Electronics World

DECEMBER, 1963
50 CENTS

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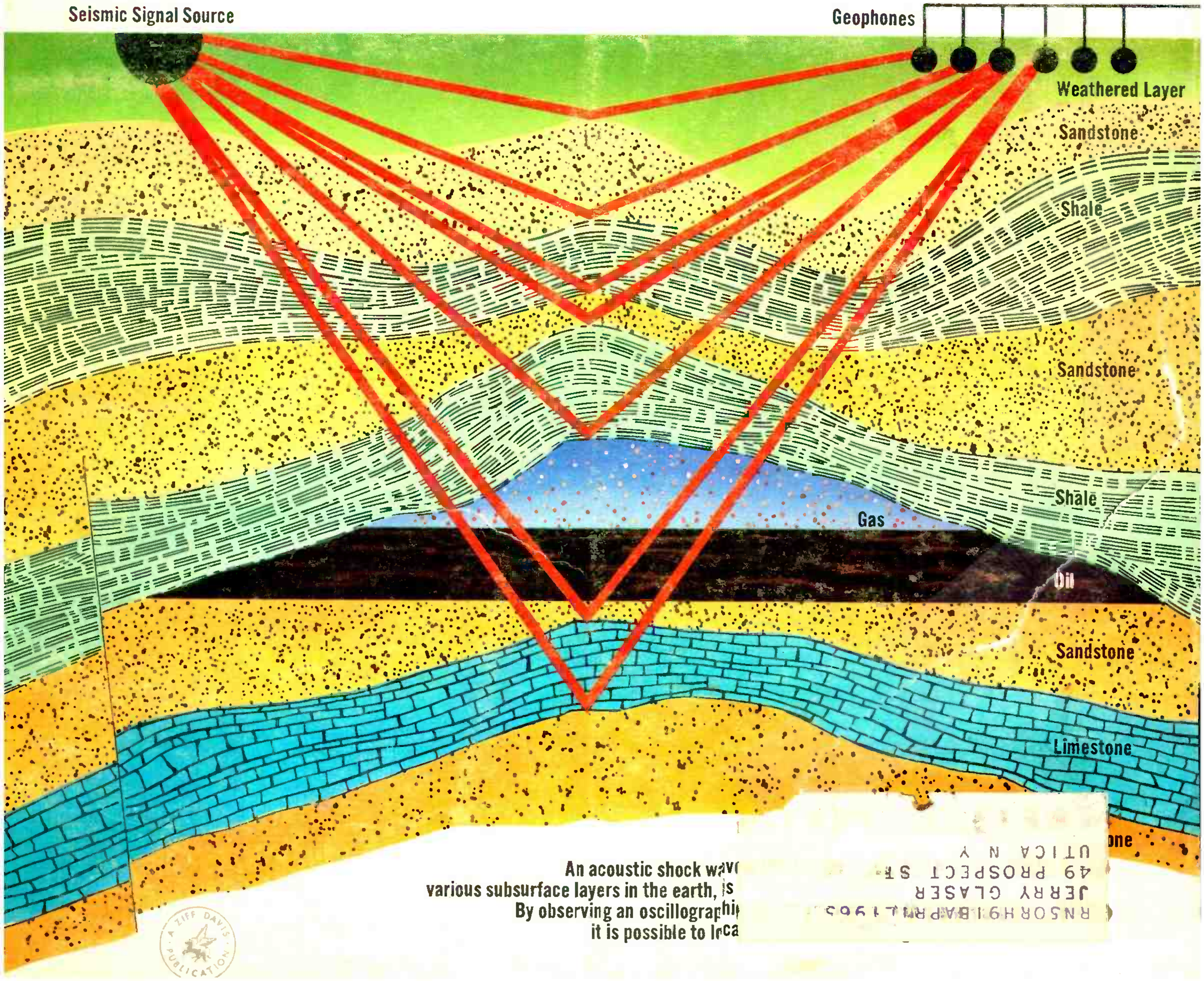

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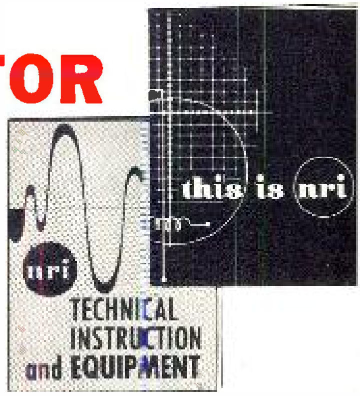

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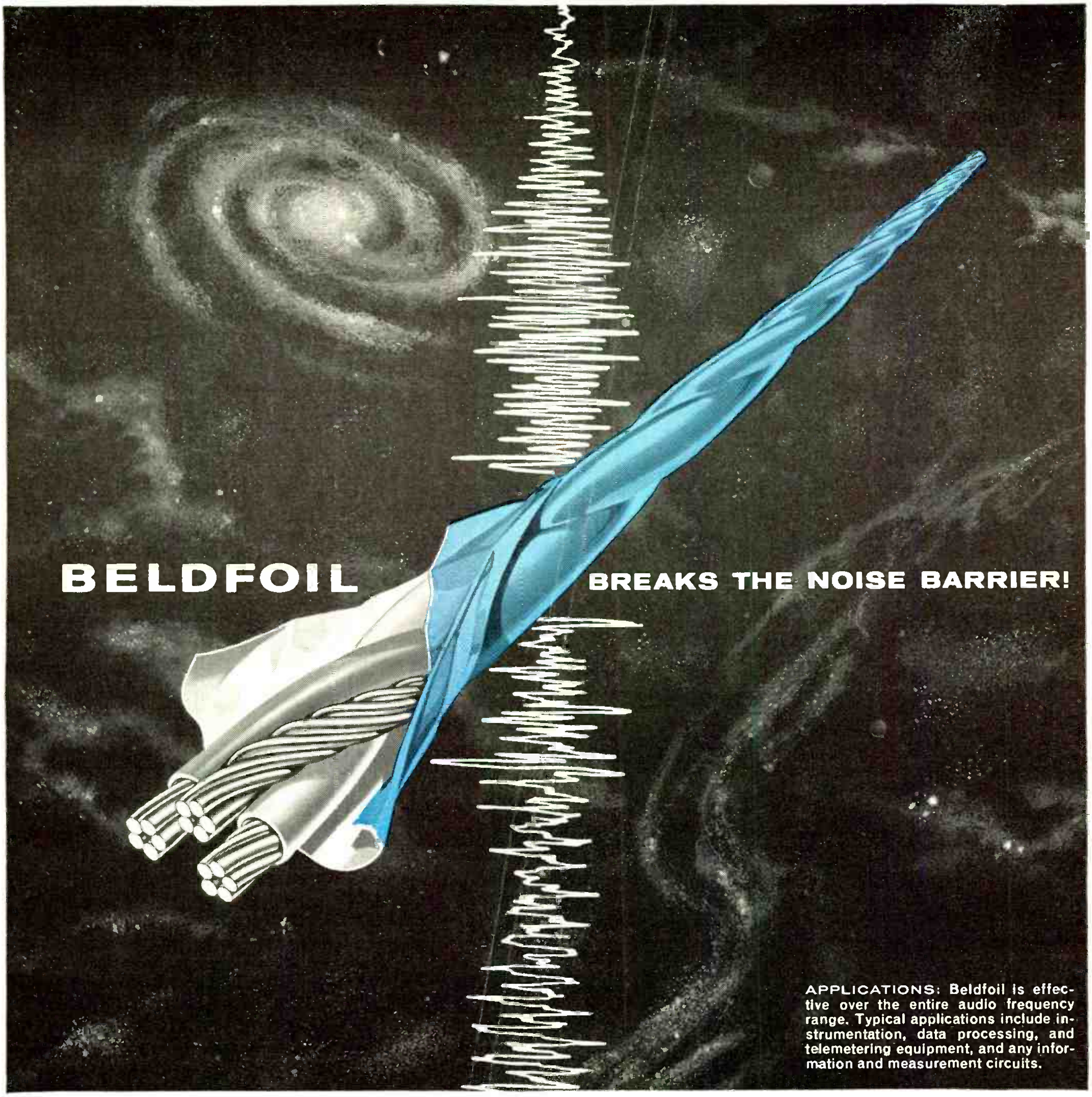

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Electronics World

DECEMBER 1963
VOL. 70 NO. 6

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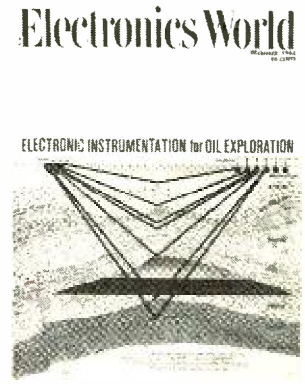
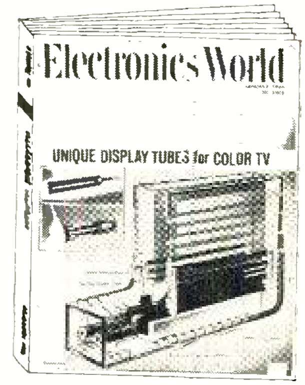
MONTHLY FEATURES



OUR COVER illustrates the subsurface layers in a cross-section of earth that is typical of the structure found with an oil deposit. Note how the oil is trapped in the anticline structure, which is an upfold, bend or arch in the rock strata. Acoustic shock waves are reflected from the various subsurfaces, are picked up by a number of microphone-like transducers (geophones), and their signals are passed through electronic circuits to a recording oscillograph or special tape recorder. For details on this important technique for finding oil, see our lead story (p. 27)......(Illustration by Otto E. Markevics.)

COMING NEXT MONTH



AUTOMATIC ELECTRONIC TESTING
Current giant electronic installations are simply too sophisticated for human checking and troubleshooting. For this reason, other electronic systems are being used to locate troubles even before they occur. Ken Gilmore describes the various systems and equipment being used for this purpose.

UNIQUE DISPLAY TUBES FOR COLOR-TV
While most present-day color-TV sets use a variation of the three-gun, shadow-mask CRT, there are many other approaches to color display tubes. This article surveys 11 of the new designs, ranging from a completely new optical projection device to a thin picture tube.

SOLID-STATE COLOR ORGAN
New methods of firing controlled rectifiers, recently available parts, and simplified filter circuits make possible this economical unit for both commercial and home use.

SPEAKERS FOR TRANSISTOR AMPLIFIERS
What characteristics are important in selecting a speaker system for use with a transistor hi-fi amplifier? What are the effects of changing impedance and improper impedance matching? What about motional feedback and integrated amplifier-speaker systems? Victor Brociner of H. H. Scott, Inc. answers these and other important questions for the prospective buyer of transistor hi-fi.

THE UNIJUNCTION TRANSISTOR
The operation and applications of a special type of semiconductor device employing a single p-n junction are covered by David L. Pippen of the White Sands Missile Range. Its use in timing and delay circuits, multivibrators, sawtooth and pulse generators, SCR firing circuits, and counters is discussed.

CB RANGE-FINDER NOMOGRAM
Gene Karlin of Hammarlund has devised a handy nomogram for determining the approximate useful range for various output powers and antenna heights in a Citizens Band installation.

NEW FACILITIES FOR WWVB & WWVL
The National Bureau of Standards has recently put into operation new facilities at its precision-frequency standard broadcast stations, WWVB and WWVL. Here are the frequencies and services being provided by these transmitters.

All these and many more interesting and informative articles will be yours in the JANUARY issue of ELECTRONICS WORLD . . . ***on sale Dec. 19th.***

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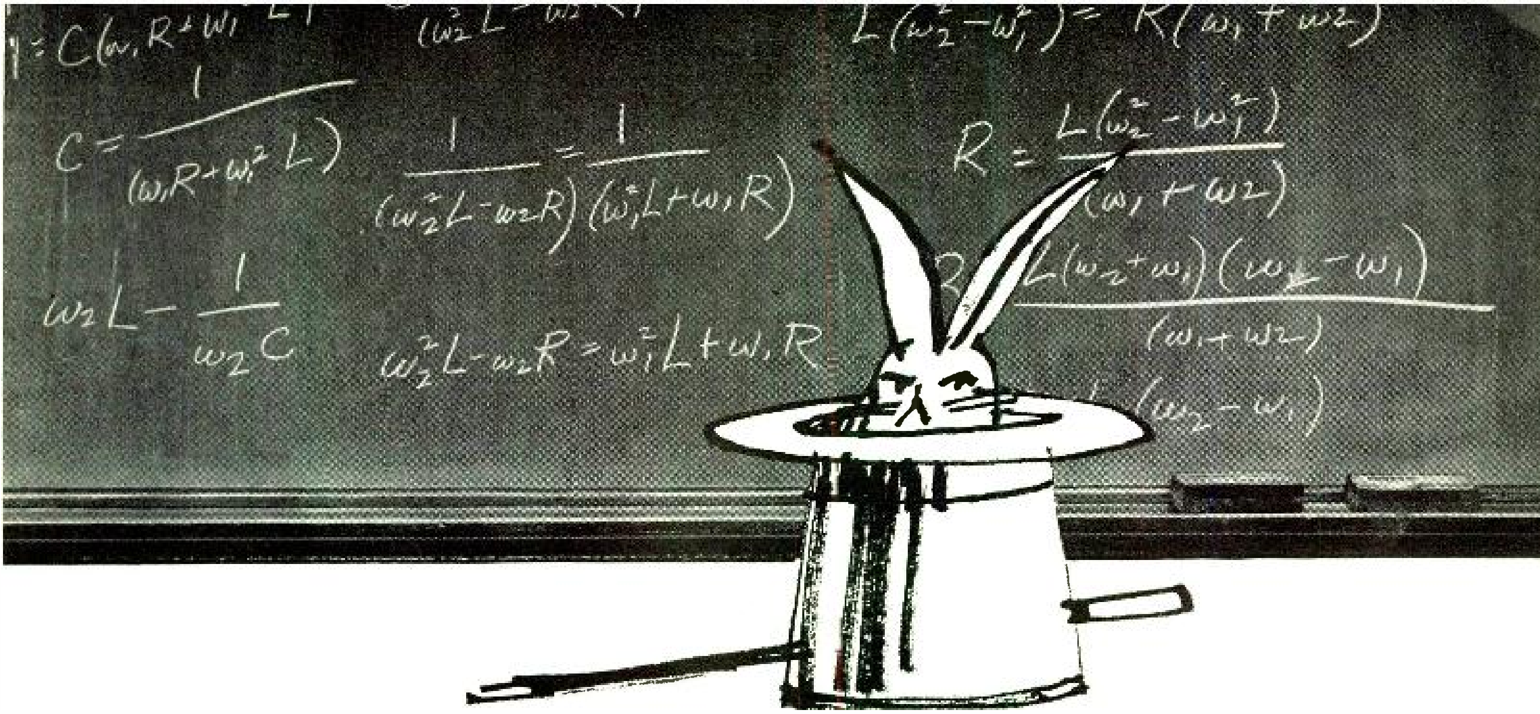

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For the record

WM. A. STOCKLIN, EDITOR

TIME FOR REAPPRAISALS

FOR years now, in fact ever since the advent of TV, the service industry has had many complaints. Probably we have been equally guilty in publicizing the various industry problems as they appeared: cut-rate TV-set sales, drug-store tube testers, parts dealers selling direct to consumers, poor set designs, captive service, etc. We could go on and on, but all of you know by now that conditions will not change materially and these problems will be with us forever.

Frank J. Moch, Executive Director, NATESA (National Alliance of TV and Electronic Service Associations), at a recent Inaugural Dinner, did more than just rehash all of the problems that plague our industry. We feel that his over-all analysis, his direct approach, and suggested solution are of such importance to the service industry that we would like to take this opportunity of quoting, in part, what he had to say.

"Ours is an industry of paradoxes. We cry among the midst of plenty and we seek help but refuse to avail ourselves of that given. We call ourselves little businessmen, yet we are part of a business that in the last year shared an almost 4-billion dollar parts and service fee market. Each year this grows and grows. At the same time the number of professional practitioners dwindles while the total number, including dabblers who operate without restraints, increases.

"We have been accused of business stupidity and, noting the lack of *Cadillacs* at association meetings, I must admit we aren't smart. . . .

"One thing sure, the service of home electronics *is* a massive and lucrative business, but only for progressive, intelligent businessmen. This year's figures reveal Mr. & Mrs. American . . . will spend almost 4-billion dollars to maintain millions of devices. Government figures show that a total of 120,000 servicers in all categories, including part-timers, will share in this business. The average take then is $33,000 plus per average man. Note I said average. I'm sure NATESA'ns are not average and that each should account for far more than $33,000. Did you get your $33,000 per man? Probably not—and the reason is that most of us are trying hard to *lower* ourselves to the status of an average man instead of shooting for the skies.

"It is time for us to junk our old ideas about business. The days of piddling jack-of-all-trades little operators are over. The day of bigness is here. Only specialization can make of us little guys 'big.' The time is now for each of us to realize that none of us is a jack-of-all-trades and yet each of us is a master of some phase. Each of us performs functions we are unqualified to do and we hate every minute of it and pay dearly for it. What is the solution? It's really simple. Why can't members of this fine association appraise the abilities and talents of each member and then channel the various activities necessary to the conduct of a solid, growing, and prosperous service business to those most capable to do them? The total volume of business waiting to be done in your area is so great that each expert in a phase or two could be occupied full time doing what he can best and most happily do. Every member then could offer truly expert services on a wide range of equipments at truly competitive prices and of such quality that no one, not the factory and surely not the catch-as-catch-can 'some timer' could possibly compete.

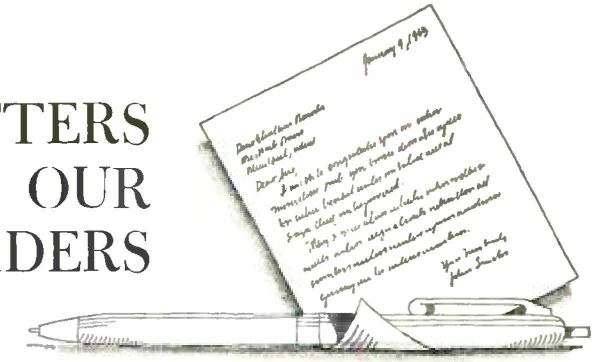
"This is the way to stabilize this business. This is the way to compete with bigness. This is the way to make a business out of a rat race. . . .

"As with any plan, this calls for intelligent leadership, trust, and fair play. In the past service people have too often abused leadership and accused it of ulterior motives. This is a luxury we can't afford. As for trust, by now every member of any worthwhile association knows that the fellow servicer down the street really did have a father and he is in the same mess we all are in, so trust should be an accepted fact. Fair play is an ingredient of any truly successful operation.

"Thus on the plus side we have fantastically good business prospects growing each year, and . . . we have the cumulative talents . . . to fulfill the needs of the business. On the negative side we have inertia, generally and conveniently labeled independence. The path we follow is yet for us to choose. Will you become big and enjoy all the benefits it brings by helping your fellow member, or will you sit under your spreading chestnut tree and die watching progress rush by?"

His comments and suggested solution are extremely realistic. We have seen it work in certain areas where service shops divide their business into three main areas: automobile sets, radio and TV, and antenna installations. We see no reason why this could not be broken down ever further. It should be worth trying. ▲

LETTERS FROM OUR READERS



THE WOMAN ENGINEER

To the Editors:

I concur thoroughly with your July editorial on the desirability of and the opportunities for the woman engineer. We ordinarily graduate one or two each year, all of whom are quite outstanding in ability.

I would like to bring you up to date on the going rate for B.S. graduates from Colleges of Engineering. You state that this is $5200 for electronic engineering graduates, whereas our current figures for the class of the past year approximate $7400. Master's degrees command approximately $9000 and doctorates whatever the man is able to sell himself for, but usually in excess of $12,000 per year.

J. D. Ryder, Dean
Michigan State University
East Lansing, Michigan

To the Editors:

Your editorial on women in engineering was a welcome part of the July issue of Electronics World. There are three points I should like to have emphasized in any future articles—concerning *salary*, *opportunity*, and *motivation*.

First, the average salary offered to me and my classmates in January 1963, was well over $600/month or $7200/-year. My offers ran from $570 to $650, with only two offers below $600. The average electrical engineer makes over $10,000/year. These figures can be verified at any college placement office.

Opportunity is less for women initially. Half of the companies who interviewed at my college refused to even interview a woman, no matter how good or bad she might be. Your "too-eager companies" are highly unusual.

As for motivation, too much has been said about challenge. The person who wants to be challenged doesn't have to be talked into engineering as a career. He or she is already there, for engineering today is the most challenging of professions. What other professional person loses 50% of his value in 10 years' time unless he keeps at top pitch?

Rather, let's emphasize the actual glamour of the job in engineering; the overwhelming majority of interesting men in college classes; the delightful thrills of being flown by jet all over the United States for interviews; the publicity attendant upon graduation; the down-right fun and stimulation of conferences and meetings in plant and at conventions all over the world. There is no job I know of as glamorous and exciting as that of a woman engineer.

(Miss) Faith Lee
Project Engineer
Motorola Inc.
Phoenix, Arizona

° ° °

TEST-EQUIPMENT ISSUE

To the Editors:

The test-equipment technicians here at the Grand Forks (North Dakota) Air Force Base were extremely interested in your August issue of Electronics World devoted to test equipment. The article written by G. Gedney and F. Winterburg ("The Instrument Calibration and Repair Technician") as well as the feature articles throughout the issue were of extreme interest to us.

Some of your readers might be interested to know that the U.S. Air Force has a very fine program of calibration and repair of their vast inventory of precision test equipment. In today's age of supersonic aircraft, guided missiles, and extremely accurate radar and communications and control systems, a need exists for a program of this type. Such a program will play an even more important role in the future as our military equipment becomes more advanced.

Because of the nature of this work, the U.S. Air Force allows only the well-qualified electronics technician to enter the program. A very tough pre-entrance exam must be passed before a technician is eligible to enter the Precision Measurement Equipment School at Lowry Air Force Base at Denver, Colorado. An additional requirement exists allowing only airmen with four years' electronics experience in a related career field to be selected. This allows the "cream-of-the-crop" to enter the calibration program enabling the precision measurement equipment to be handled by some of the best technicians the Air Force has.

Being a member of one of the 149 Laboratories mentioned in your article and a career airman, much of the test

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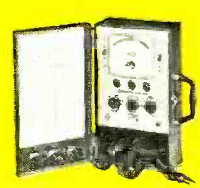

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equipment described in your issue has become familiar to me, and to the other Precision Measurement Technicians throughout the USAF Calibration and Repair Program.

Thanks for a fine magazine.

S/SGT. ALFRED A. ST. ARNOLD, USAF
Precision Measurement Lab.
Grand Forks Air Force Base
North Dakota

* * *

TV INTERFERENCE

To the Editors:

My neighbor told me that he had called a TV service shop to find out what could be done about TVI on channel 2. The serviceman told him that it could not be fixed and that he would have to get the amateur off the air. I showed my neighbor how to install a high-pass filter on his set which completely cleared up the problem. Then I made a phone survey of ten local TV service shops. I told them that I was having interference on channel 2 from a nearby amateur who was transmitting on six meters. I was amazed at the answers that I got. They ranged from "call the FCC," "it can't be fixed," "I'll have to take the set to the shop and try different filters," to "see the amateur and have him transmit on another frequency." One serviceman told me to write to the FCC and they would give me a free filter.

Not one of the servicemen that I called had any idea of what to do. And I suspect they had never heard of a simple high-pass filter.

W. P. PENCE, WA6JEU
Santa Monica, Calif.

There are quite a few TV technicians who are hams and these men are very well acquainted with TVI, its causes and cures. On the other hand, some TV technicians may not have had too much experience with the problem and how to eliminate it. There have been many good articles published on this subject, and complete chapters in the radio amateur handbooks are devoted to the subject. In addition, we have run several stories on TVI in past issues.—Editors.

* * *

TRACKING ERROR

To the Editors:

One of your laboratory reports on a stereo cartridge and tonearm indicates various measurements of tracking error at different points on a record. Just how is this tracking error measured with any amount of accuracy? I am especially interested in this since some of the figures given are on the order of one or two degrees.

CARL FAZIO
Milano, Italy

The method used by Hirsch-Houck Laboratories for measuring tracking error requires the use of a special protractor-like device that was imported from England and distributed in this country a few years ago. The device actually consists of two long, movable arms, a protractor scale that reads the angle between these two arms, and a fixed arm that fits over the turntable spindle. To use the device, the two movable arms are first placed at the point on the record at which the tracking error is to be measured. The stylus of the pickup is then put down in a small hole which is at the apex of the two movable arms. One of these arms is exactly at right angles to the radius of the record. The second arm is aligned optically so that it is parallel to the pickup and stylus. Then the angle between the two arms is read on the protractor. This represents the tracking error. The device used is accurate enough so that one can read tracking errors to a fraction of a degree. It is Hirsch-Houck Laboratory's practice to measure tracking error at several points along a record. Incidentally, the device described is no longer available in this country.—Editors. ▲

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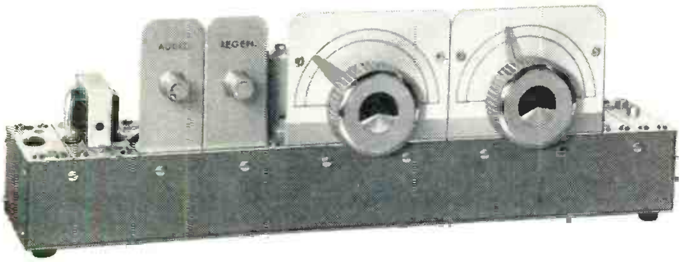
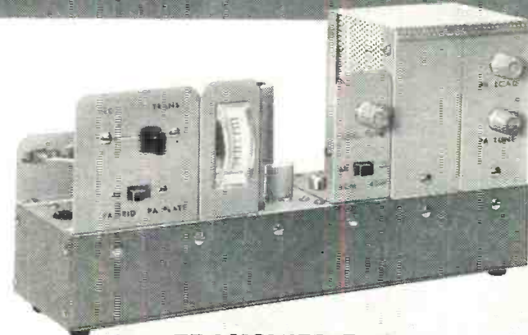




RECEIVER KITS

This new line of International receiver kits cover a wide range of amateur, citizens band and special frequencies. Designed for AM, CW, or SSB reception, this basic receiver using a superheterodyne circuit* with regenerative second detector may be expanded to a more elaborate receiver by the addition of other Add-On-Circuits. Sensitivity usable to below 10 microvolts for voice and 1 microvolt for code. Nuvistor rf amplifier, mixer, oscillator, I.F. transformer, detector/1st audio, and power audio amplifier. Tube lineup: 6DS4 nuvistor, 6BE6, 6U8, 6AQ5. Shipping weight: 15 lbs.

Receiver kit includes 4" speaker and power supply.

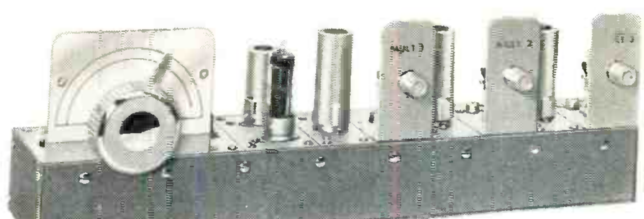
Kit	Frequency	Price
AOR-40	Special	$69.00
AOR-41	150 kc — 450 kc	62.50
AOR-42	2 mc — 6 mc	62.50
AOR-43	6 mc — 18 mc	62.50
AOR-44	80 meter/40 meter	62.50
AOR-45	15 meter/10 meter	62.50
AOR-46	6 meter	66.50
AOR-47	2 meter	66.50
AOR-48	Citizens 27 mc	62.50

*AOR-41 uses a tuned rf circuit with 6BA6

TRANSMITTER KIT

A compact package delivering a plate input of 50 watts for CW operation on 80 or 40 meters. 12BY7 crystal oscillator—6DQ6 power amplifier. Pi-network final. When used with AOR-44 receiver, transmitter operates from receiver power supply. Meter and TR switch.

AOT-50 transmitter kit less power supply and key, but with one 40 meter novice band crystal. Shipping weight: 5 lbs. **$35.00**



POWER SUPPLY KITS

AOP-100 350 volts, 150 ma intermittent or 100 ma continuous service, 6.3 volts @ 5 amps. Shipping weight: 8 lbs....... **$18.50**

AOP-200 650 volts, 250 ma intermittent or 200 ma continuous service, 6.3 volts @ 10 amps. Shipping weight: 10 lbs...... **$32.50**

VFO KITS

The International AOF series of variable frequency oscillator kits is available in three versions. For example, the AOF-91 kit is a complete driver unit to be used with 6 meter and 2 meter transmitters. Approximately .5 watt of power is available on both bands. Tube lineup: 6BH6 oscillator, OB-2 voltage regulator, 12BY7 buffer-amplifier/multiplier. Shipping weight: 5 lbs.

Kit	Frequency	Price
AOF-89	VFO 8 mc — 9 mc and buffer	**$22.00**
AOF-90	VFO 8 mc — 9 mc plus buffer multiplier and 6 meter output	**29.00**
AOF-91	VFO 8 mc — 9 mc plus buffer multiplier, 6 meter/2 meter output	**36.00**

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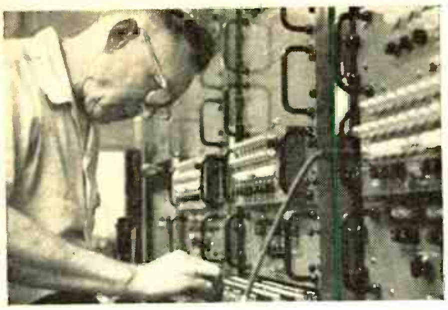

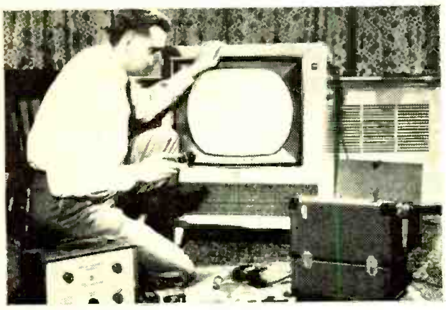

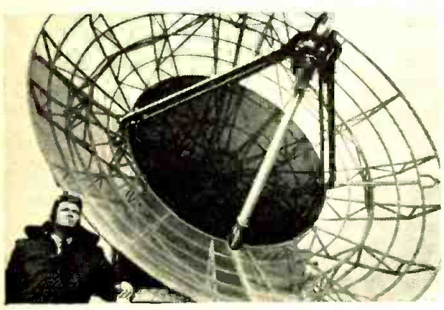

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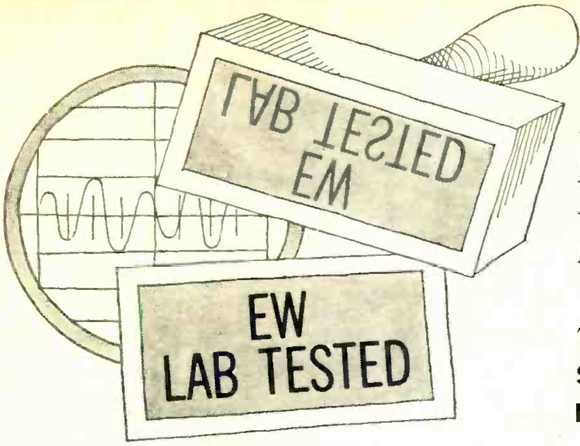


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Shure 545S "Unidyne III" Microphone

Heath AA-21 Transistorized Stereo Amplifier

Shure 545S "Unidyne III" Microphone

For copy of manufacturer's brochure, circle No. 56 on coupon (page 15).

THE *Shure* 545S "Unidyne III" is a moving-coil microphone with a cardioid directional response. It is constructed in a slim, cylindrical shape, ruggedly built, and attractively styled.

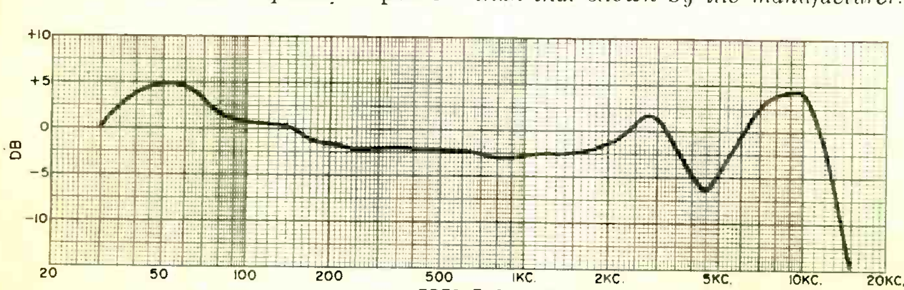
Most directional microphones are quite bulky and have different polar patterns in the horizontal and vertical planes. This microphone, which physically resembles the usual non-directional microphone, is constructed symmetrically and has the same polar response in all planes. The polar pattern is wide, being down only 6 db at the sides, yet the unit has a rejection of 15 to 20 db for signals arriving from the rear. This enables it to be oriented to reduce pick-up from the audience or from the speakers in a public-address installation. In this way, higher amplifier gain can be used without acoustic feedback.

The unit is equipped with a swivel-mount and an "on-off" switch. It has two output impedance connections, for driving loads of 50 to 250 ohms or a 100,000-ohm high-impedance load. The desired impedance may be selected by making connections to the appropriate two wires of its three-wire output cable. This shielded cable, supplied with the microphone, is 18 feet long and is fitted with a connector mating with the connector on the microphone mount.

We measured the frequency response of the microphone at a distance of 12 inches from a loudspeaker, comparing its output with that of a calibrated standard microphone in the same location. The difference between the two, corrected for the response of the standard microphone, is plotted on the accompanying graph.

The measured response is generally similar to the curve supplied by the manufacturer in the instruction booklet for the microphone. Our measurement shows a small dip at 4500 cps which does not appear on the manufacturer's curve, as well as much stronger bass response below 100 cps. The over-all response is ±5 db from below 30 cps to 13,000 cps. This is unusually wide for a public-address microphone and makes this one quite suitable for music as well as vocal amplification. Listening to recordings made on a high-quality tape recorder with this microphone revealed a crisp, clean sound, with noticeable sibilants on close talking. The bass did not sound as heavy as the curves would suggest, but this is probably a function of the distance between the microphone and sound source.

(Editor's Note: The dip at 4500 cps has also been observed with other microphones; it is probably the result of the peculiar sound field radiated by the two-way speaker system used to test the mike. Also, the manufacturer's curve was taken at a distance of 24 inches from the sound source rather than 12 inches used by our laboratory. As a result, the bass response shown in our curve is higher than that shown by the manufacturer.)



The *Shure* 545S microphone sells for $54.00. It is also available without the "on-off" switch, as the Model 545, for $50.00. ▲

Heath AA-21 Transistorized Stereo Amplifier

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

THE *Heath* AA-21 is one of the first all-transistor integrated stereo amplifiers to overcome the power, bandwidth, and stability limitations of many such units. Early efforts at transistorizing high-fidelity amplifiers were plagued by the fact that the moderate-priced power transistors of that period would not function above a few kilocycles. Improperly stabilized circuits were prone to run away at elevated temperatures or when driven hard. With inadequate overload protection, the output transistors would frequently be destroyed in a fraction of a second.

Heath engineers set out to eliminate these weaknesses when they developed the AA-21, and they have succeeded admirably. The AA-21 is rated at 35 watts per channel (continuous) with both channels operating into 8-ohm loads. Better than 27 watts (at 1% THD) can be obtained at both upper and lower limits of the audible spectrum. The special power transistors, four of which are used in each output stage, are mounted on large finned radiators, or heat sinks, which allow them to run cool in normal service and at safe temperatures even when delivering large continuous power outputs. The problem of transistor damage by overdriving or by speaker short circuits has been neatly solved by using

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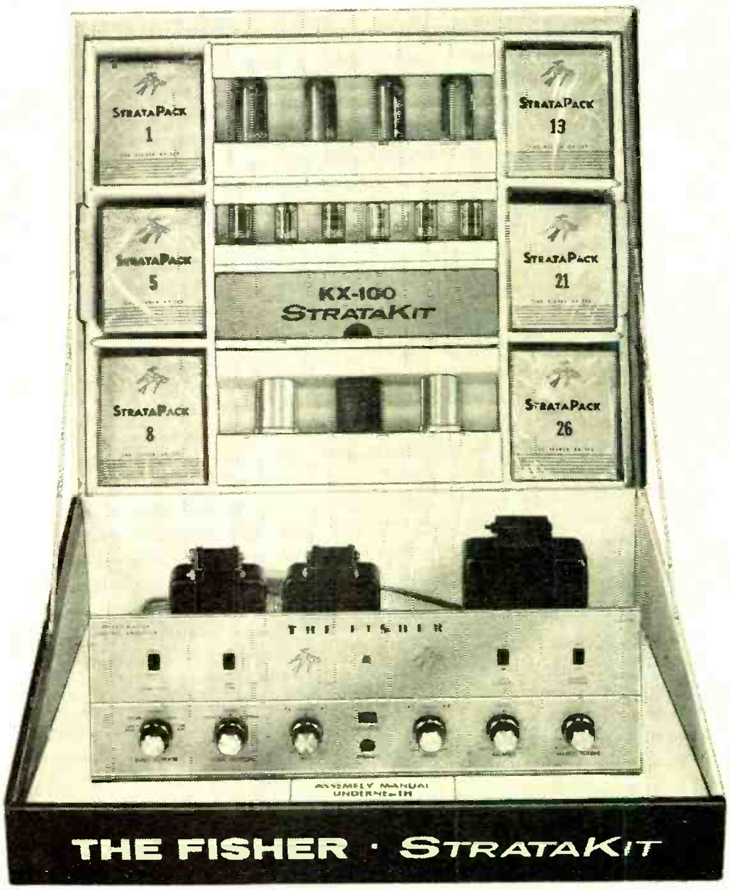

If you want a no-compromise amplifier at a compromise price, you can't buy it—you have to build it yourself. And no one can build a better 50-watt single-chassis stereo control-amplifier than the Fisher KX-100, at *any* price!

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

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

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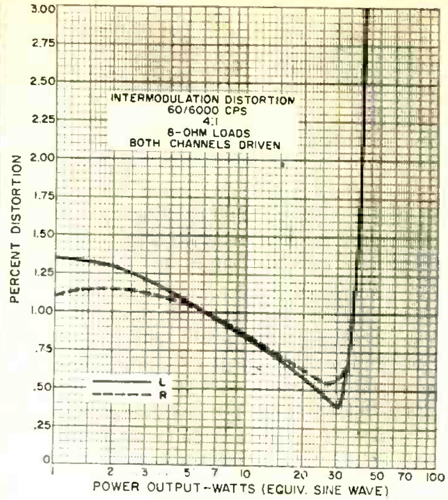


five tiny, quick-acting thermal circuit breakers. One is in each power supply line (+35 volts, −35 volts), one in each speaker line, and one in the a.c. power line. Momentary overloads trip one or more of these breakers, which reset automatically in a few seconds. They are more convenient than fuses and act quickly enough to afford real protection to the transistors.

The amplifier uses a total of 28 transistors and 10 diodes. The output transistors are driven through transformers, but are direct-coupled to the speakers. Combined current and voltage feedback is used to obtain unity damping factor. Normally, the unit is meant to drive 8- or 16-ohm speakers, with power reduction of about 30% into a 16-ohm load. Four-ohm speakers are driven through an internal 4-ohm series resistor, which reduces the available power by 50%.

The amplifier is styled like the company's other audio components, with an attractive tan vinyl-covered steel case and a panel featuring contrasting portions of chrome, clear and black plastic, and tan surfaces. Many infrequently used controls are located in front, behind a hinged panel which swings down for access. These include switches for tape monitoring, loudness compensation, and speaker phasing plus a complete set of individual level-setting controls.

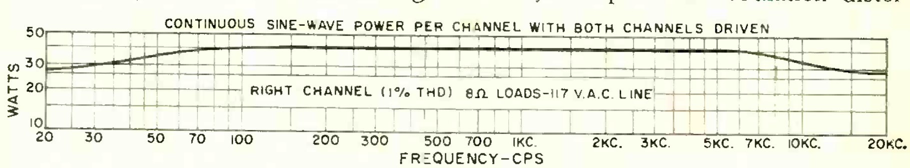
The exposed controls include source and mode selectors, volume, bass, and treble tone controls. The AA-21 source selectors are independent for the two channels, mounted concentrically. This allows the amplifier to be used as two separate mono amplifiers, or for mixing two input channels. The mode switch has positions for mixing both channels, connecting either channel to both speakers, and for normal and reversed-channel stereo operation.

The volume and tone controls are concentric types with slip clutches to allow independent adjustment of the two channels. Channel balancing is done with the two volume controls.

The measured frequency response of the unit was ±1 db from 20 to 16,000 cps with the tone controls mechanically centered. The tone-control ranges were +18.5 to −17.7 db at 50 cps and +13.5 to −17 db at 10,000 cps, with negligible effect on the 1000-cps level. The volume-control tracking was good when both channels were set to the same gain, but if they were offset by only a few db the tracking error became excessive. If this amplifier is used with speakers of different efficiencies, we recommend balancing levels with the input level adjustments rather than with the main volume controls.

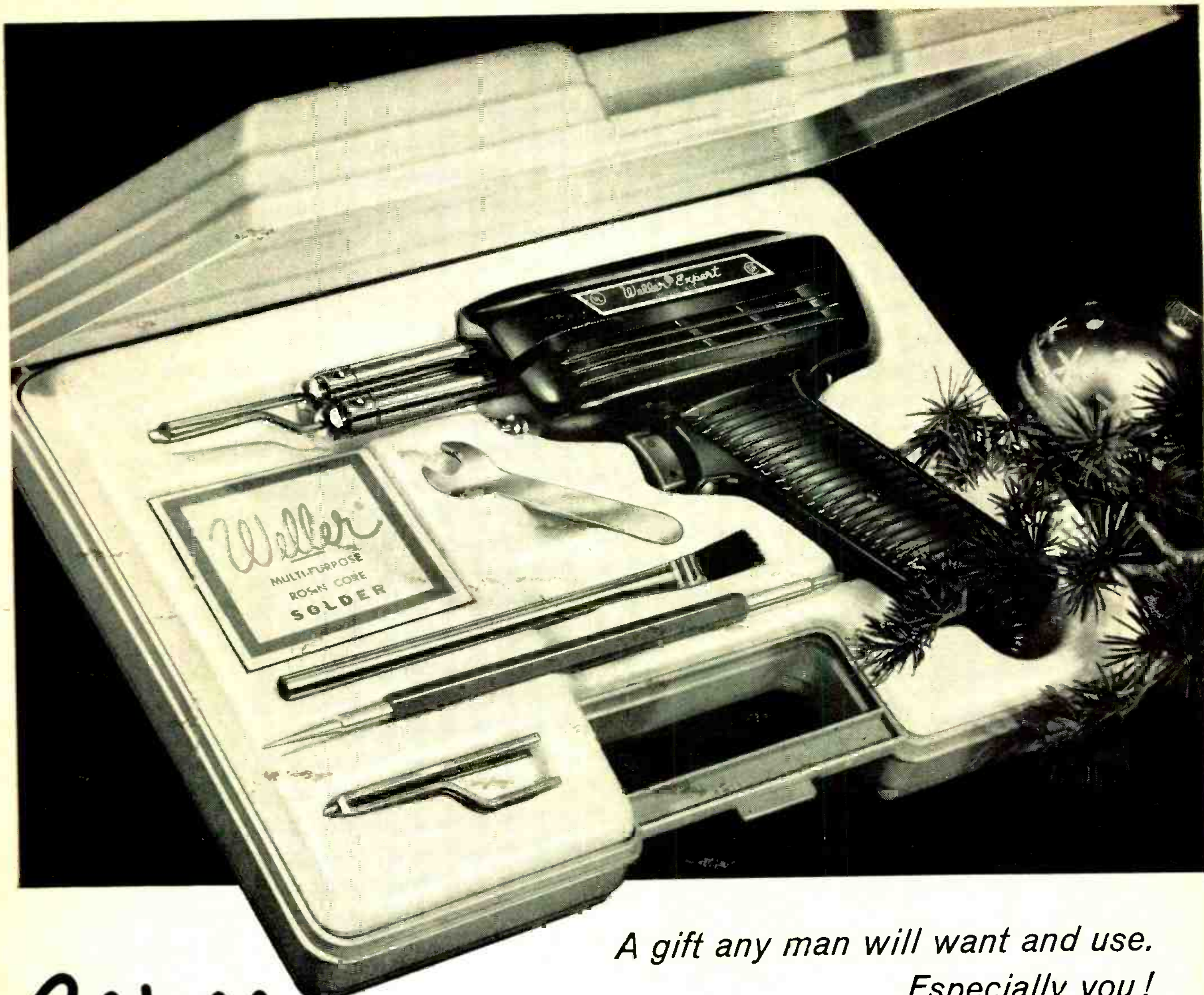
The hum and noise were −57 db on phono and tape head inputs, and −64 db on the "Aux." input, referred to 10 watts output. The gain was very high, with only 0.75 mv. needed at the tape head input to produce 10 watts output. The phono sensitivity was 1.2 mv. Stereo crosstalk was −44 db to −56 db and there was no crosstalk from unused inputs.

The power output at 1% harmonic distortion, with both channels driven and with 8-ohm loads, was 41 watts between 100 and 7000 cps, falling off to 27 watts at 20 cps and 29 watts at 20,000 cps. Hence the amplifier could have been rated at +0, −2 db of 41 watts from 20 to 20,000 cps. Intermodulation distortion was between 0.83% and 1.35% for all power outputs up to about 10 watts, falling to 0.72% at 35 watts, and rising again to 3% at 41 watts. These figures are within the manufacturer's rating of 1% IM at 35 watts.



In listening tests, the *Heath* AA-21 had all of the attributes of a good, high-powered amplifier. It was very clean, solid, and effortless in its sound. Like a few other high-quality transistor amplifiers we have heard, it gives the impression of limitless power reserves. There is no sign of break-up or other unpleasantness at extremely high listening levels, possibly due to superior overload recovery characteristics.

