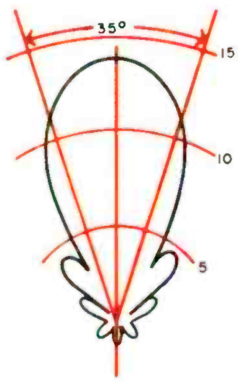
Electronics World

NOVEMBER, 1963
50 CENTS

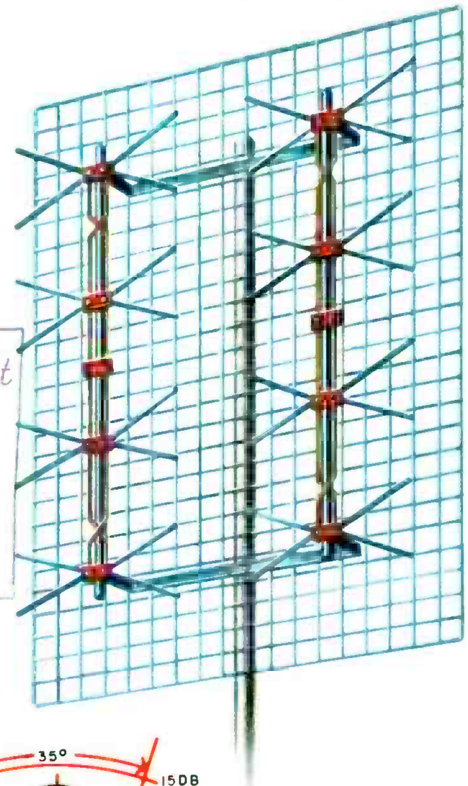
JET TRANSPORT COMMUNICATIONS
WHICH TAPE TO USE?
CHOOSING A TWO-WAY RADIO SYSTEM
THE ROLE OF THE LAB TECHNICIAN

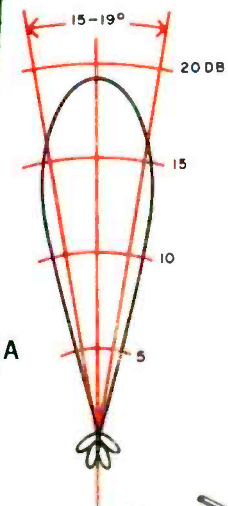
U.H.F. RECEPTION: Practices & Equipment

Effective April 30, 1964, all new TV sets must be equipped to receive the 82 allocated TV channels. Reception problems at u.h.f. are more complex than those at v.h.f. and a good working knowledge of various u.h.f. practices are a must to insure stable high-quality reception.

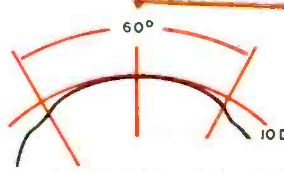


BILLBOARD ARRAY
Beamwidth: 35°
Gain: 6 to 14 db

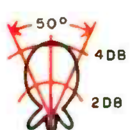




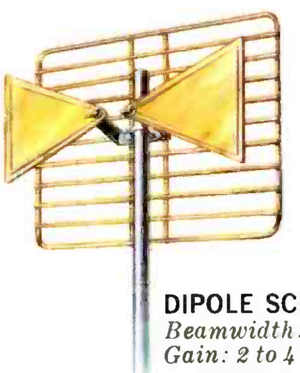
PARABOLIC ANTENNA
Beamwidth: 15° to 19°
Gain: 14 to 19 db

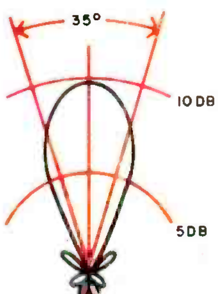


CORNER REFLECTOR
Beamwidth: 60°
Gain: 7 to 10 db



DIPOLE SCREEN
Beamwidth: 50°
Gain: 2 to 4 db





YAGI
Beamwidth: 35°
Gain: 5 to 9 db

A ZIFF-DAVIS PUBLICATION

The Most Sweeping Change in Speaker System Design... Starts with the New E-V FOUR!

Until now, there have been just two ways to determine the absolute quality of a speaker system: the scientific method, and the artistic approach. But each, by itself, has not proved good enough.

The scientist, with the help of impersonal equipment, charts and graphs, has strived to obtain the finest possible measured results. If the figures were right, then it *had* to sound right, and anyone disagreeing was dismissed as "not objective". But often, two speakers measured substantially the same, yet sounded quite different.

On the other hand, the artistic school of loudspeaker design has depended on the judgement of a handful of experts whose "golden ears" were the final yardstick of perfection. If you didn't agree with the experts, your ear was "uneducated" and not discriminating. But too often the measured response of the expert's system fell woefully short of reasonable performance—proof that even trained listeners can delude themselves when listening to loudspeakers.

Now, with the introduction of the E-V FOUR, Electro-Voice has pioneered a blend of the best features of both measurement methods to lift compact speaker performance to a new level of quality. It wasn't easy. The use of both techniques required extensive facilities, something E-V enjoys in abundance.

For instance, E-V has one of the industry's largest, most completely-equipped laboratories for the study of acoustical performance. Actually, the E-V engineering staff alone is larger than the entire personnel complement of many other speaker firms. In the E-V lab, measurement of speaker performance can be made with uncommon precision. And the interpretation of this data is in the hands of skilled engineers whose full time is devoted to electro-acoustics.

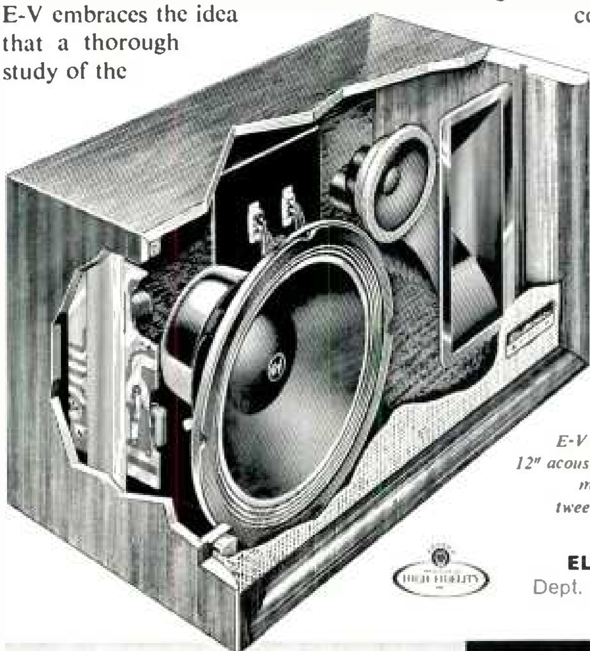
But beyond the development of advanced scientific concepts, E-V embraces the idea that a thorough study of the subjective response to reproduced sound is essential. E-V speakers must fully meet both engineering and artistic criteria for sound quality. Where we differ from earlier efforts is in greatly increasing the sample of expert listeners who judge the engineering efforts.

To this end, experts in music and sound from coast to coast were invited to judge and criticize the E-V FOUR exhaustively before its design was frozen. Adjustments in response were made on the spot—in the field—to determine the exact characteristics that define superb performance. It was not enough to say that a unit needed "more bass". What kind of bass? How much? At what frequencies? These are some of the more obvious questions that were completely settled by immediate adjustment and direct comparison.

The new E-V FOUR is the final result of this intensive inquiry into the character of reproduced sound. According to widespread critical comment, the E-V FOUR sound is of unusually high calibre. And careful laboratory testing reveals that there are no illusions—the measurements confirm the critics' high opinion of this new system.

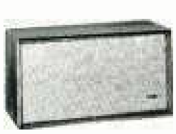
Of course, it is one thing to design an outstanding prototype—and something else to produce an acoustic suspension system in quantity at a fair price. It is here that extensive production facilities, combined with creative engineering approaches, guarantee the performance of each E-V FOUR. And these same facilities ensure reasonable value. For instance, the E-V FOUR sells for but $136.00 with oiled walnut or mahogany finish and just $122.00 in unfinished birch. Yet, in judging its sound qualities, it was successfully compared with speaker systems costing as much as $200.00.

We urge you to join in the analysis of E-V FOUR compact speaker performance. Visit your E-V high fidelity showroom and compare, carefully, this new system. We feel certain that you will agree with the engineers and the critics that the new E-V FOUR offers a truly full measure of high fidelity satisfaction.

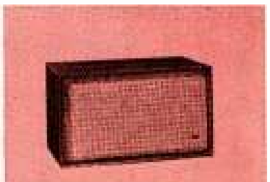


E-V FOUR components include: 12" acoustic suspension woofer / Ring-diaphragm mid-range driver / 5" dynamic cone tweeter / Etched circuit crossover

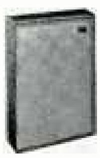
ELECTRO-VOICE, INC.
Dept. 1134N, Buchanan, Michigan



E-V TWO



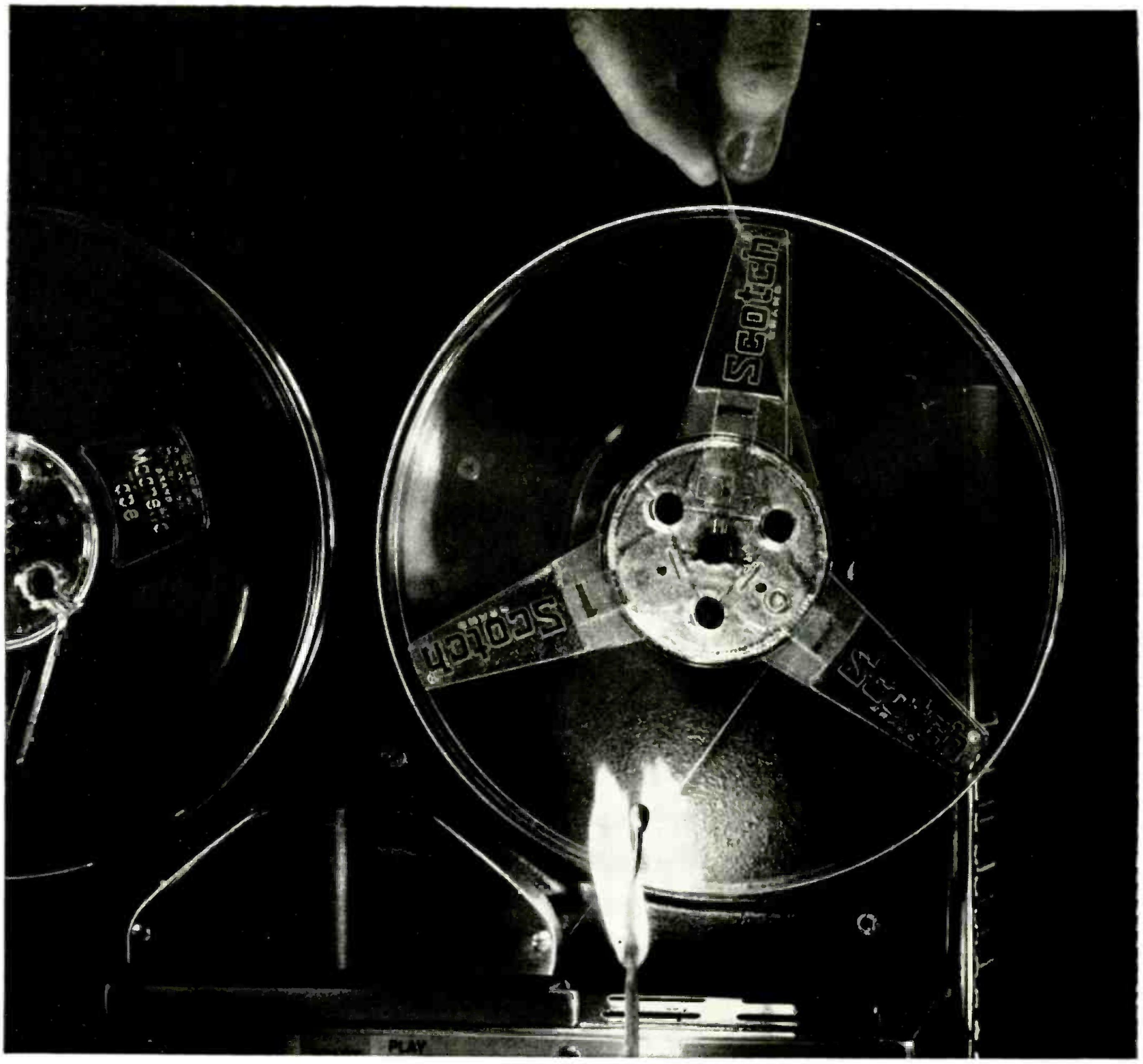
E-V FOUR



REGINA

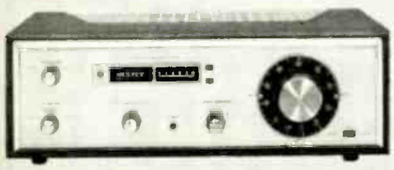
E-V SIX

Electro-Voice
SETTING NEW STANDARDS IN SOUND


Scotch
Scotch
Scotch
PLAY

3 GREAT NEW SCOTT TUNERS

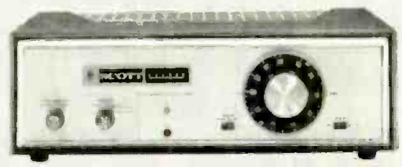
SUPER SENSITIVE



New 310E FM Stereo Tuner

Here's the multiplex version of the famous tuner used in the "Telstar" experiment. Its extreme sensitivity of 1.9μv, high selectivity, and low distortion make it the logical choice for the most critical installations. Equipped with completely automatic facilities for switching from monaural to stereo, the 310E is effortless to use. A unique "stereo only" mode of operation helps you find stereo broadcasts faster than ever before. This is the very finest tuner possible at the present state of the art. $279.95

TOP PERFORMER



New 350C FM Stereo Tuner

The first, and most popular, multiplex tuner ever made now has a new look, and vastly improved performance to match! Time-Switching multiplex circuitry pioneered by Scott assures low distortion and maximum separation. New improved sensitivity of 2.2μv guarantees perfect stereo or mono reception in the most difficult signal areas. The 350C offers a variety of exclusive Scott features like the precision illuminated tuning meter, separate level controls, convenient front panel tape outlet, and Scott's Sonic Monitor. Truly a delight to use. $224.95

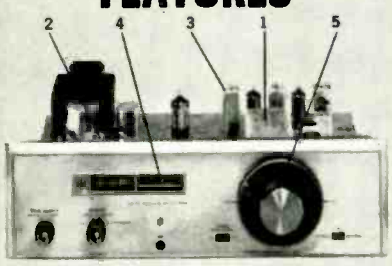
TOP VALUE

LT-110 FM Multiplex Tuner Kit

This is the kit the experts have unanimously acclaimed as one of the finest, easiest to build on the market. The fabulous LT-110 tuner gives unsurpassed reception of both FM Stereo and monophonic FM broadcasts. Critical front end and multiplex sections are pre-wired and factory tested. Wires are already cut to exact length and mechanical parts are in place on chassis. Scott's exclusive full-color instruction book positively identifies each part in full color so you can't make a mistake. Even a novice can expect top performance. $164.95

How to select the right one for your system

FEATURES



Wide Range of Features and Controls

1. Heavily silver-plated "front-end" for maximum usable sensitivity, lowest hum, distortion, and noise.
2. Time-Switching multiplex circuitry for full frequency response with extremely low distortion.
3. Famous 2 mc Wide-Band detector for drift-free operation.
4. Sensitive indicator for accurate tuning and best antenna orientation.
5. Easy-to-use vernier tuning dial with logging scale.

SPECIFICATIONS

	310E	350C	LT-110
Usable Sensitivity (μv)	1.9	2.2	2.2
Signal: Noise Ratio (db)	65	60	60
Harmonic Distortion (%)	0.5	0.8	0.8
Drift	0.02	0.02	0.02
Frequency Response (cps ±1db)	30-15,000	30-15,000	30-15,000
Capture Ratio (db)	2.2	6.0	6.0
Selectivity (db)	50	35	35
Spurious Response Rejection (db)	85	80	80
AM Suppression (db)	60	55	55
Separation (db)	30+	30	30+

WANT MORE INFORMATION

Mail this coupon for complete information on all the great new Scott components and kits.

H. H. Scott, Inc.
111 Powdermill Road
Maynard, Mass.
Dept. 160-11

Send me complete information on the new 1964 Scott line of stereo components and kits.

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Include names of interested friends and we'll send them duplicate materials.

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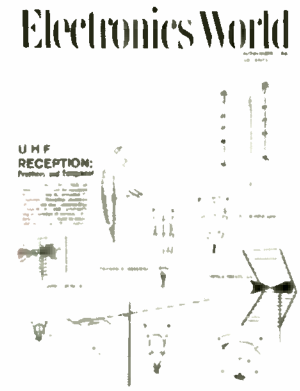
Electronics World

NOVEMBER 1963
VOL. 70 NO. 5

CONTENTS

MONTHLY FEATURES



OUR COVER shows some typical u.h.f. receiving antennas with their associated reception patterns and approximate gain figures. The many varieties of patterns point up the fact that an antenna should be chosen for a particular installation depending on signal strength, multi-path problems, and how far apart stations are with respect to antenna axis. Besides u.h.f. antennas, the article starting on page 37 also discusses u.h.f. converters, choosing the correct transmission line, and other information required in order to obtain best possible u.h.f. reception (Cover illustration by Otto E. Markevics.)

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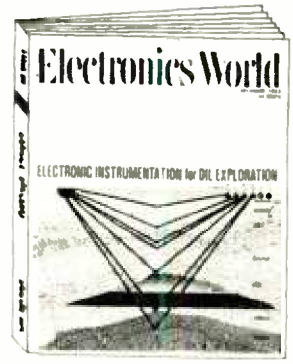

ELECTRONIC INSTRUMENTATION FOR OIL EXPLORATION
Geophysical prospecting techniques using electronics have led to many successful discoveries. Acoustic sounding is now done with the aid of transistorized equipment, oscillographs, and the latest in computers.

MINIATURE VOLTAGE REGULATORS
A simple add-on "series-tube" regulator circuit that occupies less space than a VR tube and its dropping resistor is covered in this article.

EW ANNUAL INDEX
A listing of all the feature articles which have appeared in ELECTRONICS WORLD *during 1963—in handy, quick-reference form.*

CAPACITOR FORMER FOR ELECTRONIC FLASH UNITS
You can build this instrument to prevent storage capacitor deterioration, determine their leakage, and act as a power source in lieu of batteries.

SIMPLE TESTS FOR SEMICONDUCTORS
Carl David Todd of Hughes outlines methods for measuring leakage, gain, saturation, and breakdown voltage with equipment normally on hand in the lab.

CB RADIO-WAVE PROPAGATION
What is responsible for the sometimes freak CB reception? R. L. Conhaim goes into the matter of "skip," ground- and sky-wave signals, and what can be expected in normal transmissions.

INDOOR HORN FOR TV-FM
A scaled-up version of a broadband microwave horn makes an excellent TV and FM antenna which can be mounted in confined areas such as attic crawl spaces. B. V. K. French gives details for building this handy apartment-size unit.

SCA BACKGROUND-MUSIC MULTIPLEX
For those interested in experimenting with the reception of "Storecasts," here are details on a 67-kc. adapter that can be used with any FM tuner.

QUANTUM DEVICES
When certain molecules are excited by electromagnetic radiations, they change energy levels. When they drop back to their previous levels, they give up energy. John R. Collins explains how the quantum theory is applied to masers, lasers, and atomic clocks.

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

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SUBSCRIPTION SERVICE: All subscription correspondence should be addressed to Electronics World. Circulation Dept., 434 South Wabash Ave., Chicago, Ill. 60605. Please allow at least six weeks for change of address. Include your old address as well as new—enclosing if possible an address label from a recent issue.

EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care; however publisher assumes no responsibility for return or safety of art work, photographs, or manuscripts.

ELECTRONICS WORLD is published monthly by Ziff-Davis Publishing Company at 434 South Wabash Avenue, Chicago, Ill. 60605. (Ziff-Davis also publishes Popular Photography, Popular Electronics, HiFi/Stereo Review, Popular Boating, Car and Driver, Flying, Modern Bride, Amazing, and Fantastic.) Subscription rates: one year United States and possessions $5.00; Canada and Pan American Union countries $5.50; all other foreign countries $6.00. Second class postage paid at Chicago, Illinois and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash. November 1963. Vol. 70. No. 5.

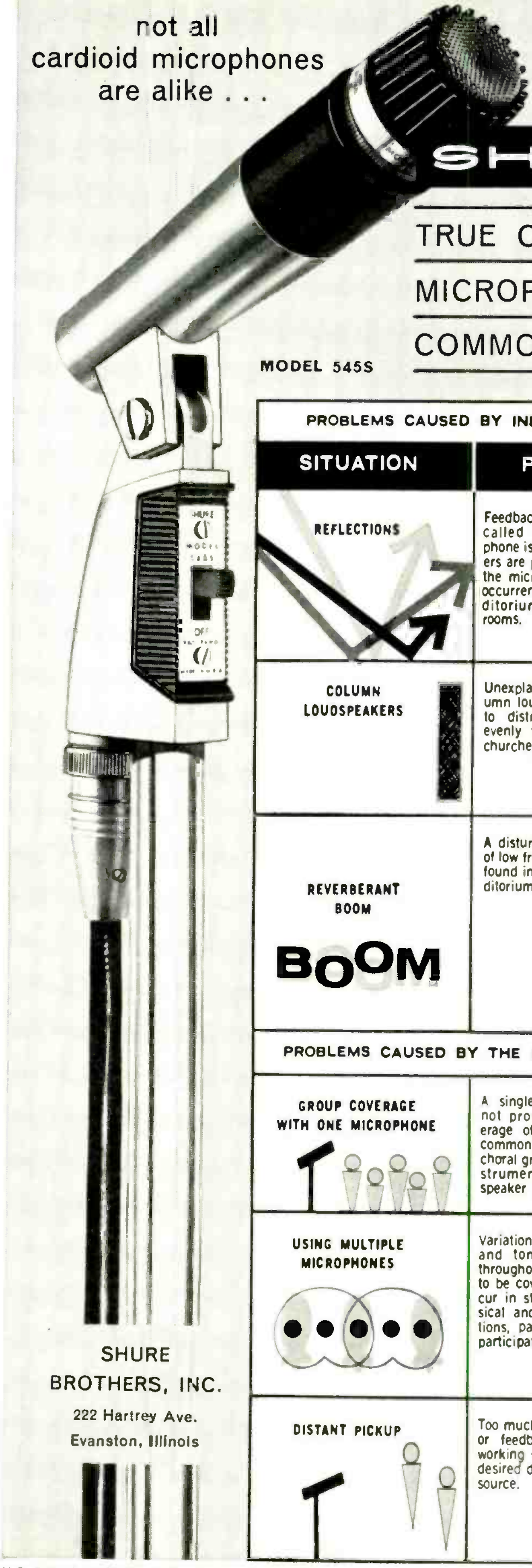
PAYMENT MAY ALSO BE REMITTED in the following foreign currencies for a one year subscription: Australian pounds (2/15/12); Belgian francs (310); Danish kroner (43); English pounds (2/1/6); French francs (31); Dutch guilders (22); Indian rupees (31); Italian lire (3900); Japanese yen (2100); Norwegian kroner (45); Philippine pesos (25); South African rands (4.50); Swedish kronor (33); Swiss francs (27); West German marks (25).

not all cardioid microphones are alike . . .

only the

SHURE UNIDYNE III

TRUE CARDIOID UNIDIRECTIONAL DYNAMIC MICROPHONE SOLVES ALL THESE COMMON MICROPHONE PROBLEMS!



MODEL 545S

PROBLEMS CAUSED BY INEFFICIENT REJECTION OF UNWANTED SOUNDS BY THE MICROPHONE

SITUATION	PROBLEM	CAUSES	SOLUTION
REFLECTIONS	Feedback occurs where a so-called "cardioid" microphone is used and the speakers are placed to the rear of the microphone. A common occurrence in churches, auditoriums, and meeting rooms.	Sound bounces off hard surfaces on the walls, floor and ceiling, in and around the audience area and the microphone used is not effective in rejecting these sounds at all frequencies, and in all planes about its axis.	The Unidyne III eliminates this problem because of effective rejection of sound at the rear of the microphone with uniformity at all frequencies. Sounds bouncing off the floor or other reflective surfaces that reach the rear of the Unidyne III are rejected.
COLUMN LOUDSPEAKERS	Unexplained feedback. Column loudspeakers are used to distribute sound more evenly to the audience in churches and auditoriums.	While column speakers direct the sound toward the audience, they also have side and rear sound lobes which may reach the microphone. Feedback occurs when the rear and side sound lobes of the speakers coincide with the rear and side lobes of a so-called "cardioid" microphone.	The Unidyne III solves this problem because it has no rear or side lobes. Thus it rejects the side and rear lobes of the sound column speakers.
REVERBERANT BOOM BOOM	A disturbing, echoing effect of low frequency sound often found in churches, large auditoriums, and arenas.	The particular "cardioid" microphone used fails to retain its unidirectional characteristics with low frequencies. In addition, its front response tends to accent low frequencies of the desired sounds. These factors result in pickup and reinforcement of the low frequency reverberation and boominess characteristic of many halls.	Using the Unidyne III Microphone will solve the problem because it maintains a uniform pattern of sound rejection in all frequencies, even as low as 70 cps. The frequency response also has a controlled roll-off of the low end. This prevents reinforcement of the low frequency reverberation and diminishes the effect of a boomy hall.

PROBLEMS CAUSED BY THE MICROPHONE'S INEFFECTIVENESS IN PICKING UP THE DESIRED SOUND

SITUATION	PROBLEM	CAUSES	SOLUTION
GROUP COVERAGE WITH ONE MICROPHONE	A single microphone does not provide uniform coverage of a group. This is commonly experienced with choral groups, quartettes, instrumental combos, and speaker panels.	The particular "cardioid" microphone used lacks a uniform pickup pattern, so that persons in different positions within the general pickup area of the microphone are heard with varying tonal quality and volume.	The Unidyne III affords uniform pickup of the group with a resulting consistency in volume and sound quality among the members of the group.
USING MULTIPLE MICROPHONES	Variation in the pickup level and tonal quality exists throughout the broad area to be covered. This may occur in stage pickup of musical and dramatic productions, panels and audience participation events.	The pickup pattern of the microphones used is too narrow, causing "holes" and "hot spots". The off-axis frequency response of the microphones also varies.	The Unidyne III permits a smoothness in pickup as the true cardioid pattern gives broad coverage with uniformity throughout the coverage area. This eliminates "holes", "hot spots", and the variations in sound quality and permits blending many microphones with ease.
DISTANT PICKUP	Too much background noise or feedback results when working with microphone at desired distance from sound source.	So-called "cardioid" and particularly long range microphones being used are less directional with lower frequencies. In addition, they have lobes or hot spots that pick up sound at the rear, resulting in the background noise or feedback problem.	Use the Unidyne III to gain relatively long range with effective rejection of sound at all frequencies at the rear of the microphone.

SHURE BROTHERS, INC.
222 Hartrey Ave.
Evanston, Illinois

U.S. Patent D 190,864; other Patents Pending

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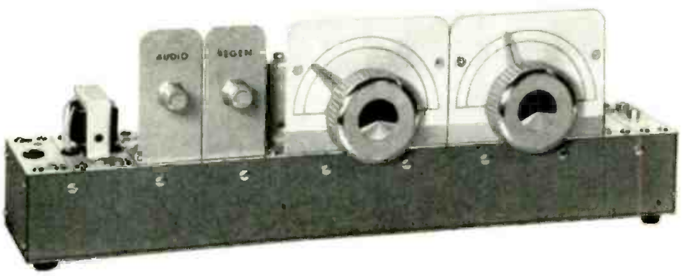
EXPERIMENTER, SWL or RADIO AMATEUR

Select your receiver, transmitter, or VFO from easy-to-build International A O C kits.

Simple step-by-step instructions show you how to assemble factory prewired units. Designed for top performance at a low cost!



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.

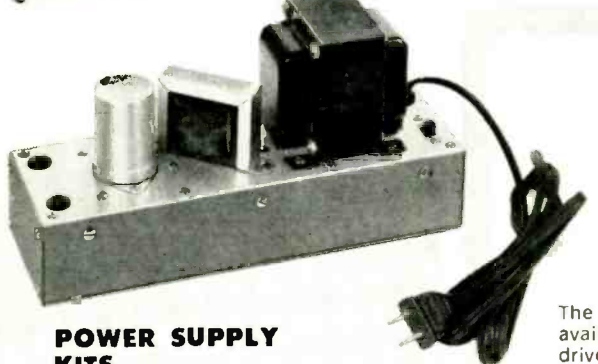
Kit	Frequency	Price
AOR-40	Special	$69.00
AOR-41	150 kc — 450 kc	62.50
AOR-42	2 mc — 6 mc	62.50
AOR-43	6 mc — 18 mc	62.50
AOR-44	80 meter/40 meter	62.50
AOR-45	15 meter/10 meter	62.50
AOR-46	6 meter	66.50
AOR-47	2 meter	66.50
AOR-48	Citizens 27 mc	62.50

*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.

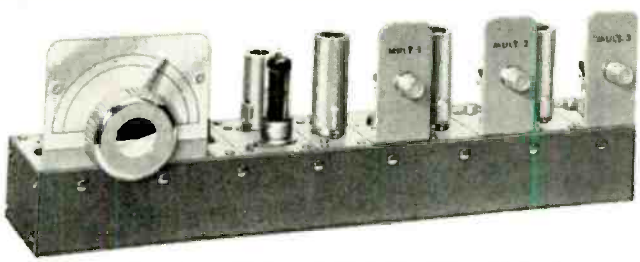
AOT-50 transmitter kit less power supply and key, but with one 40 meter novice band crystal. Shipping weight: 5 lbs. **$35.00**



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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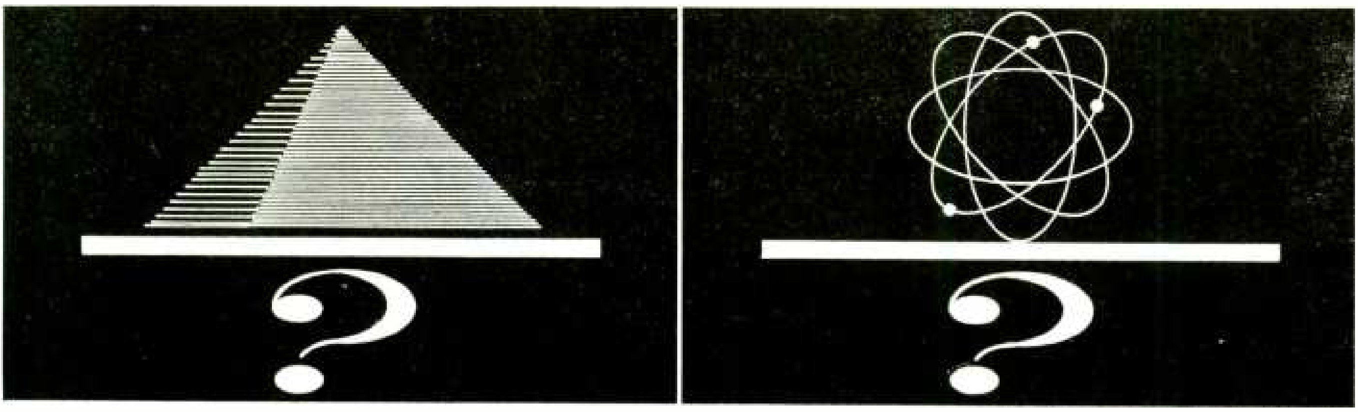

WHAT IS THE COMMON DENOMINATOR OF AN ANCIENT EGYPTIAN PYRAMID AND A SUCCESSFUL MODERN ELECTRONICS CAREER?

A STRONG FOUNDATION!

The Egyptian pyramid was built on a strong foundation. *What about your electronics career?*

Advancement in electronics depends on a solid understanding of basic principles. If you are handicapped by a poor understanding of these vital "basics," you need training—*the strong foundation training* offered by Grantham School of Electronics.

Beginning at the beginning, Grantham training progresses in a logical, step-by-step manner up through the complex theory of the Missile Age—and all of the math you will need is taught as an integral part of our lessons. Because we represent these all-important basic principles with maximum penetration, *you will learn to think and reason electronics* rather than relying on half-understood concepts and rote-memory.

The Grantham program is made up of three consecutive steps, and each completed step increases your value as an electronics man. The following is a "thumb-nail sketch" of the Grantham 3-*step program for electronics advancement:*

- Section IA leads to attainment of your First Class FCC License and may be completed in the classroom or through home study.
- Section IB gives you practical experience on a great variety of "live" electronics equipment in four weeks of intensive, supervised training in the Grantham Student Laboratory.
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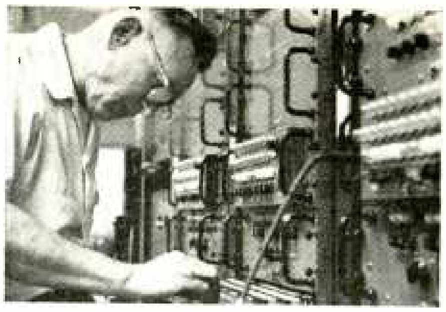

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For the record

WM. A. STOCKLIN, EDITOR

NEW YORK HI-FI SHOW

WITH the New York Hi-Fi Show over, it appears that once again we have had an exciting, well-attended show. This is the eighth consecutive year that the Institute of High Fidelity, Inc. has planned and operated these shows and this year's show surpassed all previous ones. Although the purpose is always the same—to serve as a showcase for component hi-fi equipment—each year's displays, room settings, and components become more sophisticated.

Even those attending the Show seemed to have changed. In the early days, when the term "hi-fi" carried the connotation of some strange, mysterious audio system, those who attended were, for the most part, technically oriented. They were more interested in circuit design and unusual sound recordings than in styling. But now technically oriented enthusiasts, as well as many others who are not circuit-minded, seem more interested in the realism of sound reproduction. This is as it should be, and this year's Show concurred.

One of the main attractions was a "live-*vs*-recording" demonstration in which a four-piece instrumental group played specially composed music both in person and *via* tape. The public was asked to determine when one sound source took over from the other. This was the first time that such a large audience had a chance to participate in this kind of demonstration.

A greater number of manufacturers was represented this year than at past Shows. This can be attributed to greater competition and diversification on the part of many companies.

As usual, the public attended the Show to see the new products, talk to engineers about their audio problems, and, in general, learn about recent improvements in sound reproduction. They were not disappointed. Although there have been no major breakthroughs—comparable to the stereo disc or FM-stereo of previous years—there were changes, most of them subtle. The manufacturers have made tremendous strides in providing more attractive panel designs and cabinets while retaining high-quality sound reproduction.

Tape Recorders: In this category there were many more new products to choose from than heretofore and the quality of reproduction at 3¾ ips was far superior to that offered by last year's equipment. Even at 1⅞ ips, in the more expensive recorders, performance came close to that of early 7½-ips units. *Revere-Wollensak* (3*M*) showed its new tape cartridge recorder which was widely publicized several years ago. Although it will never replace the disc record changer, it represents a new design philosophy and a new convenience in tape equipment.

Turntables: There were several new and different designs, most with higher price tags. The older designs were offered in revised versions with emphasis on improved appearance and better reproduction quality.

Cartridges: Not much change was expected in this component since quality of reproduction on almost all units has been quite high.

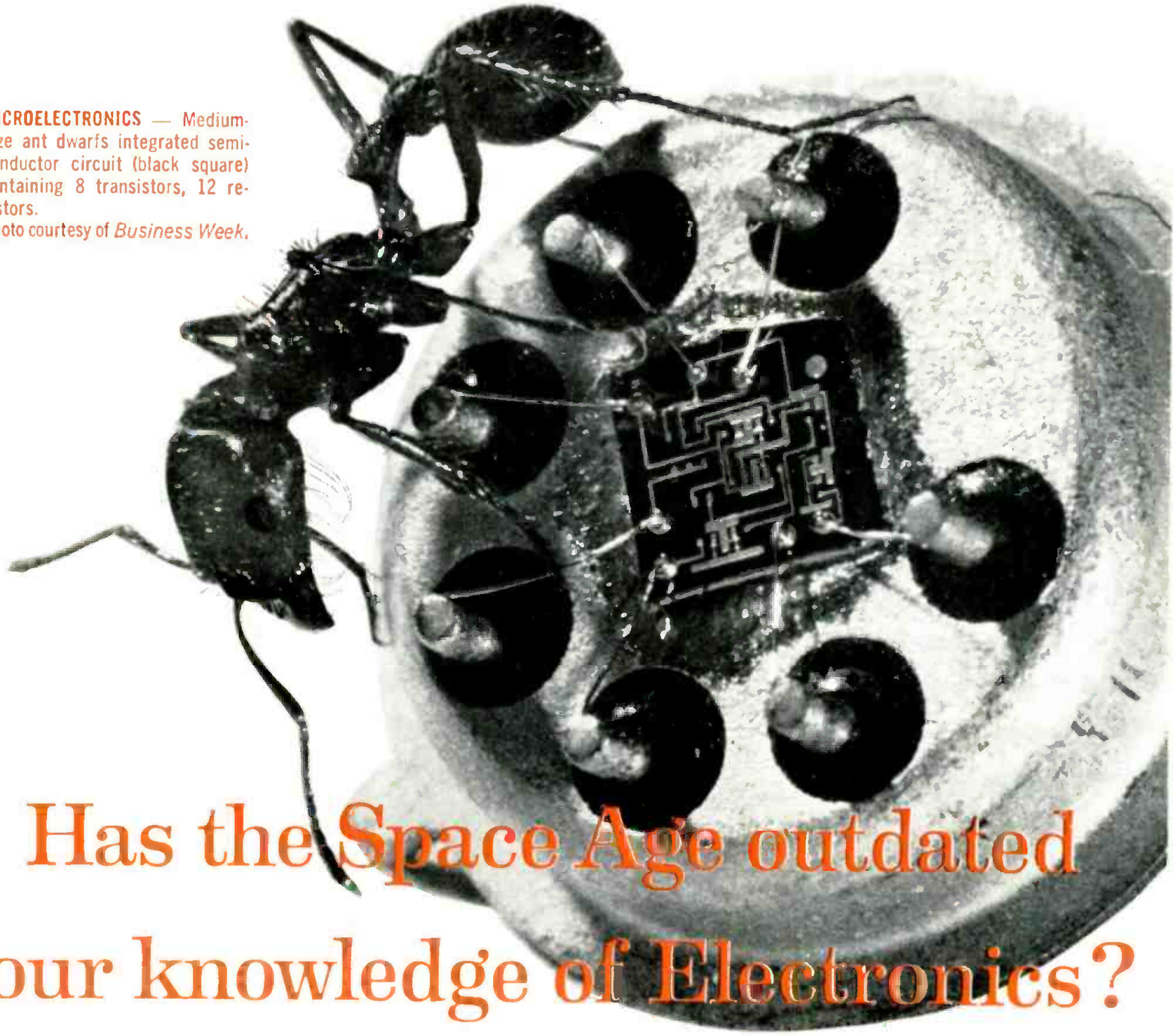
Speakers: There were many new designs displayed – but, again, no major breakthroughs. Improvements in sound reproduction were evident in a good many units. Speakers are peculiar in a way since it is difficult to outline any single design element that makes for better sound. Yet, comparing today's speakers with those of ten years ago, or even five years ago, the improvement is obvious.

Tuners: Most manufacturers displayed new designs or up-dated versions of last year's models. The emphasis was on stereo and on transistorization, with considerable improvement in performance over last year's models.

Amplifiers: There were many new transistorized designs, and it was in this area that the technically minded hi-fi enthusiast found greatest interest. The subject of tubes *vs* transistors is the most controversial one in the hi-fi field today. There have been no major design innovations since last year's Show, but almost all manufacturers have been concentrating their engineering efforts on transistorized designs. Although engineers still disagree on many points, such as the importance of square-wave response, damping factor, amount of IM and harmonic distortion, necessary frequency response, use of output transformers, and phase distortion, they all seem to agree that the semiconductor designs have tremendous possibilities in the near future. There were many such designs in evidence at the Show, and a few of them were exceptionally good – to the point where one might say they compared favorably with the best tube designs available.

All in all, it was a tremendous Show and, like many others who had the opportunity to attend, we look forward to what the coming year will bring in the way of new and better hi-fi equipment. ▲

MICROELECTRONICS — Medium-size ant dwarfs integrated semiconductor circuit (black square) containing 8 transistors, 12 resistors.
Photo courtesy of *Business Week.*



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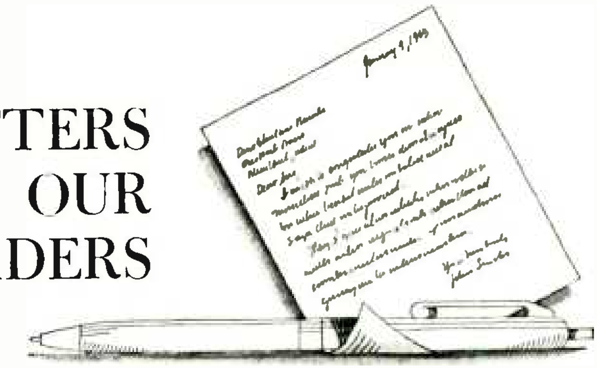

ENGINEERING SALARIES

To the Editors:

Your July editorial, "Let's Woo the Woman Engineer," is certainly aimed in the right direction. However, in attempting to lure students into engineering, it appears that you have painted a financially disappointing picture that does not accurately reflect the salary levels that a graduate engineer can expect to receive. The following salaries are the averages of the beginning salaries received by the electrical engineering class graduating from the University of Nebraska in the month indicated: Feb. '59, $519; June '59, $541; Feb. '60, $538; June '60, $545; Feb. '61, $566; June '61, $571; Feb. '62, $558; June '62, $584; Feb. '63, $603.

