast, inexpensive transistor. For Q4, Q5, and Q12, it is suggested that the Type 2N706 be used. The great speed of this transistor is capable of producing fast, clean waveforms even on sweep speeds of .5 μsec./inch. Q6, Q7, Q8, and Q9 are 2N697 silicon units. This transistor was selected because it has low leakage, high V_{CEO}, and is capable of handling high peak currents (Q6 must have a fairly high current capability to discharge *Cn* fast). If a method of checking H_{FE} is available, Q7 should be the unit with the highest H_{FE}.

Approximate values for *Rn* and *Cn* (the "Sweep Time" selected components) are shown in Table 1. However, trimming of *Rn* is necessary if accurate calibration is to be achieved. Sweep rates of .5 μsec./in. to 1 sec./in. can be provided with excellent results. Fig. 4 shows the output waveform.

Calibration and Operation

Only four connections to the scope are necessary. These are: ground, trigger input from the scope vertical amplifier, and the sweep output and unblanking pulse from the triggered sweep unit. The connections shown in Fig. 3 are for an *Eico* Model 460 oscilloscope. Unless two scopes are available, it would be advisable to check out and troubleshoot, if necessary, the triggered sweep circuit with the old internal sweep generator before making the conversion.

To aid in the initial checkout, a temporary change in circuitry will enable a sine-wave signal to be applied to the "External Trigger" input and traced through the circuit to check operation.

Disconnect *D*11 from the collector of Q4. The system loop is now open. Connect one end of a resistor having the same value as *R*13 to Q5 collector. Connect the anode of a diode similar to *D*1 to the base of Q5. Connect the loose ends of these two components together and connect them to the collector of Q3 through a capacitor having the same value as C5. When *R*16 ("Stability") is adjusted for bistable operation (its value the same as *R*17), the trigger gate now becomes a toggle. Fig. 5 shows waveforms for the following tests.

Apply a 10-kc. sine wave to the "External Trigger" input. The toggle should be triggering at every negative-going input thereby dividing the input frequency by two. The collector of Q6 should be going from zero to about +28 volts, following the collector of Q5.

If "Sweep Time" is set to 100 μsec./in., a ramp signal should be visible at the emitter of Q9. Adjust the signal generator frequency until a slight non-linearity is noted at the top of the ramp. Check the collector of Q12. A pulse should be seen if the comparator is working. If a pulse is seen, check the output of Q14 and vary the "Holdoff Time" control to see if different values of holdoff time are established. If an output is present, the circuit is operating. Remove the temporary resistor, capacitor, and diode and reconnect *D*11 to Q4 collector. The sweep circuit should then operate when the "Sweep Reset" button is depressed and released.

The sweep is first adjusted to extend exactly across the face of the CRT (from the first vertical marker to the last). This is done using the horizontal gain control of the main horizontal amplifier. The sweep circuit should provide about a 20-volt ramp to the main horizontal amplifier. If the signal generator is set to a known frequency, say 10 kc., and "Sweep Time" for the 100-μsec./in. position, one complete cycle should be displayed in one major division of the scope graticule. The calibration is then known to be 100 μsec./division (period $=1/f$). The "Sweep Time" selected values of *Rn* should be trimmed for exact results.

To improve stability at slow speeds, add 4700-ohm, ½-w., resistor (*R*46) between *R*16 and junction of *D*1, *C*7, and an 1N455 diode (Q12) anode to the base of Q14, cathode to the collector of Q12.

Operation is quite easy. Trigger the scope from the signal to be displayed or any synchronous waveform, provided it is of a lower frequency. When checking division ratios, always trigger from the lower frequency waveform. Attach the vertical scope input probe to the proper circuit point to display the desired signal, and adjust *R*16 for triggered operation. Adjust *R*3 and *R*7 to provide a sharp, stable display. ▲

TABLE 1

Sweep Rate	Cn (μf.)	Rn (kohms, approx.)	Sweep Rate	Cn (μf.)	Rn (kohms, approx.)
.5 μsec./in.	330 pf.	2.2	1 msec./in.	.05	27
1 μsec./in.	680 pf.	2.2	2 msec./in.	.1	27
2 μsec./in.	.0012	2.2	5 msec./in.	.1	56
5 μsec./in.	.0033	2.2	10 msec./in.	.2	56
10 μsec./in.	.002	5.6	20 msec./in.	.47	47
20 μsec./in.	.005	5.6	50 msec./in.	1.0	56
50 μsec./in.	.012	5.6	100 msec./in.	2.0	56
100 μsec./in.	.02	6.8	200 msec./in.	2.0	120
200 μsec./in.	.05	5.6	500 msec./in.	2.0	220
500 μsec./in.	.1	6.8	1 sec./in.	5.0	220

FURTHER NOTES ON ATOMIC TIME STANDARD

IN the past, the measurement of time was established by astronomers observing the movement of stars across the sky as the earth rotated on its axis. A mechanical clock was used to relate the instant of meridian crossing for each individual star to the instant of crossing for other stars. By means of a long series of observations, the rate of the clock could be related to the earth's rotation. Thus, the planet itself became a timekeeper with the mechanical clock used to interpolate the intervals of time between meridian crossings of the different stars. In fact, the introduction of longitude to navigation had to await introduction of an accurate clock.

Pendulum clocks, some of which exhibit a stability of performance to within a few thousandths of a second per day, were used to interpolate the intervals until the development of the more accurate quartz-crystal oscillator. However, neither of these devices maintains a rate which is as constant as that of the earth.

Prior to 1956, the second was defined as 1/86,400 of the time required for an average rotation of the earth on its axis with respect to the sun. Nevertheless, long before this date, astronomers became acutely aware of irregularities in the earth's rotation as compared with the orbital motion of the moon about the earth, the earth about the sun, and various other planetary motions.

In 1956, a new definition was internationally agreed upon—called the ephemeris second, it was 1/31,556,925.-9747 of the time taken by the earth to orbit the sun during the tropical year 1900. Although very exactly stated, this definition could not be realized by astronomical observations with anything like the precision implied by so many digits.

However, during the 1950's, research into atomic transitions indicated that oscillations associated with them could be realized with great repetition. One of them, a hyperfine transition in the cesium atom, was related to the ephemeris second with an estimated accuracy of about two parts in a billion (two parts in 10^9). Further measurements made between two such "clocks" found an agreement between each device more precise than the measurements made with either instrument could be related to the ephemeris second. This agreement, six parts in 10^{12}, meant that two clocks controlled by these two separate instruments would differ by only one second after running 5000 years. Even this accuracy will be further improved.

Therefore, in lieu of a more exact definition to be arrived at some time in the future, the atomic definition of a second was agreed upon by the Twelfth General Conference of Weights and Measures, which convened in Paris on October 8, 1964.

Atomic Standard

The atomic standard employed is the transition between two particular hyperfine levels of the atom of cesium 133, undisturbed by external fields, having the value of 9,192,631,770 ±20 cps. The 20-cycle error results from limitations on precision of the astronomical measurements. This definition is tied up with atomic processes taking place in the cesium 133 atom, the only non-radioactive nuclide of cesium which is different from the radioactive cesium nuclei which are produced in atomic explosions. Operation of such an atomic clock has been covered in detail in "Frequency & Time Standards" by George E. Hudson, Assistant Chief of the Radio Physics Division of the National Bureau of Standards, and published in the August, 1964 issue of this magazine.

By well-known electronic techniques, the individual cycles of the atomic oscillator can be counted and 9,192,631,770 of them are called one second. Further electronic circuits are used to generate other frequencies that are continuously compared with the atomic standard. It is these atomic-compared frequencies that are used to regulate the various National Bureau of Standards and U.S. Navy frequency-standard broadcast stations.

Although the atomic definition of a second enables scientists to maintain more accurate and immediately available scales of time and time intervals, astronomers will not be put out of the timekeeping business. The earth's rotation is sufficiently irregular so that for the navigator and the space scientist, timing signals must be correlated with the earth's rotation. It will still be the astronomer's responsibility to tell us when the seasons come and go, when eclipses are to be expected, and when variable dates such as Easter are supposed to come. The new time standard will greatly assist the astronomer in keeping track of the planets. Eventually, however, he will be faced with the task of determining whether the time kept by an atomic standard is the same as that kept by the planetary motions. ▲

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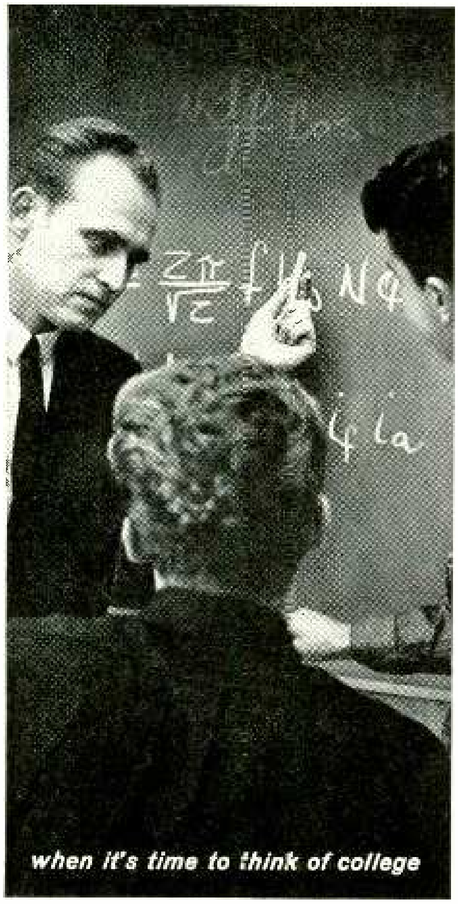

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Electroluminescence

(Continued from page 26)

which is converted to a tough plastic film on baking at relatively low temperatures. The second electrode and light-escape side of the lamp is a thin conducting glass paper cemented to the phosphor layer. The entire EL unit is then sealed in a moisture and electrical protection envelope. The assembly is approximately 1/32-inch thick, with a 1- to 5-mil separation between electrodes. At 120 volts, 60 cps, this construction is a 5-footlambert light source which increases to 30 footlamberts at 120-volt and 400-cps operation.

This construction is suitable for the production of lamps in long strips, in widths up to 8 or 12 inches. A commercial version of this construction is the "Tape Light," recently made available by *Sylvania* in 1¾-inch widths. The potential application of this flexible lamp in lengths of many feet would seem to be great, considering that it will take the shape of a variety of surfaces employed in contemporary design and construction. Like the other lamp types, phosphors are available for producing "Tape Lights" in a variety of colors (green, blue, white, yellow).

EL-Display Applications

The various types of construction just described may be used primarily for lighting purposes, or in special device applications. In practice, the display applications are at present largely confined to the glass-ceramic construction for reasons already stated. There remains to briefly summarize the manner in which the operation of lamps is altered, compared to their more simple use as light sources, when the intended use is as a display. The problem is to convert the uniform area light into a field of contrasting brightness so as to present a visual message to an observer or objective

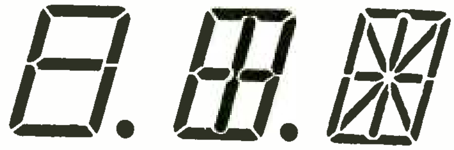


Fig. 6. (A) Seven segment readout, (B) nine segment readout, and (C) 14 segment readout. These are alphanumeric displays.

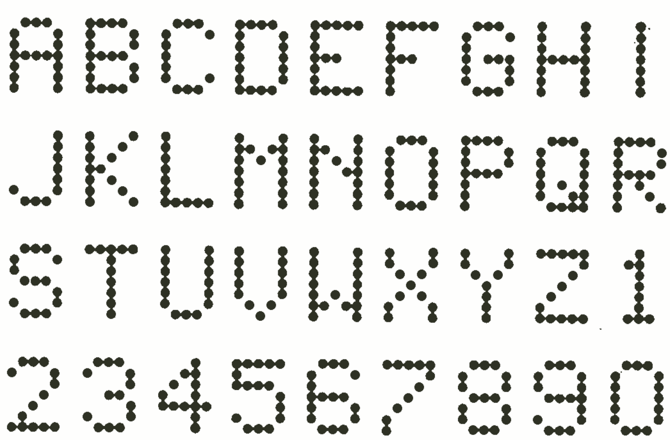
detector. Basically, this means varying voltage across the active phosphor layer from place to place in the lamp.

In practice, this means operating the lamp in localized segments at either of two voltages, namely, at *zero* (or below threshold) and some *finite* value which will excite electroluminescence. The "on-off" operation scheme is widely employed. The mechanics of doing this are provided by appropriate segmentation and design of the back electrode (metal film applied through masks). The problem is simple if a fixed stationary display is the goal. But more important, EL devices make possible variable displays. This adds complexity to their construction since various combinations of component elements of a design must be selectively activated. This requires switching of the operating power *via* wiring circuitry connected to thin metal films between segments of, at times, very small areas.

The simplest variable display device is a seven-segment numeric readout, such as the one shown in Fig. 6A. This is commercially available to give numbers ranging in size from ⅜″ to 8″ in height. Connecting these seven segments electrically (*via* the back electrodes of the lamp) in various combinations forms all numbers 0 through 9. This simple arrangement of segments cannot center the digit "1." In order to center the digit "1," a 9-segment device is available (Fig. 6B) which can be operated as an 8-segment lamp. The switching arrangement is only slightly more complicated.

A far greater range of readout appli-

Fig. 5. A complex display pattern using 35 dots in a 7 x 5 array can be used to produce a complete set of alphanumerics.



cations is provided by a 14-segment lamp (Fig. 6C) with which letters of the alphabet as well as digits can be displayed. This is the familiar *alphanumeric* readout. The added segments, however, substantially increase the switching, electrode contacting, and connecting problems. By increasing the number of segments and changing from rectangular to circular segments, more aesthetically pleasing number and letter displays are obtained. The familiar 35-dots-per-letter in a 5 x 7 array is the best-known example. Others have been developed. The practical problems become formidable with these multi-segmented lamps, both in circuitry, switching, and in applying the segmented electrode itself. Display units have been developed which carry several numerics on one lamp. This provides space economy, reduces hardware, and provides clearer viewing.

Fig. 5 shows the complex alphanumeric pattern using the 35-dot 5 x 7 array, along with a sample of the display obtainable by its use. Increased visibility of display is possible by use of neutral gray (60-70% transmission) glass in the lamp. Surface reflections are reduced by application of anti-reflection coatings to the glass. The use of a glass-surface lamp makes it possible to apply a honeycomb filter for purposes of reducing the effect of high ambient light. This, however, restricts the viewing angle to approximately 30°, but makes it possible to use it in sunlight.

The switching component requirements of EL-display devices depend on the speed demanded by the application. Mechanical switching is employed in electronic accounting and scaling equipment and in production-line status boards. For more rapid switching requirements and in conversion of intelligence from a computer, electronic switching is employed through the use of silicon controlled rectifiers, neon-photoconductors, reed switches, and transistor circuits.

With the versatility in size, geometrical form of information display elements, and switching speeds now available, the possible applications of EL-display devices seem almost unlimited.