Although many of the circuits are in the form of encapsulated modules, which mount on the printed circuit boards, the assembly procedure is lengthy and this does not appear to be a project for the novice kit-builder. The unit we tested took an experienced kit-builder about 24 hours to complete. The unit sells for $139.95 in kit form. ▲



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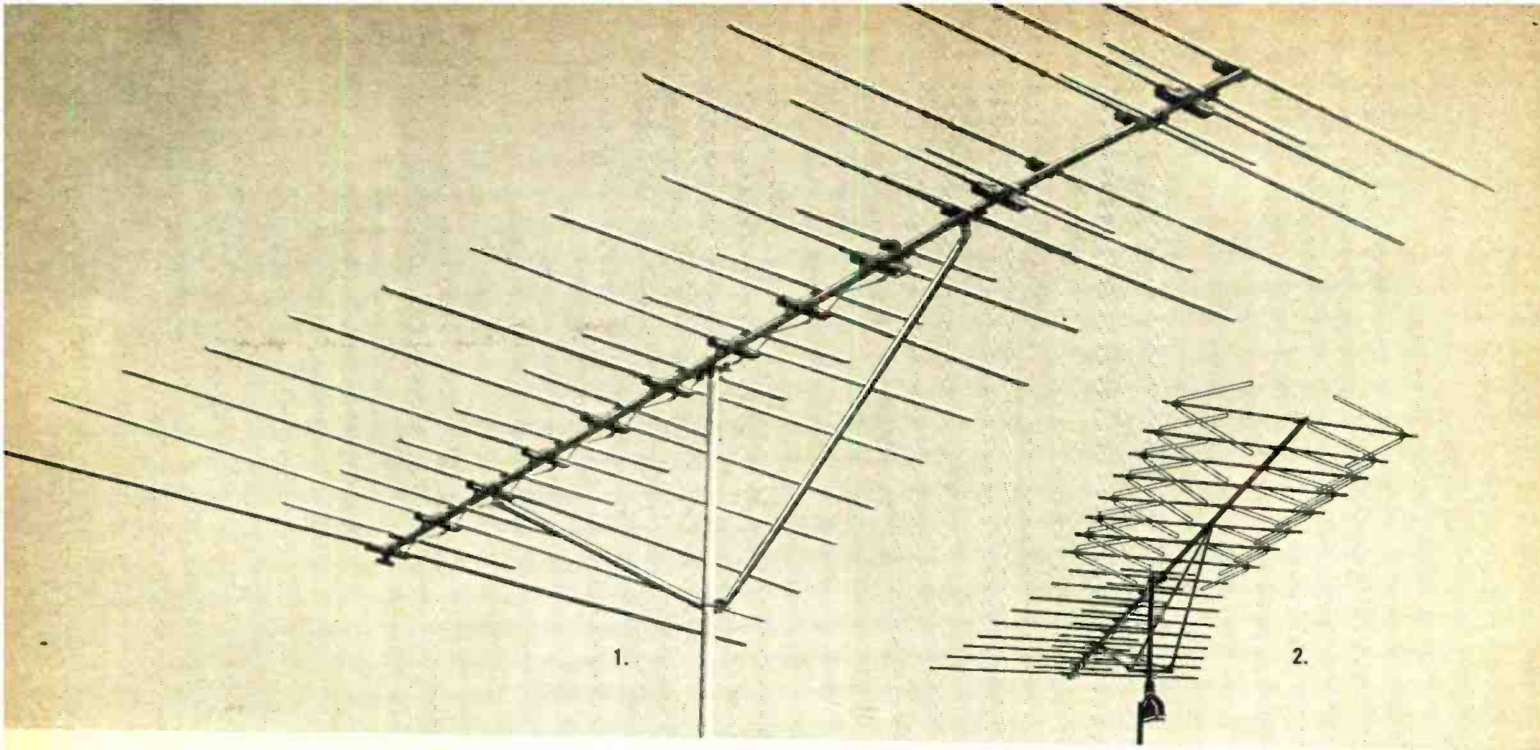

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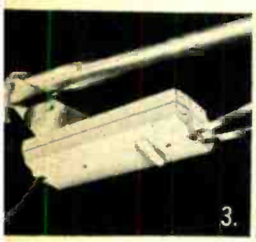

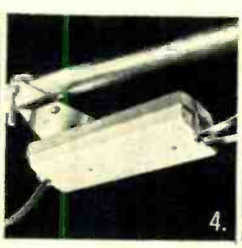

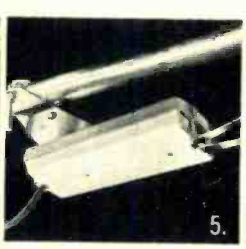

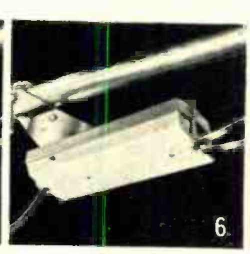

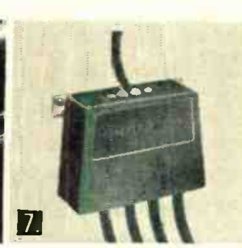

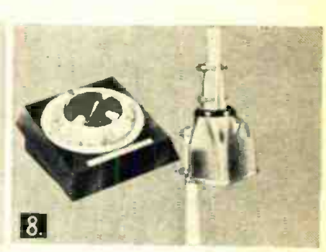

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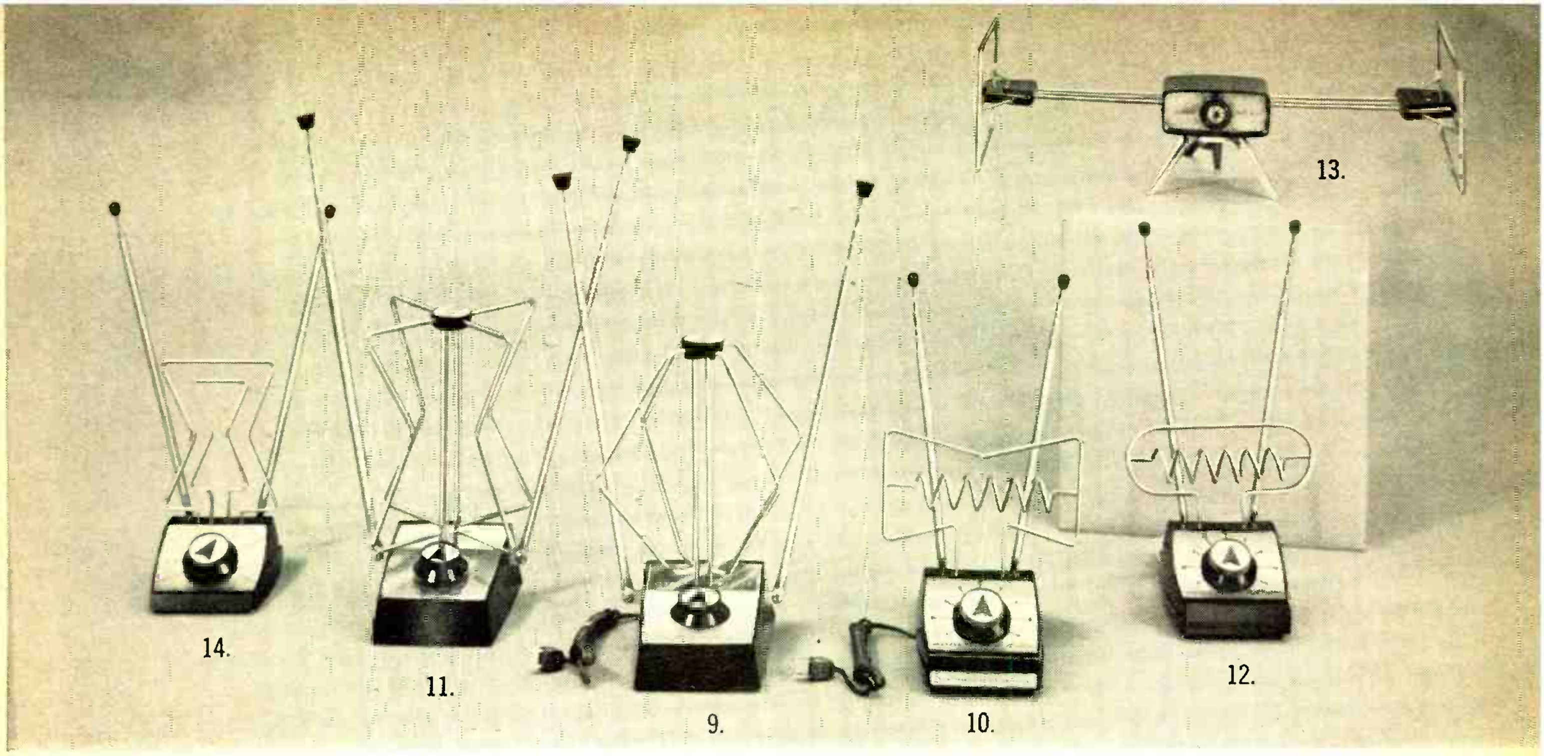

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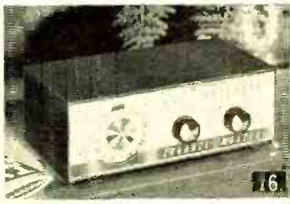

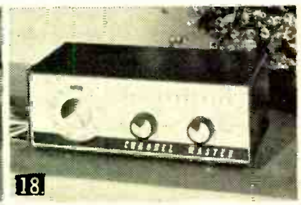

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15. **Model 6700. YOUR MARKET:** FRINGE-AREA LISTENERS WHO WANT THE ULTIMATE IN RECEPTION. **Capacitive tuning** (no sliding contacts), 1 long-life Nuvistor, 1 oscillator tube. Prevents strong-signal overloading.
16. **Model 6701. YOUR MARKET:** FRINGE-AREA LISTENERS WHO WANT TOP QUALITY AT A MODERATE PRICE! Inductive Tuning, 2 long-life Nuvistors.
17. **Translator Model 6703.** Same as above but covers only channels 70-83.
18. **Model 6702. YOUR MARKET:** METROPOLITAN AND SUBURBAN AREA LISTENERS WHO WANT TOP QUALITY AT A MODEST PRICE! Your most profitable UHF conversion market. Inductive Tuning, 1 long-life Nuvistor.
19. **Translator Model 6704.** Same as above but covers only channels 70-83.

CHANNEL MASTER CORP., ELLENVILLE, NEW YORK

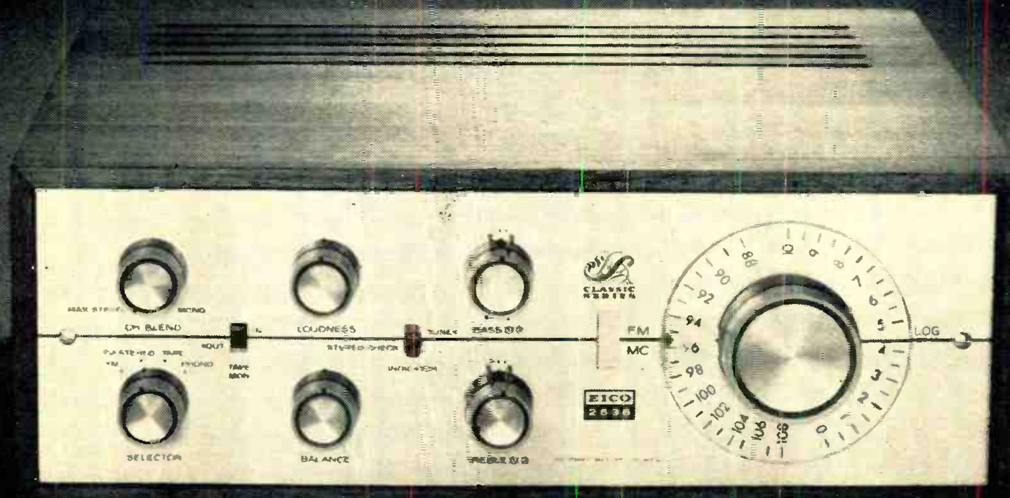
TUNER SECTION: In the kit, the two most critical sections—the front end and the IF strip—are supplied prewired and pre-aligned and a high quality circuit board and pre-aligned coils are provided for the stereo demodulator circuit. The IF strip has 4 amplifier-limiter stages and a wideband ratio detector for perfect limiting and flat frequency response. Sensitive bar-type electron-ray tuning indicator pinpoints the center of each broadcast channel for lowest distortion, and also serves as the stereo program indicator.

Antenna input: 300 ohms balanced ☐ IHFM usable sensitivity: 3 µv (30 db quieting), 1.5 µv for 20 db quieting ☐ Sensitivity for phase locking (synchronization) in stereo: 3 µv ☐ Full limiting sensitivity: 10 µv ☐ IF bandwidth: 280 kc at 6 db points ☐ Ratio detector bandwidth: 1 mc peak-to-peak separation ☐ Audio bandwidth at FM detector: flat to 53 kc ☐ IHFM signal-to-noise ratio: 55 db ☐ IHFM harmonic distortion: 0.6% ☐ Stereo harmonic distortion: less than 1.5% ☐ IHFM capture ratio: 3 db ☐ Channel separation: 30 db.

AMPLIFIER SECTION: High quality Baxandall bass and treble controls do not interact or affect loudness, permit boost or cut at extremes of range without affecting mid-range. Balance control is infinitely variable, permitting complete fade of either channel. Blend control is variable from switch-out, for maximum separation, to full blend. Tape Monitor switch permits off-the-tape monitoring with the Eico RP100 Stereo Tape Recorder.

Power: 36 watts IHFM music, 28 watts continuous (total) ☐ IM distortion (each channel): 2% at 14 watts, 0.7% at 5 watts, 0.2% at 1 watt ☐ Harmonic distortion (each channel): 0.6% at 10 watts, 40 cps to 10 kc; 0.2% at 1 watt, 30 cps to 20 kc ☐ IHFM power bandwidth at rated continuous power, 1% harmonic distortion: 30 cps to 20 kc ☐ Frequency response ±1 db, 15 cps to 40 kc ☐ Speaker output: 8, 16 ohms ☐ Inputs: Magnetic phono or adapted ceramic phono, tuner, tape auxiliary ☐ Sensitivity: 2.3 mv phono, 250 mv others ☐ Noise: −65 db at 10 mv, mag phono; −80 db others.

New Eico Classic 2536 Stereo FM Receiver



Now... every other stereo receiver seems overpriced

Take a superb stereo tuner, guaranteed stable under all conditions, and sensitive enough to give full stereo separation even on weak, fringe-area signals...

Add a virtually distortion-free 36-watt stereo amplifier with remarkable overload and transient characteristics...

Mount them on one chassis—effectively separated for the performance benefits of components plus the convenience of a single compact unit.... Price this combination at $209.95 factory-wired, and at $154.95 in a new kit pack that makes building a delightful experience—and what do you have? The Classic 2536 Stereo Receiver, star of the new Eico Classic Series, and a component that matches or surpasses the performance of components selling at substantially higher prices. How? Simple. It's pure performance. Stripped of everything but the finest basic circuitry. Examine the specifications yourself. Compare them with those of more expensive units. Listen to the 2536—then to higher priced units. Can you see or hear a difference worth paying for?

If you're interested in building a fine stereo receiver, take a long look at our new kit pack, too. Note the logical, orderly arrangement of parts. How easily it sets up for work. How easily it closes down between work sessions—with no loose parts to go astray. Thumb through the 2-color Construction Manual. Ever see such graphic diagrams? Every step is clear and unmistakable—and no diagram shows more than 20 steps. Another thing the diagrams show you: how simple the wiring is. No tricky frills; no clutter; no confusion, even around switches and controls. Plenty of space to work in. And Eico has eliminated the most tedious part by pre-mounting jacks, sockets, terminal boards, and transformers.

Does any other kit give you more building ease, or assurance of success than the Eico Classic? See it at your hi-fi dealer. Optional Walnut Cabinet WE-73, $19.95, Metal Cover E-12, $7.50. Write for catalog. Eico Electronic Instrument Co., Inc., 131-01 39th Avenue, Flushing, N. Y. 11352. Export: Roburn Agencies Inc., 431 Greenwich Street, New York 13, New York.

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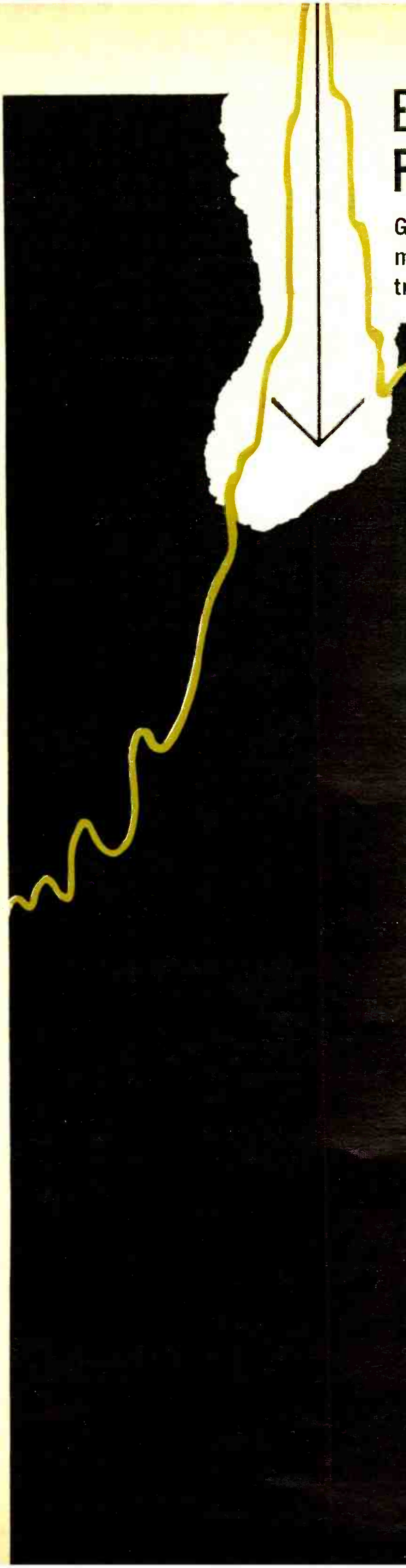


ELECTRONIC INSTRUMENTATION FOR OIL EXPLORATION

Geophysical prospecting using electronics has led to many oil discoveries. Acoustic sounding is now done with transistorized equipment, oscillographs, and computers.

By LOUIS E. FRENZEL, Jr. / McCollum Laboratories, Inc.

ALL of the major fields of science and technology have profited greatly by the use of electronic techniques over the past years. Persons in the fields of chemistry, physics, biology, medicine, and engineering are beginning to realize the great potentials that electronic techniques offer. Electronic instrumentation, when used, improves existing conditions in addition to offering new avenues of approach unheard of before the use of electronics.

One field that has "discovered" electronics is geophysics. *Geophysics* is the science and study of the earth and its various phenomena. Years ago, this was the only definition of geophysics, but today, because of advances in sciences like electronics, geophysics is now the study of our solar system and space as well as the earth. Geophysics includes the fields of geology, geodesy, seismology, technophysics, volcanology, oceanography, petrology, geochemistry, geochronology, meteorology, hydrology, aeronomy, geomagnetism, solar physics, and others. These are called the *geosciences*.

One of the most interesting fields is *seismology*, particularly the seismic oil exploration branch of this field. Oil is one of our most important natural resources and the need for large quantities of oil continues to exist. Oil and its byproducts have many important uses in our world today, and new uses are continually being found. For these reasons it is important that we be on the lookout for new sources of this valuable product. The major oil companies of this country conduct a constant search for new petroleum deposits in the earth. Geophysical prospecting techniques using electronics developed by these and other companies have led to many successful discoveries of oil deposits.

Reflection Seismology

Geophysical or seismic prospecting is the science of searching for petroleum, gas, or mineral deposits by making physical measurements on the earth. While many different techniques have been devised for making these measurements, one of the most effective and widely used in oil exploration is *reflection seismology*. In this technique, sound waves are generated in the earth. These waves travel through the earth and are reflected back to the surface from the various subsurface layers. These reflections are recorded, and the depth of the layers are computed by knowing the reflection times and the velocity of propagation. From this data, special maps of the subsurface are plotted. These maps are then interpreted by geophysicists who are able to determine if the subsurface structures are those which are usually oil bearing in nature. If results of these measurements show conditions favorable

Fig. 1. A gas-explosion chamber built into this 18-ton vehicle is used to produce an acoustic shock wave for oil exploration.

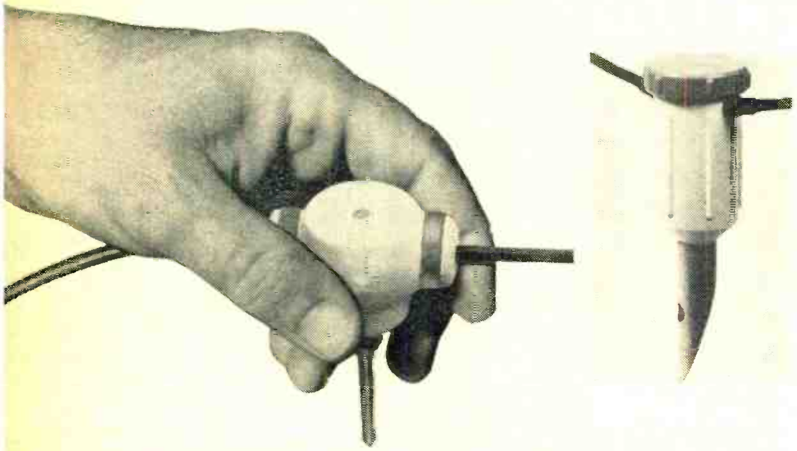


Fig. 2. Typical geophones employed to pick up sound reflections.

to oil accumulation, further tests will be made and a pilot well may be drilled.

Reflection seismology is an acoustic-sounding technique. In this technique, a generator source is used to produce a sound or shock wave that will penetrate the earth and be reflected back to the surface. The most widely used method of generating seismic waves is by detonating a charge of dynamite or other explosive. A hole, called a *shot hole*, is bored into the earth and the explosive is placed in it. The explosive is then detonated and a large impulse shock wave is produced. The wave travels through the earth in all directions and is reflected from the various subsurface layers. Reflections as deep as 20,000 feet have been recorded.

A newer method, developed by Burton McCollum, involves the dropping of a weight. A three-ton metal weight mounted on a large truck is dropped from a height of approximately nine feet. This creates a tremendous shock wave in the ground. This technique produces reflections which are just as useful as those produced by a dynamite blast.

Electric and hydraulic vibratory sources which vibrate the earth in a sinusoidal manner have also been used as seismic signal sources, but many of these are still largely experimental. The "Vibroseis", a vibratory exploration technique developed by the *Continental Oil Company*, is already being used commercially.

(*Editor's Note: Still another method of producing the shock wave was announced recently by* Sinclair Oil Corp. *A gas explosion chamber is mounted in the center of an 18-ton large-wheeled diesel-driven vehicle, called "Dinoseis." The chamber is held against the ground surface by part of the weight of the truck. When the gas mixture is exploded, a 100,000 foot-pound seismic impulse is produced (Fig. 1).*)

After the acoustic energy is radiated, it will travel through the earth with a velocity which is dependent upon the media through which it passes. Basic physics says that the velocity of propagation of acoustic energy is dependent upon the type of material through which the energy passes and other factors. For example, the velocity of sound waves is higher in rock than it is in clay soil. The earth's subsurface is made up of many different types of layers of rocks, soil, sand, and other substances. The velocity of propagation will change abruptly as the acoustic wave passes from one layer to another. Because of this velocity change, a reflection is produced. The exact nature of the reflection will depend whether the signal goes from a high-velocity zone to a low-velocity zone or *vice versa*. This reflection takes the form of a very small vibration of the earth which travels upward vertically toward the surface. This reflection is actually a low-frequency (10 to 300 cps) sound wave.

Detection and Recording

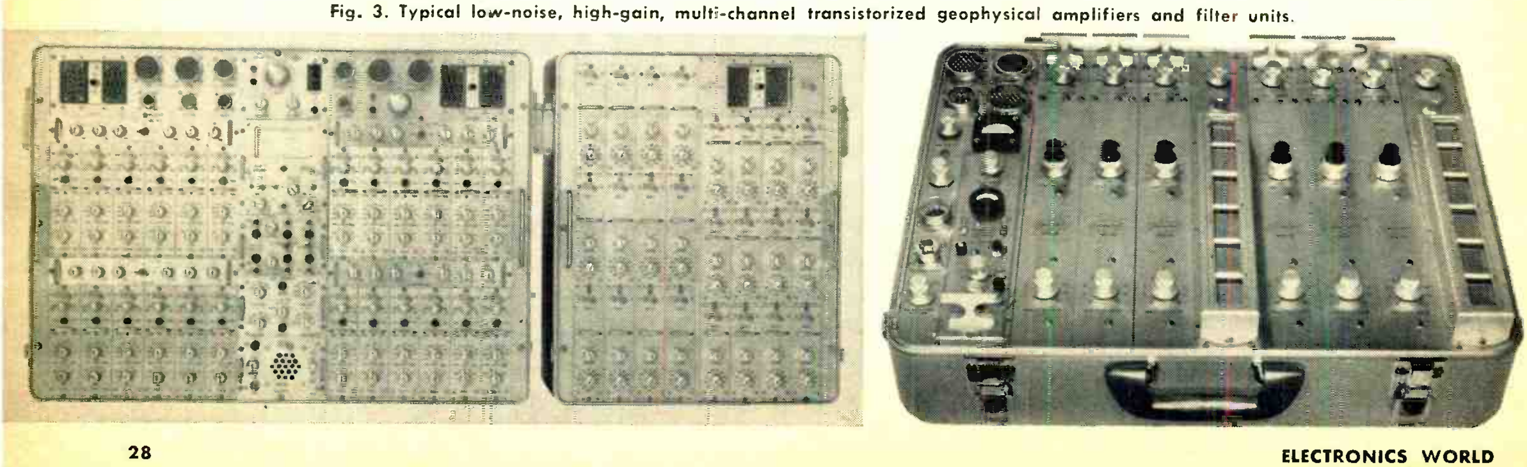
The next step in this oil exploration technique is the detecting and recording of the vertical reflections. Here is where electronics plays a major role. Fig. 4 shows a cross-section of the earth and a block diagram of the equipment used in the reflection method.

The reflections are picked up by a microphone-like transducer called a *geophone*. Fig. 2 shows two typical geophones. The geophone, also called a seismometer or detector, is usually buried several inches in the earth. Care is taken to see that the geophone makes good contact with the earth so that it moves when the earth moves during a reflection.

A typical geophone consists of a coil of wire which is suspended by a spring and which moves in the field of a permanent magnet. When a reflection appears, a small vibration in the earth will be transmitted to the geophone and will cause motion between the coil and the permanent magnet. This causes a voltage to be induced into the coil which is a function of the nature of the vibration. The geophone is made so that it will respond best to vertical movement. A cable attached to the geophone carries the voltage to other equipment.

A single geophone is never used in practical work. A large number of geophones are arranged in various patterns over a large area to obtain diversity. Diversity improves signal-to-

Fig. 3. Typical low-noise, high-gain, multi-channel transistorized geophysical amplifiers and filter units.



noise ratio. The geophones are wired together in various series-parallel combinations in order to obtain a satisfactory impedance match to other equipment.

The reflection signals from the earth are extremely weak. Even though a large amount of energy is radiated by, say, a charge of dynamite, the voltage produced by a group of geophones is still too small to record directly. Noise in various forms also complicates matters. Just as in communications and radar systems, the signal-to-noise ratio is important and steps must be taken to improve it; otherwise, good maps of the subsurface will not be obtained.

The output voltage from the geophones is fed to a low-noise, high-gain amplifier. This low-frequency amplifier provides extremely high gains in the 10- to 300-cps range. Care is taken in the design of these amplifiers to ensure a low noise figure. Fig. 3 shows two such geophysical amplifiers.

These amplifiers contain built-in low- and high-pass filters which help to improve signal-to-noise ratio by eliminating unwanted frequencies above and below the reflection signal frequency. These filters are normally of the constant-K *LC* type and are made variable to provide the desired filtering. Some amplifiers also contain a 60-cps notch filter to eliminate power-line interference which tends to be a problem in many areas.

All good geophysical amplifiers contain a.g.c. circuits. In many cases even a form of delayed-a.g.c. is used. This a.g.c. system improves performance by allowing the amplifier to operate over a wide range of input signal amplitudes without distortion. Another feature of some geophysical amplifiers is programmed gain. Programmed-gain circuits allow the gain of the amplifier to change with time. Since it takes a longer time for deep reflections to return to the surface than it does shallow reflections, naturally the deeper reflections will show up much smaller in amplitude on the record. In some cases it may take five or six seconds from the time the seismic signal was radiated for the most greatly attenuated, deeper reflections to return to the surface. The amplifier with programmed gain changes its gain with time and thereby brings all the reflection signals to approximately the same amplitude level.

After considerable amplification and some filtering, the signals are ready to be recorded. In order for the geologist or geophysicist to analyze the reflection information, it must be recorded and put into a suitable form. The most common form is a photographic record showing a number of reflection recordings. These are normally arranged so that the reflection signals from each dynamite blast or weight drop appear one beneath the other. In this way, line-ups of reflection signals will be easier to detect. This record is made by applying the seismic signal to a light galvanometer. The light is flashed onto light-sensitive paper which is moved past the galvanometer. This paper is processed and a record is produced. Timing lines are also put onto the record so that the geophysicists may know how long it takes the radiated signal to travel into the ground and to be reflected back to the surface. These timing lines are usually graduated in steps of 10 milliseconds, and the entire record can be anywhere from four to six seconds long. A device for producing such a record is called a *recording oscillograph*, and a typical unit is shown in Fig. 5. Fig. 5 also shows a seismic reflection record made on a similar recording oscillograph.

Magnetic tape recording systems are also used, particularly in poor record country where additional filtering and other processing must be done to obtain usable reflection data. The magnetic tape record can be sent to a central laboratory for processing. A record is made by placing a magnetic tape about four inches wide and three feet long on a large rotating drum. The magnetic record and playback heads are placed adjacent to this drum. The drum revolves as dynamite shots or weight drops are produced and the resulting reflection signals are recorded on the tape.

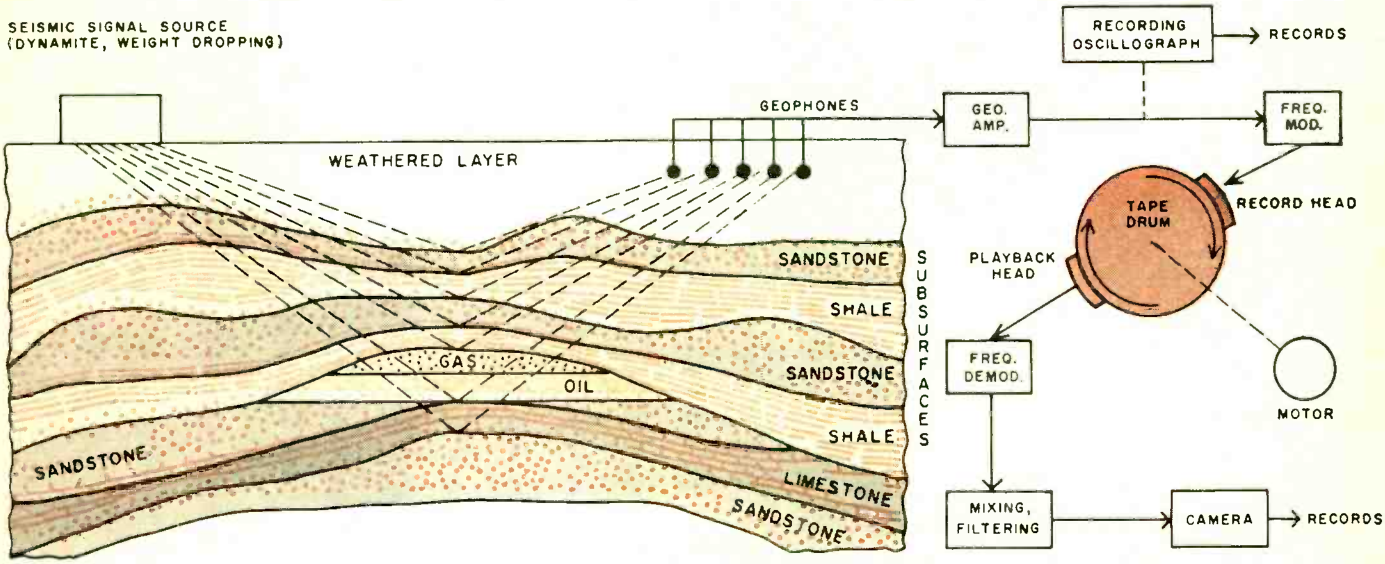
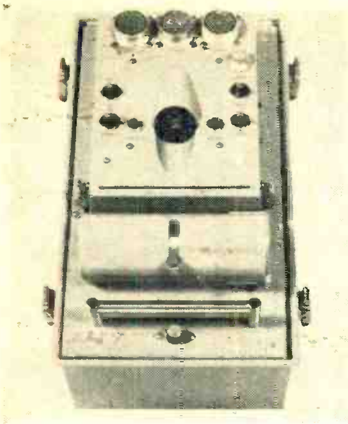


Fig. 4. Cross section of earth showing the subsurface layers and a block diagram of associated electronic instrumentation.

The recording technique actually involves frequency modulation. The amplified reflection signals frequency-modulate a high audio-frequency carrier (2-5 kc.). It is this modulated carrier that is recorded on the tape. This FM technique results in a better recording than would be obtained if no modulating system were used. It also eliminates the need for a bias signal which is usually required in magnetic tape recording systems to reduce distortion inherent in magnetic recording. Although FM is generally favored, standard magnetic tape biasing techniques are also used successfully in recording systems of this type.

A typical FM modulator consists of a free-running multivibrator which oscillates at a frequency of 4 kc. The frequency of this oscillator is dependent upon the *RC* time constant used in the grid circuits. This oscillator is frequency-modulated by the reflection signals. A tube acting as a variable resistance is connected in the grid circuit. As the incoming reflection signals are applied to this tube, its resistance changes, thus changing the circuit time constant and the frequency of the oscillator.

The FM signal from the playback head is amplified and clipped and made into a varying-frequency rectangular wave. It is then differentiated and the resulting spikes trigger a monostable multivibrator. One fixed-amplitude, constant-duration pulse is produced by the monostable circuit for each



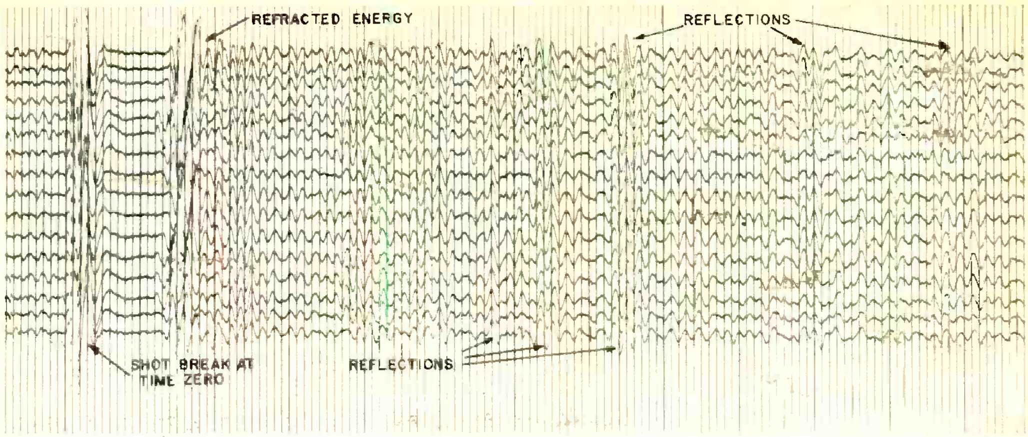


Fig. 5. (Left) A recording oscillograph of the type that is employed to produce seismic records for use in oil exploration. (Right) Typical seismic reflection record. Artificially induced shot break indicates when seismic energy was first radiated. Refracted energy is the first arrival of seismic signal at the geophones. This is energy refracted from the first high-velocity zone below the surface. The reflections indicate a change in velocity or the boundaries of reflecting layers. Reflections are picked by noting where the signals of each trace line up or where the peaks and troughs appear to fit into one another. Other reflections besides the ones that are obvious in this figure can be picked by close observation.

trigger spike. The pulses are then integrated or averaged in a suitable low-pass filter. The output is the original geophysical signal.

After the reflection signals have been recorded, they can be processed in various ways. Mixing (compositing) and filtering are the most commonly used processes, and both methods improve the signal-to-noise ratio.

After a number of shots have been recorded, the resulting reflection signals can be mixed together. The reflection signals may be obscured by noise in all of the recordings, but because the noise tends to be random it will cancel to some extent. The reflection signals, however, being the same on each record, will add. Practice has shown that the signal-to-noise ratio improves approximately as the square root of the number of records composited. Each trace in Fig. 5, for example, is actually a composite of 320 individual records.

In addition to the filtering in the geophysical amplifiers, special filters are used in cases where the signal-to-noise ratio is low. These filters have many configurations and are largely of the analog type. Digital-filtering techniques have also been developed. Because of the transient nature of seismic signals, filter requirements are rigid and care must be taken to see that the filter does not distort the signals and give false results.

In addition to filtering and mixing, processing also includes corrections. In order for the geophysicist to obtain a true picture of the various subsurface layers, there are certain characteristics of the earth that must be taken into consideration.

The uppermost layer of the earth, the weathered layer, will give false reflection data if it is not corrected. Since it varies in thickness with location, information regarding this weathered layer must be obtained before suitable reflection data can be obtained.

Ground elevation and geophone placement must also be considered. Since the geophones are spread over a large area, the elevation may be different for some geophones than for others. Also the distance between the signal radiator and the geophones may be changed during the shooting. Corrections must be made. Other corrections of various kinds must also be made depending on the equipment and methods used.

Obtaining the Information

To obtain information about the oil-bearing properties of a particular part of the earth, a crew of men is sent into the field along with the equipment just described. Since all of the work is done in the field, the equipment must be portable. It is made so by mounting it in trucks. For dynamite operations, shot-hole drilling apparatus must be taken, and with the weight-drop technique, a large truck must be provided to carry the weight and its associated equipment.

An instrument or recording truck carries most of the electronics. The recording equipment and amplifiers are mounted in this truck. Because of the complexity of this truck, a skilled electronics field technician must be present to set up, operate, and maintain this unit in the field.

The equipment used in oil exploration is sometimes mounted in boats so that water areas may be worked. Many oil discoveries have been made beneath large bodies of water —such as the Gulf of Mexico. (*Continued on page* 88)

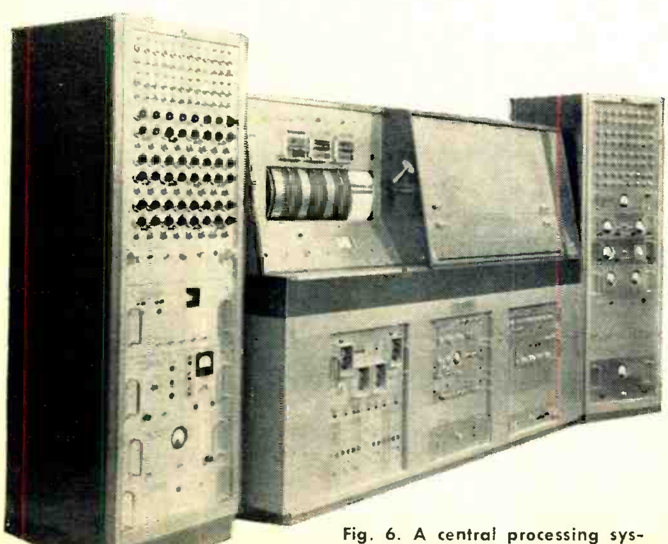
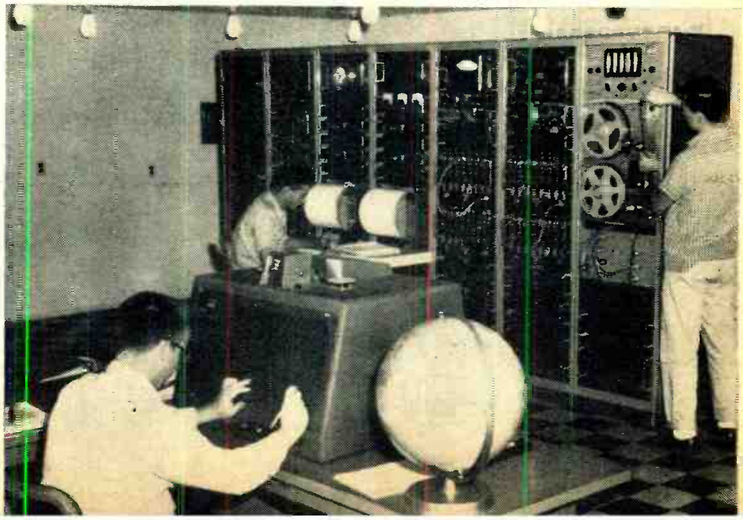


Fig. 6. A central processing system used for geophysical data.

Fig. 7. One of our nuclear explosion detection stations.



NEGATIVE-FEEDBACK NOMOGRAM

By A. L. TEUBNER

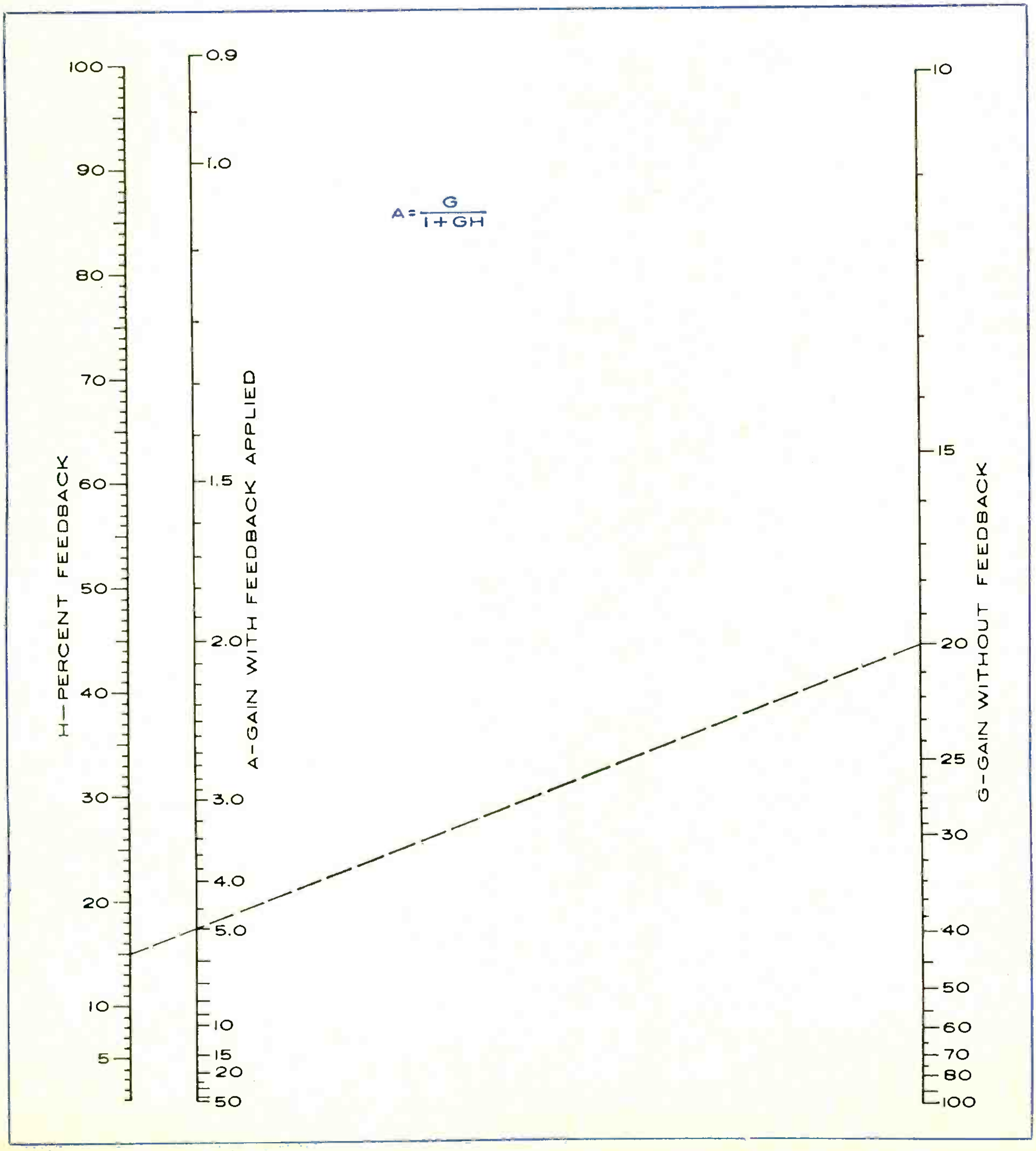
Chart employed to determine reduction in stage gain when given percent of negative feedback is applied.

THIS nomogram can be used to determine the reduction in stage gain when negative voltage feedback is applied.

If the gain of the stage without feedback and the percent of the output voltage fed back to the input are known, the over-all gain can be found simply by laying a straightedge on the chart.

For the example already drawn on the nomogram, the stage gain without feedback, *G*, is 20 and the feedback percentage, *H*, is 15%. If 20 on the "*G*" scale and 15 on the "*H*" scale are connected by a straight line, the line will cross the "*A*" scale at 5, the gain with feedback applied.

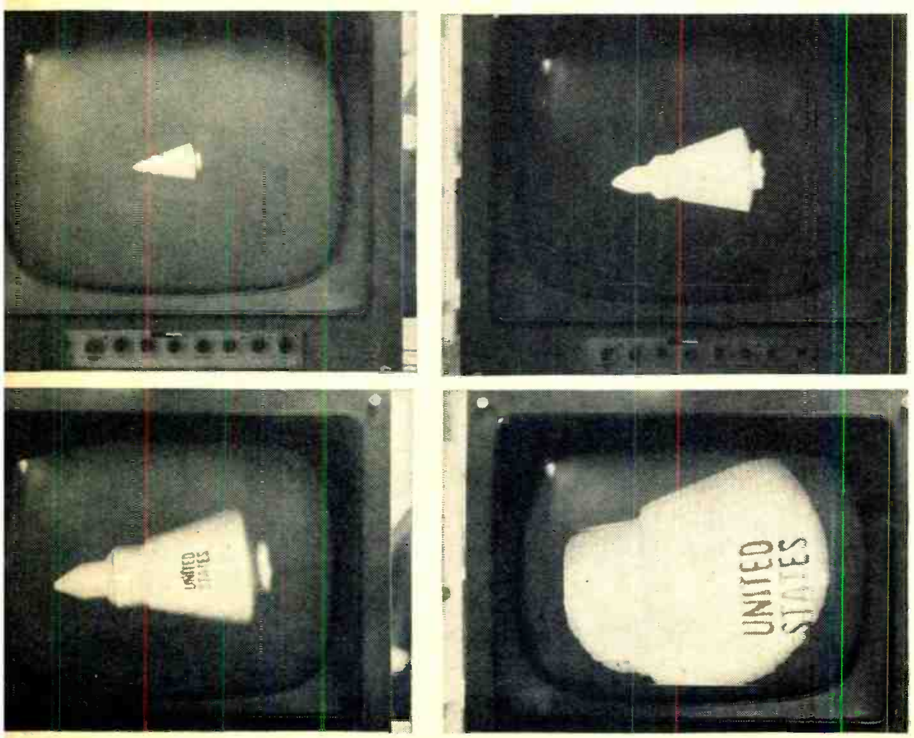
This chart provides an accurate result for a purely resistive feedback network. If the network contains reactances which produce an appreciable amount of phase shift, the over-all gain cannot be found by such a simple formula. ▲

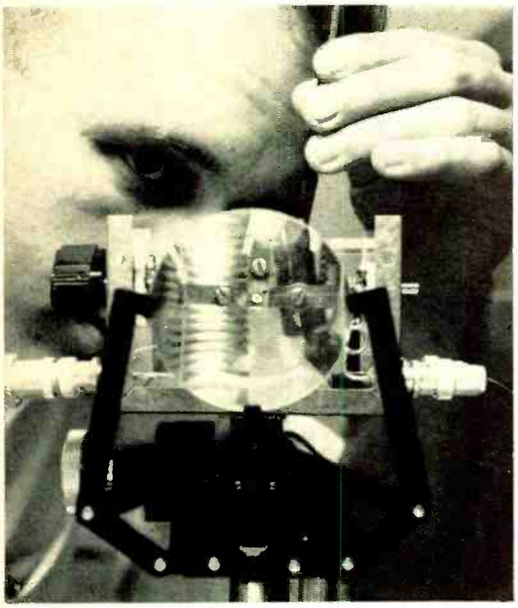


RECENT DEVELOPMENTS in ELECTRONICS

Microminiature I.F. Amplifier. (Above) The tiny i.f. amplifier shown magnified in the foreground was developed by ITT to replace a comparable electron-tube unit being held at the left. The miniature transistorized device is 100 times smaller than the predecessor unit and was made by depositing thin films of conducting, insulating, and semiconducting material on top of each other. For use at intermediate frequencies employed in beyond-the-horizon and satellite communications equipment, the new amplifier weighs but a quarter ounce. It consists of four transistors, a dozen capacitors, sixteen resistors, and associated wiring.

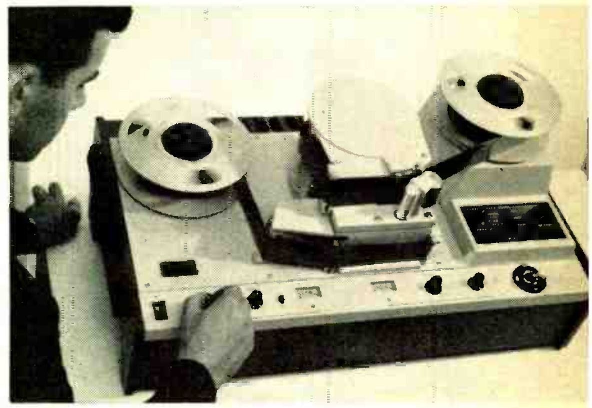
Space Flight Via Computer. (Left) Two research engineers watch a rendezvous and docking maneuver in a simulated space flight at General Dynamics laboratory. The television monitor at the far left is similar to one in the company's manned spacecraft simulator, located in another building. The tiny model in front of the screen is pictured by a "zoom" lens running on tracks between the two engineers. The lens is moved back and forth to decrease or increase the size of the image. A computer is employed to "instruct" the lens-driving system. The view that the spacecraft pilot sees in his simulator's TV monitor is shown below. This equipment is being used in a training program to help establish procedures by which astronauts or trainees can: (1) be screened for flight ability under conditions resembling an actual space mission; (2) practice manipulation of controls such as would be required in actual flight; and (3) possibly discover before a flight whether a proposed mission is feasible or not.

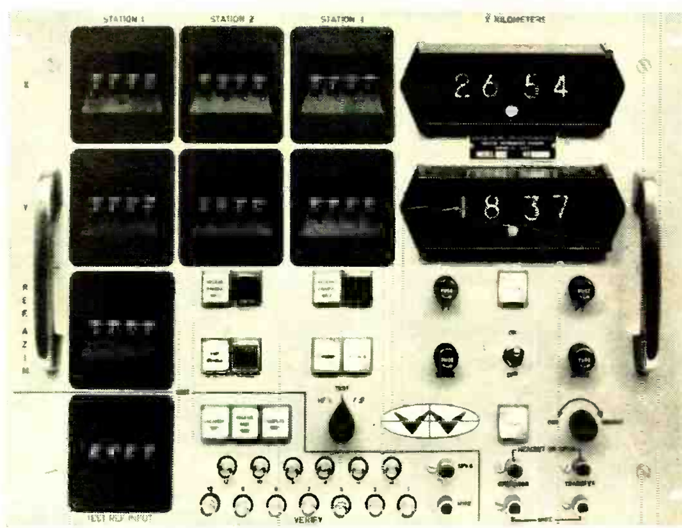




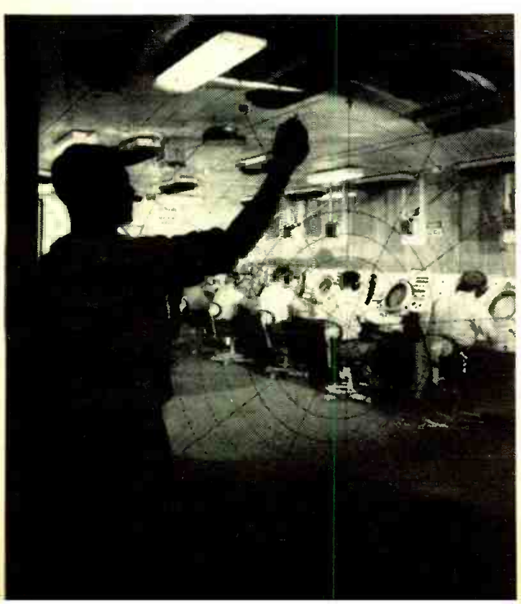
Booster for Lasers. (Above) The small white dot framed in the lens in a combination photodetector-parametric amplifier which Sperry Rand claims will boost by 100 times the receiver sensitivity of laser communication and radar systems. First tests of the new photo-parametric diode demonstrated detection and amplification of less than one-billionth of a watt of light and a modulation frequency response from d.c. to 2000 mc. In the photo above, a technician is aligning the diode for a test in which a laser fires a beam from the position of your eye into the tiny aperture of the silicon semiconductor device. Coupled with other all-integrated, solid-state devices in a functional block, the photo-parametric diode could make up a complete optical receiver that is no bigger than a matchbox.