The June 1963 class also received an average of slightly over $600 per month. These figures apply to graduates with a Bachelor of Science in Electrical Engineering degree. Graduates at the Master's level averaged slightly over $100 more per month. These beginning averages are considerably more than the $5200 figure quoted in your editorial.

According to an article in the March, 1963 issue of the IEEE "Student Journal," the median starting salary for all engineering graduates (not just electrical) entering industry who received their baccalaureate degrees in 1960 was $6350. Those starting with a Master's degree earned a median beginning salary of $7525, and those starting with a doctorate, $9750. The median salary of all engineers in 1960 was reported to be $9600 by the Engineers Joint Council. It would seem that the $7500 figure which you quote is too low, especially since electronics engineers generally rank high among the various engineering branches in salary.

Neil Wellenstein, President
Beta Psi Ch., Eta Kappa Nu Assn.
University of Nebraska
Lincoln, Nebraska

° ° °

TRADE WITH JAPAN

To the Editors:

I was pleased to read your very balanced views on the "threat" of Japanese imports upon the U.S. electronics industry, in the July issue of Electronics World (p. 68). Clearly, as you point out, there is some hardship resulting, and more on the horizon, from Japanese imports. On the other hand, as your article further points out, the U.S. exports heavily to Japan, including a great deal of electronics gear.

Further, it is clear that Japan, like Britain, must "export or die." This, of course, is because of the heavy dependence of the highly industrialized and specialized Japanese economy upon a wide range of imports which must be paid for.

One further argument needs to be stated, it seems to me: The Japanese are, so far, very much of the Western, non-Communist bloc. But, in the face of reduction in trade with the West—which means primarily with the U.S., Japan would have no choice other than to begin explorations of the great potential market which lies just to her west: China.

It's tough to live in the world these days. But it is becoming clear that few, if any, major decisions relating to our economy can be made purely in the light of their domestic impact. American management is increasingly becoming aware of the hard facts of international life, and articles such as yours are helping in this vital educational process.

Michael J. Berla, Film Supervisor
Univ. of Mich. Television Center
Ann Arbor, Mich.

° ° °

CUSTOM CERAMIC CAPACITORS

To the Editors:

On page 68 of the August issue is an item entitled "Custom Ceramic Capacitors" by Irwin Math. One correction and two comments should be added to this item.

1. Sandpaper should be used to clean the edge of the modified capacitor. Use of emery, which is a conductive material, will more probably result in a poor resistor than a good capacitor.

2. The similar process of grinding a notch in a carbon composition resistor will result in an *increase* in resistance. Furthermore, the *wattage* of the resistor will decrease, due to a concentration of the heating effect at the notch.

3. A reduction in working voltage for the modified capacitor should be recommended, because of the possibility of having created new leakage paths across the dielectric in the grinding process.

I appreciate your printing these old techniques to refresh my memory, as well as to educate the new generation of technicians. A great many of the old "make-do" tricks, although still applicable, have fallen into disuse because of the greater availability of "ready-made" components. Rare is the tech or ham these days who makes a capacitor of a few picofarards with a "gimmick" (two insulated wires twisted together).

Lt. Cdr. Robert Irving, USN
Fairfax, Virginia

° ° °

COLUMN LOUDSPEAKERS

To the Editors:

The first paragraph of Mr. George L. Augspurger's article on column loudspeakers in your June issue disturbs me.

I have designed, manufactured, and installed more than five hundred column loudspeaker systems in churches since 1938; many of these original installations are still being used today. As a matter of fact, the loudspeaker system installed in St. Peter's Basilica in Rome was designed and built by my company in 1947; only two columns were needed to properly cover the entire auditorium.

In addition, we have made many other types of commercial installations which employed this column principle.

Harry W. Becker
Harry W. Becker & Associates
Chicago, Illinois

The article's first paragraph simply indicated that this type of speaker system was almost unknown in this country until fairly recently. Evidently, Reader Becker's company has known and used column loudspeaker systems for many years, but the fact remains that only recently have many manufacturers started producing such systems.—Editors.

° ° °

MODERN BATTERIES

To the Editors:

In your article "Modern Batteries" (October issue), Author Collins calls the negative zinc electrode in a Leclanche cell the "anode." According to my dictionary, the negative electrode is a *cathode* and the positive electrode is an *anode*.

James S. Beaver
New London, Conn.

A later edition of Reader Beaver's dictionary would probably define an "anode" as the positive electrode of an electrolytic cell or the negative *electrode of a dry cell or battery that is delivering current to a load. Another dictionary definition of an anode is the electrode toward which electrons move in a cell or electron tube. This makes the plate of a diode (with its positive potential) and the zinc can of a dry cell (with its negative potential) both* anodes. *This convention is followed by most battery manufacturers and was followed correctly in our article.—Editors.*

° ° °

BURNED-OUT PILOT LAMPS

To the Editors:

While I have no quarrel with the academic accuracy of the article by R. L. Ives "Burned-Out Pilot-Lamp Indicators" on page 40 of your June issue, it does seem an overly involved way to solve an admittedly real problem.

Chicago Miniature Lamp Works (and perhaps others) make pilot lamps that are standard except that they have an auxiliary filament in parallel with the main one. The second filament is designed to burn considerably less bright than the main one and hence to last much longer. Therefore, a greatly reduced brilliance tells one to replace the lamp.

George P. Anderson
Metals Research Laboratory
Brown University
Providence, Rhode Island ▲

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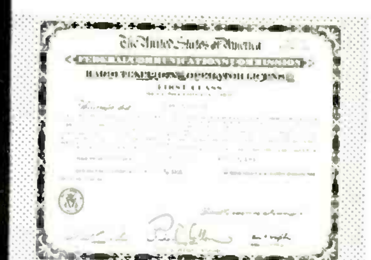

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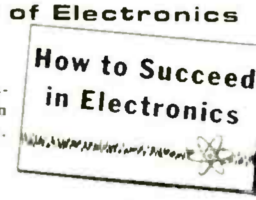

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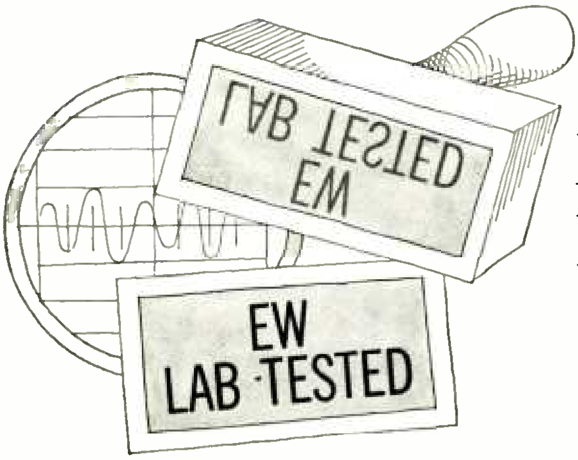


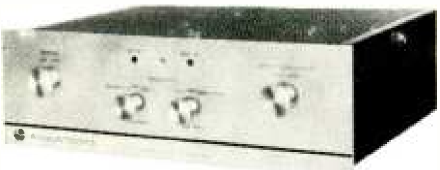
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

"Acoustech I" Power Amplifier
Audio Dynamics ADC-14 Speaker System

"Acoustech I" Power Amplifier

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



THE new "Acoustech I" transistorized stereo power amplifier is a no-compromise design which, in many respects, surpasses any vacuum-tube amplifier on the market. It is the initial offering of *Acoustic Technology Laboratories, Inc.* of Cambridge, Mass.

It is evident from the specifications of the unit that its designers adhere to the wide-band philosophy. Its frequency response is specified as being within ±0.25 db from 5 to 50,000 cps, and within ±3 db from 2.5 to 250,000 cps. Transient response has received special attention and the amplifier will reproduce square waves from 20 to 20,000 cps without overshoot or ringing and with a rise time of 1.75 μsec. The power output is rated at 40 watts per channel into 8- or 16-ohm loads, over the entire 20- to 20,000-cps range, at 0.95% harmonic or IM distortion, with both channels operating.

These are impressive specifications. To achieve them, a total of 16 transistors and 12 diodes is used. Most of the transistors, including the vitally important output stages, are silicon types. Although rather expensive, they are relatively immune to temperature effects. The output stages are mounted on large finned heat sinks. The low-level circuits are constructed on glass-epoxy boards.

Extensive precautions have been taken to prevent accidental damage to the transistors. This is especially important in an amplifier such as this, which must be serviced only at the factory, and whose output transistors are quite expensive. The left and right channel "B+" lines are individually protected with fast-acting fuses, and warning lights on the panel indicate when one of these fuses is blown. Each speaker line is also protected with a fast-acting fuse which serves to safeguard speakers against the unusually high peak power capabilities of the amplifier and the amplifier against accidental shorts in the speaker lines.

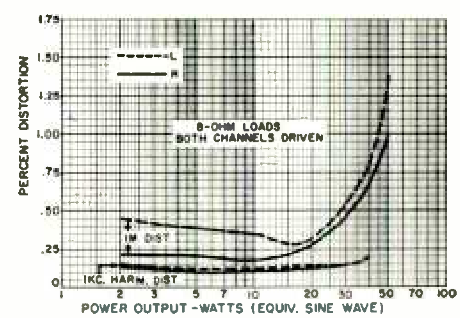
The input and output connections use standard phone (*not* phono) plugs and jacks which prevent output shorts or excessive input transients when inserting or removing any cables. The amplifier is supplied with two fifteen-foot speaker cables fitted with phone plugs and color-coded spade lugs, and two six-foot input cables with phone plugs and conventional phono plugs.

The normal input sensitivity is 2.5 volts for full output. Most good preamplifiers will drive it easily. For the occasional application requiring more gain, a front-panel switch increases the sensitivity to 1.5 volts. This is done by reducing the over-all negative feedback which correspondingly increases distortion and reduces damping factor and is not recommended for normal operation.

If the full bandwidth of the amplifier is not desired, there are front-panel-operated cut-off filters which gradually reduce the response below 10 or 20 cps at the low end and above 25 or 50 kc. at the high end.

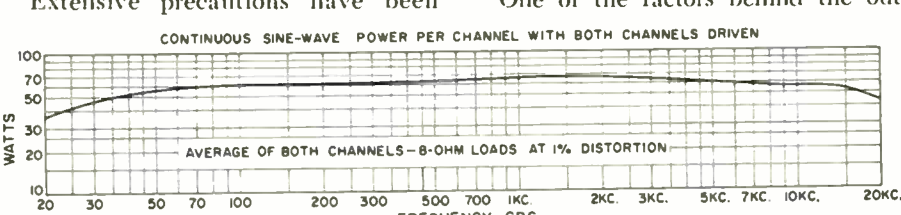
One of the factors behind the outstanding specifications of the unit is the absence of any audio transformers. Unlike most transistorized power amplifiers which use driver transformers ahead of the output stages, the "Acoustech I" is direct-coupled throughout. Two large, computer-grade 1000-μf. electrolytic capacitors couple to the speakers and three more are used in the power supply, which has exceptionally good regulation. The only iron-core device in the amplifier is an impressively large and heavy power transformer.

Having tested a prototype of this amplifier last fall, we were especially interested in evaluating a production model. As with the prototype, the new unit proved to be very conservatively rated. Driving 8-ohm loads, with both channels operating, the output at 1%



total harmonic distortion was about 65 watts per channel at 1000 cps, 43 watts at 20,000 cps, and 38 watts at 20 cps. Our test sample evidently had a minor fault in one channel which had about 1.5 db more gain than the other, and slightly higher IM distortion. The "poorer" channel had .33% IM at 20 watts and 1.38% IM at 50 watts output, which is very respectable performance by any standards. This performance is within the manufacturer's specs. The other channel, which is undoubtedly more typical of normal amplifier performance, had .28% IM at 20 watts and 1% IM at 50 watts.

The frequency response was found to be essentially flat over the audio range which was as far as we tested it. Square-wave response was better than we have seen on any other power amplifier,



with a 20-kc. square wave reproduced better than most top-quality amplifiers will do at 10 kc. There was no ringing or overshoot, except that with capacitive loads greater than 0.1 μf. shunting an 8-ohm resistor, there was a single cycle of overshoot. Hum and noise were 79 db below 10 watts, or 85 db below rated output.

One of the striking properties of this amplifier is its cool operation. In normal service, it does not get even faintly warm, which is quite a contrast to vacuum-tube amplifiers of comparable power output. In listening tests, it had an impressive clarity and solidity which place it in the top rank of amplifiers. We were unable to drive it to overload with any speakers at our disposal (our ears and/or speakers gave up first). At the highest levels as well as the lowest it produced an effortless and transparent sound which was limited only by the associated speakers and program material.

The "Acoustech I" power amplifier sells for $395.00 with metal cage. ▲

Audio Dynamics ADC-14 Speaker System

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

THE ADC-14 is the junior member of the family of *Audio Dynamics Corporation* speaker systems. Instead of the usual paper cone, the woofer has a rigid rectangular styrene foam diaphragm. The flat radiating surface, which measures approximately 9" x 12" is covered with aluminum foil. A compliant cloth surround supports the foam radiator, attaching directly to the baffle board rather than to a basket structure. The plastic radiator is driven by a voice coil mounted in a nine-pound ceramic-magnet structure. The area of the rectangular radiator is considerably greater than that of a conventional 12" speaker cone.

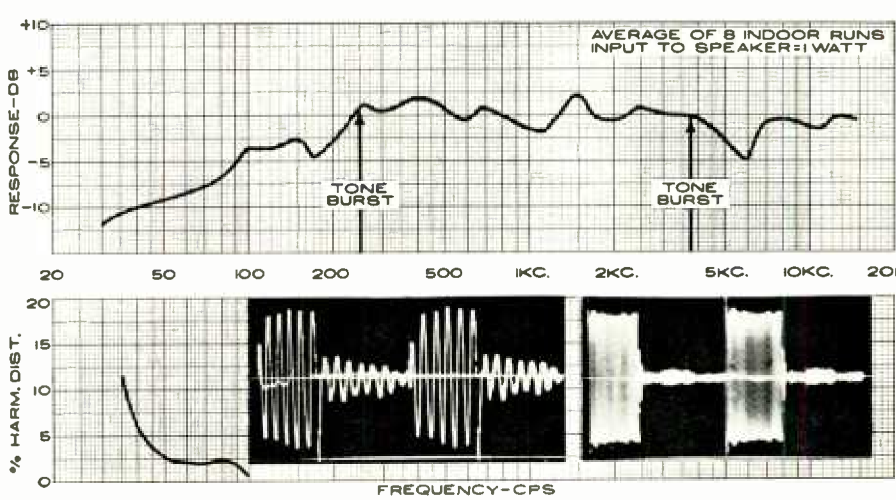
The high frequencies are handled by a specially designed tweeter, whose 1½" voice coil drives a Mylar dome radiator of the same diameter. The powerful magnet assembly and low mass of the dome give excellent transient response, as well as wide dispersion of the highest frequencies. The electrical crossover network components are mounted within the cabinet.

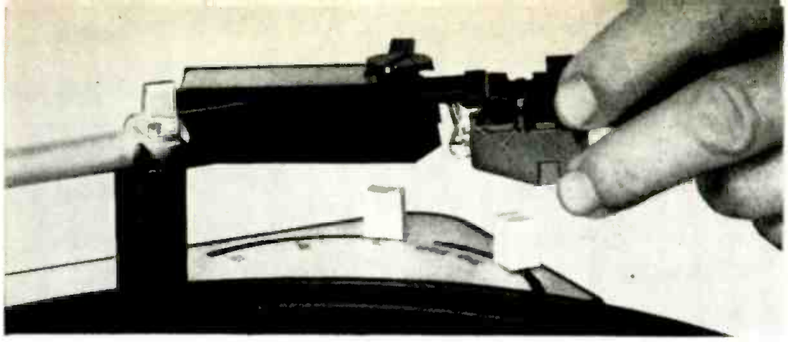
The heavy, solidly built enclosure of the ADC-14 is extensively padded internally. It is basically a ported enclosure, with a group of 1"-diameter holes on the rear panel serving as a port. The small hole diameter, together with the acoustic absorbing material which covers them internally, introduces an acoustic resistance into the port, damping the low-frequency cabinet resonance and smoothing the low-frequency response of the system.

Our frequency-response measurements were made with eight different microphone locations in the test room. The automatically plotted curves were averaged to produce a single composite response curve. The speaker was placed on the floor, near the center of one of the short walls of the room. This is not a particularly good location from the standpoint of extended bass response, so the response appeared to fall off gradually below 200 cps. Actually, the bass was clean and firm down to slightly below 50 cps, at which point the harmonic distortion began to rise.

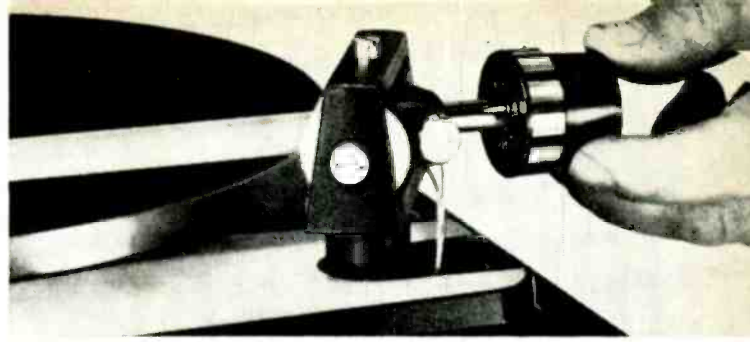
From 200 cps upward, the response was very smooth and flat, up to the

(*Continued on page 64*)

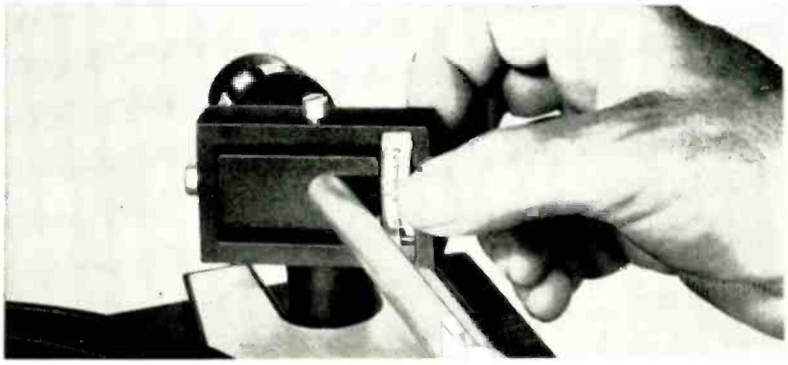




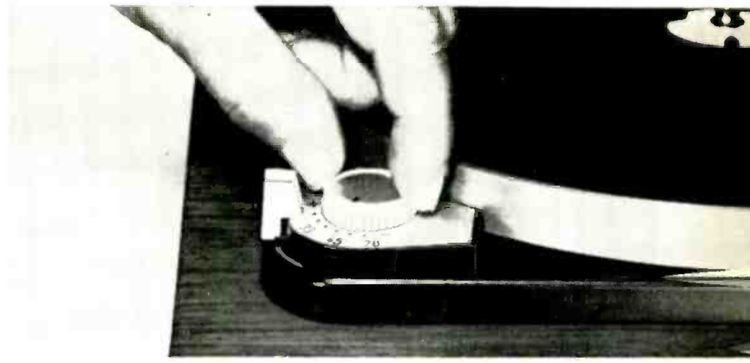
welcomes highest compliance cartridges for flawless tracking even at 1/2 gram or under



precise tonearm balance with rubber cushioned fine-thread rotating counterweight

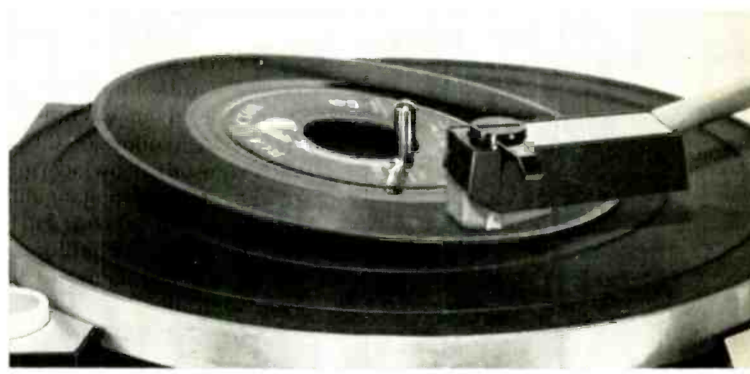


stylus force applied directly at pivot preserves perfect mass balance of tonearm



perfect pitch for the most critical ears with 6% variable range for all four speeds

superb over-all engineering permits tilt to almost 90° without spilling a note



"warped" and eccentric tracking dramatizes frictionless bearings, low tonearm mass

No wonder the new Dual 1009 Auto/Professional obsoletes every turntable and changer ever made...at any price!

Standards of performance once associated with professional turntables and separate tonearms have now been matched or surpassed by a remarkable new record playing instrument . . . the Dual 1009 Auto/Professional by United Audio. Consider this achievement: A dynamically **balanced automatic tonearm that tracks and trips below ½ gram** . . . resonance below 8 cps, tracking error below .5°/inch. A solid non-ferrous platter machined to electronically controlled tolerances, then dynamically balanced . . . final weight 7½ lbs. A powerful high-torque motor that maintains speed accuracy with one record or ten . . . and acts like a hysteresis in resisting voltage variations (even beyond ± 10%.) For a convincing demonstration of flawless automatic tonearm tracking with the finest high compliance cartridges, visit your United Audio dealer today. At $94.75, you'll find the strikingly handsome Auto/Professional a value that welcomes comparison with equipment at $100 *more!*

famous elevator-action changer spindle

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Just pushing the start button tells the quality of the EICO RP-100. Instantly, tape flows with the smoothness and precision you would expect only in a studio console. Hit the stop button: D.C. brakes halt the tape with hairbreadth accuracy. Rewind—and watch a full reel whizz through in less than a minute. Aside from the decisive snap of the solenoid controls, all runs silently—thanks to rugged construction. No mechanical whirring and buzzing obtrudes on the music. And the solid heavy-gauge chassis maintains vital mechanical tolerances under heavy use.

You can't top the RP-100 for versatility: 4-track or 2-track, stereo or mono, with each channel separately erasable, 2 speeds (7½ and 3¾ ips), monitoring directly from tape, sound-on-sound recording, facilities for mixing two inputs with separate level controls for each channel, and for recording two programs simultaneously.

. . . and as for quality factors: 3 motors—hysteresis synchronous capstan drive—transistorized electronics to eliminate hum and microphonics—automatic tape lifters—automatic shutoff—3 precision-lapped shielded heads adjustable in all planes—narrow-gap (0.0001 inch) playback head for maximum frequency response—consistency of high frequency response improved by hyperbolic-ground heads—separate record and playback amplifiers—high-torque tape start for precise cueing and editing—jamproof speed shift—dual recording level meters—non-critical bias setting—record safety interlock—rapid loading in sweep-line path that assures tight tape wrap-around on heads, no need for troublesome pressure pads—permanent bearing lubrication—digital tape index.

And the sound? Frequency response 30 to 15,000 cps ± 2 db at 7½ ips with 55 db signal-to-noise ratio. At 3¾ ips the frequency response is 30 to 10,000 cps ± 2 db with 50 db signal-to-noise ratio. Wow and flutter are below 0.15% at high speed, under 0.2% at low speed.

Summing up: *"THE EICO RP-100 will do as good a job as many recorders costing up to twice as much, and it is probably more flexible than any of them."* That's the unbiased test report of Hirsch-Houck Laboratories, published in Hi-Fi/Stereo Review. As a semi-kit the EICO RP-100 is **$299.95**. You can also buy it factory-wired for **$450.00**. Even then it's unmatched for the money. See the superb RP-100 and the complete EICO line of high fidelity components at dealers everywhere. For FREE 32 page catalog, 36 page Stereo Hi-Fi Guide (enclose 25¢ for handling & dealers' name, write: EICO ELECTRONIC INSTRUMENT CO., INC., 3300 Northern Blvd., L. I. C. 1, N. Y. EW-11

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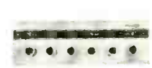

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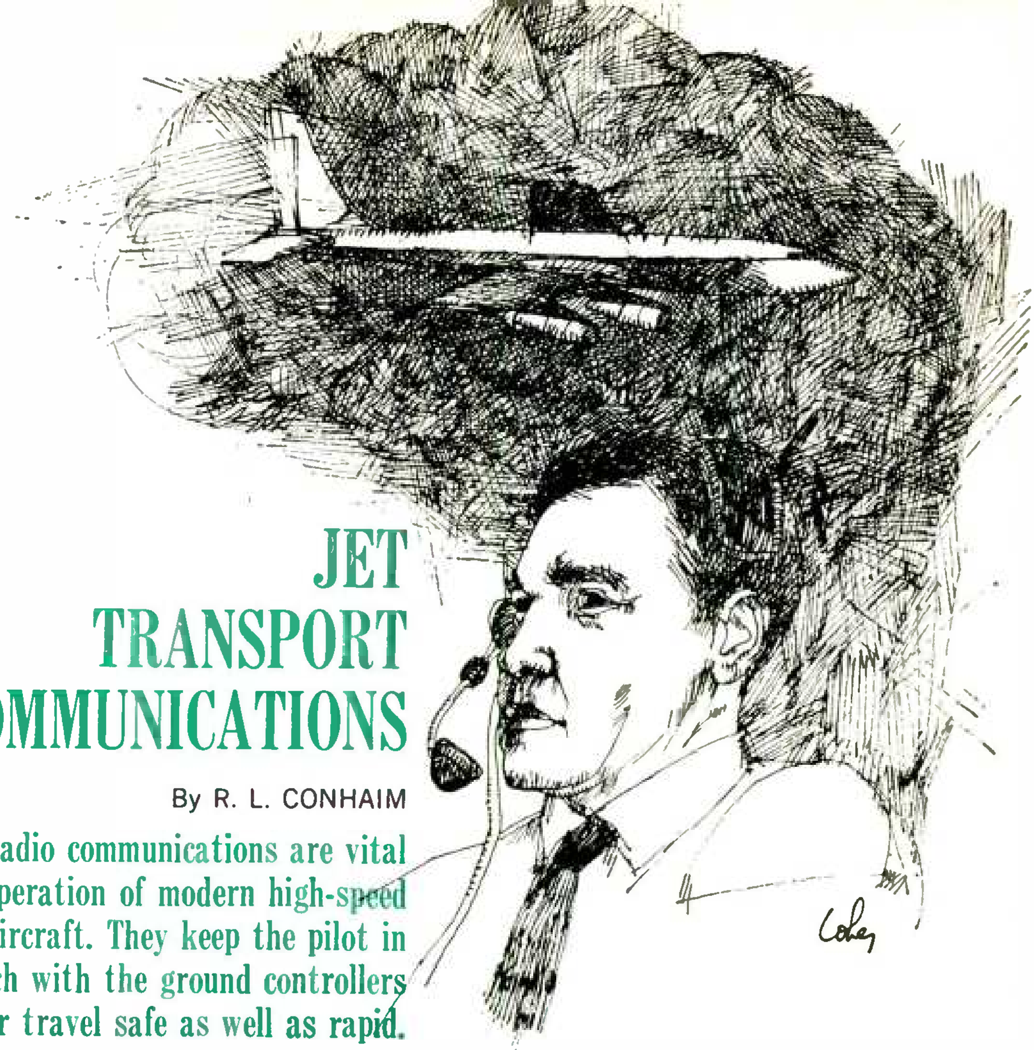


JET TRANSPORT COMMUNICATIONS

By R. L. CONHAIM

Reliable radio communications are vital to the safe operation of modern high-speed jet aircraft. They keep the pilot in constant touch with the ground controllers and make air travel safe as well as rapid.

YOU'RE comfortably seated in a plush seat of a *TWA Boeing* 707, looking out the window at the cloud cover far below you. Only a few minutes before, you had left Chicago's O'Hare Field for the 57 minute flight to Dayton, Ohio. Now the flight is nearly over and you're wondering just how the pilot will manage to penetrate the cloud cover and find the Dayton Municipal Airport.

Unknown to you, the aircraft crew has been in constant radio communication with the Indianapolis Traffic Control Center, operated by the Federal Aviation Agency. Now, as the plane approaches Dayton, the earphones crackle. It's the Indianapolis Controller.

"*TWA* 24, you're cleared to the Dayton VOR. Descend and maintain five thousand."

The first officer picks up his microphone, pushes the press-to-talk button. "*TWA* 24, Roger. The Dayton VOR descend and maintain five thousand."

Again the headphones come to life. "*TWA* 24, Roger. Expect ILS approach to runway six to Dayton Municipal. Contact Dayton Approach Control on one one eight point zero. Good day, sir."

The co-pilot acknowledges his instructions. His hand reaches for the v.h.f. control head. He turns the whole-megacycle knob until the digital control reaches 118. Now he turns the one-tenth megacycle knob until the digital indicator reads zero. He picks up his mike, "Dayton Approach Control, *TWA* 24." There is an immediate acknowledgement.

"*TWA* 24, radar contact seven miles northwest of Dayton VOR. Depart the VOR heading one eight zero. Maintain five thousand for radar vector to ILS runway six approach. Time, four eight and one-quarter. Altimeter three zero one six."

The first officer repeats the information so there can be no misunderstanding. The Dayton Approach Control voice continues: "Dayton weather estimated nine thousand, overcast. Visibility, six miles, haze, winds northeast at seven knots.

The controller then gives instructions to vector the flight to the ILS System. Once over the outer marker, the pilot is advised to contact Dayton Tower on 119.5 mc.

While you have been riding in luxurious comfort, one of the most complex and efficient communication networks ever devised has been in constant operation, providing the pilot of your plane with specific instructions and keeping him up-to-the-minute on every factor of flight about which he must be aware. Two giant networks of ground-to-air communications, one operated by the FAA, the other by ARINC (*Aeronautical Radio, Incorporated*), provide complete radio coverage for today's thriving air transport industry. And this is entirely over and apart from the radio navigation facilities that are also provided for safe and effective flight.

Most communications in the U.S. are conducted on v.h.f., within the frequency range of 118.0 to 135.95 mc. with 50 kc. spacing. Some specific frequencies are assigned for particular purposes. For example, 121.5 mc. is the universal simplex emergency and distress frequency. The frequency 121.6 mc. is used for air-to-air and air-to-ground search and rescue operations, although it can be used for other purposes provided no harmful interference to search and rescue operations is caused. The frequencies 121.65 to 121.95 mc. are used for airport utility operation, and to control airport lights. Certain other frequencies are also assigned by the FCC with

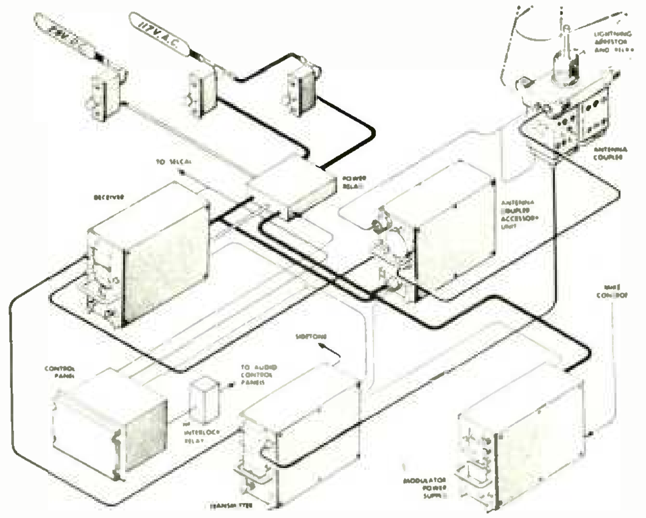


Fig. 1. Functional diagram of typical h.f. system as used in the DC-8. Two complete systems are used for maximum safety.

In a typical operations room, one to three controllers pass the aircraft along a sector of air space. An average center can handle as many as 2000 aircraft during a 24-hour period.

secondary use being allowed in some cases. Basically, however, other than these specifically assigned frequencies, the determination of frequencies for ground operations is made in cooperation with the FAA. Thus, it is the FAA that assigns tower frequencies and the frequencies of various air traffic control communications stations. In addition, the frequencies between 108.1 mc. and 117.9 mc. are assigned to v.h.f. navigational aids including the localizer portion of Instrument Landing Systems (ILS) and v.h.f. Omnirange Navigation (VOR) stations. Aircraft are not given specific frequency assignments. As a consequence, the modern jet transport must be equipped to transmit and receive on any of the possible v.h.f. frequencies used by various towers, FAA-operated radar units, Air Route Traffic Control Centers (ARTCC), and *Aeronautical Radio, Inc.* (ARINC) private communication facilities, or other private aircraft communication facilities.

High-frequency communications are for standard overseas operations and, to a limited degree, within the United States. It has been proposed by the FCC that h.f. communications in the continental U.S. (excluding Alaska) be discontinued. Final determination will be made prior to 1965. However, because of the necessity for the longer ranges provided by h.f. communications, they will continue to be used for overseas flights. Frequencies within the h.f. band are usually assigned on the basis of geographical location on the several Major World Air Route Areas (MWARA's) by international agreement. These frequencies vary from about 2875 kc. to about 18,000 kc. Thus, it is necessary for the jet transport, equipped for overseas flights, to have both h.f. and v.h.f. facilities. Also, because v.h.f. assignments in foreign countries sometimes do not correspond with the frequencies used within the U.S., jet overseas transports usually have v.h.f. capabilities above 135.95 mc.

Primary ground facilities usually have transmitting and receiving capability on more than one frequency, and sometimes transmit simultaneously on several frequencies. For example, the Dayton Municipal Airport primary tower frequency is 119.5 mc., but it also has transmitting capabilities on 278 kc., 121.5, 121.9, 126.2, 243.0, and 257.8 mc. The latter two frequencies are considered in aircraft communication parlance as u.h.f. frequencies and are used primarily by military aircraft. The Dayton Tower also has receiving capability on 122.5 mc. in addition to all the v.h.f.-u.h.f. frequencies it uses for transmitting. Of course, all FAA and military operated facilities can both transmit and receive on the emergency frequency of 121.5 mc.

While it is commonly considered that a transport pilot talks to "the tower" and possibly certain enroute stations, in actual practice, he may talk to several controllers on different frequencies, but in the same area. In any area where traffic is heavy, one tower operator simply could not handle the large volume of communications necessary, nor have at his fingertips all the information necessary to transmit to arriving or leaving transports. As a result, the communication functions may be broken down among several controllers, all in the same area. A typical example would be the Dayton Municipal Airport. While not one of the nation's largest—it ranks 40th in air carrier operations—its close proximity to Wright-Patterson Air Force Base means that the local volume of air traffic is rather heavy. As a result, the jet transport entering the Dayton area, is handed from one controller to another. First, he talks with Dayton Approach Control, probably on 118.0 mc. Next, his instructions come from the Dayton Tower on 119.5 mc. Once on the ground, he talks with Dayton Ground Control on 121.9 mc. for taxiing instructions, ramps to use, and other information. When the jet transport is ready to leave Dayton, he first contacts Dayton Ground Control for pertinent clearance information, then Dayton Tower for take-off instructions, then Dayton Departure Control on 119.9 mc. Once he leaves the Dayton area, he is under the control of the Indianapolis Air Route Traffic Control Center.

The Air Route Traffic Control Centers

There are, at present, 28 Air Route Traffic Control Centers located within the 48 continental states, and two located in Alaska. The FAA is in the process of consolidating the center areas in the 48 states so that by 1965 there will be only 21 within the continental United States. Each of these centers is radar equipped and operates on a number of different frequencies, depending upon the altitude of the aircraft and the sector in which it is operating. Our jet leaving Dayton, for example, will contact two or three Indianapolis controllers, each on a different frequency.

As the jet progresses in flight, it will be transferred to other centers in its flight path. In every case, each controller tells the pilot which center to contact and on what frequency, so

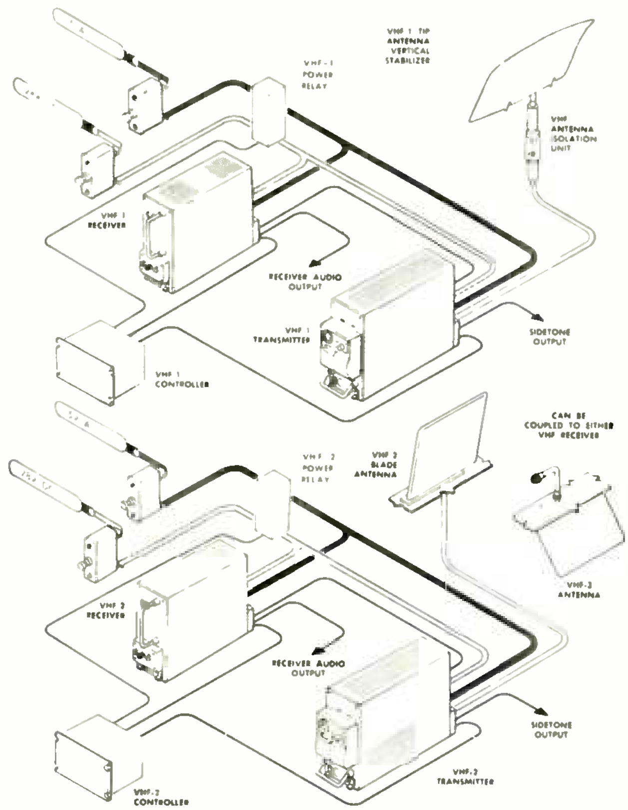


Fig. 2. Functional diagram of the two v.h.f. systems used in the DC-8. Both systems can operate independent of each other.

that it is therefore unnecessary for the pilot to memorize unusually long lists of awkward frequencies.

The ARINC Communications System

Not all the communications traffic required by a jet transport plane involves the FAA. Much of it is company business. To handle private communications, the airlines, in 1929, organized *Aeronautical Radio, Inc.*, for the purpose of furnishing airlines and other aircraft with air-ground-air and point-to-point communications. This company is owned by the airlines, helicopter operators, and a number of foreign airlines, and several corporation aircraft operators. This corporation presently serves some 150 U.S. and foreign air carriers, about 500 business and corporate aircraft operators, and various government agencies.

ARINC maintains a vast network of communications, both v.h.f. for domestic flights and h.f. for overseas flights. There are 14 ARINC control-point stations and more than 300 full-power and low-power network enroute stations. Each of the many v.h.f. networks operates on a specific assigned frequency, and is terminated at one or both ends by a control point station. All the transmitters on any one network transmit simultaneously and are linked by leased telephone lines. If a jet wishes to talk with his own company dispatcher, rather than with the ARINC radio operator, he can be quickly hooked in by telephone connection.

ARINC also provides overseas international air-ground-air services on both v.h.f. and h.f. Gateway stations for this purpose are located at New York, Miami, San Juan, New Orleans, Los Angeles, San Francisco, Seattle, Okinawa, and Honolulu. To get maximum range from v.h.f. stations at these gateway areas, transmitters have been located at the highest possible points, such as atop Mt. Washington, Lookout Mountain, and Mt. Haleakala in Hawaii. Each of these stations operates at high power and with specially designed receivers and high-gain directional antennas aimed in the direction of the over-water routes. To avoid traffic congestion and to provide a positive calling procedure on ARINC frequencies, many modern jets employ a selective calling system, commonly referred to as "Selcal." This is a tone system which can be used by the ground dispatcher to alert a particular aircraft. A light or buzzer, or both, in the cockpit notifies the pilot he is being called. In this way, he does not have to listen to all the conversations taking place on any one network.

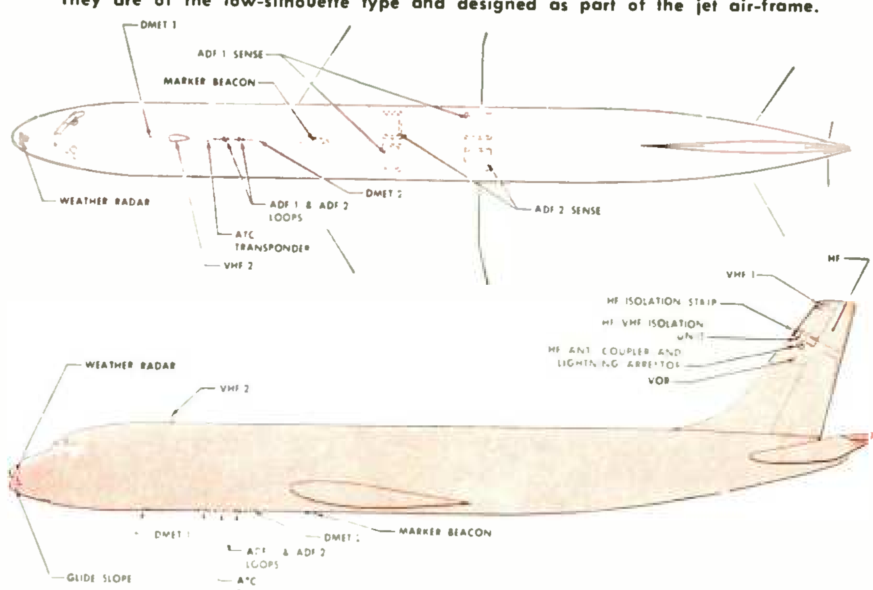
In addition to ARINC, some carriers maintain their own radio facilities for communication with their aircraft.