Producers of EL devices naturally stimulate those interests by continued assistance and developments. Efforts are continually being made to develop phosphors and lamp structures which will substantially increase the brightness of present EL light sources, so that lamps may eventually be as bright on domestic power operation as now obtainable at higher voltages and frequencies. Brightness up to 100 footlamberts, sufficient for ceiling and wall panels incorporated into the architectural structure, are not unrealistic expectations to those engaged in product development, and perhaps more so to those of us in basic research. ▲

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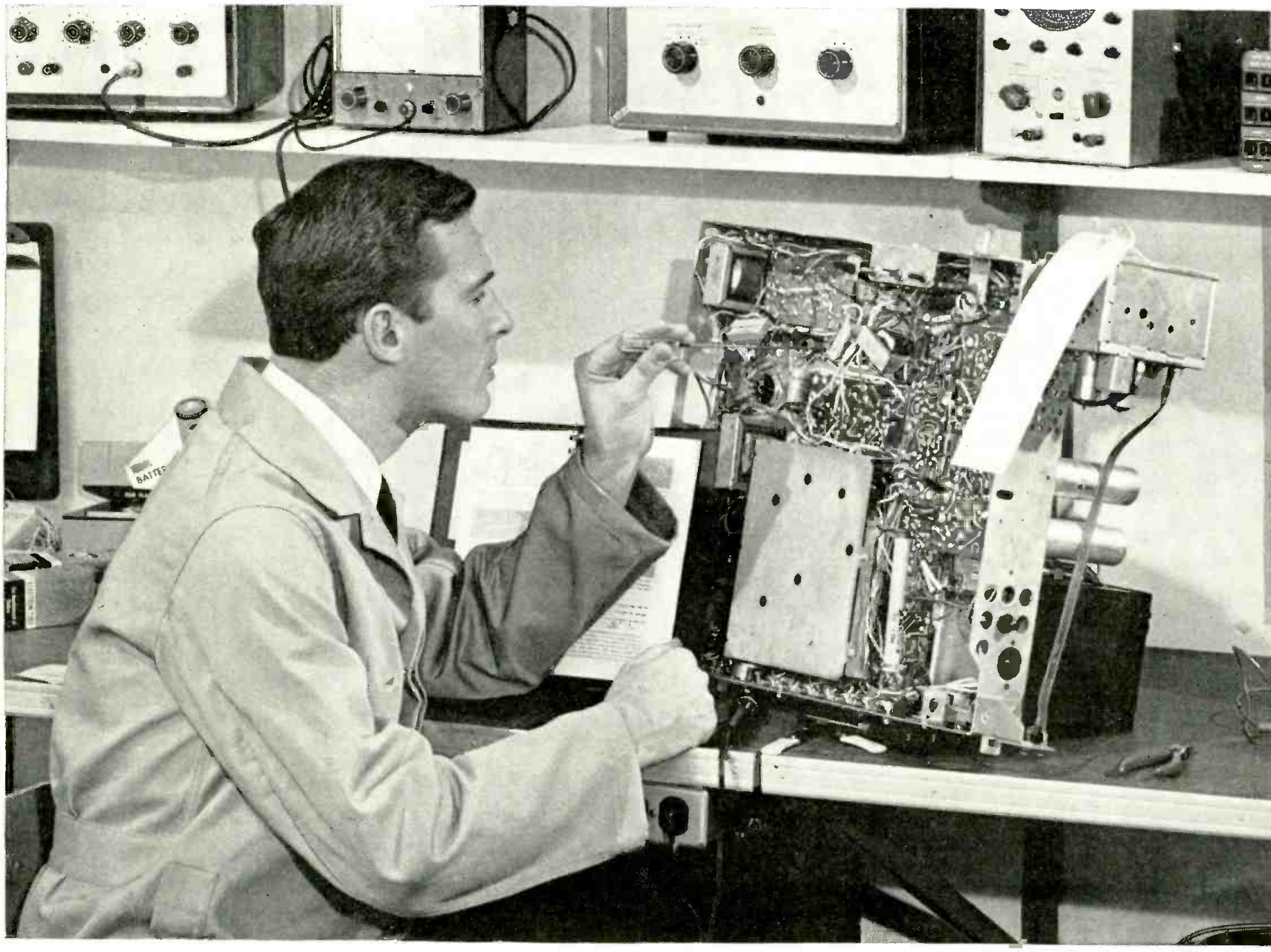

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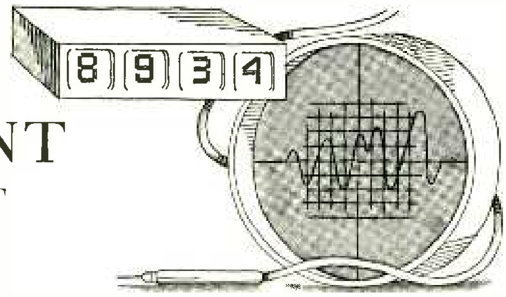
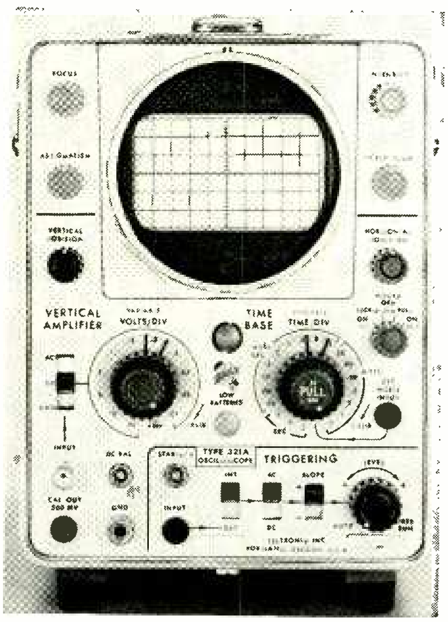


Tektronix 321A Portable Oscilloscope

For copy of manufacturer's brochure, circle No. 57 on coupon (page 17).



RAPIDLY expanding use of electronics in such diverse fields as seismology, meteorology, oceanography, astronomy, oil-well exploration, and construction; plus widespread usage of high-speed computers in business and industry and electronics at missile and satellite launching and tracking sites, has generated the need for a precision oscilloscope which can travel easily with engineers and technicians to remote locations where a.c. line power is not readily accessible, or where permanent placement of an oscilloscope is not economically practical.

The *Tektronix* Type 321A oscilloscope has been developed to perform waveform measurement and analysis with the precision of a laboratory instrument but with a high degree of portability and ease of handling. The scope is fully transistorized with the exception of the cathode-ray tube and a nuvistor used as the input stage of the vertical amplifier.

Low power requirements permit the instrument to operate from a variety of power sources, such as a 115- to 230-volt (±10%), 50- to 800-cycle a.c. line, an external d.c. source from 11.5 to 35 volts, or an internally contained battery pack. Electronic regulation insures stable operation and retains measurement accuracy.

A high-brilliance, 3-inch cathode-ray tube permits waveform viewing at field sites or in brightly lighted offices. Unblanking of the CRT trace is achieved by deflecting the trace off-screen during retrace time. This technique is called "deflection unblanking."

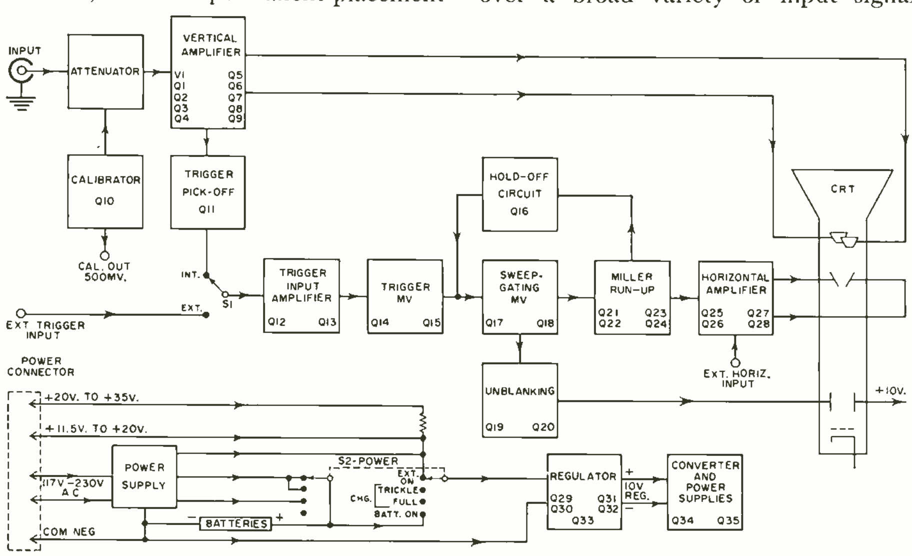
Both horizontal and vertical deflection systems have push-pull output stages to provide good linearity and uniform focus over the viewing area. The vertical-amplifier system (d.c. to 6 mc., .01 volt per division sensitivity) includes a wide-range, frequency-compensated attenuator to maintain measurement accuracy over a broad variety of input signal amplitudes. The vertical input stage is a nuvistor, Type 7586, to provide high input impedance, thus minimizing loading of the circuitry under test. This stage is connected in cathode-follower configuration to supply low-impedance drive to the following stage and to isolate the input circuit from the main amplifier. A trigger pick-off stage couples a sample of the vertical input signal to the trigger selector switch, providing internal triggering. (See diagram below.)

The horizontal deflection system consists of a push-pull output stage driven by a Miller run-up saw-tooth generator, a sweep-gating multivibrator with hold-off circuitry which also supplies the unblanking gate, and triggering circuitry. The output stages can be driven by an external horizontal input for X-Y or Lissajous plots.

Triggering circuitry is basically a bistable Schmitt configuration with a broad selection of operating modes. The triggering-level control determines the point on the trigger signal at which the sweep is started. This permits triggering from any desired point on a positive- or negative-going input signal. Another mode or interest is automatic triggering. This provides stable "hands-off" triggering over the range of approximately 50 cps to 6 mc. and presents a base-line reference trace in the absence of input signals. Automatic triggering is very useful when probing through circuitry under test, since no resetting is necessary over the range of frequencies mentioned and over a broad range of input amplitudes.

A built-in battery charger is included to permit charging of internal batteries after using the rechargeable nickel-cadmium cells. This type of cell will provide approximately five hours continual service and can be re-energized overnight by plugging the instrument into a 115- or 230-volt a.c. line source. Standard-size flashlight cells may be used, but the short life span (approximately ½ hour) makes this impractical for most applications.

Physical dimensions of the Type 321A are 8¼″ high by 5¾″ wide by 16″ deep. The scope weighs 14 pounds without batteries and 16 pounds with batteries. Price of the instrument is $900, and a set of ten rechargeable nickel-cadmium cells costs $70. ▲



B & K Model 1240 Color Generator

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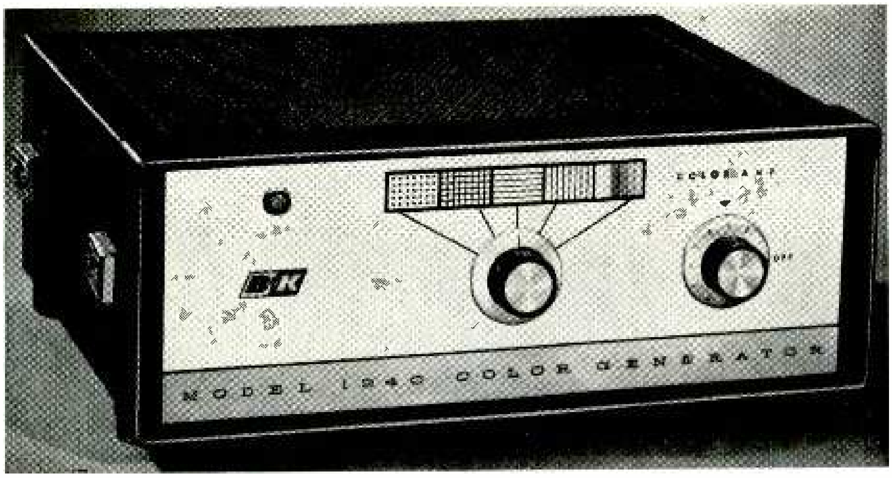
SOME rather unusual modifications have been made in the circuits of the new *B & K* Model 1240 color-bar and pattern generator to greatly improve its stability. These modifications in the conventional counter circuits insure the highly stable video pattern necessary for color-TV servicing.



A 189-kc. crystal oscillator is used to supply the vertical-line information as well as to synchronize the start of the counter circuits as shown in the block diagram. The 189-kc. oscillator, in addition to supplying the 10 vertical lines, synchronizes the 14 horizontal lines. A series of circuits are used that divide down from 189 kc. to 450 cps for the horizontal line pattern and that supply 60 cps and 15,750 cps for sync. By keying the horizontal lines, the vertical lines, and the vertical sync all to the same crystal oscillator, the unit is made highly stable.

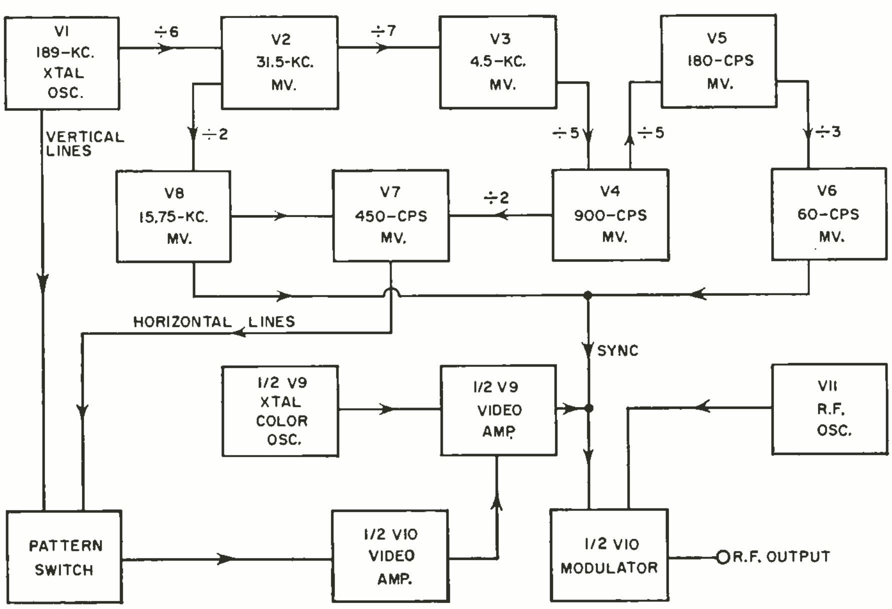
While some manufacturers use counter circuits that divide down by as much as 15:1, this unit operates with a countdown of no more than 7:1. Although this requires more circuits and is somewhat more costly, it insures the user of maximum stability.

A departure from the conventional circuits is the use of the 450-cps multivibrator. This frequency can be keyed to the horizontal scanning frequency, which allows the unit to produce interlaced horizontal lines of video information that begin and end at the same time as the horizontal raster lines. This cannot be done with a 900-cps circuit controlling horizontal lines. The 900-cps system starts and ends the video trace somewhere in the visible area of the screen. The result is a double row of dots or a double horizontal line in some areas of the screen due to overshoot or improper matching of the beginning and ending of the traces.

The Model 1240 produces 8 complete lines in one field and 7 in the other, making up the total of 15. The resulting horizontal lines of video are only one scanning line in height. The dot pattern, which is a result of blanking out portions of the horizontal video line, is also one scanning line in height. This is the smallest possible dot and adds accuracy and speed to convergence procedures.

The 60-cps multivibrator is the source of vertical sync for the generator. Because of a unique delay circuit, holding up the start of the horizontal video line by approximately 500 microseconds, the vertical sync pulse is not allowed to appear at the same time. This results in a clean sync pulse undistorted by video and adds greatly to the stability.

Another feature is a dot pattern of adjustable brilliance. Output of the generator is factory-preset to channel 4 but readjustment to channel 3 or 5



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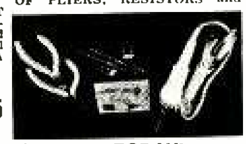

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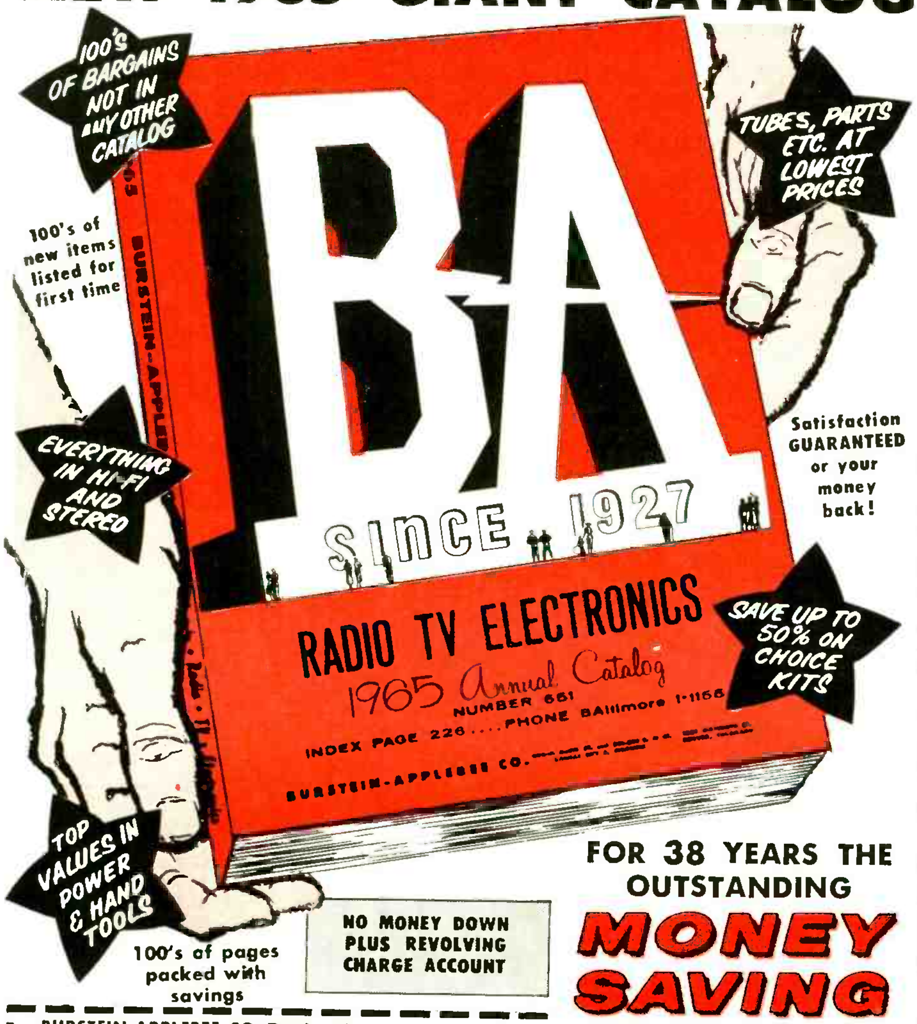

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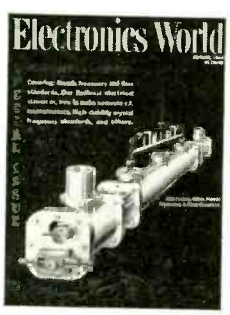

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may be made if desired. The output is in excess of 5000 microvolts.