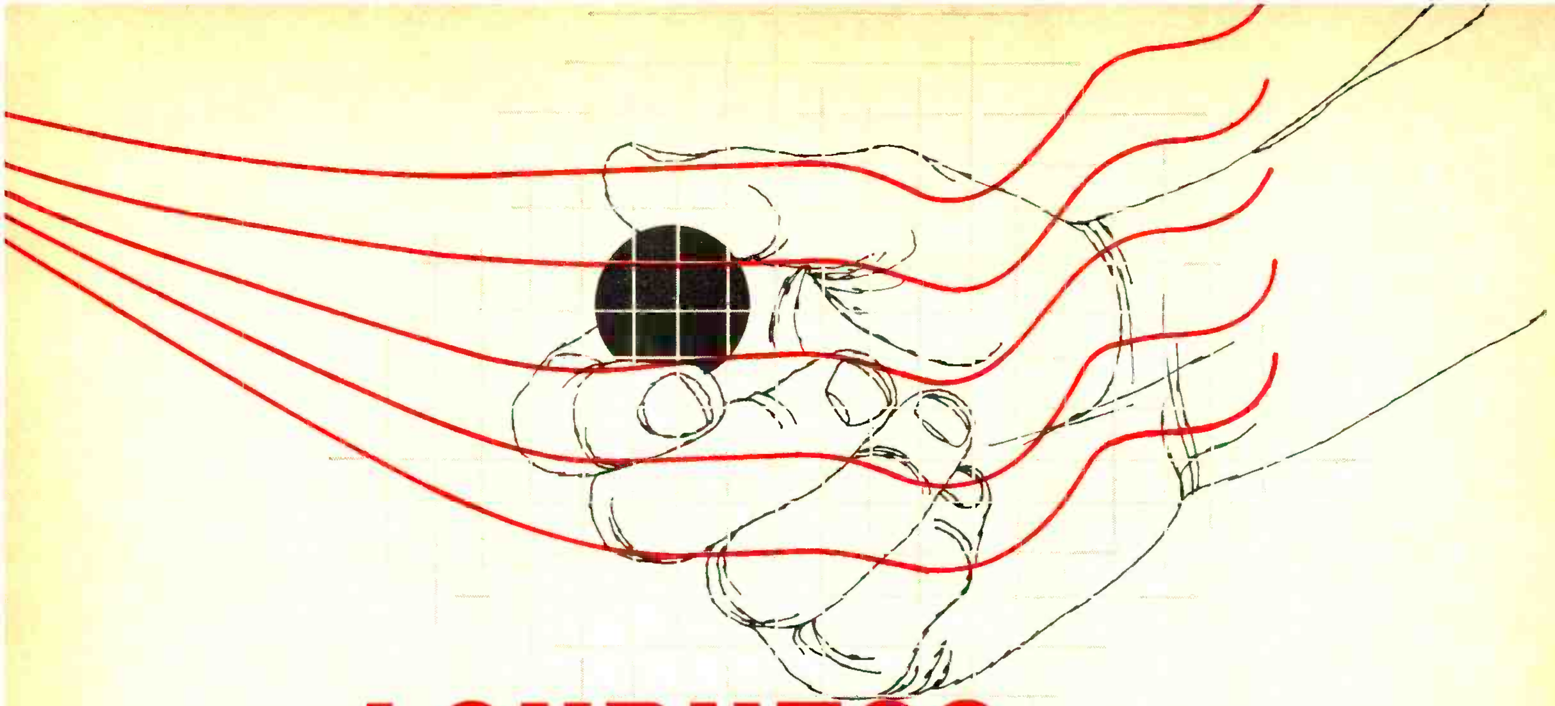
Portable Broadcast TV Tape Recorder. (Below) A new portable broadcast television tape recorder, said to be priced well below other such recorders of broadcast quality, has been introduced by Ampex. The unit weighs under 100 lbs. and is designed for mobile and studio use. Its price is $14,500 and it is completely transistorized. The unit operates at 3.75 ips and can record up to five hours of continuous program material on a single 12½-inch reel of standard 2-inch wide broadcasting video tape.





Automatic Transmitter Locator. (Above) Shown here is the front panel of the readout unit in a locator-computer system that automatically locates, tracks, and monitors distant transmitters with unprecedented accuracies. Developed by Weston, the equipment is able to pinpoint the location of a transmitter within 20 yards at a distance of 50 miles. At a similar distance, previous tactical methods would at best be expected to come within one mile. The answer to the tactical problem is solved by the computer and read out digitally on the panel. . . . **Radar-Display Consoles.** (Left) The radar detector-tracker display consoles seen through the transparent plotting board have been installed on the nuclear-powered aircraft carrier U.S.S. Enterprise. Part of the Naval Tactical Data System, these consoles display radar information which the operators enter into the computer system. The U.S.S. Enterprise is one of more than twenty Navy ships which will ultimately be equipped with the consoles designed by Hughes Aircraft.





THE LOUDNESS CONTROL

By RUDOLPH A. JACOBS, Jr.

A review of an important concept and a description of a simple circuit used for loudness compensation.

BACK in the early thirties, when the electronic reproduction of sound was in its infancy, the response characteristic of the human ear became an active subject of investigation. In 1933, the "Journal of the American Acoustical Society" published a lengthy and exhaustive paper by Fletcher and Munson containing the results of a study made in this area. Along with a great deal of other information, the paper contained a family of curves describing average human ear response *versus* frequency at different sound pressure levels. This set of curves is familiar to us as the "Fletcher-Munson Curves." (See Fig. 1.) They have been published and re-published over the years and used (sometimes misused) innumerable times. Since the correct application of the data represented by these curves is necessary in order to obtain proper tonal balance in our sound systems, let us investigate them in some detail.

The curves were obtained in the following manner: The researchers produced a tone of 1000 cps (used as their reference frequency) at a specific sound pressure level, and had a subject listen to it. They then produced a tone at another frequency and adjusted its pressure level until the subject said it sounded just as loud as the 1000-cps reference tone. The researchers recorded the sound pressure level of the new tone and then shifted to another frequency, always having the subject compare its loudness to the loudness of the 1000-cps tone. By shifting the frequency of the second tone up and down the audio range, they obtained one equal loudness contour. By repeating the test with a number of subjects they were able to approximate the response contour of the "average human ear." By shifting the sound pressure of the 1000-cps tone in ten decibel steps and repeating the whole process, they obtained equal loudness contours all the way from the threshold of audibility to the threshold of pain.

The data they obtained is far from ideal. They investigated only the region between 62 and 16,000 cps, assuming, perhaps rashly, that the response trend would continue smoothly from these frequencies to the limits of audibility. Also, they used close-fitting headsets for taking their direct data, and then attempted indirectly to convert the results to what would have been obtained by projecting the sound *via* a loudspeaker. In this rather dubious process they picked up the peculiar wiggle that appears in the mid-highs, leaving its validity subject to question. This is especially true when considering distributed or stereo-type sounds, since Fletcher and Munson themselves attributed the wiggle to diffraction patterns occurring about the head and ears of a listener facing a point-source sound reproducer.

Although the curves do have these flaws, which we should keep in mind, they still represent the best data available. Besides when we make our corrections according to their dictates, the result sounds "right" to the ear and the proof of the pudding is in the eating—so let's proceed.

Significance of Curves

Now that we have the curves, what is their significance? It is at this point that most of the misunderstandings occur. Before attempting to answer the question, let's try to pin down two elusive adjectives: "loud" and "soft." What is the power level of a "loud" musical passage? There may be momentary rests when it will drop to near zero, then leap up with an ear-splitting crash! Let us arbitrarily say that when a sustained 1000-cps tone is produced at our ear at 80 db above reference (reference level is 10^{-16} watts per square centimeter), it sounds as loud as a loud orchestral passage when we are sitting in one of the first rows of the concert hall. At the other extreme, when we are spending a quiet evening at home reading, with the baby asleep in the next room, and with our sound system adjusted for very low level background music, that same passage will sound as loud as our 1000-cps tone at 40 db above reference. These are, of course, subjective factors and individuals will vary 10 db or so in their choice of figures for "loud" and "soft," but the ones selected by the author are close enough to avoid serious objections by most people, so they will be used here.

Now that we have established the range in which we are interested, let us continue by considering a hypothetical example: The Philharmonic is performing a recently discovered work that we will entitle "Loud and Equal," in which the melody consists of a succession of tones, all sounding equally loud, running up and down the audio spectrum, with the 1000-cps tone at the 80-db level. In other words, they are creating sound pressures that exactly follow the 80-db loudness contour of Fig. 1. We are listening to the broadcast on FM at the 80-db level—just as loud as the original sound. Since the transmitting equipment, pre-emphasis network, receiving equipment, de-emphasis network, and home audio system are all naturally perfect, with tone controls flat, it sounds just like Philharmonic Hall in the parlor! We like what we hear, so we run right out and buy the record. However, night falls and out of consideration for the neighbors, we turn down the volume to the 40-db level and sit back, expecting to hear that "Equal" piece just as before, but at a nice quiet listening level.

What we have really done is taken sound pressures along the 80-db loudness contour and moved them down to the 40-db level. How does it sound? Terrible! The highs sound fine but over-all it's thin and weak—no bass. By going to Fig. 1 and superimposing the 80-db contour on the 40-db contour we can quickly see why. From 700 cps on up, the curves duplicate each other within a decibel or two, so these tones still sound about equally loud as we go from one to the other. Below 700 cps, however, a pronounced divergence begins to appear. It is apparent that, to the human ear, the loudness of bass sounds decreases faster than the loudness of treble sounds as the actual sound-pressure level is uniformly decreased. At 200 cps, we should have decreased the sound pressure 12 db less than we reduced the 1000-cps tone in order for them still to sound equally loud. At 100 cps the difference is 20 db. At 30 cps it's 30 db—a power difference of one-thousand times!

So our piece "Loud and Equal" does not sound equally loud at this lower level. In order for it to do so, we should have attentuated only those tones above 700 cps by 40 db. attenuating those below this frequency by reduced amounts: 20 db at 100 cps and only 10 db at 30 cps. What we need then is a control that will discriminate against the higher frequencies, attenuating them progressively more and more relative to the bass as we reduce the level, in other words, a uniform *loudness* control.

Now let's go a step further. We know that when we reproduce an 80-db program at an 80-db level, the sound system must be flat in order for the program to sound like the original. We have discovered that when we reproduce an 80-db program at a 40-db level, we must reduce the level of the various frequencies by the *difference* between their position on the 80-db contour and their position on the 40-db contour. Therefore, assuming that an 80-db program is the loudest material we will wish to reproduce without attenuation, and also assuming that 40 db is the maximum attenuation we will normally desire for any program, we are ready to define the characteristics of our loudness control.

Loudness-Control Characteristics

Simply enough, it will be flat when set at maximum loudness; then follow the difference between the 80-db contour and each lower contour as the level is reduced; finally reaching the difference between the 80-db and the 40-db contours at the minimum output setting. These characteristics are plotted in Fig. 2. (Note that it is the *change* in the contours of Fig. 1 that gives us Fig. 2. Do not be fooled by the uniform across-the-board treble (*Continued on page* 82)

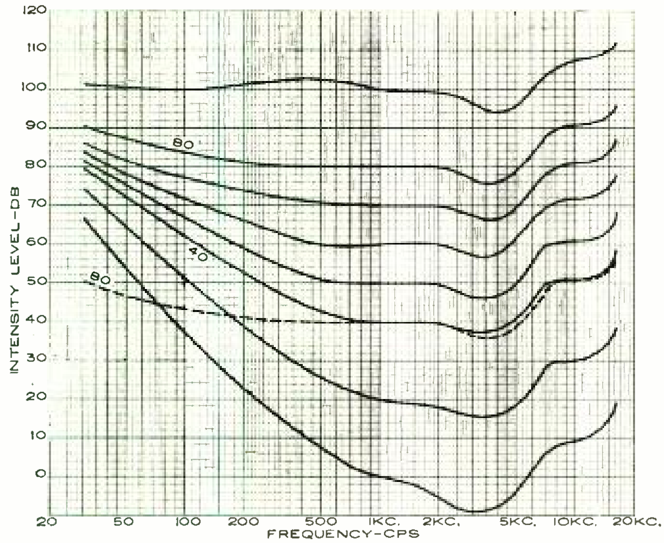


Fig. 1. The Fletcher-Munson curves of equal loudness level.

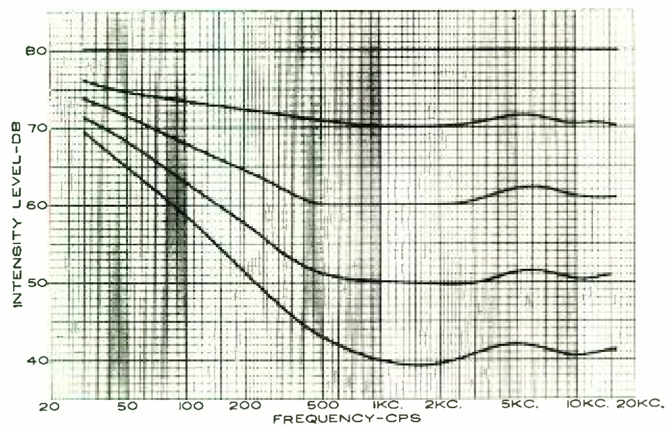


Fig. 2. Characteristic curves for loudness correction attenuator.

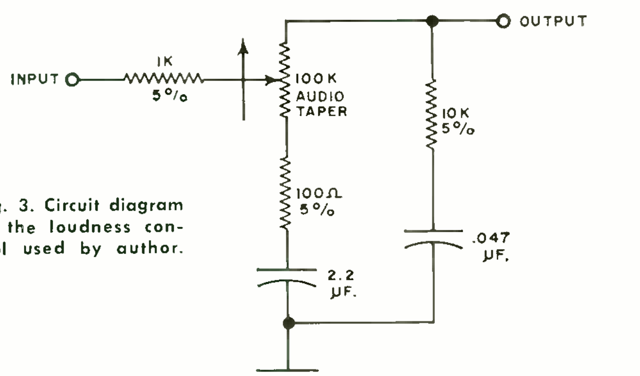
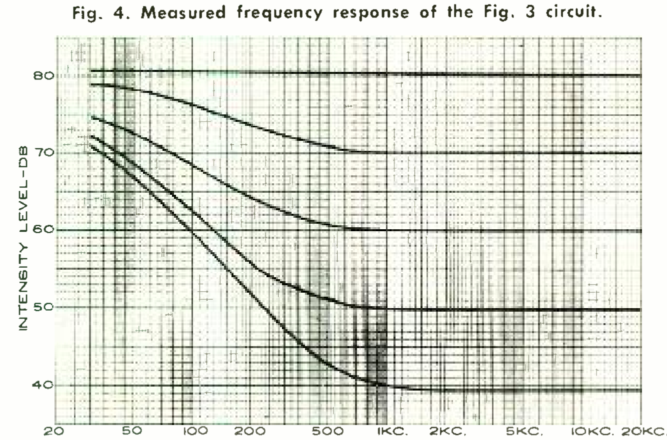


Fig. 3. Circuit diagram of the loudness control used by author.

Fig. 4. Measured frequency response of the Fig. 3 circuit.



SIMPLE TESTS for SEMICONDUCTORS

By CARL DAVID TODD / Head of Engineering, Modular Circuits, Hughes Aircraft Co.

Here are several ways to check leakage, gain, saturation, and breakdown voltages with equipment normally at hand in the average laboratory.

HOW many times have you wished you could perform a few basic tests on a transistor or diode? Perhaps you wanted to make sure that it was still good after that test, or maybe you wanted to know the value of some critical parameter. While there are several different types of simple testers on the market, it may be that the amount of testing that you do does not justify their purchase. This is particularly true where measurement of the relatively low-leakage currents of silicon transistors and diodes is concerned.

In some cases, it is desirable to perform a few basic tests on all transistors and diodes to be installed in a piece of equipment. There may be quite a few units that you would like to test in a minimum amount of time, but you cannot purchase an automatic test set to satisfy your temporary requirement.

This article discusses several ways in which parameters such as leakage currents, d.c. current gain, saturation voltage, and breakdown voltages may be measured with equipment normally on hand in the average electronics laboratory. In spite of the basic simplicity of the tests, the accuracies obtained are usually more than adequate. Some of the tests will be of the *go/no-go* type while others will yield quantitative results. Both tests are equally simple to make.

Leakage Currents

Let us first consider the measurement of leakage current since this one parameter is perhaps the most revealing with regard to damage or deterioration. A voltage is applied to two of the terminals and the resulting current is measured. One approach which gives a quantitative result is shown in Fig. 1A.

Voltage source $E1$ represents the required test voltage to be applied between the collector and base terminals (for the case for I_{CBO} as shown). Actually, $E1$ should be set to about 0.7 v. higher than the required test value to allow some drop across the current meter. A v.t.v.m. may be used to measure current by placing a shunting resistor across its terminals as shown. For example: $R1$ of 1000 ohms would give a full-scale current of 1.5 ma. (using the 1.5-v. scale on the meter). Full-scale currents of 150 μa. and 15 μa. may be obtained using values of $R1$ of 10,000 and 100,000 ohms respectively. As we increase the sensitivity to 1.5 μa. and 150 nanoamperes (na.), we must also include the input resistance of the v.t.v.m. (usually around 11 megohms) when we determine the value of $R1$. Thus, for 1.5 μa. full-scale, $R1$ should be 1.1 megohm and for 150 na. $R1$ should be 110 megohms (made up of five 22-megohm resistors in series).

Since the value of leakage current varies about 10 percent per degree centigrade, it serves little purpose to have a very accurate means of measurement and the approach described above yields adequate results. The actual test voltage will vary somewhat depending upon the voltage drop across the v.t.v.m.; however, this variation is normally small in comparison to the specified test voltage and hence contributes negligible error.

In the case of severe overload, that is, if the leakage current is quite a bit higher than expected, neither the transistor nor the meter will be damaged since the usual v.t.v.m. is capable of standing rather high overvoltages without harm and the measurement resistor serves to limit the current flow through the device under test.

Where many transistors or diodes must be tested on a *go/no-go* basis to a given specification, it is possible to use a different arrangement which yields a minimum amount of operator decision and hence requires much less test time. The over-all reliability of the test results is also increased.

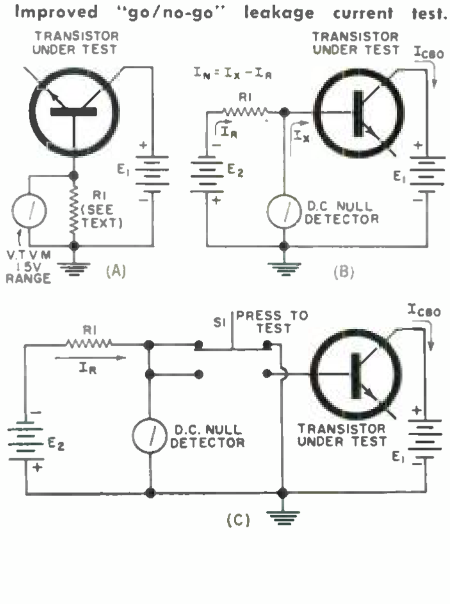
Fig. 1B illustrates the basic leakage current measurement where a *go/no-go* test result is required. Voltage supply $E1$ provides the required test voltage across the collector-base diode (for the I_{CBO} case shown). Another voltage source, $E2$, in conjunction with resistor $R1$ produces a reference current which is made equal to the current test limit. The voltage across the d.c. null detector is assumed to be insignificant with respect to the voltages $E1$ and $E2$. The value of $R1$ required is $E2$ divided by the limit test current.

The current flowing into the d.c. null detector is the net difference between the unknown current, I_X (which for the example shown is I_{CBO}) and I_R, the reference current. Thus, as long as I_X is less than the test limit, the net current, I_N, flowing into the null detector will be negative. However, as the value of I_X is increased, the net current approaches zero until I_X is exactly equal to the set limit current. Above this value, the net current into the null detector becomes positive.

Using the *go/no-go* approach, it is only necessary to note which direction the null detector moves to determine whether the leakage current for the transistor under test is less than or greater than the test limit.

The sensitivity of the null detector required depends on the magnitude of the limit current. For example, the normal v.t.v.m. with 11-megohm input resistance and a 1- or 1.5-v. range may be used for test currents down to about 15 na. For lower currents, a d.c. millivoltmeter, such as the *Dynamics* Model 4472, or a sensitive current meter such as the *General Radio* Type 1230-A or the *Hewlett-Packard* Model 425A, may be used. The null detector current sensitivity should be better than one-tenth of the limit current.

Fig. 1. (A) Basic quantitative leakage current measurements for I_{CBO}. (B) Basic "go/no-go" leakage current measurement for I_{CBO}. (C) Improved "go/no-go" leakage current test.



Using electronic meters, the circuit is capable of withstanding a substantial overload as was true in the previous quantitative measurement. It may be wise to place a momentary switch in series with the unknown leakage current path in such a manner that the null detector is shunted to ground as shown in Fig. 1C. After the transistor is inserted into the socket, switch S1 is depressed and the circuit is as given in Fig. 1B.

The improved circuit has several advantages over the more basic circuit. First, an overload will normally occur in the meter of Fig. 1B until the transistor is inserted and this may produce an appreciable delay in the reading. The meter of Fig. 1C always starts out from zero such that no overload is present and any zero drift is immediately seen. Furthermore, any severe overload produced by a faulty component under test will be noticed as soon as S1 is depressed and hence may be removed rapidly (before the meter pins for most cases). Finally, the sensitivity of detection is increased since the operator merely looks for a minor meter movement as a direct result of depressing S1.

The basic circuits of Figs. 1A and 1C may be modified to measure any of the standard leakage currents illustrated in Fig. 2. Although all examples show the testing of an *n-p-n* transistor, *p-n-p* transistors may likewise be tested merely by reversing all polarities.

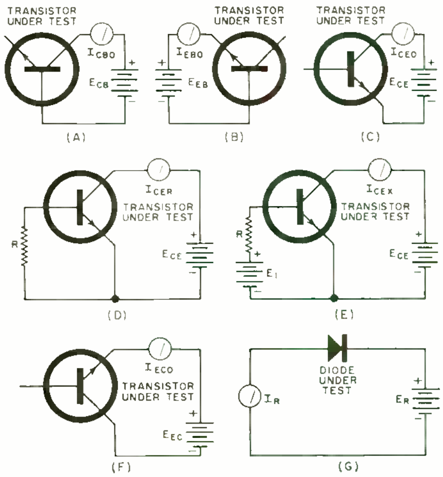


Fig. 2. Simplified measurement circuits are used for various leakage current parameters.

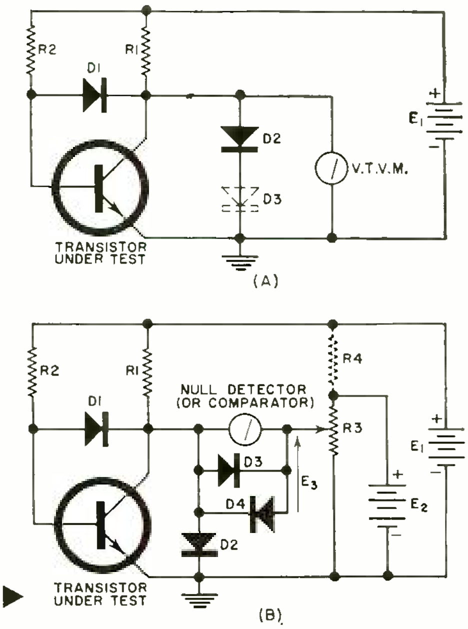


Fig. 3. (A) Quantitative $V_{CE(sat)}$ measurement. (B) For "go/no-go" $V_{CE(sat)}$ readings. ▶

The above circuits may also be used for measuring leakage currents of switches, printed circuits, or ceramic or paper capacitors. Enough time must be allowed to charge the capacitors before such a reading is taken.

Saturation Voltages

Saturation voltage of a transistor is measured with the transistor driven by a constant collector current and a constant base current. The ratio of I_C to I_B is made considerably lower than the natural d.c. current gain of the common emitter stage. In some switching applications, $V_{CE\ (sat)}$ is a very important parameter.

Measuring $V_{CE\ (sat)}$ is very simple in its basic form since it is only necessary to provide two current sources with an output voltage variation of only a volt or so. This means that a 100-volt source used with appropriate resistors will yield excellent results. The value of $V_{CE\ (sat)}$ is then the collector-to-emitter voltage under this bias condition.

To prevent the possibility of transistor damage which might result from an increase in power dissipation for a transistor which does not fully saturate, and for operator protection against electrical shock, a sampling arrangement should be used. One complete arrangement is given in Fig. 3A for the quantitative measurement of $V_{CE\ (sat)}$.

$E1$ in conjunction with resistors $R1$ and $R2$ provides the two constant-current biases I_C and I_B respectively. The resistor values are determined from the following:

$$R1 = (E1 - V_{CE\ (sat)\ Limit}) / I_C \approx E1/I_C \qquad (1)$$

$$R2 = (E1 - V_{BE})/I_B \approx (E1 - 0.5)/I_B \approx E1/I_B \qquad (2)$$

Diode $D2$ serves to limit the collector voltage to about 0.7 v. if a silicon diode is used. Below about 0.5 v., where many saturation voltage measurements are specified, the diode conducts practically no current at all, but as the collector voltage rises above this value, the diode will conduct. For $V_{CE\ (sat)}$ measurements above 0.5 v., it may be necessary to add a second diode, $D3$, in series with $D2$.

Silicon diode $D1$ prevents the base from going more positive than the collector by more than 0.7 volt. Since the collector is clamped, then the base will also be held to a voltage of about 1.4 volts or so. In some cases, it may be necessary to use two diodes in place of $D1$ if the difference between V_{BE} and $V_{CE\ (sat)}$ should be greater than about 0.5 v.

A test arrangement to yield attribute or *go/no-go* operation is shown in Fig. 3B. It is the same as the quantitative approach except for a modification in the readout circuitry. The v.t.v.m. is replaced by a null detector or comparator which is used to compare the actual $V_{CE\ (sat)}$ with a reference voltage $E3$ which is set to the desired rejection limit value.

For value of $V_{CE\ (sat)}$ exactly equal to the limit value $E3$, the null detector voltage will be zero. As $V_{CE\ (sat)}$ is varied above or below the limit value, the null detector voltage will change from one polarity to another. Using a sensitive null detector, rapid testing of $V_{CE\ (sat)}$ may be performed.

Clamping is accomplished as before for the transistor but two germanium diodes, $D3$ and $D4$, limit the voltage across the detector when $V_{CE\ (sat)}$ is excessively high or very low.

The reference voltage, $E3$, may be derived from $E2$ as shown, or from the main supply $E1$ as shown by the dotted lines. It should be adjusted with a resistor equal to the ratio of the limit saturation voltage to the value of I_C, or with the null detector and clamps removed.

The forward voltage of a diode may be measured in a test configuration very similar to that of Fig. 3, with the base current supply and clamping diode removed.

D.C. Current Gain

The d.c. current gain, or more properly, the d.c. current transfer ratio, is another very important parameter not only for d.c. switching and control circuits, but also for the proper biasing of small-signal a.c. circuits. In addition, the a.c. current transfer ratio and its d.c. counterpart have some fair amount of correlation and, since a.c. current gains are more difficult to measure, a simple d.c. measurement may be used to test the transistor. By far the more common parameter is h_{FE}, the d.c. current transfer ratio of the transistor in the common-emitter configuration.

By definition h_{FE} is merely the direct ratio of the collector current, I_C, to the base current, I_B, for a given set of bias conditions (normally a fixed V_{CE} and I_C). It would, at first thought, seem the natural procedure to set up the bias arrangement and then measure I_C and I_B by means of milliammeters and then taking the required ratio. The resulting test accuracy is very poor, and two rather expensive meters are required for precision better than ± 20%. There are several methods that yield much better results with less costly equipment and without the necessary calculations. It is possible to design a production *go/no-go* arrangement which even eliminates the necessary individual adjustment of the bias. We will now consider several of these approaches.

The simple arrangement of Fig. 4A illustrates a test circuit which will allow the quantitative measurement of h_{FE}. $E2$ supplies the base current and $E1$ supplies the bias for the collector circuit. $E2$ is adjusted until the meter reads full scale. This sets the collector current by using the meter

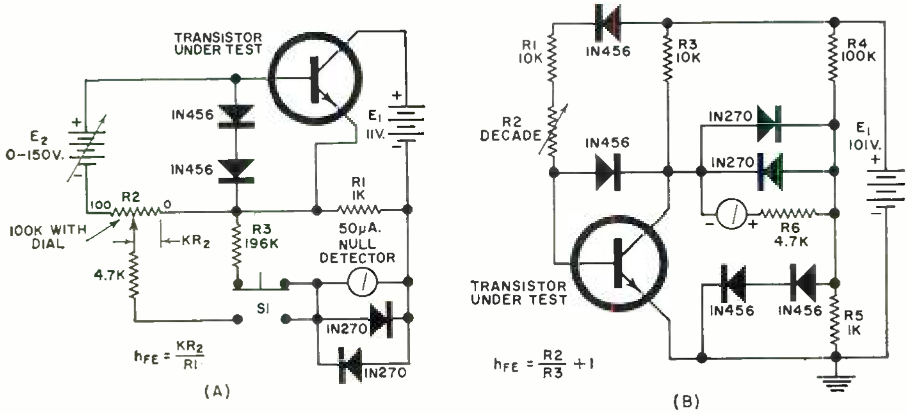


Fig. 4. (A) Simplified quantitative h_{FE} measurement circuit while the test set circuit of (B) can be used for quantitative or "go/no-go" h_{FE} measurements.

as a voltmeter across *R*1 and, with *E*1 set to a constant value, the collector-emitter voltage must also be fixed at a value equal to the difference between *E*1 and the measured drop across *R*1. For the circuit of Fig. 4A, the bias point is 10 ma. collector current and V_{CE} of 1 volt.

Switch *S*1 is now depressed and potentiometer *R*2 adjusted until the meter indicates a null or zero-current reading. The value of h_{FE} is then read off the multi-turn dial of *R*2. This technique is capable of very high accuracy.

A second circuit which may be used for either quantitative or attribute testing of h_{FE} is shown in Fig. 4B. A single voltage supply is used with two resistor networks to provide the base and collector currents. The collector current will be determined by the ratio of $(E1 - V_{CE})$ to *R*3. The meter acts as a d.c. null detector to compare V_{CE} with a reference voltage determined by voltage divider *R*4 and *R*5. The operating conditions for the particular circuit of Fig. 4B are again 10 ma. for I_C and 1 volt for V_{CE}.

The base current is provided by the resistor network consisting of *R*1 and *R*2 and will be equal to $(E1 - V_{BE}/(R1 + R2)$. For silicon transistors, the value of V_{BE} will be in the neighborhood of 0.8 to 1 volt, or approximately equal to V_{CE}. Under this condition, the value of h_{FE} will be equal to $(R1 + R2)/R3$ and since *R*1 and *R*3 are made equal, h_{FE} is equal to $(R2/R3) + 1$. Furthermore, h_{FE} will be directly available from the dial of the decade resistor. A resistance of 100,000 ohms, for example, will indicate an h_{FE} of 10 + 1 or 11. If the resistance required to cause a meter null is 900,000 ohms, then h_{FE} is 90 + 1 or 91. This circuit has the advantage over the previous one in that the same adjustment that sets the bias condition is also the one that provides the answer. Actually, resistor *R*1 is not required in the circuit from a theoretical standpoint and, in fact, the readout procedure would be much simpler if it were not present (h_{FE} would then be merely *R*2/*R*3). R1 has been inserted as a means of protecting the transistor under test, the power supply, and the decade box should the resistance value of *R*2 accidentally be made too low. It seems much easier to add the extra unit onto the value of h_{FE} than to replace the transistor or decade box.

The circuit of Fig. 4B may be used to provide a quantitative answer of the value of h_{FE} by adjusting *R*2 until the meter indicates a null or minimum reading, then reading the value of h_{FE} from the dial of *R*2 (being sure to add the extra 1).

The same circuitry may be used as a *go/no-go* test set by setting *R*2 to the proper value and then merely noting the position of the meter pointer. If an up-scale reading is obtained for the circuit shown, this indicates that the actual value of h_{FE} is higher than the set value. On the other hand, if the reading is down-scale, this indicates that the actual value of h_{FE} is less than the value of the test limit.

A word of caution should be injected here concerning some h_{FE} specifications in which the conditions call for a pulsed measurement. This is a difficult test to perform and while the measurement might be attempted on a straight d.c. basis, we must be absolutely certain that the power rating of the transistor is not exceeded. The value of h_{FE} obtained in the straight d.c. manner will be somewhat higher than that obtained from the pulse measurement.

Breakdown Voltages

Measurement of the various breakdown voltages of transistors and diodes may be accomplished in one of two ways. A simple voltage supply and meter arrangement, as shown in Fig. 5A, may be used to give approximate results if *E*1 is very much larger than the breakdown voltage of the transistor under test. Resistor *R*1 is chosen to limit the maximum amount of current which may flow in the transistor. For many breakdown voltage measurements, particularly for silicon devices, a current level may be varied somewhat without changing the resulting breakdown voltage appreciably.

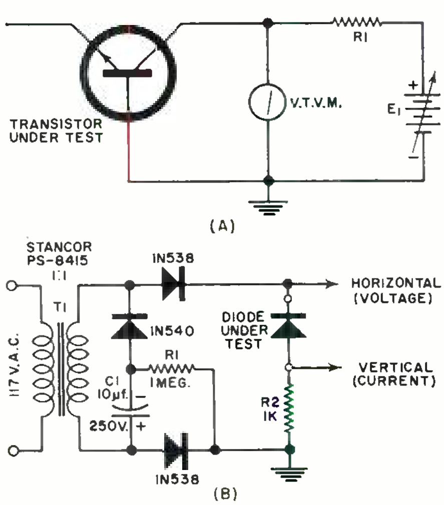
A second method of measuring the breakdown voltage is by observing the voltage-current electrical characteristics on a curve tracer. Fig. 5B illustrates a very simple circuit which can be used for this purpose. A self-limiting circuit has been included to control the maximum amount of current that may flow. For the circuit values shown, limiting will begin to occur at 150 µa. If *R*1 is reduced to 100,000 ohms, then limiting will begin to occur at roughly 1.5 ma. The brightness of the trace on the oscilloscope screen will not be uniform because of the nature of the sweep, but an indication of the sharpness of the breakdown characteristic may be observed as well as measuring the breakdown voltage for a given value of current.

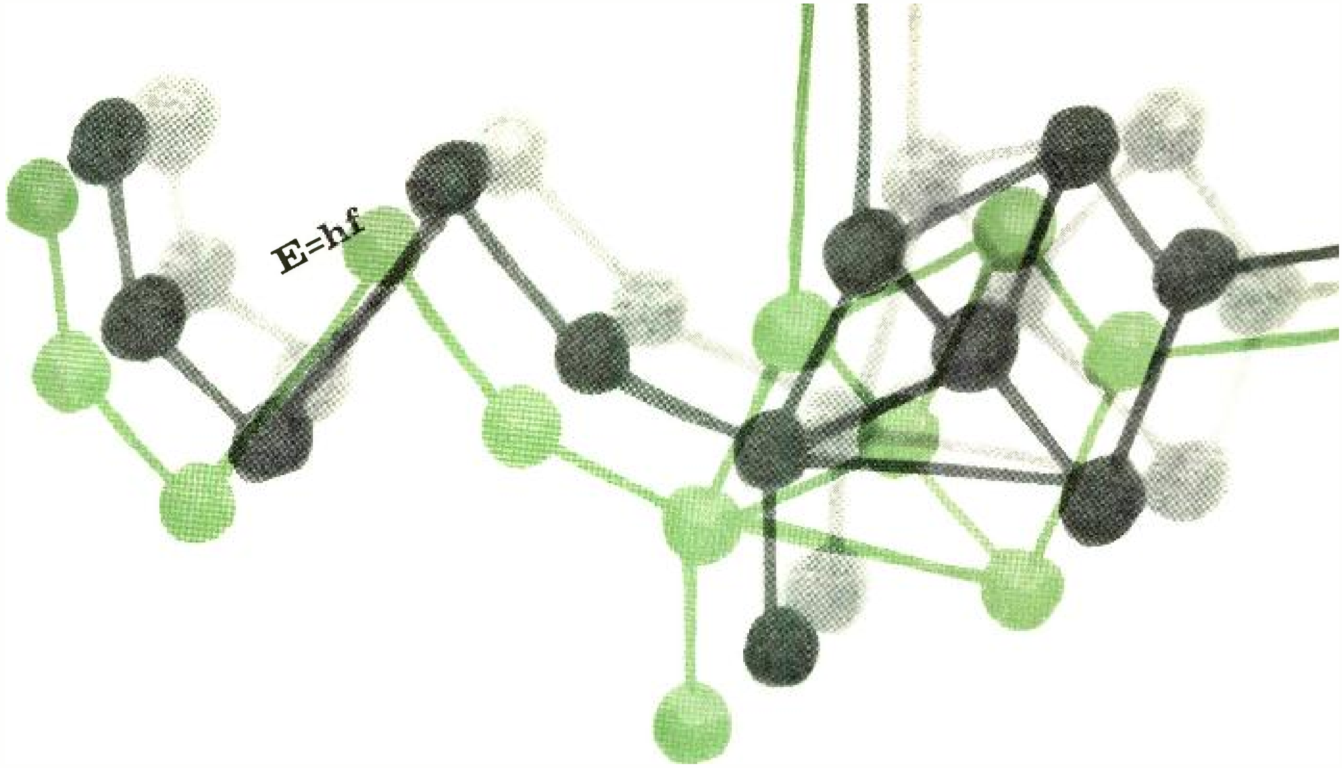
Specific breakdown voltages are much like the leakage current parameters indicated in Fig. 2. For example, we might measure BV_{CEO} by connecting the breakdown measurement terminals between the collector and the emitter, leaving the base terminal open.

In this article, we have considered simple ways to measure several of the more important, or at least more revealing parameters of transistors and diodes. While basic in nature, the techniques presented here yield accuracies equal to or better than many of the much more expensive commercial test sets available and require very little time to set up in the usual electronics laboratory or even service shop. We have not covered every possible detail but information has been presented which, when mixed with a small amount of thought and common sense, will allow valuable quantitative measurements to be taken, the economical testing of semiconductor devices on an incoming inspection basis, or the determination of possible damage to either a transistor or diode.

All of the circuits shown in this article have been bread-boarded and have been used many times with good results. ▲

Fig. 5. (A) Measurement of BV_{CBO} breakdown voltages. (B) Curve tracer for displaying breakdown voltages on oscilloscope.





QUANTUM DEVICES/how they work

By JOHN R. COLLINS

When certain molecules are excited by electromagnetic radiations, they change energy levels. When they drop back to their previous levels, they give up energy. This is basis for masers, lasers, atomic clocks.

SEVERAL striking developments in the past few years have advanced electronics in a sort of quantum jump —to use an expression that is becoming commonplace. It is especially appropriate here because many new devices are outgrowths of the quantum theory, which, although more than half a century old, is just beginning to be exploited.

The most familiar of the new quantum devices are the maser and laser, which embody entirely new principles of amplification for microwaves and light rays. In addition, there are molecular and atomic clocks with accuracies better than 1 second in 40 years, the tunnel diode which can amplify or oscillate in the gigacycle region, and certain spectrometers capable of making detailed chemical analysis of compounds by electronic means.

Much of the quantum theory is hard to visualize or to represent with mechanical models. Electronics has come a long way since water tanks represented voltage, narrow pipes portrayed resistors, and walking on a garden hose illustrated modulation of d.c. with a.c. Moreover, the quantum theory is not a single rule like Ohm's Law, but an accumulation of information about the atom that fills many volumes. While the theory is definitely an area for specialists, its impact on modern electronics has been so great that no technician who wants to understand the newest equipment can afford to remain ignorant of this phenomenon.

Energy Levels

Conventional electron devices, such as electron tubes, function by means of the effect of an electrostatic field on the movement of charged particles, usually electrons. Quantum devices, however, utilize changes that take place *inside* particles owing to the effect of an electromagnetic field on their internal structure. The particles may be either molecules, atoms, or ions. In the following discussion, the term molecule is used to denote any of the three kinds of particles.

Molecules are made up of electrons and atomic nuclei which, according to the quantum theory, can assume only certain fixed motions and orientations. Each set of motions or orientations is associated with a discrete amount of internal energy called the "energy level" (Fig. 1). At any given instant, a molecule may be at any one of a number of possible energy levels. It cannot exist anywhere in between. The fact that it jumps from one level to another is the origin of the so-called quantum jump. When a molecule jumps from a lower to a higher energy level, it absorbs energy and is said to become excited. When it drops to a lower level, it gives up energy.

A natural question is, "What takes place inside the molecule when energy is absorbed or emitted?"

There is no simple answer to explain all changes in energy levels. In some instances, the absorption of energy is accompanied by the transition of an electron from its usual orbit to a new orbit more remote from the nucleus. An equal amount of energy is emitted when the electron returns to its original orbit.

A second type of transition involves atoms having unpaired electrons. Each individual electron may be viewed as a small, spinning magnet with a north and south pole. In most substances, electrons are paired off with their poles opposite to each other, so that their magnetic fields are cancelled. In a few substances, however, cancellation is incomplete, leaving an unpaired electron in each atom.

When such substances are placed in a magnetic field, the unpaired electrons can have just one of two positions—a lower energy state in which the electron's north pole points in the direction of the magnetic field, or a higher energy state in which its south pole is in the direction of the field. The frequency at which energy is absorbed or emitted in this kind of transition is directly proportional to the strength of the external magnetic field.

In a third case, energy transitions may be accompanied by changes in the relative positions of elements making up a molecule. The ammonia molecule (NH_3), for example, is shaped like a pyramid, with an atom of nitrogen at the apex and a hydrogen atom at each of the three corners of the base. When excited, the nitrogen atom apparently drops through the base to the other side, inverting the pyramid.

Regardless of the reasons, however, the important point is that molecules will absorb and emit energy in fixed amounts, and the transition from one level to another is not smooth, but takes on the appearance of a jump.

Planck's Constant

Although the absorption and emission of energy by various substances had been observed for some time, it was not until 1900 that Max Planck made the important discovery that a fixed relationship exists between the energy and the frequency of the radiation. At the time Planck was studying radiation of energy from a hot object. He noted that the amount of radiant energy emitted at each wavelength from the ultraviolet to the infrared could be obtained by multiplying the frequency of the radiation by a constant amount of h, equal to 4.13 x 10^{-15} electron-volt-second. His discovery is expressed by the formula $E = hf$ where E in this case stands for energy, not voltage, and f is frequency.

Just as Einstein found a way of expressing energy in terms of mass, Planck's formula provides a means of expressing energy in terms of frequency. Although the theory started with Planck, its further development was carried out by many of the greatest scientists and physicists of this century, including Einstein, Pauli, Rutherford, and Heisenberg. It was soon found that Planck's formula applies not only to energy emitted from a hot object, but to the entire electromagnetic spectrum. It should be noted that Planck's constant is exceedingly small and therefore the amount of energy involved becomes appreciable only at the upper end of the spectrum—that is, in the region of microwaves, x-rays, and light.

Since h is a constant, Planck's formula implies that energy E is always absorbed or emitted in discrete packets or quanta which are called photons. A photon is equal to the product of its characteristic frequency f and the constant h. Since frequency may vary over a wide range, all photons are obviously not of equal energy. However, in no case is energy emitted or absorbed in a fraction of a photon.

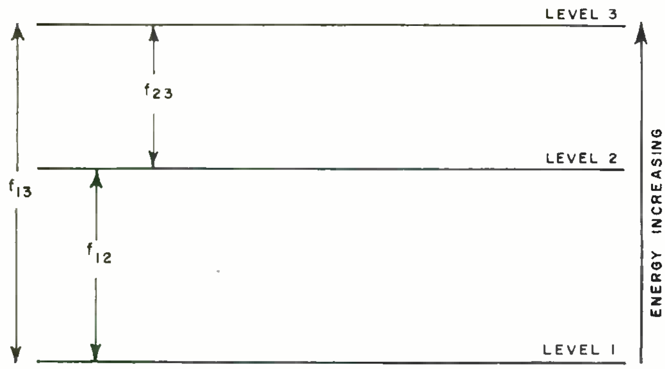
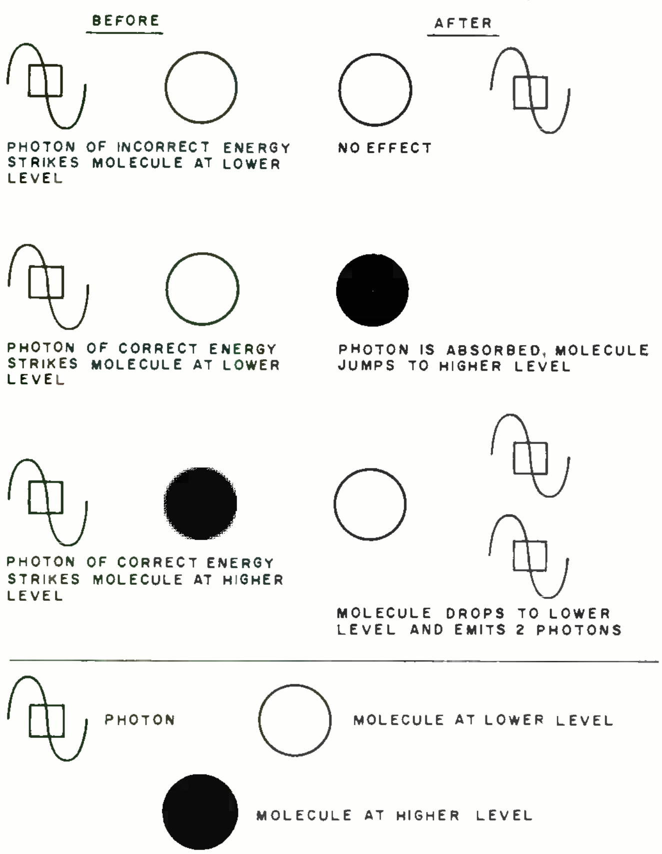


Fig. 1. Among the three energy levels in a molecule, the energy difference between each level is related to characteristic frequency. For example, f_{23} is the frequency corresponding to energy difference between levels 3 and 2.

Fig. 2. Rules for the interaction of molecules with photons.



Spontaneous and Stimulated Emission

Under ordinary circumstances, some of the particles in any substance will be at a higher energy level and some at a lower level at any given time. Particles are raised to a higher level by heat, light, electron bombardment, etc. They will naturally revert to a lower level after a period of time, and in doing so spontaneously release photons. These photons may strike other molecules and cause them to jump to a higher level in turn.

Fig. 1 shows, in diagram form, the energy levels that might be found in a molecule. Each transition from one level to another would be accompanied by absorption or emission of radiant energy of a characteristic frequency. If f_{23} represents the frequency of the radiation absorbed or emitted in a transition between levels 2 and 3, we can determine the energy E_{23} involved from the relation: $E_{23} = hf_{23}$. Similarly, if we know the energy of the photons emitted, we can find the frequency by re-arranging Planck's formula to: $f_{23} = E_{23}/h$.

The time required for a molecule in a higher state to revert spontaneously to a lower state depends on the kind of molecule and the type of transition involved. The probability of a transition taking place may be greatly increased or *stimulated* by the presence of radiation of the required characteristic frequency. The greater the density of this radiation, the greater the probability that a transition will occur.

Fig. 2 shows how molecules react with electromagnetic radiation of the characteristic frequency. It is important to note that a photon of the correct frequency (or energy) striking a molecule at the lower energy level will cause it to jump to a higher level. However, if a photon of the same energy strikes a molecule already in the higher energy state, the molecule will revert to the lower state and *two* photons will be emitted. It is this characteristic that makes possible the amplification of microwaves and light by masers and by both solid-state and gas lasers.

The Ammonia Clock

One of the first practical applications of the above principles was the molecular clock using the ammonia molecule. This molecule has two energy levels separated by a gap corresponding to 23,870 mc. Ammonia has the unusual property that at the lower level the molecule is attracted by an electrostatic field, while at the higher level it is repelled.

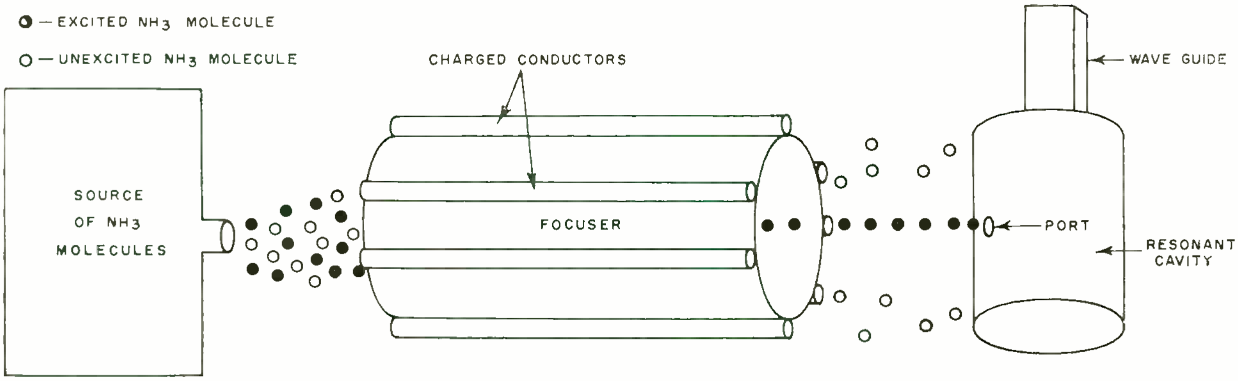


Fig. 3. Excited ammonia molecules are separated from unexcited molecules to form the basis of an ammonia frequency standard.