Equipment Performance Standards

Because passenger safety is paramount in the air transport industry, it is obvious that only equipment with the highest reliability can be employed. To ensure this kind of quality in radio equipment, the Federal Aviation Agency publishes Technical Standard Orders (TSO's) governing all types of communication and navigation equipment. No equipment may be installed on an air-carrier aircraft unless it complies with the applicable TSO. These spell out in detail the minimum performance standards which the equipment must meet. Many of these standards are worked out by the Radio Technical Commission for Aeronautics (RTCA) which is a cooperative association of all United States government-industry aeronautical telecommunications agencies. A manufacturer of communications equipment must certify to the FAA that his equipment meets or surpasses the requirements of the appropriate TSO, before it can be used on air-carrier aircraft.

In addition, because of limited space and the necessity for compactness, physical sizes of aircraft communications equipment have been largely standardized. This procedure was formalized in 1940 when specifications defining the physical sizes of air transport radio (ATR) equipment were established by a technical committee of airline radio experts working with the ARINC staff. As a result, most equipment made today for air transport use is designed to meet one of the ten ATR configurations. This has also resulted in the standardization of shock-mount sizes, even to the point of standard connectors being used, so that one piece of equipment can be removed from a shock mount and replaced by another of different manufacture and different circuitry.

Fig. 3. Location of the various communication and navigation antennas on a DC-8. They are of the low-silhouette type and designed as part of the jet air-frame.



Practically all jet communications equipment is remotely controlled. The controls usually include frequency-changing devices, volume, squelch, and function controls. There is some standardization of control panel sizes, but controls may also be custom designed to fit the requirements of particular aircraft or the desires of different airlines. This does not present any unusual problems.

With such great variety of radios, it is obvious that a complete audio system for each would take up too much space and cause too much confusion in operation. Consequently, most aircraft receivers are provided with 500- to 600-ohm output which is fed into an audio panel, so that practically any combination of equipment can be fed into any combination of speaker or headset outputs. In addition, the audio panel is used for controlling intercom, passenger public address functions, and music reproducer systems. Each *United Air Lines* jet transport, including DC-8's, B-720's, and *Caravelles*, is equipped with a 40-watt *Collins* audio amplifier and *Gables* tape reproducer. Speakers are located throughout the cabin with a speaker in each lavatory and the cockpit. Either the pilot, co-pilot or a stewardess can use the aircraft audio system to make pertinent announcements.

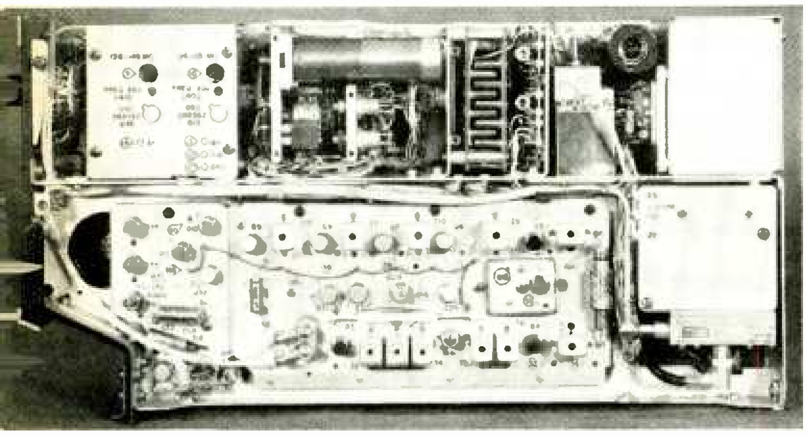


Fig. 4. This v.h.f. aircraft transceiver, made by Collins, uses semiconductors and miniature vacuum tubes to reduce size.

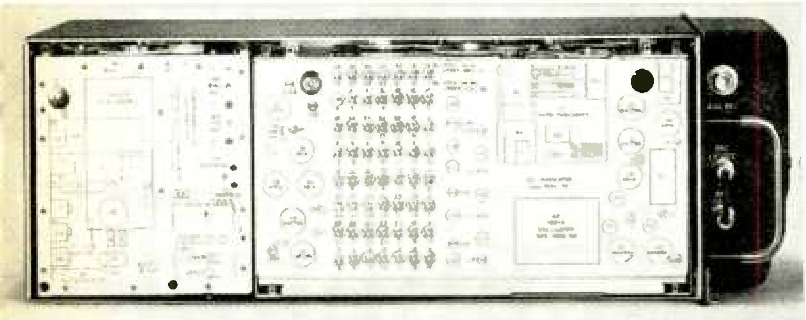


Fig. 5. This modern h.f. transceiver uses 14 tubes and 100 transistors and has 28,000 discrete channels between 2 and 30 mc.

Power for all communications equipment and for other electrical and electronic equipment on board is provided from 28-volt d.c. battery sources and 115-v.a.c., 400-cycle sources. Most of the primary power for communications equipment is derived from 115-v.a.c., 400-cycle generators. In the DC-8, for example, each of the four jet engines operates an a.c. generator. There is ample generator capacity. All of the systems on a DC-8 requiring 400-cycle a.c. can be supplied from the output of 1½ generators. Thus, there are always two in reserve for contingencies.

The location of remotely controlled communications and other electronic gear is determined in the design of each individual jet transport. In the DC-8, the equipment is located in radio racks behind the captain's position; in the *Boeing* 720, the equipment is beneath the floor aft of the cockpit; while in the *Caravelle*, radio equipment racks are aft of the cockpit on the second officer's side of the aircraft.

Fig. 1 shows a functional diagram of a typical high-frequency system as employed in the *Douglas* DC-8. Although only a single system is shown, two complete systems are normally used to provide maximum safety should a failure occur in one of the systems. This system operates in the 2- to 22-mc. range utilizing up to 168 common transmit-receive channels, 24 receive-only channels, and up to 23 transmit-only channels. Transmitter and receiver frequency selection is controlled from a panel in the cockpit, and all tuning and antenna loading are entirely automatic, performed by an ingenious servo system. In the receivers, i.f. crystal bandpass filters are employed, resulting in a bandwidth of only 3 kc. giving the receiver excellent selectivity. Isolation between the two h.f. systems, and between transmitters and receivers, is provided by switching systems in the lightning-arrester unit. With this system, it is possible to receive with both h.f. receivers simultaneously, although only one transmitter can be used at a time.

Fig. 2 shows, in functional form, the interconnection of the v.h.f. communications systems on the standard DC-8. Both v.h.f. systems operate independently of each other, so that both transmitters can be operated simultaneously if desired. The control panel is located in the pilot's overhead switch panel and includes two frequency selectors with concentric volume control, two on-off switches, two squelch controls, and two single-channel/double-channel switches. In the double-channel position, the transmitter carrier position is 6 mc. above the receiver frequency. This action is functional only when the frequency indicator reads 118.0 through 120.95 or 127.0 through 129.95 mc.

Fig. 3 shows the location of the various communications and navigation antennas on a DC-8. Antenna locations and sizes on jet aircraft differ from the conventional piston-engine aircraft. The greater speed of jet aircraft demands antennas with low silhouette and, consequently, lower drag.

Because of the large numbers of equipment available, and because each airline has its own preferences based upon experience, the selection of communications equipment is done by airline executives in cooperation with the airframe manufacturers. The *Douglas* systems shown in Figs. 1 and 2 are standard systems offered by *Douglas*. On the other hand, *United Air Lines'* DC-8's, B-720's, and *Caravelles* employ *Collins* equipment specified by the airlines. Each *United* plane has two *Collins* 51X-2 receivers and 17L-7 transmitters. The receivers are used for both v.h.f. navigation and communications. On the nine DC-8's flying between the mainland and Honolulu, dual h.f. transmitters and receivers made by *Aero Communications Company*, and known as the "Atom" and the "Star" are installed. These over-water planes also carry PRC-17 military type walkie-talkies and *Granger* self-contained life raft beacon transmitters operating on the 121.5-mc. emergency frequency. Other airlines may specify different equipment, but it is common practice to employ the antennas provided by the airframe manufacturer since these are an integral part of the aircraft, designed and located for best aerodynamic characteristics as well as optimum communications efficiency and radiation patterns.

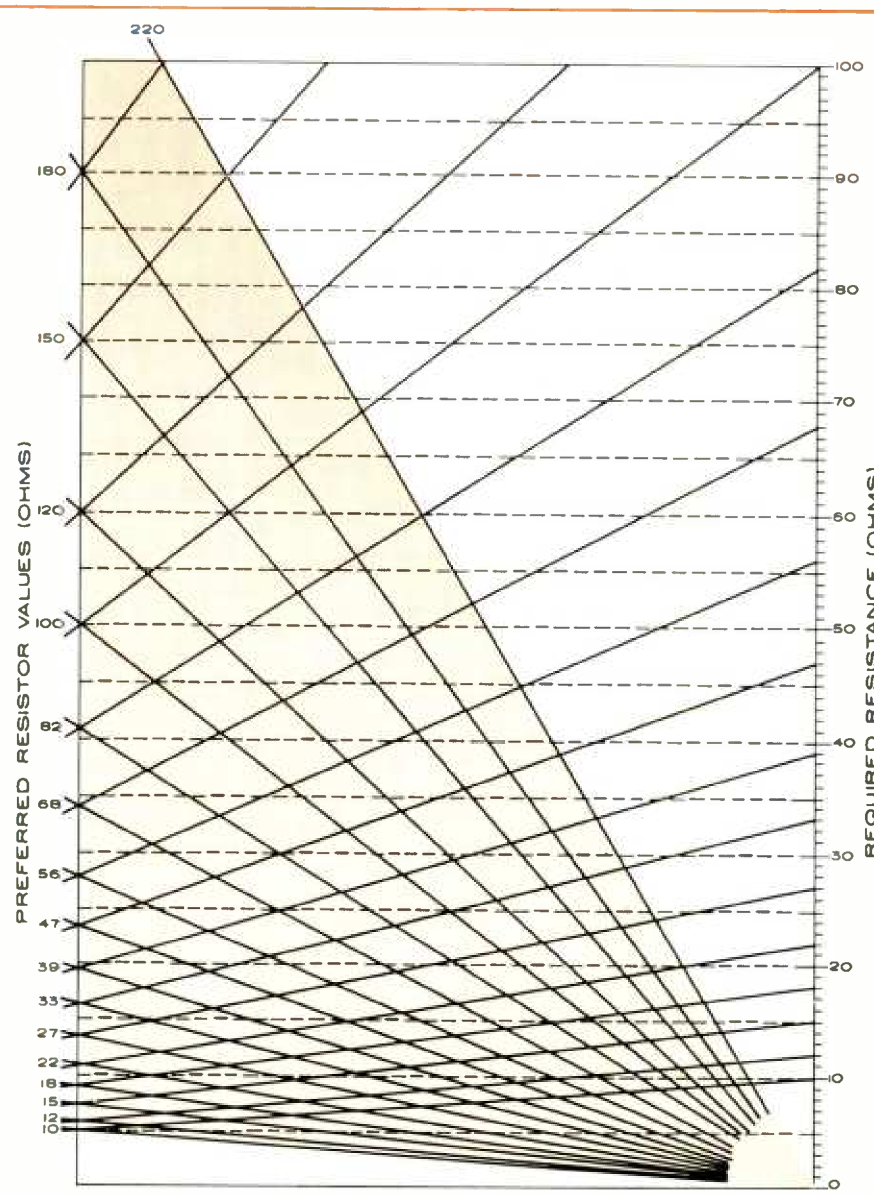
Typical Equipment

The *Collins* airborne v.h.f. transmitter, Model 17L-7, is the latest in a series which has become quite popular among airlines. It provides 25-watt output in the 118.0- to 151.95-mc. range with 680 crystal-controlled channels 50 kc. apart. The greater coverage is provided to accommodate communications in certain overseas areas where v.h.f. higher than 135.95 mc. may be used. The transmitter is partially transistorized, weighs 14 pounds, and is housed in a short ⅜ ATR case. The entire 680-channel coverage is accomplished using only 38 crystals by frequency-synthesis (*Continued on page* 94)

PARALLEL-RESISTOR CHART

By LARRY W. BRINDLEY

Useful chart for finding values of two standard resistors for any total resistance value needed.



MANY times when a technician or engineer is working on a project, he needs a resistor which is not to be found in the standard 10-percent range. This chart will indicate the two preferred standard resistance values that may be paralleled to give the required resistance value.

To use the chart, move, on the right-hand scale, to the "Required Resistance" value. Then move horizontally to the left until two intersecting diagonal lines are reached. Follow, to the left, the two diagonal lines which form the intersection until they cross the "Preferred Resistor Values" axis. At the point where they cross the axis read the values of the two preferred resistors which can be paralleled to give the required resistance value.

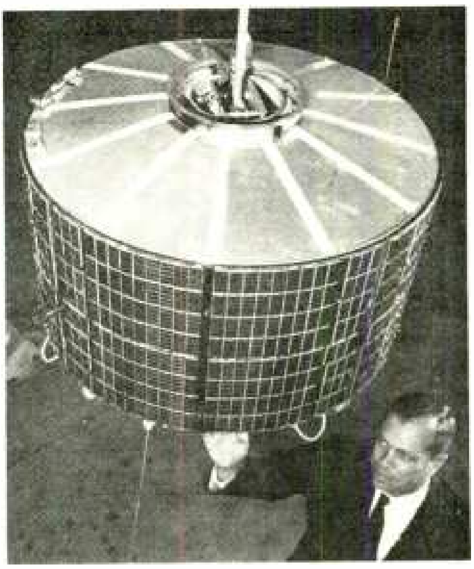
For example: Suppose we need a 30-ohm resistance. Go to the 30-ohm resistance value on the right-hand scale. Then move horizontally to the left until a pair of intersecting diagonals is reached. Follow, to the left, the two diagonal lines which intersect. They cross the left-hand scale at 47 and 82 ohms respectively. Therefore, a 47-ohm resistor and an 82-ohm resistor, connected in parallel, would yield the 30 ohms needed in the circuit.

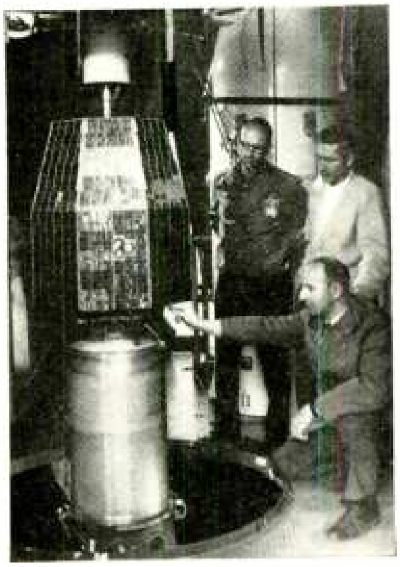
As an alternative, a 39-ohm resistor and a 120-ohm resistor or a 68-ohm and a 56-ohm resistor, in parallel, would also give the required 30-ohm resistance value. Note that the closer the intersection of the two diagonals is to the required resistance value, the closer is the parallel resistance value to the required resistance. If a 3000-ohm resistor is needed, simply add the required zeros.

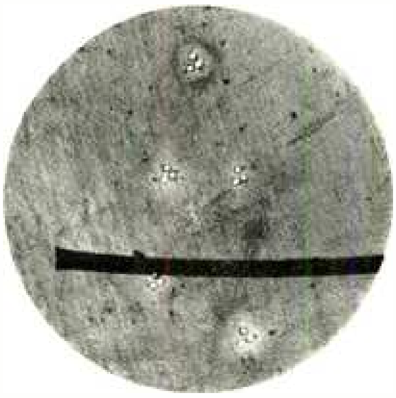
This technique can be applied to any value, by adding the required number of zeros, as long as both resistor values are in the same decade. This chart cannot be used to determine the resultant resistance obtained by paralleling, say, a 20,000- and a 2000-ohm resistor. ▲

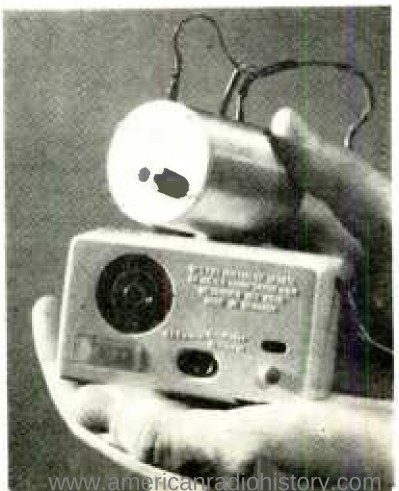
RECENT DEVELOPMENTS in ELECTRONICS

Communications Satellites. Our first successful synchronous communications satellite (near right) is, at the time this is being written, whirling in orbit 22,300 miles above earth. At its speed of 7000 mph, "Syncom" is over Brazil and is making an elongated figure-8 pattern with respect to a point on the earth. When the satellite was hovering over the mid-Atlantic, it was able to "see" both California and Africa, 8000 miles apart, and it successfully relayed voice signals between these points. The satellite can be precisely controlled from the ground at all times. Only three such satellites would be needed for world-wide communications. "Syncom" was built by Hughes for NASA. Another successful satellite is "Relay" (far right), built by RCA for NASA. This lower-orbit fast-moving satellite has already carried out over 1350 experiments in intercontinental television, voice, facsimile, and in data-processing communications.

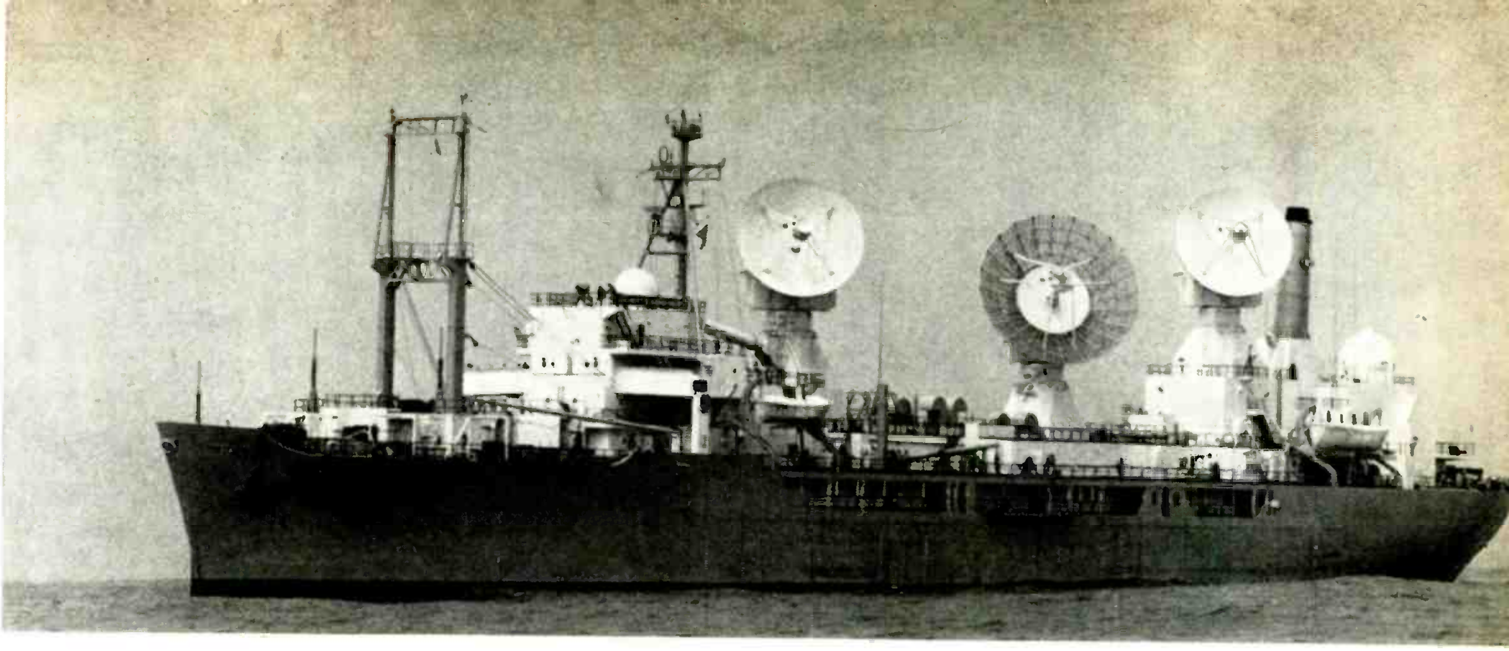


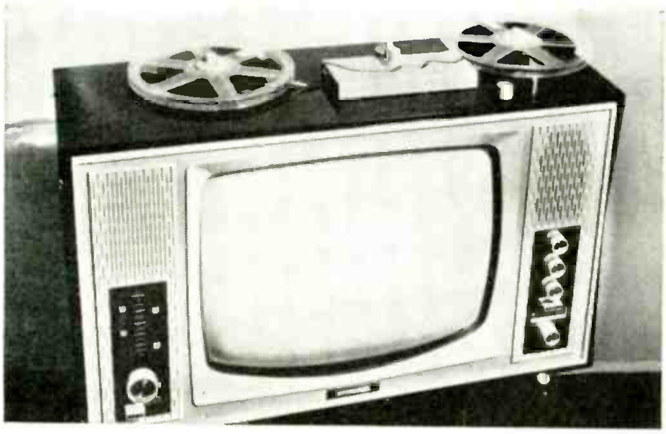






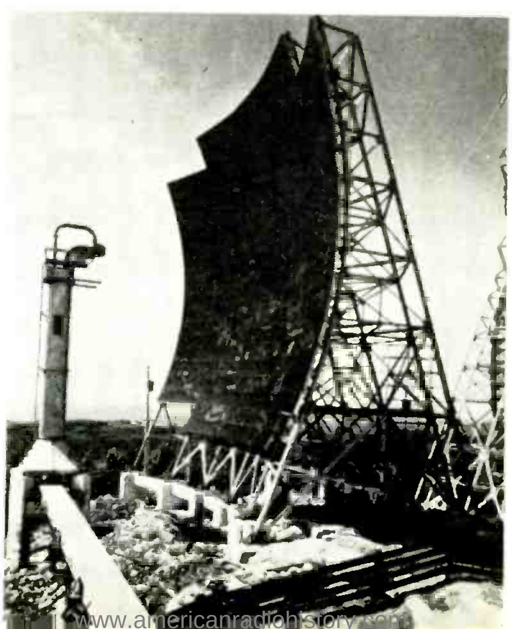
Electron-Beam Drill. (Top left) Taken through a microscope, this close-up photo shows clusters of three tiny holes drilled in a space roughly equal to the cross-section of a human hair. The hair, shown in silhouette, is about .004" in diameter. The holes were drilled through a thin sheet of tungsten by vaporizing the metal with a concentrated electron beam. The individual holes (about .0008" in diameter) are too small to be seen with the naked eye. Work is underway at a Westinghouse laboratory to develop a manufacturing tool using this technique that will drill holes, cut intricate shapes, and weld parts together in areas only a fraction of the size of a grain of sand.... **Lilliputian-Sized Laser.** (Bottom left) A highly compact laser that can be used by distressed boatsmen and downed pilots to signal their positions has been developed by Raytheon. The laser puts out pulses of invisible light that can be detected 30 air miles away with a special receiving device. The unit can be fired up to 50 times before the battery needs recharging. The laser rod, replacing the ruby crystal in a conventional solid-state laser, is doped calcium tungstate.





Missile Tracker. (Above) The second of the world's largest missile-tracking ships, the USAF's "Gen. Hoyt S. Vandenberg," aims its 3- and 4-story high tracking-radar antennas into space. These antennas are part of SINTRAK, the most powerful tracking radar on the Atlantic Missile Range. Sperry Rand developed the system and converted the ship from a troop transport. The ship will be stationed in the Indian Ocean, from which it will track our missile and space shots. . . . **TV Tape Recorder. (Left)** Built into a TV set is a tape recorder that is claimed by The Telcan Co. (England) to be able to record and play back both sound and video signals. The company has demonstrated a separate recorder, priced at about $170 in England. Some members of the press who viewed the demonstration expressed reservations about the picture quality. Standard quarter-inch recording tape was employed at an operating speed of 120 inches/sec.

Commercial Tropo Scatter System. (Below left) The $5-million tropospheric scatter communications system between Arnette Is., Alaska and Vancouver Is., British Columbia is among the largest-capacity commercial systems of its kind. The 344-mile General Telephone & Electronics Corp. system provides 240 channels for voice communications and data transmission for commercial and defense purposes. Previous systems have been government financed with a typical maximum capacity of about 120 channels. . . . **Brain-Wave Detectives.** (Below right) An experimental program to explore the use of brain waves as a possible long-distance monitor of human behavior is now underway at Honeywell laboratories. A special-purpose digital computer receives and analyzes brain responses to rigidly controlled events. These evoked responses are then rapidly accumulated by the computer.



EDITOR'S NOTE: *Because of the limited size of the sample, it would not be fair to name the brands of tape that were checked. However, the results do indicate the range of performance variation that may be expected. It should be pointed out that no attempt was made to optimize the bias adjustments for each of the tapes tested. This technique is used in professional recording when a very large amount of tape is employed. The non-professional user, however, does not expect to have to re-adjust his recorder every time he changes his brand of tape.*

ALTHOUGH most categories of audio equipment are extensively reviewed in electronics and other journals catering to the audiophile, there is very little information to guide him in his choice of tape, either as to kind or brand. This article seeks to probe a bit into the matter, but cannot aim at coming up with definitive statements because that is the job of a professional testing organization prepared to devote much time to the task and properly equipped for it.

Nonetheless, it would appear that observations based on a limited sample of tapes and a limited number of tests can be useful in drawing attention to the problem and giving the audiophile something to think about when choosing a tape.

This article is based in part on such a sample, consisting of one reel each of ten different tapes, which were tested with respect to frequency response, distortion, and output. A definitive test would take into account additional magnetic properties as well as physical properties (strength, smoothness). It would examine all varieties of tape, most name brands of each variety, and several reels of each brand.

WHICH TAPE TO USE?

By HERMAN BURSTEIN

Measurable differences, though moderate or slight, are significant to the serious recordist. Here are results of a sampling of tapes compared for response, distortion, and for output level.

The ten tapes employed in the tests are described in Table 1 which lists the base material as well as the thickness of the various tapes.

Tapes 1 through 6 in Table 1 are those of two widely advertised, well-known tape manufacturers. Tapes 7 and 8 are also brand names, but less important in the tape field. Tapes 9 and 10 are of unknown manufacture. All ten are conventional audio tapes in the sense that they are not special types designed to minimize print-through or to maximize output level (called "low print-through" and "high-output" type tapes).

Tape 1	Major brand A, 1½-mil acetate
Tape 2	Major brand A, 1-mil Mylar
Tape 3	Major brand A, ½-mil Mylar
Tape 4	Major brand B, 1½-mil acetate
Tape 5	Major brand B, 1-mil Mylar
Tape 6	Major brand B, ½-mil Mylar
Tape 7	Minor brand C, 1½-mil acetate
Tape 8	Minor brand D, 1½-mil acetate
Tape 9	Off-brand E, 1½-mil acetate
Tape 10	Off-brand F, 1-mil Mylar

Table 1. Listing of the ten reels of tape tested for this report.

Frequency Response

Using a high-quality home tape recorder, response at 15,000, 10,000, and 5000 cps was respectively tested at speeds of 7½, 3¾, and 1⅞ ips. Based on 1000 cps as the 0 db reference frequency, the results obtained are those shown in Table 2.

This tabulation shows that at 7½ ips none of the tapes exhibited a serious loss or exaggeration of treble response. On the other hand, between the best and worst of the tapes there was a difference of 3 db, which can slightly affect the coloration of reproduced sound.

At 3¾ ips, which is a tape speed frequently used in the home for recording of popular music, three of the tapes gave questionable performance, exhibiting 2.5 or 3.5 db loss at 10,000 cps. Between the best and worst of the tapes there was a difference of 5 db, which is quite substantial. Similar differences among tapes showed up at 1⅞ ips, a speed that is coming into increased home use not only for speech but also for background music.

It is interesting to note, based on the results for tapes 1 through 6, that high-frequency response in general diminished with tape thickness, that is, the 1½-mil tapes performed slightly better than their 1-mil and ½-mil counterparts.

Bass response of the ten tapes was also compared. Here differences were trivial. At 50 cps and again at 30 cps the greatest difference between any two tapes was about ½ db.

Harmonic Distortion

Using a frequency of 400 cps and recording at 7½ ips at maximum permissible recording level, as indicated by the record-level indicator, harmonic distortion was measured. The results, ranging from a low of 2.6% to a high of 4.2% distortion, are given in Table 3.

Note that in the case of major brand A (tapes 1 through 3), distortion was appreciably less for the thinner tapes than for the 1½-mil tape, while just the opposite was true for major brand B (tapes 4 through 6).

Output Level

Using a frequency of 1000 cps and recording at 7½ ips at maximum permissible level, tape output was measured in playback. Output of Tape 4 (major brand, 1½-mil acetate) was arbitrarily selected as the 0-db reference.

Inasmuch as it may be difficult in tape recording to obtain a really satisfactory signal-to-noise ratio, a reduction of even 1 db in output level must be considered significant. Three of the ten tapes exhibited such drops, as shown in the last column of figures in Table 3.

Tapes 1 through 6 show a general tendency for output to drop as tape thickness is diminished. This follows from the fact that in the 1-mil and ½-mil tapes the coating as well as the base is made thinner. It is curious to note, however, that in the case of major brand B (tapes 4 through 6), the drop in output was greater for the 1-mil tape than for the ½-mil tape.

On the whole, the differences among the various tapes tested for the purpose of this article were moderate or slight rather than profound. But that doesn't mean that they were unimportant and therefore to be ignored. It must be considered that in the already advanced state of the high-fidelity art, most improvements tend to be small rather than overwhelming. To the serious audiophile, any improvement—however small—is welcome because a series of small improvements can add up to an important total. Therefore, it would appear that the serious recordist will want to avail himself of the best tapes even though their performance surpasses the lesser tapes by only a small margin.

Properties Not Measured

There are a number of important physical and magnetic properties—such as strength, immunity to curling and cupping, accuracy of slitting, smoothness, lubrication, absence of dropouts, imperviousness to print-through, resistance to flaking, stability of characteristics within the reel and from reel to reel—which were not tested owing to lack of suitable facilities. It is difficult to get information about such characteristics in order to compare one tape with another, and it is through the purchase of premium tapes—tapes made by established, reputable companies—that the serious recordist enhances his chances of getting the best with respect to these characteristics that the art affords.

Tape	15,000 cps @ 7½ ips	10,000 cps @ 3¾ ips	5000 cps @ 1⅞ ips
1	1.0	-0.5	-5.5
2	1.0	-0.5	-4.5
3	0.0	-2.5	-7.0
4	1.5	1.5	-2.5
5	1.5	1.0	-3.0
6	0.5	-1.0	-4.5
7	-0.5	-1.5	-4.5
8	-1.0	-2.5	-5.0
9	-1.0	-3.5	-7.0
10	2.0	0.0	-4.5

Table 2. Record-playback response (in db) at high frequencies.

When tape is offered at a bargain price, substantially below that of premium tape, it stands to reason that tape quality must suffer in some way. A premium tape is manufactured to meet a set of standards making for optimum performance when recording and reproducing audio information on a tape machine. This is not necessarily so in the case of bargain tape.

Some bargain tapes are rejects of premium tape that fail to meet specifications. Some are rejects of computer or video tape. In the case of computer tape, the emphasis is on high-frequency response (because the computer is dealing with pulses), and when such tape is used for audio the mid-range and bass may suffer. In the case of video tape, the magnetic particles of the coating are oriented crosswise rather than lengthwise, so that there may be a drop in output when such tape is used for audio purposes.

Tape	Harmonic Distortion (%)	Output Level Relative to Tape 4 (db)
1	3.8	-0.25
2	2.6	-0.75
3	2.9	-1.00
4	3.1	0.00
5	3.8	-2.50
6	4.1	-1.25
7	3.5	0.00
8	4.2	-0.75
9	3.5	-0.50
10	3.9	-0.25

Table 3. Harmonic distortion and output level of the ten tapes.

Not all bargain tape consists of rejects. Some is purposely made for the low-price market by taking short-cuts in manufacturing. For example, the milling process—which finely disperses the oxide particles in a binder—uses a slowly revolving cylinder. New machines are available that can achieve dispersal in a matter of hours or minutes through a hammering process, but this tends to adversely affect both the magnetic and physical properties of the coating. A tape made in this fashion may have reduced output, reduced treble, and an increased tendency for the oxide to rub off.

Which Premium Tape?

Assuming that the recordist grants that it is worth paying the substantial price difference between a bargain tape and a premium tape, he is still faced with the question of what variety and what brand of tape to buy.

In part, his choice may be dictated by special problems that he is experiencing. If he is accustomed to recording at relatively high level, and is not bothered by the increased distortion that accompanies elevated recording level, his problem may be print-through. Special low-print-through tapes are available, achieved by a combination of a relatively thick base, a relatively thin magnetic coating, and a special magnetic oxide formulation. Such tapes reduce susceptibility to print-through by about 8 db.

If the recordist's problem is poor signal-to-noise ratio, and he is already recording at as high a level as he dare in view of the resulting distortion, high-output tape is available to him, permitting an increase of about 7 or 8 db in output. On the other hand, such tape tends to have slightly poorer treble response than conventional tape and tends to be more susceptible to print-through. This is the natural result of the considerably greater intensity of the magnetic field recorded on the tape.

If the recordist's problem is that he is forever reaching the end of the reel before he has completed taping a program off the air (for example, opera), and if he disdains the somewhat lower fidelity of 3¾ ips compared with 7½ ips, he can have recourse to 1-mil or ½-mil tape, which respectively provide 50% and 100% more playing time per reel. However, these tapes have greater susceptibility to print-through than does 1½-mil tape.

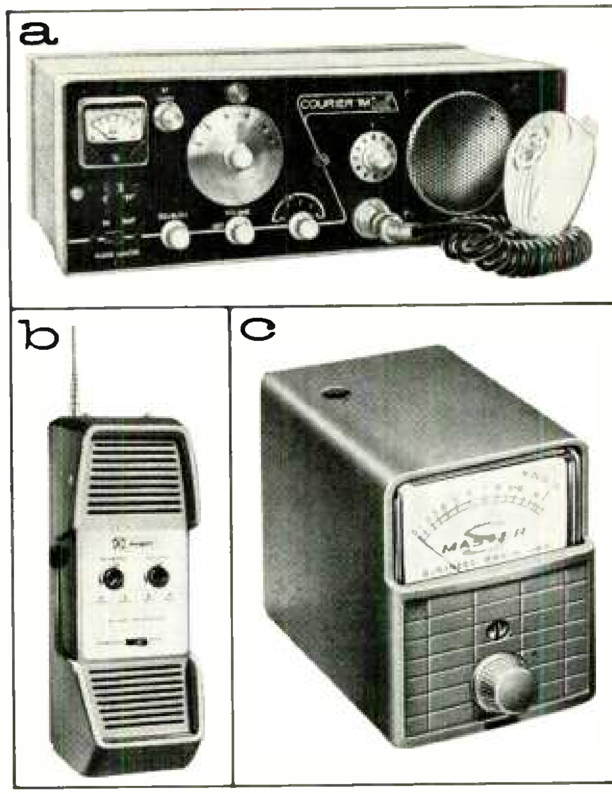
If the recordist elects to stay with 1½-mil tape but encounters difficulties, such as embrittlement, owing to the conditions of temperature and humidity of his environment, he can purchase 1½-mil tape with a Mylar rather than acetate base. Virtually all 1-mil tape and all ½-mil tape comes with a Mylar base.

Having decided what variety of tape is best for him and assuming that this particular variety is made by more than one manufacturer, it remains for the recordist to decide which brand to buy. As mentioned at the outset of this article, the reports of a professional testing organization would be very helpful at this juncture. In the meantime, the recordist has to decide for himself by trying various brands and comparing them in such respects as treble response, dropouts, squeal, and tape noise. ▲

NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

A transceiver that uses fixed LC circuits instead of crystals to select the received signals and one using ceramic i.f. filters plus a useful "S"-meter attachment for CB.



THE first circuit to be described this month employs a generally known, but rarely applied, technique for creating fixed receive channels. Contrary to standard practice, *E.C.I.'s* "Courier" transceiver uses no crystals in the receive local oscillator, but nevertheless achieves the convenience of switch-selected operation.

If the frequencies assigned to the Citizens Band are examined, it will be seen that a scant 10-kc. separates most channels. Couple this factor to the large number of on-the-air stations and the need for high receiver selectivity becomes apparent. A recent effort to reduce adjacent-channel interference appears in *Allied Radio's* "Knight-Kit" KG-4000. It is the first CB unit to utilize a ceramic filter for narrowing receiver bandwidth.

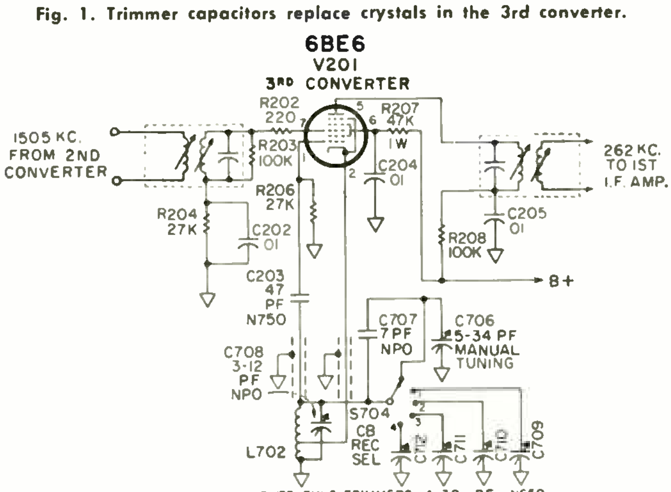
Our final description covers a new "S"-meter accessory by *Business Radio Inc.* It may be attached to any CB unit without regard for the type of power supply incorporated.

(a) E.C.I. "Courier I" Transceiver

Crystal control of a receive oscillator has been the conventional approach for providing the CB operator with an accurate, switch-type channel selector. In a departure from this technique *E.C.I.*[1] has fitted its "Courier I" with four fixed-channel positions solely through coil-capacitor tuned circuitry. In addition to eliminating receive crystals, the system permits rapid re-alignment to any set of channels required by the operator. The transmit section, in accordance with FCC law, remains crystal-controlled.

The unit contains a triple-conversion receiver. An incoming carrier on 27 mc. is heterodyned by local oscillators down to 10.4 mc., 1505 kc., and finally 262 kc. prior to detection. It is in the last oscillator that channel selection is accomplished (Fig. 1).

Fig. 1. Trimmer capacitors replace crystals in the 3rd converter.



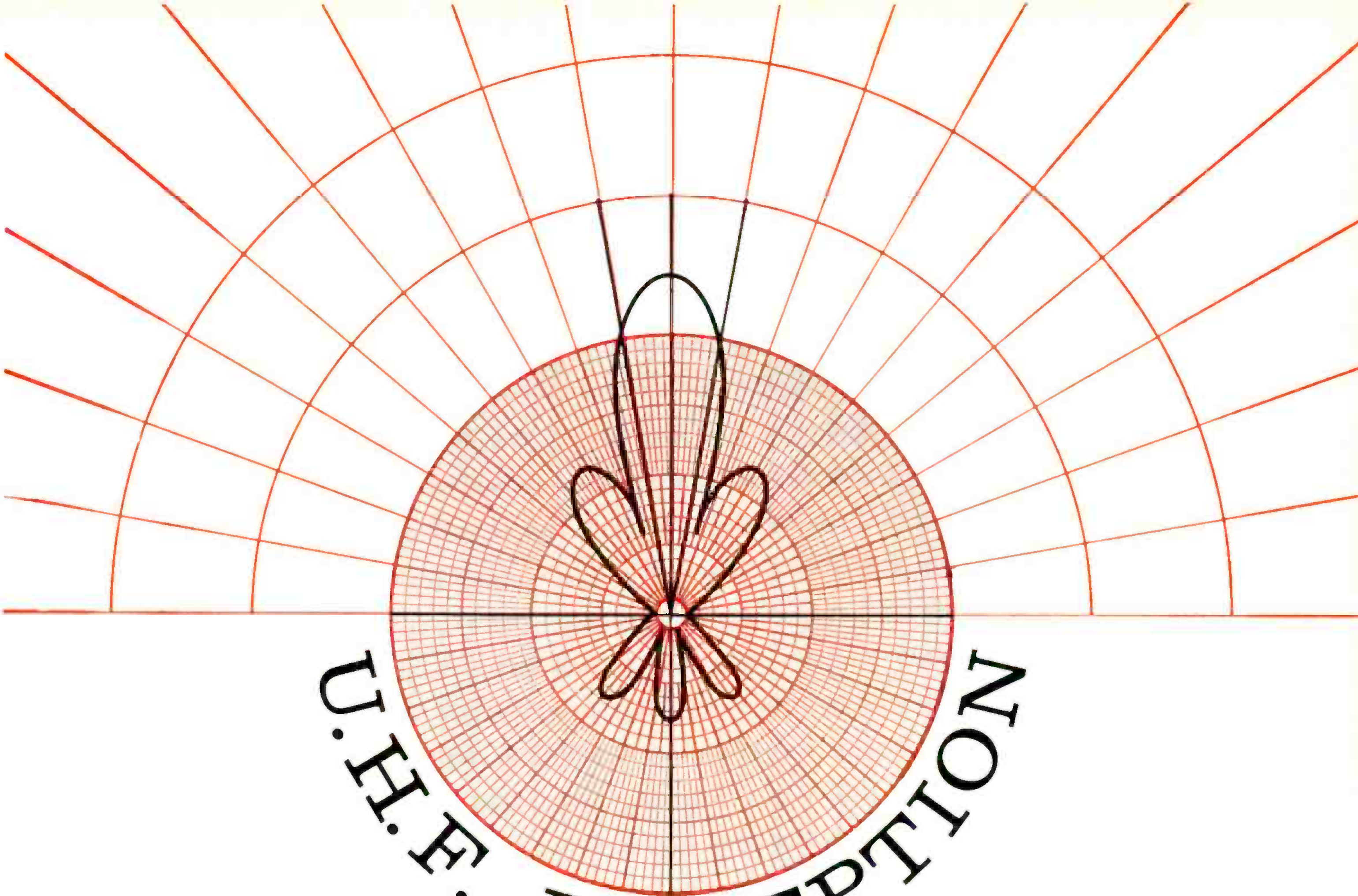
The 6BE6 oscillator forms a conventional tapped-coil Hartley circuit. As seen in the lower right portion of the schematic, a combination of variable and adjustable capacitors form the basis of crystal-less performance. Consider, first, how the receiver is manually tuned over the 23-channel band. The channel selector switch, *S704* is shown in the first or "Manual" tuning position. In this mode, variable capacitor *C706* can apply its full range of capacity—5 to 34 pf.—across the oscillator coil, *L702*. This provides the operator with a front-panel control for continuous tuning. Note that *C707* is now removed from the circuit by means of the shorting action of switch *S704*.