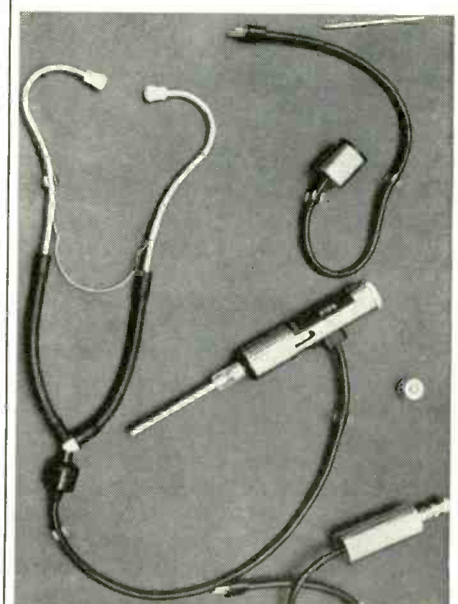
The color pattern is a keyed rainbow, which is generated by the offset subcarrier method and gated by an oscillator at a frequency 12 times higher than the horizontal sweep frequency. This produces 12 color bars, of which only 10 are visible, however, since one occurs at the time of the horizontal sync pulse and another is used as a color sync burst.

The unit is factory-tested to produce no drift at line voltages from 80 to 135 volts input. The stability is such that even tube replacements will not necessitate readjustment of the counter circuits.

The Model 1240 is housed in an attractive cabinet with provisions for storage of line cord and output cables. It weighs only 9 pounds and sells for $134.95. ▲

Minear VAT-2000 Transducer Subsystem

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



THE *Minear* Model VAT-2000 vibro-audio transducer subsystem will detect all frequencies of vibration within its range and convert them to electrical signals. It consists of a hand-held, battery-powered transducer assembly with two stages of transistorized amplification, two probes, a matched impedance network, a dual output adapter, and a headset with matched transducers. It will operate over a frequency range from 20 cps to 160 kc. with a maximum gain of 45 db ±5 db.

The probe can easily be held against vibrating equipment, such as electric motors, micro bearings, combustion engines, turbines, tubing, waveguides, or rotating gear trains allowing the operator to examine the functioning of such mechanisms both aurally with the headset and visually with an oscilloscope.

The probe is mechanically connected to a transducer which feeds a volume control. The signal is passed through a two-stage transistor amplifier whose output matches directly the headset or the impedance network.

An unusual feature of the circuit design is the limiting of output to 1.18 volts at the driver, which produces a sound level of +84 db above 0.0002 dyne per cm². This ensures complete safety for the operator's eardrums regardless of test-noise level. Furthermore, the circuit is designed so that it is impossible to overload.

The instrument is high-voltage insulated and is safe for use on electrical equipment. The circuit will drive most types of recorders, amplified loudspeakers, and oscilloscopes. The dual output allows any two to be connected simultaneously, using the assembly as an amplifier for the headset or as a preamplifier for an oscilloscope, recorder, or amplifier loudspeaker. The subsystem is designed to be used either with the headset as a diagnostic tool, in which case it is an electronic stethoscope for aural detection in awkward places or in the field, or it may be added to the existing equipment found in most industrial laboratories, enhancing its versatility.

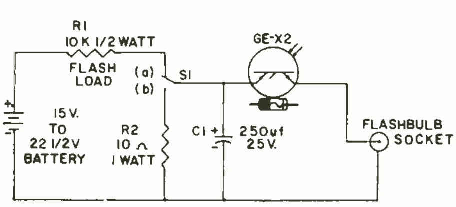
The instrument, complete with 2.7-volt mercury battery, is entirely self-contained in a one-inch, lightweight, chromium-plated cylinder. It is 8 inches long and weighs 10 ounces. The "speaker" unit is incorporated in the headset which is of conventional stethoscope dimensions. Complete with all accessories in a wooden carrying case 11¼" x 5½" x 2¼", it weighs 2 pounds.

The system costs $250 complete. Other models are available from $69.50 to $420. ▲

SLAVE PHOTOFLASH

WHEN the light-activated silicon controlled rectifier shown in the schematic is exposed to light of about 200 to 500 footcandles, it will turn on to activate many different types of loads. In this case, it will be used to fire a flashbulb. The effective sensitivity to light can be greatly increased by using lenses or reflectors. Mounting the G-E-X2 in the focus of a flashlight reflector increases the effective operating distance of the photoelectric system by a factor of about 4:1.

In operation, the switch must be in position (b) when the flashbulb is inserted in its socket. The switch is then placed in position (a) to operate. Shutter speed should be about 1/10th second. ▲



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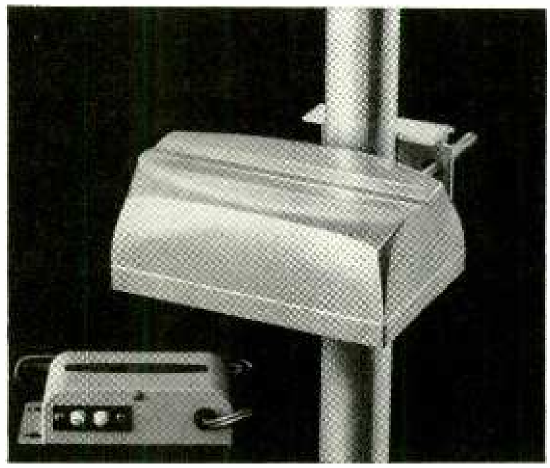

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"The new Blonder-Tongue Vamp-2 outperforms all home VHF amplifiers on the market, tube or transistor. Brings in sharp, clear pictures."
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"But, I hear transistor units can overload from strong local TV stations?"
"Not this one, that's where the extra transistor pays off."
"I've got two sets."
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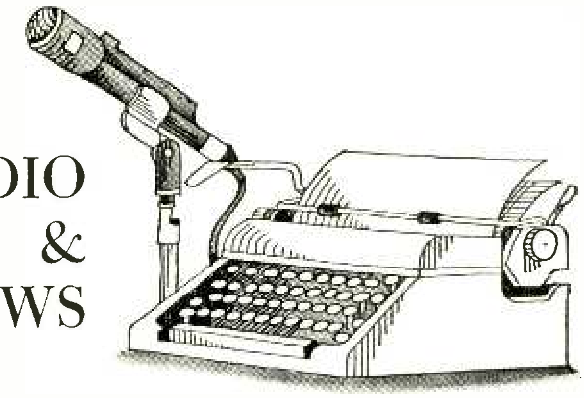
RADIO & TV NEWS



According to scientists at the *North American Aviation's Autonetics Division*, the crust of the planet we live on is not as rock-steady as we think but is constantly shivering. This slight motion is a result of the moon's influence on the earth's crust, similar to the way that ocean tides are caused. However, in this case they are called "earth tides."

These earth tides, particularly around known faults or cracks in the earth's crust, can be used in predicting time, location, and intensity of any violent earthquakes.

Dr. Neal D. Newby, Jr. of *Autonetics* suggests that a simple way of detecting and measuring these earth tremors would be to use a laser system to make continuous measurements between two fixed points a few miles apart.

The laser beam would be sent from one point to a mirror at the second point where it would be reflected back to the starting point. Here, the two beams would be mixed in an optical superheterodyne-like device.

As long as the two frequencies are similar, there will be no output.

If, however, either point should move with respect to the other due to motion of the earth's crust, then a beat frequency would be produced and the amount of motion could be read out from the electronic readout devices.

Since a laser system can detect motion changes as small as one centimeter (.3937 inch) in five miles, it can be used to detect and measure these minute earth-crust motions. Most points on the earth's crust are believed to move more than this.

How Clean is Clean?

Cleanliness is a relative term. To some it means the result of washing with soap and water, while to others it is the result of using a scrubbing brush. In the electronics industry, it has usually meant the result of working in special clean rooms, a liberal use of soap-and-water rinses, or intensive ultrasonic cleaning.

However, in each of these systems, the proof of cleanliness is usually determined by visual inspection.

Now, *Space Research Inc.*, of Orlando, Florida, has come up with its "Cleanometer," a device that can detect the presence of organic or inorganic residues to well below the monomolecular level. In use, this device sprays an aerosol-type radiochemical over the surface to be tested for cleanliness. Operation is based on the principle that the rate of evaporation of a volatile material from a surface is an inverse function of the amount of contamination that existed on that surface at the time the evaporation began. Any contamination on the surface retains more of the chemical than does the clean areas. Passing a sensitive probe over the surface produces an output proportional to the amount of chemical retained; thus the amount of cleanliness can be graphed.

New Oceanographic Ship

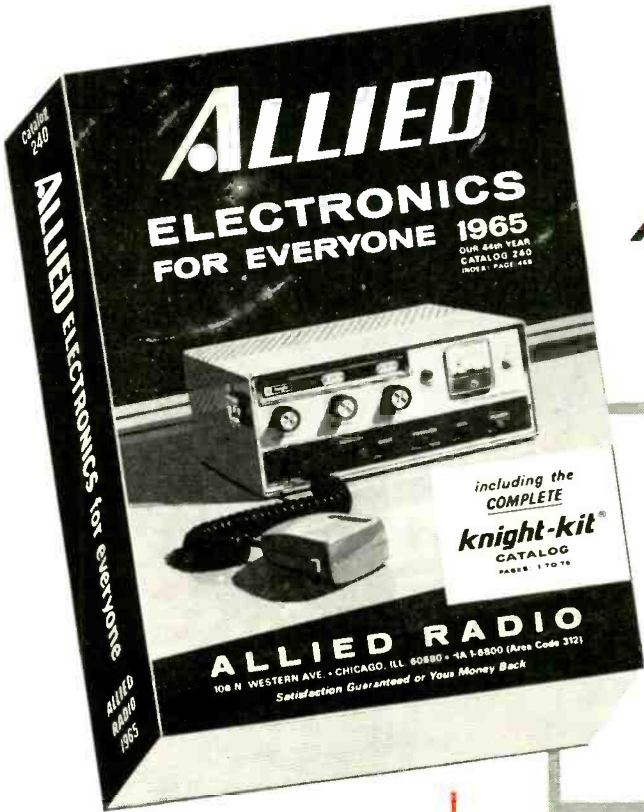
West Germany has now entered the field of oceanographic research with its latest all-electronic research vessel, the "Meteor." This 2600-ton vessel carries a scientific complement of 24 above the permanent crew of 55. Fully equipped with the very latest in electronic navigation and oceanographic equipment, the "Meteor" is soon to embark on a six-month trip through the Red Sea and along the coast of East Africa to the Arabian Gulf. In August 1965, the "Meteor" will take its place with other research activities when it sails to the intersection of the geographic and magnetic equators in the vicinity of St. Pauls Rock off the coast of Brazil, where it will participate in research connected with the International Quiet Sun Year.

Highway Safety

Road safety engineers of the West German *AEG* are now using a fully equipped illumination-measuring van for making lighting tests on their highways.

Instruments within the van ascertain the horizontal and vertical directions of light intensity from a particular light source while glare-measuring instruments measure the glare effect of a lighting installation.

Obstructions with varying degrees of reflection are used to measure the range of visibility under certain light conditions and register when in zones where they would be invisible to a driver. ▲



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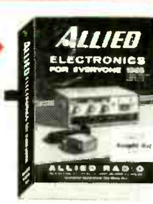

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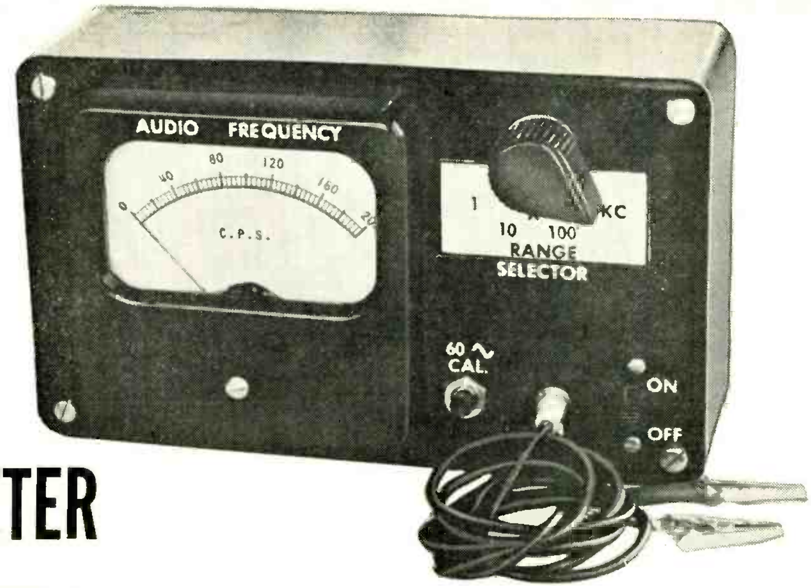
Frequency is read directly on the 1-milliampere meter scale.



Construction details on a test instrument which can measure frequencies accurately up to about 200 kc.

DIRECT-READING AUDIO-FREQUENCY METER

By R. C. APPERSON, Jr.

WHAT do you need in order to measure audio frequencies, using the present equipment on your bench? Unless the time-base generator of your scope is calibrated, you need the scope and a reference—an audio generator. After a time-consuming hook-up, another problem is to get the Lissajous pattern to stand still long enough to count the ratio. Maybe you prefer another method. If the unknown frequency is "beat" against a known frequency, no audio occurs when they coincide—still two pieces of equipment. You need a mixer and a calibrated generator. Besides, if your ear were perfect you would only get accuracy to within 40 cycles, since you have a "dead band" 20 cycles either side of zero beat.

Here is the answer: a transistorized audio-frequency meter having a direct readout. Frequencies from zero to 200 kc. may be read in cycles per second to the accuracy of the dial of the generator used to calibrate the instrument.

The Approach

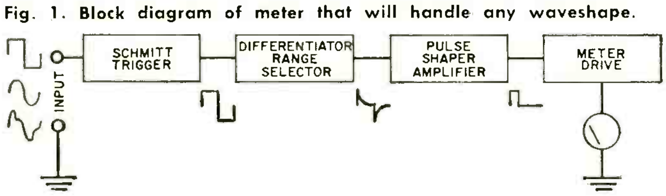
The frequency meter works on the same principle as the electronic tachometer, except that frequency range has been taken into consideration. Fig. 1 is a block diagram of the meter. Inputs of any shape must first be transformed into a fixed waveshape of constant amplitude. This is done by the Schmitt trigger. A square wave of the same frequency as the input is generated each time the input reaches a certain predetermined voltage. The Schmitt trigger will also turn off at a predetermined voltage.

The next block shows the differentiator-range selector. Here the square wave is shaped into spikes, both positive and negative, which occur at the leading and trailing edges of the square wave. We have two spikes for each alternation. The spike at the beginning of each alternation is the one used to count the frequency, later the negative spike will be clipped. The range is selected by changing the differentiator capacitor-resistor ratio.

The spikes are fed into a saturation-to-cut-off pulse amplifier. This circuit amplifies the spike, clips the top off, and removes the negative spike completely. The bias on this stage is adjustable, changing the pulse width. This is used for calibration, since the meter reading is based on both the number of pulses and the width of each pulse. The output of this stage is a series of positive pulses of fixed width, a pulse occurring at the beginning of each alternation of the input waveform.