Fig. 3 shows how this characteristic is used to separate high-energy molecules from a mixture. Ammonia gas containing both excited and unexcited molecules is emitted from a source at high pressure and is passed in a narrow stream through a focuser. The focuser is made up of a system of charged conductors that provide a strong electrostatic field. The low-energy molecules are attracted by the conductors and are thus dispersed along the sides of the focuser. The high-energy molecules, however, are repelled by the conductors and are therefore concentrated in a narrow beam at the very center of the focuser. They are thus directed into the narrow port of a resonant cavity while the low-energy types are deflected aside.

The dimensions of the cavity are exactly proportioned to make it resonant at precisely 23,870 mc. This tends to reinforce the oscillations which occur at that frequency as the molecules drop to the lower energy level, so that a strong signal is generated. This signal is conducted from the cavity by a waveguide. The flow of energized ammonia molecules into the cavity is regulated at the level necessary to make up for losses and sustain oscillations. The output is a frequency of 23,870 mc. of the utmost purity, with no sidebands or noise and serves as a precise frequency or time standard.

Masers and Lasers

It was pointed out previously that if radiation of the proper frequency strikes a molecule in the excited state, the output will be *two* photons of the same frequency. Therefore, if enough molecules are in an excited state when struck by these photons, the result will be the amplification at the characteristic frequency. The apparatus for accomplishing this is the maser—an acronym standing for *m*icrowave *a*mplification by *s*timulated *e*mission of *r*adiation.

Solids are usually employed for masers since their molecules are more concentrated than those of gases. Early masers were two-level devices in which molecules were excited by "pumping" with radiation corresponding to the transition frequency. Such masers could amplify a signal only during the interval between pumping and spontaneous relaxation.

This difficulty was solved by the three-level maser (Fig. 4). Normally, most molecules are at the lowest level, the fewest at the highest level. The pumping frequency corresponds to the energy difference between levels 1 and 3, so that molecules are transferred from the lowest to the highest level. During the relaxation period they drop in about equal numbers to levels 2 and 1.

If the pumping radiation is strong enough, more molecules can be kept in level 2 than in level 1, and the frequency corresponding to the energy difference between levels 1 and 2 can be used for amplification. Since this frequency is different from the pump frequency, the apparatus can be operated as a continuous amplifier.

A resonant cavity is used in the case of the ammonia clock, and cryogenic equipment is employed to reduce noise. Noise level is extremely low, so that masers may be used to amplify very weak signals, such as those encountered in radio telescopes and long-distance radar.

The laser (*l*ight *a*mplification by *s*timulated *e*mission of *r*adiation) is closely related to the maser and requires little additional comment. It was recognized that light could be amplified in the same way as microwaves, provided that the energy difference between two energy levels corresponds to a frequency in the light region of the spectrum. Because of the short wavelength of light, the problem of devising a resonant cavity was formidable. This difficulty was overcome,

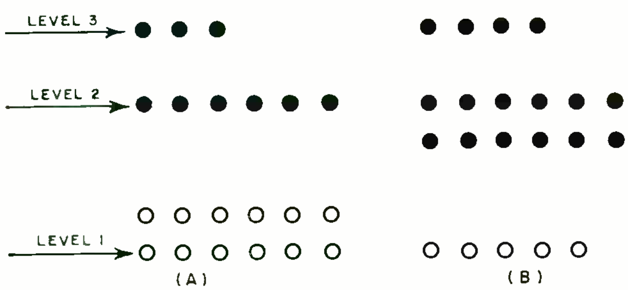


Fig. 4. Distribution of molecules in a 3-energy level maser. (A) shows normal distribution before pumping where most molecules are in the lowest energy level and fewest in the highest level. In (B), molecules pumped from level 1 to level 3 fall back to either level 1 or level 2 so that the total number in level 2 exceeds the number that are present in level 1.

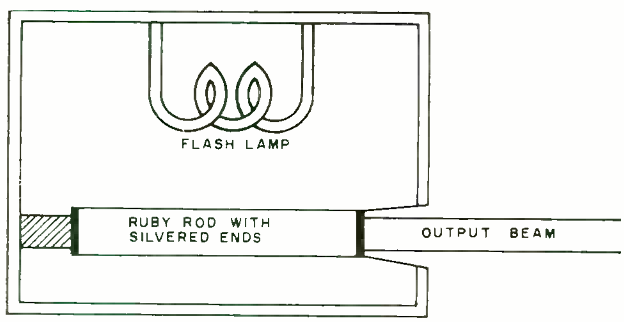


Fig. 5. When a chromium-doped ruby rod is excited by the intense light from a flashlamp, it emits a red, coherent light.

however, by using mirrored surfaces at the end of the laser crystal.

The test setup is shown in Fig. 5. A ruby crystal, composed of aluminum oxide and containing a small percent of chromium oxide which causes its red color, is formed in a rod several inches long. One end is completely silvered to give full reflection, the other with a very thin coating so that some light will pass through it.

A brilliant flash lamp pumps the chromium atoms to a higher energy level. Laser action begins when one of the energized atoms spontaneously emits a photon in the direction of one of the mirrored (*Continued on page* 84)

By ROBERT W. WINFREE

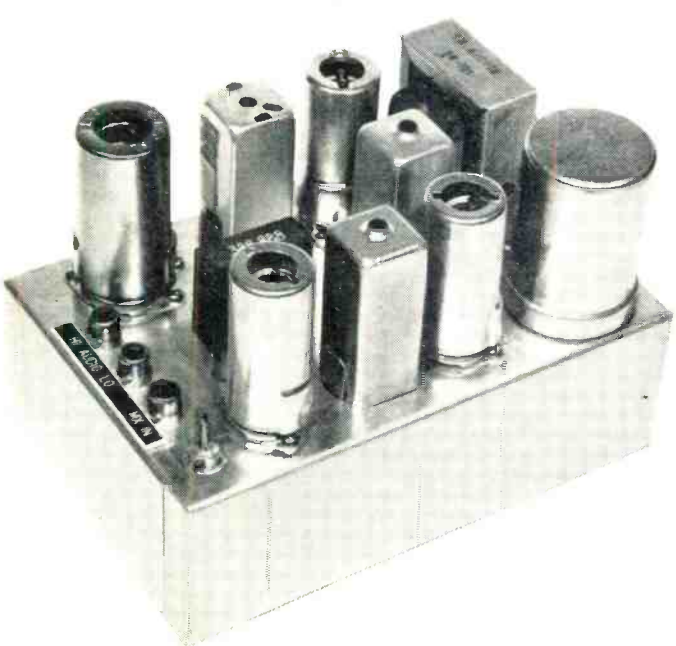
SCA

Construction of adapter, to be used with an FM tuner, that will respond to the 67-kc. "storecast" transmissions.

EVERY FM-multiplex buff knows about that mysterious SCA service that may be a source of annoyance in FM stereo reception. This Subsidiary Communications Authorization (SCA) provision for background music, or "storecast," dates from 1955 and antedates by several years compatible FM-stereo broadcasting. Although of greater significance to broadcasters than to the public, this multiplexing was welcomed at that time by nearly two hundred stations as a means of supplementing their incomes through this private point-to-point service.

Prior to FM-stereo broadcasting, the FCC permitted SCA channels to be located anywhere between 25 and 75 kc. Popular frequencies for multiplexing were 37, 41, 42, 57, and 67 kc., with only the last being sufficiently separated in frequency from the present 23- to 53-kc. stereo passband to be interference free. Since stations are not required to move their SCA to 67 kc. until they convert to stereo, some of the other frequencies may be around for a long time. Any discussion of equipment here assumes operation on the 67-kc. channel although minor changes in multiplexer design will make its use possible on other frequencies.

Over-all view of adapter built by author on 4" x 6" x 2" chassis.



Although the SCA service is completely analogous to the stereo multiplex transmission, there are several important points of difference to be considered. While the stereo difference information (L-R) is transmitted as amplitude modulated sidebands on a 38-kc. suppressed subcarrier at 80 to 90% modulation, the background music is frequency modulated on a 67-kc. subcarrier at a maximum of 10% of the total modulation. Besides this technical difference, the stereo program is "broadcast" while the background music is "transmitted," this difference being clearly distinguished by the FCC. While unauthorized reception and use for profit (such as playing it in a place of business) is not allowed, reception of and listening to an SCA transmission in one's own home apparently does not constitute "reception and use for profit." While program quality may not meet hi-fi standards (most stations play tapes at 3.75 ips or slower), the program content of uninterrupted, easy-to-listen-to music is most attractive to the home listener.

Since most FM service areas have at least one station providing background music, the addition of a multiplexer will enable the owner of the average FM tuner, either with or without stereo multiplex facilities, to receive the SCA programs in the home.

The connection necessary between the FM tuner and the multiplex converter is to the output of the discriminator or ratio detector at a point ahead of the usual de-emphasis network. This is exactly where a stereo multiplexer would be connected and if the tuner has a "MPX Jack" not in use, this may do. Since the converter to be described has a relatively low impedance input circuit so as to be tolerant of connecting cable lengths, the addition of a simple one-transistor emitter-follower output circuit in the tuner will improve the operation for both stereo MPX and background-music use by isolating the tuner high-impedance detector circuitry from a multiplex converter.

Since the background music is transmitted on a 67-kc. frequency-modulated subcarrier, all that is needed to listen to it is a suitable FM receiver operating on this frequency and plugged into the MPX jack on the tuner. Since this proves to be a scarce item on the market, a little construction work on your part will be necessary here. There are several approaches to this problem and each must meet the several requirements of such a unit. Selectivity or filtering must adequately attenuate stereo subcarrier sidebands and noise below 60 kc. and above 74 kc., and amplification and limiting circuits must pass a suitably tailored FM signal to the frequency-sensitive detector while rejecting AM noise and signal components in the passband. Of course, no tuning adjustments should be necessary since the operation is on a fixed frequency.

Of the several basic designs for such a unit, the one to be described has the important advantage of not requiring complex tuned circuits or filters operating at the subcarrier frequency. By using a crystal oscillator with conventional superheterodyne circuitry and a standard intermediate frequency, no special, hard-to-find, or home-made components are required in the equipment and no tuning adjustments are needed during use. In fact, aside from the 388.888-kc. crystal and the 455-kc. discriminator transformer, most parts can be found in the experimenter's junk box or are easily obtained at the parts house. The crystal is a surplus type available from, among others, *Texas Crystals*, Fort Myers, Fla., as the Type 241 channel 280 crystal for 50 cents plus 5 cents postage. The Type SSO-1 crystal socket is a good buy at 15 cents. The total cost of all parts if purchased new will be around $20.00. The output of the converter is a high-quality audio signal suitable for feeding the tuner or auxiliary inputs to a music-system power amplifier. An output level control allows setting to a level compatible with other program sources of about 2 to 3 volts and a separate low-impedance cathode-follower output at about one volt is provided to feed remote distribution amplifiers in the author's home.

Circuit Description

Having read this far, you are probably interested enough to take a look at the circuit diagram and parts list and follow a detailed circuit analysis. The composite input signal as provided by the FM tuner will consist of frequencies from a nominal 50 cps at the low end to at least 75 kc. at the upper range, unmodulated, amplitude modulated, and frequency modulated where the station provides all FM services. Where this composite signal is supplied from a high-impedance detector output you will want to add, in the tuner, the simple emitter-follower stage using one 2N508 transistor shown in Fig. 1. When adding this MPX output isolation amplifier, the diagram indicates where to tap off the signal for either this background music converter or a commercial stereo adapter. In fact both may be used at the same time if desired. Even if your tuner does not have wide-band i.f. and discriminator circuitry so desirable for FM stereo, this background music converter will give good results. Remember, we are working with a frequency-modulated subcarrier here instead of the amplitude-modulated subcarrier for stereo and a falling off of the signal level at the higher frequencies due to tuner shortcomings which is so disastrous in stereo, is easily made up by amplification in the unit.

Referring to Fig. 2, the input tuned circuit, *T1*, a slug-tuned TV horizontal width coil, tunes to 67 kc. with the step-up provided by autotransformer action giving a signal level of about 100 to 150 mv. at the mixer input grid. Grids 1 and 2 function in the oscillator circuit of the 388.888-kc. crystal oscillator with feedback controlled by the 82- and 100-pf. capacitors. The mixer plate circuit contains the desired 455.888-kc. i.f. signal as well as a strong component of the oscillator frequency. This undesired component is blocked by *T5*, a miniature 455-kc. i.f. transformer which, by the addition of a parallel 20-pf. capacitor, tunes sharply to the undesired 388.888 kc. signal. Elimination of this signal allows better limiting in the i.f. stages. The interstage i.f. transformer, *T2*, couples the converter stage to the 6BJ6 first i.f., which provides most of the gain and some limiting due to grid current. Most of the limiting action takes place in the 6BH6 second i.f. stage operating at very low plate voltage. Grid rectification in this stage provides a d.c. voltage on the order of −25 volts at the grid which is brought out through a 100,000-ohm resistor as a test point, designated "*T.P.*" for alignment purposes.

The remainder of the circuit is unusual and worthy of mention. The detector uses two germanium diodes in a balanced bridge discriminator which, at first glance, may appear to be a type of ratio detector. This circuit, when properly balanced, is capable of the high AM and noise rejection required here, as its electrical balance produces no output from these sources. This circuit is similar to that used in the "Dynatuner" and various industrial equipments. Loading of the discriminator is optimized by the high input impedance of the cathode-follower triode, ½-12AX7A. A low-impedance

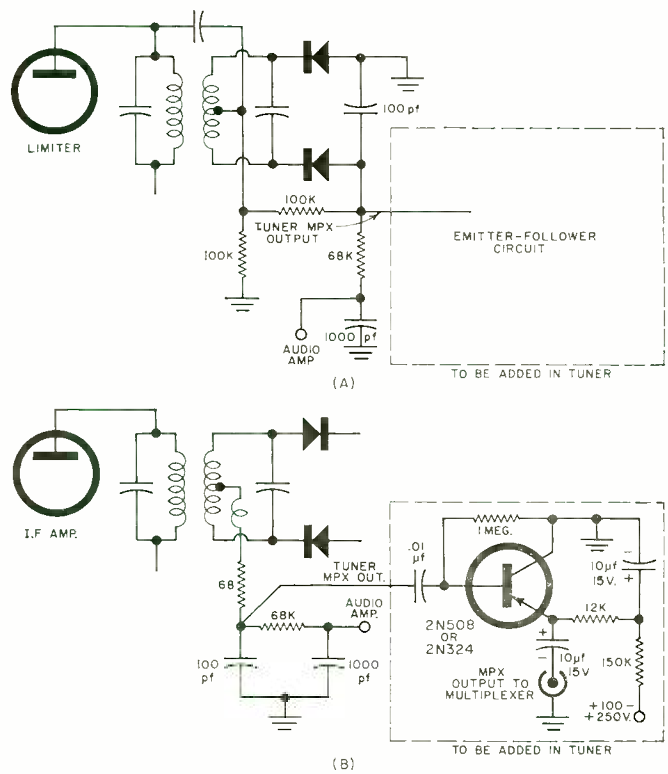
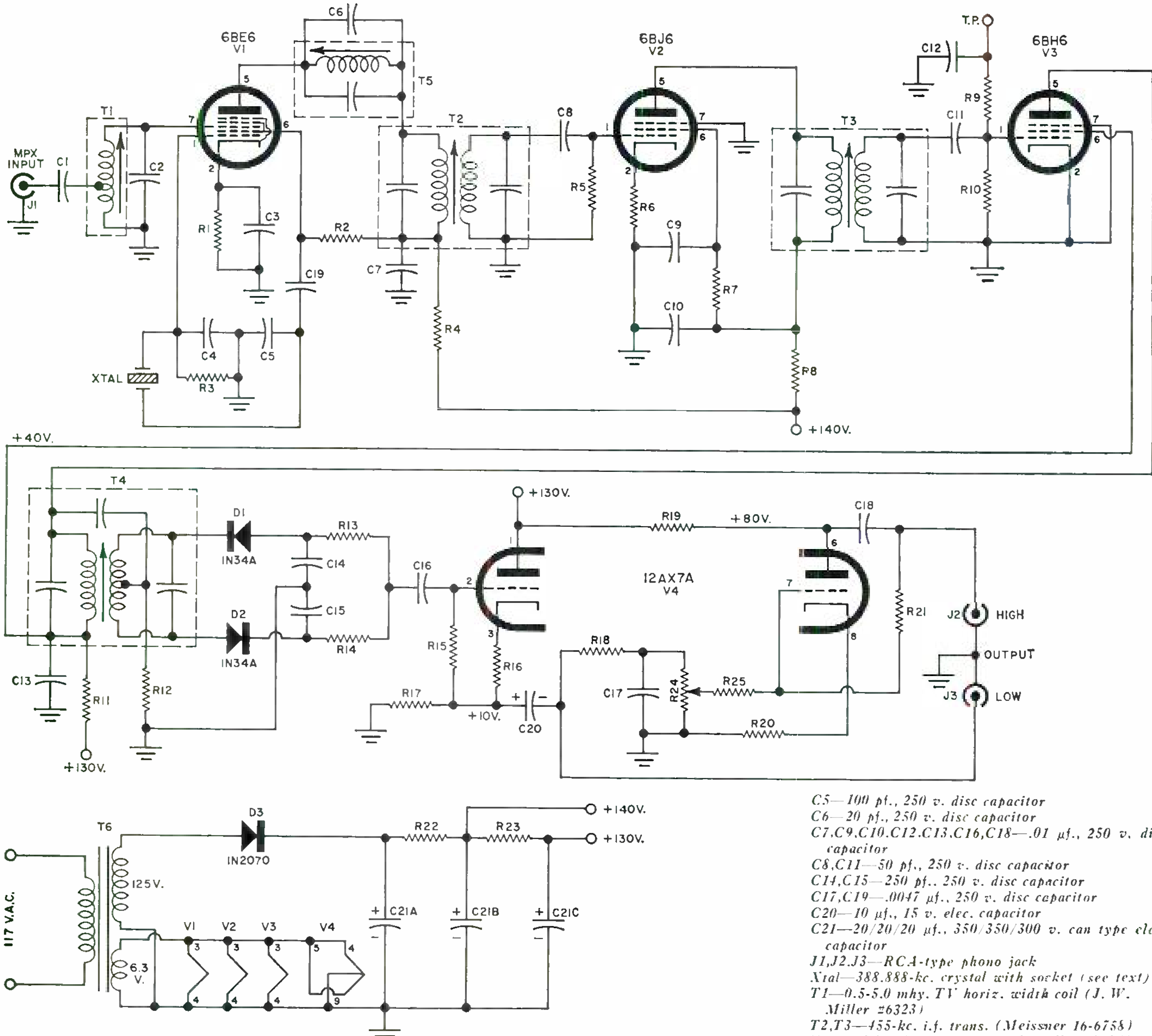


Fig. 1. Addition of a transistor emitter-follower circuit to (A) discriminator and (B) ratio detector in FM tuner.

output is tapped off here for remote audio lines. Then follows the de-emphasis network and volume level control feeding the ½-12AX7A output stage operating with plate-to-grid feedback. The maximum audio level available from this stage is in the order of 3 volts.

The power supply is entirely conventional and need not be built if suitable facilities are available in the tuner or elsewhere. The transformer 6.3-volt winding supplies all tube heaters while the 125-volt supply is half-wave rectified by a silicon diode followed by adequate filtering and decoupling circuits. The high resistance of the transformer winding obviates the use of the usual surge resistor in the rectifier circuit. The total d.c. current drain is under 20 ma. with no signal. No a.c. switch is included since the unit normally plugs into a controlled outlet on the author's tuner. Obviously you may include a switch if you wish.

The emitter-follower transistor multiplex output stage added to a typical FM tuner is diagrammed in Fig. 1. It is most important to locate the proper point in the detector circuit to pick off the multiplex signals. This must be before



C5—100 pf., 250 v. disc capacitor
C6—20 pf., 250 v. disc capacitor
C7,C9,C10,C12,C13,C16,C18—.01 µf., 250 v. disc capacitor
C8,C11—50 pf., 250 v. disc capacitor
C14,C15—250 pf., 250 v. disc capacitor
C17,C19—.0047 µf., 250 v. disc capacitor
C20—10 µf., 15 v. elec. capacitor
C21—20/20/20 µf., 350/350/300 v. can type elec. capacitor
J1,J2,J3—RCA-type phono jack
Xtal—388.888-kc. crystal with socket (see text)
T1—0.5-5.0 mhy. TV horiz. width coil (J. W. Miller #6323)
T2,T3—455-kc. i.f. trans. (Meissner 16-6758)
T4—455-kc. disc. trans. (J. W. Miller 12-C45)
T5—Miniature transistor-type 455-kc. i.f. trans., sec. unused (Lafayette MS-780)
T6—Power trans. 125 v. @ 15 ma.; 6.3 v. @ 0.6 amp. (Lafayette TR-121 or equiv.)
D1,D2—1N34A germanium diode
D3—1N2070 silicon diode
V1—6BE6 tube
V2—6BJ6 tube
V3—6BH6 tube
V4—12AX7A tube

R1—150 ohm, ½ w. res.
R2—18,000 ohm, ½ w. res.
R3,R5,R9,R10,R19,R25,—100,000 ohm, ½ w. res.
R4—560 ohm, ½ w. res.
R6—47 ohm, ½ w. res.
R7—22,000 ohm, ½ w. res.
R8,R16—330 ohm, ½ w. res.
R11,R12—47,000 ohm, ½ w. res.
R13,R14—68,000 ohm, ½ w. res.
R15—1 megohm, ½ w. res.
R17—8200 ohm, ½ w. res.
R18—24,000 ohm, ½ w. res.
R20—1000 ohm, ½ w. res.
R21—680,000 ohm, ½ w. res.
R22—470 ohm, ½ w. res.
R23—2200 ohm, ½ w. res.
R24—500,000 ohm miniature audio-taper pot
C1,C2—.001 µf., 250 v. disc capacitor
C3—.05 µf., 250 v. disc capacitor
C4—82 pf., 250 v. disc capacitor

Fig. 2. Adapter circuit. Output of crystal oscillator mixes with the 67-kc. SCA signal to produce the desired 455-kc. i.f.

the de-emphasis filter, usually a series 68,000-ohm resistor and shunt .001-µf. capacitor. The usual 10.7-mc. filter elements of 50- to 100-pf. capacitors will help locate the right place and corresponding locations for both a typical discriminator and a ratio detector are shown. The transistor socket and other components may be hung by their leads under the tuner chassis in a convenient location, providing short connections, while the 150,000-ohm dropping resistor is adequate for all tuner d.c. voltages from 100 to 250 volts. Be sure to observe polarity when connecting the electrolytic capacitors. In addition, for longest transistor life do not plug in or remove the 2N508 from its socket while the power is on.

It is most convenient to feed the new MPX output to an *RCA*-type jack as usually provided for such connections. The full mono program will be present at the jack as well as all MPX subcarriers. Circuit values permit use of any type of multiplex adapter that the builder may desire to employ.

Construction & Alignment

A look at the photographs will show the logical layout of components on the 4" x 6" x 2" aluminum chassis. At the front edge are three jacks for MPX input, low audio output, and high audio output, with the oscillator crystal socket just to the rear of the input jack and the audio level control in back of the high output jack. The three 455-kc. i.f. transformers are mounted with the clips supplied and the filter can by its twist tabs. The four shield base tube sockets are fastened with 4-36 screws and shields are used on all tubes. Orient the sockets to insure the best lead arrangement under the chassis. Be sure to mount everything that fastens to the chassis before beginning any wiring. A few suitably placed lug strips will provide terminals for those resistors and capacitors not soldered directly to the sockets and coil lugs. A three-point strip, center ground, fastened on one of the power transformer screws will mount the 1N2070 rectifier and the limiter test point resistor and capacitor.

A strip with three insulated lugs, fastened in the center of the chassis between the discriminator i.f. transformer and the input i.f. transformer, provides distribution points for the two d.c. voltages used in the i.f. amplifier and for the common terminal of the discriminator 68,000-ohm bridge resistors and output capacitor. Another three-lug strip, center ground, between the discriminator can and the 12AX7A socket, is used to tie the detector diodes to the bridge resistors and bypass capacitors.

Follow the usual practice of putting in the heater and power supply wiring first, then a bare wire bus connecting the grounded points, and finally add the small components, building from the chassis out. The small 24-gauge solid hookup wire is a good size to use. The power transformer primary leads are brought out through a rubber grommet and terminated in an a.c. plug: you may want to use a regular line cord here. The resistors and capacitors are all supported by their terminal leads in a point-to-point wiring arrangement, as is the midget i.f. transformer 388-kc. trap coil.

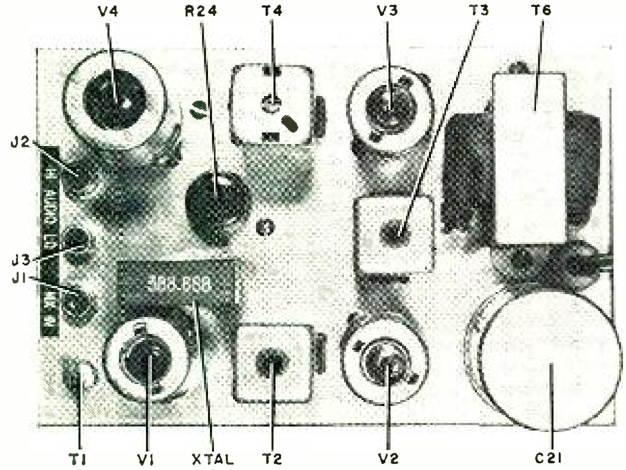
The tune-up requires at least a d.c. voltmeter, preferably a 20,000-ohms-per-volt v.o.m., and a station on the air with an SCA signal.

A visual check of the wiring and parts values after the wiring is completed may save considerable grief later. If no trouble is found, plug the unit into the a.c. line before putting in the tubes, then check the "B+" d.c. voltages. They should be around 200 volts with no load. Plug in all tubes and check the voltages when they settle down, comparing with the diagram values. Then with the v.o.m. on the 10-volt range, connect to the test point and chassis ground to measure the 6BH6 limiter negative grid voltage. If this is about ½ volt, plug in the channel 280 crystal. The leak-through signal from the oscillator on 388.888 kc. will increase the negative grid voltage to 5 to 10 volts. Now carefully adjust the 388-kc. trap coil T5 slug-tuning to dip this voltage to a minimum of less than 1 volt.

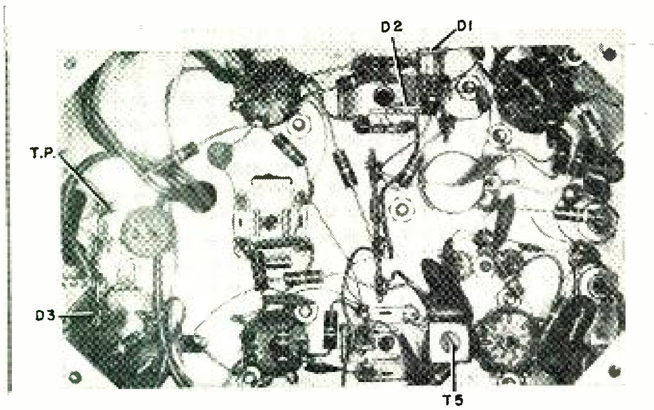
Cable the unit up to the tuner MPX output and adjust the input coil tuning slug until it is out about 1/16" beyond the end of the form. Now tune to a station providing SCA service or tune over the band while watching the limiter grid voltage with the meter on the 50-volt range. Adjust the input coil slug and top and bottom slugs of the two i.f. transformers to peak the meter reading at maximum. Be sure the FM tuner has been exactly centered on the channel with its a.f.c. turned off while doing this. If the tuner is off resonance, a spurious indication may appear on a station without SCA. The voltage should be 20 volts or more when everything is peaked. It is advisable to unplug the tuner and check the trap coil adjustment again for best oscillator rejection. Now clip the v.o.m. between the junction of the two 68,000-ohm discriminator resistors and ground, using the 10-volt range on the meter, and carefully screw in the discriminator slug (top of can) to produce a maximum voltage, positive above ground, of about 3 to 5 volts. After noting the voltage reading, screw the tuning slug *out*, watching the voltage decrease through zero and increase with the opposite polarity. You will swap the meter leads here and continue to screw the slug out until a peak is reached. If this voltage is within 10 percent of that previously noted, the *primary* tuning is satisfactory as is. If not, adjust this tuning (bottom screw) by running it in about one turn.

Now repeat the top tuning procedure, checking the balance of the peaks. If the positive and negative voltage readings are more nearly the same, the primary adjustment just made was in the proper direction. If there is a greater discrepancy between the readings, the adjustment was in the wrong direction and it should be reversed for the next attempt. Continue this juggling until the voltage maximums, positive and negative, produced by the secondary tuning are about equal. This leaves the primary tuning on frequency. Now adjust the secondary tuning to the zero voltage point halfway between the peaks. A small correction may be made later but this will leave the secondary very nearly correct. All this can be done in less time than it takes to describe it. For signal generator users, the discriminator peaks are about 30-kc. apart and the characteristic is quite linear over the ±7-kc. modulation swings.

Now connect the audio output jack to a power amplifier and speaker and check the audio signal for music quality and background hiss. During the silent period in the music, carefully adjust the discriminator secondary to minimize any noise and modulation from the main program. Objectionable hiss here will be due to weak signal level and poor signal-to-noise ratio on the main carrier. As with stereo multiplex,



Top-chassis view showing the compact but uncrowded arrangement.



Wiring is not too critical as frequencies involved are fairly low.

antenna improvements to boost signal levels will be helpful. For average signals, the noise may be barely noticeable during pauses.

Stability of the oscillator and other components is very good and no trouble will be experienced with the unit drifting off the center of the channel. Very accurate frequency measurements of subcarrier signals reveal that not all SCA subcarriers are exactly on 67 kc. A slight variation here, within the range encountered in commercial operations, will not cause tuning troubles since the discriminator will accept signals as much as one kc. off center with no strain. If you find that you prefer a particular station's programming, however, all adjustments may be optimized to it. Finally, while enjoying the easy-to-listen-to music in your home, remember that you are really intercepting point-to-point transmissions intended for someone else. ▲

CB RADIO-WAVE

Discussion of ground and sky-wave signals for normal and unusual conditions, and distances to be expected.

By R. L. CONHAIM, 19W7577

DURING the early days of CB, I was having a short conversation one Sunday morning using my mobile. There were skip signals coming in from the West and South. Some locals were even trying to work the distant stations. Being a law-abiding, FCC-fearing citizen, I ignored the skip signals as best I could. When another 19W called me, I answered immediately.

"How far are you from Akron?" he inquired.

"Oh, about 175 miles. Why?"

"Well, that's too far" the voice on the other end said. "I thought maybe you could telephone my Dad and tell him where I am, but that would cost too much."

I began to get a little suspicious.

"Where are you?" I inquired cautiously.

"Oh, driving along about sixty-miles-an-hour on a beautiful highway in the Arizona Desert!"

I gulped when I heard that and ended the conversation as quickly as I could without being rude. Here I'd been talking to a mobile almost 2000 miles away, just as though he'd been down the street. His signal was loud and clear, never wavering, and ten-over-nine for the duration of the conversation.

Here was one example of "skip," the kind of signal which legally I should not have answered. But, it is something which plagues the class D Citizens Band, especially during the winter months. It's often the subject of lively arguments, some of them quite inaccurate. But the subject is one that CB users should understand so they know what to expect at certain seasons of the year and from one year to the next.

Most explanations of radio-wave propagation are concerned with determining the best operating frequencies for point-to-point communications. We on the class D Citizens band are confined to one band of frequencies. Our interest in skip signals is based upon either the interference they cause or, out of curiosity, their reason for being. Some of us are inclined to believe that the reception of signals from such distant locations is due to superior receivers or exceptionally good antennas, or even the locations of our stations. In fact, the reception of skip signals has little to do with the quality of our equipment. We're all subject to receiving skip on either base or mobile stations. Let's examine the mechanism of 27-mc. radio-wave propagation and see why this band has its own peculiar characteristics.

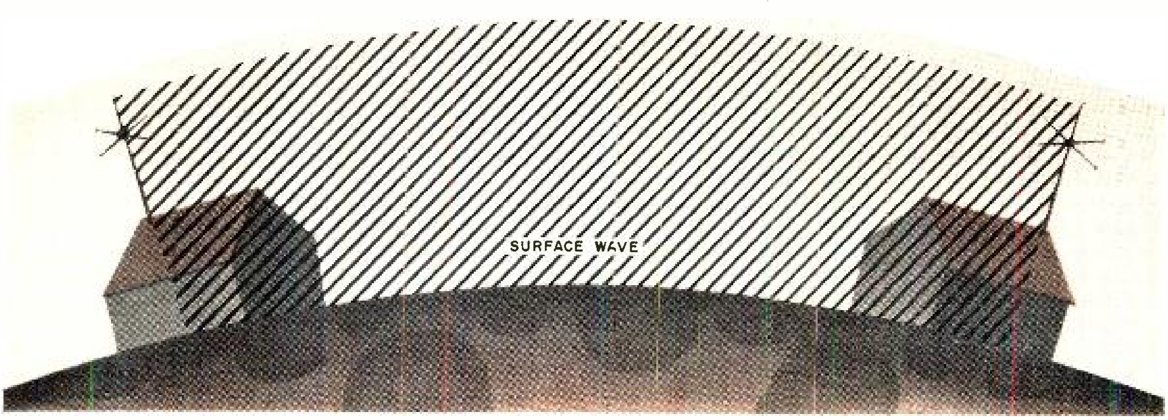
Communication from one CB station to another is based on one of two basic types of propagation. One is called the *ground wave*. This is basically the wave we use in our daily communications and the type referred to in the FCC regulations. The other is referred to as the *sky wave* and is the one that accounts for the reception of skip signals.

The Ground Wave

Although we think of the ground wave as being one particular type of wave always propagated in the same manner, it is actually composed of four kinds of waves. These are known as the *direct wave*, the *ground-reflected wave*, the *surface wave*, and the *tropospheric wave*. These waves are shown in Figs. 1 and 2. From the figures it is evident how each type of wave travels. The direct wave is limited only by line-of-sight, or distance to the horizon, plus a small distance caused by diffraction of the wave around the curvature of the earth. The actual total distance can be approximated quite closely by assuming that the earth's radius is actually 4/3 of its true value. This will take into consideration the diffraction of the atmosphere. In other words, the radio line-of-sight distance, is actually slightly greater than a visual one.

The direct wave could be very important in class D CB if we could erect antennas as high as we would like, but since we are limited by the 20-foot regulation, the direct wave can provide only limited distance communications. Assuming both receiving and transmitting antennas are about 20 feet off the ground, radio line-of-sight distance over even terrain is 9 to 10 miles. If, for base-to-mobile operation, we assume a 30-foot house with a 20-foot antenna or a total of 50 feet above ground for one end and 10 feet above ground for the mobile, we have a line-of-sight distance of about 11 miles. Or suppose we are talking base-to-base, with one station's

Fig. 1. That portion of the ground wave that travels in contact with the surface of the earth is called the surface wave.



PROPAGATION

Even thousands of miles can be covered by means of a low-powered CB transmitter because of sky-wave "skip"

antenna on a house, 50 feet above ground, and the other on top of a tall office building, 500 feet above ground, then the line-of-sight distance is about 40 miles. Conversations from an airplane at 5000 feet with a base station at 50 feet would cover a line-of-sight distance of about 110 miles.

The ground-reflected wave is relatively unimportant in CB work because the reflected wave tends to be subject to phase reversal which results in a cancellation effect between the ground-reflected wave and the direct wave. This is especially true when the antennas are located relatively close to the ground, as is the case with the class D Citizens Band.

The most important part of the ground wave for our work is the surface-wave component. The surface wave is not necessarily confined totally to the surface of the earth but may extend to some height, diminishing sharply in intensity with height. Part of the energy of a surface wave is absorbed by the ground and the rate of attenuation or the distance we can communicate is dependent upon the character of the surface over which communication takes place. If we rate the various types of ground over which communication is to take place, we find relative conductivity as shown in Table 1.

Over very good surfaces, distances up to 40 or 50 miles can be worked with our 5-watt transmitters, noise being one of the limiting factors. When man-made noise is low, as is the case late at night, working distances can be expected to be greater.

Since the surface wave actually extends for some height into the atmosphere, the condition of the air can affect characteristics of reception. On rainy, foggy days we may notice increased signal strength, due to greater conductivity experienced by the surface-wave component. The types of antennas we use, with relatively low angles of radiation, are also important for good surface-wave propagation because they concentrate more of their energy into a low angle of radiation.

The tropospheric wave has little application in the 27-mc. CB band, but occasionally it accounts for reception of signals at somewhat longer than normal distances. It is caused by relatively rapid changes in atmospheric moisture, density, or temperature with respect to height. This results in refraction of the transmitted signal. One of the most common causes of the tropospheric wave is temperature inversion. This can result from a warm air mass overrunning a colder mass, the sinking of an air mass heated by compression, rapid cooling of surface air after sunset, or the heating of air above a cloud layer by reflection of the sun's rays from the upper surface of the clouds. Since tropospheric propagation is so dependent upon weather conditions, it is an unreliable means of 27-mc. CB communications, but can account for some of the effects which we have all noted. The greatest effects are at higher frequencies—50 mc. and up.

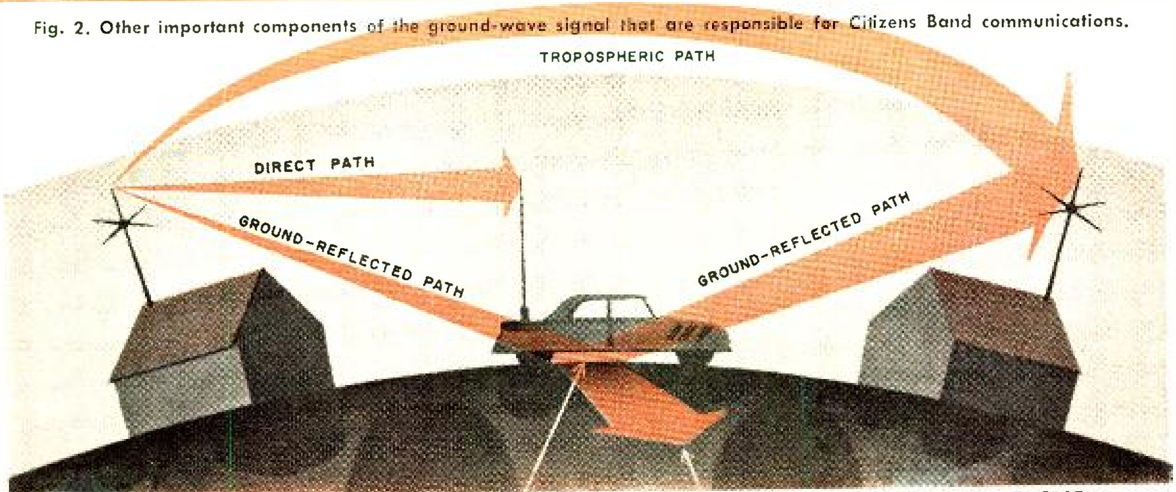
The Sky Wave

The sky wave is the culprit in all long-distance 27-mc. reception. It is not by any means confined to the 27-mc. Citizens Band and is used advantageously in other services where long-distance communications are permitted. On the amateur bands it is responsible for pea-power transmitters reaching remote corners of the world and this is one of the exciting and rewarding phases of amateur radio. The proud possessor of a DX Century Club Award for having worked 100 countries can thank the sky wave, and his own hard work, for this distinguished and cherished memento.

The sky wave is that portion of a radio wave which is reflected from the layers above the earth's surface. As shown in Fig. 3, the atmosphere above the earth is more than one homogeneous layer of air. It consists of a number of different layers termed the troposphere, the stratosphere, and the ionosphere. It is the latter in which we are most interested. The ionosphere derives its name from the fact that it contains, instead of the stable gases of the lower atmosphere, a high proportion of electrically un-neutral ions.

These ions are created largely by ultraviolet radiation from the sun. In areas where gas molecules are few and far between, ionization will become quite high because there are relatively few positive ions with which the negative ions can recombine. Although this same phenomenon exists in the lower atmosphere, the air is so dense that gas molecules

Fig. 2. Other important components of the ground-wave signal that are responsible for Citizens Band communications.



SURFACE OR TERRAIN	RELATIVE CONDUCTIVITY
Sea water	Excellent
Large lake	Very good
Wet soil	Good
Flat, loamy soil	Fair
Dry, rocky terrain	Poor
Desert	Very poor

Table 1. Relative conductivity of various types of terrain.

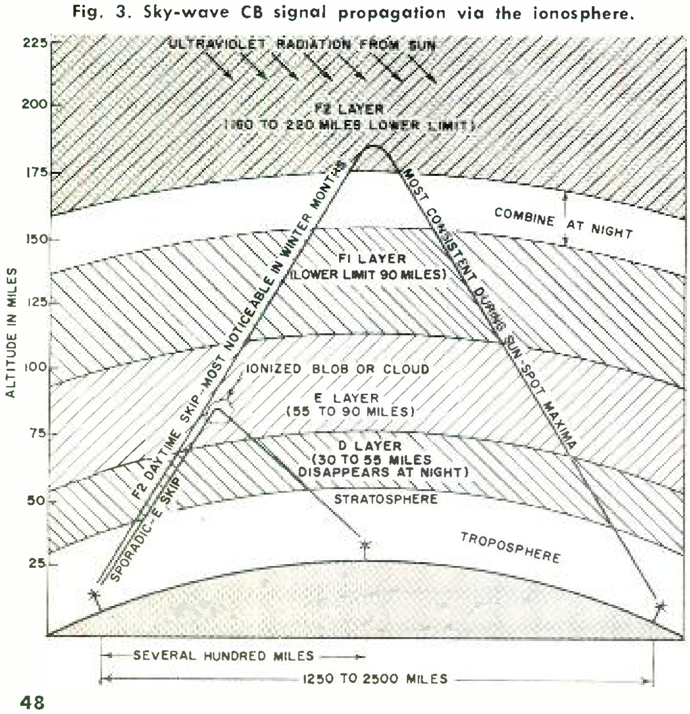
collide with each other at the rate of four billion collisions per molecule per second. Obviously, in such a dense atmosphere, an ion can have only a very short life—estimated to be only a few millionths of a second. Such a dense atmosphere tends to absorb rather than reflect radio waves, especially at lower frequencies.

But in the sparse regions of the ionosphere where there are relatively few gas molecules, the ions re-attach themselves at fairly slow rates. In the upper regions of the ionosphere, called the F2 layer, recombination is so slow as to be relatively unimportant. The important thing about these ions is that they make the atmosphere electrically conductive. Thus the electromagnetic energy of a radio wave is partially transformed into kinetic energy represented by the motions of the ions. If these ions do not recombine, this energy is converted back to electromagnetic energy and the radio wave continues to be propagated. If, on the other hand, the ions recombine, absorption of the radio wave occurs and the wave is sharply attenuated.

Now, one of the most important factors about this ionization is the fact that the greater the degree of ionization, the higher the frequency that will be refracted and returned to the surface of the earth. For any one frequency, there is a degree of ionization that is required to refract the wave sufficiently to return it to earth depending upon the angle of radiation. Frequencies higher than this, for the same angle, will not be sufficiently refracted and will not return to the earth.

As far as the 27-mc. band is concerned, the required degree of ionization occurs in the F2 layer of the ionosphere which is the uppermost portion shown in Fig. 3. However, ionization alone does not tell the story. In addition to the factors of ionization and frequency, radio-wave propagation is also dependent upon the angle at which the wave strikes a particular layer of the ionosphere. At low angles of radiation,

Fig. 3. Sky-wave CB signal propagation via the ionosphere.



a lesser degree of ionization is required than at high angles. And, since most of our CB antennas are designed for low radiation angles, we can get reflections from the ionosphere when we could not if the angle of radiation from the antenna were considerably greater.

Changes in Ionization

Ionization of the atmosphere is not a constant thing. It changes from day to day, hour to hour, season to season, and from one year to the next. It tends to be greatest during daylight hours, as in summer, and is further influenced by sunspot activities, magnetic storms, the magnetic field of the earth, the passage of meteors, and the presence of other types of radiation such as cosmic rays.

Thus the ionosphere is undergoing changes in its ionization constantly. At night, for example, the lower or D layer practically disappears with the setting of the sun. Thus, broadcast-band waves are absorbed in the daytime but not at night, resulting in long-distance broadcast reception at night only. At night, the height of the E layer is lowered and the F1 and F2 layers combine into one layer somewhat closer to the earth than during the day. Peculiarly, although the D and E layers are less ionized in winter, the F2 layer is ionized more so and this effect is thought to be due to the magnetic field of the earth which seems to have a greater effect upon the F2 layer than the mere ionization of gas molecules by the ultraviolet rays of the sun. It is for this reason that we notice skip signals on 27 megacycles during the winter months and also because there is less attenuation of the signals in the lower regions of the atmosphere due to their reduced ionization during winter months. Since sunspot activities increase the ionization of the ionosphere, skip is more prevalent during the more intense period of the 11-year sunspot cycle.

Now, let us see what happens when some winter month you are communicating with your mobile and your signals are heard 2000 miles away. As you transmit, part of your signal is radiated at a relatively low angle toward the ionosphere. When the signal enters the ionosphere it is entering an area of different density. At this point the wave is slowed down and starts to be refracted or bent by the difference in densities. The same effect can be noted optically when you thrust your arm into the waters of a lake. To your eye, it appears that your arm is bent where it enters the water. This is due to the different densities or different refractive indexes of air and water.

As your radio wave continues into the ionosphere, it is bent more and more until it reaches a degree of ionization which is so high that it actually will reflect a 27-mc. signal. At this point the radio signal from your transmitter starts downward toward the earth, returning to the surface of the earth at the distant receiving station.

Skip Distances

Now you may be wondering what determines the distance at which your signal can be heard. It is determined by a great many factors. The frequency is one factor, but we can ignore it since we are limited to the 27-mc. band. Other factors are the angle of radiation, the height of the ionized layer at which the 27-mc. signal is reflected, the absorption of the lower atmosphere, and the curvature of the earth. You must remember that your signal is not all radiated at the same angle and, consequently, you may be heard at several distant points. Generally, for 27-mc. CB, the minimum distance is about 1250 miles, when the ionized reflecting layer is low, with the maximum about 2500 miles when the ionized reflecting layer is high. Within this range your signal can be heard at many different points. You should also bear in mind that it is not the ionization over your own station or over the receiving station which is important, but the ionospheric conditions at a point midway between the two stations where the reflection takes place. (*Continued on page* 88)

COLOR-TV in KIT FORM

Featuring a built-in dot generator, this color-TV kit comes with a degaussing coil and with all critical circuits factory assembled and tested.

UP to the present time, this writer and, in fact, many manufacturers of kit equipment, felt that to design and market a color television set kit would be a foolish venture. Black-and-white TV sets in kit form have been successfully marketed, but to develop a color design seemed to have been much too complicated, as far as alignment and color adjustments were concerned, to hope that the consumer could construct one. The *Heath Company,* on the other hand, apparently had a different viewpoint, because they have just announced the availability of a 21-inch color TV receiver in kit form making it obvious that the apparent difficulties in alignment and testing have been solved. This new TV kit is basically an *RCA* design and, in itself, does not warrant much comment. There are, however, many innovations in the original design that provide foolproof alignment and color adjustment. This is the first kit, at least to the writer's knowledge, that has its own built-in test equipment. Actually there are four major points that not only simplify the alignment and color adjustment, but sufficient details are available so that anyone with a fair knowledge of electronics can service and maintain the performance of the unit for the life of the set.

As an aid to the constructor who may not have access to certain items of test equipment usually required for color set adjustment, this new kit has a built-in dot generator, provisions for shorting out the separate color guns of the tube, is supplied complete with a CRT degausser, and incorporates an instruction manual that includes a complete schematic diagram with service and maintenance information. It is, in essence, not only a service manual but, in itself, an important educational tool for those interested in knowing more about the design and maintenance of a color-TV set.

The built-in dot generator, a unique circuit in itself, is shown in Fig. 1. This circuit is used during the original convergence procedure and can be switched in at the convenience of the viewer at any time he desires to check the CRT color convergence.

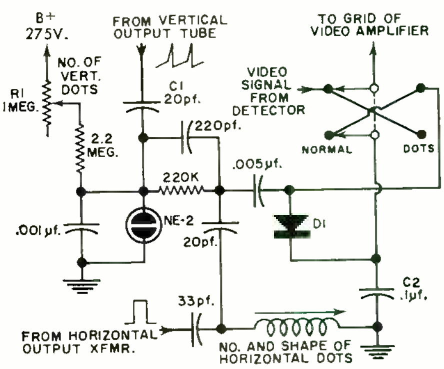


Fig. 1. The built-in dot generator is essentially a cross-hatch generator with only the intersections of the vertical and horizontal line pattern showing up as a dot pattern on the cathode-ray tube screen.