The first fixed-tuned channel is activated when the common switch pole moves to terminal 1. This inserts the first of four adjustable capacitors across the oscillator coil. (These capacitors, *C709-C712*, are initially set up on four desired channels.) But observe that the manual tuning capacitor remains active during all positions of the selector switch. Its range of capacity, however, is considerably reduced during fixed-channel reception. As the switch pole moves off "Manual" tuning, the capacitor is placed in series with *C707* and it becomes a frequency vernier for precise trimming of each fixed-channel capacitor. Such vernier action, which allows the operator to fine-tune over a 3- or 4-kc. range, is required with the triple-conversion circuitry. High selectivity of the i.f. strip would otherwise clip slightly off-frequency signals that are being received.

Two design features contribute to the stability that is mandatory in the crystal-less system. Critical capacitors, as indicated in the schematic, are temperature-compensated types (NPO). Also, low operating frequency of the oscillator stage minimizes problems of drift. When it is desired to re-align an adjustable capacitor to a new channel, a spotting switch on the transmitter will provide an accurate transmit frequency.

(b) Allied Radio "Knight-Kit" KG-4000 Transceiver

Many CB receivers rely on dual-conversion, added i.f. stages, or crystal filters to attain sharp selectivity. *Allied Radio*[2] has elected to use a (*Continued on page 70*)



U.H.F. RECEPTION

PRACTICES and EQUIPMENT

By JACK BEEVER / Jerrold Electronics Corporation

Why do some u.h.f. converters reduce set sensitivity while others can improve an all-channel set? How do you choose the correct u.h.f. antenna and can you mount it too high? What precautions must be taken to avoid losing most of the signal in the transmission line?

A LOT of mythology and exaggeration surrounds the subject of u.h.f. reception, so a list of pros and cons about u.h.f. may be a good way to start this article. Here are the "pros."

1. The u.h.f. antennas are smaller and easier to handle than v.h.f. antennas.

2. You get much more antenna gain for the buying dollar, with the result that very sharp patterns are readily available—hence good ghost rejection.

3. Man-made interference and 'sferic interference are greatly reduced.

4. Co-channel and adjacent channel interference are unknown at u.h.f.

5. Stations can fill in "holes" in their coverage pattern by using low-powered, unattended translators. Some stations have as many as four translators working for them.

6. Such u.h.f. antennas have much less wind-loading surfaces than v.h.f. antennas, and thus can get along with smaller, less expensive, supporting masts.

Against these benefits are the following "con" points.

1. Signals at u.h.f. don't "get out" as far as v.h.f. The recent New York City tests indicated that channels 2 to 6 are best when you get out past 45 miles (depending on transmitting antenna height), channels 7 to 13 are next best, and channels 14 to 83 (u.h.f.) are worst. But—the difference between 2 to 6 and 7 to 13 is greater than the difference between 7 to 13 and 14 to 83.

2. Antennas for u.h.f. need a little more care in installation—careless installation of down-lead is apt to cause more trouble at u.h.f. than at v.h.f.

3. Receiver noise figures are not as good at u.h.f. as they are at v.h.f., so you need more signal to get snow-free pictures. Offsetting this is the fact that u.h.f. stations can go up to 5-megawatts effective radiated power (e.r.p.), while channels 2 to 6 are allowed only 100-kilowatts e.r.p. and channels 7 to 13 are allowed 316-kilowatts e.r.p. You also get more receiving antenna gain for equivalent sizes of antenna.

4. The u.h.f. tuners are continuous types. So far, no detent-type tuners similar to v.h.f. tuners have been produced. However, the demand for u.h.f. reception is bound to produce detent-type tuners of some sort in the future.

The recent FCC ruling which says that any television set shipped in interstate commerce after April 30, 1964 must have the ability to receive all TV channels, 2 to 83, will put a tremendous pressure on the television and antenna installer to get on the bandwagon. Meanwhile, top-of-the-set converters are available to provide u.h.f. reception to owners of v.h.f.-only sets.

The problem of reception breaks down into four categories—all-channel receivers, top-of-the-set converters, antennas, and down-lead systems. We will discuss these in order.

All-Channel Receivers

The all-channel receiver is essentially a conventional television set equipped with two tuners, one v.h.f. and one u.h.f. Each of the tuners is really the front end of a superheterodyne receiver and consists of the oscillator and mixer portion. They are so wired that the u.h.f. tuner is out of circuit until the v.h.f. tuner is set at the "U.H.F." position of the tuning dial,

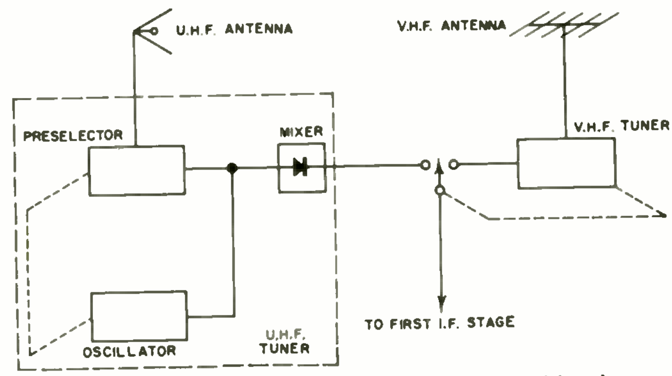


Fig. 1. Typical all-channel TV set uses a common i.f. strip and mechanical switching for either v.h.f. or u.h.f. tuners.

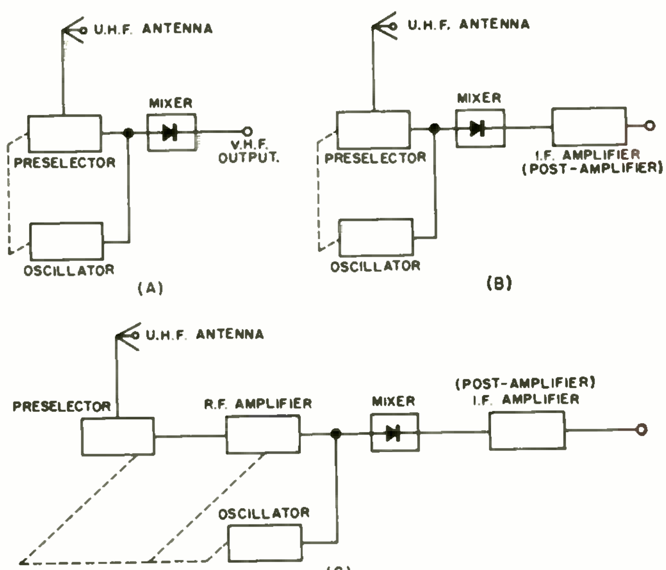


Fig. 2. There are three types of u.h.f. converters. The oscillator-mixer combination for strong-signal areas (A), the same using an i.f. post-amplifier for gain (B), and a high-gain converter (C) using both an r.f. and i.f. post-amplifier.

at which time, the v.h.f. tuner is disconnected from the i.f. input and the u.h.f. tuner is connected. Both tuners, of course, provide the same i.f. In some sets, the u.h.f. tuner output is fed to the v.h.f. tuner input for extra gain.

This design requirement has produced a change in the i.f. strips of receivers. Attention is being directed toward a first i.f. stage that is very sensitive and has a good noise figure, since practically all present u.h.f. tuners have *loss*—not gain. This is called "conversion loss" and may be from 10 to 14 db. This statement, by the way, is not necessarily true of top-of-the-set converters, since these units often have a built-in i.f. amplifier that can give them a net gain of anywhere from 6 to 15 db, depending on make and frequency. Fig. 1 is a block diagram of a u.h.f. tuner, and the method of connection.

Transistor development has reached the point where solid-state u.h.f. tuners have been designed with noise figures as good or better than tube units. One design has a built-in r.f. amplifier, a considerable improvement in the art, which results in a greatly improved noise figure. Present designs without the r.f. amplifier are dependent on the mixer crystal for their noise figures, and these vary considerably from unit to unit. A snowy reception problem can sometimes be cleared up by trying various mixer crystals in the tuner or changing to a superior crystal type. In the latter case, manufacturer's recommendations should be followed closely.

U.H.F. Converters

Top-of-the-set converters are u.h.f. tuners quite like the tuners in all-channel sets. They differ in using an intermediate frequency which is a v.h.f. channel, usually channels 5 or 6. Presently available types use either an oscillator and mixer crystal or a combination of oscillator, mixer crystal, and i.f. amplifier. One model, designed for only the translator frequencies, channels 70 to 83, uses a tube r.f. amplifier, crystal mixer, nuvistor oscillator, and transistor i.f. The reason for this elaborate converter lies in the low power of translators, with an allowed maximum of 100 watts.

Strangely enough, it sometimes pays to use a top-of-the-set converter even when an all-channel receiver is available, because the top-of-the-set converters of the more elaborate type have better gain than the built-in tuner. Fig. 2 diagrams the three types of converters. Fig. 3 illustrates one type.

Take care not to re-dress any leads in the r.f. sections of these units—that crinkled piece of wire or silver strap may be a tuning inductor, and bending it can throw the unit completely out of alignment. These portions of the circuit rarely go wrong—usually troubles are quite simple things such as a shorted rectifier, blown bypass capacitors, and occasionally, dirty tuner contacts. These latter should be washed with a solvent and relubricated—do not bend the wiper contacts or you'll change the over-all alignment.

Antennas

The bugaboo of all urban TV reception is ghosting. It also can become a serious problem in some rural areas, especially in the vicinity of bridges and elevated water tanks. The only practical solution to the ghosting problem is to use an antenna of a highly directive nature—a narrow beam. This allows the installer to aim at the station and ignore as much as possible ghosts, which, in practically every case, come from a different direction than the main signal. Sometimes the better signal is the ghost signal, and then he may orient on the ghost signal. The success of the effort depends on the directivity of the antenna, and the directivity of the antenna increases as the gain increases.

Let us look at indoor antennas first, since they are a major source of signal to u.h.f. receivers. At v.h.f., indoor antennas occupy a large area. The basic antenna is a dipole, and it is totally impractical to try to add other elements to increase directivity and gain—there just isn't room on top of the TV set. In u.h.f., the dipoles are small—about a foot long—and it is not unusual to mount two of them against a reflector screen. This is the familiar "twin bow-tie-on-a-screen" which will have gains up to 6-db higher than a v.h.f. indoor antenna, with a correspondingly better pattern of reception. Such antennas are small, easily maneuvered, and unlikely to be knocked over.

Use of an indoor antenna is predicated on being able to move the antenna into a position that can take advantage of the immensely complex standing waves occurring inside a building. Since u.h.f. uses much shorter waves than v.h.f., the standing-wave patterns repeat oftener in a given volume of space, and a greater choice is given the user in the selection of a good location for the indoor antenna. Much smaller movements of the u.h.f. antenna produce picture changes than is required for similar changes at v.h.f. The good looks of u.h.f. indoor antennas is sometimes against them—house-

Type Cable: pair of #22 conductors in polyethylene web with cellular polyethylene jacket. (Belden 8285)

	Low U.H.F. (500 mc.)	Mid U.H.F. (700 mc.)	High U.H.F. (900 mc.)
Dry	3.8 db	4.8 db	5.6 db
Wet	17.0 db*		

Type Cable: pair of #20 conductors, tubular polyethylene jacket with inert-gas filled polyfoam core. (Belden 8275)

	Low U.H.F. (500 mc.)	Mid U.H.F. (700 mc.)	High U.H.F. (900 mc.)
Dry	2.98 db	3.62 db	4.3 db
Wet	50.0 db*		

Type Cable: pair of #20 conductors in brown, flat, polyethylene ribbon (Belden 8230)

	Low U.H.F. (500 mc.)	Mid U.H.F. (700 mc.)	High U.H.F. (900 mc.)
Dry	3.1 db	3.7 db	4.5 db
Wet	72.0 db*		

*The wet figures are for total immersion in water, which would not occur in practice, but are indicative of water losses in rain.

Table 1. Losses in parallel-pair transmission lines at u.h.f. measured in db per hundred feet of transmission-line length.

wives want to line them up parallel with the front edge of the TV set cabinet.

Indoor antennas do a good job—but they never do as good a job as an outdoor antenna, simply because the outdoor antenna is in a "cleaner"—less complex field. The reflections of signals occurring inside the house do not reach far outside the walls, and they are weakened in their passage out, just as they were weakened going in.

The problems outdoors are likely to fall into either the weak signal area or the ghosting area, and both call for the same solution—a high-gain antenna. If signals are strong and clean, with no echoes (ghosts), the antenna choice depends upon the number of stations desired or available, and must be made according to the reception patterns of the antennas. Typical reception patterns of various types of u.h.f. antennas are shown on the front cover. These will vary slightly in different makes and models, but the patterns shown provide a good idea of the results to be expected.

For instance, suppose the situation were such that two stations were available, but that the location of reception sees these two with an angle of about 45° between them. The situation could be handled with an antenna rotator, but a glance at the reception patterns indicates that either the dipole-and-screen combination, or the corner-reflector type would receive quite well from the two directions without being rotated. The yagi, billboard, or parabolic would have to be aimed at each station as it was needed. But if the problem of ghosts exists—which is actually a multi-path problem—the installer should go to the yagi, the billboard array, or the parabolic antenna, regardless of signal strength. What is needed is the directivity of these antennas. In the case described above, a rotator would probably be called for with those arrays.

The problem of weak signals is one of antenna gain—the weaker the signal, the more gain is required—and perhaps other refinements of technique such as high towers to support the antenna clear of obstruction. These ancillary techniques are no different than those used in fringe v.h.f. installations.

An interesting comparison can be drawn between the size-gain relationship of u.h.f. and v.h.f. antennas. For example, a 6-foot parabolic reflector, which exhibits a 19-db gain at 890 mc. would need to be 25 feet across to provide the same gain at channel 2. Another example is the corner reflector, which at channel 2 would be 17 feet across and about 24 feet high for the same gain. Compare this to the u.h.f. corner reflector at roughly 20x30 inches.

One final note on antennas. Since the standing waves, which are always with us, repeat their patterns closer together at u.h.f., orientation of an antenna is a little trickier. Small movements of the antenna can make quite large changes in the signal strength delivered, so it is necessary to orient carefully—making slow, small moves of the antenna, and moving up and down, sideways, and back to front.

A great many installations will consist of adding a u.h.f. antenna and down-lead to an existing v.h.f. antenna installation. If no bad problems exist, such as ghosts or weak signals, no objection can be made to mounting the u.h.f. antenna on the same mast as the v.h.f. antenna. Certain precautions should be taken to avoid difficulty caused by the antennas interfering with each other.

In general, the u.h.f. antenna is considerably smaller than the v.h.f. antenna, which means that the v.h.f. antenna has elements out front which will pick up u.h.f. signals and re-radiate them into the u.h.f. antenna. This can produce either strengthened or reduced u.h.f. signals, depending on the phase of the re-radiated signals. The phase of these re-radiated signals can be changed by altering the relative vertical spacing.

Boiling this down to practice, in most cases of the typical 10-foot mast, the u.h.f. antenna should go on top of the mast, and the v.h.f. antenna at least 3 feet down from the driven elements (dipoles) of the u.h.f. antenna. If signals are less than expected or smeary pictures are noted, move the v.h.f. antenna up and down on the mast while watching u.h.f. pictures. When satisfied, recheck the v.h.f. signals.

When more mast room is available, keep the antennas

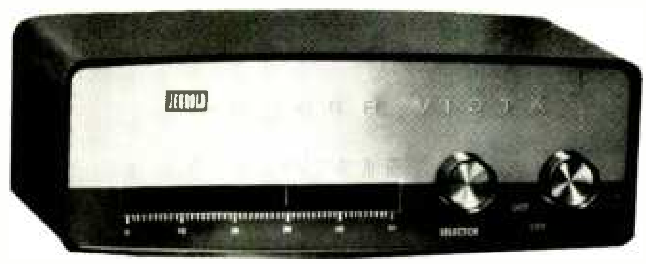


Fig. 3. This top-of-set u.h.f. converter uses a nuvistor in oscillator portion and high-frequency, low-noise transistor as the i.f. amplifier. Output is either v.h.f. Ch. 5 or 6.

Fig. 4. A mast-mounted, broadband u.h.f. preamplifier can be used to greatly improve the system's signal-to-noise ratio.

spaced vertically apart by a distance equal to the length of the longest element of the v.h.f. antenna. At this spacing, almost no interaction between antennas will be seen.

Transmission Lines

The next subject is the down-lead system—the transmission line. This area is probably the one where most mistakes are made. Parallel-pair transmission lines (both 300-ohm flat and tubular lines are parallel-pair lines) are bothered by things that are close to them—not necessarily touching, just close by. They are particularly prone to metal in close proximity, although any dense material will affect them. Certain points in using these lines are so important that we'll put them in the form of rules.

1. *Never* use flat-ribbon line outdoors for u.h.f. Use tubular or expanded, foam-type (*Continued on page* 78)

THE ELECTRONICS LAB TECHNICIAN: HIS ROLE IN INDUSTRY

By CYRUS GLICKSTEIN

What are the duties, responsibilities, requirements, and salary ranges for this important job in our R & D labs?

THE amazing growth of the electronics industry in recent years has been sparked by the outstanding achievements of scientists and engineers in the R&D (research and development) laboratories of our nation. Working side by side with engineers, laboratory technicians have also contributed substantially to progress in the industry. Engineers generally agree that lab technicians serve a vital function on the R&D team.

The laboratory technician is far from being just a handy man with a soldering iron who assembles circuits on a breadboard at the direction of an engineer.

Exactly what are the functions of a laboratory technician in an electronics manufacturing firm? What qualifications are expected of him when he applies for his first job and later on, when he is more experienced? What are the possibilities for advancement? What particular satisfactions does the job offer?

Most large- and medium-sized firms produce a variety of electronic equipment, while smaller firms tend to be more specialized in their output. The specific area of electronics the technician works in depends on the company he works for and the department and section within the firm to which he is assigned. The lab technician, therefore, may be assigned to a project in any one of the following fields: space electronics, radar, navigation or communications equipment, computers, antennas, industrial electronics, ultrasonics, TV transmitters or receivers, test instruments, automatic controls, medical electronics, nucleonics, or any other area of specialization covered by his firm. The lab technician may be assigned to either a military or commercial R&D program. If the firm does a substantial amount of military business, a number of projects may be classified and the technician will probably be required to obtain a security clearance.

Lab technicians function under a number of different titles, which may vary from company to company. Some of the more familiar job titles are: laboratory technician, electronics technician, R&D technician, and development technician. While there may be some differences in the specific duties assigned to a lab technician in various companies, the following is a generalized description of his activities.

The main duties of the lab technician consist of breadboarding; constructing experimental, prototype, and similar models of equipment; debugging; and testing. He may also be required to perform various paper chores such as requisitioning supplies, running curves, drawing up schematic and other diagrams, keeping test and other records, and helping to formulate specifications and handbook data.

Types of Projects

The company assigns a new project to the section concerned with that type of program. Within the section, the project is assigned to at least one team, consisting of engineers and lab technicians with a project engineer in charge.

In addition to R&D projects which have new or improved hardware as the end item, a firm may undertake study programs under contract to various government agencies and private organizations. These programs are generally preliminary studies of the feasibility of new circuits or an analysis in depth of a whole area of activity prior to determining the feasibility of new types of equipment.

If the project is a small one—for example a study program to determine the feasibility of a parametric amplifier in a frequency range higher than has yet been achieved—one team may be assigned. In this type of program, the lab technician's main duties would consist of breadboarding various circuits under the supervision of engineers, checking known and new types of circuit components and circuit arrangements, making measurements, running tests, plotting curves, and similar duties. Where called for, he will usually do most of the construction of the final breadboard which demonstrates the feasibility of the newly developed circuit.

If the project is a large one, a number of teams are used, each assigned to a key portion of the project, again with one project engineer in charge of the over-all program.

Program Phases

A large project involving the development of a complex piece of new equipment entails several phases. For example, a typical program for one of the armed services may call for a number of production units of the equipment as the end item, but the contract may also require several preliminary units to be developed, fabricated, and tested by the R&D teams. These preliminary phases will assure that the final units for field use will have the optimum design and maximum reliability that can be engineered into the equipment within the time limits specified for the program. In many cases a crash program is involved including the following:

1. *Breadboard model.* This consists of a breadboard of the entire system, after breadboards of all of the component subassemblies have been built and tested, to determine if the equipment can perform as required. The appearance and design of the breadboard version need not approximate the final production model.

2. *Experimental (XPM) model.* This model of the final equipment is used to demonstrate the technical soundness of the basic idea. This model does not have to have the required final form or necessarily contain parts of final design.

3. *Service test model (STM).* This model is used for testing under service conditions for evaluation of suitability and performance. It must closely approximate the final design, have the required form, and use approved parts or interchangeable equivalents. After an STM is completed, it may be given various environmental tests (vacuum, heat, humidity, cold, vibration, etc.) and delivered to the contracting

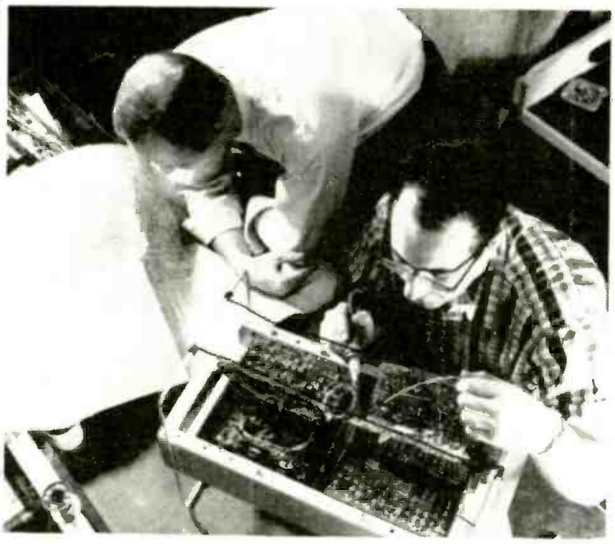


Fig. 1. Lab technician is constructing a breadboard subassembly following schematic prepared under engineering direction.

Fig. 2. The operation of a breadboard circuit is checked by a technician using signal generators and an oscilloscope.

Fig. 3. Technicians troubleshoot, debug, and check operation of completed subassemblies using various types of test gear.

Fig. 4. Subassembly is being subjected to extremes of temperature in the high-temperature test chamber shown in the center.

Fig. 5. After breadboard of entire system is completed and assembled, lab technicians perform system tests and debugging.

Fig. 6. Technicians make comprehensive performance check of completed system to see if it meets required specifications.

agency for test under various field conditions. As a result of these environmental and field tests, certain changes may be incorporated in subsequent models.

4. *Prototype (pre-production) model.* This model is suitable for making a complete evaluation of mechanical and electrical form, design, and performance. It must be of final mechanical and electrical form, use approved parts, and be representative of the equipment in its final form.

After approval by the customer, the prototype model is turned over to the production department which then fabricates production units. These incorporate final mechanical and electrical design changes and are made by production tools, jigs, fixtures, and methods, as applicable. In some cases, when the production runs are small and the equipment particularly complex, these production units may be turned over to the original R&D teams for final alignment and system testing prior to delivery.

R&D teams in larger projects involving military equipment are concerned essentially with the following models: breadboards, XPM's, STM's, and prototypes. R&D projects for commercial equipment generally involve fewer models between the breadboard and prototype stages.

In the initial design stages of the project, the broad lines of approach are laid down by the engineering groups involved—design, project, and staff engineers and various department consultants, while reliability engineers may pass on the reliability aspects of preliminary designs. In many cases, preliminary designs must be accepted by the customer before further development proceeds. The preliminary design on paper is based on past experience with similar circuits or on what is considered to be the most likely approach to new or radically different circuitry.

Technician's Duties

After the initial design has been accepted by the customer, breadboarding begins. See Fig. 1. Here, most of the actual work of constructing the breadboard version is done by the lab technician. He follows the schematic diagrams provided by the engineer, draws the necessary parts from the stockroom, solders circuits together where necessary, and checks as he goes along to determine if the circuit is operating as specified by the engineer in charge. Fig. 2. If not, he makes further checks, using appropriate test equipment, to determine if the circuit is wired up incorrectly or some part is defective. Depending on his qualifications, he may also test the effects of changes in some component values before reporting the results to the engineer. For breadboarding, the technician must know how to read schematic diagrams, have some degree of specialized knowledge in the area of electronics in which he is working, have a good knowledge of circuit behavior, and be familiar with construction and soldering.

At various points in the program, the lab technician may be required to run various operational and performance tests on the sub-assemblies (Figs. 3 and 4) and on the completed breadboard to determine if the equipment is operating correctly. In performing these tests, the technician may be called upon to use such test equipment as oscilloscopes, v.t.v.m.'s, digital voltmeters, power meters, counters, signal generators, and bridges. Tests may cover everything from an operational check of each step in firing up the equipment and verifying the operation of each control to measuring precise performance parameters including frequency, power output, selectivity and image rejection, distortion, s.w.r., noise figure, and similar characteristics.

In making such measurements, the technician must be familiar with various types of test equipment, know how to make such tests accurately, and how to record the results correctly. In many cases he will be expected to know when the test results indicate that the circuit is not operating properly and be able to report on the probable cause of the difficulty.

Debugging is an important part of developing new designs. When subassemblies are interconnected and tested, the circuit may not operate as planned. See Fig. 5. The cause may be one or more of the following: an incorrect connection, a defective part, unexpected interactions between circuits, complications introduced by loading, parts values which must be changed either because cumulative tolerances have affected operation, or for a number of other reasons. In debugging, the technician first tracks down the general cause of the difficulty, using test equipment if necessary. If the trouble is simple—such as a defective part—he makes the repair and re-tests the circuit. In more complex problems, where redesign may be involved, he makes circuit changes under the supervision and direction of the engineer in charge.

After the breadboard model is completed, tested, and accepted, the other models are constructed in turn. In each case, circuits are completed, tested, and debugged as necessary. Fig. 6. It is often discovered that in transforming a breadboard design into a more sophisticated model, new problems arise due to the use of new parts, differences in parts placement, space and weight limitations, and miscellaneous causes. Also, as the program proceeds, the customer may request changes in the original design to extend the capabilities of the unit; thus additional development work may be required as later laboratory models are constructed. The prototype model generally incorporates final design changes before a production run is started. However, because of the pace of new developments in electronics, additional design changes may be required in completed production units to improve or extend equipment performance.

At various points in the activities outlined thus far, the lab technician may be involved in different types of paper work. He may, on occasion, be asked to draw neat schematic, block, interconnection, or other kinds of diagrams for use by the drafting department as a guide for final drawings. He will usually record results of various tests covering performance parameters on appropriate data sheets, draw graphs when necessary, and assist engineers in providing technical writers with operation and maintenance data for use in reports and instruction manuals to go with the equipment.

Job Requirements

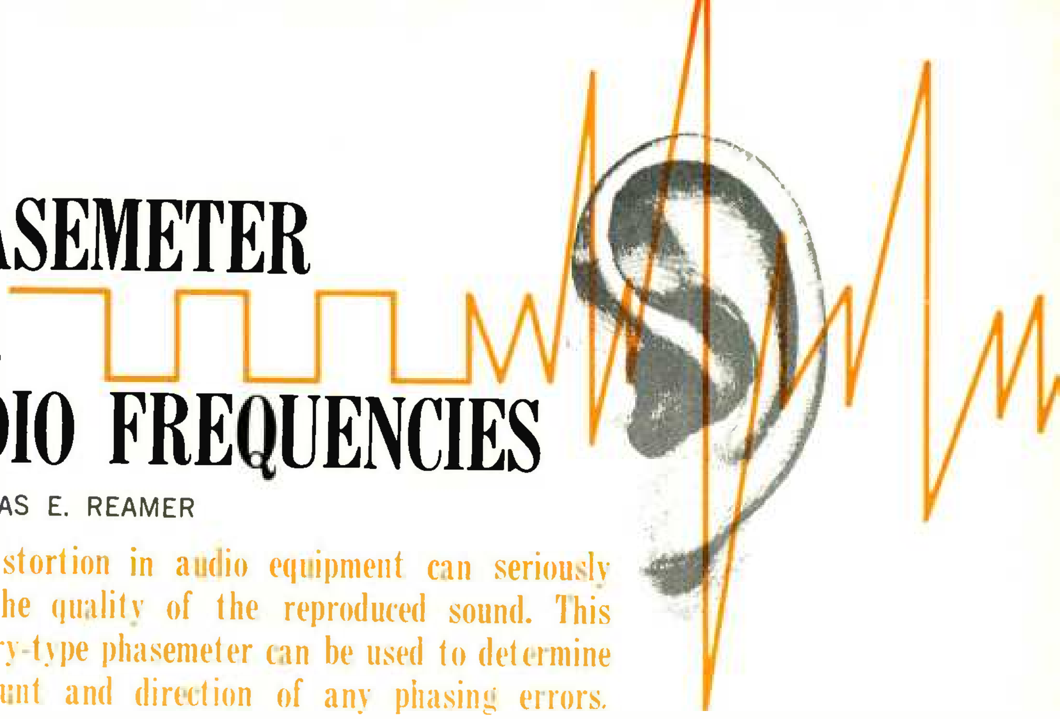
What are the requirements for a job as a lab technician? Many firms employ three grades of technicians—"A," "B," and "C," with "A" indicating the highest grade. Hiring may be done on all three levels, as dictated by personnel requirements at a given time. The job applicant is usually screened by the personnel department interviewer, then may be interviewed by an engineer from the department making the job request. In general, the following qualifications are expected of the applicant:

1. *Lab Technician Grade "C."* High school graduate plus technical training, such as a two-year electronics technology course, plus 1 to 3 years of qualifying experience, or an equivalent combination of these three requirements. The applicant will usually be tested on his technical knowledge.

2. *Lab Technician Grade "B."* High school graduate plus two years of college or equivalent plus 3 to 5 years of closely related experience. He must be familiar with specific types of test equipment, know how to use these in various electronic circuits, be familiar with laboratory procedures and construction practices, and have some specific knowledge of the area of specialization in which he will work (r.f. circuitry, digital circuits, radar, etc.). He can be expected to answer specialized technical questions.

3. *Lab Technician Grade "A."* High school graduate plus two years of college or equivalent plus 5 to 7 years of experience. Some recognition is given to specialized experience as a ham operator, FCC licensee, TV bench technician, Armed Forces electronics technician, but major experience is expected in laboratory work and in (*Continued on page 81*)

PHASEMETER FOR AUDIO FREQUENCIES



By THOMAS E. REAMER

Phase distortion in audio equipment can seriously impair the quality of the reproduced sound. This laboratory-type phasemeter can be used to determine the amount and direction of any phasing errors.

THE instrument described in this article measures the phase angle between an unknown voltage and a reference voltage of the same frequency at audio and ultrasonic ranges between 20 cps and 50 kc., and at voltage inputs from 0.5 volt to 60 volts r.m.s. without adjustment. The meter is calibrated from 0° (360°) to 180° full-scale and is accurate to ±3° of phase shift in the audio range. A 0°-18° full-scale range may be switch selected, and a phase shift direction circuit indicates the input with the leading phase angle. Phase readings may be made with much greater rapidity than with an oscilloscope and are generally more precise, especially at angles near 0° and 180°. The phase angle between waveforms such as saw-tooth, triangular, and square may also be determined; a difficult task with an oscilloscope.

Phase angle measurements are of significance when evaluating the performance of amplifiers, preamplifiers, crossover networks, transformers, loudspeakers, filters, and attenuators. The phase shift of low- and high-pass filters in multiplex circuitry is of recent interest. Several of these applications are discussed in some detail later in this article.

Phase-Shift Definition

Phase shift may occur when reactive elements (inductors or capacitors) are in the circuit. Reactive capacitances may cause a phase delay, *i.e.*, the output voltage from the circuit lags behind the input voltage. Reactive inductances may result in the output voltage leading the input voltage. These effects are shown in Fig. 1A.

Phase shift may be defined as the displacement in degrees, θ, of like zero-axis crossings of the reference and unknown voltages. If this definition is accepted, the indicated phase shift is correct even in the case where the reference voltage is a sine wave and the unknown voltage is a harmonically distorted wave.

The oscilloscope is a versatile and widely used instrument for the measurement of phase angle. A high-quality, dual-trace instrument can be used to display both the reference wave and the unknown waveform. Measurement of the displacement of the peaks of the two traces will indicate directly the phase angle. A spiral sweep circuit for use with an oscilloscope was devised by K. S. Lion and J. Goodman.[1] Two spikes radiate from the small circular sweep on the oscilloscope screen. Measurement of the angle between the spikes indicates the phase angle. Other techniques involving Z-axis trace blanking of a spiral sweep have been described.[2]

Lissajous figures, named after Jules Antoine Lissajous who first observed them with a pendulum forming a trace in sand, are a generally used oscilloscope procedure for the measurement of phase angle. The scope internal sweep is turned off and the two input signals directed to the vertical and horizontal inputs. The distances shown in Fig. 1B are measured and the phase angle, θ, determined with the aid of a sine table.

The method is limited to distortionless sine waves and the measurements must be carefully made, preferably from a photograph. The internal phase shift of the vertical and hori-

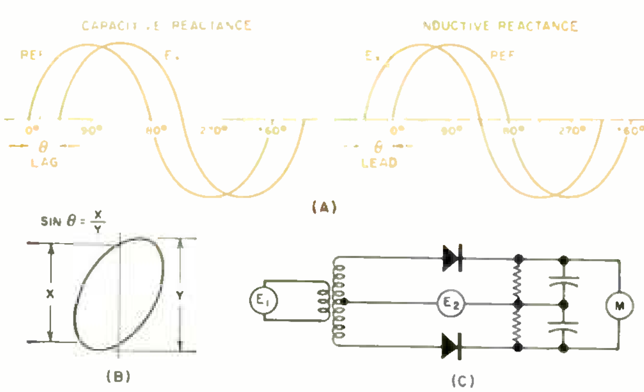


Fig. 1. (A) Phase shift resulting from capacitive and inductive reactance, (B) determination of phase angle from a Lissajous pattern, and (C) balanced modulator phase-measurement.

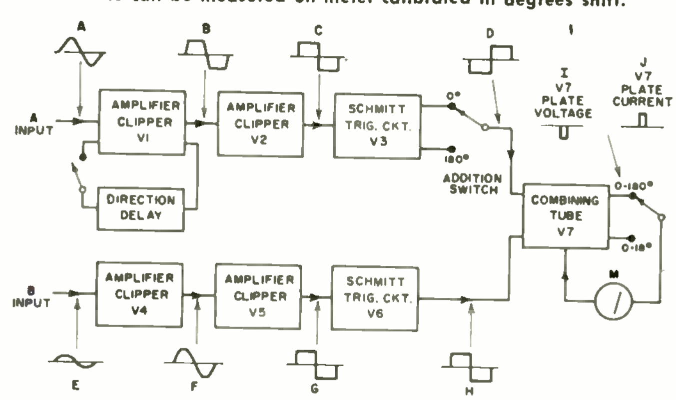


Fig. 2. The two series of square waves from each input channel are combined in a dual-grid tube so that any phase difference can be measured on meter calibrated in degrees shift.

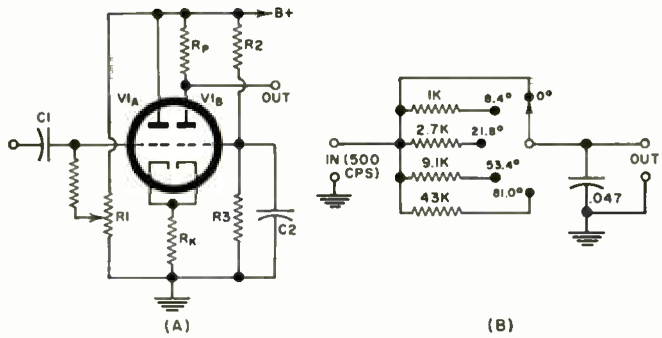
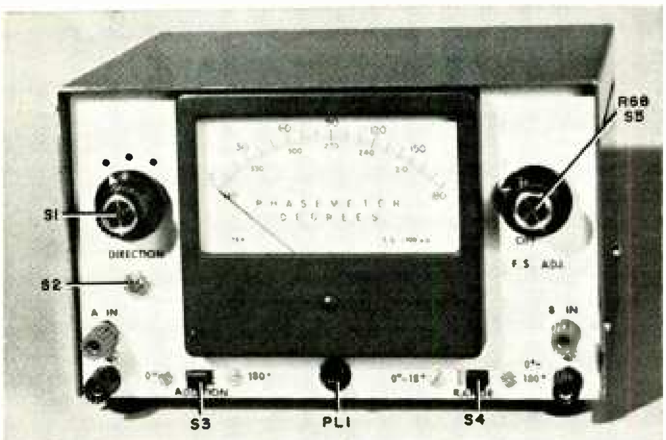
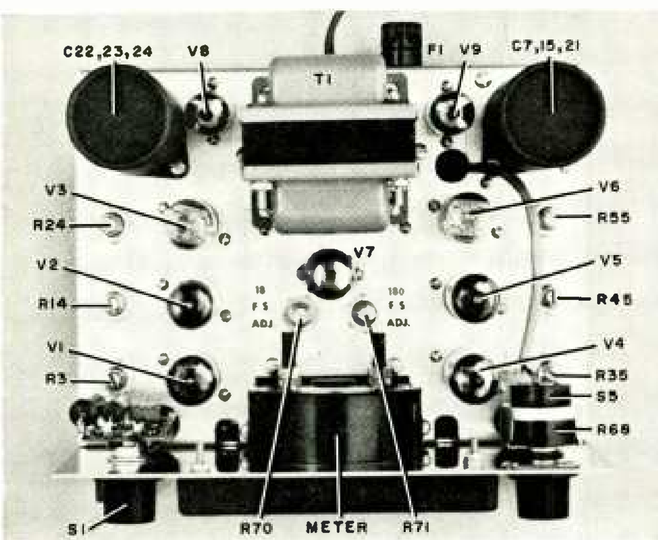


Fig. 3. (A) Cathode-coupled clipper amplifier circuit. (B) Phase standard circuit uses four 1% resistors, 5% capacitor.



Front-panel view of the audio phasemeter shows all controls.



Top-of-chassis view shows mechanical arrangement of parts.

zontal amplifiers of the scope should be identical. Measurements of phase angle near 0° and 180° are difficult as the ellipse is quite flat.

Another procedure for measuring phase difference is by the null method.[2] The phase and amplitude of the reference voltage is varied by a known amount until it just matches the unknown voltage as indicated by a null meter. Since most phase shifters are more or less frequency sensitive, this method is not as versatile as some others, although wide-band phase shifters have been described.[2]

A balanced modulator arrangement may be used for phase measurement[2,3] (see Fig. 1C). The meter indicates zero d.c. voltage when the phase of E_1 and E_2 differ by 90°, a negative voltage for 180° shift and a positive voltage for 0° shift. If the meter is calibrated in degrees, the input voltages must always be sine waves and have the same preset amplitude for all measurements.

A phasemeter operating on a different principle has been described.[4] The voltage of the unknown phase input is resolved into two basic components at right angles to each other. One component is in phase with the reference voltage, and a second component is at 90° to the reference voltage. The instrument separates these components and, with a precision multiplying circuit and meter, indicates the phase angle. Measurement is not affected by one-channel harmonic distortion.