The last stage is the meter driver, a direct-coupled current amplifier. It is biased off. Each pulse applied to the base causes the transistor to turn on, allowing current to flow through the meter for the duration of the pulse. The meter integrates, or sums up, the current so that it is proportional to the number of pulses during a given interval.

Fig. 1. Block diagram of meter that will handle any waveshape.



Circuit Description

The schematic diagram is shown in Fig. 2. Transistors $Q1$ and $Q2$ comprise the Schmitt trigger. A diode ($D1$) clips the negative alternation of the input, since all that is needed is the positive-going portion of the waveform, the area above the zero reference point. Switch S2 selects the differentiator capacitor. Note that each bank of capacitors (except $C3$) is made up of a fixed and a variable capacitor. This allows calibration for each of the three higher ranges. Resistor $R8$ adjusts the bias on the pulse amplifier, $Q3$. It is used to calibrate the low range and is used, after initial calibration, as a calibration adjust control. Transistor $Q4$ drives meter $M1$, the readout device.

A full-wave bridge is used in conjunction with $T1$, a filament transformer, as the power supply. It is filtered by $C11$, a large capacitor. A signal is taken from the power-supply transformer and used as a 60-cycle calibrate check. It is a distorted 60-cycle wave applied to the input by depressing switch $S1$.

This calibration check is performed on the low range, but compensates all ranges, since compensation changes the bias on $Q3$, thus the pulse width. This compensates for temperature or component age. After being adjusted, the padder capacitors will not change, and they alone affect each range.

Components and Construction

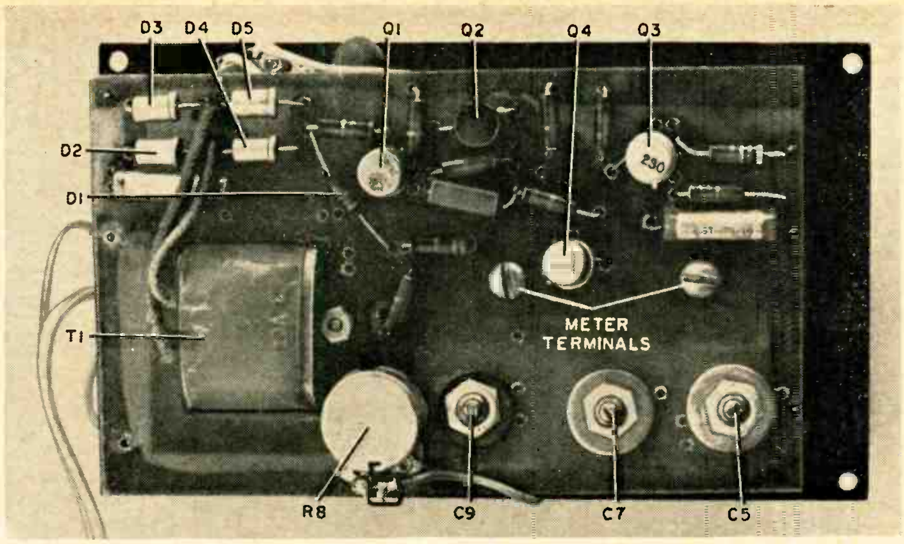
The layout is not critical but should be made fairly rigid, since moving components could affect the highest range. A printed circuit is suggested. As can be seen from the photo, the board is mounted directly to the meter terminals. Spacers ⅜" long were used to set the board away from the meter to clear components. A plastic case is handy and makes a nice package.

The transformer ($T1$) is a standard filament transformer with the bracket removed. Care must be taken to mount it securely to the circuit board, as shown. The author coated the outer edges of the laminations with glue to eliminate vibrations. The circuit board is cut out to accept the winding of the transformer.

Resistor $R8$ is a long-shaft, slotted type and is mounted so that it may be adjusted through a hole drilled in the front panel. The hole is located next to the calibrate button.

The meter scale was removed and recalibrated. The scale may be retained and, since the unit is linear, frequency simply replaces current as the calibration digits.

If a physically larger capacitor is used in place of $C11$, it may be placed on the side of the board which faces the front panel. Capacitor $C11$ may be composed of two or three capacitors in parallel as there is ample space on the underside of the board to accommodate a number of capacitors.



Construction should be rigid for good high-frequency results.

Calibration

A signal generator of known output frequency must be used. Each of the three higher ranges is calibrated at full scale, but checks should be made across each band to assure linearity.

Press the calibrate button with the selector on "XI". The meter should read 60 cycles. Each time you use the meter, press the test button and compensate, if necessary. The switch is so arranged that you may check calibration even with an input connected to the meter. The switch disconnects the input and automatically connects the calibrate signal for convenience.

Proceed to the "X10" position. Set the generator to 2000 cps. Adjust capacitor $C5$ for full-scale deflection. It is a good idea to check several additional points on this range as well.

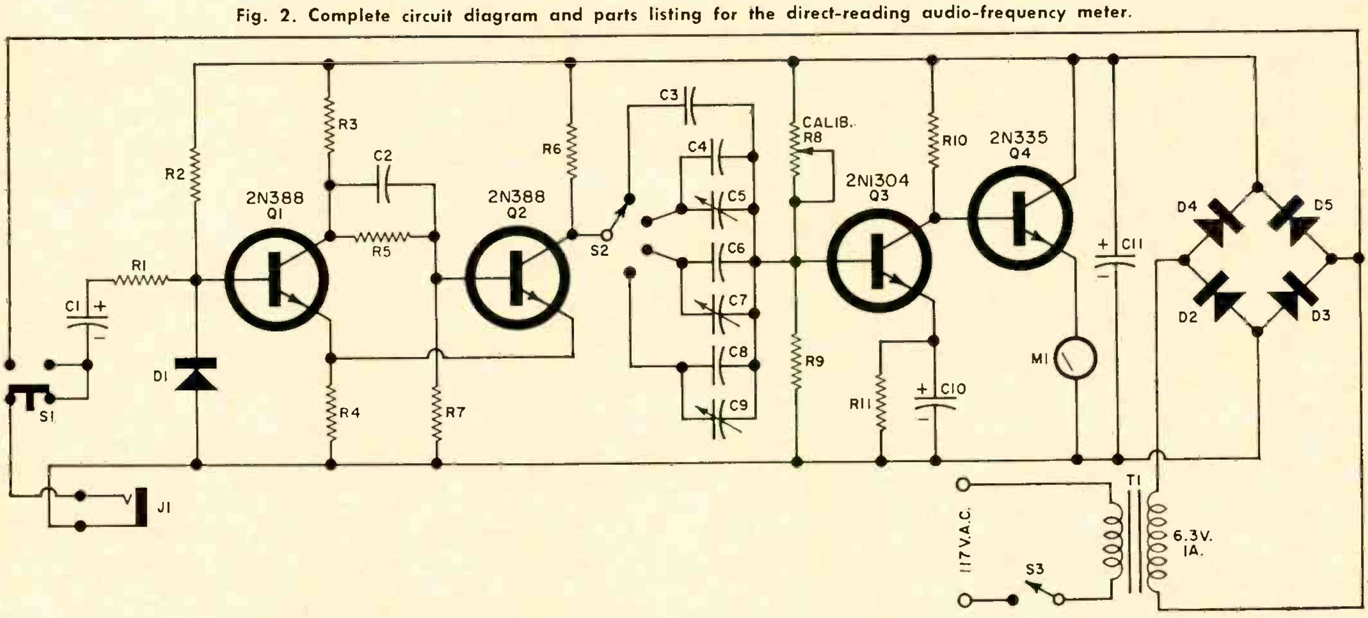
Set selector to "X100". The generator is now adjusted to 20 kc. Adjust $C7$ for full scale and check the linearity.

Now set the selector to "X1kc". The highest range is 200 kc. Adjust the generator to this and set $C9$ for full-scale deflection. Check the linearity.

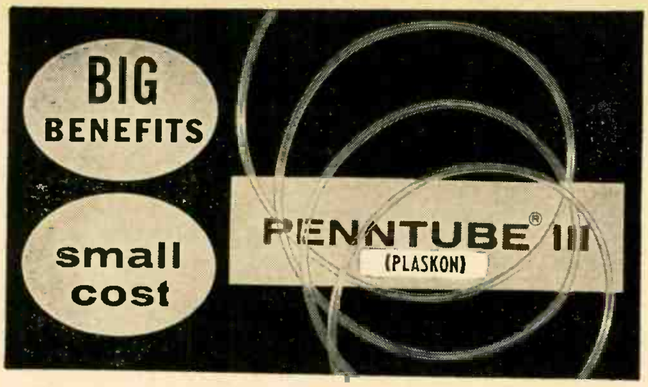
The meter is now ready to operate. A final check is to change your generator from sine to square wave. The meter should read the same unless the generator shifts slightly. Check this with your scope if there is a difference.

The frequency meter is handy for most audio measurements. It does have a fairly low input impedance, though, so it will load high-impedance circuits. It, like any test instrument, has its limitations. When used properly, it will serve you well. ▲

Fig. 2. Complete circuit diagram and parts listing for the direct-reading audio-frequency meter.



R1—200 ohm, ½ w. res.
R2—3300 ohm, ½ w. res.
R3—2200 ohm, ½ w. res.
R4—820 ohm, ½ w. res.
R5—1500 ohm, ½ w. res.
R6—2700 ohm, ½ w. res.
R7,R10—5100 ohm, ½ w. res.
R8—50,000 ohm miniature pot
R9—47,000 ohm, ½ w. res.
R11—110 ohm, ½ w. res.
C1,C10—10 µf., 25 v. elec. capacitor
C2—470 pf. capacitor
C3—.05 µf. capacitor
C4—.003 µf. capacitor
C5—50-400 pf. capacitor (Miller No. 160-B or equiv.)
C6—220 pf. capacitor
C7—25-280 pf. capacitor (Miller No. 160-E or equiv.)
C8—5 pf. capacitor
C9—10-160 pf. capacitor (Miller No. 160-D or equiv.)
C11—200 µf., 15 v. elec. capacitor
J1—Open-circuit jack
S1—Two-circuit, or s.p.d.t. push-button switch
S2—Four-circuit rotary selector sw.
S3—S.p.s.t. slide sw.
M1—0-1 ma. meter (Lafayette TM-60 or equiv.)
T1—6.3 v., 1 amp. fil. trans. (Merit P2944 or equiv.)
D1—1N474 diode (5.2-6.4 v. double-diode used by author. Can also use less expensive, non-critical diode here.)
D2,D3,D4,D5—500 ma., 400 p.i.v. diode (Lafayette SP-240 or equiv.)
Q1,Q2—2N388 transistor
Q3—2N1304 transistor
Q4—2N335 transistor



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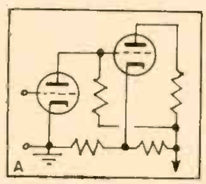
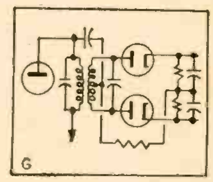
CO-INVENTORS QUIZ

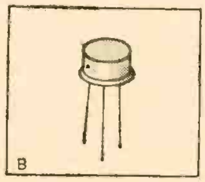
By ROBERT P. BALIN

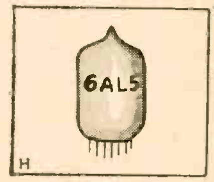
MANY important discoveries and inventions in the field of electronics were made by men who worked together as a team, and current textbooks still include the names of the co-inventors (1-10) listed below. See how many of these teams you can match with the sketches (A-J) which illustrate the devices or theory which they helped to develop. Turn page for the answers. ▲

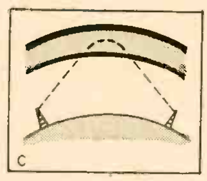


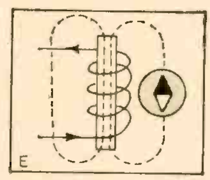


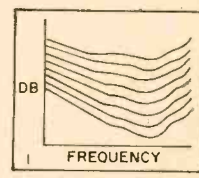
1. BARKHAUSEN-KURZ ____
2. BIOT-SAVART ____
3. ECCLES-JORDAN ____
4. FERMI-DIRAC ____
5. FLETCHER-MUNSON ____
6. FOSTER-SEELEY ____
7. GEIGER-MULLER ____
8. KENNELLY-HEAVISIDE ____
9. LANGMUIR-CHILD ____
10. LOFTIN-WHITE ____

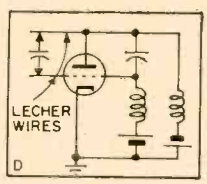


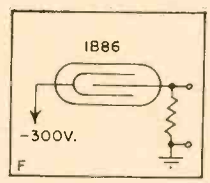


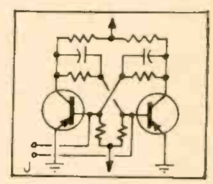












ANSWERS

1-D. The BARKHAUSEN-KURZ oscillator circuit is a positive-grid u.h.f. oscillator by Lecher wires in the grid and plate circuits.

2-E. The BIOT-SAVART Law, or Ampere's Law, specifies the direction and magnitude of the magnetic field at any point in the vicinity of a current-carrying conductor.

3-J. The ECCLES-JORDAN trigger circuit, or flip-flop, is a bistable multivibrator in which the conducting state of each half is changed only by the incoming pulses.

4-B. FERMI-DIRAC statistics predict the availability of current carriers in the semiconductor materials used to make transistors.

5-I. FLETCHER-MUNSON curves show the relationship between the signal frequency and the sound intensity required by a listener to hear a constant loudness.

6-G. The FOSTER-SEELEY FM discriminator circuit converts a frequency-modulated radio-frequency carrier into an amplitude-modulated signal from which the audio is detected by a balanced diode circuit.

7-F. A GEIGER-MULLER tube detects nuclear radiation when beta particles ionize the gas inside the tube to start a discharge of electrons between the cathode case and highly positive anode.

8-C. The KENNELLY-HEAVISIDE layer is the original term for the ionosphere, now known to consist of various layers, whose height and degree of ionization determine their effect upon high-frequency radio transmission.

9-H. The LANGMUIR-CHILD Law, or Three-Halves Power Law, describes the relationship between the applied voltage and the resulting current in a diode vacuum tube.

10-A. The LOFTIN-WHITE amplifier circuit uses direct coupling between stages and can handle signal frequencies down to d.c.

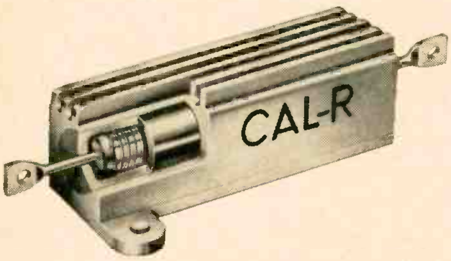
NEW PRODUCTS & LITERATURE

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

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

WIREWOUND POWER RESISTORS

1 **California Resistor Corporation** is now offering a new line of "Cal-R" metal-clad, wire-wound power resistors which have been specifically designed for high-power heat-sink



application. Each has design characteristics to enable the resistor to meet or exceed all electrical and environmental requirements of MIL-R-18546C.

Features of these new resistors include copper-weld lead, hot tin dipped, completely welded construction, and a high density extruded aluminum housing that is deep finned for maximum heat dissipation.

D.C. POWER SUPPLY

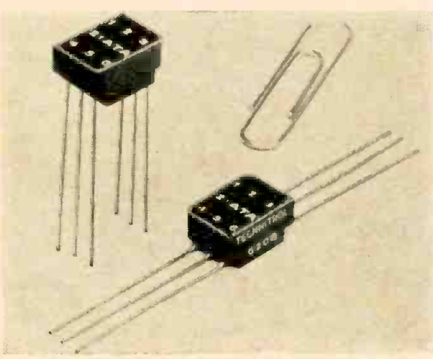
2 **Perkins Electronics Corporation** is now marketing the Model TVR040-30-20, a unit specifically designed for ground support d.c. needs where RFI elimination and wide voltage range (0-36 volts) and high current (0-30 amperes) are needed.

Input power is 105-125 volts a.c., single phase, 57-63 cps at 20 amperes max. Being fully transistorized, regulation of ±0.01% or 2 mv. for line and ±0.02% or ±4 mv. for load with 50 µsec. recovery time is standard. Additional features include dynamic regulation of ±50 mv. for input line step change, ±1 volt for full-load step change, and stability of ±0.1% or ±20 mv.