The circuit consists of a synchronized oscillator operating at a multiple of the frame frequency and a ringing coil operating at a multiple of the line frequency. (If these two signals were made visible on the CRT screen, they would form a cross-hatch pattern.) The two signals are mixed in a diode that produces an output pulse whenever the two signals coincide. This, of course, would be at each intersection of the cross-hatch pattern, thus making the resulting output signal a dot pattern.

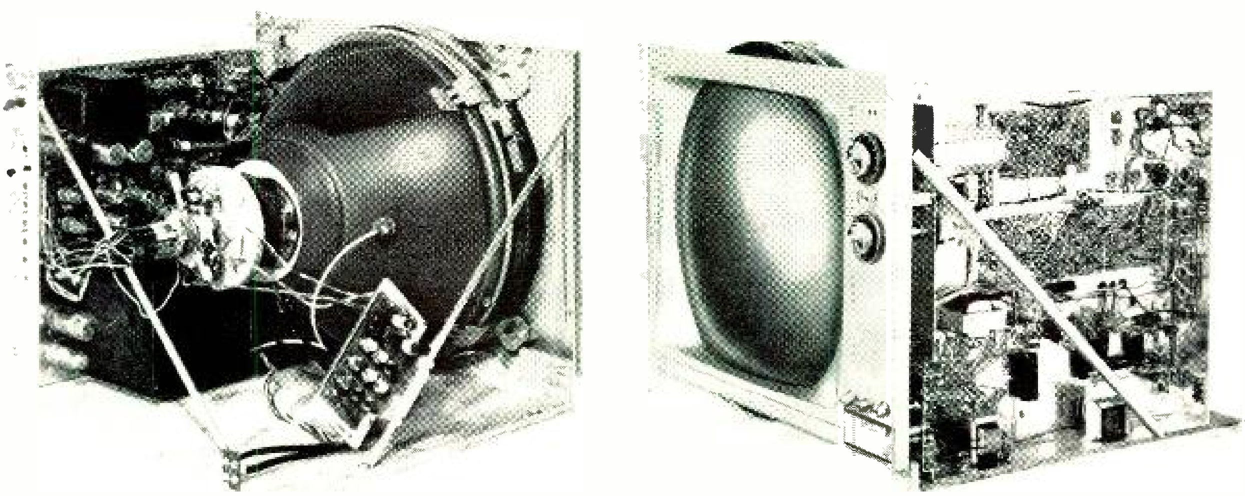
The horizontal line generator is a neon-lamp relaxation oscillator whose output frequency is controlled by *R*1. When the frequency is set and synchronized to some multiple of the vertical rate, then the series of horizontal lines for the cross-hatch pattern will be generated. This portion of the circuit is synchronized to the set's vertical rate by application of a pulse, *via C*1, from the vertical output tube.

To produce the series of vertical lines for the cross-hatch pattern, a positive-going pulse is taken from the horizontal output transformer and applied to a fairly high-"Q" coil tuned to some multiple of the line frequency. The frequency of the coil determines the number of vertical lines.

When the "Normal-Dots" switch is in the "Dots" position, the video signal from the picture detector is bypassed to ground by *C*2 and the dot generator output signal is fed to the video amplifier. When the switch is in the "Normal" position, the output of the dot generator is bypassed to ground and the video signal from the detector is then allowed to pass to the amplifier.

During the original adjustment, or even when moving the set from one wall to another, it is necessary to demagnetize the color picture tube. Instead of depending on the builder having a degaussing coil available, *Heath* has taken the precaution of supplying a rather inexpensive, small-sized coil, consisting of 30 turns of #18 wire operated directly from the 6.3-v., 13-amp. filament supply. ▲

Interior views of the color set showing the vertical chassis, with the convergence board mounted near the CRT yoke assembly.



AN INDOOR HORN FOR TV-FM RECEPTION

By B. V. K. FRENCH / Avco Corp., Electronics and Ordnance Division

Scaled-up version of a broadband microwave horn makes an excellent TV and FM antenna that can be mounted in confined indoor areas such as attic crawl spaces.

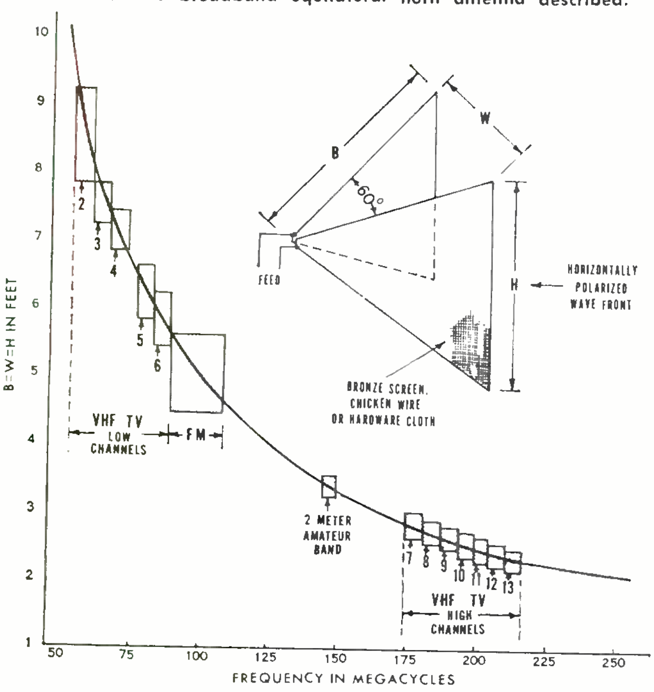
AMONG the vicissitudes and occupational hazards of professional existence in the electronic industry, is the necessity of compromising a desire for high-quality, noise-free TV and FM reception with the rabbit ears pick-up usually imposed by apartment-house regulations.

Having lived in apartments in five large metropolitan areas, the writer has found that apartment rules prohibit the use of an outdoor antenna, or at least one visible from outside the building; multiple ghosts are invariably present due to reflections from the framework of nearby buildings, power lines, or other metallic structures; commutator-type electrical appliances such as kitchen mixers, vacuum cleaners, and electric razors cause a high intermittent noise level in multiple-unit apartments; and conditions are often aggravated by nearby shopping centers or service stations with flashing signs, animated displays, or other electrical noise-producers.

Single unit suburban dwellings on which an outside antenna is objectionable for aesthetic or other reasons are often subject to the same restrictions as multiple unit urban apartment houses.

Under these conditions, the only possible solution lies in using the attic of the single unit dwelling or the attic crawl area of the apartment. Here, convincing the landlord or rental agency that the installation will not damage the building or constitute any greater fire or lightning hazard than is presented by the electrical wiring of the building itself, is the only major problem. The lead-in from the antenna is routed unobtrusively down the corner of a clothes closet and along the baseboard of the room to the receiver to provide a finished installation.

Fig. 1. Dominant mode cut-off frequency versus physical dimensions for the broadband equilateral horn antenna described.



Elimination of ghosts and man-made noise dictate the use of antenna structures which have extremely high front-to-back ratios, high gain for horizontally polarized television and FM transmission but with reduced pick-up of vertically polarized radiation such as noise. Additional important requirements are broad frequency response and a good impedance match over the required frequency band. The last two considerations are particularly important when the desired stations are widely separated in the TV band, or when color reception is a requirement.

The choice of antenna type to fulfill these requirements depends largely upon the receiver location with respect to: number and frequency allocations of required TV broadcast transmitters; angular relationship between the incident direct signal from the transmitter and the reflected signal causing the ghost; and adequate antenna gain to produce pictures with a sufficiently high signal-to-noise ratio.

If only a single broadcast station is involved, the use of a multi-element yagi antenna array—consisting of a driven element, a reflector, and sufficient directors—will provide the required pattern for the elimination of ghosts. Adequate response at video carrier, color sub-carrier, and sound frequencies dictate broader bandwidth parameters than are provided by a narrow-pattern yagi. A number of such arrays, as would be required for multiple station reception, necessitate the addition of multiple lead-in wires and cumbersome switching arrangements either at the antennas or at the receiver. Thus the yagi array provides only a partial solution to the problem.

The writer has found by experiments in urban multi-unit apartments and suburban single-unit dwellings in a number of large cities, that a scaled-up version of the familiar microwave horn admirably fulfills a majority of the requirements for a broadband antenna.

No originality is claimed for this use of the microwave horn for television reception since at least two references to such possible use have appeared in the literature.[1,3] However this application has received nowhere near the attention it deserves.

The early investigators of the microwave horn radiator (W. L. Barrow, F. D. Lewis, and L. J. Chu of Massachusetts Institute of Technology) in the first published articles (1939)[1,2] originally proposed its use as an aircraft blind landing localizer radiator, but suggested, "This (broadband) feature of the electromagnetic horn, which is perhaps not equalled in any other type of ultra-high-frequency radiator, fits it peculiarly to wideband applications like television. . . ."

The first specific application of the sectoral horn to v.h.f. television reception was proposed by D. O. Morgan (1951).[3] He described its use as a tower mounted, fringe-area outdoor antenna for use with a rotator. In spite of its excellent performance characteristics it presents wind resistance problems and it is hardly a thing of beauty when exposed to public view. These considerations, of course, will not apply when

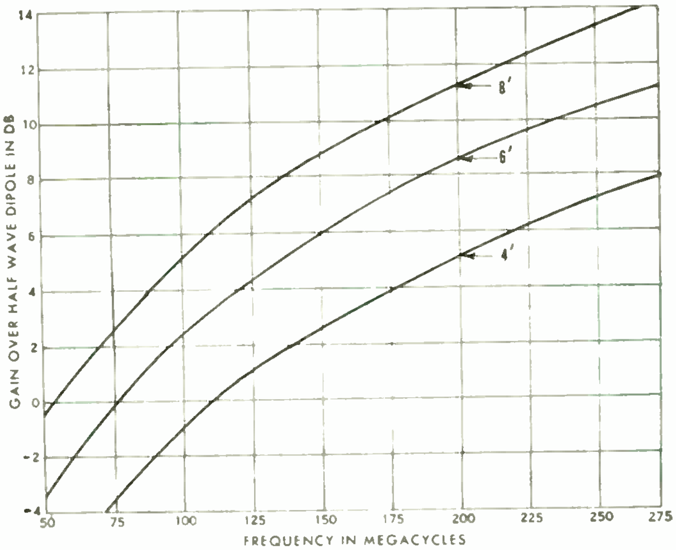


Fig. 2. Gain versus frequency for various sizes of antennas.

the antenna is secreted either in an attic, or in some other convenient out-of-sight place.

Theoretical Considerations

The configuration chosen for this application is a bi-sectoral, equi-angular, pyramidal horn. The literature is replete with pertinent theoretical and design information.[1,2,3,4,7] In reading these references, several items should be noted:

1. Vertically polarized transmissions (electric field lines perpendicular to the earth's surface) are employed in all radio services, except television and FM broadcasting, therefore vertically polarized transmission is generally assumed in the literature although not specifically so stated. For this reason, illustrations should be rotated 90-degrees for application to horizontally polarized reception and the text interpreted accordingly.
2. Sectoral horn discussions are mainly concerned with "flare" (inclined at an angle) in one plane only while pyramidal horns are flared in both planes.
3. The version considered here consists of two sides only of the pyramid (top and bottom omitted) since the desired mode of reception is that for horizontally polarized waves.

In Fig. 1, dimension *H* determines the low frequency cut-off of the horn. When operating in the dominant mode, a half-wavelength of the electric field occurs across this dimension. The electric field distribution, across the rectangular aperture, when operating in the dominant mode is identical to that in rectangular waveguides. See any standard text. Dimensions of a 60-degree flare pyramidal horn *versus* cut-off for various frequencies in the television bands are also shown in Fig. 1.

As the flare angle varies, the gain of a pyramidal horn referred to a half-wave dipole goes through a broad maximum between 40 and 60 degrees. The equilateral version with a 60-degree angle is within 0.2 db of the maximum. Such variation is negligible. The gain *versus* frequency characteristic of 60-degree bi-sectoral horns having apertures of 4, 6, and 8 feet are shown in Fig. 2. The reference base is a normal 72-ohm, resonant half-wave dipole.

The directional reception patterns of electromagnetic horn antennas as a function of flare angle are shown in detail in the literature.[4] While flare angles of less than 60-degrees will provide narrower reception patterns, this is accompanied by a reduction in gain. The antenna polar pattern is sufficiently narrow to accomplish its purpose of ghost elimination and yet allow adequate gain over a 20° included angle. (It is of interest to note that the bow-tie antenna for u.h.f. television is a horn with a 180° angle.) For a perfect match, a lead-in impedance of 377 ohms is required. Means of attaining a satisfactory impedance match will be covered while discussing antenna construction later in this article.

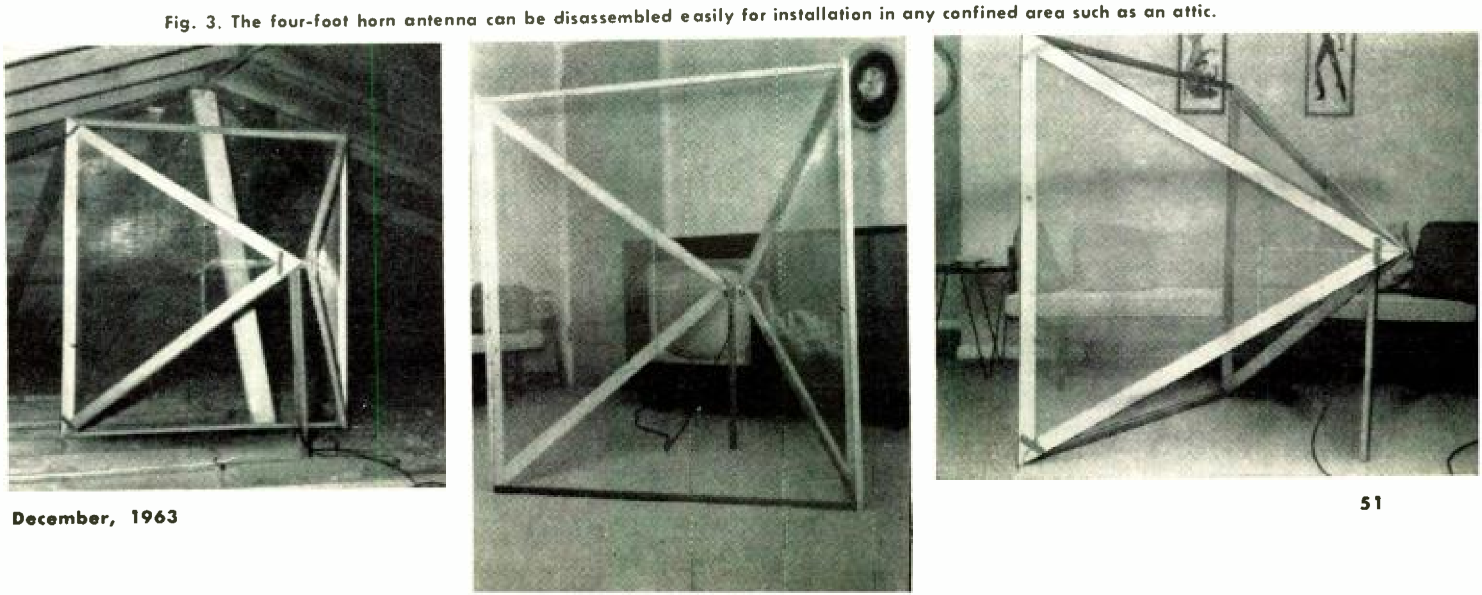
Practical Construction

Many apartment houses have a slightly pitched roof construction with an attic crawl space provided for ventilation and heat insulation purposes. Access to this space is usually provided through a small trap door often located in the ceiling of a clothes closet or hallway and may be a scant three feet or less in its diagonal dimension. To meet these cramped conditions, as well as to make preliminary performance and orientation tests before final installation, a design was adopted which permitted ready disassembly. A screwdriver is all that is required for re-assembly in the attic.

Fig. 3 shows the assembled antenna which consists of two equilateral triangular frames made from 1" x 2" pine furring, and covered on the facing or interior surfaces with bronze screen cloth. The frames are held together at the corners by hardware mending plates (1/8" x 1" x 2") fastened with wood screws. The screen cloth is tacked to the upper and lower side pieces and secured with screws and flat washers at the vertical front piece. Thus, the front parts of the frame can be removed and the entire antenna folded for passage through the attic door.

Fig. 4 illustrates some of the constructional details at the apex of the horn. The screen cloth is trimmed off at the apex corner of both sides to prevent an accidental short circuit. The nose block or brace was made by gluing together two of the 30-60-90-degree pieces of wood cut from the ends in forming the sides of the frame. (The nose block is shaped like an equilateral triangle.) Assembly employs small angle brackets held to the sides (*Continued on page 78*)

Fig. 3. The four-foot horn antenna can be disassembled easily for installation in any confined area such as an attic.



CHOOSING A TWO-WAY RADIO SYSTEM

By HOWARD H. RICE / Technical Information Center, Motorola Inc.

PART 2 / Types of communications systems, simplex and duplex operation, and various types of repeater systems are covered in concluding part.

PART I of this series covered the design parameters of a two-way radio system. This portion will cover types of systems currently available.

The simplest, and undoubtedly the most prevalent type of two-way radio system is of the one-frequency *simplex* design. Each transmitter and receiver in the system is tuned to a common frequency and communications travels in one direction at a time. For most business radio users, the one-frequency simplex system is completely adequate. Its chief benefit is simplicity, not only because of the equipment economy but also because one-frequency simplex radios are easy to operate. This type of system can be licensed in all three business radio bands. (See Part 1.)

If the user can install an antenna tower on the roof of his building or adjacent to the building, a locally controlled radio set can be mounted on the dispatcher's desk and the transmission line run from the installation directly to the antenna. As a rule-of-thumb, transmission line should not exceed 500 feet in the 25-50 mc. range, 250 feet in the 150-174 mc. range, and 125 feet in the 450-470 mc. region. Therefore, if the user's dispatching desk is some distance from his antenna site or if he requires a higher powered transmitter, a remotely controlled base station is necessary.

Remote control of a base station is usually achieved by leased landlines. Most remote control consoles are compatible with either 2-wire lines (in which the d.c. control voltages use the same pair of lines as the a.c. audio voltages) or with 4-wire lines (in which the control lines are separate from the audio lines). The remote control console should also contain a microphone preamplifier and a compression amplifier to make certain that the input level to the line meets telephone company specifications.

Additional dispatch points may be added to either locally controlled or remotely controlled base stations. The dispatch point might be only a telephone-type handset on the manager's desk or it might be another remote control console installed in an alternate or emergency dispatching office. The FCC insists, however, that the system be under the control of the main dispatcher at the control point; he must be able to monitor both sides of any conversation which originates from an auxiliary dispatch point, unless some emergency situation has disabled the control point.

A variation of the one-frequency simplex system might be called a "multi-frequency option" since it is not truly a two-frequency system. Suppose, for example, a local police department wanted to contact its own mobiles as well as the mobiles of a nearby police department, or perhaps state police vehicles. A dual-frequency transmitter and receiver would then be installed at the base station. However, only one switch-selected frequency would be used at a time, so the system would still be, essentially, a one-frequency simplex system. In other cases, the user might require this two-frequency option for his mobile units as well as his base station—or instead of it—depending on his needs.

A full step up from the one-frequency simplex system is the true two-frequency simplex system. This system is still a simplex system since communication still occurs in only one direction at a time. However, the system operates on two different frequencies: the receiver on one and the transmitter on another. If the base station transmitter operates on frequency 1, the receiver operates on frequency 2. The mobile units are set up in the opposite way, transmit on frequency 2, and receive on frequency 1. The mobile units cannot communicate directly with each other, since their transmitters and receivers are not tuned to the same frequency.

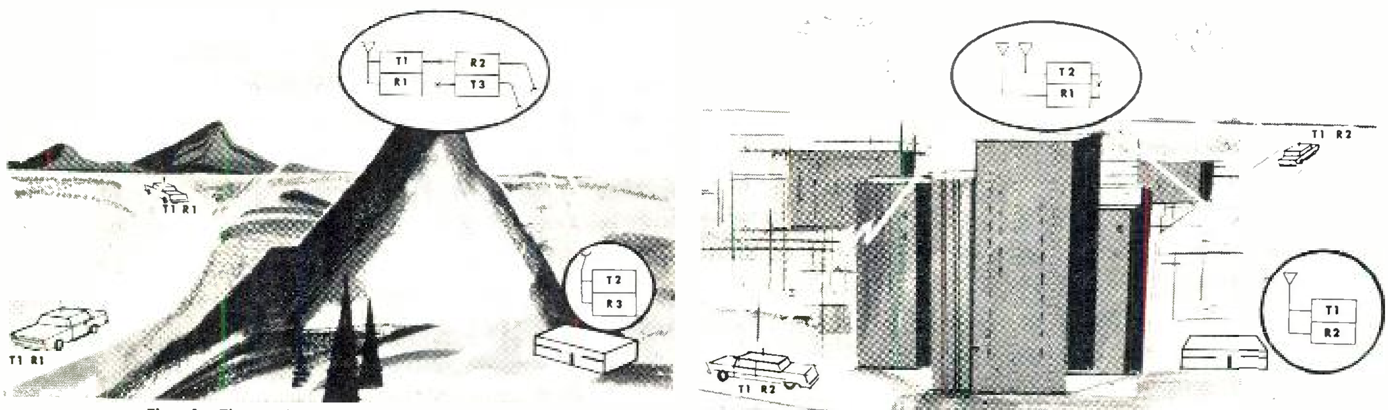


Fig. 1. The radio circuit of the radio-controlled base station (left) replaces the wire control lines in those systems where the cost of leased landline may be prohibitively high. In the mobile relay system (right), the base station dispatcher is connected to the repeater by a radio link. Both the dispatcher and the mobiles are tuned to same frequency.

This arrangement is used most often by taxicab companies and by large police departments. As a matter of fact, the taxicab radio service has been specifically divided into pairs of channels so that two-frequency systems can be used. The advantage of the two-frequency system is that it permits rapid-fire dispatching, such as that necessary for police or taxicab operations. In such systems there is usually more traffic originating at the dispatcher's office than there is coming into the dispatcher from the mobiles.

An expansion of the dual frequency idea is the two-frequency *duplex* network. This type of system differs from the previous one in that communications can take place in both directions at the same time. All radio sets in the system require two antennas, one for the transmitter and one for the receiver. If the two frequencies are sufficiently separated from each other, a single antenna can be used with a *diplexer*, a band-reject filter which prevents the strong transmitter energy from entering the associated receiver. The full two-frequency duplex arrangement is rarely used in applications other than mobile radiotelephone systems.

A modified two-frequency duplex system, in which the base station is set up for duplex operation but the mobiles are limited to simplex facilities, is often used in situations where traffic from the dispatcher is extremely heavy. With such a system, a transmitter dispatcher is responsible solely for outgoing messages. Because base station traffic can be transmitted and received simultaneously, a separate dispatcher is on duty to receive all incoming messages. This type of system is utilized for large metropolitan police departments and also by users whose radio dispatching requirements are exceptionally heavy during most of the working day.

Repeater Systems

Repeater systems are, in essence, a more complex integration of several basic two-way communication system designs. Repeater stations are used to take advantage of an exceptional antenna tower site and are becoming more and more prevalent, not only in mountainous regions but also in large metropolitan centers. There are two types of repeater stations: the radio-controlled base station repeater and the mobile relay repeater shown in Fig. 1.

Consider the situation in which a nearby mountain or hill provides an ideal location for the base station antenna site. However, the cost of leasing telephone lines up to the base station might be prohibitive. One successful solution to the problem is a separate control circuit using radio instead of the conventional wire lines. A low-powered control station is installed at the dispatcher's location (which we'll call "headquarters") with a directional antenna beaming the signal up to the remote base station.

On the mountaintop, the signal is picked up by the receiver in the repeater station. The audio portion is then used to modulate the base station transmitter which sends the message out to the various mobile units in the system. Communication from the mobile units operates in the same way. The message is picked up by the base station receiver and is automatically rebroadcast back down to headquarters by the repeater transmitter. Note that the mobile units can communicate directly with each other.

Between the base station and the mobile units, we have a one-frequency simplex system which can be operated on any of the available two-way communications frequency bands. The control circuit is a directional point-to-point system which is usually operated on a pair of frequencies in the 450-470 mc. or up in the 960-mc. region.

There are several variations of the mobile relay concept and we will explore each. The basic mobile relay system is exactly what its name implies: a relay for expanded mobile-to-mobile coverage. The relay station is usually located on a high hill or mountain, or on a tall building in metropolitan areas. It is completely unattended and is arranged in such a way that all signals picked up by the receiver are automatically rebroadcast by the transmitter. This, of course, requires that the station have two antennas since it is receiving and broadcasting simultaneously.

The major benefit afforded by mobile relay operation is the vastly extended coverage it affords; it actually gives each mobile station a range equivalent to the range of the mobile plus the range of the repeater. Beside the improved range, the system is also important because it can be licensed to business radio users in the 450-470 mc. band.

The dispatcher can be connected into the system in one of two ways. The headquarters can be equipped with a locally controlled base station, tuned to the same pair of frequencies as the mobile units, and a directional antenna beamed at the repeater site. With this arrangement, the dispatcher's radio operates as though it were a "tied-down" mobile unit; each radio in the system has equal access to the repeater.

The other method used to link the dispatcher with the rest of the system is a wire control line. When the repeater (see Fig. 2) is operated in this manner, the dispatcher has complete control of the system. For additional system flexibility, the dispatcher's remote control console is often equipped with a special "Repeater On/Off" switch. With the switch in the "Off" position, the system is operated by the dispatcher as though it were a simple two-frequency system. When the dispatcher goes off duty and the headquarters is left unattended, the switch on the remote control console is thrown to the "Repeater On" position and the systems reverts to mobile relay operation.

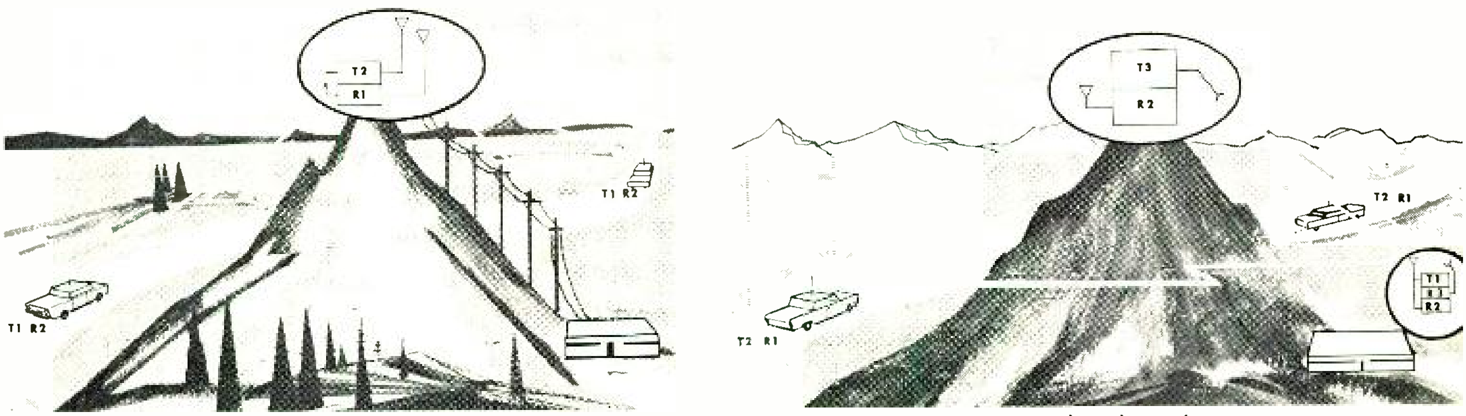


Fig. 2. In the mobile relay system (left), base station dispatcher is connected to repeater through a wire line. In the one-way talk-back repeater system (right), messages from dispatcher go directly to mobile units; messages from mobile units can go directly to base station; or over greater distances, can be relayed by repeater.

An example of this wire-line control mobile relay system might be a county or state highway department. During the day when many mobile stations are in operation, the system is under the control of the headquarters dispatcher. At night, a few vehicles are still operating. The dispatcher closes the base station when he leaves for the day and the responsibility of the system goes to a night supervisor who is operating one of the vehicles. The next (*Continued on page 82*)

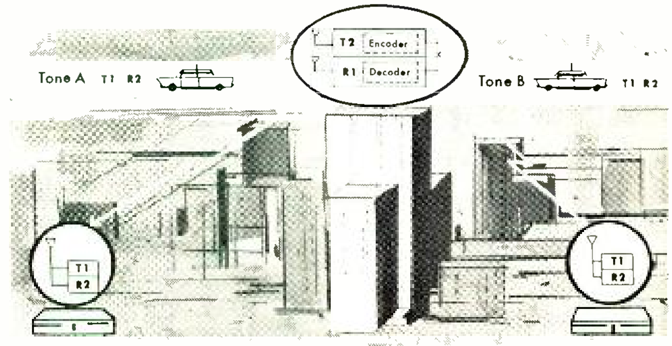
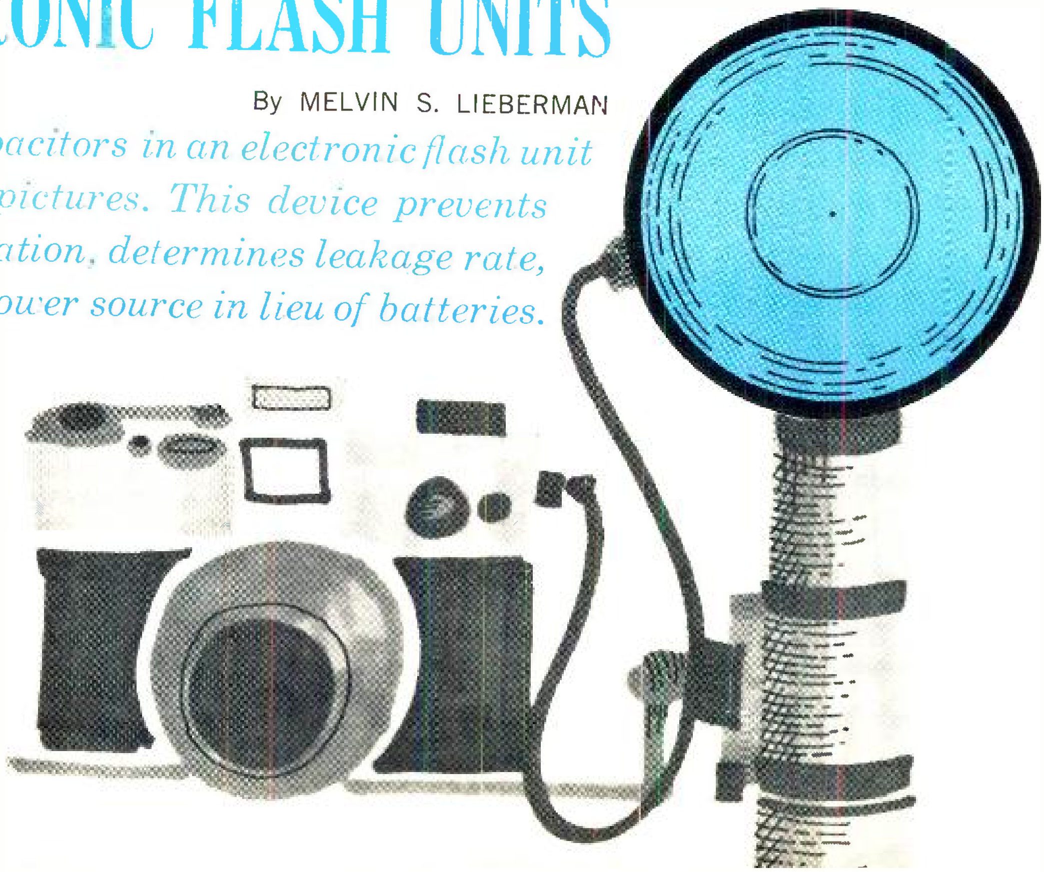


Fig. 3. A tone-coded squelch is used in the shared or community repeater system so that each user hears only those messages originating within his portion of the over-all system.

CAPACITOR FORMER for ELECTRONIC FLASH UNITS

By MELVIN S. LIEBERMAN

Leaky storage capacitors in an electronic flash unit can cost a lot of pictures. This device prevents capacitor deterioration, determines leakage rate, and can act as a power source in lieu of batteries.



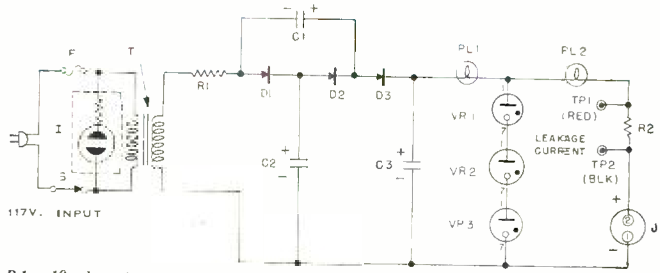
WHEN electronic flash units of the high-voltage battery type perform in a faulty manner, the trouble is often caused by bad storage capacitors. The units described in this article were designed to fulfill a long-standing need for an instrument which could be used to prevent storage capacitor deterioration by keeping the capacitors formed, determine the condition of the storage capacitors, and act as a power source when a flash unit is operated near a power line (for example, in a photo studio).

Capacitor Deterioration

The first sign of storage capacitor deterioration is an increase in the electronic flash unit's recycling time. The second sign is that the batteries do not last as long as usual. The third sign, and this happens when the storage capacitors are quite bad, is that the "Ready" light will not indicate a ready condition. This is due to a lack of high voltage at the storage capacitors because of the high leakage current causing a sizeable voltage drop across the de-ionizing resistor in the flash unit. The de-ionizing resistor is usually on the order of 500 to 1000 ohms. As a single bad storage capacitor can easily draw 100 ma., and as some flash units have two or more such capacitors, a voltage drop of 50 v. or more can appear across the de-ionizing resistor. Most ready lights are set to operate at from 80 to 100% of the intended flash unit operating voltage, therefore a drop of 50 volts and more would keep the ready light from operating. Some flash units of the 450-v. variety can have less than half voltage at the storage capacitors because of high leakage currents dropping an appreciable voltage across the de-ionizing resistor.

Electrolytic capacitors for electronic flash units are manufactured of the highest-quality materials under highly controlled conditions and have very-low leakage currents.

The storage capacitors become deformed in an electronic flash unit which has not been used for some time. The degree of deformation depends upon such things as length of idle period, quality of the capacitors, prior condition of the capacitors, temperature, and humidity. When a flash unit is placed in service with deformed capacitors, even to a small degree, the result is a greatly decreased battery life and a definitely lessened watt-second output.



R1—10 ohm, 1 w. res.
R2—100 ohm, ½ w. res. ± 5%
C1—40 µf., 450 v. elec. capacitor
C2—12 µf., 250 v. elec. capacitor
C3—20 µf., 600 v. elec. capacitor
PL1,PL2—250 v., 10 w. bulb
S—S.p.s.t. switch
F—¼-amp "Slo-Blo" fuse
D1,D2,D3—1N2071 diode
I—Neon lamp assembly (Dialco 95408X or equiv.)
J—Socket (Cinch-Jones S-302 or equiv.)
T—Isolation trans., 40 w. (UTC R-72 or equiv.)
TP1,TP2—Jack, (GC 33-240 or equiv.)
VR1,2,3,—0A2 tube

Fig. 1. The circuit and parts list for the 450-v. flash unit battery eliminator and capacitor former. The device is easy to construct and features built-in, short-circuit protection.

When flash units which are not in use, even for short periods of time, are subjected to a proper forming voltage, not only will battery life be greatly extended, but these deforming troubles do not generally appear.

In designing a suitable forming unit, the following features should be incorporated: it must have as great a degree of safety as possible, therefore line isolation is required; the unit must be simple to build and operate and have no controls to adjust; it must apply the correct voltage to the flash unit over wide variations of line voltage; it must be able to be used as a battery eliminator in addition to performing the function of capacitor forming; and it must be entirely dependable.

The circuits for 450-v. and 510-v. units are shown in

Figs. 1 and 2 respectively. An underside view of the completed 450-v. capacitor former is shown in Fig. 3.

Effects of Leakage Currents

Let us consider the effect of leakage currents in the storage capacitors of high-voltage, battery-type electronic flash units. A typical 450-v. flash unit, using two *Burgess* N150 or *Eveready* 492 batteries, will give approximately 1500 flashes when operated at 100 watt-seconds. (The actual number of flashes depends upon numerous conditions, such as the amount of continuous or intermittent use, temperature, age of the batteries, and storage conditions, to name a few.) These units are in the very best of shape if the leakage current is no greater than 1 ma. per 100-watt-second rating. If the storage capacitors had 10-ma. leakage, the recycle time of the flash unit would become slightly longer due to the *IR* drop across the de-ionizing resistor, and this 10 ma. represents 4.5 watts (450 v. × 0.01 amp.), or in 10 minutes of "on" time this would be 2700 watt-seconds (60 × 10 × 4.5). Now just what does 2700 watt-seconds mean to us who use these types of flash units? It means that we will have lost the equivalent of 27 flashes at 100-watt-second rating or 54 flashes at 50-watt-second rating with a unit whose storage capacitor's leakage was 10 ma. In terms of economy, we would lose 1.8 percent of our battery life (27/1500 or 54/3000) for an "on" (but unused) time of 10 minutes. Now you can see the importance of keeping your capacitors well formed. Better formed capacitors means less leakage and less waste.

As a matter of interest let's consider the effect of having accidentally left on, for 24 hours, a 450-v., 100-watt-second flash unit that was in such excellent shape as to have only 1 ma. of leakage current. This leakage current represents 0.45 watt (450 v. × 0.001 amp.), and in 86,400 seconds (24 hours) the leakage energy lost would be 38,880 watt-seconds (86,400 × 0.45). This is equivalent to 776 flashes at 50 watt-seconds (38,800/50) or 388 flashes at 100 watt-seconds (38,800/100). And if this doesn't impress you then let's look at it in terms of lost battery capacity on the basis of 1500 flashes per 100 watt-seconds or 3000 flashes per 50 watt-seconds. You would lose 25.87 percent of your battery capacity (388/1500 or 776/3000). As you can easily see now, it is definitely to your advantage to have your flash unit off when not in use and in top shape when in use.

In the opinion of the author, a 10-ma. leakage current in a 100-watt-second flash unit is intolerable. Even though a 100-watt-second flash unit with this leakage current and a 500-ohm de-ionizing resistor will charge up to 98.9 percent of the battery voltage, this leakage current does represent a substantial loss of battery capacity. A 10-ma. leakage amounts to a loss of 81 flashes in a 450-v. flash unit and 90 flashes in a 510-v. flash unit for every 30 minutes of flash unit "on" time. If a typical photographic assignment lasted 30 minutes, then the loss of battery life would amount to half of the battery capacity for ten such assignments.

If you do not use your flash unit several times weekly, or do not find it practical to put it on "capacitor forming," or do not have a voltmeter to monitor the capacitor-forming voltage to determine that the capacitors have been fully formed when put on capacitor forming, then use the graph of Fig. 4 to determine how long the unit should be placed on forming. This is, however, only an approximate guide since the forming time varies with the condition of the capacitors.

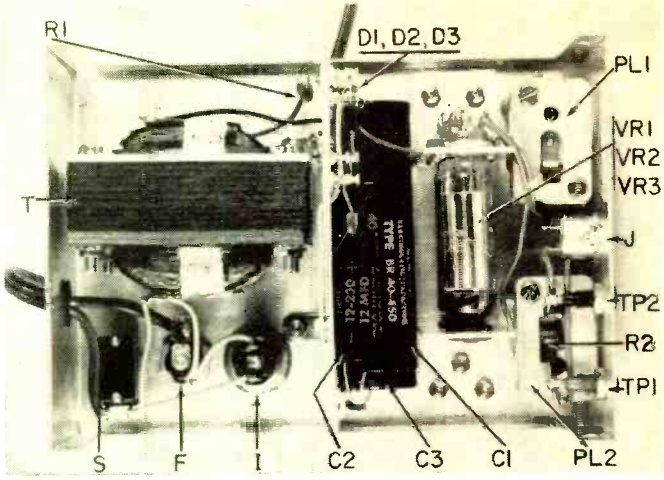


Fig. 3. Underchassis view of completed 450-v. capacitor former.

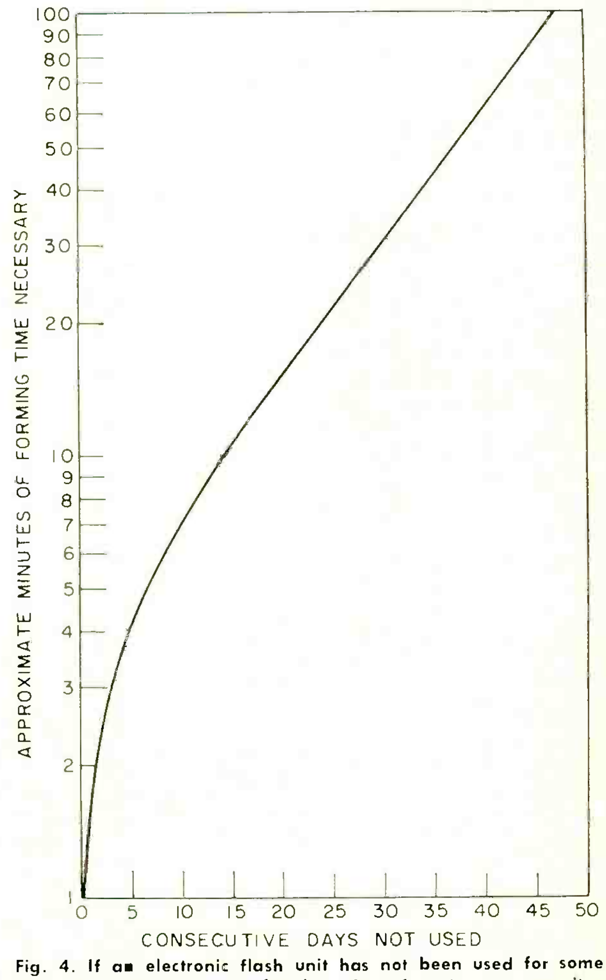


Fig. 4. If an electronic flash unit has not been used for some time, this graph shows forming time for storage capacitors.

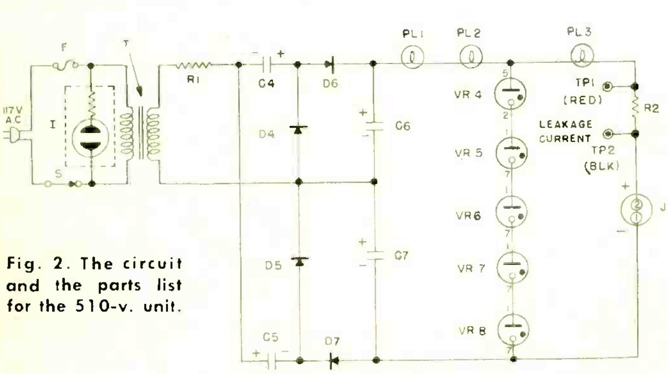


Fig. 2. The circuit and the parts list for the 510-v. unit.

R1—10 ohm, 1 w. res.
R2—100 ohm, ½ w. res. ± 5%
C4,C5—12 μf., 250 v. elec. capacitor
C6,C7—12 μf., 450 v. elec. capacitor
PL1,PL2,PL3—250 v., 10 w. bulb
S—S.p.s.t. switch
F—¼-amp "Slo-Blo" fuse
I—Neon lamp assembly (Dialco 95408X or equiv.)
J—Socket (Cinch-Jones S-302 or equiv.)
T—Isolation trans., 40 w. (UTC R-72 or equiv.)
D4,D5,D6,D7—1N2071 diode
TP1—Jack,red (GC 33-240 or equiv.)
TP2—Jack, black (GC 33-242 or equiv.)
VR4—0B3 tube
VR5,VR6,VR7,VR8—0B2 tube

Leaving the unit on for longer or indefinite periods of time with the formers described here will in no way be harmful to the flash unit or to the forming unit.

Voltmeter Test Points

The finished units were constructed with two test points (*TP*1 and *TP*2). These test points are connected to each side of a 100-ohm resistor, which is in series with the positive side of the high-voltage output lead. By connecting a voltmeter (10,000 ohms/volt or better) to these two test points and reading the voltage after the storage capacitors are charged, you can determine the leakage current with the aid of the graph of Fig. 5. The voltage at these test points will never exceed 4.6 volts in either of these two units even with shorted storage capacitors. Fig. 6 shows the circuit of a voltmeter that the author built to use with these units for reading leakage current directly.

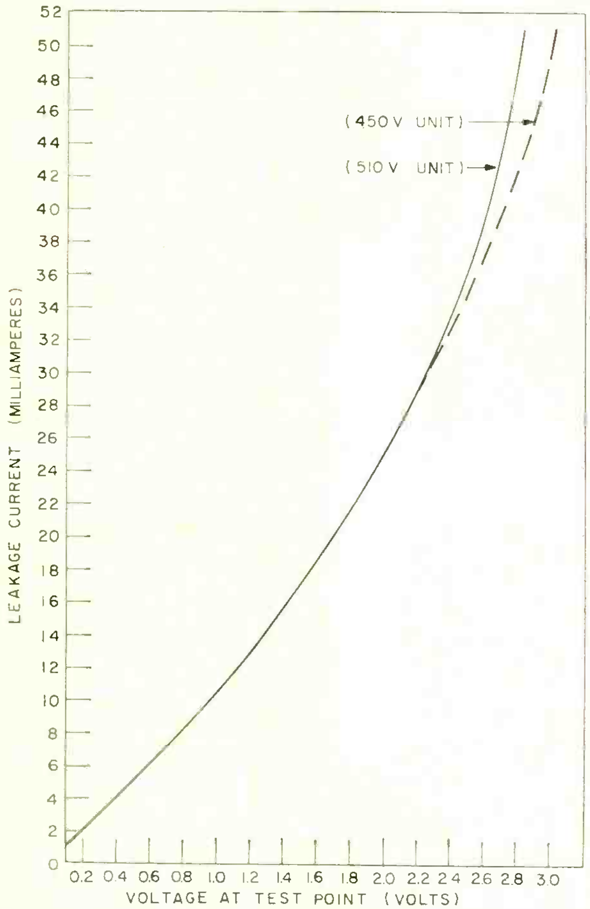
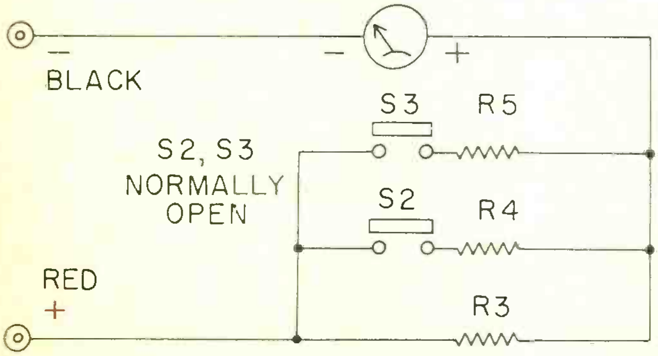


Fig. 5. Leakage current can be determined using a 10,000-ohm-per-volt voltmeter at the leakage current monitoring points.

Fig. 6. Novel leakage current meter has automatic overload protection because push-button must be held down on the sensitive ranges. Device is to be used with the capacitor former.



AMMETER RANGE	R5 SCALE C	R4 SCALE B	R3 SCALE A
0-50μA.	25K	100K	100K
0-100μA.	12.5K	50K	50K
0-1MA.	25K	2.5K	5K

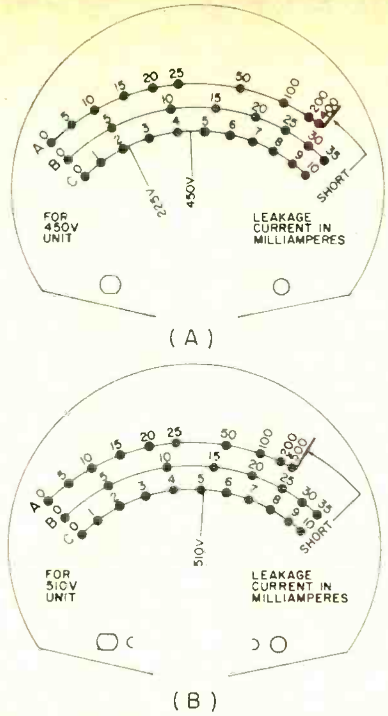


Fig. 7. These meter scales may be used for the leakage current monitor. The meter face of (A) is to be used for the 450-v. unit, while the one at (B) is to be used for the 510-v. unit.

The circuit design of the battery eliminator and capacitor former unit described here limits charge and leakage current flow to a nominal 45 ma. If we were to read leakage currents up to 400 and 500 ma., we would have to have a specially calibrated meter scale. In other words, the available current of 0 to 45 ma. from these units has to represent 0 to 500 ma., where 45 ma. must equal a short. We therefore make an assumption that capacitors with given amounts of leakage at 450 and 510 v. can be represented by some value of resistance which remains constant with a change in voltage. By connecting these different values of resistance, which represents known values of leakage at 450 and 510 v., to the two completed units, we can calibrate the new meter scale. The results of this calibration are the meter scales of Fig. 7. The special scales may be cut out and glued on the original meter scale. Since this scale is calibrated directly in leakage current, there is no need to refer to the graph of Fig. 5 if you build this companion meter.

Applying the rated voltage all at once to a capacitor which has not been in use for some time, is actually hard on the capacitor because of the high initial surge and leakage currents. The very nature of the protective features of the units described here prevents high surge or leakage currents due to ballast action. As the capacitor charging and forming currents decrease, the ballast circuits allow a higher voltage to be applied to the capacitors. Thus, the capacitors are formed in a very gentle fashion. As a matter of fact, these units never allow more than a nominal 45 ma. of current to flow into the capacitors even if they are shorted!