A number of direct-reading, phase-measuring circuits have been developed. Instruments that determine phase angle at audio and ultrasonic frequencies include an early and basic design by Ginzton.[5] The two input channels of the instrument successively amplify and clip the peaks of the waves. Two stages of amplification and three dual diode tubes are used for each input. Pentode sum tubes terminate each channel and share a common plate resistor. The voltage drop is measured by a voltmeter calibrated in degrees.

A method of simultaneously amplifying and clipping a sine wave with a cathode-coupled, dual-triode clipper was suggested by Goldmuntz and Kraus.[6] This is a very worthwhile circuit and is described in detail later in this article. A phasemeter using this method of clipping was devised by Kretzmer.[1] Instead of using a sum tube at the termination of each input channel, the clipped wave is differentiated and converted to a pulse that triggers an Eccles-Jordan multivibrator circuit.[7] The output of the multivibrator is measured by a calibrated meter.

In 1953, Holman[8] suggested the use of a 6BN6 gated-beam, dual-grid tube as a means of measuring the phase difference between two sine waves. The unique construction of this tube results in rapid and sharp transition of plate current with moderate fluctuations in grid voltage. In addition, maximum plate current is limited and very positive grid voltages do not cause tube damage.

A phasemeter using three cathode-coupled clippers in each channel was described by Y. P. Yu.[9] The 6BN6 is used as a combining tube or coincidence slicer. The output of this tube is measured by a calibrated meter. Several ranges of sensitivity are provided by switch selection.

A transistor version of a phasemeter was designed by Woodbury.[10] An amplifier and diode limiters are used in each channel. The output of a multivibrator is measured with a calibrated meter.

The above instruments using limiters or clippers in each channel, followed by a combining circuit and a calibrated meter, may have an ambiguity of the direction of the phase shift in certain ranges. Partridge[3] describes the application of a capacitive delay circuit that may be inserted momentarily in one of the input circuits by a push-button. Correct interpretation of the results of the temporary delay will usually clarify the ambiguities. A circuit of this type is used in the author's instrument.

A very complete review of various types of phase measuring methods at low and very high frequencies is given by

Specifications of the Audio Phasemeter

Frequency Range: 20-50,000 cps, same frequency to each channel

Phase Measurement Range: High ±180°, or 0° to 360°
Low 0° to 18°

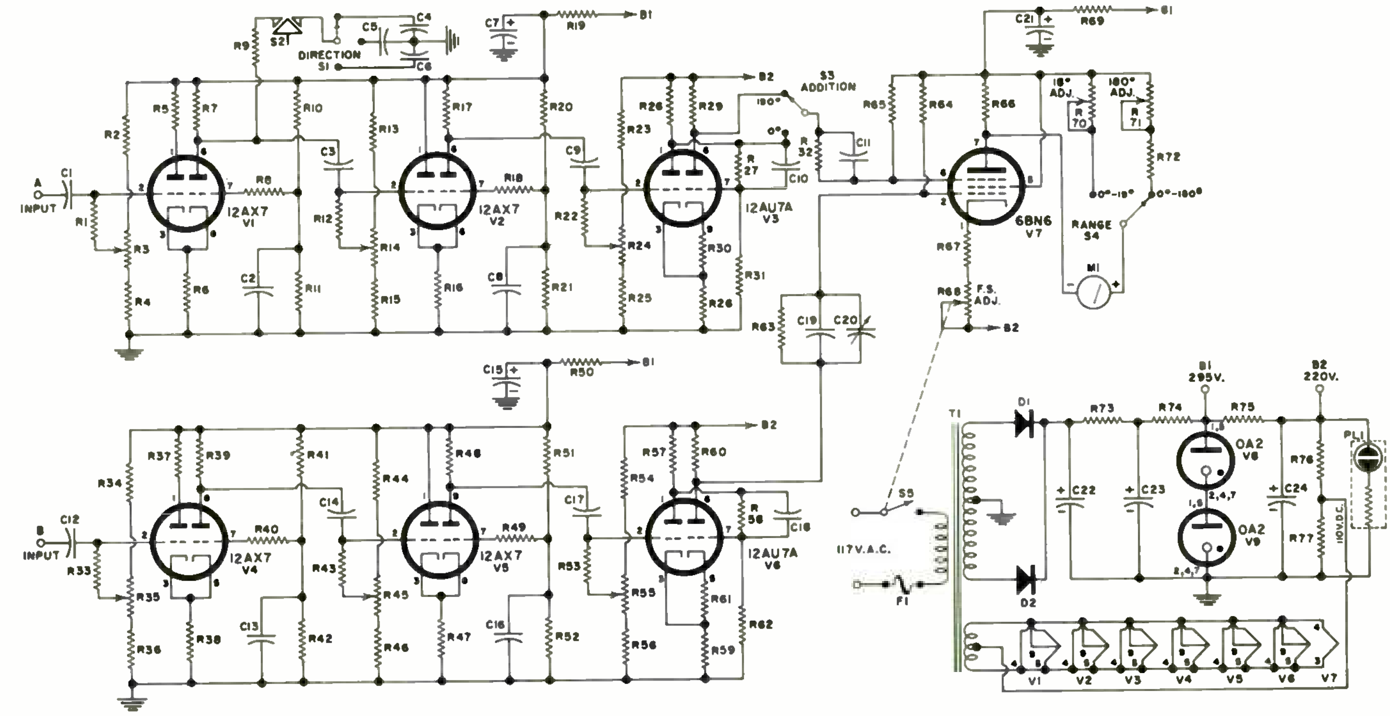
Input Voltage: 0.5 to 60 v. r.m.s.

Input Waveform: sine, saw-tooth, triangular, or square

Accuracy: ±3°, 20-20,000 cps; ±7°, 20 kc.-50 kc.

Input Impedance: about 1 megohm

Power Consumption: about 55 watts



R1,R33—2.2 megohm, ½ w. res.
R2,R34—330,000 ohm, ½ w. res.
R3,R14,R35,R45,R71—50,000 ohm, linear-taper pot
R4,R23,R36,R54,R72—100,000 ohm, ½ w. res.
R5-R37—100,000 ohm, ½ w. res. (matched pair)
R6-R38—220,000 ohm, ½ w. res. (matched pair)
R7-R39—100,000 ohm, ½ w. res. (matched pair)
R8,R18,R40,R49—270 ohm, ½ w. res.
R9—15,000 ohm, ½ w. res.
R10-R41—330,000 ohm, ½ w. res. (matched pair)
R11-R42—100,000 ohm, ½ w. res. (matched pair)
R12,R43—510,000 ohm, ½ w. res.
R13,R44—1 megohm, ½ w. res.
R15,R27,R46,R58,R64,R65—220,000 ohm, ½ w. res.
R16-R47—22,000 ohm, ½ w. res. (matched pair)
R17-R48—22,000 ohm, ½ w. res. (matched pair)
R19,R50—220 ohm, ½ w. res.
R20-R51—1 megohm, ½ w. res. (matched pair)
R21-R52—220,000 ohm, ½ w. res. (matched pair)
R22,R53—1.5 megohm, ½ w. res.
R24,R55—20,000 ohm linear-taper pot
R25,R56—47,000 ohm, ½ w. res.
R26-R57—10,000 ohm, ½ w. res. (matched pair)
R28-R59—22,000 ohm, 1 w. res. (matched pair)
R29-R60—10,000 ohm, ½ w. res. (matched pair)
R30-R61—470 ohm, ½ w. res. (matched pair)
R31-R62—150,000 ohm, ½ w. res. (matched pair)
R32,R63—33,000 ohm, ½ w. res.
R66—10,000 ohm, 1 w. res.
R67—27 ohm, ½ w. res.
R68—500 ohm, 5 w. linear-taper pot
R69—470 ohm, ½ w. res.
R70—10,000 ohm linear-taper pot
R73—1000 ohm, 10 w. wirewound res.
R74—2000 ohm, 10 w. wirewound res.
R75—15,000 ohm, 10 w. wirewound res.
R76,R77—150,000 ohm, ½ w. res.
C1,C12—.1 µf., 200 v. Mylar capacitor
C2,C8,C13,C16—.5 µf., 200 v. Mylar capacitor
C3,C9,C14,C17—.1 µf., 400 v. Mylar capacitor
C4—220 pf. mica capacitor
C5—.002 µf., 400 v. paper capacitor
C6—.02 µf., 400 v. paper capacitor
C7-C15-C21,C22,C23,C24—40/40/20 µf., 450 v. elec. capacitor
C10,C18—20 pf. mica capacitor
C11,C19—39 pf. mica capacitor
C20—8-50 pf. ceramic trimmer capacitor (Centralab 822-AN or equiv.)
S1—S.p. 3-pos. rotary switch
S2—S.p.s.t. push-button switch
S3,S4—S.p.d.t. slide switch
S5—S.p.s.t. line switch (on R68)
T1—Power trans. 300-0-300 v. @ 65 ma.; 6.3 v. @ 2.7 a. (Triad R5-A or equiv.)
D1,D2—1N2071, 750 ma., 600 p.i.v. rectifier
F1—½ amp fuse
M1—0-100 µa. meter ±2% (Weston Model 1941 or equiv.)
PL1—NE-2 with 100k res. (Dialco 249-7841-931 or equiv.)
V1,V2,V4,V5—12AX7 tube
V3,V6—12AU7A tube
V7—6BN6 tube V8,V9—0A2 tube

Fig. 4. Schematic and parts list for the audio phasemeter. A dual-grid, sheet-beam tube is used as the combiner stage.

such authorities as Terman and Pettit[2] and by Partridge.[3]

Phase-Shift Meter

The instrument operates on the principle of determining the zero-axis crossing points of the incoming waves. The exact crossing points are maintained while the rest of the wave above and below the zero axis is amplified and converted into a square wave. The two series of square waves from each input channel are combined in a dual-grid tube and the output measured on a meter calibrated in degrees of phase shift. A block diagram is shown in Fig. 2.

The operation of the instrument is best described by considering in detail the functions of the various sections.

The clipping of the unused positive and negative peaks of the input wave is advantageous in that the range of the input voltage to the instrument is greatly expanded. It may extend from voltages just sufficient to cause clipping, to voltages just below the grid current limit of the circuit; a range of 0.3 to 60.0 volts per channel in the present circuit. There are several means of clipping peaks of waves including limiting diodes, triode and pentode amplifier limiters, cathode followers, and cathode-coupled clippers.[11] The cathode-coupled clipper was selected for use because the upper and lower clipping levels are readily adjusted, the input impedance is high, some amplification of the signal occurs, and the usable voltage range of the input signal is large. The elements of the circuit are shown in Fig. 3A.

The positive bias potential of the two grids is controlled by the values of $R1$, and voltage divider, $R2$ and $R3$. Cathode resistor, R_4 is large. Capacitor $C2$, from the second grid to

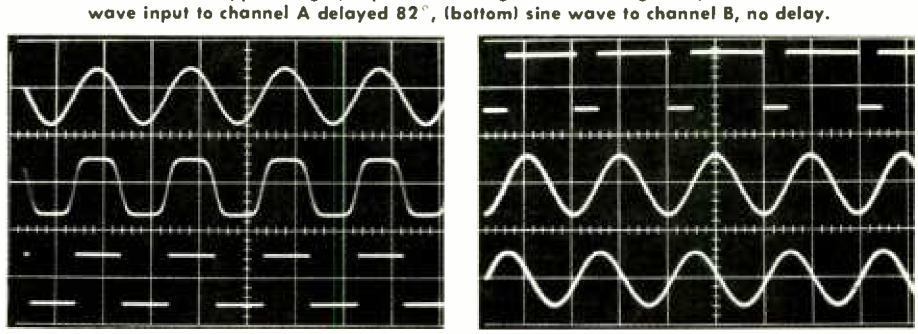


Fig. 5. (Left) Squaring action of cathode-coupled clippers. (Top) Original input sine wave, (middle) output of first clipper, and (bottom) final square-wave output from second clipper. (Right, top) Plate voltage of combining tube, (middle) sine wave input to channel A delayed 82°, (bottom) sine wave to channel B, no delay.

ground helps stabilize the d.c. voltage to this grid. A resistor in the plate circuit of *V1A* is often used, but is not essential to the operation of the circuit. The action of the circuit is as follows. On the positive half cycle of the input voltage, the plate current of *V1A* increases, raising the cathode potential of both *V1A* and *V1B*. Since the potential of *V1B* grid is fixed, the grid-to-cathode voltage decreases, reducing the plate current of *V1B* and increasing the plate potential toward "B+". The output remains at the high level until the input to *V1A* reverses and permits plate current to flow in *V1B*. The output then drops to a new voltage level determined by the bias on each of the control grids.

The amplification of the two cathode-coupled clippers before limiting occurs is about 200, considerably less than the possible amplification for these tubes in a conventional amplifying circuit. The progressive clipping action of this circuit is illustrated in Fig. 5 where the oscilloscope trace photo of

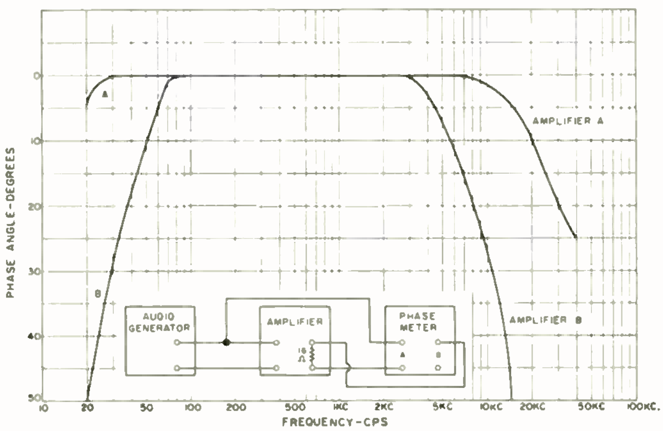


Fig. 6. Phase shift occurring at the output of a high-quality audio amplifier (A) and a low-cost preamplifier-amplifier B.

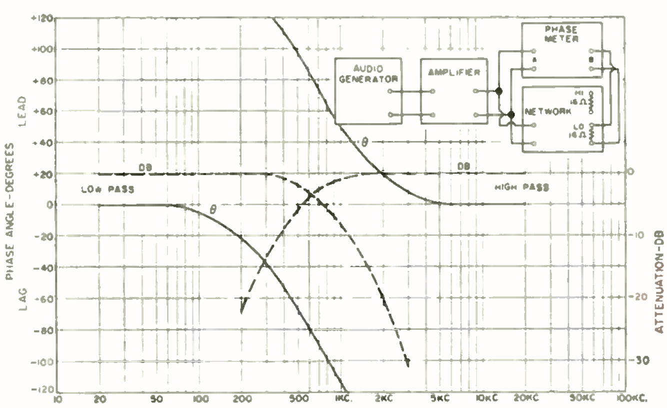
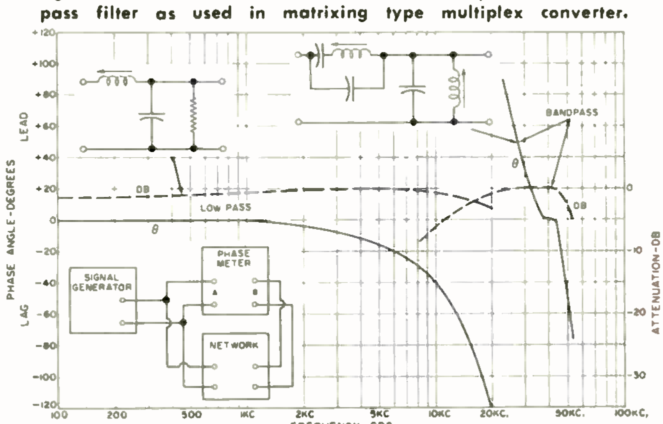


Fig. 7. Phase shift and attenuation in a constant-resistance 12 db-per-octave crossover network. Note extreme phase change.

Fig. 8. Phase shift and attenuation of a low-pass and bandpass filter as used in matrixing type multiplex converter.



the input sine wave and the outputs of the first and second clippers are shown.

A cathode-coupled binary, or Schmitt trigger circuit, is used as the third duo-triode in each input channel (*V3* and *V6* of Fig. 4). This is a conventional circuit except for the extra resistors, *R30* and *R61*, in the cathode circuits.[11] These resistors reduce the circuit hysteresis limits, *i.e.*, the minimum grid voltage swing required to trigger the binary. The circuit used in this instrument will respond to input voltages of about ±1 volt. The resistors in the plate circuit of the right triodes, *R29* and *R60*, are not essential to the operation of the Schmitt, but do restrict the output voltage to desired limits. The zero-axis crossing points of the Schmitt trigger square wave will vary somewhat as the input voltage varies. Since this effect cannot be tolerated in a phasemeter of this design, the voltage input to the Schmitt is kept constant by the use of the preceding cathode-coupled clipping circuits. Otherwise the entire circuit of the phasemeter could have been simplified. The output square wave in the A channel is taken from either the left or right plates of the Schmitt as determined by the position of the "Addition" switch, S3. The slight rounding of the top and bottom of the square wave from the left plate under some conditions of low input voltage is of no consequence as the following 6BN6 tube operates on voltage differences as low as ±2 volts.

Combining Circuit and Meter

The dual-grid, sheet-beam 6BN6 tube used in the combining circuit for the A- and B-channel outputs is unique in that it varies from full-plate current to cut-off with a grid voltage change of ±2 volts. A parallel resistive-capacitance coupling connects the clipped output of the A and B channels to the two control grids of the tube. In addition, bias is applied from the high-voltage supply to each of the grids through resistors *R64* and *R65*.

The plate of the tube is supplied from the +295-volt *B1* supply while the cathode is supplied from the 220-volt *B2* supply. The voltage drop across the tube is consequently about 75 volts, well within its working limits. The large voltage difference between cathode and heater is reduced by applying a fixed d.c. voltage to the heater by resistors *R76* and *R77*. Ideally, a separate filament supply winding, at about 200-volts d.c., could have been used. The circuit used for the 6BN6 tube is adapted from the design published by Y. P. Yu.[9]

The waveform at the plate of the 6BN6 tube is shown in Fig. 5. The top right trace shows the abrupt voltage change in this tube. The two sine-wave inputs to the instrument's A and B channels are shown displaced 82°.

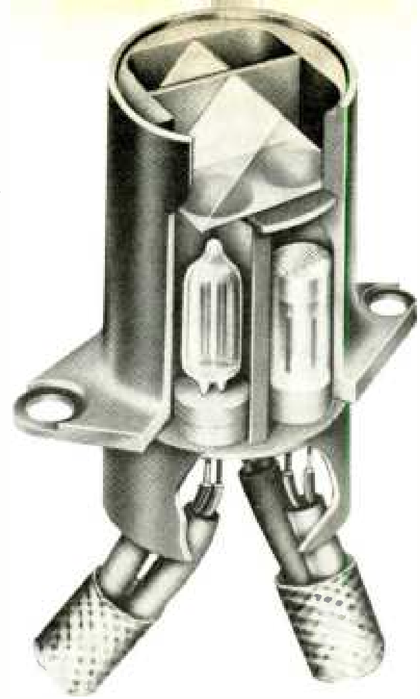
The meter connected to the plate of the 6BN6 measures a fixed proportion of the plate current; the balance of the current is shunted by the plate resistor, *R66*. The circuit constants are chosen so that the current indicated by the meter is linearly related to the phase displacement of the incoming signals and, in addition, a phase shift of 180° represents full-scale deflection, or 100 μa. on the meter (18° on the reduced scale). The meter is calibrated in degrees of phase shift. Fixed and variable resistors are connected in series with the meter to permit exact calibration.

A phase-direction circuit is incorporated in the instrument and permits the application of a phase delay to the A channel. This circuit consists of *R9* in series with switch-selected capacitors *C4*, *C5*, and *C6*. The delay circuit is momentarily activated through push-button switch, S2. The use of the circuit is described in the section on operation.

Construction

Despite a generous supply of components, especially resistors, a relatively small, 6"x 8¼", chassis is used. The chassis and cabinet, *LMB* W-1C, are purchased as a unit. As will be noted in the photographs, (*Continued on page* 97)

NEW LIGHT-OPERATED SWITCH



Description of Raytheon "Raysistor," a photocell with self-contained light source, along with an application in an automatic gain control circuit for SSB receivers.

By DONALD E. WHATELEY
Applications Engineer, Industrial Components Div.
Raytheon Company

In this dual prototype unit, light from glow lamp (at the left) is reflected by the prism onto the photocell, mounted at the right.

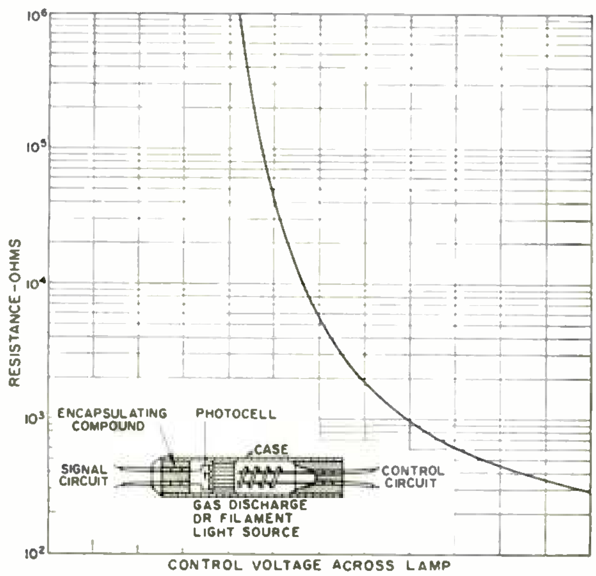


Fig. 1. Construction of "Raysistor" and its characteristics. Actual control voltage depends on which "Raysistor" is used.

DO you want a device which will let you control an a.c. signal with a d.c. voltage? Or that will let you control a high-voltage supply by adjusting a rheostat in series with a 1-volt supply? The new *Raytheon* "Raysistor" is designed to fit these applications and many more.

The device is made up of a lamp and a special photocell in a light-tight enclosure (Fig. 1). When light falls on the photocell, its resistance changes. By varying the power into the lamp, the photocell resistance is made to vary. There is no electrical connection between the two components and they are coupled only by the light beam. As the voltage applied to the lamp is changed, photocell resistance changes as shown.

In order to cover a wide range of applications, *Raytheon* manufactures various types of "Raysistors." These differ mainly in the type of lamp used to illuminate the photocell. Units incorporating ionized-gas lamps have a fast response time but a rather limited resistance range, so these are intended for switching applications. Units incorporating filamentary lamps have a slower response due to the thermal lag of the hot filament but these cover a wide resistance range and are intended for variable resistance types of applications.

Most of the devices have similar types of cases, using either a 2" x ¼" Monel metal tube with flexible leads or an epoxy resin case with stiff leads intended for printed-circuit use. One of the "Raysistors" using a filamentary lamp is built inside a TO-5 transistor case for use where weight and space are limited. Other special larger cases (up to 3" x ½") are used for units designed for controlling very high voltage circuits where isolation between the lamp and the photocell of up to 25,000 volts is required.

Although most applications of the light-operated switch are industrial, one interesting use of the device is in the amateur or commercial communications field.

Automatic Gain Control Circuits

The "Raysistor" can be used as a remote volume control or to provide a simple means of applying a.g.c. to single-sideband suppressed-carrier amateur or communications receivers. When operating an SSB receiver in an amateur radio station, very often a discussion is carried on among a number of different stations of differing signal strengths. Listening then entails the rapid adjustment of the a.f. volume control in order to keep the audio output constant. Under these circumstances an a.g.c. (*Continued on page 72*)

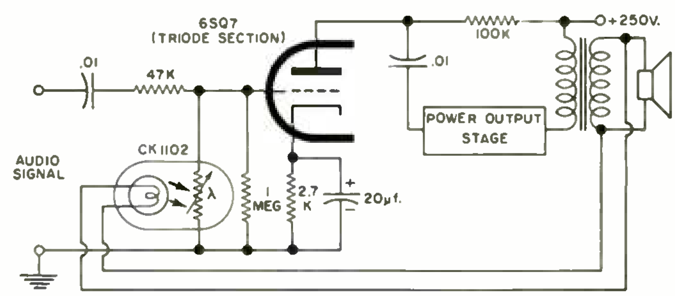
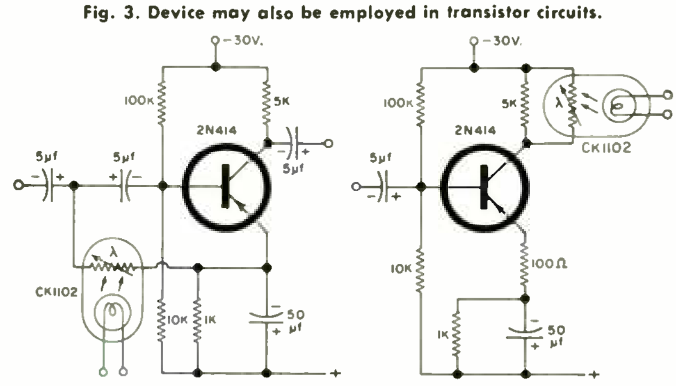


Fig. 2. Use of the new device in a receiver a.g.c. circuit.

Fig. 3. Device may also be employed in transistor circuits.



By EDWARD S. MILLER, R. GRODINSKY, and C. WESTRA
Sherwood Electronic Laboratories, Inc.

TRANSISTORS vs TUBES for HI-FI

Here is Sherwood's design philosophy on the use of transistors versus tubes in hi-fi power amplifiers.

Editor's Note: Our September and October issues contained an important two-part article "Transistors for Hi-Fi: Panacea or Pandemonium?", which represented the views of H. H. Scott engineers on the use of transistors for hi-fi power amplifiers. We felt that many of the points made were important enough and controversial enough to warrant further discussion and comments. Therefore, we sent copies of the article to a number of authorities in the hi-fi field soliciting their comments—whether in agreement or opposed. Our first response is given below. In further issues we hope to publish comments from Robert E. Furst of Harman-Kardon, Fred L. Mergner of Fisher Radio, Morley D. Kahn of Acoustech, Dave Hafler of Dynaco, and others.

THE transistor design engineers at *Sherwood Electronic Laboratories* did not find many points in the article with which they disagreed. Many of the design philosophies discussed correlate with our own findings as evidenced by the design techniques involved in our solid-state integrated amplifier. Our comments, therefore, are primarily an extension of the discussion and relate especially to higher powered equipment suitable for operation in more difficult environments. First, let us discuss some of our findings relative to the so-called "transistor sound," and then we will cover the types of transistors to be used and outline some of the design techniques involved.

Transistor-Amplifier Sound

Some of the possible reasons for the superiority of a transistor amplifier's sound over that of a comparable vacuum-tube amplifier have been analyzed. In addition to the effects mentioned by Mr. von Recklinghausen and his co-authors, two special differences were noted. The first of these is that the typical tube amplifier will not only cause a sine wave to have its crest clipped when the overload point is reached, but also the waveform will be collapsed or kinked in the middle at the zero-axis crossing. (This is similar to severe crossover distortion in an improperly biased transistor amplifier.) See Fig. 1.

It was discovered, through listening tests, that the kinking-type distortion was several times more noticeable to the human ear than was a comparable amount of peak-clipping distortion. Almost all common tube amplifiers exhibit a large amount of the kinking distortion when overloaded because the grid circuit of the output tubes contains a resistive element that may develop a distorting bias due to grid-current flow. A good transistor amplifier design, on the other hand, can supply the low-impedance base drive requirements *without* disturbing the bias even under high overload conditions.

A transistor amplifier was found to sound like its tube counterpart with up to 75% greater power output rating when operated in overloaded conditions. It was also observed that listeners seldom were aware that slight overloading, causing clipping and some kinking of the waveforms, was taking place in their tube amplifiers although an oscilloscope proved that this condition existed. The typical listener's analysis was that the tube amplifier "just did not sound as clear as the transistor amplifier"; however, he did not believe that either amplifier was being operated beyond its rated capability as the oscilloscope proved the case to be.

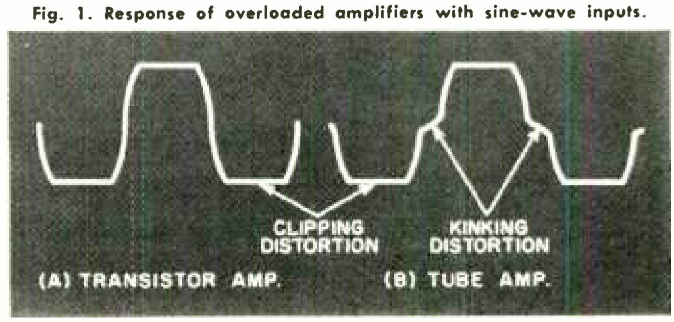
In addition, we believe Mr. von Recklinghausen's quick survey of typical speaker systems to be somewhat conservative, because we have discovered several speaker-system designs with impedances as low as 40% of rated speaker impedance in the tweeter range. *(We have scheduled for an early issue an article dealing with loudspeaker matching problems and hi-fi transistor amplifiers.—Editors)*

Typical integrated tube amplifiers unfortunately have increasing attenuation at the very high frequencies, produced by a shunt capacitor to ground in a driver stage. This has been done purposely by the designer for stability and to prevent waveform overshoot and oscillation with reactive loads. However, the use of this capacitor results in reduction of feedback voltage causing loss of regulation and a poor damping factor. This aggravates the condition pointed out in Fig. 6 (Part 1, September issue). This figure showed quite a difference in speaker response when the speaker was used with an amplifier with very low damping factor as compared to one with a very high damping factor. Good transistor amplifier design, because it is free from output-transformer phase shift, generally requires less shunt capacitance to ground within the feedback loop for stability so that the damping factor can be maintained almost constant to 15 kc. and beyond.

The resultant high-frequency square-wave response is generally much smoother and freer of overshoot as compared to the response of its tube amplifier counterpart. See Fig. 2. This is due to the elimination of the output transformer with its complex phase shifts caused by its leakage reactance and interwinding resonances. Our listening tests indicated that even small amounts of overshoot peaks and ringing could be detected when compared to the smooth waveform of the transistorized amplifier.

Finally, it was observed that with waveforms that do not have half-wave symmetry, the transistor low-frequency re-

Fig. 1. Response of overloaded amplifiers with sine-wave inputs.



sponse was more faithful to the proper waveform than with comparable tube designs, as shown in Fig. 3. A waveform without half-wave symmetry is a saw-tooth. This waveform is not commonly used in amplifier evaluation tests. (Sine-wave distortion, intermodulation distortion, and square-wave checking are all done with symmetrical waveforms containing only odd-order harmonics.) The saw-tooth with its even- as well as odd-order harmonic structure is quite similar to the waveform of many sounds in nature. This can be observed with human speech as well as wind instruments.

Types of Transistors

We believe inadequate emphasis was placed on the superiority of silicon over germanium transistors for low- and medium-level audio applications. One of the early bugaboos of transistors was the failure and deterioration of circuit performance due to base-current variations caused by rising ambient temperatures. This problem was severe with germanium types thus requiring various stabilizing techniques in the design. Silicon types are gratifyingly free from this difficulty in the temperature range anticipated with high-fidelity component equipment. We find that some silicon types are presently being manufactured which can offer noise figures, frequency response, and distortion levels which are entirely adequate for high-performance audio amplifiers.

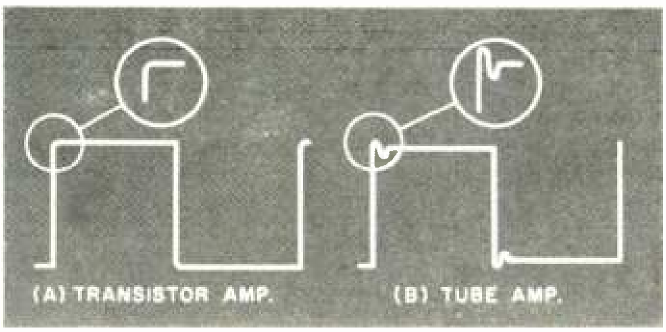


Fig. 2. Square-wave response at fairly high (5-kc.) frequency.

Unfortunately, this is not true for the power stages which still require germanium diffused-alloy transistors. Although the technique of using finned, extruded, and black-anodized heat sinks (with the fins vertically oriented) might barely suffice for 30-watts-per-channel amplifiers, this does not allow a great enough safety margin for a 50-watts-per-channel amplifier. This is especially true if the amplifier is subjected to extreme environmental conditions that might destroy the germanium output device junctions in a short time.

These environmental situations include:

(1) Enclosed-area custom installations with confined air-circulation possibilities.

(2) Installation in the same custom-built enclosure with a vacuum-tube tuner.

(3) Vertical mounting of the chassis (with the control knobs up) in a custom installation which destroys the "chimney-effect" air flow needed to cool the output transistor heat-sink fins.

(4) Unusual operation calling for continuous duty at or near full output, as would be the case with a continuous-tone test recording.

(5) Operation into a shorted or near-shorted output load such as might occur during the original installation. Here, the installer might not be aware of this short circuit until he has turned up the volume control to see why the amplifier isn't performing properly; in which case, several amperes would be delivered by the output transistors. Furthermore, the designer's precautionary measures of specifying large separating barriers on the amplifier output terminal board cannot prevent a short circuit at the speaker terminals.

(6) Finally, the environmental temperature can rise to over 100 degrees F in some communities during the summer months, while poor placement of the equipment can subject it to the heat of radiators during the winter.

Because any or all of the above conditions could quickly (sometimes in less than 20 seconds) exceed the safety factor allowed for germanium output transistors, we have decided that a compact, dual 50-watt integrated amplifier should be constructed with forced-air ventilation, constantly passing over the finned aluminum heat sink. In addition, should the forced-air fan motor be stopped for any reason or prove to be cooling inadequately, a thermostat located on one of the output transistors will immediately remove the power-supply voltage from the power-output stages.

Should a momentary short be applied to the output for a period of 1 msec. or more, the amplifier has a special feedback circuit (patent pending) utilizing a non-linear current-sensing element which will immediately remove the audio-drive voltage. This non-linear current-sensing circuit can be bypassed by a short circuit from an output terminal to chassis, but, in this case, a small 3AG fuse would open here and protect the output transistors against damage. (Our experience with using fuses as fool-proof devices to protect the output transistors is that even the new fast-acting types do not open rapidly enough to protect the transistors.)

The circuit designer must also consider the possibility of the output being shorted during installation *before* the amplifier is turned on. When the voltage is applied initially in this shorted condition, a well-regulated "B" supply could deliver up to several hundred watts of power through the output transistors to charge up the grounded (by the short) output coupling capacitor. This would be sufficient to destroy most output transistor junctions immediately.

One technique that would safeguard against this occurrance would be to provide a relay to delay application of full "B"-supply voltage until the operating coil sensed that the supply voltage could rise further without problems. Another technique would be to use a double "B"-supply voltage arrangement (one negative supply and one positive supply). With this circuit the output transistors are matched so that their junction point, from which the output is taken, will be at zero volts, thus eliminating the output coupling capacitor. We have preferred not to use this circuit because of the possibility of a d.c. voltage being developed here that would affect speaker performance.

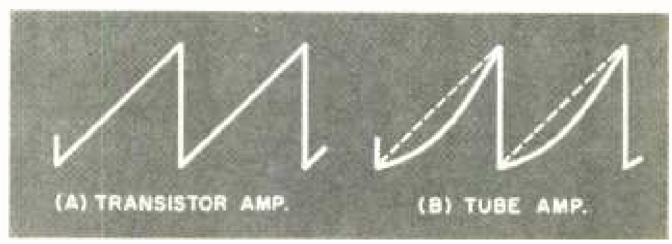


Fig. 3. Saw-tooth wave response obtained at frequency of 30 cps.

With all these protective features, a compact, integrated high-performance transistor amplifier has been built which can be operated with both channels delivering 55 watts r.m.s. at any audio frequency. This performance can be obtained even when the unit is confined in a typical custom installation without fear of losing the output transistors (at $12 each to the consumer) even when both channels are short-circuited.

In order to achieve this type of continuous operation, it is necessary for the power-supply regulation to be optimized and the series-load path losses to be minimized. Some of the possible series losses that can be encountered are in the output coupling electrolytics which must have unusually low series losses. (We specify less than 0.25 ohm.) Series resistive elements in the "B"-supply necessary for filtering are kept to below 3 ohms. ▲

CHOOSING A TWO-WAY RADIO SYSTEM

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

PART 1. Before choosing a two-way business radio system, some of the problems associated with frequency, range, and type of equipment should be understood.

Transistorized hand-held unit delivers 1.4 watts of r.f.

HOW far can I talk? This same question, in one form or another, is among the first asked by most businessmen when they are considering a two-way radio system. Certainly one of the major considerations in two-way radio system design is range.

Considering a simple system with an omnidirectional base-station antenna, coverage area will be simply the area of a circle with the base-station antenna at the center. If we can squeeze an extra mile out of such a hypothetical system, the coverage area will increase dramatically. For example, if the original range of the system were 10 miles, that extra mile in range would increase the coverage by 65.9 square miles, with this added coverage at the extremities of the system. Suppose, because of inefficiencies such as equipment operating at less than peak performance, impulse noise, and other factors, the range of our hypothetical system is only 90% of its maximum value, then the loss in range is 10% and the coverage area lost is 19%.

The most startling figure is derived when we consider an even distribution of clients throughout that circular area. With a 10% reduction in range, the two-way radio user cannot service almost 1 out of every 5 customers because of the limitation placed on his communications ability. His gross income is only $4.05 instead of the $5 he deserves.

These figures, of course, depend on many ideal situations, none of which really occurs: a perfectly circular radiation pattern, a perfect distribution of clients throughout the area, each customer spending the same amount of money, and many other factors which can exist only in mental exercises such as this. The figures do point out, however, the importance of range to the two-way radio user.

Before diving headlong into range considerations, the prospective two-way radio user should first determine under what section of the FCC Rules and Regulations his proposed system will be licensed. Most business radio systems will probably be eligible under Part 11 of the FCC Rules, The Industrial Radio Service. Other applicable sections of the FCC Rules which regulate most of the remaining commercial two-way systems are: Part 10, The Public Safety Radio Service; Part 16, The Land Transportation Radio Service; Part 19, The Citizens Radio Service; and Part 21, The Domestic Public Radio Service.

The first step in the actual design of a two-way radio system is the selection of the frequency band on which the system will be operated. The frequency band can not only influence the ultimate range of the system, it can also be an important factor by which over-all system performance—and, therefore, satisfactory communications—is measured.

Although some users are more restricted as to the band in which they can be licensed, most users have three separate portions of the spectrum available.

The band which is commonly referred to as the *low* band includes those frequencies between 25 and 50 mc.; the *high* band covers 150 to 174 mc.; and the u.h.f. (or 450) band is made up of channels between 450 and 470 mc. Since frequency choice determines many of the operational benefits the user can derive from his system, we would do well to examine each of the different bands in some detail.

Low Band

Because of the longer wavelengths of frequencies in the low band, signals tend to follow the curvature of the earth. Consequently, communications range, per transmitter watt output, is the highest at these frequencies. On the detrimental side is the fact that gain antennas are generally not practical because of the longer wavelengths involved. Noise, particularly ignition and other types of impulse noise, can be especially troublesome, although several manufacturers have recently made remarkable strides in overcoming impulse noise with electronic noise suppressors which operate within the receiver itself. Skip interference, during periods of extreme sunspot activity, has also been a problem to low-band users; cases are on record of skip signals having been received at distances greater than 1000 miles from a relatively low-powered two-way radio transmitter.

High Band

The antenna-to-antenna range of systems operating in the 150-174 mc. region is somewhat less than that obtained in the 25-50 mc. band. However, gain antennas are much more practical at these frequencies and a high-gain antenna can be used quite effectively to increase the "talking range" of high-band equipment. Radio signals at 150 mc. are more subject to obstruction by hills or mountains than are signals at 25 mc. On the other hand, high-band signals tend to bounce about large buildings in metropolitan areas and, as a result, this frequency band is more suitable for metropolitan systems than is the 25-50 mc. band. There is less impulse noise present in this portion of the spectrum and skip interference at these frequencies is rare.

U.H.F. Band

Until recently, the variety of two-way radio equipment available for operation in the 450 to 470 mc. band has been quite limited. However, such compensating factors as exceptionally high-gain u.h.f. antennas and a greatly improved selection of reliable radios combine to produce operational benefits equivalent to those afforded by the 150 to 174 mc. high-band allocation.

One of the chief reasons for the recent interest in the u.h.f. band is that the lower frequency channels are overcrowded to the point of saturation in many sections of the country. Furthermore, u.h.f. frequencies have a high reflective ability and these signals fill in metropolitan areas where lower frequency communications would be virtually impossible. Such u.h.f. signals also rebound inside tunnels and underpasses and often allow readable messages to be received by a mobile unit while the vehicle is passing through a tunnel. Noise and skip interference are virtually non-existent at 450 mc.

Another interesting phenomenon which occurs at 450 mc. is the near absence of a fringe area—an area at the extremities of the system in which communications is questionable but not impossible. At u.h.f. frequencies, the signal will usually be strong enough to override noise and other interference all the way out to the limit of usable range, because of the low level of interference at u.h.f. frequencies. Beyond the limit of range, however, incoming signal strength will drop off quite rapidly. For this reason, the user should not depend on even questionable communications beyond his normal operating range, and the system design should be a bit more conservative than is necessary at the low- and high-band frequencies.