PULSE TRANSFORMERS

3 **Technitrol, Inc.** has developed a new line of subminiature temperature-stabilized pulse transformers which is being marketed as the "Type T Genie."

The inductance of the transformers varies no more than 15% of room temperature value from −60 C to +130°C. Total volume is less than 0.05 cubic inch, permitting their use in circuits requiring a high component packing density. The pulse transformer can be mounted on 0.10 grid spacing. When the transformer is mounted flush against a PC board, the case design exposes the leads on both sides of the board for easy testing. This lead clearance eliminates the need for tight tolerances on hole spacing.



The line is currently stocked in five standard turns ratios from 1:1:1 to 3:3:1 and in 25 individual magnetizing values from 15 µhy. to 200 µhy.

4-WATT POTENTIOMETER

4 **Clarostat Manufacturing Co., Inc.** has announced the availability of a new, compact 4-watt potentiometer in a case diameter no larger than that of a 2-watt pot.

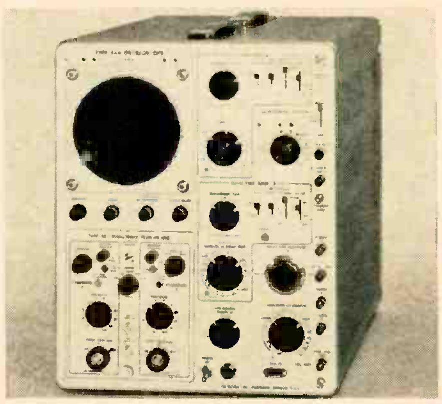
The Series 45 potentiometer is rated at a true full 4 watts at 40 C and derated to zero power at 150°C. It is 1⅛" in diameter and available in a resistance range of 10 ohms to 15,000 ohms linear. Standard tolerance is ±10%. The series is available with standard bushing mounting or split-locking bushing for "set-and-forget" applications.

WIDE-BAND OSCILLOSCOPE

5 **Tektronix, Inc.** has announced the availability of a new wide-band oscilloscope, the Type 546.

The new unit accepts the company's 1-A plug-in units for general-purpose d.c.-to-50 mc. dual-trace applications as well as the firm's "letter-series" plug-ins for strain gage, multi-channel, differential, and operational amplifier applications in the d.c.-to-30 mc. areas.

Dual-trace sensitivity with a Type 1A1 plug-in unit is to 50 mv./cm. from d.c.-to-50 mc. and



to 5 mv./cm. from d.c.-to-28 mc. For applications demanding even greater sensitivity, the two input channels can be cascaded to provide single-trace displays at approximately 500 µv./cm. sensitivity from 2 cps to 15 mc.

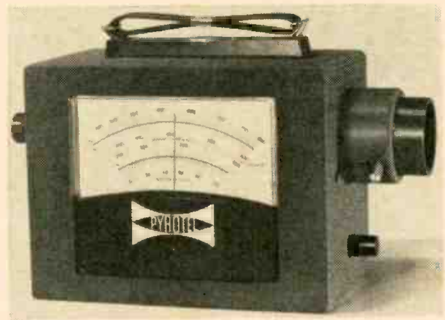
SHOCKPROOF SCREWDRIVER/TESTER

6 **Littelfuse, Inc.** has introduced two models of an inexpensive combination screwdriver/voltage tester, one 4 inches long and the other 5 inches long. These units test for opens or hot lines in any circuit carrying 110 volts to 380 volts. Incorporated in the transparent plastic handle are a resistor and a long-life neon lamp that glows when the screwdriver tip is applied to a live line.

INFRARED THERMOMETER

7 **Pyrotel Corporation** has announced the availability of a portable, low-temperature infrared thermometer, the PY1500. Requiring no support amplifiers or power supplies, the new unit is completely self-contained and capable of measuring temperatures of 125°F and above.

Ruggedly packaged for high accuracy measure-



ment requirements in plant and field use, the instrument measures target temperatures without contact and independent of target distance. Subjective operator errors are eliminated by a direct calibrated meter. Sensitive to temperature changes of less than 2°F, the instrument provides reproducible measurements of better than 1% and an accuracy of better than ±2%. Response time is 20 msec. and targets as small as ⅛" may be resolved with complete accuracy.

TRANSISTORIZED INVERTER

8 **Topaz, Incorporated** has announced the availability of an all-transistorized, 300-watt power inverter which changes 12-volt auto battery power to 60-cycle power capable of running household appliances, small power tools, and test instruments.

Designed for emergency power in storm areas as well as normal power requirements, the inverter weighs 12 pounds and measures 5⅜" x 5⅜" x 5⅜". It comes complete with operating instructions and cables.

GENERAL-PURPOSE pH METER

9 **Corning Glass Works** has just introduced a high-reliability, general-purpose pH meter, the Model 7.

The new instrument features stable operation to take advantage of the low drift characteristics of the firm's new pH electrode with triple-purpose glass membrane. The meter employs up-to-date solid-state chopper-amplifier techniques and high-reliability components for long life and trouble-free operation. Instrument drift is less than 0.01 pH per day.

The Model 7 has a measuring range from 0 to 14 pH units and ±0 to 1400 millivolts. Readings are made on a 7" mirror-scale, taut-band

suspension meter. The instrument comes with an accessory kit which includes all the basic equipment required to operate the instrument.

PRECISION-FILM POT

10 **Computer Instruments Corp.** has developed a new multi-gang precision-film potentiometer for use in high vibration areas.

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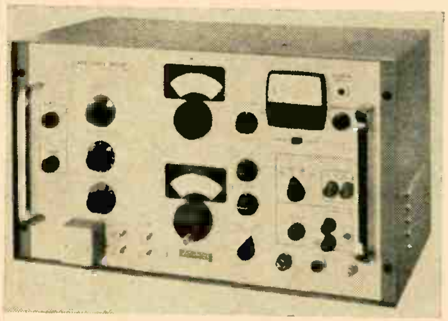
The Model 177S is available in both linear and non-linear special and standard models. Standard electrical specifications call for a resistance range of 1000 to 250,000 ohms (±10%); 2% to 0.05% independent linearity and conformity; 350° electrical function angle (±3°); 356° electrical contact angle; and 3 watts power dissipation at 25°C.

Two types of taps are available, depending upon the application; −55°C to +150°C operating temperature range, and 750 volts r.m.s. dielectric strength.

WIDE-RANGE CAPACITANCE BRIDGE

11 **Boonton Electronics Corporation** is now marketing a new 100-kc. bridge which provides capacitance measurements from 0.0002 pf. to 110,000 pf. with a basic accuracy of 0.1%.

The new instrument, Model 74D, also measures



conductance from 0.001 micromhos to 1000 micromhos and shunt resistance from 1000 ohms to 1000 megohms. The instrument may be operated in either the three-terminal (direct) mode in which measurements are essentially independent of capacitance to ground, permitting precise remote measurements, or in the conventional two-terminal (grounded) mode.

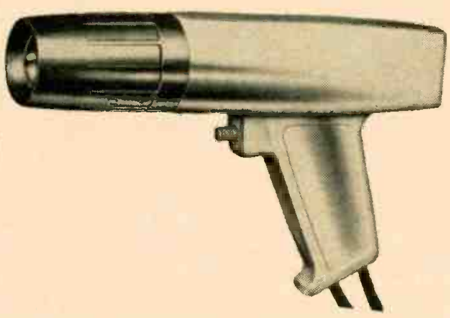
The capacitance bridge is completely self-contained, including 100-kc. test oscillator and detector, d.c. bias supply, and all required power supplies.

D.C. POWER TIMING LIGHT

12 **Rite Autotronics Corp.** is now offering a new d.c. power timing light for a wide variety of timing and tune-up applications.

The unit provides a brilliant, blue-white timing flash which is controlled by a trigger switch. A unique feature of the unit is the easily replaceable, plug-in xenon tube. Solid-state electronic circuitry is employed for high reliability. There are no moving or vibrating parts.

No external power is needed as the gun operates directly from the 6- or 12-volt car battery. If polarity is accidentally reversed, no damage occurs.



CONDUCTIVE PAINT

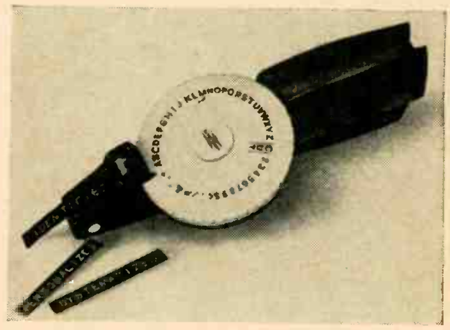
13 **R. T. Dorl & Co.** has developed "Liquid Wire," a non-epoxy, electrically conductive paint-like compound which will conduct 200 watts and can be applied to most surfaces and dries in 30 minutes.

The compound can be brushed, dipped, stencilled, or silk screened. It can support temperatures up to 400°F when dry. Compatibility with standard electronic hardware is possible by staking or screwing into it.

Circuits made with the product can be "erased" with a solvent. The compound can be film-insulated to permit stacked circuits. The product is available in kit form, production quantities, or for custom silk-screened printed circuitry.

HAND EMBOSSER

14 **Duramatic Co.** is now marketing its new "Label Mate," a hand-embossing machine which prints large raised letters 5/32" high on



self-sticking plastic tape. New features include a fully visible rotating dial to allow the user to see each letter as it is embossed. The dial contains 44 characters including a number of often used symbols.

A zip-tab allows easy removal of the protective backing and the label is ready to adhere to any smooth, clean surface. There is a choice of 11 tape colors, each 144 inches long x 3/8" wide.

INDUCTANCE BRIDGE

15 **Path Products Corporation** is handling the U.S. distribution of a new all-transistor inductance bridge and "Q" meter made in England by **Nombrex.**

The Model 66 has four inductance ranges from

1 μhy. to 100 μhy.; 100 μhy. to 10 mhy.; 10 mhy. to 1 hy.; and 1 hy. to 100 hy. "Q" is measured from 0.1 to 1000.

The instrument operates from a standard 9-volt transistor battery and measures 6⅝" x 4⅝" x 2⅝" and weighs less than 2 pounds.

SHIELDED IGNITION SYSTEM

16 **Webster Manufacturing** is now offering a new fully transistorized shielded ignition system which the company claims will increase gasoline mileage up to 10% and nearly 5% in engine horsepower of boat and automobile engines.

The self-contained package replaces conventional marine and auto ignition systems that depend on breaker-point switching and coils whose voltage drops as engine speed increases. Completely shielded and filtered for noise-free radio operation, the Model 5600 ignition system can be added to a 12-volt engine without removing the presently installed ignition system.

AIR FLOW SENSING SWITCH

17 **G-V Controls Inc.** is now offering a new air flow sensing switch of the thermal type which is used to provide alarm and automatic shutdown if cooling air flow ceases or drops below a safe value. Its small size, 13/16" diameter x 1¾" high, produces minimum interference with

air flow. Inherent thermal lag avoids contact operation on brief, insignificant interruptions of flow.

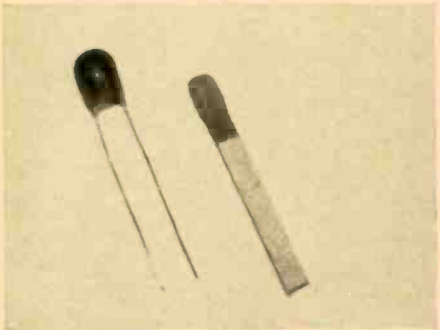
The switch is mounted in a standard 9-pin miniature tube socket. Heater voltages of 6.3, 26, and 115 are standard. The heater draws 2½ watts. Contacts may be normally closed, opening on air flow failure, or normally open, closing on air flow failure. Contact rating is 2 amps, 115 volts a.c. or 1 amp, 28 volts d.c. resistive.

MINIATURE INDUCTORS

18 Automatic Coil Company is now offering a new line of miniature inductors which have been specifically designed for printed-circuit and transistorized circuit applications.

The new ML series is available in inductance values from 25 to 350 μhy. $\pm$0.5% tolerance. The series can be supplied with a tap and additional lead. Each unit is stress-relieved and temperature stabilized through four seasoning cycles.

Maximum dimensions are .250" x .250". The



inductors are encapsulated in flame retardant epoxy resin with copper-tinned leads 1¼" long.

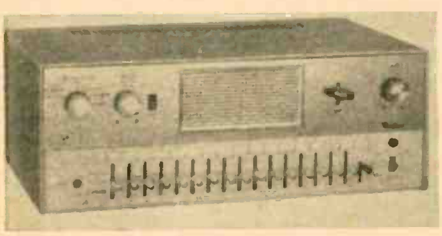
HI-FI — AUDIO PRODUCTS

PROGRAM/INTERCOM CONTROL CENTER

19 Rauland-Borg Corporation is now offering a solid-state, dual-channel program/intercom control center as the Model S330. This all-transistor unit provides two separate program and intercom channels and makes available versatile facility expander companion units.

The circuit of the Model S330 includes an acoustic noise suppressor and overload protection; inputs for 3 low-impedance microphones, 3 high-impedance auxiliaries, 16 station-selector keys, voice call-in facilities, selective privacy on intercom, an ultra-reliable "talk-listen" switch, and an all-call key.

Designed especially for small and medium-sized schools, the system can be expanded by means of an AM-FM tuner and/or a record



player. The unit can also be used for continuous-duty commercial industrial paging and background music systems.

"FOOLPROOF" TAPE RECORDER

20 North American Philips Company, Ltd. has announced the availability of the "Norelco Carry-Corder 150," a tape recorder which the company claims is characterized by its simplicity and foolproof operation.

The unit is a cordless, transistor tape recorder using tape cartridges that can be inserted into the machine in a single motion for instant, automatic, fumble-proof recording. A single master control that starts, stops, winds, and rewinds the tape makes the unit as simple to operate as a radio.

The recorder weighs only 3 pounds with batteries. It comes complete with microphone, deluxe carrying case with microphone pouch, four cartridges, and a patchcord. The cartridge comes loaded with 300 feet of triple-play tape for a playing time of 60 minutes. Operation is at 1⅞ ips and frequency response is 120 to 6000 cps.

MULTI-CHANNEL RECORDER

21 Magnasync Corporation has developed a rack-type recorder/reproducer that will accommodate up to 10 simultaneous telephone or audio communications without interruption for 24 hours. A unique "fail-safe" feature instantaneously detects possible mechanical or electronic failure and automatically starts a tandem recorder.

Especially suited for "back-up" record applications in commercial and military aircraft-tower, aircraft-carrier, ship-shore, security installations, telephone switchboards, TV, radio, fire control centers, etc., the Model TR-1510 uses ½", 10-channel tape. Plug-in, solid-state circuitry minimizes down time, maintenance, and heat problems. Optional features include remote control, remote mode indicator, and synchronous time injection.

AUTOMATIC TAPE PLAYER

22 Tape Cartridge Player Inc. has recently introduced the "TCP" tape player which will accept almost all standard continuous loop cartridges and is designed to meet the rugged requirements of continuous duty in commercial operation.

The tape cartridge player will activate any electro-mechanical device and play back messages in perfect synchronization with slide or filmstrip projectors. The unit will repeat sound continuously, stop on cue, or be activated by a remote-control push-button, footswitch, etc. Other features include built-in speaker, output speaker jack, remote start, automatic start, and immediate response.

70-WATT STEREO AMPLIFIER

23 Lafayette Radio Electronics Corporation has added the LA-350 to its line of high-fidelity amplifiers.

This deluxe 70-watt stereo amplifier has 11 front-panel controls and 6 pairs of stereo inputs. Separate bass and treble controls are friction-locked, enabling each channel to be adjusted independently or simultaneously.

Frequency response is from 15 to 30,000 cps $\pm$1 db at normal listening level. Harmonic distortion is less than 1%. Hum and noise is 55 db down on phono inputs and 76 db down on high-level inputs. Channel separation is 50 db at 1 kc.

The instrument is housed in a case measuring 14⅝"x 5¼"x 10".