Meter and Meter Circuit

This meter circuit is unique because the high range, scale *A*, is always connected unless the push-button switch for scale *B* or scale *C* is pressed. Thus, protection against meter overload is automatic. The values for *R*3, *R*4, and *R*5 using three common ammeters, are shown in Fig. 6.

In addition to leakage current scales, the meter templates have markings for using the meters to read 225 v., 450 v., and 510 v. with an external series resistor. The series resistor should be sufficient for converting whatever basic meter movement is used to a 1000-v. meter. ▲

OUTPUT-TRANSFORMER CHART

Listing of output powers and required audio output transformer primary impedances for over 200 tubes.

THE following chart will be helpful in selecting the proper output transformer as a replacement in radio receivers or in the construction of audio amplifiers. To use the chart, simply check in the first column for the tube type being used, then read across for the applicable operating characteristics and required output transformer primary impedance.

The transformer should be able to handle the amount of power given and should have a secondary winding that will match the loudspeaker impedance. In most receivers, this value is 3.2 ohms, while in amplifiers, common impedances are 4, 8, and 16 ohms. Note that "S" stands for single-ended and "P.P." means push-pull. All load resistances are given in thousands of ohms. This chart was based on information supplied by *Stancor Electronics, Inc.* ▲

Tube	Use	Class	Pwr. Out. Watts	Load Res. in K Ohms
1A5-GT	S	A	.10	25
1AC5	S	A	.05	25
1AG4	S	A	0.035	12
1B8-GT	S	A	.21	14
1C5-GT	S	A	.24	8
1D8-GT	S	A	.20	12
1E7-G (GT)	S	A	.29	16
	PP	A	.575	24
1F4	S	A	.31	16
1F5-G	S	A	.31	16
1G5-G	S	A	.55	9
1G6-GT	PP	B	.675	12
1H4-G (GT)	PP	B	2.1	8
1J5-G	S	A	.45	13.5
1J6-G (GT) (GX)	PP	B	2.1	10
1LA4	S	A	.1	25
1LB4	S	A	.2	12
1N6-G (GT)	S	A	.1	25
1Q5-GT	S	A	.27	8
1S4	S	A	.27	8
1T5-GT	S	A	.17	14
1V5	S	A	.05	25
1W4	S	A	.2	12
2A3	S	A	3.5	2.5
	PP	AB1	15	3
2A5	S	A	4.8	7
	PP	AB2	18.5	10
2E24	S	A	3.9	6
2E26	S	A	4.0	5.5
2E30	S	A	4.5	4.5
3A4	S	A	.7	8
3B5-GT	S	A	.2	5
3B7/1291	PP	AB2	1.5	16
3C5-GT	S	A	.2	8
	S	A	.26	10
3D6	S	A	.6	14
3E5	S	A	.25	8
3LE4	S	A	.325	6
3LF4	S	A	.4	8
3Q4	S	A	.27	10
3Q5-GT	S	A	.4	8
3S4	S	A	.18	5
	S	A	.27	8
3V4	S	A	.27	10
3W4	S	A	0.25	11
4A6-G	PP	B	1.0	8
5AQ5	S	A	2.0	5.5
	S	A	4.5	5
5CM6	S	A	4.5	5
	PP	AB1	10.	10
5CZ5	S	A	5.4	5
	PP	AB1	21.5	7.5
5V6 (GT)	S	A	5.5	5
	PP	AB1	10.	10
6A3	S	A	3.2	2.5
	PP	AB1	15	3
6A4/LA	S	A	1.4	8
6A5-G	S	A	3.75	2.5
	PP	A	15	3
6A6	PP	B	10	8
6AB8	S	A	1.4	11
6AC5-GT	PP	B	8	10
6AC6-GT	S	A	3.6	3.5
6AD7-G	S	A	3.2	7
6AE7-GT	PP		9.5	10
6AG6-G	S	A	3.8	8.4
6AG7	S	A	3	10
6AH5-G	S	A	10.8	4.2
6AJ5	PP	AB1	1.0	28
6AK6	S	A	1.1	10
6AK7	S	A	3	10
6AL6-G	S	A	6.5	2.5
6AM5	S	A	1.4	16
	PP	AB1	4.8	20
6AN5	S	A	1.3	2.5
6AQ5-W	S	A	4.5	5
6AR5	S	A	3.4	7.6
6AS5	S	A	2.2	4.5
6B4-G	S	A	3.2	2.5

Tube	Use	Class	Pwr. Out. Watts	Load Res. in K Ohms
	PP	AB	15	3
6B5	S	A	4	7
6BF5	S	A	1.9	2.5
6BF6	S	A	0.3	10
6BJ5	S	A	4.0	7
6BK5	S	A	3.5	6.5
6BM5	S	A	3.5	7
6BM8	S	A	3.5	5.6
6BQ5	S	A	5.7	4.5
	PP	AB1	11.0	8
6BS5	S	A	4.5	5
6BU6	S	A	0.3	10
6BW6	S	A	4.5	5
	S	A	5.5	8.5
6CA5	S	A1	1.5	4.5
6CA7	S	A	11.0	2
6CL6	S	A	2.8	7.5
6CM6	S	A	4.5	5
	PP	AB1	10.	10
6CS5	S	A	3.8	4
6CU5	S	A	2.3	2.5
6CZ5	S	A	5.4	5
	PP	AB1	21.5	7.5
6D5G	S	A	1.4	7.2
6DB5	S	A	3.8	4
6DG6-GT	S	A	3.8	4
6DS5	S	A	3.6	8
6DZ8	S	A	2.0	2.5
6E6	PP	A	1.6	14
6EH5	S	A	1.4	3
	PP	A	3.8	6
6F6 (GT)	S	A	4.8	7
	PP	AB	18.5	10
6G6-G	S	A	1.1	10
6K6-GT	S	A	4.5	9
	PP	A	10.5	12
6L6 (G) (GA)	S	A	6.5	2.5
	S	A	10.8	4.2
	PP	A	17.5	5
	PP	AB1	26.5	6.6
	PP	AB1	18	3.8
	PP	AB2	31	6
	PP	AB2	47	3.8
6M5	S	A	3.9	7
	PP	AB1	9.4	7
6N6-G	S	A	4	7
6N7	PP	B	10	8
6R8	S	A	0.3	10
6SR7	S	A	0.3	10
6U6-GT	S	A	5.5	3
6V5-GT	S	A	4.5	5
	PP	AB1	10	10
6V6 (GT)	S	A	5.5	5
	PP	AB1	10	10
6V7-G	S	A	0.35	20
6W6-GT	S	A	3.8	5
6Y6-G (GT)	S	A	6.0	2.6
6Y7-G	PP	B	8.0	14
6Z7-G	PP	B	4.2	12
7A5	S	A	1.5	2.5
7B5	S	A	4.5	9
	PP	AB2	19	10
7C5	S	A	5.5	8.5
	PP	A	8	10
8BQ5	S	A	5.7	4.5
	PP	AB1	11.0	8
9DZ8	S	A	2.0	2.5
10	S	A	1.6	10.2
11C5	S	A	1.5	2.5
12A5	S	A	3.4	3.3
12A6 (GT)	S	A	3.4	7.5
12A7	S	A	.55	13.5
12AB5	S	A	4.5	5
	PP	AB1	10.0	10
12AL8	S	A	0.02	.8
12AQ5	S	A	4.5	5
	PP	AB1	10.0	10
12BF6	S	A	0.3	10
12BK5	S	A	3.5	6.5
12BU6	S	A	0.3	10

Tube	Use	Class	Pwr. Out. Watts	Load Res. in K Ohms
12C5	S	A	2.3	2.5
12CA5	S	A	1.5	4.5
12CM6	S	A1	2.0	5.5
	S	A1	5.5	8.5
12CS5	S	A	3.8	4
12CU5	S	A	2.3	2.5
12DB5	S	A	3.8	4
12DL8	S	A	0.04	.8
12DM5	S	A	1.9	2.5
12DU7	S	A	0.025	2.7
12DV8	S	A	0.005	1.25
12DZ8	S	A	2.0	2.5
12ED5	S	A	1.5	4.5
12EH5	S	A	1.4	3
	PP	AB1	3.8	6
12EM6	S	A	0.01	3.5
12J8	S	A	0.02	2.7
12K5	S	A	0.04	.8
12L6-GT	S	A	3.8	4
12L8-GT	S	A	1.0	10
12V6-GT	S	A	4.5	5
	PP	AB1	10.0	10
12W6-GT	S	A	3.8	4
14A5	S	A	2.8	7.5
14C5	S	A	5.5	8.5
	PP	AB	14	8
17C5	S	A	2.3	2.5
17CA5	S	A	1.5	4.5
17CU5	S	A	2.3	2.5
17L6-GT	S	A	3.8	4
19	PP	B	2.1	10
19AQ5	S	A	4.5	5
25A6 (GT)	S	A	2.2	5
25A7-GT	S	A	.77	4.5
25AC5-GT	PP	B	6	4.8
	S	A	2	2
25B5	S	A	3.8	4
25B6-G	S	A	7.1	2.5
25BK5	S	A	3.5	6.5
25C6-G	S	A	6.0	2.6
25CA5	S	A	1.5	4.5
25EH5	S	A	1.4	3
	PP	AB1	3.8	6
25F5	S	A	1.2	2.5
	PP	A	2.9	4.5
25L6 (GT)	S	A	2.1	2
	S	A	4.3	3
	S	A	3.8	4
25N6-G	S	A	3.8	4
25W6	S	A	3.8	4
26A7-GT	S	A	.18	1.5
26E6-G	S	A	6.0	2.6
28D7	S	A	.1	4
31	S	A	0.375	5.7
32ET5	S	A	1.2	2.8
32L7-GT	S	A	1	2.6
33	S	A	1.4	6
35A5	S	A	1.5	2.5
	S	A	3	5
35B5	S	A	1.5	2.5
35C5	S	A	1.5	2.5
35DZ8	S	A	2.0	2.5
35L6-GT	S	A	1.5	2.5
	S	A	3	5
38	S	A	2.5	10
41	S	A	4.5	9
	PP	A	10.5	12
42	S	A	4.8	7
	PP	A	18.5	10
43	S	A	2.2	5
45	S	A	2	4.6
	PP	AB2	18	3.2
46	PP	B	20.0	5.8
47	S	A	2.7	7
48	S	A	2.5	1.5
49	S	A	0.17	11
50	S	A	4.6	4.35
50A5	S	A	2.1	2
	S	A	3.8	4
50B5	S	A	1.9	2.5

Tube	Use	Class	Pwr. Out. Watts	Load Res. in K Ohms
50BK5	S	A	3.5	6.5
50C5	S	A	1.9	2.5
50C6-G	S	A	3.6	2
50CA5	S	A	1.1	3.5
50EH5	S	A	1.4	3
	PP	A	3.8	6
50L6-GT	S	A	2.1	2
	S	A	3.8	4
55	S	A	0.35	20
59	S	A	3.0	6
	PP	B	20.0	6
70A7-GT	S	A	1.5	2.5
70L7-GT	S	A	1.8	2
71A	S	A	0.79	4.8
79	PP	B	8.0	14
85	S	A	0.35	20
89	S	A	3.4	6.75
112A	S	A	0.285	10.65
117L7/ M7-GT	S	A	.85	4
117N7-GT	S	A	1.2	3
117P7-GT	S	A	.85	4
1631	PP	AB1	26.5	6.6
1632	S	A	2.1	2
1644	PP	A	1.0	10
5640	S	A	1.25	3
5670	PP	AB1	1.0	27
5672	S	A	.065	20
5686	S	A	2.7	9
5812	S	A	4.3	1.7
5824	S	A	4.3	1.7
5871	S	A	5.5	8.5
5902	S	A	1	3
6005	S	A	2.0	5.5
6095	PP	AB1	10.0	10
6216	S	A	3.8	4.5
6287	S	A	4.5	6
6360	PP	AB1	9.3	8
6516	S	A	1.4	16
6526	S	A	0.375	10
6669	S	A	4.5	5
	PP	AB1	10.0	10
6677	S	A	2.8	7.5
6945	S	A	0.8	3
6973	PP	AB1	15	5.5
	PP	AB1	20	7.5
7061	S	A	3.0	5
High-Fidelity Applications				
807/W	PP	A*	8.0	10
	PP	A#	25.0	7.6
	PP	AB1	15.0	3
	PP	AB2	55.0	3.2
1614	PP	A*	10.0	10
	PP	AB1	26.5	6.6
5881	PP	A*	8.0	10
	PP	A#	25.0	7.6
	PP	AB1	26.5	6.6
6146	PP	A*	18.0	10
6550	PP	A	55.0	3.5
	PP	AB1#	60.0	4.3
	PP	AB1#•	100.0	5
7027	PP	AB1	31.5	4.5
	PP	AB1	34.0	6.6
	PP	AB1	50.0	6
	PP	AB	24.0	8
7189	PP	AB1	24.0	8
	PP	AB1	16.5	11
7212	PP	TR1	22.0	8
	PP	AB1	37.0	6.6
EL-34	PP	AB1	37.0	6.6
(6CA7)	PP	AB1#	60.0	4.3
EL-37	PP	AB1	69.0	3.25
EL-84	S	A	5.7	5.2
(6BQ5)	PP	AB1	17.0	8
KT-66	PP	A*	10.0	10
	PP	AB1#	20.0	10
	PP	AB1#	25.0	7.6
KT-88	PP	AB1#	60.0	4.3
	PP	AB1#•	100.00	5

*Triode-connected (Williamson Circuit). #Ultra-linear (Williamson Circuit) • Pentode Operation

JOHN FRYE

Technical curiosity can reap some satisfying rewards even when it just involves solving a case with freak symptoms.

CASE OF THE BAD BYPASS

"I GUESS this knocks the props from under those fur-on-the-wooly-worms forecasters who said we wouldn't see any cold weather until after the first of the year," Barney remarked as he hung up his heavy coat and started rubbing his half-frozen ears. "It took me twenty minutes to get my car started this morning."

"Here's just the thing to warm you up," Mac suggested, sliding a playing little radio down the bench toward his assistant. "It's one of your jobs that bounced. The owner admits it now takes longer for the noise to start up after the set is turned on than it did before; but once it starts, it's just as bad as ever. The ticket says you replaced a noisy 12BE6 tube."

"I remember that set, and I'll swear the 12BE6 was bad!" Barney exclaimed. "It was one of those jobs in which you could trigger the noise on or off by flipping the envelope of the tube with your finger nail. After I put in a new tube, no amount of jarring produced any noise; so I made out the bill—"

He was interrupted by a great crackling, frying sound from the little receiver. Quickly he removed the back and struck each tube in turn with a tube tapper. The noise was unaffected. "Guess it must be a bad i.f. transformer," he hazarded, reluctantly starting to pull the flimsy printed-circuit chassis from the case.

But when the noise-testing probes of the signal tracer were placed across each winding and between the windings of the i.f. transformers, there was no indication of defective coils or of leakage from coil to coil through the plastic in which the coil-tuning capacitors were embedded. Similar tests revealed nothing wrong with the oscillator coil. Even when Barney tried gently flexing the printed circuit board to see if a break in a printed circuit lead might be causing the trouble, the noise kept merrily grinding away.

Mac, who was aligning a receiver on his end of the bench, noticed the noise from Barney's receiver was heard almost as loudly in the set he was aligning. When Barney's set was turned off, the noise disappeared from Mac's set.

"Whatever is causing that noise must be pretty close circuit-wise to where the line enters the set," Mac suggested; "otherwise it wouldn't be feeding back into the line so strongly. Try removing the capacitor that connects directly across the input when the set is turned on."

Barney did, and instantly the noise disappeared. When the capacitor was returned to the circuit, the noise returned. A new capacitor produced no noise.

"That's a new one on me," Barney admitted. "The defective capacitor feels pretty warm. It must have an intermittent high-resistance leakage path through the dielectric. Probably lightning caused it. The erratic leakage current doesn't start until the capacitor reaches a certain temperature. That's why I didn't catch it before. I was looking for one, not two, sources of noise. Having found the noisy tube, I looked no further."

"I can't honestly criticize you too much this time," Mac admitted. "I had that set playing a good forty-five minutes before you came in, and it was as quiet as you could wish. Furthermore, I can't remember seeing more than two or three cases like that in all the years I've been servicing. It's not uncommon to find a line bypass that makes an intermittent noise when it is tapped simply because the poor connection between foil and lead is disturbed by the vibration; but this capacitor was soldered firmly to the printed circuit, and vibrating it had no effect whatever. The leakage path is inside the capacitor. Ordinarily the heavy line current follows across any leakage path there and literally blows the capacitor apart. Let the defective capacitor cool down, and then we'll run some checks on it as we gradually warm it up with a lamp. I'd like to know what's peculiar about it."

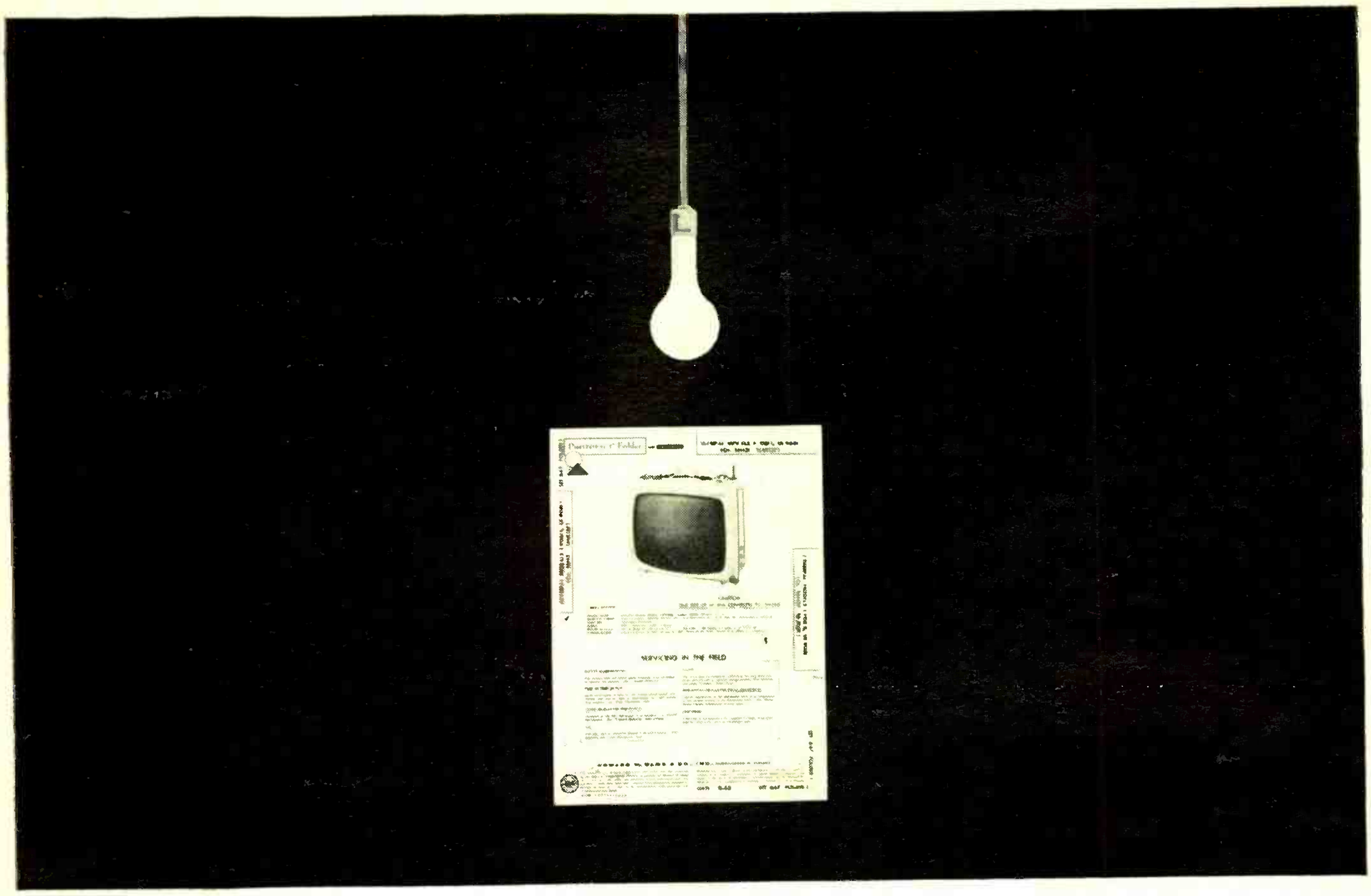
"I used to think I got all the odd-ball cases," Barney remarked; "but the other day I was talking to a technician over at the parts store, and he came up with a really wild tale. A man who lives at the edge of Cantorville to the west of here was sitting on his front porch one evening last fall watching a neighbor's dog frisking about the yard. The dog happened to brush against a downspout that came down alongside the porch, and immediately let out a howl of anguish and went yelping for home as hard as it could lope. The man walked over to the downspout to investigate, and when he touched it he was almost knocked flat by an electric charge.

"He called the electric company, and the electrician found a full 120-volts a.c. between the downspout and ground; yet neither spouting nor eavestroughs came anywhere near any wiring about the house. The electrician methodically began pulling fuses and he soon discovered one line in the house that killed the charge when its fuse was pulled. Next he unplugged things from that line one at a time, and when he unplugged the TV set, the charge on the downspout was gone.

"The electrician suggested a TV technician be called to see what was wrong with the set, and that's where my friend came in. It didn't take him long to discover lightning had shorted a line bypass capacitor between the hot side of the line and the chassis. When this was replaced, the charge disappeared from the downspout, and the receiver seemed to work normally. It was supper time when the job was completed; so my friend packed up his tools and left.

"But that night he couldn't sleep. He lay awake trying to figure out how on earth the 120-volt a.c. was getting from the TV chassis to the downspout. He reasoned it must have something to do with the owner-installed TV antenna, for he had noticed on the diagram that the center-tap of the antenna coil was grounded to the chassis and that there were no capacitors in the antenna leads. What's more, the antenna mast had not been grounded. But the closest the antenna lead came to the downspout or eavestrough was right where the lead went through the wall and connected to a lightning arrester; and that arrester was at least a foot away from the downspout, and both were fastened securely to the painted wooden siding.

"The next morning he went back to the house and asked permission to do some more investigating on his own time. To simulate previous conditions, he disconnected the antenna



"...like switching on the light in a pitch-dark room..."

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CIRCLE NO. 135 ON READER SERVICE PAGE

lead from the receiver and connected it to the hot side of the a.c. line through a 10,000-ohm resistor. Sure enough, the voltmeter revealed almost 120 volts on the downspout. Looking very closely at the lightning arrester, my friend thought he saw a faint dark line beneath the paint going over to a metal clamp that held the downspout. When he carefully scraped away a bit of the paint, he revealed a carbonized path burned right into the wood leading from the arrester to the clamp. Checks with an ohmmeter revealed only thirty ohms resistance in this path. When the arrester was replaced with a new one mounted at a slightly different spot on the siding, the downspout was cool as a cucumber. What's more, TV reception was improved because signal pickup by the eavestrough and downspouting fed into one side of the lead-in had been messing up the directivity of the antenna.

"My friend reasons the same flash of lightning that knocked out the line bypass must have jumped from the arrester to the downspout and burned the carbonized path into the wood. Possibly lead in the paint smeared over the case of the arrester made this jump easier. Anyway, my friend claims he slept like a baby the next night."

Mac nodded in agreement. "I know exactly how he felt, and I like this friend of yours. He has that most important characteristic of a good technician, a good engineer, or a good scientist: technical curiosity; and he's not afraid to spend time and effort, with no prospect of immediate monetary return, to satisfy it. You used the phrase 'on his own time' to describe the investigation your friend made into the puzzling case of the hot downspout. In my book, every technician worth his salt puts out a lot of effort 'on his own time' in his daily work. When he encounters a puzzling situation in his servicing, he's not content with merely restoring the set to operation through lucky accident. For his own peace of mind he must try to find out why the defective component made the receiver behave the way it did, if there was any reason for the failure of the component that could be corrected, and if there was any best way to pinpoint the trouble should it be encountered again."

"Yeah, but aren't you going to be griping because I'm not turning out sets instead of educating myself at your expense?"

"Have I ever criticized you for following through on a puzzling service job? It's not that I'm just interested in seeing you satisfy your curiosity. I know that each time you do this you improve yourself as a technician, and a really smart and alert technician is worth three times as much to me as a half-baked one capable of doing routine servicing and nothing more. You don't get smart by doing service work mechanically. You have to think and to wonder and to check and to double-check until you *know*. Out of this knowledge comes diagnoses that are quicker, surer, and more accurate."

Mac had been replacing an FP filter capacitor with an under-the-chassis cartridge type as he talked. After all the unanchored connections were carefully taped, he bundled the leads together and wrapped some sort of flexible white strap around them and cut off the excess length.

"Hey, what you doing there?" Barney demanded.

"I'm using a 'Ty-Rap' manufactured by the *Thomas & Betts Company* of Elizabeth, New Jersey, to hold the wires in place," Mac answered, tossing one of the objects to Barney. "As you can see, it's sort of a long, flat needle of nylon shaped something like an old-fashioned cut nail. There's an 'eye' running crossways in the flat head, and a piece of metal is embedded in this eye so that when the tapered tail of the 'Ty-Rap' is threaded through the eye and pulled tight around a bunch of wires, the loop is locked solidly in place and the excess tail can be snipped off with the diagonal cutters.

"They are used in cabling in place of lacing. They come in a wide variety of shapes and sizes. Some of them have provision for fastening each unit to a chassis or board after it has been wrapped around the wires. In addition to these hand-installed units that I think will be most useful in our work, there is another group designed to be installed with a tool that pulls the 'Ty-Rap' tight around a bunch of wires, locks it in place, and snips off the tail all in one operation. These would be fine in production, but I believe the hand-installed units will come in quite handy for us in making neater auto-radio, custom hi-fi, and other installations where keeping wires fastened securely together and out of sight adds to the appearance."

"It sure beats taping wires together," Barney agreed. ▲

CHASSIS-PUNCH HINT

By JAMES L. HARTLEY

INSTEAD of using a wrench with a chassis punch, clamp the head of a bolt tightly in a bench vise, with the bolt standing vertically. Next place the die section of the punch on the bolt. Put the pilot hole in the chassis on the bolt, then screw the cutter section down with your fingers.

Rotate the chassis until the hole is cut through. Spin the chassis in the opposite direction to screw the cutter section off the bolt. Lift the die section on the bolt until the cut-out washer is just clear of the top of the bolt. The tip of a screwdriver inserted in the pilot hole then permits the cut-out to be removed easily. ▲

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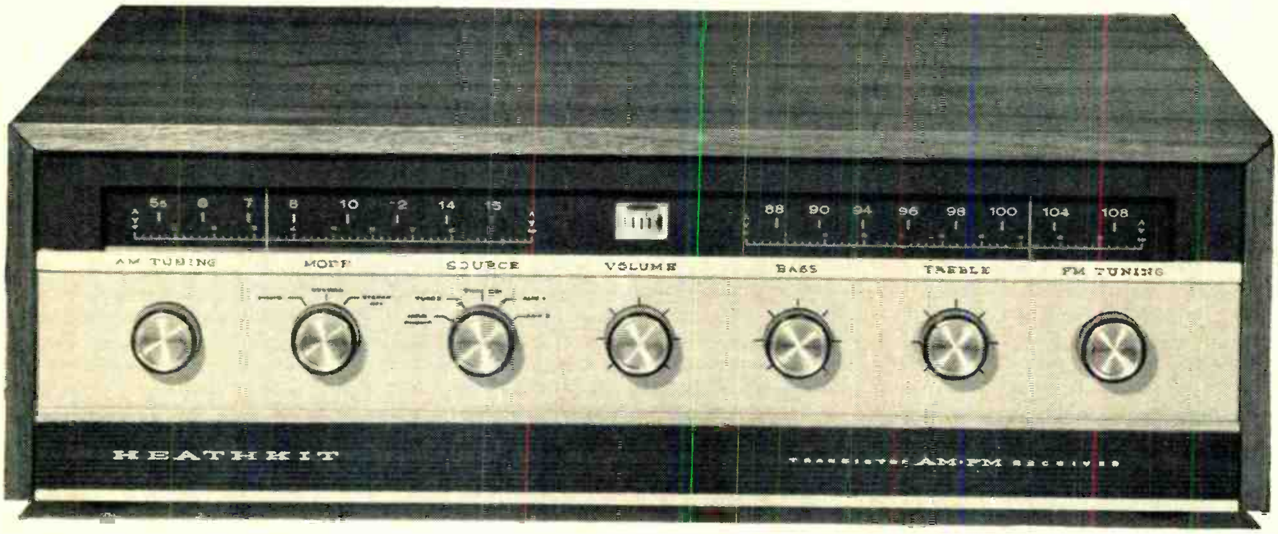

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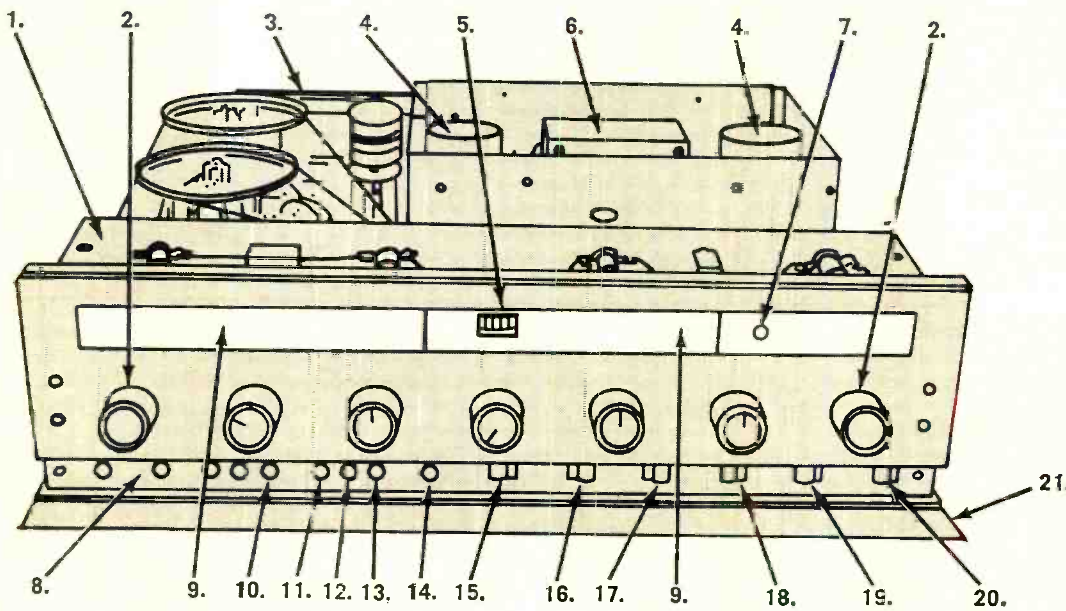

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Other quality features include a local-distance switch to prevent overloading in strong signal areas; a squelch control to eliminate between-station noise; AFC for drift-free reception; heavy die-cast flywheel for accurate, effortless tuning; pin-point tuning meter; and external antenna terminals for long-distance reception. For added convenience the secondary controls are "out-of-the-way" under the hinged lower front panel to prevent accidental system changes.

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AUDIO TRENDS IN BRITAIN

By PATRICK HALLIDAY

A rundown on some new high-fidelity developments at the recent International Audio Fair held in London.

SOME 85 exhibitors from Britain, the United States, Japan, and Continental Europe were represented at this year's International Audio Fair in London. Although relatively few completely new ideas in hi-fi and tape equipment were seen, a number of interesting trends were noted.

The rooms in the average British home are small by American standards and the emphasis, except for the dyed-in-the-wool audio enthusiast, is increasingly on fairly compact speaker units designed to provide a standard of audio reproduction which a few years back would have demanded bulky cabinets to obtain.

Typical of this trend is the extremely shallow *Goodmans* "Eleganzia" system in a rectangular cabinet 27" high, 20" wide, and only 6¼" in depth. This has a 12-inch bass unit with a composite diaphragm using lightweight impermeable cellular plastic, differing considerably from the more familiar expanded polystyrene diaphragms. The voice coil is unusually long to provide constant drive conditions at high amplitude with a deep roll center suspension. At 900 cps, a crossover network transfers the audio to an 8-inch middle- and treble-range speaker. Both speakers are sealed in the enclosure so that the bass diaphragm operates on an air cushion.

Wharfedale, the speaker firm founded by Mr. G. A. Briggs, the well-known writer on audio, also has a number of slim cabinets. The firm has developed roll surrounds which permit large cone excursions and lower resonances which are necessary as the cabinets are reduced in size. The "Slimline 2" model is 25" x 20" x 7". Most of these speakers are rated to handle 15 watts r.m.s.

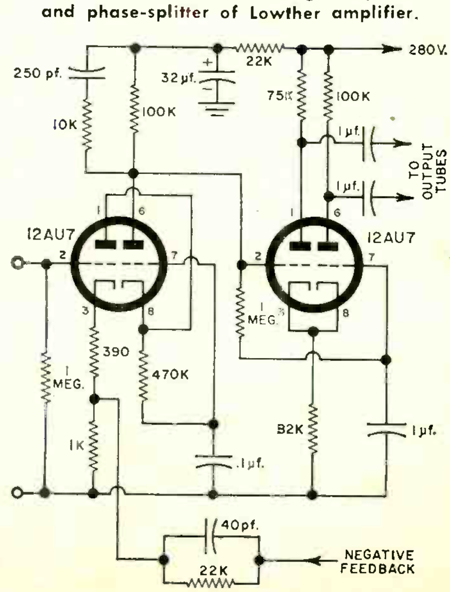
Another miniature full-range speaker system is the *Kelly* "Mini Enclosure," 23" x 13½" x 7½", with bass and treble speakers. This trend can be seen in the lines of almost all speaker firms.

Transistor amplifiers are still rare in Britain, but we listened with interest to a good, fully transistorized integrated stereo amplifier with 20-25 watt music rating (15 watts r.m.s.) per channel and with no output transformer to impair transient response. This particular unit has been introduced by *Pye*, one of Britain's largest radio firms, and sells in Britain for about $185.00.

Lowther has similar master control preamplifier units in both transistor and tube versions, the transistor unit being preferred for installations where space and heat are important considerations. An interesting feature of one of this firm's massive power amplifiers (Model LL15S) is the use of a cascode first stage: this and the associated phase-splitter are shown in Fig. 1. The low noise and good linearity of the cascode are often neglected in audio work, although we know of some tape recorders using them. The low noise allows an over-all hum and noise level of −85 db to be achieved. Another unusual feature in this amplifier is the use of −30 volts of fixed bias on the output stage. The same firm also features an FM tuner with a zener diode automatic frequency control circuit.

A new type of phase-splitter was noted in one of the *Radford* amplifiers. This circuit, Fig. 2, was developed recently by Mr. A. R. Bailey and has attracted considerable attention from British audio enthusiasts. It is a modified form of the conventional direct-coupled, long-tailed pair circuit with plate-to-grid feedback reduced by the use of a pentode in the first section.

Fig. 1. The cascode first-stage amplifier and phase-splitter of Lowther amplifier.



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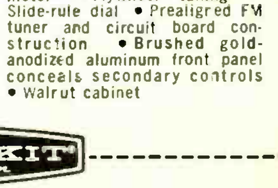
AA-22 40-watt Transistor Stereo Amplifier, 14 lbs. $10 mo. $99.95

• 40 watts of power (20 per channel) • 5 stereo inputs • Speaker phase switch • Miniature indicator light for each position on mode switch • Transformerless output circuits • Brushed gold-anodized aluminum front panel conceals secondary controls • Walnut cabinetry

AJ-33 Transistor AM-FM-FM Stereo Tuner, 14 lbs. $10 mo. $99.95



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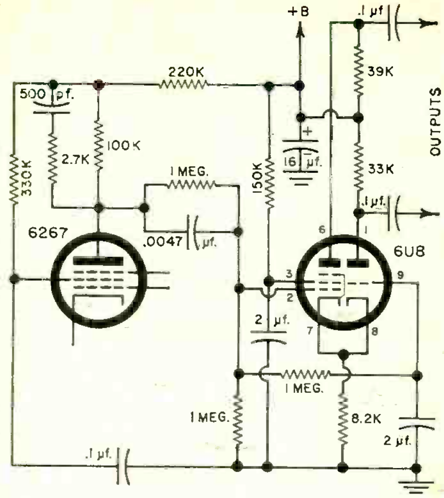

Fig. 2. Triode-pentode phase splitter used in Radford amplifier to reduce the feedback.

A number of domestic tape recorders using tubes have a low-noise transistor as the first preamplifier stage; this is partly because of their low noise and partly because of the reduction in microphony. Our eye was also caught by a neat and attractive all-transistor stereo unit from *Siemens Norge* of Oslo, Norway. Equipment from such countries as Germany and Switzerland is often outstanding in its clean modern cabinet styling—*Braun* of Frankfurt/Main providing several notable examples.

Among the larger professional recorders for broadcasting was one by *EMI* claimed to be world's first with a reversible head block to meet both the British-American standard for tapes wound with the oxide surface on the inside and also the continental European standard which puts the oxide surface on the outside.

Austrian engineers of *A.K.G.* have developed a special "polarscope" unit for measuring the directional characteristics of transducers such as microphones. A turntable unit and the transducer are placed in an anechoic chamber and remotely controlled from a cathode-ray display unit which provides an immediate picture of the directional characteristics of wave emitting and receiving transducers.

Multiplex stereo broadcasting, using the *Zenith-G-E* system, has been tested during recent months in Britain and in a number of other European countries. This technique is now known officially as the "pilot-tone" system. Although the trials have been favorable, there seems little likelihood of any regular FM stereo broadcasting in Europe in the near future. One of the main reasons advanced for this reluctance to transmit stereo is that in European countries the FM networks have usually been designed to provide almost complete coverage of the countries, and the reduction in transmitter range with "pilot-tone" stereo would thus deprive some listeners of programs during stereo transmissions. ▲

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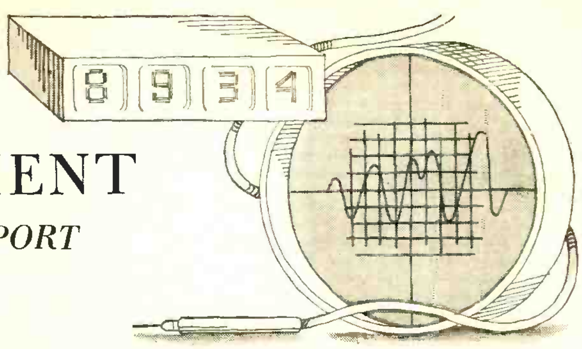
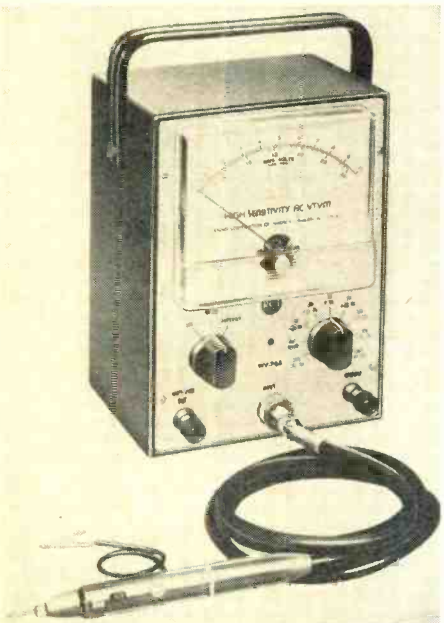
PRODUCT REPORT



RCA WV-76A A.C. V.T.V.M.

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



FOR years, the audio voltmeter has been restricted to the designer's bench or sound studio by specialized applications and "laboratory" prices. Today's tremendous hi-fi market, however, has brought audio servicing—and the audio voltmeter—right into the neighborhood TV-audio service shop.

One of the most recent instruments—the *RCA* WV-76A high-sensitivity a.c. v.t.v.m.—symbolizes the design trend toward higher performance and lower cost. Because it is a vacuum-tube voltmeter, the WV-76A has many inherent advantages. Included are protection against meter burnout, high input impedance to minimize test-circuit loading, wide frequency response on a.c.-voltage measurements, very high sensitivity to low signal levels, excellent stability, and—of primary importance—good over-all measurement accuracy.

These features enable the service technician to troubleshoot and adjust almost any audio component, such as phono cartridges, tape heads, preamplifiers, power amplifiers, tone control and mixer circuits, and audio networks of all types. The instrument is also an invaluable aid in balancing stereo channels and determining the frequency response of circuits and systems.

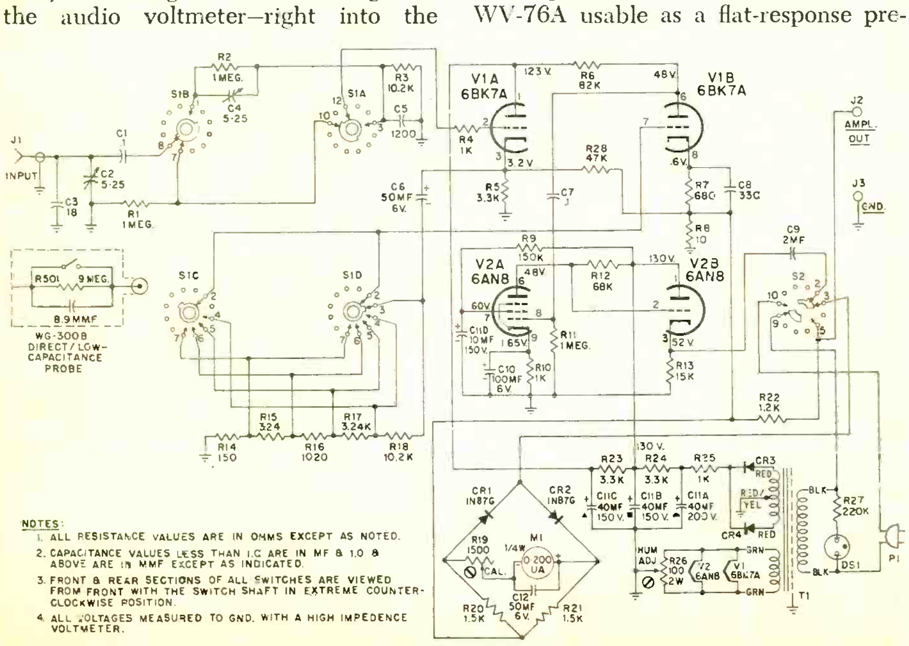
Three basic functions are provided: (1) a.c. voltage measurements from 0.0002 volt (lowest scale division) to 100 volts in nine overlapping ranges; (2) direct decibel readings from −40 to +40 db in nine ranges for measuring stage or over-all amplifier gain; and (3) an auxiliary amplifier function having 38-db gain. This last feature makes the WV-76A usable as a flat-response preamplifier for low-gain audio systems or oscilloscopes. All readings are taken from a 4½" meter having only two basic scales.

Frequency response—a limiting factor with most a.c. voltmeters—is flat within 1 db from 10 cps to 1.5 megacycles. Full-scale instrument accuracy on all 18 voltage and decibel ranges is ± 5% or better—which is more than adequate for general service and laboratory use.

A contributing factor to high performance is a switch-type direct/low-capacitance probe and shielded cable. In the low-C position of the probe switch, the WV-76A presents 10 megohms of input resistance shunted by only 13 pf. of capacitance. The low-capacitance function also extends the voltage and decibel ranges to 500 volts and +56 db.

Four stages are used for maximum stability and sensitivity. The input signal is fed into a cathode follower, *V1A* (see figure). Voltages from 3 to 100 volts are passed through a precision attenuator ahead of *V1A*. On the 10-millivolt to 1-volt ranges, the signal is attenuated between *V1A* and the first amplifier stage, *V1B*. The a.c. output from *V1B* is further amplified in *V2A* and fed to the second cathode follower, *V2B*. The output is then applied to a meter through a half-bridge circuit. A feedback loop from the meter circuit to the first amplifier stage provides additional stability and linearity. Heavy filtering in the power supply and a hum-adjustment potentiometer in the tube-heater circuit effectively eliminate hum.

The optional user price for the factory-wired version of the instrument is $79.95. It is also available in kit form at an optional user price of $57.95. Prices include the probe. ▲



Simpson Model 261 V.O.M.

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

A NEW multi-range v.o.m., the Model 261, has been introduced by *Simpson* to answer the need for a more accurate, moderately priced instrument. The meter has a sensitivity of 20,000 ohms per volt on d.c. and 5000 ohms per volt on a.c. Its accuracy is 1½% or better of full scale for d.c., and 3% or better of full scale for a.c. On the lowest current range, the accuracy is that of the movement itself—1%. The accuracy of the meter makes it more useful for design work where exact values must be determined rather than just an indication that the parameter under test is "about normal." The instrument has the usual a.c. and d.c. voltage ranges, as well as d.c. current, decibel, and resistance scales.

An interesting feature of the Model 261 is the built-in overload protection. As shown in the schematic, the move-

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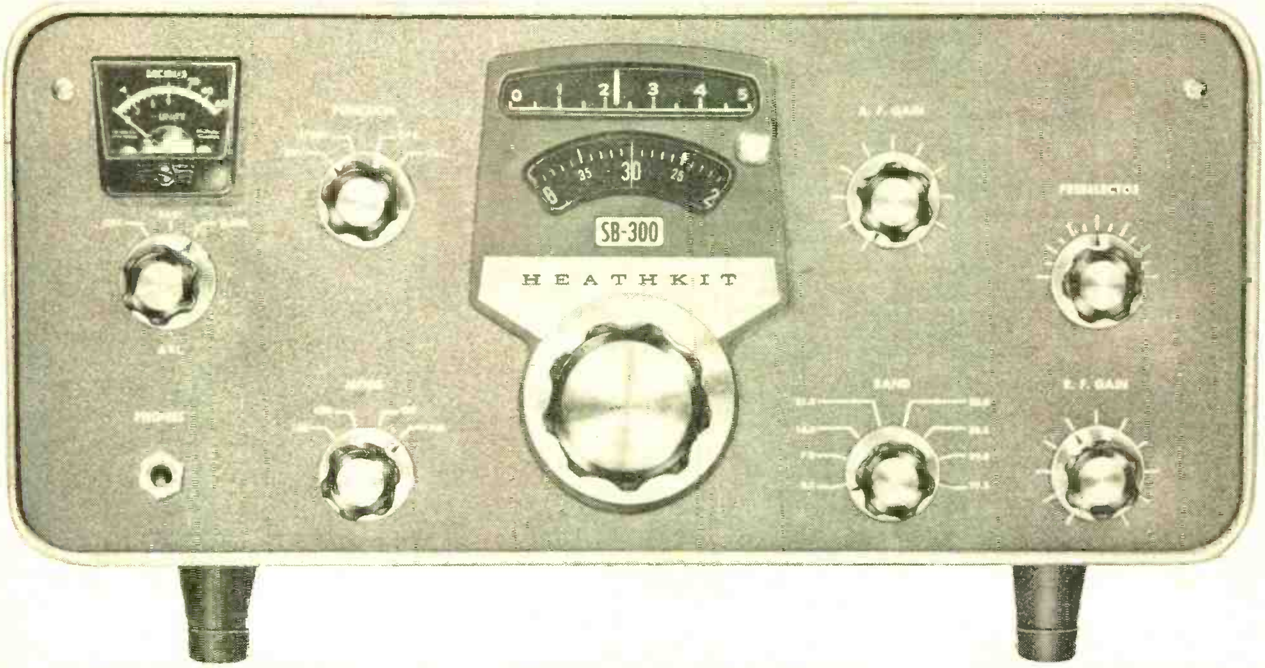

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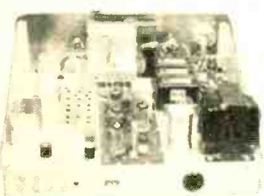

SPECIFICATIONS–Frequency range (megacycles): 3.5 to 4.0, 7.0 to 7.5, 14.0 to 14.5, 21.0 to 21.5, 28.0 to 28.5, 28.5 to 29.0, 29.0 to 29.5, 29.5 to 30. **Intermediate frequency:** 3.395 megacycles. **Frequency stability:** 100 cps after warmup. **Visual dial accuracy:** Within 200 cps on all bands. **Electrical dial accuracy:** Within 400 cps on all bands. **Backlash:** No more than 50 cps. **Sensitivity:** Less than 1 microvolt for 15 db signal plus noise-to-noise ratio for SSB operation. **Modes of operation:** Switch selected: LSB, USB, CW, AM. **Selectivity: SSB:** 2.1 kc at 6 db down, 5.0 kc at 60 db down (crystal filter supplied). **AM:** 3.75 kc at 6 db down, 10 kc at 60 db down (crystal filter available as accessory). **CW:** 400 cps at 6 db down, 2.5 kc at 60 db down (crystal filter available as accessory). **Spurious response:** Image and IF rejection better than 50 db. Internal spurious signals below equivalent antenna input of 1 microvolt. **Audio response: SSB:** 350 to 2450 cps nominal at 6 db. **AM:** 200 to 3500 cps nominal at 6 db. **CW:** 800 to 1200 cps nominal at 6 db. **Antenna input impedance:** 50 ohms nominal. **Muting:** Open external ground at Mute socket. **Crystal calibrator:** 100 kc crystal. **Front panel controls:** Main tuning dial; function switch; mode switch; AGC switch; band switch; AF gain control; RF gain control; preselector; phone jack. **Rear apron connections:** Accessory power plug; HF antenna; VHF #1 antenna; VHF #2 antenna; mute; spare; anti-trip; 500 ohm; 8 ohm speaker; line cord socket; heterodyne oscillator output; LMO output; BFO output; VHF converter switch. **Tube complement:** (1) 6BZ6 RF amplifier; (1) 6AU6 Heterodyne mixer; (1) 6AB4 Heterodyne oscillator; (1) 6AU6 LM osc.; (1) 6AU6 LMO mixer; (2) 6BA6 IF amplifier; (1) 6AU6 Crystal calibrator; (1) 6HF8 1st audio, audio output; (1) 6AS11 Product detector, BFO, amplifier. **Power supply:** Transformer operated with silicon diode rectifiers. **Power requirements:** 120 volts AC, 50/60 cps. 50 watts. **Dimensions:** 14⅞" W x 6⅝" H x 13⅜" D.