Once the proper frequency band has been selected, the problem still remains of obtaining maximum range within that band, or at least as much range as is economically possible. The range of a communications system is theoretically limited to line-of-sight. This, of course, is not true of the lower frequencies, but it does form a good rule-of-thumb from which to begin. We can define line-of-sight, in this application, as the distance from the antenna to the horizon. Thus, the range of the system is a function of the effective height of the base-station antenna.

It may surprise some readers to learn that base-station antenna height is actually more important in range considerations than is the rated power of the base-station transmitter. For example, doubling the height of the base-station antenna adds about 6-db gain to the entire system; doubling the transmitter power adds only 3 db. Antenna height is also effective both for talk-out (base-to-mobile) range and for talk-back (mobile-to-base) range, while base-station power is effective only in the one direction. Antenna towers are quite economical when compared to the cost of a higher powered transmitter and existing buildings can even be used to achieve part of the necessary height. For an antenna mounted at a fixed height above ground, the effective height increases as a function of earth conductivity at the antenna location as shown in Fig. 1.

The subject of two-way radio antennas has been dealt with in a previous article "Antennas for Business Radio," ELECTRONICS WORLD, March, 1963, and the reader is referred to this article for a more comprehensive discussion of the subject. It should be sufficient, here, merely to say that gain antennas are another important consideration in obtaining maximum over-all system range. Directional antennas, on the other hand, provide added gain over non-circular areas in those systems which require the most efficient communications through only a restricted portion of territory. Once the base-station antenna and antenna tower have been chosen for optimum range, the next major consideration—r.f. power output—is then ready to come into play. All the considerations which precede the selection of the r.f. power rating allow a more efficient use of each watt radiated and once the previous steps have been taken to optimum advantage, the base-station power can be used to bring the range up to final expected values.

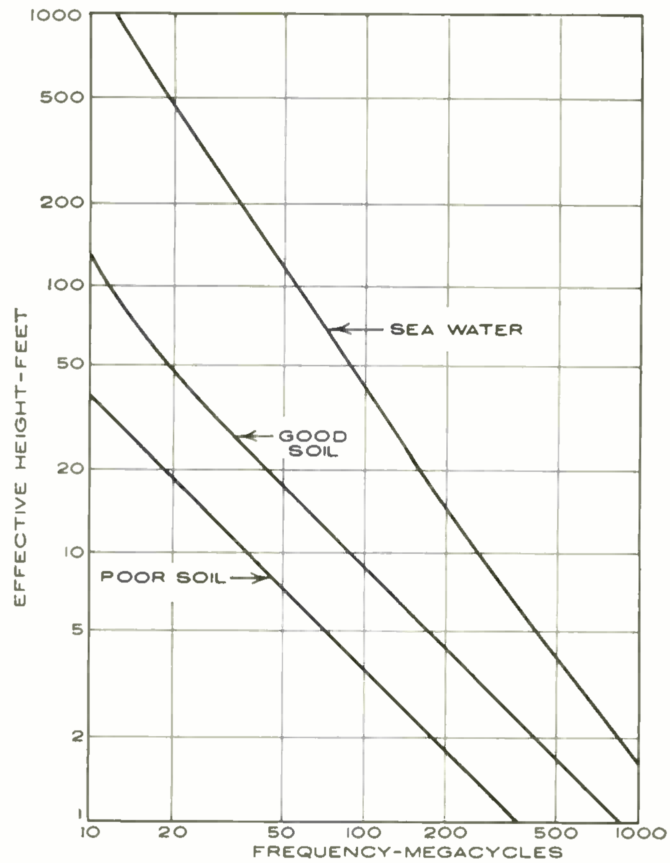


Fig. 1. Minimum effective antenna height, vertical polarization.

Typical self-contained mobile radio for vehicular mounting.

There is very little which need be said at this time on the subject of power, as Table 1 should tell the story quite adequately. The information shown in this table is valid for smooth earth using a dipole base-station antenna and a quarter-wave mobile-whip antenna. Notice that the entire system is referenced to the height of the base-station antenna, even though the power figures can be used for the r.f. output of both the base-station transmitter and the mobile (or portable) transmitter. Therefore, the table gives mobile-to-base as well as base-to-mobile ranges. Remember, however, that the range figures are strictly average values and are published for reference only; they should not be used as the sole basis for absolute range predictions. This caution cannot be emphasized too strongly. Final range values should be judged by a competent two-way radio specialist only after a study of specific system requirements.

A great deal of useful and interesting information can be derived from this table by interpolation and by considering additional factors. As an example, values are based on a unity-gain base-station dipole antenna. However, gain antennas in the 150-174 mc. and 450 to 470 mc. regions will increase the over-all range of the system. Each db of gain

Portable two-way radio is outgrowth of wartime walkie-talkie.

Antenna Tower Height → / R.F. Power Output ↓	25-50 mc.				150-174 mc.				450-470 mc.			
	50'	100'	150'	300'	50'	100'	150'	300'	50'	100'	150'	300'
10 Watts	15	19	22	30	11	14	16	21	8	10	12	16
30 Watts	18	24	28	37	13	17	20	26	10	13	15	19
60 Watts	21	27	32	43	15	19	23	30	11	14	17	22
100 Watts	23	31	36	48	16	21	25	33	12	16	19	24
250 Watts	27	37	43	58	19	26	29	37	14	18	22	27

Table 1. Nominal mobile coverage is valid for smooth earth using dipole base-station antenna and quarter-wave mobile whip. Ranges are given in miles. Each db gain adds about 5% while each db loss subtracts about 5% from the basic range. Doubling the antenna height adds 6 db. Doubling power adds 3 db. 5 times power adds 7 db while 10 times power adds 10 db.

represents approximately 5% increase in range. An 8-db gain antenna would improve range by about 40%, so an additional 10 miles is quite possible if the table shows a basic range of 25 miles and an 8-db gain antenna were used. By the same token each db of loss—such as along the transmission line—will subtract about 5% from the value cited in the table. This must also be considered.

Additional interpolation data is shown on the table. Each time the antenna height is doubled, an additional 6 db (or 30% range factor) can be added to the system. Twice the power adds 3 db, 5 times the power adds 7 db, and 10 times the power adds 10 db.

The only other point to be made concerning power is that the base-station r.f. power should generally be greater than that for the mobile units. If a mobile unit has trouble raising the base station, the vehicle can always be moved to a more favorable position. The base station, on the other hand, is stationary and can't move. Therefore, it is advisable for the base station to have somewhat greater range than the mobiles. Each additional watt of mobile r.f. power must be weighed against greater drain on the vehicular electrical system and the possible necessity of heavy-duty generators or alternators.

Thus far, nothing has been said of mobile-to-mobile range. Most two-way radio systems are designed primarily around communications between the base-station dispatcher and the various mobile units in the system. Generally speaking, communications between mobile units is of secondary importance. Should distance be too great between two mobile units, the message can be relayed by the base-station dispatcher. In those systems where wide-area, direct mobile-to-mobile communications is necessary, one expedient is the use of mobile relay operation. The type of system depends upon a repeater station, and will be discussed in detail in the second portion of this article which will deal with the various types of communications systems.

Portable Equipment

Portable and pocket radio equipment can be used to increase the flexibility of the communications network by providing the man-on-foot direct radio contact with the base station and the mobile units. Although primary power input is a major consideration in portable equipment—large and heavy power packs tend to reduce portability—these "pint-sized" radio sets deliver performance rivalling their mobile counterparts. A 6-watt, 25- to 50-mc. portable transmitter can often talk 6 or 7 miles across open terrain to a ground level antenna, and a 10-mile range is not at all unusual for a 1.4-watt portable unit working into a 100-foot, base-station gain antenna at 150 mc. With receiver sensitivity of 0.5 microvolt or better, reliable two-way communication can be achieved by such hand-carried radios.

Band Sharing

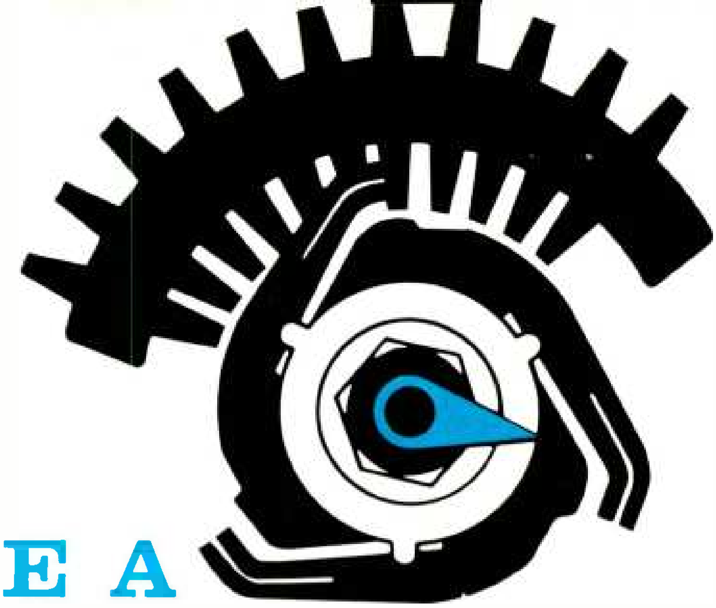
There is one other aspect of radio system design which, although it does not affect range directly, does have an important bearing on system performance. In many sections of the country, the number of two-way radio users far exceeds the available frequencies on which systems may be licensed. Consequently, it is not unusual to find several users in the same general vicinity sharing a common frequency. This practice can lead to quite a bit of annoyance and confusion since the mobile operator and the base-station dispatcher must listen to every on-frequency message, whether that message originated within his own system or within the radio network of a co-channel user. Because of multiple systems operating on a common frequency, most manufacturers of two-way radio equipment have available tone-coded squelch circuitry—as a factory-installed option—for base station, mobile, and even some portable equipment.

The tone-coded squelch system depends upon a sub-audible tone that acts as a trigger to unmute the receiver audio section. The code tone, from a highly stable oscillator, modulates the transmitter along with the voice message. At the receiver, the tone passes through an exceptionally high-"Q" bandpass filter. The tone is then rectified to form a d.c. control voltage that is applied as bias to one of the audio stages. This audio stage is normally biased to cut-off, but when the d.c. control voltage is present, the stage conducts and allows any audio signal to pass on to the loudspeaker. Therefore, only a signal containing the proper code tone will unsquelch the receiver; a signal with no tone or with an improper tone will ordinarily not reach the loudspeaker.

In accordance with FCC regulations, a means is also provided to disable the receiver tone-coded squelch circuitry so that the entire channel can be monitored—to see if the channel is clear of traffic—before a transmission is made.

We have mentioned only the most general of the considerations affecting two-way radio range. Others, such as the conductivity of the earth and the general terrain over which communications will be attempted, certainly exert a marked influence. The scope of these articles does not permit going into all considerations in detail; those that remain will vary from one individual system to another and can best be handled by someone who is familiar with communications problems in the immediate area.

A word of warning is in order to anyone who is acting as a consultant on the design and installation of a two-way or any other type of radio system. You are permitted by law to supply your client with all the *technical* information required for an FCC application. However, under no circumstances are you allowed to offer any legal advice about the application; this can *only* be handled by an attorney licensed to practice before the FCC. *(Concluded next month)*



INSIDE A DIGITAL VOLTMETER

By SAM MESSIN / Instrument Assembly Manager, Non-Linear Systems, Inc.

A complete analysis of a stepping-switch type instrument, its circuit details, along with its operating principles.

DURING the past decade, the digital voltmeter has become a familiar device, finding numerous applications in the electronic field, in production-line testing, missile check-out systems, and many other areas of industry.

The fundamental purpose of the digital voltmeter is to make a highly accurate measurement quickly with practically no chance of error. This is possible because the measurement is displayed in easy-to-see numbers complete with correct polarity sign and properly placed decimal. The displayed reading can also be automatically recorded, again reducing any chance of error.

Depending on requirements, digital voltmeters are available that can take a reading in a second or two, up to speeds as high as several hundred readings per second. Digital voltmeter accuracies of .01% of the readings are typical, so that a four-digit display will show a resolution of one part in ten thousand.

Just as a regular moving-coil meter can be used as a voltmeter or ohmmeter, the digital voltmeter can be built as an ohmmeter by proper circuit modifications. The digital ohmmeter has all of the above-mentioned advantages of the digital voltmeter.

Because the digital voltmeter is a unique type of electronic instrument rather unlike most other electronic devices, we will describe a digital voltmeter beginning with basic ideas, building up to the more sophisticated circuitry that is employed in an actual working instrument.

The Potentiometer Principle

Fig. 1A illustrates a simple potentiometer circuit, the basis for most digital voltmeters. As shown in the figure, an unknown voltage can be determined by simply adjusting the voltage divider until the reference voltage is equal to the unknown voltage. In this figure, the galvanometer indicates zero current flow when electrical balance exists. The voltmeter then indicates the voltage at balance. Note that when a zero condition exists, there is no load on the voltage being measured.

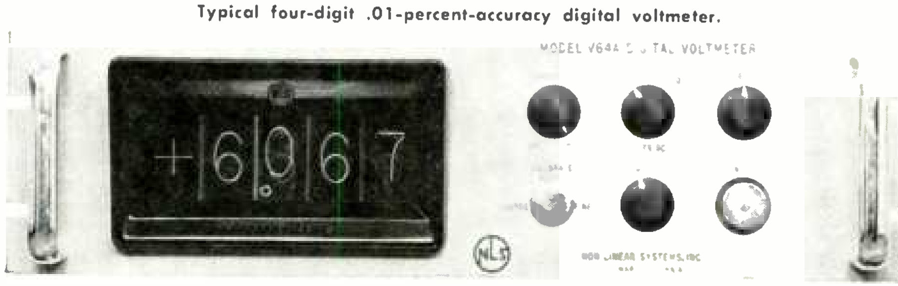
In order to produce a digital voltmeter which is capable of indicating voltages at a millivolt or sub-millivolt level, some means of amplification must be used. A conventional practice is to sample the unknown voltage with an electro-mechanical chopper so as to produce an a.c. signal which may be readily amplified. Such a circuit is shown in Fig. 1B.

Basically, a chopper is a single-pole double-throw switch which, in this application, is actuated by an electro-magnetic coil assembly connected to a 60-cps source. As shown in Fig. 1B, the chopper arm swings between the unknown input voltage and the reference voltage, generating a voltage waveform at the chopper arm. This waveform is a 60-cps square wave whose peak-to-peak amplitude is the difference between the unknown voltage and the reference voltage. A series of waveforms is shown in Fig. 2. This figure illustrates the chopper output under various conditions of input voltage and reference voltage.

Fig. 3 illustrates an elementary digital voltmeter using a chopper and an amplifier. The reference voltage is applied to a voltage divider which has been assembled around a 10-position rotary stepping switch. The switch arm is "stepped" around these 10 positions by pulsing the stepping-switch coil with the amplifier output. An additional arm is ganged to the divider arm so that both may be driven by the same stepping mechanism. This second arm has its own set of contacts which are used to select and illuminate the correct readout lamps under the appropriate readout numerals. Each numeral, 0 through 9, corresponds to the voltage present at the switch arm of the voltage divider.

To observe the operation of the elementary digital voltmeter shown in Fig. 3, assume that any voltage in one-volt steps, from 0 to 9 volts, is applied as the unknown input. Also assume that one volt or more is sufficient to drive the

Typical four-digit .01-percent-accuracy digital voltmeter.



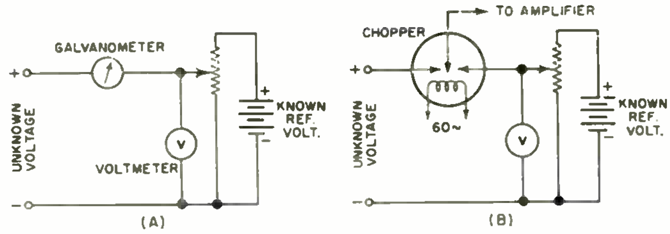


Fig. 1. (A) Potentiometer circuit. (B) Use of a chopper.

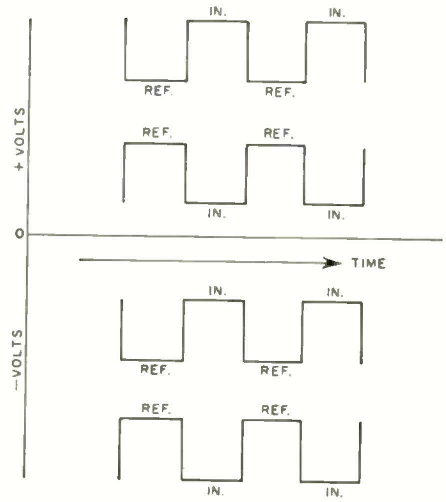
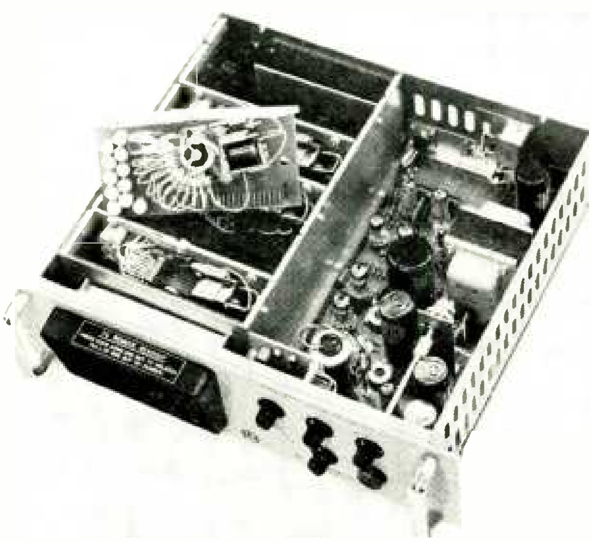


Fig. 2. Chopper output for two cases of positive input voltage and two cases of negative input voltage. Square-wave polarity depends on whether input is greater or less than reference.



Inside view of the voltmeter discussed. One of the four stepping-switch panels has been unplugged in this photo.

amplifier which, in turn, drives the stepping switch. When these conditions occur, the following facts become evident:

1. With any input from 0 to 9 volts, only one particular position on the reference voltage divider will match the input voltage.

2. All other positions will produce a voltage output of one volt or more at the chopper arm. This is sufficient to drive the amplifier and the stepping switch.

3. The stepping switch will receive one pulse for each full swing of the chopper arm as long as a difference exists between the unknown input voltage and the reference voltage.

4. When the reference voltage-divider output equals the unknown input voltage, no output is developed at the chopper arm, and the amplifier ceases to operate the stepping switch.

5. The second section of the stepping switch connects to a specific readout lamp when balance is reached. An appropriate numeral is illuminated, which corresponds to the reference voltage divider tap and therefore corresponds to the amount of unknown voltage applied.

A Practical DVM

Although the simplified circuit of Fig. 3 illustrates the principle upon which a digital voltmeter works, considerably more sophisticated circuitry is required to produce a practical instrument. The following discussion, based on the specific circuit used in the *NLS* Model V64A, illustrates some of the details. This instrument does not have automatic range switching or automatic polarity indicating features. Instead, it uses front-panel controls to establish range and polarity.

First of all, the elementary circuit shown in Fig. 3 cannot measure an input voltage of reverse polarity unless the reference voltage is also reversed. Second, like all voltmeters, the digital voltmeter requires a range multiplier to extend its useful range. Third, the chopper must be protected against the inadvertent application of excess voltage.

Fig. 4 shows the circuit changes made to meet these requirements. A polarity-reversing switch has been added to reverse the reference voltage; an input voltage divider and range switch have been added to extend the voltage ranges by ten times and a hundred times; also, a neon lamp and limiting resistor have been added to protect the chopper against accidental high-voltage inputs.

Any practical digital voltmeter must contain an extremely stable voltage source for reference purposes if the instrument is to be consistently accurate over long periods of time. Fig. 5 shows a typical reference supply used in digital voltmeters.

To obtain the precise increments in voltage required of a digital voltmeter, a modified Kelvin-Varley type voltage divider is used. With this modified divider, the value of each decade resistor is the same, thus permitting each decade, along with its stepping switch, to be made into interchangeable plug-in units. Since all decades are interchangeable, production, troubleshooting, and replacement are simple.

As shown in Fig. 6, each decade consists of eleven 5000-ohm resistors. The decade output is selected by a pair of switch arms across two adjacent resistors. The last decade output is shunted by a 12,500-ohm resistor and a 50,000-ohm terminating resistor. A quick calculation will show that the 10,000-ohm output shunted by the 12,500-ohm resistor and the 50,000-ohm terminating resistor, equals 5000 ohms. Therefore, total decade resistance is 50,000 ohms, and 1/10th the decade voltage appears across the output. Each decade is similarly divided and terminated by the next decade.

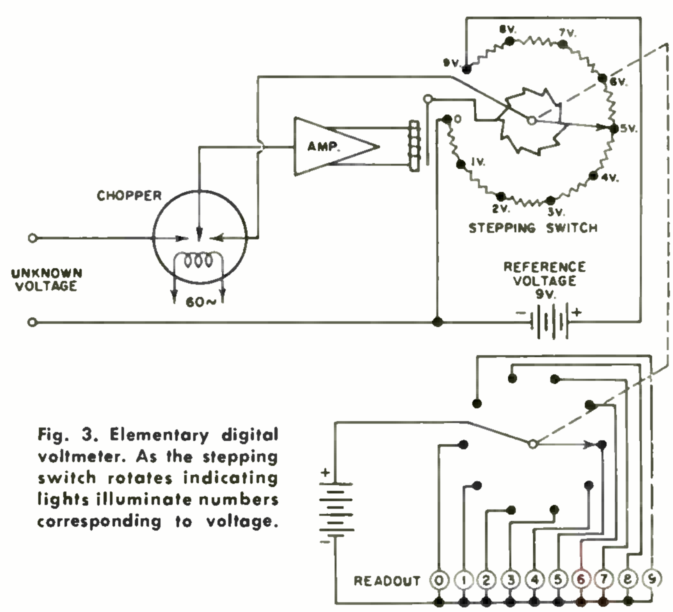


Fig. 3. Elementary digital voltmeter. As the stepping switch rotates indicating lights illuminate numbers corresponding to voltage.

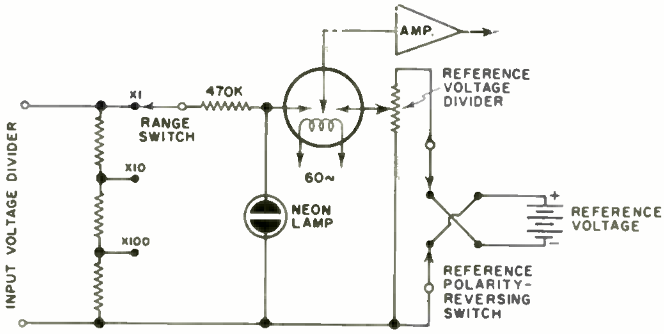


Fig. 4. Range and polarity switching plus chopper protection.

By tracing the output of the reference voltage supply into the Kelvin-Varley divider, it will be seen that the voltage output of the most significant decade (on the left) appears across a pair of switch arms. These arms "bracket" a one-volt region of the reference voltage. Once the desired voltage has been bracketed, it is passed on to the following decade which again brackets the voltage, but this time to within one-tenth of a volt. The third decade is now able to select a desired voltage within one-hundredth of a volt. Finally, in the fourth decade, a voltage can be selected in the millivolt region. In Fig. 6, the ten-volt reference has been bracketed down to produce a voltage of 4.321 volts.

It can be seen from the foregoing discussion that an amplifier is needed to balance out voltage increments which are on the order of one millivolt. Fig. 7 shows a typical amplifier with two outputs, one in phase and the other of opposite phase to the input. As also shown in this figure, the chopper arm swings between the input terminal and the Kelvin-Varley voltage-divider output, thus generating a square waveform as previously described. Note that the square wave may have either a positive- or negative-going polarity, depending upon whether the input signal is of higher or lower potential than the Kelvin-Varley divider output. The square wave is applied to a cathode-coupled amplifier stage. The second stage is also a cathode-coupled stage which has a variable-resistance coupling between its two cathodes, provided to adjust the digital voltmeter sensitivity. An over-all amplifier gain adjustment is provided at the plate of the second amplifier to compensate for variations in tube and amplifier gain. Phase inversion is required to develop a pair of amplifier output signals which are directly related to the polarity of the original square-wave output of the chopper. This pair of signals is used by the instrument to determine whether the Kelvin-Varley divider is to be driven "up" or "down" in order to seek a balance.

Manually Operated DVM

Fig. 8 shows the instrument at the present stage of this discussion. We now have a practical instrument, one which can be operated with manual controls so as to provide highly accurate readings. By observing the amplifier output waveform with an oscilloscope, we can determine if the unknown signal is higher or lower than the Kelvin-Varley divider output, and adjust the four decades of the divider so as to produce a nulled output. If the output signal reduces but cannot be nulled out when the divider output reaches zero, then reference polarity must be reversed to balance against the input. On the other hand, if the amplifier output is reduced but not nulled out when the Kelvin-Varley divider is at maximum, then the input signal is greater than the reference voltage, and the input divider must be brought into action with the range switch. The Kelvin-Varley divider is then re-adjusted for a null.

The readout lamps are wired to ganged switch sections operating with each Kelvin-Varley decade. Plus or minus polarity is indicated by operating similar plus or minus readout lamps also ganged with the polarity switch. The proper decimal points are indicated by means of the decimal readout lamps that are ganged to the range switch.

Automated DVM

In order to automate this digital voltmeter, the amplifier outputs must be processed to drive the stepping switches. Since considerable power is required to drive stepping switches, only a very few types of electron tubes are suitable as drivers. The type 2D21 miniature thyratron lends itself well to this purpose.

Fig. 9 illustrates circuitry from the amplifier outputs to the thyratrons which drive the stepping switches. Note that the thyratron tubes operate from an a.c. plate supply, thus simplifying power-supply design and automatically extinguishing the thyratrons after each conducting period. A series of waveforms is shown in Fig. 10. These indicate the timing relationships of the circuits from the phase-inverter outputs to the final stepping switch output pulses.

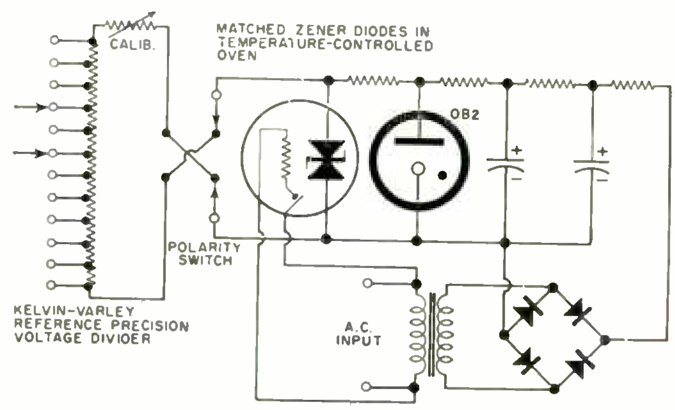


Fig. 5. Circuit of a typical reference-voltage power supply.

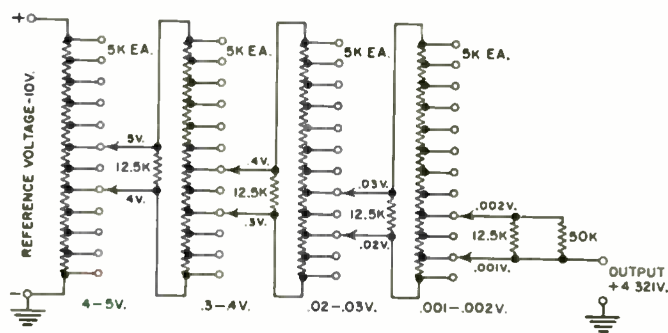
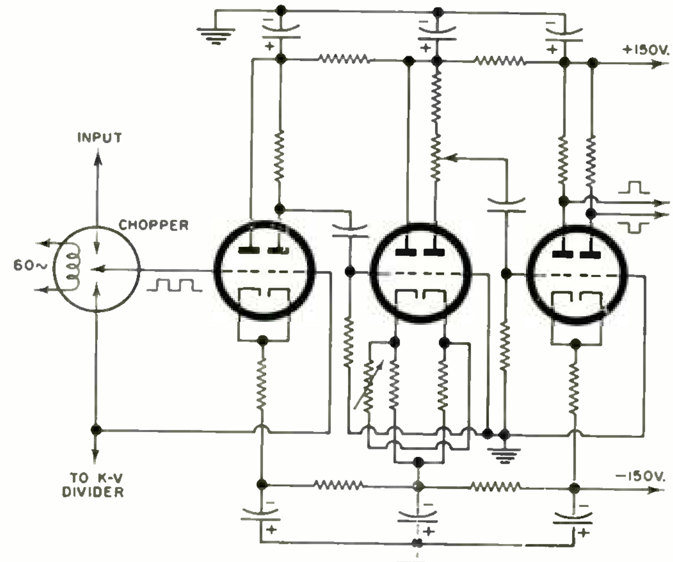


Fig. 6. A 4-decade Kelvin-Varley divider indicating 4.321 volts.

Fig. 7. A typical amplifier circuit with opposite-phase outputs.



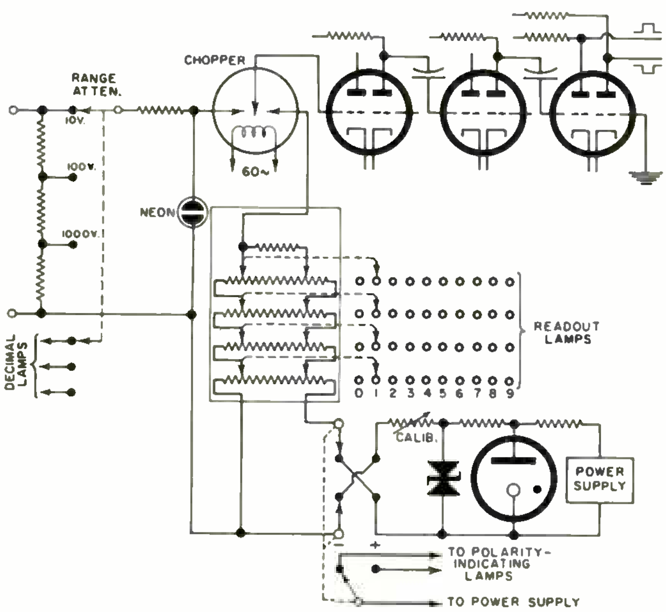


Fig. 8. Simplified circuit of manually operated digital voltmeter.

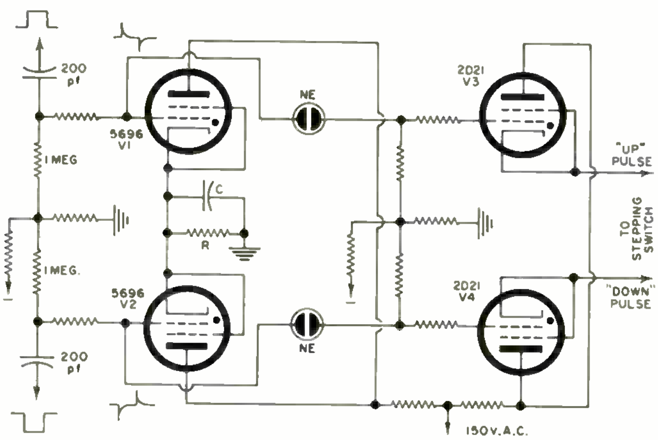


Fig. 9. Four thyratrons are employed to drive stepping switch.

The stepping switch drive circuit consists of a pair of small thyratrons, *V1* and *V2*, which are actuated by the phase-inverter outputs, and which in turn trigger thyratrons *V3* and *V4*, the stepping-switch drivers.

These thyratron circuits operate as follows: The square-wave outputs of the phase-inverter stage are differentiated, producing positive pulses corresponding to the leading edges of the positive-going square waves, and negative pulses corresponding to the trailing edges. This pulse polarity is inverted when the square wave is inverted as shown in Fig. 10. These differentiated pulses are applied to a pair of 5696 thyratrons, *V1* and *V2*, which are normally biased to their cut-off points by a resistive divider. The positive differentiated pulse turns *V1* on, while the negative pulse applied to *V2* has no effect. With *V1* turned on, a large current flows through *R*, the common cathode resistor. The voltage drop across *R* charges *C*, connected across *R*, and also puts *V2* further into the cut-off state. Once *V1* is turned on, it remains on until a.c. plate voltage returns to zero at the end of the positive half-cycle. *V1* and *V2* would normally be ready for another cycle of operation every 60th of a second except for the delay resulting from the time constant of *C* and *R*. These are proportioned to hold *V2* or *V1* in a cut-off condition for a full a.c. cycle after either *V1* or *V2* has fired. This is done to provide a frequency-halving action so that the stepping switches operate at a 30-cps rate.

When either *V1* or *V2* fires, the ionized interior of the tube creates a low-impedance conducting path from the control grid to the plate. The resulting voltage pulse at the control grid turns on the neon lamp which is coupled to the 2D21 output thyratron. The 2D21 switches on, passing a large current sufficient to operate the stepping switch.

The Stepping Switches

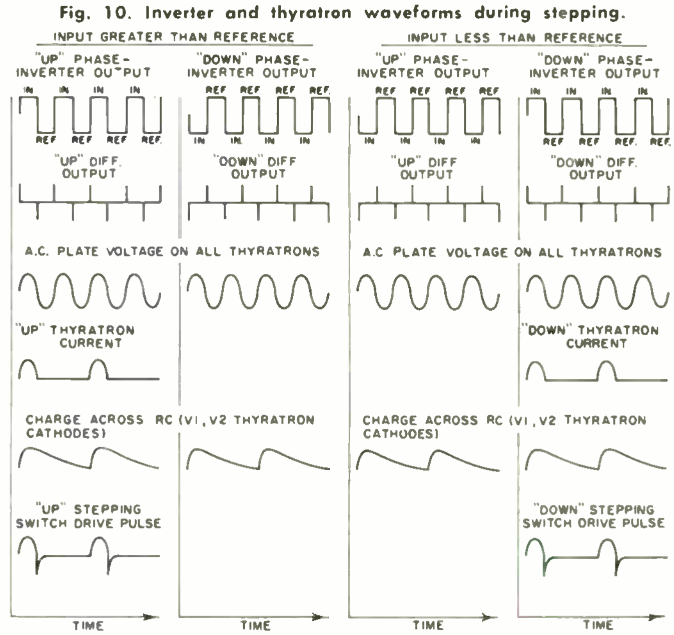
Stepping switches operate mechanically in one direction. When the electromagnetic driving mechanism is energized, an armature is pulled toward the coil against the force of a helical spring. The action cocks the switch, but does not advance the contacts. When the electromagnet is de-energized, the helical spring returns the armature to its original position. This return movement operates a ratchet so that the rotary contacts will advance one step. In this way, switching occurs only after the driving current has ended; thus the return spring rather than driving current advances the contacts. When the last switch position has been reached, the next pulse advances the switch to the first position again, and additional pulses cause the stepping switch to repeat this cycle.

Both "up" and "down" pulses operate the stepping switches in the same direction of rotation. The manner in which these pulses are routed through the stepping switches determines a sequence of operation which allows a balance to be reached in a minimum number of steps. Both "up" and "down" pulses are usually required to achieve a balance, and several decks of switches are needed to route "up" and "down" pulses.

To follow the operation of the stepping switches and the pulse-switching circuits, assume that all switches are resting at zero as shown in Fig. 11. With the switches in this position, there is no output from the Kelvin-Varley divider and, if no input voltage is present, no "up" or "down" pulses are generated and the instrument remains at zero, electrically at balance.

To demonstrate the "up"-pulse action, assume +.009 volt is applied to the digital voltmeter. The polarity switch must be set to "Plus" and the range switch to the "10-Volt" range. Application of this input voltage will cause the chopper to detect the unbalance, thereby creating a square-wave signal of proper polarity, which results in the "up" thyratron pulsing the first stepping switch—producing the least significant number in the right-hand window. This stepping switch will proceed to step up to the tenth position ("0" equals the first position) decreasing the unbalance at each step until at the tenth position, the +.009 volt from the Kelvin-Varley divider will balance the input voltage applied to the instrument, caus- (*Continued on page 84*)

Fig. 10. Inverter and thyratron waveforms during stepping.



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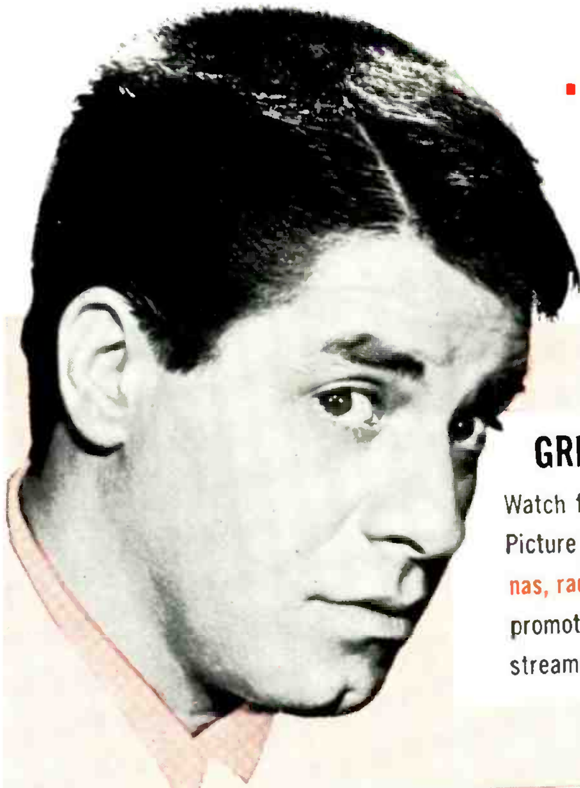

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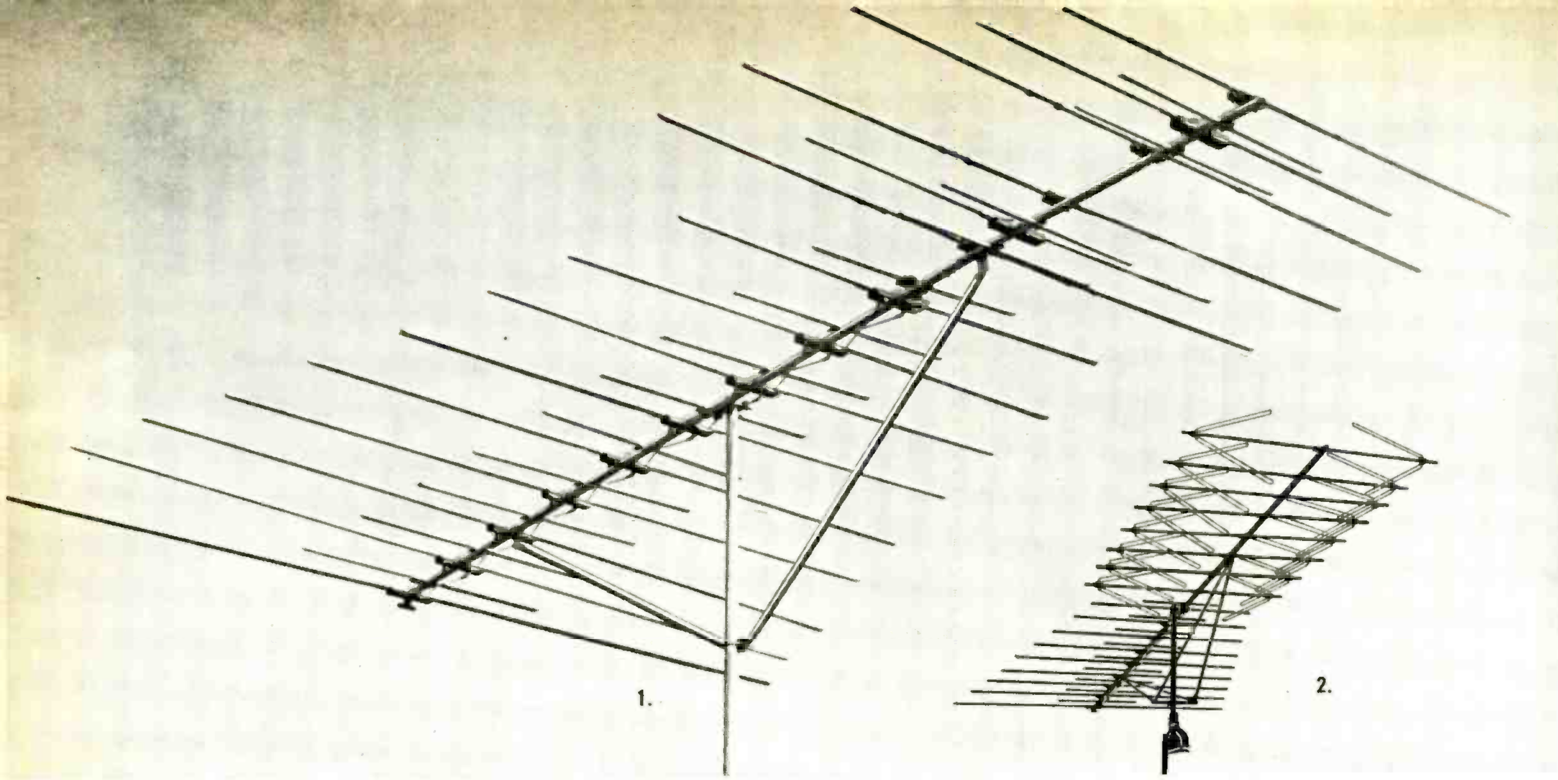

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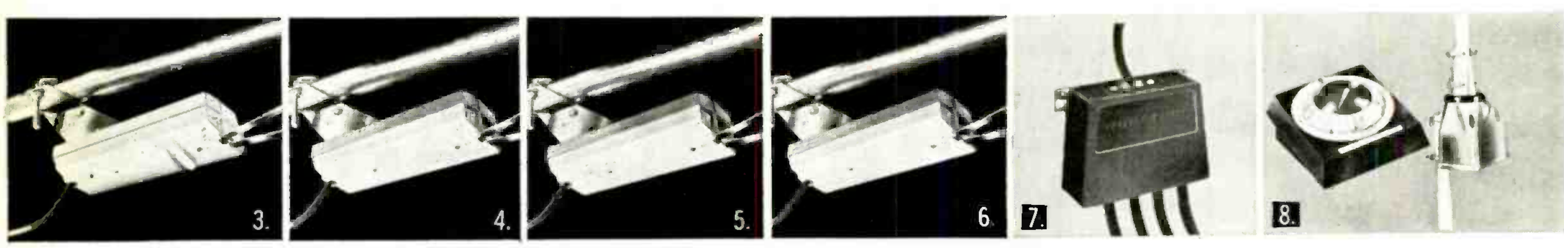
High-performance balance can be obtained only by using the right combination of both driven and parasitic elements. **Only** the Crossfire—with its unique dual dipole system—has this power combination. The Crossfire patent protects this system—and no other antenna, old or new, can use it.