PORTABLE P.A. AMPLIFIER

24 Southern Solid State Electronics is now marketing the "Port-a-Call," a portable p.a. amplifier which provides coverage up to ½ mile. Weighing less than 8 pounds including its

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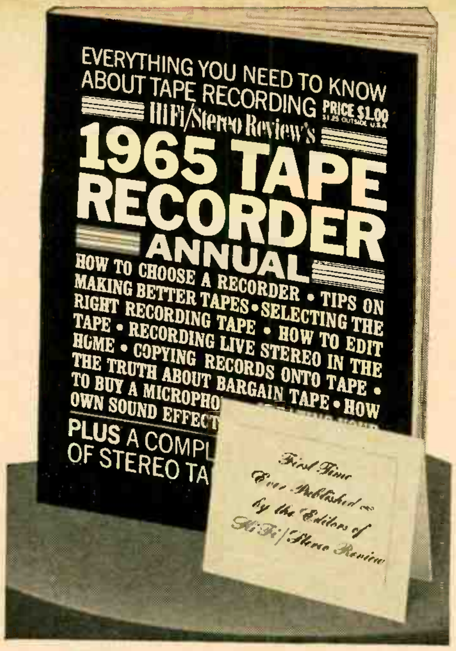

Know-it-all.

It's easy to be an authority on tape when you have a copy of *Hi Fi/Stereo Review's* **1965 TAPE RECORDER ANNUAL** handy. Look at the photo above. The special articles listed on the cover of this 132-page factbook are just a few of the **23 complete features!** You get expert tips by the dozens, on equipment — making better tapes—editing—copying—sound on **everything** you need to know about tape recording. Plus...

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internal power source, the amplifier measures only 9" x 6" x 3", yet is capable of driving 12 speakers at the same time using only two 6-volt lantern batteries. Operating power can also be obtained from an automobile cigarette lighter, or 117-volt source when used with a converter.

Frequency response is 50 to 15,000 cps. The amplifier can be carried over the shoulder or placed on the ground. A lavalier mike eliminates the need for the user to cover the mouth and face.

Numerous accessories are available to enlarge the operating applications of the unit.

ELECTRONIC MEGAPHONE

25 **Fanon-Masco** is now marketing a high-output, compact, economy megaphone which incorporates a three-transistor circuit and de-

velops a full watt of audio output. Range of the Model MV-2 is 150 yards.

The unit operates on eight standard penlite batteries and is made of durable high-impact plastic. A handy wrist cord is provided to secure the electronic megaphone. The unit is equipped with a talk-lock switch which permits continuous talking ease, and a volume control to adjust audio output according to the area coverage required.

The unit weighs 1¼ pounds and measures 7" x 4" x 2½".

STEREO CONTROL AMPLIFIER

26 **Electro-Voice, Inc.** has entered the high-fidelity component field with an extensive line of fully transistorized equipment.

Among the new units being offered is the Model E-V 66 stereo control amplifier which incorporates a total of 26 transistors, 14 of which are silicon. Four silicon diodes are used in the power supply.

The unit incorporates automatic contour regulation, a unique tone-control circuit linked to the volume control in a manner which provides infinitely variable loudness compensation. Any amount of boost selected on the bass and/or treble control is regulated by the volume control to reduce the amount of boost automatically as the volume is increased and raise the amount of boost as the volume is lowered.

Power output is 80 watts IHF music power, 160 watts instantaneous peak power. Frequency response is 8 to 50,000 cps ±1.5 db at rated power. Channel separation is 40 db minimum at 1000 cps. Output damping factor is 50 at 8 ohms.

The unit is supplied complete with a black perforated metal wrap-around cover. An optional oiled walnut wood case is also available. The model E-V 44 is similar to the E-V 66 except that it has a 40-watt IHF power output, a conventional tone control circuit, and twelve transistors.

STEREOPHONIC PICKUP

27 **Grado Laboratories, Inc.** has discontinued its entire pickup line and will henceforth be represented only by its new Model A stereo pickup.

The new unit employs jewel bearing construction and contains several dozen precisely machined parts. Tolerances in millionths of an inch are maintained in production, according to the company. Tip mass is 3/10th of one-thousandths of a gram and frequency response measures well beyond 50,000 cps. The pickup has a twin-tip diamond stylus (pat. pending) of unique shape. The pickup is limited in required tracking force only by the tonearm in which it is being used. It may be tracked in a moderately high-mass transcription arm at approximately 1½ to 2 grams; in a light-mass tonearm, 1-gram tracking is easily achieved.

32-WATT MOBILE AMPLIFIER

28 **Perma-Power Company** has announced the availability of a 32-watt, all-transistor amplifier that can be used in any mobile application.

The "Ampli-Vox" Model S-300 can be used with any speaker system for vehicular public address or music programming. The 12-volt d.c. amplifier plugs directly into an automobile cigarette lighter socket for a convenient power source. Terminals are also provided for permanent installation.

The circuit is of all-transistor, push-pull design. It is rated 32 watts EIA music power (50

watts peak) and provides a frequency response of 50 to 15,000 cps. Signal-to-noise ratio is 80 db.

CB-HAM-COMMUNICATIONS

CB CRYSTAL LINE

29 **Semitronics Corp.** is now marketing a complete line of CB crystals that meets 95% of all popular replacement requirements.

The crystals are hermetically sealed, which the company claims meet or exceed industry standards, have a frequency tolerance of 0.005% or better, cover all 23 CB channels, and are fully guaranteed.

5-BAND CB TRANSCEIVER

30 **Heath Company** has added the "Heathkit MW-34" to its line of CB equipment. This new CB transceiver has five crystal-controlled transmit and receive channels, one of which is a new front-panel crystal socket to allow quick, easy changing of one transmit crystal without removing the cabinet. With this feature it is possible to transmit on all 23 channels.

Another feature is a spotting switch which is used with variable receiver tuning for the receive function. The spotting switch turns on the transmitter oscillator without going on the air, thus generating a signal for tuning the receiver to exactly the same frequency as the transmitter. Also featured is a TVI filter to minimize interference with sets operating in the surrounding area. A

new calibrated "S" meter, which automatically shifts from transmitter to receiver, indicates strength of received signals and relative power output during transmit.

The kit is supplied with complete step-by-step assembly instructions and includes a microphone, a.c. and d.c. power cords, and crystals for one channel.

23-CHANNEL CB UNIT

31 **Pearce-Simpson, Inc.** has just introduced its "Guardian 23," a 23-channel two-way radio for the Citizens Band service.

Featuring the company's exclusive "HetroSync" circuitry which mixes two frequencies instead of three, the unit uses special close-tolerance crystals for a transmitted frequency tolerance of

±.003%. There is also a noise-limiting circuit, an illuminated "S" meter, illuminated channel selector, and modulation indicator.

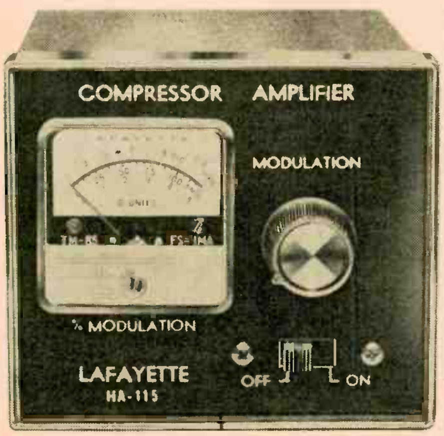
The unit utilizes a transistorized universal power supply (12 volts d.c. or 117 volts a.c.) and a dual-conversion superhet receiver.

The "Guardian 23" measures 11½" wide x 4¾" high x 10½" deep and weighs just 15 pounds complete with all-angle mounting bracket on a slide rail.

CB COMPRESSOR-AMPLIFIER

32 **Lafayette Radio Electronics Corporation** is now offering a new CB accessory, the Model HA-115 audio compressor. This device automatically increases the average modulation of a CB transmitter without overmodulating the carrier. An illuminated meter reads modulation percentage directly.

The unit works with all popular 6- or 12-volt d.c. or 117-volt a.c. CB transceivers. It comes com-



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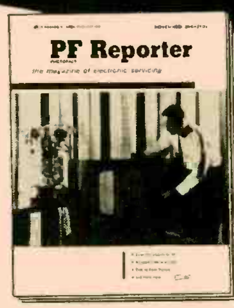

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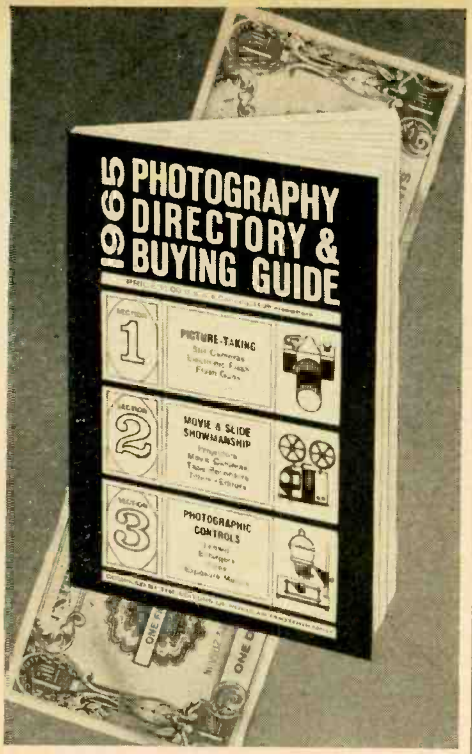

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plete with operating and installation instructions. It measures 3" high x 3 7/8" w. x 5" d. and is catalogued as the No. 42-0117.

DEPTH SOUNDER

33 **Pearce-Simpson, Inc.** has recently released its Model DS-464 flasher-type depth sounder which features a variably controlled illuminated

depth scale which is fully enclosed and horizontally mounted to insure readability even in brightest sunlight.

The unit features a calibrated scale, 21" in circumference, providing the greatest possible spread of depth markings for easy, accurate readings. The entire scale can be rotated to bring the desired operating depth into the most convenient viewing position. Range is 240 feet and the unit operates from 12 volts d.c. Over-all dimensions are 9 7/16" wide x 6 11/16" high x 9 3/8" deep; weight is 14 pounds. The package includes the transducer, mounting bracket, connecting cable, and fairing block.

VIBRATOR ELIMINATOR

34 **I.E.H. Manufacturing Co., Inc.** is now offering a new solid-state vibrator eliminator for mobile equipment using mechanical vibrators. The new unit, called "Vi-Tran," simply plugs into the vibrator socket; no tools are required for installation.

The unit is being marketed in two versions, the Model VE-194-P (vibrator pin #1 positive), and VE-195-N (vibrator pin #1 negative). According to the company, the all-transistorized construction insures that the "Vi-Tran" will outlast the standard vibrator installed in most CB units. It will operate at temperatures from −50°F to +180°F. Power is maximum as authorized by the FCC.

2- AND 6-METER TRANSMITTER

35 **Ameco Equipment Corp.** is now offering the Model TX-62, a 2- and 6-meter amateur transmitter with built-in power supply and modulator.

The new unit is fully wired and tested. Frequency coverage is 50-54 mc. and 144-148 mc. Power input to the final is 75 watts on c.w. and 75-watts peak on phone.

Controls include power switch, phone-c.w. switch, meter, selector switch, crystal or v.f.o.

switch, audio gain control, drive control, bandswitch, final plate tuning, and loading. The solid state power supply is built in.

The transmitter is housed in a compact two-tone gray cabinet which measures 11½" wide x 9" deep x 6" high.

HAND-HELD CB UNIT

36 **Raytheon Company** is now marketing the TWR-6 hand-held CB unit which features a full 2 watts input. Completely portable and weighing only 2¾ pounds, the new unit is especially designed for search and rescue; safety, security, and firefighting forces; as well as construction and survey crews, sportsmen, and ranchers.

Two crystal-controlled channels are offered in the tubeless two-way radio that employs 13 transistors, two diodes, and a thermistor for greater reliability and minimal battery drain.

A meter on the side of the set shows the amount of charge in the self-contained nickel-cadmium batteries. These can be easily recharged from any household outlet.

SYNTHESIZED CB UNIT

37 **United Scientific Laboratories** has just introduced a second model in its new CB transceiver line.

The "Contact!-23" is a synthesized 23-channel CB unit that permits operators to transmit and receive over all 23 channels. Each channel is crystal controlled. The transceiver is housed in a sloped, illuminated panel cabinet. Features include a mechanical bandpass filter; built-in speech compressor; illuminated "S" and r.f. meter, and modulator indicator; a built-in 12-volt/117-volt transistorized power supply; and a p.a. system and earphone jack.

The unit comes with a 117-volt power cord, a 12-volt cigarette lighter power cord, a press-to-

talk hand microphone with electronic switching, and snap-lock mounting brackets and hardware.

MANUFACTURERS' LITERATURE

TESTING PROGRAMS

38 **Corning Glass Works, Electronic Products Division** has just published an 8-page technical paper entitled "Significance of Large Life Testing Programs."

Basis of the discussion is the large-scale testing and component-part evaluation work performed at Corning on the CFYR fixed-glass capacitor. The booklet contains illustrations and references.

NEW PRODUCTS BOOKLET

39 **Motorola Semiconductor Products Inc.** has published a pocket-sized, 24-page brochure listing device descriptions, specifications, and recommended circuit applications for the company's more than 75 new products introduced at this year's WESCON show.

Included are radar i.f. transistors and low-storage "p-n-p" and "n-p-n" transistors.

HIGH-CURRENT RECTIFIERS

40 **Motorola Semiconductor Products Inc.** has put out a 12-page brochure which describes a multi-cell assembly process for high-current power rectifiers.

Electrical data on the company's rectifier line is presented in tabular form, and a device replacement cross-reference chart is provided.

TIMER PROGRAMMING

41 **Bayside Timers, Inc.** is making available a 12-page booklet which explains how to diagram a timer program. Amply illustrated with charts, the brochure will interest the designer, engineer, and display and exhibit builder.

THERMOCOUPLE TABLES

42 **Omega Engineering, Inc.** has compiled complete calibration tables for thermocouples tabulated in both centigrade and Fahrenheit in one-degree increments. Based on the National Bureau of Standards Circular #561, the technical bulletin contains 14 tables for iron-constantan, chromel-alumel, copper-constantan, and other types of thermocouples.

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Although there are many stereo test records on the market today, most critical checks on existing test records have to be made with expensive test equipment.

Realizing this, HiFi/STEREO REVIEW decided to produce a record that allows you to check your stereo rig, accurately and completely, just by listening! A record that would be precise enough for technicians to use in the laboratory—and versatile enough for you to use in your home.

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Stereo Checks That Can Be Made With the Model 211

- ✓ Frequency response—a direct check of eighteen sections of the frequency spectrum, from 20 to 20,000 cps.
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- ✓ Hum and rumble—foolproof tests that help you evaluate the actual audible levels of rumble and hum in your system.
- ✓ Flutter—a test to check whether your turntable's flutter is low, moderate, or high.
- ✓ Channel balance — two white-noise signals that allow you to match your system's stereo channels for level and tonal characteristics.
- ✓ Separation—an ingenious means of checking the stereo separation at seven different parts of the musical spectrum—from mid-bass to high treble.

ALSO: ✓ Stereo Spread
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PLUS SUPER FIDELITY MUSIC!

The non-test side of this record consists of music recorded directly on the master disc, without going through the usual tape process. It's a superb demonstration of flawless recording technique. A demonstration that will amaze and entertain you and your friends.

UNIQUE FEATURES OF HiFi/STEREO REVIEW'S MODEL 211 STEREO TEST RECORD

- Warble tones to minimize the distorting effects of room acoustics when making frequency-response checks.

Warble tones used are recorded to the same level within ± 1 db from 40 to 20,000 cps, and within ± 3 db to 20 cps. For the first time you can measure the frequency response of a system without an anechoic chamber. The frequency limits of each warble are within 5% accuracy.

- White-noise signals to allow the stereo channels to be matched in level and in tonal characteristics.
- Four specially designed tests to check distortion in stereo cartridges.
- Open-air recording of moving snare drums to minimize reverberation when checking stereo spread.

All Tests Can Be Made By Ear

HiFi/STEREO REVIEW's Model 211 Stereo Test Record will give you immediate answers to all of the questions you have about your stereo system. It's the most complete test record of its kind—contains the widest range of check-points ever included on one test disc! And you need no expensive test equipment. All checks can be made by ear!

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

DON'T MISS OUT—ORDER NOW

The Model 211 Stereo Test Record is a disc that has set the new standard for stereo test recording. There is an overwhelming demand for this record and orders will be filled by ELECTRONICS WORLD on a first come, first served basis. At the low price of $4.98, this is a value you won't want to miss. Make sure you fill in and mail the coupon together with your check ($4.98 per record) today.

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1. Date of filing: October 1, 1964. 2. Title of publication: Electronics World. 3. Frequency of issue: monthly. 4. Location of known office of publication: 434 South Wabash Avenue, Chicago, Illinois, 60605, Cook County. 5. Location of the headquarters or general business offices of the publishers: 1 Park Avenue, New York, New York 10016.