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Features include a crystal-controlled front-end for same rate tuning on all bands; prebuilt, Linear Master Oscillator (LMO) for linear tuning with 1 kc dial calibrations; built-in crystal calibrator; hermetically-sealed 2.1 kc crystal band-pass filter; smooth, non-backlash vernier dial drive mechanism; optional AM & CW filters; high frequency I.F.; AGC control; provision for transceive operation with matching transmitter available soon. This new deluxe Heathkit SSB series is the greatest value ever announced in the Amateur Radio Industry! Send for free specifications on the SB-300 today, or order now for early delivery!

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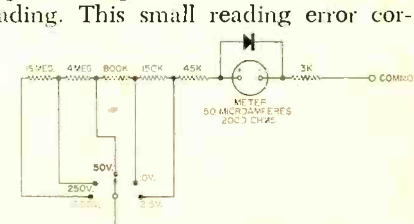
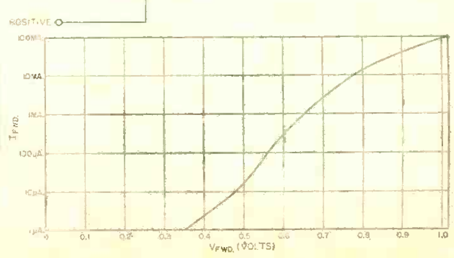
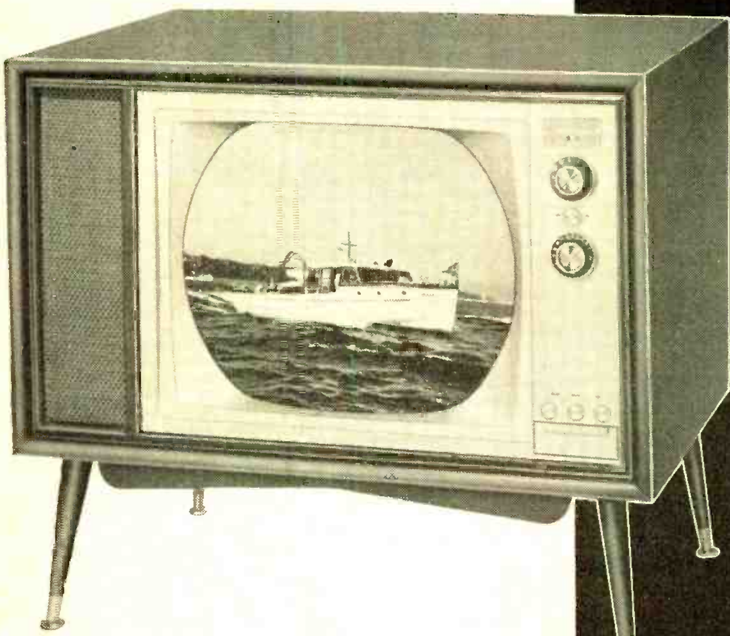
ment has a resistance of about 2000 ohms and a full-scale sensitivity of 50 μa. Therefore, at full-scale deflection, the voltage drop across the movement will be about 0.1 v. The movement overload protection is provided by the diode connected (in the forward direction) in parallel with the movement. As shown in the graph, essentially no forward current will flow through the diode when rated current passes through the movement. If an overload of 2000 times rated (100 ma.) is applied to the metering circuit, most of the current will flow through the diode. With 100 ma. of diode current, the voltage drop across the diode and across the movement will be 1.02 volts. This means that the movement will have a current of 510 μa. flowing through it. Thus, with an applied overload of about 2000 times, the movement is subjected to an overload of only 10 times rated. This small overload will not cause damage to the movement even if applied continuously.

The Model 261 also includes a mirror scale and knife-edge pointer to insure highest accuracy of reading. For example, because of parallax, it is quite possible that the indicated reading might be displaced 1/16" from the true reading. This small reading error cor-







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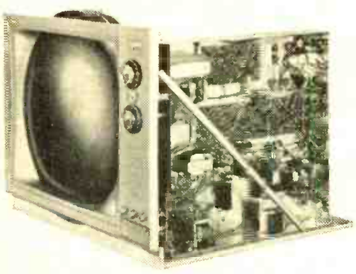

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CL-164

responds to a reading that is off by 1.71% of full scale. Since 1.71% is greater than the d.c. accuracy of 1.5%, it is obvious that it is essential that parallax errors be minimized by use of a mirror scale.

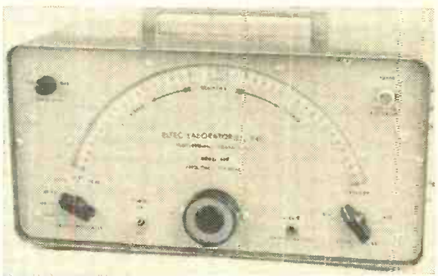
Although generally not recognized, the Model 261 (or any 20,000 ohms per volt v.o.m.) has a higher input impedance on the 1000-volt d.c. range than most v.t.v.m.'s. The input impedance on this range is 20 meg., which allows reading voltages in very high impedance circuits. Since each division on the range corresponds to 20 volts, it is possible to read voltages as low as about 10 volts on the 1000-volt range with virtually no circuit-loading effect.

In addition to the features mentioned above, the meter uses a self-shielded movement that is not affected by outside magnetic materials or fields. Spring-backed jewels are used so that the movement will withstand greater shock and vibration without damage.

The Model 261 measures 5¼" x 7" x 3⅛" and weighs 3½ lbs. It is available at $59.95 from electronic parts distributors. ▲

Eltec Model 600 Frequency Standard

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



IN order to take accurate measurements of receiver and transmitter frequencies, some sort of frequency standard is required. The *Eltec* Model 600 combines the principles used in a heterodyne frequency meter and a highly accurate crystal calibrator in order to check frequencies in the 25- to 54-mc. range. Hence, the instrument can be used to accurately set the frequency of Citizens Band equipment and low-band equipment operating in the two-way radio service. The accuracy of the instrument is .0002 percent, exceeding FCC requirements by five times. The unit can also be used from 10 kc. upward in amateur radio applications, such as in checking 100-kc. calibrators and spot-checking frequencies up to 54 mc.

Heart of the instrument is an accurate 100-kc. crystal, which is mounted within a thermostatically controlled oven to maintain its temperature and its operating frequency. Although highly stable, it is suggested that the circuit be checked against WWV regularly to make sure of its setting. A built-in audio detector, amplifier, and speaker are used in order to respond to the beat note generated by the instrument's oscillator mixing with the output of a transmitter. When receiver circuits are to be adjusted, it is common to use the receiver's audio circuits for this purpose.

In addition to the 100-kc. output of the instrument, four other oscillator frequencies are available that are locked to the 100-kc. crystal oscillator. These are 10 kc., 20 kc., 25 kc., and 50 kc. As a result, harmonic frequencies are generated that are separated from each other by 10, 20, 25, 50, or 100 kc. Since all assigned frequencies in the 30-50 mc. two-way radio band are exactly divisible by 20 kc., all receivers and transmitters in this band can be set and aligned to their exact frequencies with the Model 600 set to its 20-kc. output. Since the crystal trimmers in commercial transmitters cannot vary the frequency by more than about 5 kc., there is no chance of reading the wrong harmonic.

In the Citizens Band, however, most frequencies are not exactly divisible by any of the above frequencies. To cover these channels, the instrument's deviation control is adjusted. This permits the user to select any frequency between two of the locked-oscillator harmonics. Deviation dial settings for these intermediate frequencies are shown in an individually hand-calibrated chart supplied with the unit. Hence, it is not necessary to use mathematics or interpolations.

The Model 600 is available from the manufacturer at $349.95. ▲

REVISED STANDARDS

THE Defense Electronics Supply Center has announced the availability of nine new and revised specifications and standards which received approval in July. All of the documents listed below can be obtained from the Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pa.

MIL-E-1/89 Revision C: Electron Tube, Receiving, JAN-5787WA (for BuShips).

MIL-E-1/1333 Revision C: Electron Tube, Receiving JAN-7266 (for BuShips).

MIL-E-1/639, Revision C: Electron Tube, Receiving JAN-12AY7 (for Buships).

MIL-E-1/940, Revision E: Electron Tube, Receiving JAN-OB2WA (Equivalent to JAN-6627) (for BuShips).

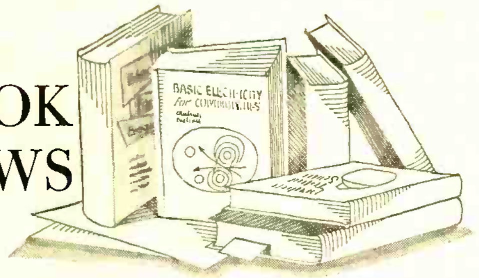
MIL-E-1/1225, Revision A: Electron Tube Receiving Pentode, Miniature JAN-6688 (for BuShips).

MIL-E-1/1416, Revision A: Electron Tube, Receiving JAN-6900 (for BuShips).

MS 24655, Revision B: Switch, Toggle, Miniature Aircraft, Single Pole, One Hole Mounting (for USAF).

MS 24656, Revision B: Switch, Toggle, Miniature Aircraft, Double Pole, One Hole Mounting (for USAF). ▲

BOOK REVIEWS



"BASIC ELECTRONIC TEST INSTRUMENTS" by Rufus P. Turner. Published by *Holt, Rinehart and Winston, Inc.* 287 pages. Price $5.95. Revised Edition.

Since the first edition of this book appeared in 1953, many new pieces of test equipment have entered the repertoire of the service technician while others have faded out of the picture. In revamping his text, the author has acknowledged the trend by eliminating obsolete units and adding the newer instruments.

As was the case with the earlier volume and, in fact, with all of this author's output, the presentation is clear, factual, and easy to understand. He avoids the mathematical approach and eschews basic radio and electronic theory because it is to be assumed that the reader is somewhat familiar with the field.

The text is divided into 17 chapters dealing with simple meters for current and voltage, ohmmeters and v.o.m.'s, electronic voltmeters, power meters, impedance checkers, capacitance checkers, inductance checkers, special-purpose bridges and accessories, oscilloscopes and applications, r.f. test oscillators and signal generators, audio test oscillators, frequency-measuring devices for r.f. and a.f., audio-amplifier testing devices, r.f. signal tracers, tube and semiconductor testers, and miscellaneous instruments. Each type of test instrument is described in detail and commercial examples and circuits are given.

* * *

"BASIC RADIO REPAIR" by Marvin Tepper. Published by *John F. Rider Publisher, Inc.* Two volumes. 204 pages total. Price $5.30 (2 vols.).

The idea back of these two volumes is to present radio servicing techniques as they would be practiced in a commercial radio shop. The first volume covers the test equipment most likely to be found in the non-specialized shop, the various components encountered in radio receiver circuits, servicing procedures, and the actual servicing of superhets, portables, and auto sets using tubes.

The second volume is devoted to the servicing of FM receivers, transistorized receivers of various types, and transmitters.

In both volumes, line drawings, pictorials, cartoons, and schematics have been included to illustrate basic points.

For the experienced hand at servicing, much of the material will be familiar but there are still some interesting short-cuts to servicing that might surprise even the oldest of old-timers.

* * *

"ELECTRONICS IN BUSINESS MACHINES" by Tom Jaski. Published by *A. S. Barnes & Company.* 306 pages. Price $5.95.

This book has been written for the layman and the student of electronic data processing. It is not a service handbook nor is it an operating instruction manual, rather it is an over-all survey of the general operating principles of data-processing machines in industrial automation.

The first chapter traces the history of calculating devices of various types and deals with present-day applications of these different types of computers. A second chapter covers arithmetic and the common languages of business machines and computers while the balance of the text covers the means, methods, and equipment involved in this important field.

Photographs and partial schematics of commercial units are used throughout the book to point up specific details of the text. For the layman weak in electronic theory, the author has provided an appendix covering basic electronics and another listing the basic glossary of computer technology.

° ° °

"MORE ABOUT LOUDSPEAKERS" by G. A. Briggs. Distributed by *Herman Publishing Service, Inc.*, Stamford, Conn. 134 pages. Price $2.50.

This is an up-dated volume by the erudite and delightful author of "Loudspeakers," "Sound Reproduction," among many books in the hi-fi field.

Although he loudly proclaims that this is a book for the music lover and layman, there are many professionals who will benefit from his guided tour of the speaker world. As all of Mr. Briggs' long-time readers know, instruction is painless at his hands. Pixy humor, outrageous puns, and sly asides pepper the text which nevertheless provides basic and vital information about magnets, response and impedance curves, transient response, distortion, load matching, outboard speakers, crossover networks, listening tests, stereo, enclosures, grille cloths, various types of speakers and their performance, plus a fine selection of reference material in tabular form.

° ° °

"GETTING STARTED IN ELECTRONICS" by *Allied* Staff. Published by *Allied Radio Corp.* 109 pages. Price 50 cents.

Since many people who have no intention of making engineering their life work are still interested in certain phases of electronics as an avocation, hobby, or as a means of keeping the old homestead in tip-top shape, this little handbook is one approach to a simple, clear, and easy understanding.

There are six chapters which provide not only basic theory and information about components, but offer practical instruction on building ten everyday projects.

° ° °

"HIGH-SPEED SWITCHING TRANSISTOR HANDBOOK" by *Motorola* Staff. Published by *Motorola Semiconductor Products Inc.* 346 pages. Price $2.50.

This handbook combines detailed design procedures for saturated-mode, current-mode, and avalanche-mode switching circuits with complete device characterization and switching-transistor reliability.

This volume characterizes the behavior of transistors in switching circuits and interprets device characteristics from the standpoint of optimizing switching performance in "worst-case" designs.

A separate chapter is devoted to reliability from the circuit designer's viewpoint and explains methods of enhancing over-all system reliability by proper circuit design.

° ° °

"TV SERVICING METHODS GUIDEBOOK" by R. G. Middleton. Published by *Howard W. Sams & Co., Inc.* 158 pages. Price $2.95.

This volume is a collection of specially developed and tested short cuts that the author has garnered in his many years of practical experience with television receiver circuits. He has dubbed his system "self-cheks"—and involve simple yet efficient methods of using one section of a TV receiver to check another. Thus by utilizing signals generated in one section of a receiver, visual or aural indications will help pinpoint defects in another section.

The book is made up of troubleshooting charts, step-by-step "self-chek" instructions, schematic diagrams, and photos of the symptoms. The text material is merely supplementary and has been held to a minimum in the belief that the technician at his bench doesn't have time to read lengthy explanatory material while the set cooks.

As a key to quick and easy television troubleshooting and repair, this volume may do the trick for the busy electronics service technician. ▲

TECHNICAL PERSONNEL SHORTAGE

By 1970 we will need more than 2 million scientists and engineers, up 90% from 1959.

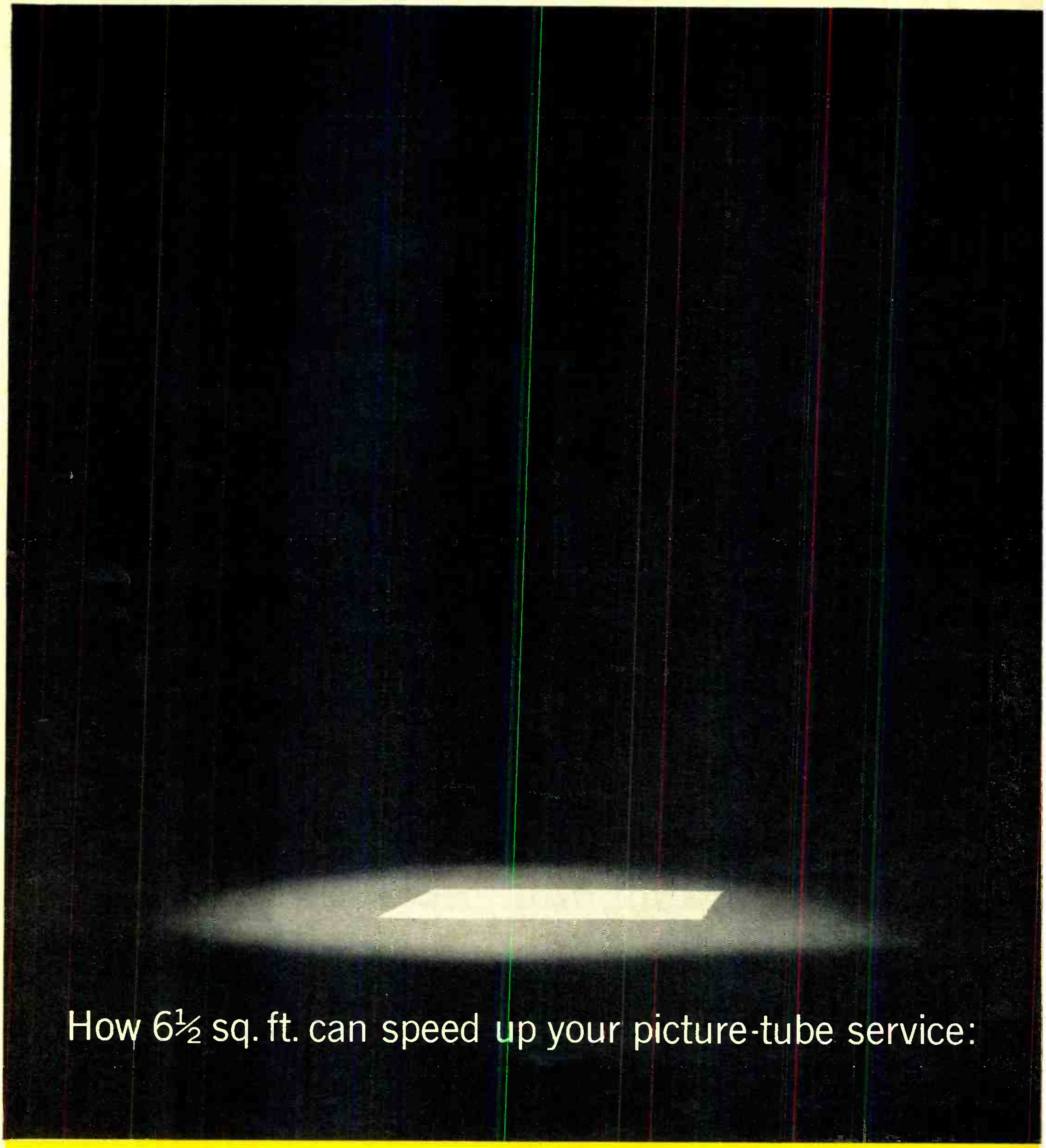
According to researchers for the National Science Foundation, the United States will not have enough technically trained personnel in the year 1970 to satisfy the expected needs of industry and government. More than 2 million scientists and engineers, for example, will be needed in 1970, an increase of 90 percent above 1959 employment levels, but the universities will probably train only a little more than 700,000, the researchers predict.

A similar shortage is also predicted for the other types of technically trained personnel. These predictions are included in the "Proceedings of the Conference on Progress in Nuclear Education," recently published by the U.S. Department of Commerce.

Demands for trained technical personnel in general have been rising at a much more rapid rate than the increase in the labor force, the researchers point out. Our labor force has grown by 23 million workers, or approximately 50 percent since 1930, while the various technical workers as a group have increased from 3.3 million to 7.4 million, or more than double their number. The demand for engineers alone increased four-fold, while the demand for natural scientists increased more than six times by the end of the 30-year period.

Present and future demands for scientists and engineers and other technical workers are largely created by the Federal Government research and development programs, that is, for defense, space, and atomic energy. About 65 percent of the estimated $15-billion expenditures for research and development in 1962 was financed by the Federal Government, requiring 65 percent of all the technical personnel employed.

Currently more than 800,000 engineers are employed in the United States, more than twice the number of scientists employed. The demand for scientists, however, has been growing more rapidly than the demand for engineers. Eighty-three percent of the engineers and 50 percent of the scientists are employed by industry, mostly in production and research and development work. Fourteen percent of the engineers and 20 percent of the scientists are employed by the government. Most of the others are employed in the universities. ▲



10 versatile "Universal" picture-tube types from Sylvania's SILVER SCREEN 85 line may be all you need to fill 52% of your renewal needs! This fact, verified by a recent industry survey, stems from a remarkable streamlining of the Sylvania line—making fewer, more versatile types that can be used as replacements for many others. Already 54 types can replace 217.

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21ACP4A			
21YP4A			
21EP4B			
21FP4C			
24AEP4			
21DFP4			
21AUP4A			
21DEP4A			

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GENERAL SYSTEM

Indoor Horn Antenna

(*Continued from page* 51)

and the nose block by 3/16 machine screws, nuts, and washers. These provide contact for feed to the receiver. Fig. 3 (left) shows the completed antenna in position in an attic area.

Transmission Line

The 377-ohm antenna impedance will not be seriously mismatched if the usual 300-ohm twin lead is used. The loss will be about 1.3% in power or .06 db in addition to the attenuation due to the length of the line itself.

Reduction of interference due to man-made electrical noise will, in many instances, dictate the use of coaxial cable for antenna to receiver connection. This

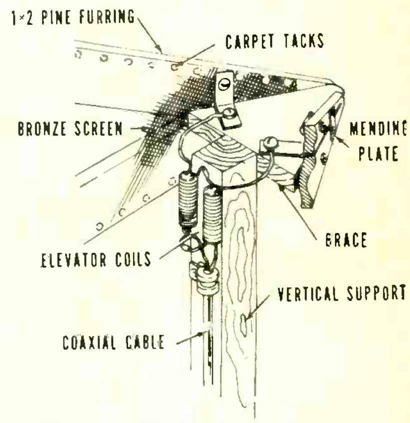

Fig. 4. Construction details of the apex.

will require impedance matching at both the antenna and the receiver. An antenna-to-coax match, which is close to ideal, can be obtained by using RG-62/U cable with a characteristic impedance of 93 ohms and a four-to-one matching network employing bifilar antenna matching coils. This transformer network or balun is shown in Fig. 5.

The matching coils, also known as elevator coils, are *RCA* Part No. 73591 or equivalent (*Merit Coil and Transformer Corp.* TV-172 or *J. W. Miller Co.* No. 6104). The match from cable to receiver, 300-ohm impedance, is accomplished by the use of an identical network. In this case the mismatch 93 ohms to 300 ohms rather than 377 ohms will be found to be negligible in effect.

The horn illustrated is currently being used for reception of channels 5, 9, and 12. For cut-off below channel 5, the dimensions should have been 7 feet on a side. Attic dimensions limited the height to 4 feet. A trial of this size of antenna at the receiver indicated that picture quality was satisfactory on this channel and that objectionable ghosts could be eliminated on all channels. A similar compromise of dimensions for reception of low-frequency channels has also been

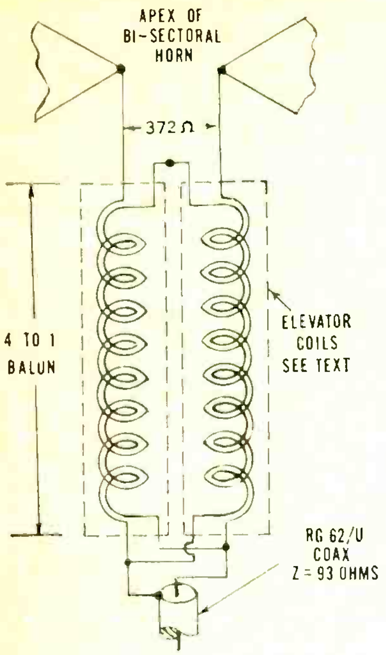

Fig. 5. The antenna-to-coaxial line matching network is a 4:1 balun transformer.

previously discussed by D. O. Morgan.[3]

While the foregoing discussion has been concerned with an application in which all three desired stations were within the 20-degree included angle of the reception pattern of a single horn, the use of two or more horns for complicated patterns can be accommodated by a simple two-pole, multiple-position switch at the receiver. In many instances the combination of a horn with a single-channel yagi will suffice.

An alternative method of construction which has been suggested involves the use of overlapping strips of aluminum cooking foil taped to large sheets of wrapping paper for the triangular metallic sides.

If the antenna is to be mounted in an attic or other place where it would not be exposed to wind loading, then solid metal sheets of either aluminum or copper flashing material could be used.

The author wishes to thank E. J. H. Bussard of *Avco*, E & O Division, for his helpful advice in the preparation of this article. ▲

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HUM INTERFERENCE IN CAR RADIOS

By DAVID T. GEISER

Nearby high-voltage power lines can sometimes produce an a.c. hum in a car radio. An r.f. choke across antenna input will usually cure trouble.

OCCASIONALLY, power companies have received complaints of interference to auto radios, which on investigation have not been on radio frequencies. The car antenna has picked up a strong 60-cps field and carried it into the a.v.c. system of the receiver, creating severe hum. The usual cause of this difficulty is that the control grid of the radio r.f. stage has a low 60-cps impedance to the car radio antenna and a high impedance to the car frame. The first grid usually has the a.v.c. voltage applied to reduce strong signal levels, so when 60-cps voltage appears on it, the received signal will be amplitude modulated by the 60-cps frequency. This amplitude modulation will appear as a hum on a received signal, with the set being quiet between stations. The actual circuit existing in one such case of interference is shown in Fig. 1. The effective power-frequency circuit is shown in Fig. 2.

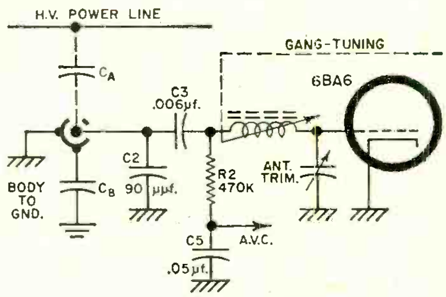


Fig. 1. Power line frequency can be capacitance-coupled to car radio antenna.

The reason that all power lines do not cause this difficulty is that some power line construction is such that nearly equal capacitance is presented to the car antenna by each of the individual power lines and voltage reaching the antenna by capacity coupling from one line is cancelled out by the coupling from the other line.

Where this does not occur, there is a power-frequency voltage fed into the car radio. If the power line is a high-voltage one (10,000 v.), and the car antenna is fully extended, more than a volt of the 60-cps frequency may be developed at the first grid with the car located thirty feet away from the power line. This will cause a hum to appear even on a strong local station.

As the difficulty is caused by power feeding into the car antenna through a high-impedance circuit, the simplest cure is to make the receiver input look like a short circuit at power-line frequencies.

This may be done by shunting the receiver input with an r.f. choke having high impedance to broadcast frequencies but low impedance to power-line frequencies. There is one precaution to be taken when choosing the choke. Every coil has inductance, capacitance, and resistance. The inherent inductance and capacitance of the coil will have a tendency to misalign the receiver input circuit. Ideally, a choke having a very high inductance should be chosen to minimize this effect, but the distributed capacitance of this choke would be high and the effective self-resonant frequency would be lower in frequency than the broadcast band. In this case, the choke might look like a capacitance and reduce the net sensitivity by reducing the signal level that the antenna can present to the radio. If the resonant frequency is higher than the broadcast band, the

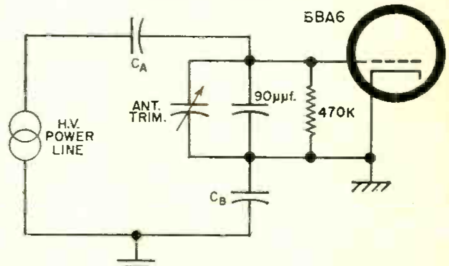
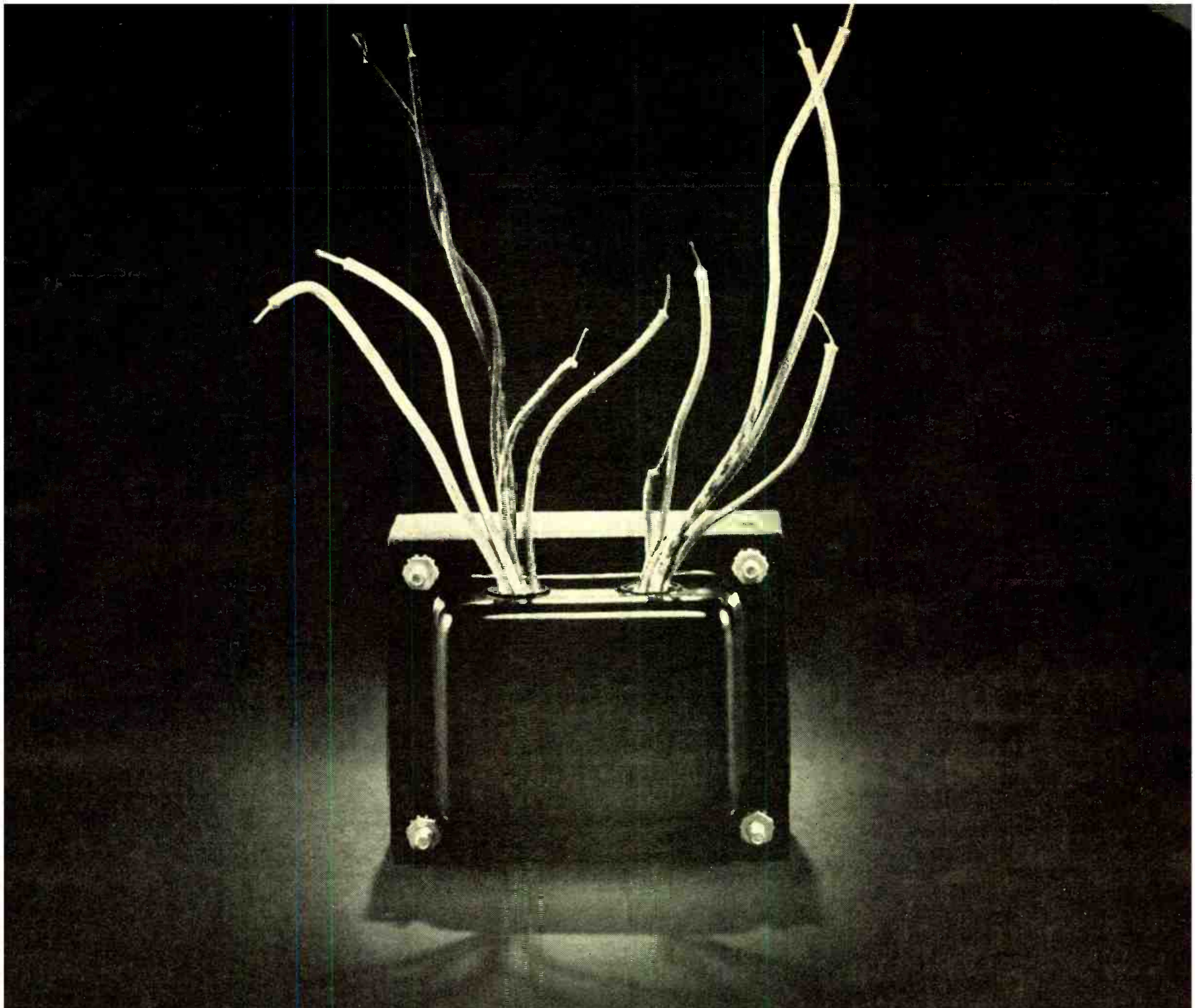


Fig. 2. Effective power frequency circuit appears like a signal generator.

inductive effect will also misalign the set. The best choice appears to be a choke whose resonant frequency is at, or slightly higher than, the broadcast band. A *National* R-100ST, a 10-millihenry choke, has been successfully used by the author and seems to be a natural choice because of its small diameter.

Two mounting precautions must be observed. The choke must be mounted where it will not couple inductively into other coils and it must be mounted with lock washers. Thus installed, the r.f. choke has completely cured receiver power-line hum with minimum re-alignment and signal loss. ▲



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Two-Way Radio

(*Continued from page* 53)

morning, the dispatcher opens the base station again and regains control of the system.

Another use for the basic mobile relay system is for a one-way talk-back circuit. Such an arrangement, shown in Fig. 2, could be used where the base station is in a high noise area (where reception from distant mobiles is difficult) or where the base station r.f. power has been made considerably higher than that of the mobiles to achieve wide area base-station coverage. In either case, a mobile relay repeater station can be used in a one-way network to boost the signal strength of mobile-to-base messages. Three frequencies are usually used in such a system with the mobile relay transmitter operating on a point-to-point frequency, beaming its energy back to the base-station receiver. The base station is usually equipped with a second receiver tuned to the mobile transmitter frequency so that close-in mobiles can talk directly to the base station without having to go through the mobile relay repeater station.

The final variation on the mobile relay theme is the shared, or community repeater system. This type of system is enjoying increased popularity with business radio users because each user has the advantages of mobile relay operation at a cost well below that of a privately owned repeater network. It is used primarily in large cities in situations where the user desires complete metropolitan coverage including, possibly, reliable suburban communications.

The basis for the shared repeater is a system of tone-coded squelch discussed in Part 1. Each user is assigned a different code tone and every radio set in his sub-system is squelched until the proper tone is received. The repeater station is unsquelched by any of the code tones operating in the system, but the individual radio receivers remain squelched until the correct tone is received. Because of the tone-coded squelch system, each user ordinarily hears only the messages originating within his own portion of the system, although several users are sharing a common repeater station. A typical setup is shown in Fig. 3.

The dispatcher for each of the subsystems has a locally controlled, low-powered base station that beams the message to the repeater usually located atop a tall building in the center of the city. The code tone unmutes the repeater receiver and automatically causes the encoder at the transmitter to remodulate the outgoing signal with the same code tone. The code tone is regenerated at the repeater, rather than being fed directly through from the repeater receiver, to minimize distortion and therefore assure accurate unsquelching and minimize "falsing" at the mobile or dispatcher receiver.

This discussion of the basic types of radio systems by no means exhausts the variety of networks possible. The various systems can be still further combined and their versatility can be increased with the addition of other techniques such as selective-signalling equipment, multiple base-station antenna sites, and so forth.

Remember, too, that a large variety of highly reliable portable equipment is available which can be combined with the basic two-way radio systems to further enhance the services of a communications network. Each individual system is a separate, highly interesting challenge. It can be made to do virtually any communications job required by the two-way radio user. ▲

The Loudness Control

(*Continued from page* 35)

rise of Fig. 1 from one curve to the other. It requires no compensation since it does not change at various levels.)

Assuming we can build a control with the characteristics of Fig. 2, how do we use it? Simply set the *level* control so that a program sounds as loud as the original with the loudness control wide open, after which we need adjust only the loudness control to obtain natural sounding reproduction at any level we wish.

You may have been following along to this point saying, "This is great for 80-db programs, but what happens when we run into a program that is 60 decibels in the orchestra? Supposing we are listening to a piece that we will call 'Moderate and Equal' which runs up and down the 60-db contour, instead of 'Loud and Equal' on the 80-db contour – then what?" There are no problems as long as the broadcast or recording engineer keeps his fingers off the controls so that the modulation comes through at the correct relative level. If we run our loudness control wide open, we will now hear "Moderate and Equal" going up and down the 60-db contour at the 60-db level—just like the original. If we decide we want to hear it at 40 db, we turn down the loudness control to 20 db. It won't be exactly right because the difference between the 80- and 60-db contours is not identical to the difference between the 60- and 40-db contours, but it's close enough. "But," you may ask, "What if I want to listen to 'Moderate and Equal' at an 80-db level?" In that case, you'll have to bring up the level control and adjust the tone controls until it sounds right.

A lack of understanding of the loudness phenomenon has in the past led to some strange mores and way-out activi-

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ties among audio enthusiasts who had been misled by two mistaken postulates: First, that only lowbrows enjoy the bass turned way up and, second, that highbrows with golden ears (like us) prefer their music *pure* (*i.e.*, tone controls flat). This latter group play their rigs at full concert level to make it sound right or else sublimate their normal desire to hear full, rich bass tones in favor of impressive highs.

Now that we recognize the need for following the shift of the contours whenever we change levels, let us consider some practical means of accomplishing this action.

One way is simply to crank up the bass tone-control knob on the amplifier as we reduce level. This is better than no compensation, but it has three basic faults: First, the break frequency of most bass controls does not follow the loudness shift break frequency very well; second, every time we change level we have to make some kind of guess as to where to position the bass control; finally, and most serious, typical bass-boost circuitry rarely exceeds 18 db of boost wide open, and as we have seen, as much as 30 db may be required to achieve the desired compensation.

A separate control which will follow the loudness contour shift over a range of about 40 db is the only satisfactory solution.

Some loudness controls attenuate over a greater than 40 db range. To accomplish this they either become quite complex or else do a rather poor job of approximating the contour shift.

The simple control developed by the author, shown schematically in Fig. 3, covers the ample, if not ultimate, 40-db range. More important, it never deviates from the desired contours by more than a couple of decibels over this range, as its measured attenuation characteristic (plotted in Fig. 4) clearly indicates. It requires a low-impedance source (an emitter or cathode-follower of not more than 100 or 200 ohms) and a high-impedance load (about 300,000 ohms). It can be added to almost any preamplifier.

To use the control, set it wide open and adjust the level control so that the program sounds as loud as the original. Next, set the tone controls for proper balance. These would be set flat if everything in the system from microphone to room acoustics were perfectly balanced. However, since this is never the case, some tone-control trimming is almost always necessary. This done, we need not touch the level control or the tone controls again unless the sound source is shifted to a different power level or tonal balance.

The loudness control may now be used to achieve any listening level desired, with the program remaining full and natural sounding at any level. ▲

Quantum Devices

(*Continued from page* 41)

ends. Emission in other directions passes through the side of the rod and has little effect. However, emission in the direction of one of the mirrors sets up a chain reaction as photons bounce back and forth between the mirrored surfaces, striking other energized atoms in the process and causing each to emit two photons.

When amplification is great enough, a narrow beam of extremely intense red light is emitted from the partially silvered end of the rod. The light is coherent, covering a single frequency, and provides a striking demonstration of the operation of the quantum theory.

The laser is finding wide use in medical, chemical, and biological research, and may be the principal means of communications for space vehicles. Lasers may also lead to the design of very-high-resolution radar systems.

Spectrometers

The quantum theory has provided two new kinds of spectrometers, called the nuclear magnetic resonance (NMR) and the electron paramagnetic resonance (EPR) spectrometer. The first type uses the gyromagnetic properties of atomic nuclei, the second the orientation of unpaired electrons. Electromagnetic radiation is provided by a combination of an r.f. signal and a strong magnetic field. The r.f. signal is usually maintained at a constant level while the magnetic field is usually increased.

Energy is absorbed from the system at resonance points that correspond to energy level transitions. Since these are different for each kind of atom making up the unknown sample, the composition can be determined by measuring the density of the magnetic field at the points where absorption occurs. The degree of energy absorption is related to the number of atoms involved, so both a qualitative and quantitative analysis is provided.

An r.f. signal of about 10 kc. is usually employed for NMR spectrometers. Since EPR spectrometers are designed to take advantage of fields associated with unpaired electrons which resonate at much higher frequencies than atomic nuclei, it is necessary to use microwave plumbing.

The above descriptions cover some of the more important quantum devices. The list is not exhaustive, as quantum mechanics is influencing much current developmental work. In view of the successes already attained, there is reason to believe the quantum theory will be a major factor in invention for many years to come. ▲

TRANSISTORS vs TUBES for HI-FI

By RICHARD S. BURWEN / Consulting Electronics Engineer

Comments on "transistor sound," over-all performance, and reliability of transistors in hi-fi power amplifiers.

Editor's Note: Following are some additional comments on our article "Transistors for Hi-Fi: Panacea or Pandemonium?", which appeared in our September and October issues. Mr. Burwen specializes in audio and transistor circuitry and was responsible for the design of several high-power transistorized hi-fi amplifiers and other audio equipment.

MY views on transistors for hi-fi are generally the same as those given by the authors of the original article. Here are some additional points not covered previously.

One factor that can make a transistor power amplifier sound cleaner than a tube amplifier is its superior clipping action under overload conditions. Some transistor amplifiers recover from an overload much faster than vacuum-tube amplifiers by virtue of d.c. coupling. This makes the distortion produced by overloading much less objectionable and may even be completely unnoticeable when the amplifier is occasionally overloaded as much as 5 db.

Another characteristic that can make a very noticeable difference in the listening quality of the amplifier is the damping factor. Fig. 6 in Part 1 of the original article showed that the acoustic response of the speaker system did not change much when the damping factor was changed from 4 to 1 to infinity. Had the impedance of the speaker system been much lower than rated value at certain frequencies, as is the case in some of the more efficient systems, there would have been a greater difference in the response curves. This difference can be as much as 3 or 4 db at certain frequencies and does produce a very noticeable difference in the sound quality.

With either vacuum tubes or transistors the amount of distortion produced depends primarily on the ingenuity of the circuit designer in using negative feedback. Both can produce very low distortion if enough feedback is used.

On a performance-per-dollar basis, transistors are still slightly behind tubes. Silicon planar transistors, recently available at a low enough price, make practical preamplifiers which can provide noise figures of 1 to 2 db over the audio range without microphonics. They can even perform well with source impedances up to 500,000 ohms.

The power transistors that really solve the problems of hi-fi, silicon planar types, are too expensive, but prices are falling.

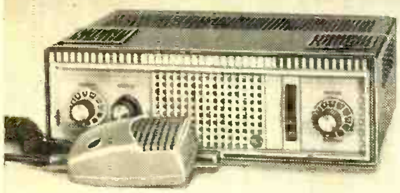
Transistors have been developed for military equipment, for example the "Minute Man" missile, which are so reliable that if 100,000 transistors were operated for 1000 hours, not more than one would fail. The same technology which produces such high reliability is being applied, although to a lesser degree, to the transistors now available for hi-fi equipment. Since they lack the basic wear-out mechanism of the tube, the heater cathode, it can be assumed that transistors will last many times longer in hi-fi equipment provided that they are properly applied.

It is true that transistors are very easily destroyed, especially when someone unfamiliar with transistor circuitry reaches into an amplifier with a test prod. Complete short-circuit protection for a d.c.-coupled power stage is rather costly. One compromise solution which the author has used is to incorporate a fuse together with an output coupling capacitor which limits the low-frequency energy in the transistors at a slight sacrifice in low-frequency power output.

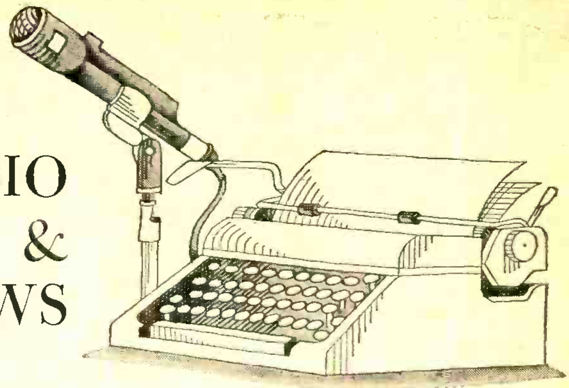
Whether it is tubes or transistors, it takes a lot of feedback and a lot of components to produce extremely high-quality performance. In general, it takes three to five transistors to accomplish the job of a 12AX7, but there are some compensating savings on the power supply, size, and the amount of heat produced.

A power amplifier using silicon alloy power transistors has been built to deliver 25-watts power output. This amplifier uses d.c. coupling, has only millivolts of d.c. offset across the loudspeaker voice coil, recovers from overload instantly, incorporates complete overload protection for both short circuits and reactive loads, delivers full power with less than 0.05% total harmonic distortion up to 5 kc., and does all this over a wide temperature range with production transistors without matching and without adjusting their bias currents. With planar output transistors the same circuit will produce full power to 20 kc. with similar distortion characteristics. *(Sorry, but we cannot supply the circuit and construction details.—Editor)*

Thus, transistors right now can produce higher quality than has generally been available from tube amplifiers. ▲



RADIO & TV NEWS



THE x-ray warning note that all manufacturers of picture tubes include in their data sheets, has caused many inquiries as to the possibility of x-ray radiation damage emanating from a typical picture tube.

The standard warning given in the data sheets states that radiation shielding may be necessary if the picture tube is operated at higher than manufacturer's ratings. A number of magazine articles have appeared on this subject and recently *Sylvania* passed along some information they had gleaned along these lines.

When a high-velocity electron beam strikes a target, various types of energies are released, some of it in the form of x-rays. As TV picture tubes are usually operated with anode voltage of 8 to 20 kv., mostly "soft" x-rays are formed. Ordinary glass will pass soft x-rays only with a substantial loss by absorption, and since the face-plate of a CRT is heavy glass, a considerable shielding effect is present.

Another reason for low x-ray output is that the electron beam current is on the order of tens of microamperes and spread out over a large surface area rather than the small target area of x-ray tubes. In addition, the "target" in a CRT is very inefficient in producing x-rays.

Thus, it becomes evident that an average TV picture tube, operated at its rated voltage values, is being used in such a manner that very weak, if any, x-rays can be detected at a few inches from its face-plate.

It is of interest to note that all-glass picture tubes are even less subject to radiating x-rays than the all metal type. This is because the all-glass types have a thicker face-plate made of a glass that absorbs x-rays to a greater extent than the glass face-plate on the metal-glass tubes.

To put some numbers to it, *Sylvania* recently made measurements on several typical all-glass and metal-glass picture tubes and found that a typical 27-inch, all-glass tube, operated at above maximum second-anode voltage of 27 kv., produced no reading on a radiation detector held 3 inches in front of the face-plate. A 21-inch, all-glass tube, operated at above maximum second-anode voltage of 24 kv., also produced no reading.

However, a 21-inch, metal-glass tube, operated at above maximum second-anode voltage of 24 kv., produced 11, 36, and 68 mr-per-hour radiation when operated at 20, 50, and 100 footlamberts highlight brightness respectively. This is far in excess of the 2.5 mr-per-hour allowable by Bulletin UL492-10th Edition, of the *Underwriters Laboratory*. (A limit of .5 mr-per-hour is under discussion by the International Commission of Radiological Protection.) When a ¼-inch safety glass was used with this CRT, radiation level dropped down to a safe .6 mr/hr. All measurements were taken 3 inches from the face-plate.

The same tube type (21-inch, metal-glass), operated at the same three brightness levels as before, with above maximum second-anode voltage of 22 kv., produced radiation levels of 3, 9, and 16 mr-per-hour. However, with a ¼-inch safety glass installed, radiation dropped to well within the safe value. Reducing the second anode voltage to the maximum rated value of 18 kv., produced radiation levels of .6, .8, and 1 mr-per-hour, and all were reduced to far within the safe value when the safety glass was used.

The same metal-glass CRT types produced no measurable radiation when they were operated at normal recommended second-anode voltages.

The numerical values associated with these tests illustrate some radiation levels that can be encountered whenever picture tubes are operated with voltages in excess of what the manufacturer specifies. The tests also point up the protection afforded by the normally used safety glass. In many of the newer CRT's, the safety glass is built-in at the face-plate end of the tube.

The lessons to be learned are very simple: never, but never, juggle the CRT circuit to raise the voltages in the interests of a brighter or sharper picture; and never operate a CRT without the manufacturer's specified safety glass.

By the way, when are you going to check the voltages and put a safety glass on that cathode-ray tube that you use as a bench tester? ▲

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CB Radio-Wave Propagation

(*Continued from page* 48)

The basic conditions of the ionosphere are reasonably predictable; so much so that it has enabled predictions with a fair degree of accuracy several months in advance of the propagation characteristics at various points around the earth. These are published by the National Bureau of Standards in the form of earth charts. By the use of these charts, you can determine, if you are interested, where you might be heard for any month of any given year.

Up to now we've explained the minimum distance for F2 skip, but what about maximum distance. Greater distances than 2500 miles are due to multi-hop transmissions, that is, those which are reflected back to earth, bounced off the earth and back into the ionosphere, then returned to earth perhaps another 2500 miles away. This is a rare bird for CB, due to the fact that with only 1 to 3½ watts output, the chances of multi-hop transmissions are not very good. If the signal bounces back to earth, the earth itself will usually absorb most of the energy so there is very little, if any, which can be bounced back into the ionosphere again. It does, however, happen occasionally, especially where the return to earth is at a place with good reflecting properties.

Short Skip

Now that we've indicated that 1250 miles is about the minimum skip distance, you are apt to say, "OK, but what about the short skip signals I've received from only a few hundred miles away, or even less?"

Shorter distance skips are due to the E layer, where the ionization becomes quite high, especially during the summer months or to so-called sporadic-E skip. This latter condition is one in which there are blobs or clouds of highly ionized gases in the E layer which may persist for a few minutes or a few hours. They occur quite often in early evening hours and may persist even after the sun has set, usually disappearing by midnight local time. These ionized clouds occur quite often, especially in summer, and can account for reception of signals from transmitters only a few hundred miles away from you.

The characteristics we have discussed thus far account for most of the skip signals in the 27-mc. band. There are some unusual conditions which can account for the sudden appearance of signals from almost any distance up to several hundred miles or even farther. These include such effects as meteor showers, tropospheric scatter, ionospheric scatter, back scatter, reflections from satellites, and other causes—all of which are relatively minor but which may account for some of the bizarre results we sometimes get.