2. GOLDEN SUPER-CROSSFIRE Model 3607

The World's Most Powerful Antenna

1. Up to 48% more TV gain than 28-element Crossfire.
2. On FM Stereo ... gives more gain than a 5-element yagi.



EXTRA-POWERFUL BOOSTERS THAT MEET EVERY NEED!

3. BRAND-NEW Nuvistorized "TV ONLY" TELE-VISTA Model 0026

YOUR MARKET: TELEVIEWERS IN AREAS WHERE **BOTH TV AND FM STRONG SIGNAL OVERLOADING** FROM NEARBY STATIONS IS A PROBLEM. The only "TV/only" Amplifier with the long-life "Duo Nuvistor" circuit ... and a built-in coupler! Strong local TV and FM signals won't overload it.

4. BRAND-NEW Transistorized "TV ONLY" TELSTAR Model 0027 **with Built-In FM Trap ... plus 4-set coupler.**

YOUR MARKET: TELEVIEWERS IN AREAS WHERE **FM STRONG-SIGNAL OVERLOADING** FROM NEARBY STATIONS IS A PROBLEM. **Twice the TV overload protection of any other transistorized booster ... thanks to Texas Instruments' brand-new EPITAXIAL MESA TRANSISTOR. Virtually eliminates possibility of local FM interference.**

5. TV/FM TELSTAR WITH 4-SET COUPLER Model 0023A
America's most outstanding, best-selling booster

YOUR MARKET: VIEWERS AND LISTENERS WHO WANT THE WORLD'S MOST POWERFUL BROAD-BAND AMPLIFICATION! Unbeatable Combination of High Gain and Low Noise figure ... plus built-in Lightning Resistance and other outstanding features.

6. TELSTAR FMX (for FM exclusively) WITH 2-SET COUPLER Model 0025

YOUR MARKET: THE EXPANDING NUMBER OF MONAURAL AND STEREO FM LISTENERS! Most powerfully stepped-up FM performance of all!

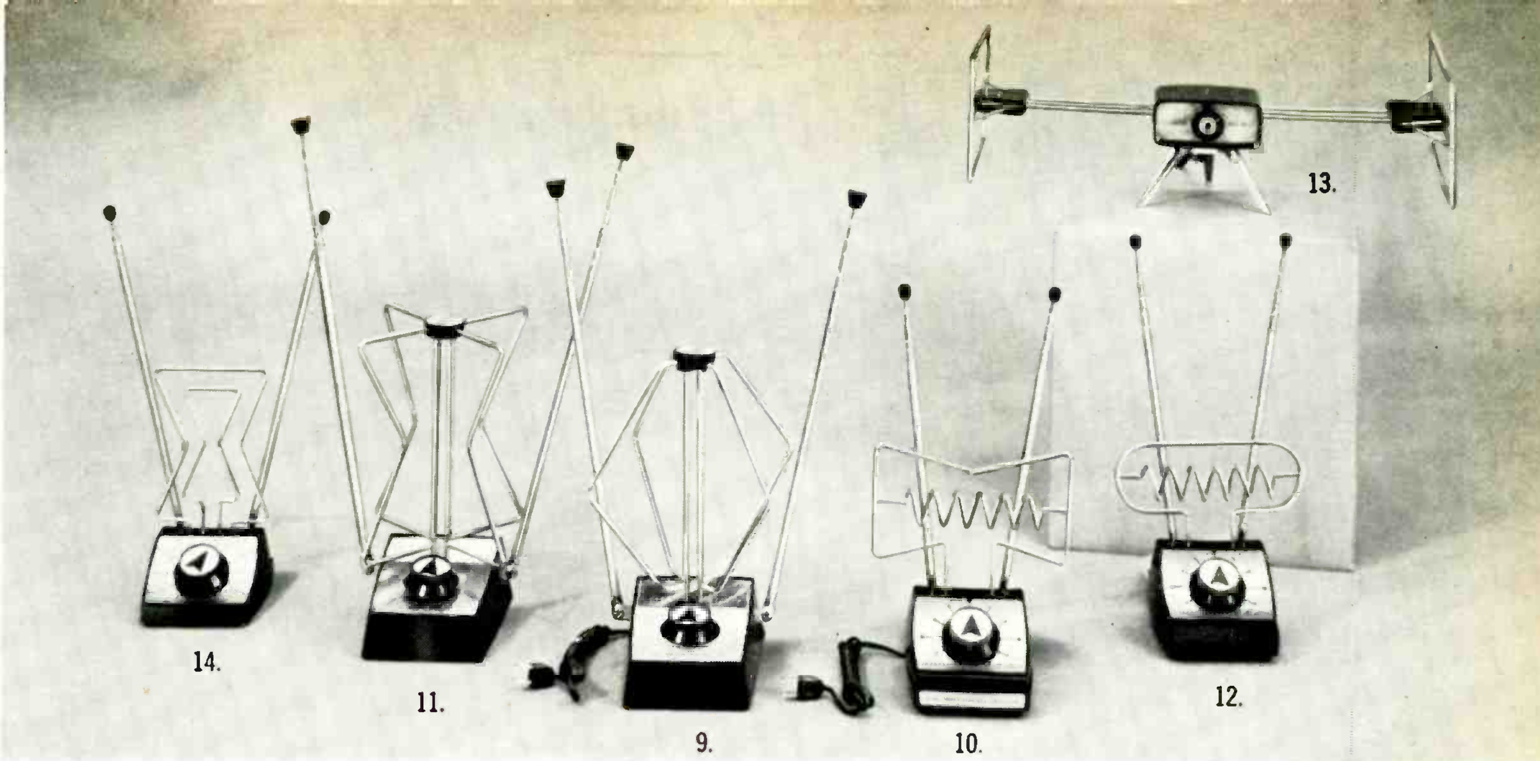
7. Improved! Higher Gain VUTRON II FOR TV/FM Model 0024

YOUR MARKET: THOSE WHO WANT THE BEST IN AN IN-THE-HOME SIGNAL AMPLIFIER AND COUPLER.

NOW FOR THE FIRST TIME ... OUTSTANDING ALL-IN-1 ROTATOR AND TV AMPLIFIER!

8. GEMINI Model 9527

YOUR MARKET: THOSE WHO NEED AND WANT EXTRA POWER ... PLUS DIRECTIVITY. **Fast, neat installation saves money 4 ways! World's Finest Automatic Rotator (Tenn-a-liner).... plus Telstar TV booster. Built-in FM TRAP. Simple to Service. 2-set coupler.**



with CHANNEL MASTER

WORLD'S MOST POWERFUL NEW INDOOR ANTENNAS

These beautifully-designed antennas open a whole new market ...because they work where only outdoor antennas could work before!

9. NEW! Revolutionary, Transistorized **APOLLO** Model 3721 **(with Built-in Amplifier)**

GETS CLEAR, GHOST-FREE, TV RECEPTION 15 TO 45 MILES OUT.

YOUR MARKET: SUBURBAN VIEWERS WHO WANT **OUTDOOR** ANTENNA POWER FROM AN **INDOOR** ANTENNA. Exclusive "Miraclick" Switch electronically adjusts to different signal strengths. Super-effective hidden amplifier gives extra pull-in power where needed.

10. NEW! **World's First Transistorized FM/STEREO INDOOR ANTENNA with Built-in Amplifier.** Model 3731

GETS POWERFUL FM RECEPTION 15 TO 60 MILES OUT!

YOUR MARKET: SUBURBAN LISTENERS WHO WANT TOP FM PERFORMANCE WITH EASY ANTENNA ADJUSTABILITY AND ROTATOR-TYPE DIRECTIVITY. Booster is peaked—dipoles tuned—for FM exclusively! Fidelity Switch.

11. Golden **CANAVERAL** Model 3720 **(Non-Amplified)**

YOUR MARKET: METROPOLITAN AREA VIEWERS WHO WANT TOP TV/FM RECEPTION UP TO 15 MILES FROM STATION. Same features as Apollo.

12. **NEW! FM/STEREO INDOOR ANTENNA** Model 3730 **(Non-Amplified)**

YOUR MARKET: METROPOLITAN AREA LISTENERS...WHO SEEK FM PERFORMANCE WITHOUT COMPROMISE! Same advance features as 3731.

13. **Improved! SHOWMAN** Model 3900 (Mahogany and Gold)
Model 3901 (Blond and Gold)

YOUR MARKET: CUSTOMERS WHO WANT SOMETHING DIFFERENT! Beautiful ...improved...priced to move! "Metro-Dyne" Variable Inductance Electronic Tuning. Like no other antenna.

14. **NEW! AURORA** Model 3718

YOUR MARKET: THOSE WHO WANT A LOW-PRICED LUXURY ANTENNA! Tops for the money! Magnificently styled. "Automagic" Clarifier Switch.

FREE GIFTS! SEE YOUR CHANNEL MASTER DISTRIBUTOR FOR FULL DETAILS ON INDOOR ANTENNA PREMIUM DEAL.

NEW! BEAUTIFUL, POWERFUL "VU-CON" UHF CONVERTERS

GIVE YOU THE EDGE IN EVERY RECEPTION AREA ... NOW AND IN THE FUTURE!

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

JOHN FRYE

Even as familiar a piece of test equipment as a v.o.m. has undergone some radical changes and improvements recently.

A "NEW LOOK" IN V.O.M.'S

IT WAS a dull and gloomy late fall day outside, and a bit of coming-of-winter melancholy apparently had seeped indoors and was weighing down the spirits of Mac and Barney working silently at the service bench. They needed a cheerful diversion, and it was not long coming.

"One side, woman!" they heard a high-pitched masculine voice saying to Matilda in the front office. "I'm here to have words with your niggardly Scottish boss who obviously doesn't pay you enough to keep you in decent lipstick and high heels. I assume old MacGregor is back there in his lair gypping the gullible public as usual; so I'll go right in."

The door opened to frame a rather plump, short man with a bristling crew-cut and a pair of bright eyes sparkling mischievously through his glasses.

" 'Well bless my shoe laces!' Tom exclaimed brokenly, 'if it isn't Mr. Damon!' How are you, Ron?" As Mac ended this strange, disjointed speech, he grasped the hand of the stranger and pumped it vigorously. "It's all right, Matilda," he reassured the girl standing in the doorway; "he's harmless. Barney, this is an old and good friend of mine, Ron Damon."

"Lay off that Tom Swift jive, will you?" Ron said to Mac while he was shaking hands with Barney. "You want to give our ages away, or something? Speaking of ages, boy, get up off that stool and let your elder sit down."

Dazedly Barney obeyed.

"What good luck brings you here, Ron?" Mac asked.

"On my way home from Chicago, I noticed your sleepy little hamlet wasn't far out of the way; so, 'Ron,' I said to myself, 'it's your duty. You see so much, and poor old Mac sitting down there in the electronic doldrums sees so little. Go to him. Take him the *word*. Open the window just a little and let him look out.' "

While talking, Ron had been unfastening a cardboard carton he had with him; and now he lifted out a gleaming v.o.m.

"Feast your eyes on this little jewel and eat your heart out," he continued.

"We've seen a v.o.m. before," Barney sniffed.

"Ah rash, impetuous, ignorant youth! You have not seen a v.o.m. like *this* before. Hold your rude tongue and watch while I set the meter to the ultra-sensitive 100-microampere range and touch the probes to *my* tongue. See the pointer being deflected by the very weak battery action of mouth acids reacting with the prod tips?"

"It figures, with your acid tongue," Mac offered.

Ron did not reply. Instead he took the prods from his mouth and jabbed them into a 117-v. a.c. receptacle on the rear of the bench. The meter pointer flickered, and there was a clicking sound from the v.o.m. Mac and Barney exchanged horror-stricken looks.

"Now you've done it!" Barney exclaimed. "You must be completely kooky. Anyone who would do that to a meter would kick a dog or slap a baby."

Ron still said nothing. He merely pushed in a little white button above and to the right of the function switch and stuck the prods back against his tongue. The pointer swung easily up-scale as before. He switched to the × 1K ohmmeter range, zeroed the pointer with the test prods shorted, and again thrust the prods into the a.c. receptacle. Once more there was a clicking sound from the meter; but when the white button was pushed in, the ohmmeter performed normally.

"This, my open-mouthed friends, is *Triplett's* brand-new Model 630-PLK 20,000 ohms-per-volt v.o.m. in which all ranges are protected against accidental damage to the meter and associated components," Ron lectured. "The 1 and 10 amp ranges are protected by fuses. The × 100K ohms and the 1000- and 5000-volt a.c. and d.c. ranges are self-protecting because the high resistance of these circuits keeps current below damaging levels.

"All other ranges are protected by a resettable, latching-type, transistor-operated relay which opens the input circuit whenever an overload of two to four times is impressed on the 50-microampere meter movement—an overload it can easily take. Finally, a diode network across the meter movement bypasses instantaneous transient voltages and prevents their damaging the movement or bending the pointer.

"The special cut-out circuit is not polarity sensitive and works equally well with a.c. or d.c. The relay itself is a special job with minimum momentum and fast action designed to open in a very few milliseconds. It and the × 100K-ohms range are both powered by a 30-volt battery which can be expected to last for several years. Satisfactory condition of the battery for operating the relay is indicated by ability to zero the pointer on the × 100K-ohms range.

"It's easy to see this is the ideal meter for a careless, fiddle-footed, wooly-witted technician, as your assistant here undoubtedly is; but even we old timers are likely, in the excitement of closing in on an elusive trouble, to forget to change the meter from 'Ohms' when we measure volts and end up with a bent pointer or worse. On top of that, this little package of carelessness-insurance will reveal the presence of meter-wracking current surges easily overlooked. For instance, the other day I wanted to see if a transistor radio was drawing its rated 4 ma.; so I set the 630-PLK for 10 ma. and placed it in series with one of the battery leads. The relay kicked out when the set was turned on, indicating a current of at least 20 ma.; yet when I tried again on the 100 ma. range, and then came down to the 10 ma. range, the proper 4 ma. was indicated. Charging of a 100-μf. capacitor directly across the battery input was shooting a high-current pulse of such short duration through the meter the pointer never had time to show it; yet that pulse exerts great strain on the jeweled bearings and other parts of a conventional v.o.m. without your knowing it exists."

"We'll not argue with that," Mac broke in hastily as he saw Barney's neck turning redder and redder. "I suppose you're familiar with the *Triplett* 630-NS v.o.m. we've been using for a couple of months." He opened a cupboard and took out a v.o.m. that closely resembled, in appearance, the one Ron had.

"No; can't say I am," Ron admitted grudgingly.

"It has some features we like," Mac said. "The meter move-

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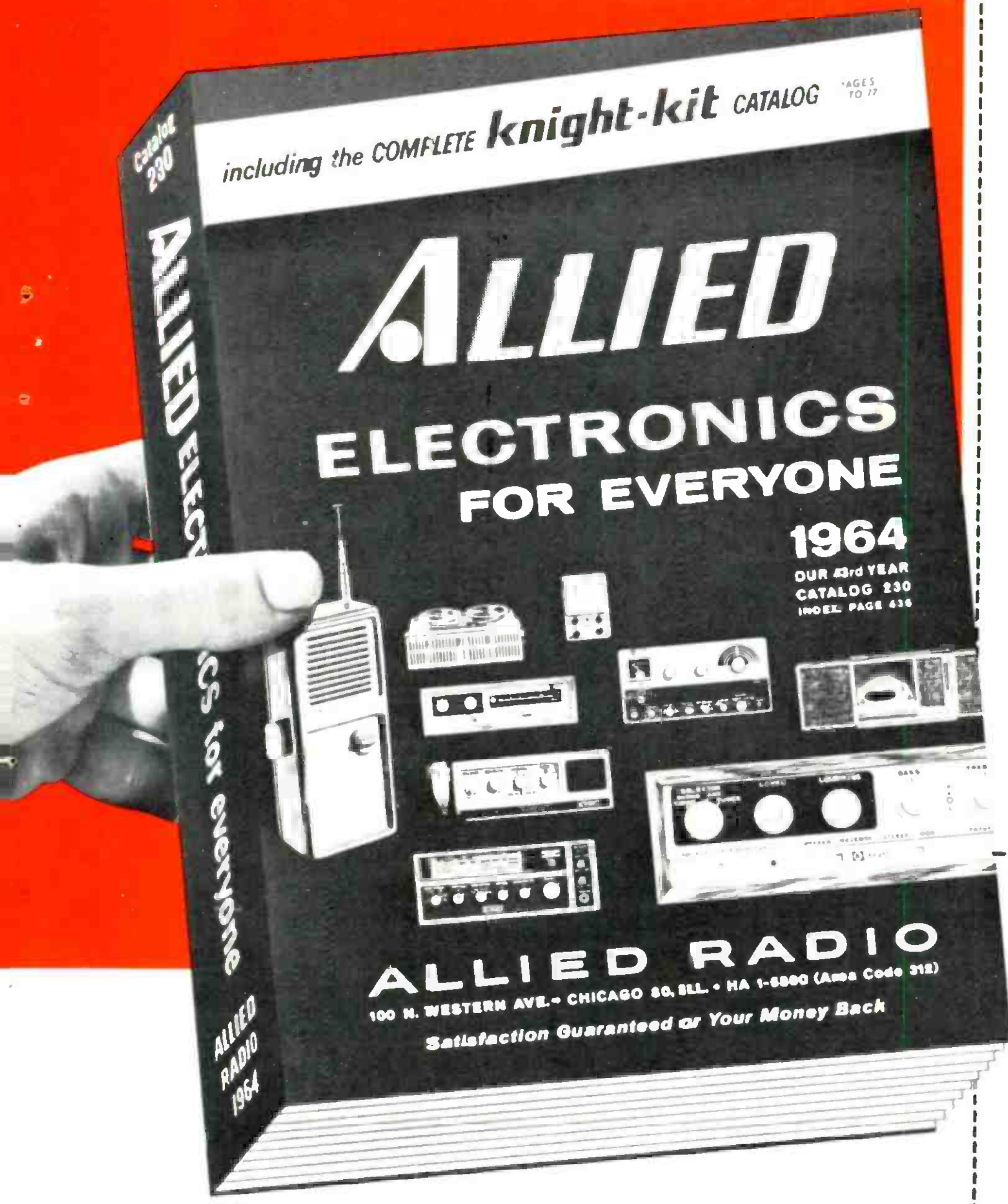

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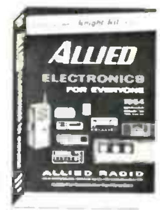

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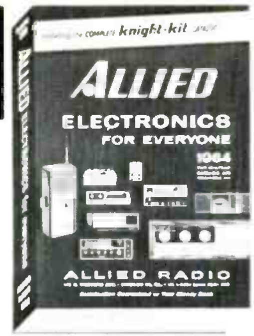

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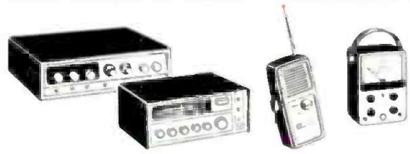

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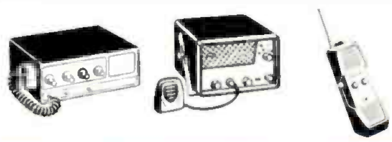

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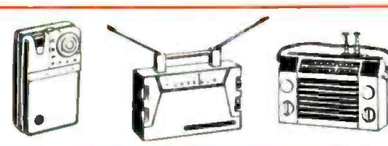

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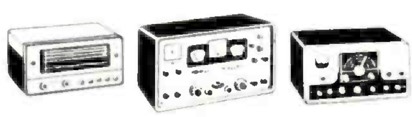

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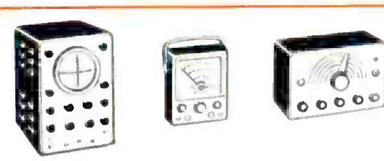

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ment is the new taut-band type with no bearings or hair-springs. The coil is suspended by two tiny bands of platinum alloy 1/10 the thickness of a human hair but five times stronger than steel. It works like this," he said as he snapped a rubber band over his thumb and forefinger and stuck an alignment tool through the loop and moved it so that it pried against the two strands of rubber.

"Getting rid of bearing friction creates a very sensitive meter movement. Five microamperes through the coil deflects the meter full-scale. The movement is shunted so all voltmeter ranges shown on the function switch are at 100,000 ohms-per-volt d.c. and 10,000 o.p.v. a.c.; but when this slide switch below the function switch is moved to the 'V-A/2' position, the shunt is removed and the sensitivity goes up to 200,000 o.p.v. d.c. and 20,000 o.p.v. a.c. With the switch in the V-A/2 position, another scale is used that halves the voltage or current range shown by the function switch."

"A meter that sensitive is too easily damaged," Ron objected.

"Oh I don't know. The movement itself is rugged, and then it's protected by diodes the way your meter is. Overloads of 1000 times have been applied to the meter movement without affecting the accuracy."

"Of course the operator is expected to use *some* sense," Barney remarked, staring pointedly at Ron.

"Several other features warrant its extra cost," Mac quickly continued. "A mirror scale prevents parallax. The d.c. voltmeter accuracy is 1½% of full scale, and 60-cycle a.c. is 3%. The a.c. scales to 300 volts are frequency-compensated for 5% accuracy from 35 cycles to 20 kc. While this extra accuracy is not required in ordinary radio and TV servicing, it's nice to have to check our other meters and to make critical measurements in industrial servicing."

"And it's no hothouse lily that can't go with you on service calls," Barney injected. "A thermistor keeps readings accurate from 32°F. to 104°F. The high input resistance of that 200,000 o.p.v. lets it take back many jobs the 20,000 o.p.v. v.o.m. lost to the v.t.v.m. In fact it's better than an r.f.-sensitive v.t.v.m. working around a transmitter, say for reading the forward and reverse voltages of a resistor-type s.w.r. bridge. With that V-A/2 switch, you can always put a reading in the accurate upper-half of a scale. The .3-volt d.c. full-scale range is the stuff for making critical low-voltage readings—"

"Enough!" Ron shouted, putting his v.o.m. back in the carton. "I've just invented a definition: a bore is someone who talks about his meter when you want to talk about your meter. Your twaddle is interesting in a dull sort of way, but I must be off. My child bride is eagerly awaiting my prompt return."

Before Mac or Barney could say another word, he was gone.

"Whew, what a character!" Barney exclaimed. "It's a good thing he left before I popped him in the snoot."

"Don't let that act fool you," Mac admonished. "You've just met one of the most knowledgeable and experienced electronics technicians I know. He has done about everything there is to do in electronics: first-class radio operator and technician in the navy, two-letter-call ham, broadcast station engineer, production supervisor of a radio factory, state police and airways operator, service shop owner, radio engineer with a railroad, and now specialist in two-way radio communication installation and service. But he dearly loves to get someone's goat, and I think he took off with yours.

"His call points up one thing: we service people are not as up-to-date as we should be about what's going on in the service instrument field. We'd never heard of his v.o.m.; he'd never heard of ours. Every major test instrument manufacturer is constantly bringing out more sensitive, accurate, dependable, versatile, and helpful instruments; but most of us keep plugging away year after year with what we have. We don't need a new v.o.m.; we've got a v.o.m.! Reading ads in the magazines more carefully and dropping a card to an instrument manufacturer requesting a catalogue will undoubtedly open the eyes of many technicians as to just how out-moded their test equipment is."

"What was that stuff you said to Ron when he came in?" Barney asked.

"Oh that! It's an old joke between us. We both read Tom Swift stories as boys. One of the characters in these stories was an eccentric Mr. Damon, who was always exclaiming, 'Bless my shoe laces; bless my fountain pen; bless my eyeglasses, etc. Since Ron's last name is Damon, I usually come up with one of these 'bless my . . .' things when we meet."

"How were those stories? I've wondered ever since the Tom Swifties were so popular last summer."

"I suppose they were no great shakes as literature," Mac said, "but they did a lot for me. You see I ran across the stories right after I learned there was no Santa Claus, no Easter Rabbit, and no Little People hiding under toadstools. Suddenly all the magic had gone out of my boyish life, and a boy needs to believe in magic. Then along came *Tom Swift and His Electric Rifle*, *Tom Swift and His Giant Cannon*, *Tom Swift and His Electric Runabout*, etc. My bruised imagination got up and took off on wings. There *was* magic in the world, the magic of science. And my faith in and love for this magic has stayed with me right down through the years." ▲

EW Lab Tested

(Continued from page 24)

15,000-cps limit of our microphone calibration. Except for a dip of about 5 db at 6000 cps, the response was within ± 2 db from 200 to 15,000 cps. It was not possible to determine the actual crossover frequency from examination of the response curve.

The tone-burst response pictures reveal the outstanding transient response of the tweeter. The 3.8-kc. tone burst shown is typical of the tweeter's response throughout its range. The woofer transient response, shown at 250 cps, is not quite as good, but may have been slightly influenced by room characteristics.

The listening quality of the system is smooth and well balanced, as the response curve would suggest. Its sound is neither boomy nor thin, free from screechiness or stridency, yet with a pleasing crispness and liveliness. The speaker has moderate efficiency. The manufacturer states that amplifiers rated at from 10 to 65 watts may be used and we found that a good 15-watt amplifier was adequate to drive the speaker.

The ADC-14 is attractively and distinctively styled, measuring 13½" wide x 25" high x 12½" deep. It is finished in oiled walnut and may be mounted either horizontally or vertically. The price is $175. A base is included for floor mounting. ▲

ENGINEERING SALARIES UP

According to statistics gathered by the Illinois Institute of Technology about their engineering graduates, it pays to be an engineer if current starting salaries are any criterion.

By IIT findings, engineers start out with a salary three times greater than the average national per capita income recorded by the Department of Commerce.

The average engineering incomes vary according to specialized fields, with electrical engineers taking home the biggest pay checks. In 1962 electrical engineers received an average starting salary of $585 while this year the figure has risen to $607. ▲

EX-CB-ER ARRESTED

The Federal Communications Commission has announced the arrest of Warren J. Currence of Elkins, W. Va. for the alleged operation of an unlicensed CB station in Elkins. Three CB transmitters were seized.

This was Currence's second appearance before the U.S. Commissioner in four months. Earlier he ran afoul of the communications laws which resulted in his being charged with using obscenity on the air. This caused revocation of his CB license by the FCC on July 22. His illegal operations brought complaints by hundreds of CB licensees in the central West Virginia area. ▲

LEADS IN TRANSISTOR STEREO

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ALL-TRANSISTOR AM-FM & FM STEREO TUNER PLUS ALL-TRANSISTOR 40-WATT STEREO AMPLIFIER—ALL IN ONE SMART WALNUT CABINET FOR JUST $195.00

Now in time for Christmas giving, Christmas listening! Two 20-watt power amplifiers...two separate preamplifiers...plus wide-band AM, FM, and FM Stereo...all beautifully housed in this one, compact Heathkit All-Transistor Stereo Receiver. For Heathkit this means another first! For you it means experiencing the uncompromising realism of "transistor sound" in a handsomely styled receiver that *won't* overheat...just the coolest, fastest, most "hum-free" operation possible! Just the purest, most "solid sound" possible! This is the why of transistor stereo. This is why you should move up to the new AR-13 Receiver. And the traditional Heathkit economy makes this advanced performer easy to own...just $195.00

All the electronics you need for a complete music system are "Heath-Engineered" into this handsome unit...just add two speakers and a phonograph or tape recorder! And there's plenty of advanced features to match the advanced performance of the AR-13. You'll like the way this unit *automatically* switches to stereo, thus eliminating any manual operation. In addition the automatic stereo indicator light silently signals when stereo is being received. For versatility there's three stereo inputs (mag. phono and two auxiliary) plus two filtered tape recorder outputs for direct "off-the-air" beat-free stereo recording. Dual-tandem controls provide simultaneous adjustment of volume, bass, and treble of both channels. Balancing of both channels is accomplished by a separate control. The AM tuner features a high-gain RF stage and high-Q rod antenna.

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.

Building the AR-13 is quick and easy with the pre-assembled FM "front-end" and 3-stage AM-FM I.F. strip, plus circuit board construction. Styled in Heathkit's new low-silhouette design, the beautiful walnut cabinet accented with the extruded gold-anodized aluminum front panel makes the AR-13 a handsome addition to any home decor. This Christmas, move up to the better listening of "transistor sound" with the new AR-13 Stereo Receiver...another example of superb Heathkit quality at unmatched savings.

Kit AR-13, 30 lbs., no money dn., $19 mo. $195.00

SPECIFICATIONS—Amplifier: Power output per channel (Heath Rating): 20 watts/8 ohm load, 13.5 watts/16 ohm load, 9 watts/4 ohm load. (IHFM Music Power Output): 33 watts/8 ohm load, 18 watts/16 ohm load, 16 watts/4 ohm load @ 0.7% THD, 1 KC. **Power response:** ±1 db from 15 cps to 30 KC @ rated output; ±3 db from 10 cps to 60 KC @ rated output. **Harmonic distortion (at rated output):** Less than 1% @ 20 cps; less than 0.3% @ 1 KC; less than 1% @ 20 KC. **Intermodulation distortion (at rated output):** Less than 1%, 60 & 6,000 cps signal mixed 4:1. **Hum & noise:** Mag. phono, 50 db below rated output; Aux. inputs, 65 db below rated output. **Channel separation:** 40 db @ 20 KC, 60 db @ 1 KC, 40 db @ 20 cps. **Input sensitivity (for 20 watts output per channel, 8 ohm load):** Mag. phono, 6 MV; Aux. 1, .25 v; Aux. 2, .25 v. **Input Impedance:** Mag phono, 35 K ohm; Aux. 1, 100 K ohm; Aux. 2, 100 K ohm. **Outputs:** 4, 8, & 16 ohm and low impedance tape recorder outputs. **Controls:** 5-position Selector; 3-position Mode: Dual Tandem Volume; Bass & Treble Controls; Balance Control; Phase Switch; Input Level Controls (all inputs except Aux. 2); Push-Pull ON/OFF Switch. **FM: Tuning range:** 88 mc to 108 mc. **IF frequency:** 10.7 mc. **Antenna:** 300 ohm balanced (internal for local reception). **Quieting sensitivity:** 2½ uv for 20 db of quieting, 3½ uv for 30 db of quieting. **Bandwidth:** 250 KC @ 6 db down (full quieting). **Image rejection:** 30 db. **IF rejection:** 70 db. **AM suppression:** 33 db. **Harmonic distortion:** Less than 1%. **Multiplex: bandpass:** ±½ db, 50 to 53,000 cps. **Channel separation:** 30 db, 50 to 2,000 cps; 25 db @ 10 KC. **19 KC suppression:** 50 db down, from output @ 1 KC. **38 KC suppression:** 45 db down, from output @ 1 KC. **SCA rejection:** 30 db. **AM: tuning range:** 535 to 1620 KC. **IF frequency:** 455 kc. **Sensitivity:** 1400 KC, 3.5 uv; 1000 KC, 5 uv; 500 KC, 10 uv—standard IRE dummy antenna. **Bandwidth:** 8 KC @ 6 db down. **Image rejection:** 30 db @ 600 KC. **IF rejection:** 45 db @ 600 KC. **Harmonic distortion:** Less than 1%. **Overall dimensions:** 17" L x 5⅜" H x 14¾" D.

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New CB Circuits

(*Continued from page 36*)

new solid-state device to sharpen the i.f. bandwidth of its KG-4000 1-watt, hand-held transceiver. It is a ceramic filter inserted into the second i.f. amplifier. Deriving its special properties from the piezoelectric effect, the filter may be compared directly to a high-"Q" resonant circuit on 455 kc. The specific component is the *Clevite* TF-O1A, a "Transfilter" guaranteed by the manufacturer to remain, for ten years, within 0.2% of 455 kc. ±2 kc. No initial or long-term alignment is required.

How the filter is applied is shown in the partial schematic of the receiver's second i.f. amplifier (Fig. 2). Replacing the conventional emitter bypass capacitor is *FL*1, the ceramic filter. Note that the emitter resistor *R*16 parallels the filter to signal ground. In operation, the i.f. signal encounters both circuit components.

The ability of the filter to reject spurious signals above or below 455 kc. is based on degenerative feedback. When the signal is precisely on 455 kc., the series impedance of the filter is extremely low, on the order of 15 ohms. Thus, a virtual short circuit occurs across the resistor and emitter bias is lowered. Under these conditions, the transistor provides maximum amplification.

The i.f. signal produced by an adjacent-channel signal, however, enters the i.f. strip slightly above or below the nominal 455 kc. Since filter impedance rises for off-resonance signals, *R*16 is effectively re-inserted into the emitter lead. Negative feedback occurs and transistor gain drops for interfering frequencies. The attenuation curve of the TF-O1A (functioning as an emitter by-pass) is given in the accompanying graph in Fig. 2.

(c) Business Radio "S-Master"

An "S"-meter is a valuable addition to any CB unit not already equipped with the accessory. Besides the ability to indicate relative strength of an incoming signal, it is handy for antenna orientation and comparison tests, or receiver calibration and alignment. The *Business Radio*[3] Model 601 "S-Master" provides these functions in a two-transistor circuit that requires only two connections to the CB chassis. An internal battery makes the device independent of the transceiver power supply.

Shown in the schematic (Fig. 3) is the complete "S"-meter circuit. The device samples receiver a.v.c. voltage (a function of signal strength) and reads it out in "S" units on the meter. In circuits of this type, the key problem is imposing too great a load on the receiver's a.v.c. bus. The solution here lies at *Q*1. It is connected in the common-collector configuration; a hookup that is characterized by high input impedance. The a.v.c. introduced at the base of *Q*1 (*via* isolating resistor *R*1) experiences negligible shorting effect.

As the strength of an incoming carrier rises, a.v.c. applied to the base of *Q*1 increases in the negative direction. Output of the transistor is similarly negative-going; another consequence of the common-collector arrangement, no phase reversal occurs. Thus, a negative signal is made available to the base of transistor *Q*2 in the meter circuit.

Rising negative bias on the *Q*2 base increases the current flow through the

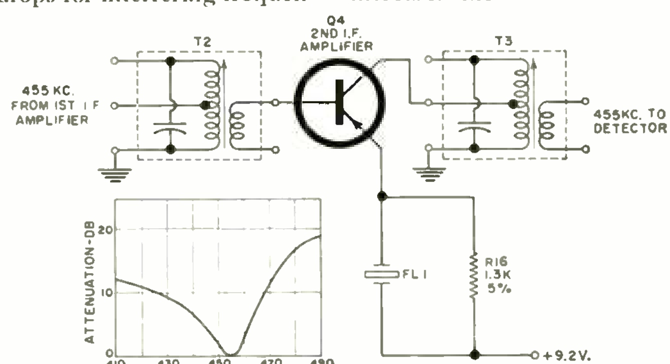
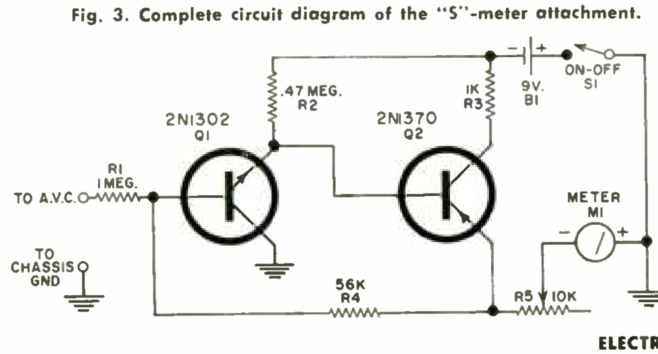


Fig. 2. Circuit using ceramic filter and its response curve.

Fig. 3. Complete circuit diagram of the "S"-meter attachment.



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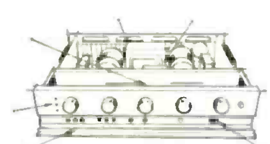
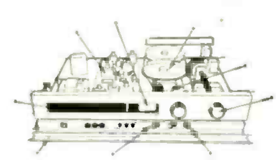
AA-22 40-watt Transistor Stereo Amplifier, 14 lbs. $10 mo. **$99.95**



• 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**



• Stereo phase control • Automatic stereo indicator • AFC and AGC • Filtered stereo tape recorder outputs • Built-in stereo demodulator • Tuning meter • Flywheel tuning • Slide-rule dial • Prealigned FM tuner and circuit board construction • Brushed gold-anodized aluminum front panel conceals secondary controls • Walnut cabinet

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transistor and the meter, in series with the emitter, commences to indicate. Potentiometer *R5* is used for calibrating the pointer to zero under no-signal conditions. When the CB receiver is driven by a 100-μv. carrier, the meter deflects to an S-9 reading. Other carrier levels or atmospheric noise are indicated in a proportional manner. ▲

REFERENCES

1. E.C.I., 325 No. MacQuestion Pkwy., Mt. Vernon, N.Y.
2. Allied Radio Corporation, 100 N. Western Ave., Chicago 80, Ill.
3. Business Radio, Inc., P.O. Box 5652, Minneapolis 17, Minn.

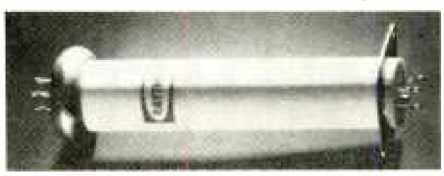
Light-Operated Switch

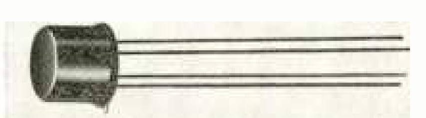
(*Continued from page* 47)

circuit is almost mandatory. Normal a.g.c. circuits will not work since they all operate off the carrier signal, and in SSB transmission there is no carrier when there is no modulation.

The circuit in Fig. 2 will cut down the variation in output from the loudspeaker to about 6 db for a change of 30-40 db in the audio input signal. A refinement is to use an output transformer with two output windings: use one of these for the a.g.c. control "Raysistor" and the other for the loudspeaker channel. The speaker is tapped onto a 25-ohm pot that is connected across this secondary winding. Then the audio output level can be set independently of the a.g.c. system.

"Raysistors" come in various cases and in various electrical ratings.





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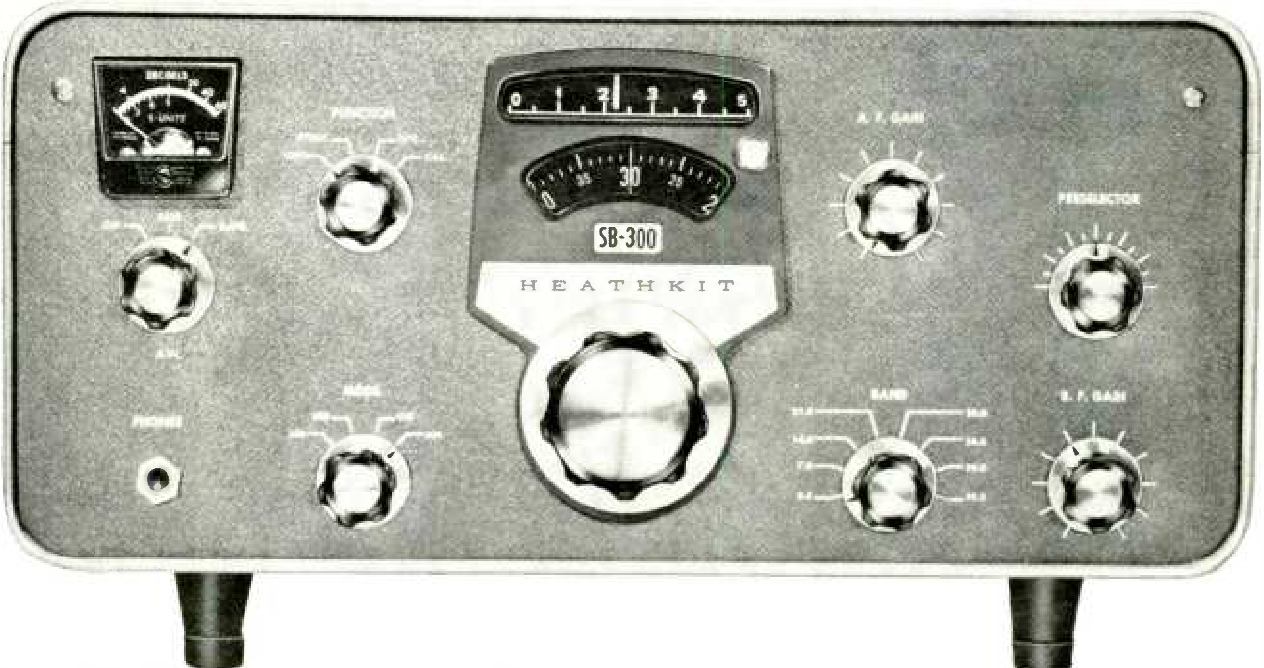

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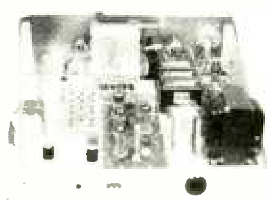

• Professional styling & features at 60% savings! • Complete coverage of 80 through 10 meter amateur bands with all crystals furnished, plus provision for VHF converters • Prebuilt, calibrated linear master oscillator (LMO) • 25 KC per tuning knob revolution offers bandspread equal to 10 feet per megacycle • Built-in crystal calibrator • 2.1 KC crystal bandpass filter • Stability of 100 cps after initial warmup • Wiring harness & two heavy-duty circuit boards for easy assembly

The SB-300 SSB Receiver is the first in an exciting new series of Heathkit SSB amateur gear designed to bring you the finest in communications facilities at great savings. Its professional styling, quality and features offer performance never before found in kit equipment.