6. Names and addresses of publisher, editor, and managing editor: Publisher, Phillip T. Heffernan, 1 Park Avenue, New York, New York 10016: Editor, William A. Stocklin, 1 Park Avenue, New York, New York 10016; Managing editor, None.

7. Owner: Ziff-Davis Publishing Company, 1 Park Avenue, New York, New York 10016; Amelia Ziff 1 Park Avenue, New York, New York 10016; David Ziff, 1 Park Avenue, New York, New York 10016; William Ziff, 1 Park Avenue, New York, New York 10016; Priscilla Stafford, 1 Park Avenue, New York, New York 10016.

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9. Paragraphs 7 and 8 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. Names and addresses of individuals who are stockholders of a corporation which itself is a stockholder or holder of bonds, mortgages or other securities of the publishing corporation have been included in paragraphs 7 and 8 when the interests of such individuals are equivalent to 1 percent or more of the total amount of the stock or securities of the publishing corporation.

10. This item must be completed for all publications except those which do not carry advertising other than the publisher's own and which are named in sections 132.231, 132.232, and 132.233, Postal Manual (Sections 4355a, 4355b, and 4356 of Title 39, United States Code)

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A. Total no. copies printed (net press run)	264,334	262,690
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1. To term subscribers by mail, carrier delivery or by other means.	138,753	138,000
2. Sales through agents, news dealers, or otherwise.	57,588	52,100
C. Free distribution (including samples) by mail, carrier delivery, or by other means.	4,591	4,327
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MAGNETIC TAPE RECORDERS

43 Ampex Corporation has compiled its 1964-65 price list of professional magnetic tape recorders. The 12-page catalogue gives complete specifications on the full professional audio-equipment line and was put together by the company as an aid to government procurement agencies.

Included are audio recorders/reproducers, tape duplicators, and instrumentation recorders.

TIMING RELAYS

44 Cutler-Hammer Inc. has issued an 8-page illustrated booklet covering the company's line of industrial-rated timing relays. Featured are pneumatic, synchronous, and electronic timers. Methods of operation, operating specifications, design features, and options are detailed.

Other factors discussed include timing ranges, accuracy factors, circuit functions, and reset time.

TORQUE MOTORS

45 Inland Motor Corporation, a subsidiary of Kollmorgen Corporation, is offering a 2-color, 42-page booklet describing the fundamentals and installation of d.c. direct-drive torque motors and listing the company's line.

Liberally illustrated, the brochure contains electrical and physical data for d.c. torque motors with ratings from 6.6 oz.-in. to 3000 lbs.-ft.

ELECTROMANOMETER

46 Consolidated Electrodynamics Corp., a subsidiary of Bell & Howell Co., has released a 12-page illustrated bulletin describing the firm's "Universal Electromanometer."

The booklet includes complete specifications on the instrument, and its applications as a portable, low-pressure calibration system and as a multi-channel data-collection system are fully explained.

LOUDSPEAKER CATALOGUE

47 Jensen Manufacturing Company, a division of The Muter Company, has published a new 24-page, 2-color catalogue which gives complete acoustical and dimensional specifications and prices for the firm's line of stereo and monaural hi-fi loudspeakers, headphones, speaker components, and speaker system kits.

IMPEDANCE BRIDGE

48 General Radio Company is offering a 4-page illustrated leaflet explaining the features, specifications, and applications of its Model 1650-A "Orthonull®" impedance bridge.

SPECTRUM ANALYZER

49 Hewlett-Packard Company's "Journal" (Vol. 15, No. 12) is devoted to a description of the firm's Model 8551A/851A microwave spectrum analyzer. The illustrated 8-page booklet contains complete specifications on the unit, as well as detailed sections on its frequency range, resolution, sweep-tuned phase lock, and signal identifier.

POTENTIOMETERS

50 Computer Instruments Corporation is now making available a 20-page catalogue featuring the firm's line of rotary precision-film potentiometers. Complete electrical and mechanical specifications are provided, as well as diagrams and photographs.

Also included are sections on special mechanical configurations and special electrical characteristics.

MEMORY CORES

51 Computer Test Corporation has issued a new 26-page technical booklet on automatic memory core and plane and stack testers. The publication explains the principles of core testing and plane and stack testing, and also describes the operation of a completely instrumented system for high-speed testing of both individual ferrite cores and core planes and stacks.

Photographs, block diagrams, waveforms, and circuit diagrams are included, along with complete specifications on the individual functional modules and on each test system.

POWER SUPPLIES

52 Trio Laboratories, Inc. has announced publication of a 2-page technical bulletin (Application Bulletin SRZD-102) covering circuits that use zener diodes in series-regulated power supplies.

Typical circuit values are provided, as well as actual test results of line and load regulation.

HEAT DISSIPATORS

53 IERC Division has issued a revised short-form catalogue containing the company's line of semiconductor heat dissipators and heat-dissipating tube shields.

The 8-page reference booklet covers more than 200 separate products and product variations and describes them in brief.

TAPE CARTRIDGE CATALOGUE

54 Orrtronics, Inc. has released a 32-page catalogue which describes 349 cartridges for use with the company's "AutoMate" tape player. Offerings from 20 music firms are included, and a cross index is supplied which lists tapes by artist's name, type of music, and solo instrument.

CIRCULAR SLIDE RULE

General Industrial Co., 1788J Montrose Avenue, Chicago, Illinois 60613, is now offering a pocket-sized circular slide rule for engineers and for other plant and office executives.

The device performs simple calculations, and complete instructions are included with each slide rule, which is available free if requested on business letterhead or for 50¢ otherwise. ▲

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Answer to Electronics Crosswords

(Appearing on page 63)

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FOR SALE

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

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

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

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

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

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

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

COMPLETE KNIFE catalog 25¢. Hunting, Pocket, Utility. Heartstone, Dept. ZD, Seneca Falls, New York.

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

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

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

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

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

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

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

CAPACITORS Clorinol 40 MFD 330 AC $5.95 Filament transformers Stancer 117/107 volts 60 cycles Secondary 6.3 volts CT @ 6.0 amps $3.95 all new postpaid. Goodman, 5826 South Western, Chicago, Ill. 60636.

NOW ! ! ! LOW COST AC POWER IN YOUR CAR ! !
12 V DC to 115 V AC TRANSISTORIZED (50 W)

POWER SUPPLY KIT

$9.95

w/step by step instructions, schematic, etc. has many uses, easy to wire. Approx. size of alum. box 3x3x5" (Factory wired; complete ready to use—$16.95 ea.)

(Not rec. for phono)

SCRs

	SILICON CONT. RECT.		COMPANION RECTIFIERS		
	TESTED				
PRV	7 Amp	25 Amp	¾ Amp	1½ Amp	2 Amp
70	.90	1.90	.20	.30	—
140	1.30	2.25	.25	.35	.40
200	1.50	2.40	.30	.40	.45
250	1.90	2.60	—	—	—
300	2.15	2.85	—	.45	.50
350	2.40	3.10	—	—	—
400	2.75	—	.45	.50	.55
450	3.10	—	—	—	—
500	—	—	.55	.60	.65
600	3.85	—	.60	.65	.72
700	—	—	.70	.75	.85
800	—	—	.77	.85	.95
900	—	—	.85	1.00	1.10
1000	—	—	.95	1.20	1.25

GLASS SILICON DIODES 200 MA

PRV	20 Pcs	100 Pcs
50	1.25	5.00
100	1.60	6.50
150	2.00	8.00
200	2.50	10.00

1½" Sq
0-1MA . . . . $2.95 ea.
0-2MA . . . . $2.95 ea.
0-100 MV . . . $2.95 ea.
0-500 MMA . . . $2.95 ea.
0-100 MMA . . . $3.95 ea.

4"
AC Volts 0-2; 3; 5; 10; 25; or 50 . . . $2.75 ea.
DC-MA 0-250, 100 . . . . $4.95 ea.
200, 300 or 500 $4.95 ea.

3"
0-30 VDC . . . . $5.25 ea.
0-5 MA DC . . . . $3.95 ea.

2" Rd
0-200 VAC . . . . $4.49 ea.
"S" meter 0-9 $3.75 ea.
0-200 MA DC . . $4.25 ea.
0-200 MMA . . . $4.95 ea.
0-100 MMA . . . $5.25 ea.
0-1 MA (Arbitrary Scale) . . . . . $3.95 ea.
0-1MA . . . . $4.25 ea.

3"
0-150 VAC 3" Rd. . . . . $4.95 ea.
0-1 MA (Arbitrary Scale) . . . . . $3.95 ea.
0-150 VDC Weston (dual scale) . $4.95 ea.
0-150 VDC . . . . $4.75 ea.
0-20 MA DC . . . $3.95 ea.
0-5A AC (marked 0-150) . . . . . $3.75 ea.
0-75 VDC . . . . . $3.95 ea.

Spectrum Analyzer Vectron SA-20 w/s Band Plug-In Model #20-S $195.00
SCR 70PRV-7 Amps. tested $75/100
Germanium Diodes . . . . Computer type—$8./100
Capacitor Rd. Aerovox 8MF 330 VAC boxed w/ bracket, new type . . . . $1.29 ea.
Transformer 110V PRI 1100 VCT—400 MA 3.95
Tsfmr. 115V PRI 10V sec. 80 Amps . . . . . $19.85 ea.

All Shipments FOB NYC

ADVANCE ELECTRONICS
79 Cortlandt St., New York 7, N.Y. RE 2-0270

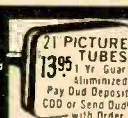
CIRCLE NO. 152 ON READER SERVICE PAGE

TUBES

33¢ PER TUBE

100 TUBES OR MORE: 30¢ PER TUBE

One Year Guaranteed
Mutual Conductance Lab-tested Individually Boxed, Branded and Code Dated
Tubes are new, or used and so marked.



0Z4	6AT6	6CD6	6EM5	6SC7	6V6	12BH7
1B3	6AT8	6CF6	6F6	6SH7	6W4	12BL6
1H5	6AU4	6CG7	6H6	6SJ7	6W6	12BY7
1J3	6AU5	6CG8	6J5	6SK7	6X4	12C5
1L4	6AU6	6CM7	6J6	6SL7	6X5	12CA5
1T4	6AV6				7A7	12SN7
1U4	6AW8				7A8	12SQ7
1X2	6AX4				7B6	25L6
3CB6	6BA6				7B7	25Z6
5U4	6BC5				7B8	35W4
5V4	6BD6				7C5	35Z3
5Y3	6BG6				7N7	35Z5
6A6	6BH6				7Y4	50L6
6A8	6BJ6				12AD6	24
6AB4	6BL7				12AE6	27
6AC7	6BN4				12AF6	41
6AG5	6BN6				12AT7	45
6AK5	6BQ6	6CZ5	6K6	6SN7	12AU7	47
6AL5	6BZ6	6D6	6K7	6SQ7	12AX7	75
6AN8	6C4	6DA4	6Q7	6SR7	12BA6	77
6AQ5	6C6	6DE6	6S4	6U7	12BD6	78
6AS5	6CB6	6DQ6	6SA7	6U8	12BE6	84
					12BF6	

If Not Shipped in 24 hrs. YOUR ORDER FREE!

Other tubes and CRT's at low prices—send for free list

NO SUBSTITUTIONS WITHOUT YOUR PERMISSION

TUBE CARTONS

TUBE CARTONS
HIGH GLOSS
CLAY COATED
RED & BLACK WITH BUILT IN DIAGONAL PARTITIONS

SIZE	FOR TUBE SIZE	PRICE PER 10 CARTONS
MIN	6AU6	29c
GT	6SN7	39c
LG GT	5U4GB	59c
G	5U4G	89c

Finest **ELECTRONIC CLEANER**

all purpose ELECTRONIC CLEANER **79¢** plus 20c shipping

- Contains amazing new TOLUOL cleaner
- Instantly cleans without leaving residue
- Silicone added for Lubrication
- Removes and inhibits RUST
- No unpleasant smell
- Unconditionally guaranteed
- Restores original life to all controls and contacts
- Nozzle adapter for hard to reach places with each can

DIODES/RECTIFIERS

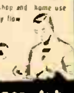
39¢ per pack plus 5c shipping — sensational **KIT VALUE!**

These diodes have all been checked for Go No go and the original cost ranged from $1.00 to $11.00 each. These are brand new diodes and were manufactured by International Rectifier Corp.

Electronic **SOLDER**

- Handy plastic container convenient for shop and home use
- Thickness ideal for fast melting and easy flow
- Custom formulated for electronic work
- Quality guaranteed by Cornell

29¢



Special! With every $10 Order **25¢ per tube** (No Limit) from this list.

6AG5		6SN7
6AU6	6J6	6V6
6AQ5	6K6	6W4

Console Self Service Tube Tester **$34.95**

Prestige & Success are yours as an ***ELECTRONIC EXPERT!***

FOR CORNELL CUSTOMERS ONLY by special arrangement with the publisher, these amazing bargains are available

COMPLETE RADIO SERVICING AND BASIC ELECTRONICS COURSE ONLY $3.00
($2.50 + .50 packaging charge)
Practical home study course will teach you how to repair all radio sets faster and better. These 21 lessons cover all topics just like correspondence courses costing hundreds of dollars. To CORNELL customers this complete course is priced at only $2.50, nothing else to pay. Use this training to get ahead in radio and as your introduction to TV work.

NEW PRACTICAL TV TRAINING COURSE ONLY $3.50
($3.00 + .50 packaging charge)
Easy to follow well illustrated 14 lessons on circuits, picture faults, adjustments, short cuts, UHF alignment, antenna problems, trouble shooting, service hints, how to use test equipment, etc. Large in size and scope, just like correspondence courses selling for over $200 and specially priced to CORNELL customers at only $3.00 nothing else to pay. With this new course, you will find yourself doing TV repairs in minutes—instantly finding faults.

TERMS: Add 3c per tube shipping. Orders under $5.00 add 3c per tube shipping plus 50c handling. Canadian orders add approximate postage. Send 25% deposit on C.O.D. orders. No C.O.D. orders under $5.00 or to Canada. No 24 hr. free offer on personal check orders
5-DAY MONEY BACK OFFER!

CORNELL ELECTRONICS CO.
Dept. EW 1 4217 University Ave., San Diego, Calif. 92105

CIRCLE NO. 172 ON READER SERVICE PAGE

"TAB", SILICON 750MA* DIODES

Factory Tested: Gtd.!

*NEWEST TYPE! LOW LEAKAGE

Piv/Rms 50/35 .05	Piv/Rms 100/70 .09	Piv/Rms 200/140 .12	Piv/Rms 300/210 .14
Piv/Rms 400/280 .15	Piv/Rms 500/350 .19	Piv/Rms 600/420 .23	Piv/Rms 700/490 .27
Piv/Rms 800/560 .35	Piv/Rms 900/630 .45	Piv/Rms 1000/700 .65	Piv/Rms 1100/770 Query

ALL TESTS AC & DC & FWD & LOAD!

1700Piv/1200Rms @ 750Ma$1.20 @ .10for$10
same 1100Piv/770Rms 75¢ @ . 16 for $11

"TAB" ★ SCR's ★ TRANSISTORS ★ DIODES!!!

Full Leads Factory Tested & Gtd! U.S.A. Mfg.

PNP/HiPower/15Amp Round TO36 Pckg!
2N441, 442, 277, 278, D5501 up to 50volts VCBO $1.25 @ . 5 for $5
TN278, 443, 174 up to 80v @ 2 for $5
PNP Diamond/3A-2N155, 156, 235, 242 254, 255, 256, 257, 301, 351 ¢35 @ , 4/$1
PNP/Signal up to 350Mw TO5 ¢25 @ , 6 for $1
NPN/Signal IF, RF, OSC, TO5, OV5, ¢25 @ , 6 for $1
PNP 2N670 300 Mw ¢35 @ , 4 for $1
PNP 2N671 1watt ¢50 @ , 3 for $1
Silicon PNP TO5 & TO18 Pckg ¢25 @ , 5 for $1
Power Heat Sink Finned 100Sq $1 @ , 6 for $5
STABISTOR Diodes Fwd Regulators . . . 1watt 5 for $1
Zener Diodes up to One Watt 6to200v ¢70 @ , 3 for $2
Zener Diodes Ten Watt 6to150v $1.45 @ . . . . 4 for $5
Zener Diodes 1watt/5% Tolerance $1.25 @ , 3 for $3
Zener Diodes 10Watt/5% Tolerance $2 @ , 3 for $5
TO36 or TO3 or TO10 Mica Mtg Kit Pckg ¢30 @ , 4 for $1

Sil Pressfit 18A up to 100 Piv . . . . . . 4 for $1
Micro or MuSwitch CSD 35 Amp/AC-DC . 3 for $1

SILICON POWER DIODES STUDS & P.F.**

D.C. Amps	50 Piv 35 Rms	100 Piv 70 Rms	150 Piv 105 Rms	200 Piv 140 Rms
3	.08	.14	.17	.24
12	.30	.55	.70	.85
18**	.20	.30	.50	.75
35	.70	2.05	1.35	1.50
100	1.65	1.00	2.50	3.15
240	3.75	4.75	5.75	8.75
D.C. Amps	**300 Piv 210 Rms**	**400 Piv 280 Rms**	**500 Piv 350 Rms**	**600 Piv 420 Rms**
3	.29	.30	.40	.48
12	1.00	1.35	1.45	1.70
18**	1.00	1.50	Query	Query
35	2.15	2.45	2.75	3.33
100	3.75	4.60	5.50	8.00
240	11.70	19.80	27.90	Query

N1038 6/$1, TO39 4/$1, 1040 /$1, 1041 $1
TN1046 $1.40 @ , 3 for $4! 2N1907 $1.75 @ . . . . 4 for $6
ZENER AUTO IGNITION 50to60v/10watt $1
2N538, 539, 540, 3A/TO10/Small Pckg ¢50 @ . . . . 3 for $1

"SCR" SILICON CONTROLLED RECTIFIERS!