What To Do About Skip

The first thing, of course, is not to answer skip signals, even though some eager beaver calls your number from 2000 miles away. But, other than ignoring them, there is little you can do about the interference they might cause. Skip signals have one characteristic which antenna manufacturers may use some day to reduce the reception of CB skip. Although your signal is vertically polarized when it is transmitted, the polarization becomes circular or elliptical when it is refracted by the ionosphere. Such a signal has both horizontal and vertical polarization. Now, if some antenna manufacturer can come up with a device which reduces or cancels out the horizontal component of a skip signal, he might be able to attenuate such signals and so reduce interference.

The propagation of radio signals can be an intensely interesting subject. Much is known about it, and more is being learned as we advance into the space age with space probes capable of entering or going through the ionosphere. ▲

Oil Exploration

(*Continued from page* 30)

While most of the work of producing data for the geophysicist is done in the field, many times recordings are sent to a central processing point. The processing center may do all or part of the filtering, mixing, and correcting usually necessary and, in addition, may handle the work of several field crews. A typical central processing unit is shown in Fig. 6.

Other Exploration Techniques

The exploration technique described here is only one of a number of methods used in finding oil and investigating the interior of the earth. Others include refraction seismology, magnetic and gravity measurements, and well logging. Like reflection seismology, most of them are dependent upon electrical or electronic instrumentation.

Refraction seismology is quite similar to the reflection method in that it requires almost exactly the same equipment. The technique makes use of the refracting properties of the subsurface layers. This technique is generally inferior to the reflection method because it does not give an exact picture of the subsurface. It is useful in many instances, however, particularly where it is desired to determine the velocity of propagation in certain areas.

In well logging, a deep hole is drilled in the earth and instruments are lowered to the bottom. As the instruments are pulled up, measurements are made on the rock and soil and a chart or log is plotted as a function of depth. Among the properties measured are acoustic velocity, electrical resistivity, density, self potential, *gamma*-ray radiation, and others. Geologists have said that this is one of the most useful of all of the various exploratory techniques used.

The Mohole and Vela Uniform

While a large percentage of the electronic instrumentation used in the geosciences is concerned with locating oil and gas deposits, electronics is also helpful in other areas. Two recent interesting uses of electronics in the geosciences are the drilling of the Mohole and Vela Uniform.

The Mohole project is an attempt to drill through the outer crust of the earth into the mantle or inner earth. The mantle comprises about 80% of the earth's volume, but little is known of its character. Knowing the nature of the inner earth will aid scientists in proving or disproving theories and the history of the earth.

The Mohole will be drilled at sea because the mantle is closer to the surface under the sea than it is under land. Naturally, this brings on many complications. The drilling ship must, at all times, be accurately positioned over the hole being drilled regardless of the condition of the weather and the sea. This requires a special drilling ship as well as an excellent positioning system. The positioning system will make extensive use of electronic techniques. Electronic instruments will also be used to log the hole as it is drilled. Reflection and refraction seismic tests have been run over the water areas that are being considered as drilling sites. We can expect to see some interesting results of the experiment.

Vela Uniform is part of the government's research project for the development of a satisfactory arms control in the form of an underground nuclear blast detection, identification, and location system. The entire program is dependent upon electronic instrumentation. Seismological observatories or detection stations will be set up at carefully chosen locations over the world. These stations will be equipped with seismometers, amplifiers, processing and recording instruments, and other devices necessary to the detection of nuclear blasts and other seismic disturbances. Underwater seismometers with telemetry equipment will also be used. Fig. 7 shows a typical detection station for nuclear explosions.

As advances are made in electronics, so will advances be made in the geosciences. It is hard to predict what lies ahead but it will no doubt be of considerable value to mankind—and much of it because of the contributions made by electronics. ▲

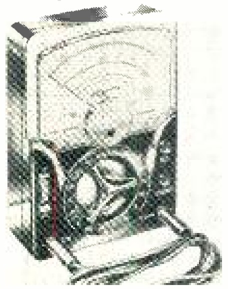
NEW PRODUCTS & LITERATURE

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 15.

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

COMPACT MULTITESTER

1 **Lafayette Radio Electronics Corporation** is now offering a low-cost, compact 20,000-ohms/volt multitester as the TE-58.



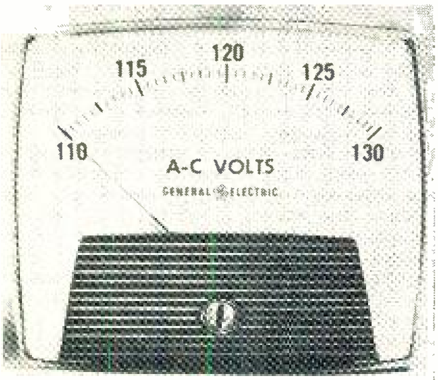
The 40-μa. d'Arsonval meter has a 3½" scale in two colors. High input resistance is possible on all ranges: 20,000-ohms/volt on d.c. and 10,000-ohms/volt on a.c. In addition, 1% precision resistors are used for maximum accuracy.

Full-scale ranges include: 0-.6, 6, 30, 120, 600, and 1200 d.c. volts; 0-6 30, 120, 600, and 1200 a.c. volts; 0-60 μa., 0-6, 60-600 ma. d.c.; 0-10,000, 100,000, 1 megohm, and 10 megohms resistance; −20 to +63 db; plus a special capacitance range of 200 pf. to 0.2 μf. The unit operates on two standard 1½-volt batteries and measures 3⁹⁄₁₆" w. x 5⅛" h. x 1⅞" d.

EXPANDED-SCALE VOLTMETERS

2 **General Electric Company** is now offering its "Big Look" voltmeters with scales expanded up to six times. Incorporating zener-diode references, these meters provide accuracy of ± 0.5% and excellent narrow-range readability. Expanded-scale meters are available in 3½" and 4½" self-contained a.c. or d.c. models.

Standard a.c. ratings are 110-130 and 105-125



volts. Standard d.c. ratings are 24-30, 110-130, and 220-260 volts. The d.c. meters are available in either pivot and jewel or taut-band construction The d.c. d'Arsonval mechanisms are self-shielded from stray magnetic fields and require no special calibration for magnetic panels.

TRANSISTORIZED COUPLER

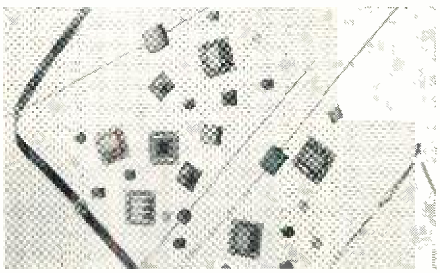
3 **Winegard Company** has just introduced a transistorized two-set coupler which has been designed to overcome splitter loss especially in fringe or weak-signal areas.

With the model EC-230 Color-Coupler, it is possible to operate two TV sets, or a TV and an FM set simultaneously from a single antenna and down-lead without loss of signal.

A high-gain transistor boosts the signal a minimum of +7 db to provide equal or better TV or FM reception for two sets than was possible for just one. In addition, 15 db isolation between coupler outputs prevents interaction of sets which degrades reception, color in particular. The unit features the same isolation at all frequencies.

PELLET CAPACITORS

4 **The Scionics Corporation** is marketing pin-head-size pellet ceramic capacitors for use in microelectronic programs. Values up to 1000 pf. are available in thickness of .020" or greater, if desired. Typical capacitor element size for .01



μf., 50 v. is .1" x .1" x .062" while a .1 μf., 50 v. unit measures .2" x .2" x .062".

Larger capacitance values, higher voltage ratings, and special form factors are available on request. The line is available with ribbon leads, 30-gauge wire leads, solderable disc terminations, and in micromodule wafers.

TEMPERATURE-MEASURING KIT

5 **H. V. Hardman Co., Inc.** is now marketing a temperature-measuring kit that has been specifically developed for the electronics industry.

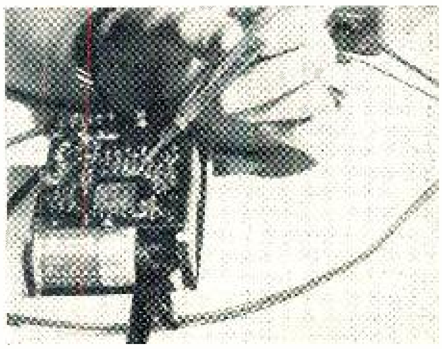
The kit includes a selection of color-changing "Thermochrom" crayons and "Detectotemp" paints for indicating temperatures and heat distribution from 40 degrees C (104°F) to 440 degrees C (824°F.). Easy-to-see color changes, unaffected by ambients, clearly show surface temperatures reached, not reached, or exceeded to within ± 5°C accuracy irrespective of range.

The kit can be used for checking out critical temperatures on microminiature circuitry, transistors, diodes, breadboards, motors, generators, bearings, transformers, and packaged equipment.

CLIP-PROBE COMBINATION

6 **Gator Probe Corporation** has announced the development of a combination test lead that features an insulated alligator-type clip plus a retractible probe.

The plug, at the end of a 52-inch, 18-gauge lead, will accommodate either banana tips or pins. Both pairs of tips are included so the combination can replace a minimum of three



sets of standard leads. Clips have swivel jaws that clamp securely to flat, square, or round surfaces—from ¼" stock down to .005 wire. Plastic parts are designed to withstand at least 10,000 volts d.c.

HI-FI — AUDIO PRODUCTS

PROFESSIONAL RECORDING TAPES

7 **Eastman Kodak Company** is now marketing two professional-quality sound recording tapes with a rugged, new Durol base.

The Type A303 is a low-print tape with a signal-to-print-through ratio of 54 db. The Type A304 is a high-output tape which is said to have more than double the undistorted output of conventional tapes. The signal-to-noise ratio, as measured by zero signal to saturated output is 79 db. Print-through has been held to a 49-db level.

The new Durol base virtually elminates stretching; residual elongation is held to less than one percent. In case of recorder malfunction, however, the tape has a built-in "shear pin" effect so that it will ultimately break clean rather than stretching and snarling.

CABINETED TAPE RECORDERS

8 **Allied Impex Corporation** is now importing two completely self-contained stereo tape recorders which are housed in teak cabinets.

The top recorder in the line is the "Sorrento" which features solid-state circuitry with 21 transistors and 19 diodes in an OTL circuit and an

all-electronic matrix-type push-button switching system. Tape movement is controlled by three separate motors; for capstan drive (7.5 and 3.75 ips), rewind, and fast forward. There are individual volume and tone controls for each channel, illuminated vu meters, and two built-in 4" x 6" speakers. The motor and power cut off automatically at the end of the tape.

The "Nocturne" (photo) is a three-speed unit with switch-controlled mono/stereo playback selection.

INTEGRATED TUNER/AMP

9 **Transwave Electronics Co. Ltd.** is marketing the TW-50, an integrated AM-FM stereo system incorporating the company's Model TW-2 AM-FM tuner, a comprehensive stereo control center, and a stereo amplifier capable of delivering 50 watts of power. FM-stereo facilities are built in and only the connection of two speakers is required for a complete system.

The FM tuner section features stereo channel separation of 40 db at 1 kc., and 1.25 μv. sensitivity for 20 db quieting or 3 μv. IHF. AM sensitivity is 5 μv. for 20 db signal-to-noise ratio. Audio frequency response of the amplifier is

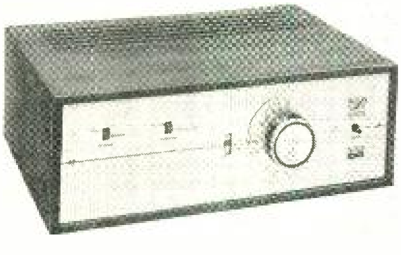
18-22,000 cps ±1 db at rated output. Power output is 16 watts music power per channel and 25 watts peak power per channel.

FM-STEREO TUNER SEMI-KIT

10 **Eico Electronic Instrument Co. Inc.** is now offering the Model 2200 "Classic Series" FM-stereo tuner in semi-kit form.

The front-end and the i.f. strip are pre-assembled and pre-aligned at the factory. A circuit board is provided for the stereo demodulator circuit and the coils supplied are pre-aligned.

The Model 2200 features a precise rotary tuning dial with illuminated readout, bar-type



electron-ray tuning indicator, and a stereo defeat switch. IHF usable sensitivity is 3 μv. for 30 db quieting, signal-to-noise ratio 55 db, and harmonic distortion 0.6%. Channel separation is 30 db.

The unit measures 5⅝" h. x 15⅞" w. x 11⅝" d. and weighs 12 pounds. A wired version of the tuner is also available.

EQUIPMENT/SPEAKER CABINETS

11 **Lafayette Radio Electronics Corporation** is now marketing the new "Criterion" line of hi-fi cabinetry. The complete stereo ensemble consists of one equipment cabinet and two speaker cabinets. Both types of cabinets are available in walnut, oiled walnut, or mahogany.

The equipment cabinet, which measures 44" w. x 32½" h. x 18" d., has four compartments which will house a turntable or changer, amplifier, tuner, plus room for record storage.

The speaker cabinets are designed to handle any 12" speaker. A specially designed elliptical port with diffracting ring broadens frequency response, increases transient response, and eliminates cancellation effects between front and rear radiation. Dimensions are 16" w x 32½" h. x 18" d.

SOLID-STATE STEREO AMP

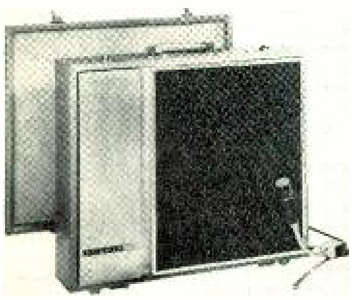
12 **Harman-Kardon, Inc.** has previewed its Model A-1000T stereo amplifier, an integrated solid-state unit rated at 70 watts, mono, across the entire audio band.

Frequency response is 10-100,000 cps ± ½ db. Using no output transformers, the A-1000T employs computer-grade silicon output transistors which yield high power output with virtually unmeasurable distortion. The circuit employs 28 transistors plus 6 diodes.

PORTABLE SOUND SYSTEM

13 **Wm. A. Holmin Corporation** is now marketing a self-powered, self-contained public-address system as the Model 300.

The unit comes in a compact, attache-type portable case which sets up as a p.a. system in seconds. A single "on-off" switch and volume



control are at the microphone which the user can operate even as he talks to suit coverage and acoustics. Transistorized, it requires no electrical outlets. The system includes a microphone which can be worn as a lavalier, used on a desk stand, or hand-held. The microphone itself rejects feedback whines and other noises.

The entire unit measures 4½" x 15" x 17¼" and weighs only 15 pounds.

AM-FM-FM STEREO TUNER

14 **Heath Company** has added a deluxe all-transistor AM-FM-FM-stereo tuner to its line of audio equipment in kit form.

The AJ-43 is completely transistorized and uses 25 transistors and 9 diodes. The circuit features automatic stereo switching, automatic stereo indicator light, pre-assembled FM tuning unit and four-stage FM i.f. circuit board, separate AM and FM tuning meters, filtered stereo tape recorder outputs, a.f.c. and a.g.c., and stereo phase control for maximum separation and minimum distortion.

The tuner is designed to match the company's AA-21 amplifier kit.

ANTENNAS FOR FM

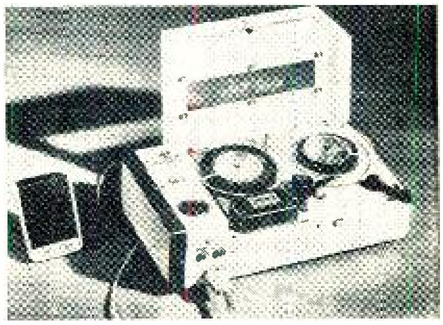
15 **Jerrold Electronics Corporation** has added three FM antennas to its "Paralog" line of television units.

All three antennas provide a front-to-back ratio of 18 db for the smallest model to 23 db for the largest model. The v.s.w.r. is rated at 1:1.2 to 1:1.8. Paralog gain is 12 db. The flat response means that the antennas respond to all signals in the FM band with an equal amount of amplification.

MINIATURE TAPE RECORDER

16 **Ricoh Industries, U.S.A., Inc.** is introducing a Japanese-built miniature tape recorder which features two speeds and operates on batteries or from house current with an adapter.

The tape recorder, which weighs under 5



pounds without accessories, measures 5" x 9" x 3" and has a 2" x 4" oval dynamic speaker. It has a volume control and sound-level indicator which also shows battery condition.

The recording is 2-track on 3¼" reels with tape speeds of 3.75 or 1⅞ ips. The circuit uses 7 transistors and has a.c. bias.

FM-STEREO RECEIVER KITS

17 **Merrell Electronics Inc.** is marketing two FM receiver kits, one completely equipped for FM-stereo reception and the other with multiplex facilities.

Both the Model SR-436K and the SR-400K feature 10 front-panel controls, a pre-wired front end, a.f.c., pre-aligned i.f. transformers, output of 20 watts total (10 watts each channel), frequency response of 20-20,000 cps for the tuner and 20-18,000 cps for the amplifier.

STEREO AMPLIFIER

18 **H. H. Scott, Inc.** has added the Model 299D, an 80-watt stereo amplifier, to its "299 Series."

The new unit features switched front-panel headphone output for private listening without the use of loudspeakers, powered center-channel output for driving an independent speaker system without need for a separate power amplifier, and an 80-watt output stage for low distortion.

IHF power rating is 40 watts per channel, the power band width is 18-25,000 cps ± 1 db. THD is 0.8%, and hum level −80 db. Power rating (steady-state) is 32 watts per channel.

SPEAKER SYSTEM KIT

19 **Electro-Voice, Inc.** has added another loudspeaker system in kit form to its line as the "Coronet."

Designed around the company's "Wolverine" and "Michigan" eight-inch extended-range speakers, the enclosure is of the phase-inverter type to provide full frequency coverage. Of the high-efficiency type, the system can be used with any amplifier.

The pre-finished enclosure is designed to be used on a shelf or table. It comes in walnut finish.

AM-FM/FM-STEREO UNIT

20 **Radio Corporation of America** has recently unveiled the MX-7, a stereo hi-fi receiver that requires only the addition of speakers to provide reception of AM and FM programs as well as FM-stereo offerings.

The instrument combines a high-performance FM-stereo tuner, an AM tuner, 30-watt stereo amplifier, plus input receptacles for tape recorder connections, phono turntable and changer, microphone, or TV set.

The unit, which measures 6⅛" h. x 17⅜" w. x 12½" d., features keyboard-type function controls, dual volume controls, separate balance control, visual tuning indicator, and an FM-stereo signal indicator.

PORTABLE TAPE RECORDER

21 **Superscope Inc.** has added the **Sony** Model 801-A portable tape recorder to its line of products distributed in the U.S.A. This battery-powered, two-speed, dual-track mono recorder has a full 5" reel capacity.

The Model 801-A features all push-button operation, self-storing microphone with remote stop/start switch, built-in amplifier and speaker, plus a vu meter which indicates accurate record level or battery condition. The unit also features a variable back-spacing lever which when activated provides instant repetition of a word, phrase, or entire paragraph.

The unit measures about 13" w. x 11" d. x 4" h. It weighs 13 pounds.

CABINET FOR DYNA UNITS

22 **Ruxton Electronics** is now offering an attractive oiled-walnut wood cabinet designed to house the **Dyna** PAS-3 preamp and FM-3 tuner. This complete stereo tuner control center has the

appearance of a single unit while retaining all the virtues of independent components with full ventilation.

The cabinet measures 14½" wide by 9" high by 8" deep.

FOUR-TRACK STEREO RECORDER

23 **Inter-Mark Corp.** has added the "Cipher Denon 800" professional four-track stereo unit to its line of tape recorders.

The new stereo/mono tape recorder and playback unit has three hysteresis synchronous motors: one 4-pole/8-pole 2-speed motor, one fast forward motor, and one rewind motor. Tape speeds (7.5 and 3.75 ips) are stabilized and both fast-forward and rewind can be performed in approximately 50 seconds for a 1200-foot tape.

The unit has a three-head system for recording, playback, and erasing. It also features push-button control for easier operation. Frequency response is 30-15,000 cps @ 7.5 ips and 30-8500 cps @ 3.75 ips. The entire unit measures 19½" x 16½" x 9" and weighs 55 pounds.

CB-HAM-COMMUNICATIONS

AMATEUR ROTOR SYSTEM

24 **Cornell-Dubilier Electronics Division** is now offering an amateur rotor system, the TR-44, which supplies increased torque, braking, and accuracy necessary for large v.h.f. antenna arrays and small h.f. combination antennas. Typical applications include amateur, mobile and CB radio, TV, FM, and FM-stereo.

The rotator is enclosed in an all-weather bell-shaped casting which allows the unit to "free" itself from ice and protects the mechanism from rain and snow. An "end-of-rotation" electrical motor cut-off stops the rotator 5 degrees before the mechanical stop. A 50 ball-bearing movement increases ability to carry weight and absorbs wind forces. The TR-44 can be mounted on masts up to 2" in diameter or on a flat plate for interior tower mounting.

MULTI-PURPOSE CB UNIT

25 **Pearce-Simpson, Inc.** is now marketing the "Escort," a multipurpose two-way unit for the Citizens Band service. Designed for both land and marine applications, the unit is housed in a heavy-duty enclosure which is rust- and corrosion-proof. A dual transistorized power supply permits 12-volt d.c. and 115-volt a.c. operation.

The circuit features 8 channels plus an accessory crystal socket for use on any channel, 8 illuminated channel markers that are synchro-

nized with the channel-selector switch and indicate operating channel, squelch circuit for quiet standby operation, low power drain, pre-set noise limiter, plus universal mounting bracket.

Dimensions are 11½" w. x 4¾" h. x 9½" d.

GARAGE-DOOR CONTROL

26 **The Alliance Manufacturing Co., Inc.** is now in production on a palm-sized high-frequency radio transmitter that will operate garage doors by remote control. Known as the "Genie Model AT-10," the transistorized transmitter offers a range up to 125 feet and provides 21 channels instead of 9 formerly available.

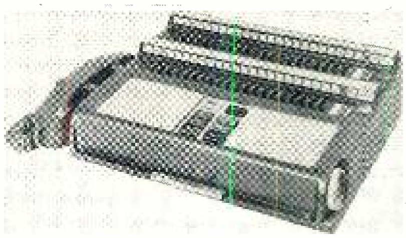
Housed in a black and white case of high-impact plastic, the 3¾" x 2¾" x 1¼" transmitter weighs only 9 ounces. It is powered by a single low-cost 22½-volt battery.

Both the transmitter and its companion receiver, Model AC-10, meet FCC specifications. The receiver operates on 117 volts a.c.

HOSPITAL INTERCOM SYSTEM

27 **Executone, Inc.** is now offering a complete hospital communications system which provides a wide range of features and benefits.

The new system provides two-way voice com-



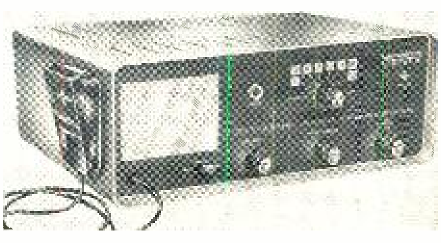
munications between nurse and patient, two-way communications between nurses and ancillary department, remote infusion monitoring, remote bed occupancy monitoring, provision for remote physiological monitoring, pillow speakers for individually controlled radio and television programming, announcement and alarm facilities, and an administrative intercom network.

CB TRANSCEIVER

28 **Lafayette Radio Electronics Corporation** has added the HB-115 push-to-talk transceiver to its line of CB equipment.

The new unit features eight crystal-controlled transmitting channels operating at the maximum legal power of 5 watts fully modulated; a pi-network output which matches 30-100-ohm antennas for maximum output; an r.f. stage in the transceiver section; and a superhet receiver tunable on all 23 channels with over 2 watts audio output.

There is a.v.c. and a full-wave variable noise limiter, accurate planetary vernier tuning, separate "on-off" power switch, external speaker/earphone jack, and electronic push-to-talk switching.

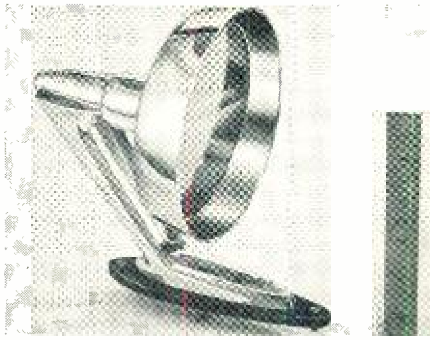


The transceiver comes complete with a channel 15 transmitting crystal, push-to-talk ceramic microphone, and mounting brackets. It measures 11½" w. x 5" h. x 6⅝" d. The power receptacle in the rear is for the 117-volt line with a connection for an optional external 6- or 12-volt d.c. power supply.

MOBILE ANTENNA

29 **Sinclair Radio Laboratories, Inc.** has developed an omnidirectional v.h.f. communications antenna, housed in a fender-mounted rear-view mirror, which defies detection, prevents vandalism, and eliminates unsightly attachments to the vehicle.

The Model 50037 consists of a ruggedly constructed mirror that requires no unusual mounting procedures—just two bolt holes to hold the mirror and connection of the antenna. When



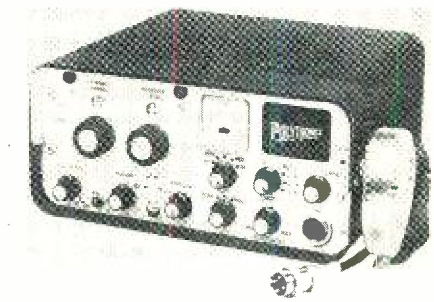
the vehicle is replaced, a standard rear-view mirror can be mounted in the same location.

The antenna itself operates in the 150-174-mc. range and is factory tuned to the exact frequency required by the user. The v.s.w.r. is less than 1.5:1 at design frequency while the antenna's efficiency, according to the company, is equal or greater than that of a quarter-wave whip mounted in the same location.

24-CHANNEL TRANSCEIVER

30 **Polytronics Laboratories, Inc.** is currently introducing a 24-channel, crystal-controlled transmitter and tunable receiver which features precision selectivity.

The "Pro" operates on all channels in the Citizens Band service and has an additional channel for CAP, government, or county frequencies. The circuit features an all-nuvistor front end including cascode r.f. amplifier, nuvistor



first mixer, nuvistor crystal oscillator, and tunable oscillator.

Other features include a tunable receiver with 6:1 vernier dial, 6-mc. 1st i.f., 455-kc. second i.f., and separate peak and null controls.

MANUFACTURERS' LITERATURE

INDUSTRIAL D.C. GROWTH

31 **Amprobe Instrument Corporation** has just published a 16-page information bulletin entitled "D.C. Growth in Industry."

Written in easy-to-understand language, this manual is being released in conjunction with the firm's new line of d.c. current recorders and 50-mv. shunts. The booklet provides the reader with such useful background information as: reasons behind the rapid growth in d.c. current, why d.c. current has become so popular, the advantages of d.c. plus details on the company's products for this service.

EMI GLOSSARY

32 **Ace Engineering & Machine Co., Inc.** is now offering without charge copies of a 12-page booklet entitled "A Short Glossary of EMI Terms."

The publication lists some of the more frequently encountered terms in electromagnetic interference work. It covers such terms as attenuation, cell-type enclosure, hash, TVI, RFI, EMI, spectrum signature analysis, and others.

SOUND MEASURING EQUIPMENT

33 **General Radio Company** has published a 20-page, illustrated brochure which describes its line of sound and vibration measuring instruments and associated apparatus. Among the instruments included are two new analyzers, one with constant-percentage bandwidths and one with constant-frequency bandwidths; a new microphone reciprocity calibrator, and stroboscopic equipment adaptable to vibration measurements.

REPLACEMENT TRANSFORMERS

34 **Triad Distributor Division** has issued a 24-page catalogue covering its entire line of replacement transformers. Prices, application data, specifications, and dimensions are given for more than 735 transformers, yokes, flybacks, and filter chokes.

All of the items listed are stocked by the firm's distributors.

INDICATOR-LIGHT DATA

35 **Drake Manufacturing Company** has announced availability of its Catalogue #6302 which covers complete details on the firm's line of indicator lights, lampholders, and lenses. Halftone illustrations and tabulated data cover main features of the different units.

IGNITRON SELECTION CHART

36 **National Electronics, Inc.** has made available a two-page "Ignitron Selection Chart," No. SB-21.

The chart shows the demand current vs percent duty rating of all welder ignitrons (size A to size E) on a single chart. This makes it easy to select the correct ignitron for an application as soon as the current and duty requirements are determined.

RECORDING INSTRUMENT LINE

37 **Esterline Angus Instrument Co., Inc.** has published a 16-page catalogue covering its new line of "GraphLine Series "S" " recorders. In addition the new publication carries information on the firm's line of servo recorders, single- and two-channel recorders, inkless and ink-type event recorders, among others. Specifications and selection data are provided.

LABORATORY TEST EQUIPMENT

38 **Houston Instrument Corporation** has published a short-form catalogue covering its complete line of X-Y recorders, T-Y recorders, and laboratory test equipment. The catalogue provides complete technical descriptions of all instruments.

TAPE RECORDING IN CHURCH

39 **The 3M Company** is now offering copies of its free booklet "The Tape Recorder in the Church." It outlines the uses of tape recordings to bring services to shut-ins, rehearse sermons, dramatize Bible stories, and create interest in choir improvement. In addition, the booklet outlines ways to use taped music for various church occasions.

PRECISION INSTRUMENTS

40 **Wayne Kerr Corporation** has announced publication of a 6-page, 2-color catalogue describing its complete line of quality instrument for a variety of measurements and types of analysis and control.

Included are ratio-arm bridges, self-balancing capacitance bridge, bridge standards and adapters, transfer function computer, primary standards, plus various audio and video instruments.

MATHEMATICAL PUZZLERS

41 **Litton Industries** is again offering copies of its popular "Problematical Recreations"—41 illustrated mathematical puzzles and their answers.

The Fifth Edition carries an interesting assortment of brain teasers ranging from those involving simple reasoning to posers that may stump the professional mathematician.

ELECTRIC SOLDERING EQUIPMENT

42 **Electric Soldering Iron Co., Inc.** is now offering copies of its Catalogue No. 763, a complete listing of its entire line of electric soldering equipment.

Pictured and described is an extensive line of solder pots, industrial soldering irons, miniature irons, soldering tips, and soldering guns. Complete specifications are included.

"CORDLESS POWER" REPRINT

43 **Sonotone Corporation's** Battery Division is offering copies of an illustrated reprint of the article "Cordless Battery Power" by Robert J. McCarthy.

The four-page folder covers the firm's complete line of commercial, rechargeable sintered-plate, nickel-cadmium battery cells. Included are cross-section views, operational curves, packaging concepts, charts, and tables on physical and electrical characteristics, plus photos.

ELECTRONICS CATALOGUE

44 **Allied Radio Corporation** has made "Electronics for Everyone" the theme of its new 444-page 1964 catalogue.

The new publication lists the latest in hi-fi components, "Knight-Kits" in all categories, CB and amateur radio units, p.a. and intercom equipment, test instruments, recorders and accessories, radios and phonographs, tubes, parts, antennas, tools, and technical books.

EDUCATIONAL TV DATA

45 **Adler Electronics, Inc.** is now offering copies of an address given by **Stanley P. Lapin** of the company before the Third Annual Conference on Educational Television in which he described an FCC-approved, economical 2500-megacycle closed-circuit service for instructional television.

TV-FM ANTENNA CATALOGUE

46 **Jerrold Electronics Corporation** has issued a 7-page, 2-color catalogue describing its new line of Paralog TV-FM antennas. Catalogue DS-CS-518.1 includes an explanation of the modular parasitic element concept, plus specifications on both non-amplified and amplified antenna types.

INTEGRATED CIRCUITS

47 **Signetics Corp.** has issued an 8-page condensed catalogue which carries data on 25 integrated circuits available off-the-shelf. The publication includes data on the firm's SE115 dual "nand/nor" gate which also provides "exclusive-or" function. Special-order products and packages are also described.

TV TUBE REBUILDING

48 **Windsor Electronics, Inc.** has published a booklet entitled "The Open Door to TV Profits" which describes the rebuilding of TV picture tubes by TV dealers and service technicians. Details on the company's rebuilding equipment are also included in the compact, pocket-sized manual.

PICTURE-TUBE REPLACEMENTS

49 **General Electric Company** has announced publication of its new "Television Picture Tube Replacement Chart" which includes an interchangeability guide and essential characteristics of 575 tube types now available.

The chart is printed on heavy stock and measures 28" x 30" for case in wall mounting to serve as a ready reference in television service work. The new chart is No. ETR-702H.

MAGNETRON APPLICATIONS

50 **Sylvania Electric Products Inc.** is now offering a free brochure entitled "Magnetron Application Notes" which has been prepared by the Microwave Devices Division of the company.

The 21-page booklet is divided in seven sections which include chapters on test specifications, essential tube information, measurement of system and tubes as a unit, and application notes for testing.

INDUSTRIAL PARTS LISTING

51 **Semiconductor Specialists Inc.,** distributor of industrial components, has issued a 20-page listing of a comprehensive line of diodes/rectifiers, transistors, zener diodes, silicon controlled rectifiers, field-effect transistors, 4-layer diodes, diode assemblies, multiple-chip circuits, micro-logic circuits, and accessories.

The listings are presented in tabular form for easy identification of specific components.

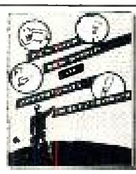
PRINTED-CIRCUIT DATA

52 **Centralab** has announced publication of the Seventh Edition of its popular "Packaged Electronic Circuit Guide." The guide contains information on how to select, test, and replace PEC circuits used in radio, television, and high-fidelity equipment.

The 8-page booklet contains a complete listing of over 200 of the firm's packaged electronic circuits, as well as complete replacement data.

CAPACITOR RELIABILITY FACTORS

53 **The Electro Motive Mfg. Co., Inc.** has prepared a special treatise entitled "Reliability Factors Affecting the Selection of Mylar-Paper



Dipped, Paper Dipped, or Mylar-Dipped Capacitor" as a service to military and industrial users of capacitors.

The publication provides the latest data and reports covering the life characteristics of the firm's "El-Menco" line of capacitors.

1964 KIT CATALOGUE

54 **Heath Company** has published the 1964 edition of its electronic kits catalogue. The 100-page publication includes a wide selection of kits for all ages and interests. Products illustrated and described in detail include all types of audio equipment, color and black-and-white TV, electronic organ, tape recorders, radio receivers of all types, CB equipment, ham and short-wave gear, marine equipment, automotive accessories, and test and lab instruments.

VARIABLE ATTENUATORS

55 **Microlab** is offering an illustrated catalogue which contains design and application data, dimensions, specifications, ordering information, and prices on four basic continuously variable attenuators in combination with various connectors.

DX CIRCULAR SLIDE RULE

Electro-Voice, Inc. is now offering an ingenious circular slide-rule for hams as the "W9IOP Second Op."

Priced at $1.00, the device provides complete DX operating information including prefix; great circle beam heading; time and data at DX location; air mail, first class, and QSL card postage rates; IRC coupon exchange table; continent; DX zone; prefix-to-country translation; and QSL bureau addresses. Also included is a log to indicate contact and receipt of QSL cards for each country.

Orders for the "Second Op" should be sent direct to the company at Buchanan, Michigan.

BELL EDUCATIONAL AID

Bell Telephone Laboratories has announced the availability of a new teaching aid for use in high schools.

The new unit, which is entitled "Speech Chain," consists of material for use in physics and biology classroom and an experiment that an advanced student can do on his own.

The classroom material is based on the book "The Speech Chain: The Physics and Biology of Spoken Language" by Drs. Peter Denes and Elliot Pinson, a motion picture, a phonograph record, and a group of demonstration devices.

The entire package will be made available to high schools and science teachers through local **Bell Telephone** business offices.

HI-FI/STEREO GUIDEBOOK

The Institute of High Fidelity, Inc. has issued "An Introduction to Hi-Fi & Stereo" designed to provide the layman with basic information on selecting and setting up a component hi-fi system.

The booklet carries a number of photographs showing how audio equipment can be installed in various room settings without being obtrusive or detracting from the decor, then the various components comprising a hi-fi system are discussed individually with emphasis on performance standards. A glossary of hi-fi terms, a hi-fi equipment planning guide, and a listing of audio specialists completes this attractive 64-page booklet.

Copies are available for 25 cents each from **The Institute of High Fidelity, Inc.**, 516 Fifth Avenue, New York, N.Y. 10036.

HOBBY MANUAL OF SCR CIRCUITS

General Electric Company has published a "do-it-yourself" manual for hobbyists interested in constructing circuits using silicon controlled rectifiers.

This 76-page handbook contains a variety of practical home, workshop, and industrial circuits using low-cost SCR's, rectifiers, and associated semiconductor components.

In addition to its use as a build-it-yourself book, this manual can serve as a valuable introduction to solid-state devices for engineers and technicians not already familiar with power semiconductors.

All fifteen of the circuits included have been tested in the laboratory and are ready for breadboarding. Copies of the "SCR Hobby Manual" are $1.00 each. They may be ordered by writing direct to Hobby Manual, Box A, Auburn, N.Y. 13022. ▲

CHOOSING TOOL SIZE

By ELWOOD C. THOMPSON

SELECTING the proper wrench or nut driver for a nut, bolt, or other such hardware item is not much of a problem ordinarily. However when the hardware is under a chassis or otherwise hidden from view, although accessible, determining the correct tool size can be a nuisance. Several may have to be tried, with reliance on an uncertain sense of touch, before the right combination is obtained.

Use of the fingertip provides a "handy" shortcut. The finger is pressed against the nut or other part, leaving a clear, if temporary, impression on the tip. The appropriate tool can generally be matched up to this impression on the first try. ▲

1963 INDEX

VOLUMES 69-70

As a service to our readers we are again presenting a complete listing of all feature articles which appeared in ELECTRONICS WORLD during 1963. We suggest you keep this for reference.

COMMUNICATIONS

COMPONENTS

CONSTRUCTION

HIGH-FIDELITY & AUDIO

EW LAB TESTED

INDUSTRIAL ELECTRONICS

MEDICAL ELECTRONICS

NOMOGRAMS

TELEVISION & RADIO

TEST EQUIPMENT

REFERRAL SERVICE

THE Library of Congress has established a National Referral Center for Science and Technology which will serve as a clearing house for information sources available to scientists and engineers.

The Center's job is advisory. It is designed to make information resources known to the country's scientists and engineers and to assure the fullest possible utilization of these resources. It does not answer technical questions directly but refers inquirers to the organizations, institutions, or individuals—within and outside the Government.

Requests for referral service may be made by visiting the Center between 9 a.m. and 5 p.m., weekdays, on the fifth floor of the Library of Congress Annex, Second Street and Independence Avenue, SE, or by calling STerling 3-0400.

Written requests should be addressed to National Referral Center for Science and Technology, Library of Congress, Washington 25, D.C. ▲

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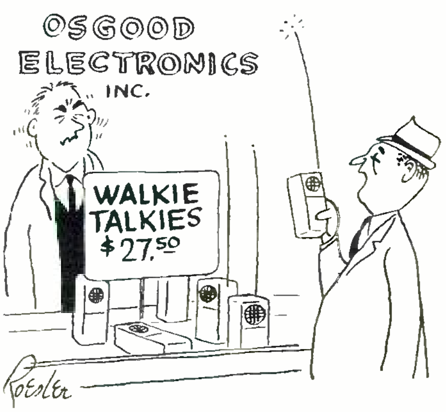
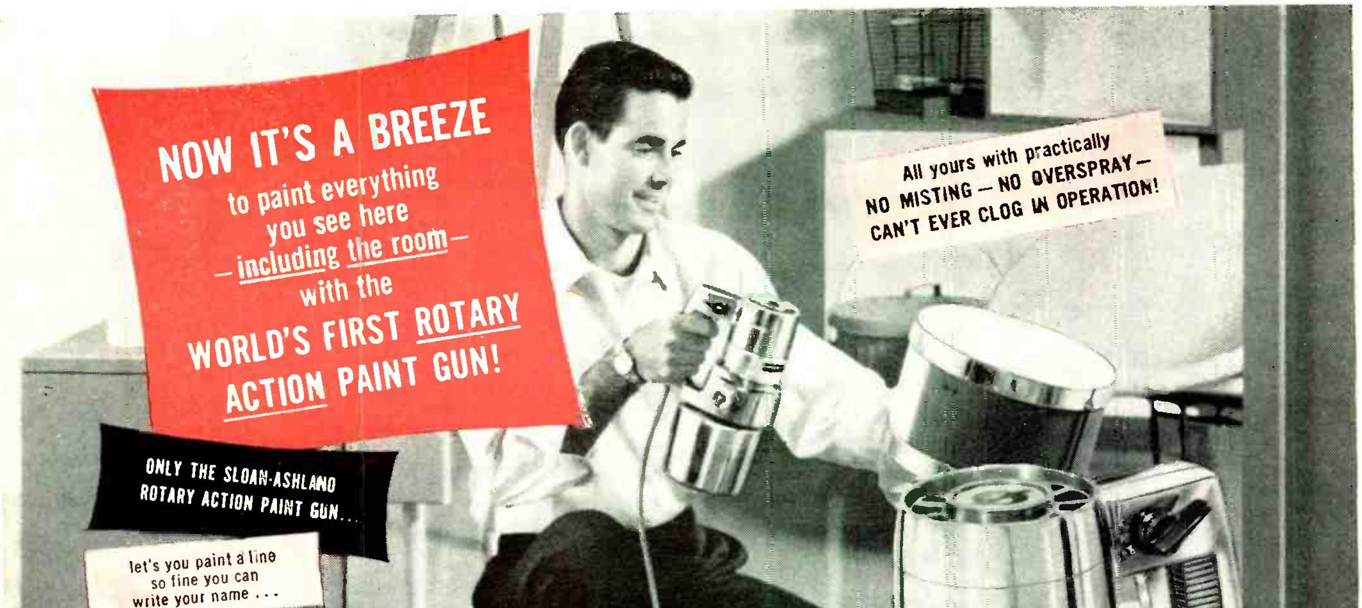
28 (Fig. 2, right), (Fig. 3, left), 30 (Fig. 5)	Electro-Tech Division, Mandrel Industries, Inc.
28 (Fig. 3, right), 30 (Fig. 6)	Dresser Electronics, SIE Division
30 (Fig. 7)	Geotechnical Corp.
52, 53	Motorola Inc.
68	Radio Corporation of America
70	Simpson Electric Co.
72	Eltec Laboratories, Inc.



"Come in Ace Electronic Supply . . . What's your best price on walkie-talkies?"



let's you paint a line so fine you can write your name . . .

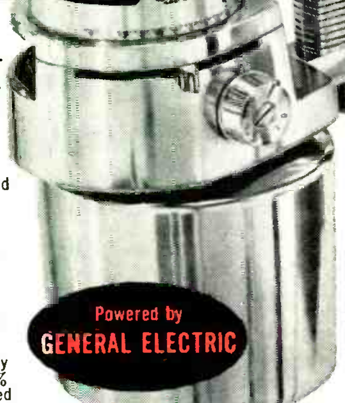
cover a full foot-and-a-half swath with one pass . . .

paint within inches . . .

Delivers as much paint per minute as a $200 industrial compressor model. HANDLES WATER SOLUBLE, RUBBER BASE, OIL BASE, FLAT, SEMI-GLOSS AND ENAMEL PAINTS. LIGHT OILS . . . INSECTICIDES . . . FLOOR WAXES, POLISHES AND OTHER LIQUIDS.

- No costly compressors
- No nozzles, needles, strainers to clog
- No air hoses to drag
- No flimsy vibrators
- 2-SPEED OPERATION for perfect control of light and heavy liquids.
- FINGER-TIP CONTROL OF PAINT FLOW—trigger lets you start and stop spraying instantly
- ADJUSTABLE GATE FOR EXACT WIDTH OF SPRAY YOU WANT—from ¼" to 18"—can't ever clog in operation.

- CLAMP-ON CAN holds full quart
- PAINT VOLUME CONTROL lets you deliver just the amount of paint-desired to the working surface
- For 115V AC operation
- Fully guaranteed
- ALUMINUM DIE CAST HOUSING for light weight and rugged durability
- CAN'T EVER CLOG IN OPERATION
  Powerful GE motor and rotary action spin the paint at a steady 17,000 RPM . . . actually makes the Sloan-Ashland Paint Gun impossible to clog in operation!
- Reduces misting and overspray to a minimum. Eliminates 90% of usual masking! No more need to cover everything in sight.



$59.95

AMAZINGLY EASY TO CLEAN OR CHANGE COLORS . . . Fill container with water or proper solvent, run gun for a minute or two. That's all there is to it! No mess, no bother!

FREE TWO QUARTS OF SPRED-SATIN PAINT

Covers 300% more width in each stroke than a 6" brush or roller . . .

Now you can do 100 Sq. ft. of surface in minutes—because you cover three times as much area on each stroke, with the Sloan-Ashland Rotary Paint Gun. You cover a full foot-and-a-half swath with perfect control. Big job or small . . . inside or outside . . . whether you're spraying paint or other fluids—nothing does the work as quickly, as easily as this amazing paint gun!

Typical Oval Pattern of Ordinary Spray Gun.

Oval spray and wide feathering around edges make precise work difficult, requires extensive masking.

"Straight Line" Pattern of Sloan-Ashland Paint Gun.

Straight line spray and minimum of feathering gives you perfect control for the most precise painting.

American Products Division, 589 Broadway, New York 12, N.Y.

Send me your new Sloan-Ashland Rotary Paint Gun. I may use it for seven days **free**, and return it **at your expense** if I am not fully satisfied.

Also—send me two free quarts of Spred Satin Paint (worth $4.30) which I may keep and use whether or not I agree to buy the Sloan-Ashland Rotary Paint Gun.

If I do agree to keep it, I will pay only $8.50 a month until I've paid the low price of just $59.95 (plus shipping and handling).

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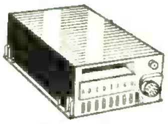


ARC-3 RECEIVER!

Complete with All Tubes Exc. Used **$21.50**

Like NEW $33.50

Crystal-controlled 17-tube superhet. tunes from 100 to 156 MC., AM., on any 8 preselected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.

110 V A.C. Power Supply Kit for above 15.00
Factory Wired and Tested 19.95

ARC-3 TRANSMITTER

Companion unit for above tunes 100 to 156 MC on any 8 pre-selected channels. 9 tubes, crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6. Exc. Used .... Only **$18.95**

Like new condition $28.50

ARC-3 PUSHBUTTON CONTROL BOX $5.95

LORAN APN-4
FINE QUALITY NAVIGATIONAL EQUIPMENT

Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.

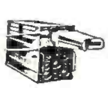
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes, Exc. Used. $69.50

NEW! APN-4A Receiver-Indicator as above, changed to operate same as APN4-B for improved performance .... NEW $88.50
Shock Mount for above $2.95

INVERTER POWER SUPPLY for above APN-4. INPUT: 24 V DC. OUTPUT: 115 V AC, 800 cycles. Like New $22.50

12-Volt Inverter Power Supply for above APN-4. Like New. P.U.R.
We carry a complete line of replacement parts and accessories for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR

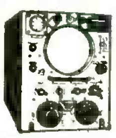


Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. IN LIKE NEW Condition $79.50

Used, with all parts, less tubes, crystal and visor .... Special **$29.50**

INVERTER POWER SUPPLY for above APN-9. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. Like New $22.50

12-V. Power Supply for APN-9, like New P.U.R.
Shock Mount for above $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of replacement parts and accessories for above.



LORAN APN/4 OSCILLOSCOPE

Easily converted for use on radio-TV service bench. LIKE NEW! Supplied with 5" Scope, type 5CPI only........ **$14.95**

APN-12 3-INCH SCOPE

Has vertical and horizontal sweep with focus and intensity controls, coaxial antenna changeover motor. Complete with 11 tubes and 3JP1 CR Tube. For 115 V. 400 cycle AC and 24 V DC. Circuit diagram included. LIKE NEW. **$14.95**

TS-100AP 'SCOPE

EXC. USED (worth $750)
OUR LOW PRICE **$39.50**
Brand New $69.50

Can be used with linear sweep or general purpose test scope. Cables included. Also used with circular sweep as precision range calibrator. Self-contained in metal case 8" x 12½" x 16" deep. For 110 V 50 to 1200 cycles AC. Excellent used, like new, with all tubes including crystals and C.R. Tube.

LM FREQUENCY METER

Crystal calibrated modulated. Heterodyne, 125 Kc to 20,000 Kc With Calibration book
Complete, Like New $69.50

BC-906 FREQ. METER—SPECIAL

Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. **BRAND NEW, OUR LOW PRICE.. $12.88**

BC-221 FREQUENCY METER

SPECIAL BUY! This excellent frequency standard is equipped with original calibration charts, and has ranges from 125 Kc to 20.000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book. Crystal, and all tables. CHECKED OUT!

Unmodulated ... **$79.50**
Modulated ...... P.U.R.
BC-221 1000 Kc Crystal Brand New **$8.95**

IMPORTERS—EXPORTERS of ELECTRONIC EQUIPMENT

We specialize in the export of military surplus electronic equipment:

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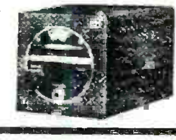

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DM-36	28V 1.4A	220V .080A	1.95	2.95
DM-43	28V 23A	925V .220A		
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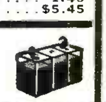

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ELECTRONICS WORLD DECEMBER 1963 ADVERTISERS INDEX

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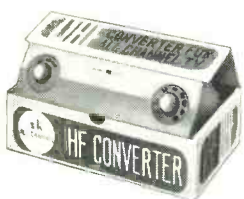

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