PRV	7A	16A	25A	PRV	7A	16A	25A
25	.30	.50	.85	250	1.85	2.25	2.60
50	.50	.75	1.00	300	2.00	2.45	2.80
100	.90	1.35	1.60	400	2.50	2.90	3.35
150	1.00	1.65	2.00	500	3.25	3.60	4.00
200	1.30	1.90	2.30	600	3.50	4.35	4.60

Silicon Diodes 3&6 Amp Studs Untested 12 for $1
Glass Diodes 1N34/48/60/64 Untested 20 for $1

"TAB"

TERMS: Money Back Guarantee! Our 18th year. $2 Min. order F.O.B. N.Y.C. Add shpg charges or for C.O.D. 25% Dep. Prices shown subject to change.

111-WJ Liberty St., N. Y. 6, N. Y.

SEND 25¢ Phone: REctor 2-6245 *for CATALOG*

CIRCLE NO. 225 ON READER SERVICE PAGE

GET IT from GOODHEART!

BERKELEY COUNTER #5571/5580/5581 set-up, 0-155 mc & 392-455 mc. **995.00**
BERKELEY COUNTER #550, 0-100,000 cy. . . 225.00

ALL-BAND SSB RCVR BARGAIN: Hallicrafters R-45/ARR-7, 550 kc to 43 mc continuous: Voice, CW, MCW: 2 RF's, 2 IF's: S-meter: 455 kc Xtl: 6 select choices. Pwr required 270 v 110 ma dc. 6.3 v 4 A ac. Less pwr sply, w/Handbook, other data, checked, aligned, clean. 100% grtd. fob Los Ang. **149.50**
Same w/60 cy pwr sply, ready to use. 179.50
(Add $20 for SSB Product Detector installed.)

TIME PAY PLAN: Any purchase totaling $100.00 or more, down payment only . . . **10%**

ARC-5 Q-5'er Rcvr 190-550 kc w/85 kc IF's Use as 2nd converter for above or other rcvrs (electrically, w/lots of tech. data, w/spline knob. 9 lbs fob Los Ang. **14.95**
(Add $3 for extra-clean selected unit.)

AN/APR-4 RECEIVING SET: Tune 38 to 1000 mc. Includes TN-16, 17, 18/APR-4: plug: handbook: checked, grtd OK, fob Los Angeles . . **179.50**
Add $60 for TN-19, 975-2200 mc; add $125 for TN-54, 2175-4000 mc; add $30 for AM/FM version of the rcvr, w/60 cy pwr sply; add $125 for RDP Panadapter w/5" CR, 30 mc ±5 mc.

LM FREQ. METER 125 kc to 20 mc is combin. heter. freq. meter & signal source. CW or AM, accuracy .01%. xtl calib. Clean, checked, 100% grtd, w/plug, data. 16 lbs fob LA **57.50**
Add $22 for LM sply w/plugs, data, or $10 for EAO. converts for LM w/parts, data, included.

TS-323/UR, 20-400 mc, similar GERTSCH FM-1. Crystal, 001%. W/handbook supplement giving supplementary xtl check points & instruct. to ". . . . closely approach crystal accuracy." W/schematic, instruct., pwr sply data, clean, checked, 100% grtd. fob Los Ang. **199.50**

TEKTRONIX SCOPES grtd OK & gorgeous, w/books:
#514A: DC to 10 mc; sensit. 30 mv/cm; sweep calib. uv/cm: calib. deflection. . . **350.00**
#514AD is same plus Video Delay Line. . . . 395.00
#513: HV accel. for pulses, 20 mc pass. . 450.00
#512 5" scope adds very slow sweeps. . . . 325.00
#524D TV-Station & General Purpose 550.00

HEWLETT-PACKARD GOODIES grtd OK & w/books:
#100D Secondary Low Freq. Standard. . . . 295.00
#202A Low-Freq. Function Generator. 295.00
#410A all-purpose VTVM up to 700 mc. . . . 150.00
#400D ac vtvm plus Ind. Contr. #200A dc: ac converter enables ac & dc VTVM used down to as low as 1 mv full scale. As pair 265.00
#650A Oscil. 10 cy to 10 mc. 295.00

For L&N Galvanometers, other Bridges, Voltage Dividers and Gertsch RatioTrans, see Sept. ad. For LINE VOLTAGE REGULATORS, see Oct. ad. OR WRITE FOR DATA! We have the widest assortment of DESIRABLE material of this nature in the U.S.A.

R. E. GOODHEART CO. INC.
Box 1220-A, Beverly Hills, Calif. 90213
Phones: Area 213, office 272-5707, messages 275-5342

CIRCLE NO. 243 ON READER SERVICE PAGE

FLIP-FLOPS: Transistorized circuit mounted on a printed circuit board with plug-in connector. Operation up to 10.000 cps in set-reset or trigger mode. Can be used in counters, shift registers, and memories with no additional circuitry. $3.87 complete. Send for free literature. KOMTRON, Box 275, Little Falls, N.J. 07424.

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

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

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

DETECTIVES! Free brochures! Electronic intelligence devices for your needs and budget. SILMAR ELECTRONICS. 3476 N.W. 7th Street, Miami, Fla. 33125.

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

16 TESTED Transistor plans—25¢. "Radio Operator's Handbook"—50¢. Catalog. Laboratories, 1131-H Valota, Redwood City, Calif.

RESISTORS, NEWEST TYPE METAL-FILM, RESISTOR KITS, COPPER CIRCUIT BOARD, CAPACITORS, TERMINAL BLOCKS. FREE CATALOG. FARNSWORTH ELECTRONIC COMPONENTS, 88 Berkeley, Rochester 7, New York.

METERS—SURPLUS, new, used, panel and portable. Send for list. Hanchett, Box 1898, Riverside, Calif.

FREE catalog: Wholesale electronic parts and equipment. Western Components, Box 2581. El Cajon, Calif.

ATTENTION. Antique Edison Cylinder Phonographs. Released from storage. Complete, working, $80.00 each. Tracy Storage, 114 State, Brewer, Maine.

COAXIAL RF CABLE ⅞" Air Dielectric Low Loss. .5db.-144; .6db.-220; .9db.-440; 1.2db.-1200 MC. Per 100'. John Link, 542 Jupiter Rd. (I.R.C.), Titusville, Fla. AM 7-2372.

ORDER TRANSISTORS, PARTS OF ANY PROJECT IN EW. Send 25¢ for Interchangeability Guide listing 3000 transistors. Serviceman! New accounts will receive 10% off transistors and parts during January. 30 Watt stereo amp/preamp, kit form, $36.50. Brandwein Co., 306 W. 100 Street. N.Y.C.

TUBES

TUBES—TV, Radio Transmitting And Industrial Types At Sensibly Low Prices. New, Guaranteed, 1st Quality. Top Name Brands Only. Write For Free Catalog or Call WAlker 5-7000, Barry Electronics, 512 Broadway, New York N.Y. 10012.

RADIO & TV Tubes—33¢ each. Send for free list. Cornell, 4215-W University, San Diego, Calif. 92105.

BEFORE you buy receiving tubes, test equipment, Hi-fi components, kits, parts, etc. . . . send for your giant free Zalytron current catalog, featuring Standard brand tubes; RCA, GE, etc.—all brand new premium quality individually boxed. One year guarantee—all at biggest discounts in America! We serve professional servicemen, hobbyists, experimenters, engineers, technicians. Why pay more? Zalytron Tube Corp., 469-W Jericho Turnpike, Mineola, N. Y.

7" TV test tube—$6.99. Tubes—6146—$2.95; 6211 (12AU7 equiv.) 39¢, 3 for $1.00. Germanium diodes, tested, equiv. 1N34, 1N60 etc., 30 for $1.00. Tophat silicon rectifiers, 750 MA—1000 piv 75¢. Transistors, tubes, resistors, condensers etc., bargain priced. Free catalog. Arcturus Electronics, Dept. ZD, 502-22nd St., Union City, N.J. 07087.

DO-IT-YOURSELF

PROFESSIONAL ELECTRONIC PROJECTS—$1.00 up. Catalog Free. PARKS, Box 1665, Seattle, Washington 98125.

DETECTIVES

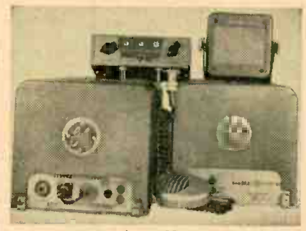
DETECTIVE Opportunities. Experience unnecessary. Write, Wagzner, 125 W. 86th, New York 10024.

HYPNOTISM

FREE Hypnotism, Self-Hypnosis, Sleep Learning Catalog! Drawer H400, Ruidoso, New Mexico 88345.

GREGORY ELECTRONICS RECONDITIONED FM 2-WAY RADIO SAVINGS

THIS IS A PARTIAL LIST—
WRITE FOR NEW FALL '64
E-X-P-A-N-D-E-D CATALOG



30-50mc MOBILES

GE 2-Piece Unit—6 volt or 12 volt
4ER6—4ET5 30w 30-40mc 40-50mc . . . $ 88
4ER6—4ET6 60w 30-40mc 40-50mc . . . $108
Complete with all accessories except antenna and crystals.
Equipment can be crystalled and tuned to any frequency in the 30-50mc band.

GE 2-Piece Unit—6 volt or 12 volt
4ER6—4ET5 30w 30-50mc $168
4ER6—4ET6 60w 30-50mc $188
Complete with all accessories including antenna and crystals. Fully narrow banded (Tx & Rx) and tuned to your frequency with in the 30-50mc range.

148-172mc RCA CMC 60B

6/12v dual dynamotor 60 watt (a) Fully narrow banded complete with all accessories, less crystals & antenna **$198**
(same unit without accessories $178.00)
(b) Same unit tuned to your frequency including brand new antenna **$233**

Extra Special Purchase

Reconditioned General Electric

Voice Commander

Personal FM Transmitter-Receiver
132 to 172 MC, 1 W
9.5"x5.3"x1.7"

The General Electric VOICE COMMANDER I Personal Transmitter-Receiver is a high performance, completely self-contained two-way FM Radio. Extremely compact and lightweight, the VOICE COMMANDER is simple to operate and easily hand carried.

Except for the final stages of the transmitter, the VOICE COMMANDER is completely transistorized.

PRICE, including Brand New rechargeable Nickel-Cadmium Battery Pack

$178

If crystals and tuning is desired, add $40.00.

We also have the proper chargers for these units, GE Model #4EP27A10, Price: $18.

If additional nickel cadmium Battery Packs are required, they are available at a price of $25.00 each.

We Buy Late Model Equipment for Cash —Write; Wire or Phone!

GREGORY ELECTRONICS CORPORATION
249 Rt. 46 • Phone 773-7550
Saddle Brook, N.J. • Area Code 201

CIRCLE NO. 185 ON READER SERVICE PAGE

The NEW 'POP' RiveTool with Interchangeable Heads for "INSTANT" RIVETING

- NO ANVIL OR HAMMERING
- NO SPECIAL SKILL REQUIRED
- A STRONG, NEAT FASTENING EVERY TIME

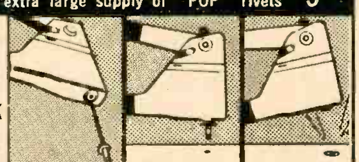
Cadmium Plated Steel Rivets replace screws, bolts, soldering, etc. in repairs or workshop projects. Use on appliances, TV antennas, gutters and downspouts, toys, bicycles, ductwork, chassis-virtually anything from hardwoods to plastic, leather, metals, etc.

ONLY $5.95

COMPLETE KIT WITH "POP" RIVETS

DELUXE GIFT KIT in metal box with extra large supply of "POP" rivets $9.95

HOW THEY WORK



1. Insert rivet in tool.
2. Place rivet in hole of materials to be fastened.
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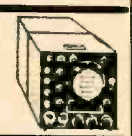

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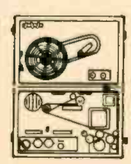

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CIRCLE NO. 183 ON READER SERVICE PAGE

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500	20¢	*Top hat only		200	25¢	All tests	

Full Leads. Tested. Guaranteed. American made.

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50	.60	.90	1.10	300	2.30	2.70	3.10
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12	.45	.65	.75	.90
35	.90	1.15	1.50	1.70
50	1.60	1.90	2.30	2.80
100	1.75	2.15	2.55	3.15

D.C. AMPS	300 PIV 210 RMS	400 PIV 280 RMS	500 PIV 350 RMS	600 PIV 450 RMS
3	.40	.45	.55	.65
12	1.10	1.35	1.50	1.70
35	2.35	2.55	3.00	3.50
50	3.50	4.20	5.25	7.00
100	3.75	4.60	5.65	8.00

"SCR" SILICON CONTROLLED RECTIFIERS "SCR"

PRV	7 AMP	16 AMP	25 AMP	PRV	7 AMP	16 AMP	25 AMP
25	.50	.85	1.20	250	2.30	2.65	3.10
50	.85	1.20	1.40	300	2.60	3.00	3.40
100	1.35	1.80	2.20	400	3.00	3.40	4.15
150	1.60	2.10	2.65	500	3.75	4.25	4.75
200	1.75	2.40	2.90	600	4.00	5.00	5.25

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CIRCLE NO. 167 ON READER SERVICE PAGE

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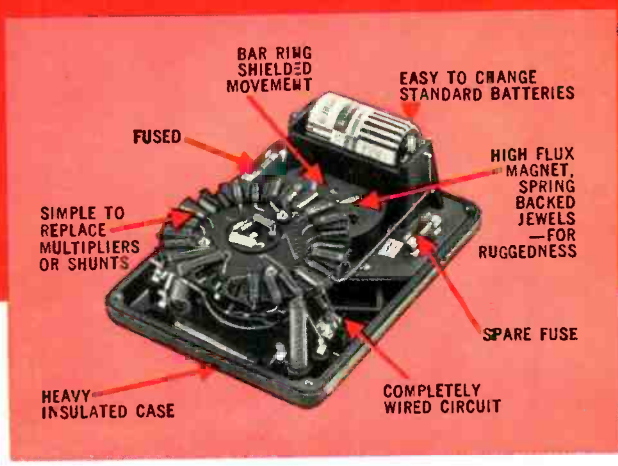

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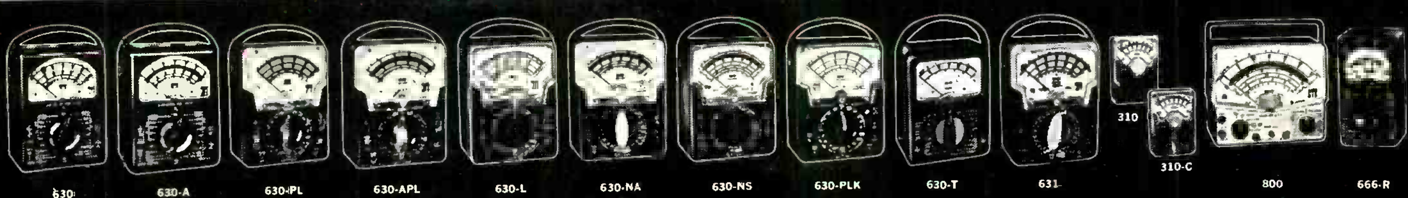

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