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 bandpass 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!

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 13¼" D.

Kit SB-300...17 lbs....no money dn., $25 mo.	....	**$264.95**
SBA-300-1 CW Crystal Filter (400 cps)...1 lb.	....	**$ 19.95**
SBA-300-2 AM Crystal Filter (3.75 kc)...1 lb.	....	**$ 19.95**

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If instead of running the "Raysistor" lamp off the audio output, it is driven off a rheostat in series with the heater winding on the power transformer, then variation of the rheostat will provide a remote volume control with no hum pickup problems.

The light-operated device can also be used in transistor a.g.c. circuits although the range of control is more limited. The final choice of the type of circuit used will depend on the particular application.

The circuit in Fig. 3A will keep a constant output signal for a variation of approximately 10 db in the input signal. Since the photocell is between base and emitter, there is no change in the frequency response of the circuit. Fig. 3B shows the "Raysistor" across the collector load. Here the range of control is increased to approximately 15 db, but because of the changing load the low-frequency response will shift at the same time. If the circuit is to be used for narrow-band signal amplification or for d.c., then this response change can probably be tolerated. In both cases the lamps are driven from the secondary of the loudspeaker transformer as in the vacuum-tube circuit.

All these a.g.c. circuits have fast "on" action and slow "off" action. The control is noise-free and has excellent voltage isolation.

For a discussion of other applications of this new device, the reader is referred to *Raytheon* Technical Information Bulletin 163-1. This bulletin is available from Technical Information Service, *Raytheon Co.*, 55 Chapel St., Newton 58, Massachusetts. ▲

EUROPEAN RECEIVING-TUBE NUMBERING SYSTEM

By E. L. ELIZONDO / Senior Design Engr., Blonder-Tongue Labs.

Unlike our own U.S. numbering system, European tube designations provide specific data on rating, class, type of base, and electrode structure.

WITH the increasing popularity of European tube types in high-fidelity and r.f. applications, the user is faced with what at first sight might be taken for an almost incomprehensible jumble of letters and numbers. This, however, is not the case.

In reality, these European tubes have a much more descriptive numbering system than the EIA system to which we are accustomed and actually provide more information about the tube, without resorting to the tube manual, than one would imagine.

The table below, adapted by permission of *International Electronics Corporation*, was taken from the *Mullard Ltd.* "Valve Tube and Semiconductor Guide." This table can be of considerable help in eliminating any confusion which might arise when dealing with these tube types. ▲

FIRST LETTER	OTHER LETTERS	FIRST NUMBER	OTHER NUMBERS
Rating of Filament or Heater	Electrode Structure & General Class of Tube	Type of Base	Design Number
A. 4-v. fil. **C.** 200-ma. heater **D.** .5-1.5-v. fil. **E.** 6.3-v. heater **G.** 5-v. heater **H.** 150-ma. heater **K.** 2-v. fil. **P.** 300-ma. heater **U.** 100-ma. heater **Z.** cold cathode	**A.** single diode **B.** dual diode **C.** triode **D.** power triode **E.** tetrode **F.** pentode **H.** hexode (4-grid type) **K.** heptode (pentagrid) or octode **L.** power pentode **M.** electron beam indicator **N.** thyratron **P.** secondary emission tube **Q.** nonode (9 electrodes) **T.** miscellaneous **X.** full-wave gas rect. **Y.** half-wave rect. **Z.** full-wave vacuum rect. Note: Two or more of the above letters may be combined. Thus CC would indicate two triodes in one envelope.	1. (base indicated by second number) 2. loctal 3. octal 4. rimlock (B8A) 5. special 6. subminiature tube 7. subminiature tube 8. 9-pin miniature (noval) 9. 7-pin miniature	Any numbers after the first are included to differentiate between tubes that have the same general description but have different characteristics. Note: the second number indicates the type of base if the first number is a 1.

EXAMPLES:

ECC83—6.3-v. heater, dual-triode with 9-pin miniature base.

EL34—6.3-v. heater, power pentode with octal base.

GZ34—5-v. heater, full-wave rectifier with octal base.

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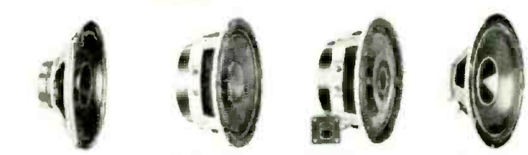

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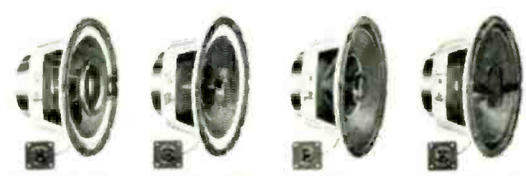

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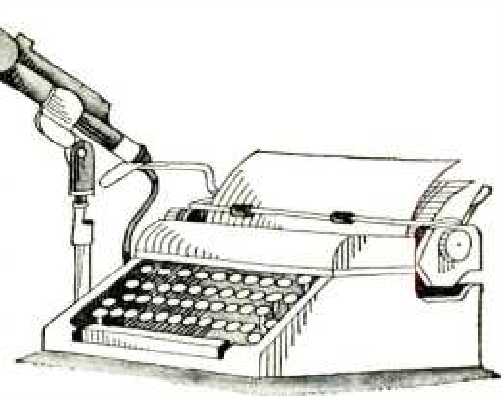
RADIO & TV NEWS



AFTER many years of looking at industry figures for the total sales of TV sets and radios, large numbers become rather commonplace. Even after seeing the various models displayed in the local department stores, the number of sets on parade are soon forgotten.

Recently, we were checking over some releases issued by the EIA on the total number of sales of TV and radio sets. As sometimes happens, the information on the sheet suddenly became very realistic, and after looking at the various figures, we got to wondering where all the sets are going. These figures include only U.S.-made items.

Distributors sold 541,810 TV sets to dealers in June, 1963 as compared with 378,215 the month before and 480,510 in June of last year. This year's cumulative sales through June stood at 2,956,808 while last year during the same period, sales stood at 2,724,038.

Radio sales by distributors in June soared to 811,923 from the 598,410 sold in May. Despite this sharp increase, it is still below the 1,040,598 turned over in June of last year. This year's six-month total was 3,935,670 which lagged well behind last year's tally of 4,800,574 for the same period.

Production of all-channel TV sets shot up to 107,500 units in June making the total June output of TV sets 665,004 compared with the 507,499 sets the month before, and 620,653 sold in June, 1962. The year-to-date tallies were 3,459,921 through June of this year and 3,295,501 for the same period last year.

The total output of radios for the month of June, 1963 was 1,653,866. This fell short of the 1,721,873 produced in June, 1962. The cumulative radio output through June, 1963 was 8,585,238 against 9,264,445 produced during the first six months of last year.

According to these figures, it appears that our consumer electronics industry is healthy and will enjoy a good year. But, I still wonder, where are all those sets going?

Imports From Japan Up

Exports of electronic products from Japan to the U.S. totaled $159-million in 1962, a 32% increase over the 1961 total, according to the U.S. Department of Commerce. Sales to the U.S. accounted for over half of the total Japanese electronics exports in 1962. Meanwhile, U.S. exports of electronics products to all countries registered a 22% gain to $747-million in 1962.

Japanese exports of TV receivers and chassis to the U.S. totaled $9.2-million, more than five times the level of 1961. Exports of transistor radios continued to show the largest dollar increase, accounting for more than 45% of the total electronic export to the U.S. Exports of tube-type, and other radios declined.

A total of 162,000 Citizens Band tranceivers, valued at $3.1-million, was exported to the U.S. in 1962. It is reported that many small transistor radio manufacturers have switched to the production of CB equipment, primarily for export to the U.S.

Educational Microwaves

A recent FCC ruling opened a band of 30 channels in the 2500-mc. range for instructional use and now permits all school buildings within a school district or on a college campus to be interconnected with as many as ten closed-circuit channels.

According to Stanley Lapin of *Adler Electronics Inc.*, teaching by TV will become as familiar as the use of textbooks by 1970, as a result of this new ruling. For the past year, his company has been operating an experimental on-the-air system in the Plainedge, N.Y., school district. Originating in the high school, the instructional programs are sent to seven other schools in the 10,000-student district.

While the cost of the 2500-mc. system is dependent on many local factors, such as district size and terrain, number and location of schools, and number of channels desired, a two-channel instructional system can be installed in a large city for $2.25 per pupil, while in smaller districts, initial costs may be higher.

Although the 2500-mc. systems are designed to serve local districts, they can be interconnected with other systems for exchange of programs. ▲

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Kit GD-232R, Organ, 160 lbs., no money dn., $23 mo.................. **$349.95**

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U.H.F. Reception

(Continued from page 39)

lines. Flat lines may be used indoors as long as they are kept several inches away from metal objects.

2. Use stand-off insulators *sparingly*, and avoid the ones that put metal close around the line.

3. *Never* bring the line through holes in metal window sashes or other metal dividers.

4. *Never* staple or tack the line. If it is necessary to hold the line in place, use plastic cable clamps, but use even these sparingly.

5. If you can't avoid the above practices, go to coaxial lines of the expanded polyfoam, low-loss types.

Let's look at the reasons for following these rules. In the first place, losses in transmission lines increase with frequency, hence line losses are greater at u.h.f. than v.h.f. Rule 1 says never use flat lines outdoors. This is because rain, lying practically between the conductors of flat ribbon lines, causes greatly increased losses in these lines. Table 1 illustrates the significance of wet losses in transmission lines at u.h.f. For example, if the installer were to choose a line for use in the New Mexico-Arizona desert areas, he would be justified in choosing the tubular type, with losses ranging between 3 and 4.3 db per 100 feet. But if he were on the New England, Florida, Gulf, or California coasts he should avoid it in favor of the flat cellular jacket types, because he is much more likely to get rain and salt deposits. To clarify the figures, the cellular polyethylene jacket cable has roughly 15% of its voltage left at the end of 100 feet totally immersed in water. The tubular version has only about 0.3% left, while the flat twin-lead has only 0.025% left! The choice is very simple with such figures. The tubular lines or expanded foam lines hold the water at a distance from the conductors, and the effect is lessened. Losses still increase, but not nearly as much.

Rule 2 says to be careful with standoff insulators. This is merely another way of saying "keep the lines away from metal." The practice of squeezing a metal loop shut and tight around the line is virtually the same thing as shorting the secondary of a power transformer, causing the primary to draw large amounts of current. In the stand-off case, the primary is the down-lead, with the r.f. fields around it. Absorbing these fields in a metal loop on the side of the house doesn't help the receiver.

Rules 3 and 4 are just extensions of this technique of avoiding putting extra losses in the down-lead system.

Most u.h.f. installations at present are in combination with a v.h.f. installation, and the duality of purpose introduces some peculiarities. Since all-channel sets have two antenna inputs, one for v.h.f. and one for u.h.f., the common practice is to run a separate line from each antenna to the appropriate input terminal. When this is done, keep the two lines at least six inches, preferably a foot, apart. This is merely an extension of the "metal proximity" prohibition. Actually this is more important than it appears because the proximity occurs over such a long span that small effects pile up astoundingly.

When line losses become too great, and no relief is available from following the rules of installation, a mast-mounted broad-band u.h.f. preamplifier will overcome the difficulty. These devices amplify the signals at the antenna, where the signal-to-noise ratios are highest, then feed it into the down-lead. The over-all effect is to "wipe out" the line losses. If the amplifier's gain is greater than the line loss, the noise of the system will be essentially that of the preamplifier. When gain equals line loss, the system noise figure will be the sum of the receiver's noise and the preamplifier's noise, but the system signal-to-noise ratio will be better than it would be without the preamplifier.

At the time of writing, none of these units is available in home-use packages, but they have been announced and will be on the market shortly. Elaborate narrow-band models are available for TV distribution system use and may be used in home installations where a customer feels that cost is justified. Fig. 4 illustrates one of these preamplifiers.

A few antennas have been made which work quite well with low gains at both v.h.f. and u.h.f. A good example of this is the double-V type so commonly seen as an economy v.h.f. antenna. When these types are used for all-channel reception, the single lead should be of the u.h.f. type, and a "band-splitter" used to separate the v.h.f. and u.h.f. signals.

These devices pick off the high-frequency u.h.f. signals and shunt them out one set of terminals, pushing the v.h.f. signals out the other set, thus accommodating the single line to the dual inputs of the all-channel receiver. The full name of one of these devices is "UHF-VHF Splitter Mixer." They can be used both ways. You may, for instance, connect a v.h.f. antenna and a u.h.f. antenna to a single down-lead with one of these devices.

A final note: Be careful of high antenna installations. It is quite possible, in reaching up for signal, to increase the down-lead losses so much that the extra signals are more than cancelled. In these cases it is better to go for more antenna gain lower down the mast. Have a go at u.h.f.—it isn't nearly as bad as it's painted. ▲

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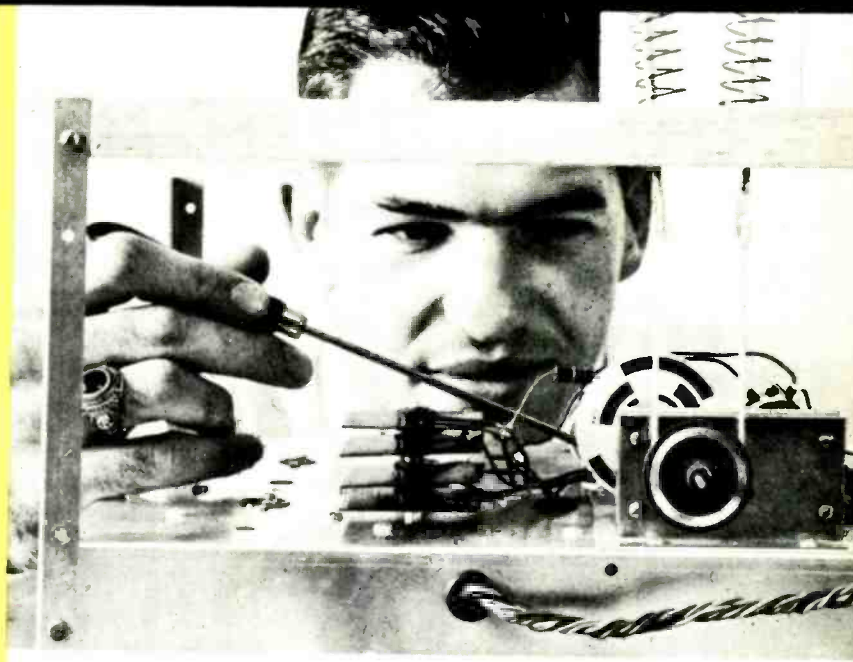

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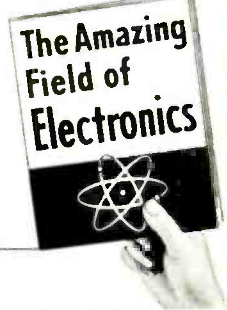

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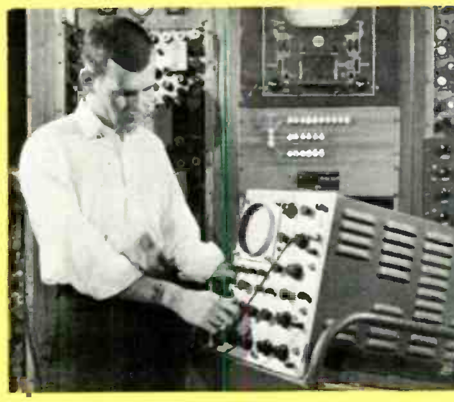

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Electronics Lab Technician

(*Continued from page 42*)

the specialized area covered by the job opening. At this level the applicant must show that he is qualified to work with a minimum of supervision from an engineer, be familiar with breadboard techniques and all necessary tools, have an extensive knowledge of test equipment and general electronic circuitry, be able to use standard electrical formulas in solving mathematical problems, be able to assume responsibility for simple designs under the supervision of engineers, collaborate with engineers in working out practical problems in construction and operation of equipment and, when necessary, be able to supervise technicians in lower categories. The applicant must be able to demonstrate a high degree of technical knowledge.

In many cases, a lab technician in Grade "A" can be promoted to the post of assistant engineer (known variously as assistant engineer, engineering associate, engineering aide). Qualifications for such promotion vary from firm to firm but generally require a recommendation from supervisors plus the ability to pass an oral and/or written test. The aspiring engineering associate may be tested in mathematics, circuit problems, and simple design areas.

An engineering associate is usually expected to have a minimum of six years experience, but education at the college level may be accepted as a substitute year for year. He is usually required to have a minimum of two years of technical education at the college level or the equivalent with satisfactory grades in these courses. Duties of an engineering associate include working under the supervision of a project engineer or section head; assist in the performance of engineering duties; design, construct, and test equipment as required; prepare sketches for fabrication and assembly; help in the preparation of proposals, parts lists, specifications, and a description of purchased components; apply engineering and mathematical methods in solving given problems, when necessary; and be able to accept some engineering responsibility and supervisory control over technicians. Engineering associates may spend more time in design, proposal, and similar work than at the bench.

Many electronics firms also employ test technicians in addition to laboratory technicians. Test technicians work mainly in the production area with test engineers and must be able to align, test, troubleshoot, and diagnose failures in equipment coming off the production line. They must have a thorough knowledge of the types of test equipment used by the company and the highest grade of test technician may be expected to construct special test jigs as required. Test technicians may be required to have a knowledge of government specifications, to collaborate with engineers in working out test problems in the early stages of production, and to assist in writing test procedures.

What about someone who would like to become a lab technician and who has the minimum educational requirements but not the specified experience? It boils down to the old problem—how can a person get experience if employers hire only experienced applicants? The answer is to get experience in as closely related electronics fields as possible—as a tester (preferably of complex electronic equipment), TV bench serviceman, field service technician, or even wireman, while continuing with more advanced technical education. With a good enough educational background and sufficient related experience, many companies will give an applicant the opportunity to qualify for a lab technician opening if he can successfully complete either a written or oral examination.

What About the Pay?

Wages for lab technicians doing equivalent work may vary somewhat in the same geographical area depending on factors such as the size of the company, type of equipment built, fringe benefits, specific experience, training, and skill of the individual. Other factors which may affect the wage scale to an even greater extent include geographical location of the company, the general wage level in that area, and the tightness of the skilled labor market there. The wage ranges outlined here are general approximations which may not be completely applicable to a given company.

Wages for the lab technician in Grade "C" may range from $65 to $100 per week; those for Grade "B" from $85 to $125 per week; and for Grade "A" from $100 to about $150 per week.

In the larger companies especially, lab technicians in all categories receive periodic wage reviews and are eligible for merit raises. Promotions are usually made from a lower to a next higher category when the technician accumulates sufficient experience and skill and is recommended for promotion.

Most electronics manufacturers also offer a number of fringe benefits. These usually include vacation, sick leave, holidays, and tuition refunds and may also include such additional benefits as partially or completely paid hospitalization and surgical insurance.

When a firm provides tuition refunds, the lab technician receives partial or complete tuition reimbursement for a technical course when he completes it successfully. A substantial number of technicians are continuing their studies at technical or engineering schools. If the technician decides to continue his schooling until he receives an EE degree, he is often able to have part or all of his tuition paid by his firm in addition to the fact that after obtaining his degree he is qualified for promotion to engineering status in his own firm.

What are the job satisfactions of a laboratory technician? In almost all instances, his work is challenging and stimulating. His duties involve a continuous process of self-education and professional growth since he works closely with engineers who design and develop new equipment types and models. For the technician interested in keeping up with and participating in new developments in his field of interest, laboratory work is ideal. In addition, his tasks are unusually varied since they range from constructing circuits to using many different types of test equipment for alignment, testing, troubleshooting, and debugging.

Just a note of caution here. This does not imply that the lab technician's duties consist solely of wrestling with exciting technical problems on the frontiers of knowledge day after day. Lab technicians will find that, like engineers, they have a certain amount of routine work to do, such as making a long series of repetitive checks to determine why a unit is not functioning properly or being assigned temporarily to some of the duller paper work that seems to be an integral part of almost every project. But the fact remains that, by and large, the work provides considerable variety and a great deal of personal satisfaction to most technicians.

Future Role of Technicians

What will be the status of the lab technician in coming years? Without overstraining the crystal ball, it seems safe to say that laboratory technicians will continue to assume an important role in electronics. As in all other areas of the industry, there is a trend toward requiring higher degrees of skill from technicians entering the field as well as from those already in it. If R&D programs continue at current or expanded levels, following the trend of recent years, the demand for skilled laboratory technicians will no doubt continue to increase. In fact, many observers feel that at least part of the much-discussed and debated engineering shortage in the United States may actually be a shortage of qualified technicians.

It may well be that, on a nationwide basis, as more well-trained and experienced lab technicians become available and assume greater responsibility, engineers will be freer to devote more time to work at their highest level of skill. An almost certain result will be even greater progress than in the past. ▲

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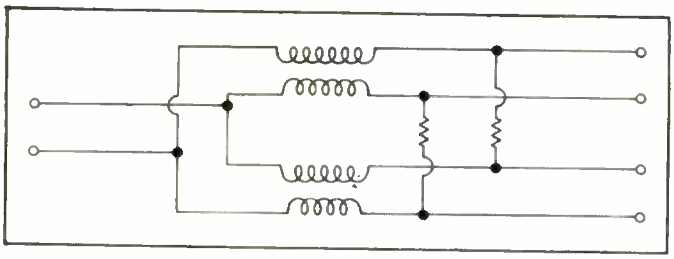

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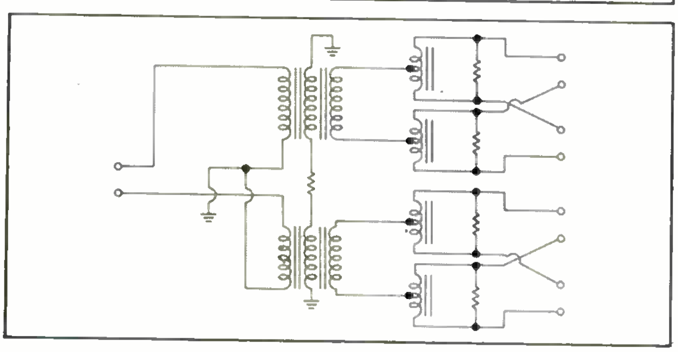

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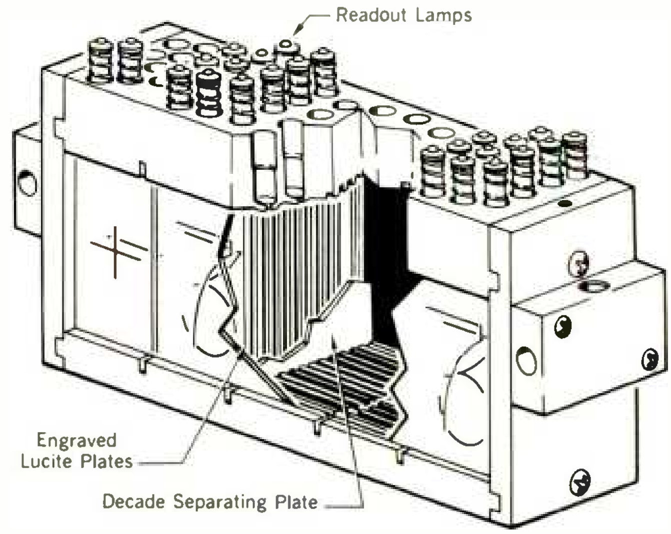
CIRCLE NO. 165 ON READER SERVICE PAGE

Digital Voltmeter

(*Continued from page 56*)



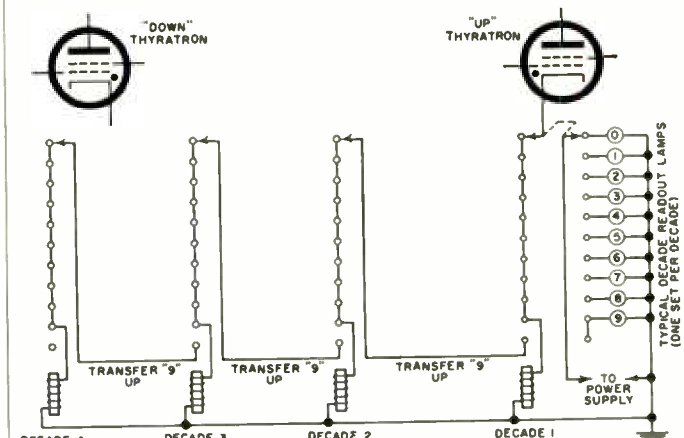
Readout consists of four sets of Lucite plates with numerals and decimal points engraved. Each of the readout lamps is arranged to edge-light a single plate which illuminates the proper numeral. Two plates and lamps at left indicate "+" or "—."

ing the error signal to disappear. With the other decades still at zero, the instrument now illuminates "+0.009" in the readout windows.

For a second example, assume +.099 volt is applied to the digital voltmeter. Again "up" pulses are generated to drive the first stepping switch. Observe that the switch will now step to the eleventh position, at which time the "up" pulses are transferred from the first stepping switch coil to the second stepping switch coil through the switch wiring (Fig. 11). The first switch is left in the nine position while the second one continues until a balance is reached at the tenth position, at which time the Kelvin-Varley divider arms reach a balance against the input signal. The readout now shows "+0.099." In a similar manner, increasing voltage inputs will cause the instrument to eventually reach the end of each stepping-switch position, and transfer to the next switch until a final reading of +9.999 volts is reached.

"Down" pulses are routed through other decks of the stepping switches in a somewhat different manner. Starting with the digital voltmeter at +9.999 volts, assume that the input voltage has dropped to zero. With the Kelvin-Varley divider at +9.999 volts and the input at zero, a square wave of proper polarity is generated which results in the "down"

Fig. 11. All stepping switches are in their "0" position.



thyratron pulsing the fourth stepping switch coil (Fig. 12). A "down" pulse causes the switch to move one step, that is, to zero. Observe that the next "down" pulse is now transferred to the third switch coil which is at nine. One additional pulse results in the switch going to zero and again transferring the next pulse to the second coil. In this manner four "down" pulses can reset the readout to all zeros.

In situations where the stepping switches are at settings other than transfer 9's up, "down" pulses are routed through the least significant switch coil which is pulsed until a zero is reached. The "down" pulses, if continued, are transferred to the next most significant switch, which again repeats the sequence.

Under operating conditions such as proceeding from .009 volt to .010 volt, the stepping switches go from 0.009 volt to 0.019 volt, which causes the "up" pulses to change to "down" pulses. By following the foregoing sequence, it can be seen that the least significant digit will be actuated so as to produce the correct number. In this way, most inputs will cause a balance to be achieved by a combination of "up" and "down" pulses. See Fig. 13.

The stepping-switch techniques described here are commonly used in lower priced digital voltmeters. These may cost around $800 to $1000. Medium-priced machines may also use stepping switches but in oil-filled sealed metal containers. In the more expensive, higher speed digital voltmeters, other switching techniques are used. Banks of transistor-driven reed relays may be used for switching. Transistor-driven mercury-wetted contact relays are similarly used. More recently, transistor solid-state switches are being utilized in these instruments. All of these methods increase the complexity of the machine as compared to the much simpler, although slower operating, stepping-switch circuits that have been described in this article. ▲

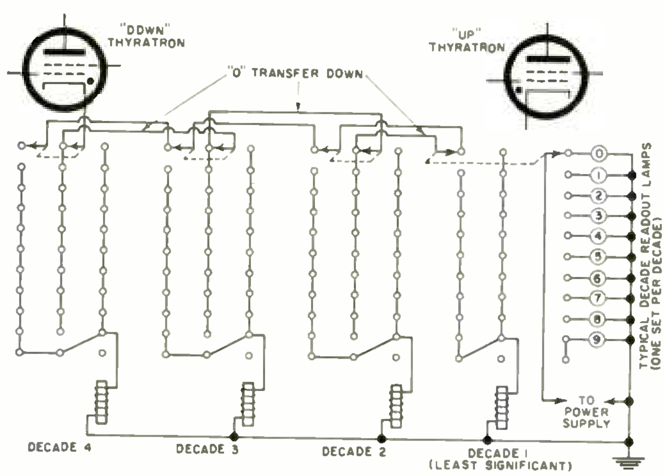
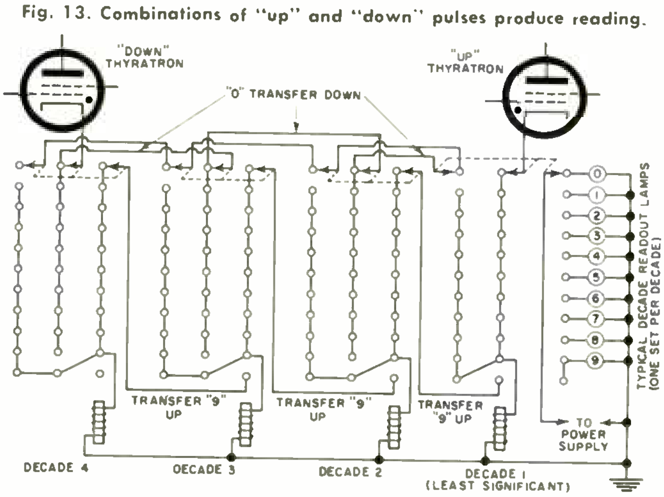


Fig. 12. Unit has been stepped down to "0000" in four pulses.

Fig. 13. Combinations of "up" and "down" pulses produce reading.



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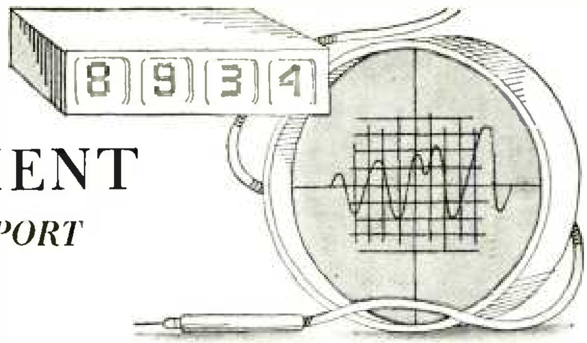


Eico Model 430 Oscilloscope

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

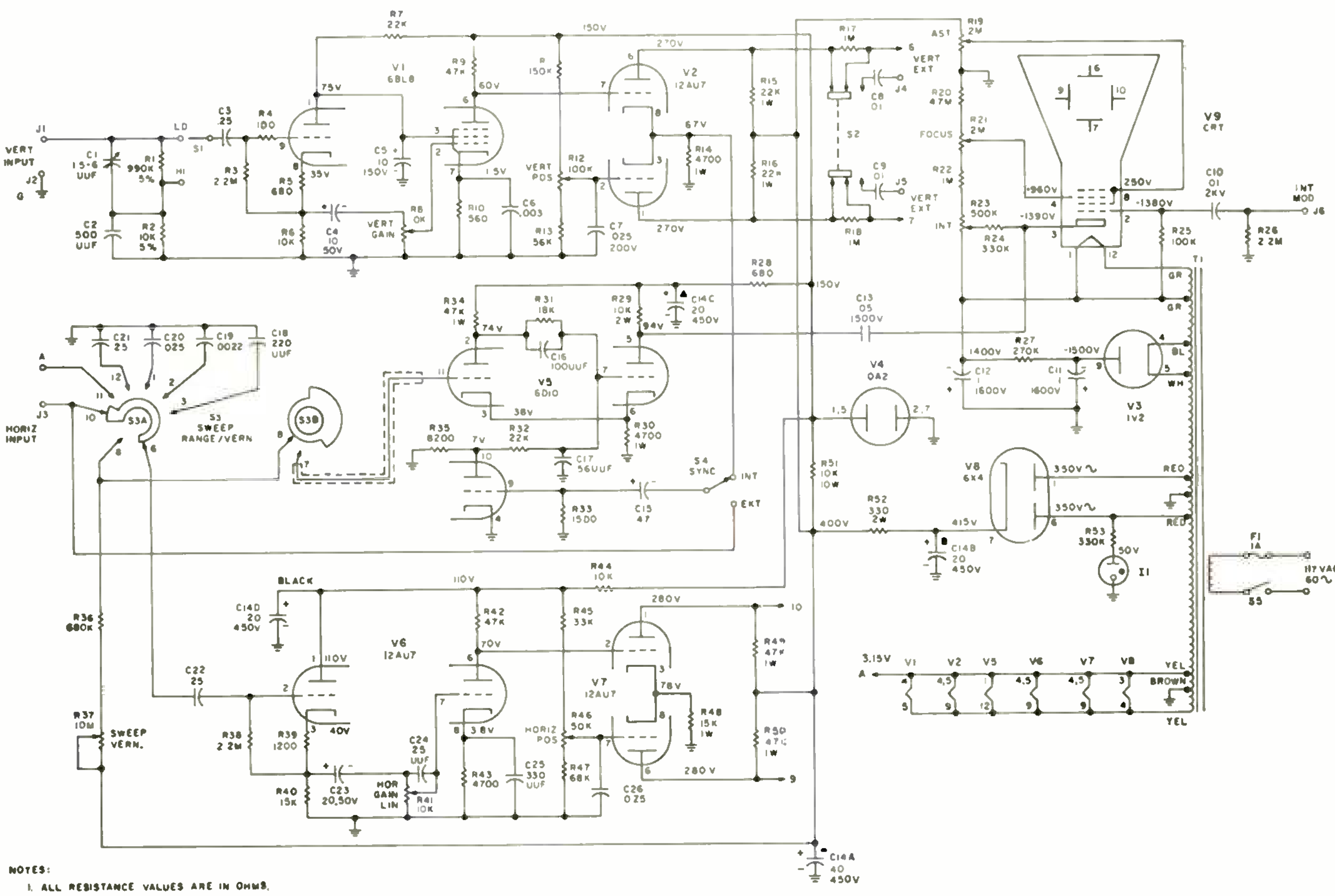
VERY often the versatility and usefulness of a scope are not taken advantage of because the instrument is too large and bulky for convenience. True, some scopes have to be large because they include much elaborate circuitry that does many useful jobs. Also, the 5-inch CRT needs its share of space too. On the other hand, if we are just interested in a general-purpose scope and if a 3-inch tube will give us enough viewing area, then there is no reason why the scope can't be made almost as compact and convenient as a v.t.v.m.

The new *Eico* Model 430 fits into this category. This general-purpose, 3-inch-tube scope measures only 8½" high by 5¾" wide by 11¼" deep, and weighs 11 pounds. The vertical amplifier is flat from 2 cps to 500 kc. with an input sensitivity of 25 mv. (p-p)/cm. Its input impedance is 1 meg shunted by 30 pf. The sweep circuit has four overlapping ranges, from 10 cps to 100 kc., and is automatically synchronized. Both a.c. line sweep and external sweep provisions are incorporated. Retrace blanking is used.

The CRT is a flat-face type with a Mu-metal neck shield to keep external fields from affecting the beam. The 1500-volt accelerating potential results in a sharp, bright trace with no blooming. Direct connections can be made to the deflection plates by simply operating a switch on the rear of the scope. This feature is especially useful in monitoring the modulation of an amateur transmitter.

The usual cathode-follower inputs are used with a frequency-compensated two-step vertical attenuator. The low-voltage power supply is regulated for stability. For other circuit details refer to the complete schematic diagram shown here.

For the kit-builder, the company has supplied its usual clear step-by-step construction details along with a separate booklet of pictorial diagrams showing every stage of assembly. The stiff cardboard covers of this booklet have been made in one piece and are folded so as to form an easel—a most convenient way



NOTES:
1. ALL RESISTANCE VALUES ARE IN OHMS.
2. ALL RESISTORS ARE 1/2W 10%, UNLESS OTHERWISE SPECIFIED.
3. ALL CAPACITANCE VALUES ARE IN UFD. (MICROFARAD) UNLESS OTHERWISE SPECIFIED.

of keeping the diagrams in front of the constructor.

The Model 430 is available in kit form at $65.95 or factory-wired for $99.95. ▲

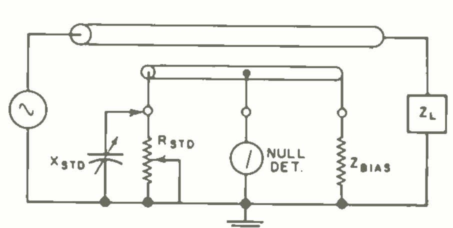
Delta OIB-2 R.F. Impedance Bridge

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

THE new *Delta Electronics* Model OIB-2 high-frequency operating impedance bridge permits the direct measurement of the impedance of a load while normal power is being applied. The bridge operates between 2 and 30 mc. and can handle a through power of 1000 watts. The operating impedance can be read out directly from the bridge dials in resistance and reactance values. The rated accuracy of the instrument is 5% over the frequency range.

The basic principle is an extension of the directional-coupler technique used in h.f. reflectometers. See the diagram. The heart of the bridge is a coupler box containing the main transmission line and a lightly coupled secondary line. The bias impedance sets the range of the variable resistance standard and permits the variable capacitor to measure both inductive and capacitive loads. These variable standards are connected to drum dials which can be read directly from the front panel. A front-panel connector is provided for an external detector. This permits the bridge to be used as an ordinary impedance bridge with a signal generator and communications receiver.

Since the bridge is able to handle 1 kw. of power, it can be inserted directly in antennas to measure the operating impedance in any part of the circuit.



The only insertion effect is that produced by a 5-inch length of transmission line. The instrument is, therefore, particularly useful for measuring the operating impedance of separate radiation network inputs, and transmission lines employed throughout an entire antenna system.

Another important feature of the bridge is its use for measuring antenna impedance in the presence of other operating antennas. The interference can be greatly reduced by using a relatively high power driving source for the bridge. With low-power bridges, it is often necessary to close down the entire transmitting plant to make antenna-impedance measurements.

The low insertion effect and high power-handling capability make the unit useful for applications other than antenna measurements. For example, in dielectric-heating systems, the operating impedance is a function of the power applied. The bridge can be inserted between the r.f. source and the load, and the impedance measured at any power level.

The Model OIB-2 is housed in a heavy 7" x 9" x 6" aluminum case and its rugged construction makes it suitable for field operation. The resistance and reactance dials are individually calibrated and engraved at the factory. The bridge is priced at $695.00. ▲

Pioneer Model 36 Photo Tachometer

For copy of manufacturer's brochure, circle No. 60 on coupon (page 17).

THIS new portable electronic tachometer, made by the *Pioneer Electric & Research Corp.*, will measure accurately the number of revolutions per minute of any turning device. It has two scales, one to 2400 rpm and the other to 12,000 rpm. The measurement is made without making any connection to or contact with the revolving member. Instead, the tachometer uses a cadmium sulfide photocell to sense the change in light reflection from a mark placed on the member. A built-in light source illuminates the mark so that taking an rpm reading is as easy as using a flashlight.

The photocell signal is amplified, differentiated, and then fed into a two-transistor circuit whose output is a square wave of constant amplitude and whose frequency equals the rate of signal received by the photocell. The square wave is peaked by another differentiator, the pulses are applied to a bridge rectifier to make them unidirectional, and then delivered to a meter movement. By reading the average value of these pulses, the meter is able to indicate rpm.

The accuracy of the instrument is within ±2% of the full-scale reading. By using a number of equally spaced markers, the full-scale reading is reduced and the accuracy is increased. For example, while accuracy on the lower scale is ±2% of 2400 rpm, by using two markers this accuracy becomes 2% of 1200 rpm. Use of four markers would increase accuracy to 2% of 600 rpm, or a maximum error of only 12 rpm.

To check the calibration, the instrument is pointed at a fluorescent light fixture and a reading taken. If properly calibrated, the meter will read 7200 rpm. This is the rate that the light varies in intensity with a 60-cps power line. (120 times a second times 60 gives the number of times per minute.)

The tachometer weighs two pounds complete with six small mercury cells. The price of the Model 36 is $150, and it is available from *Graybar* and *Central Scientific* branches. ▲

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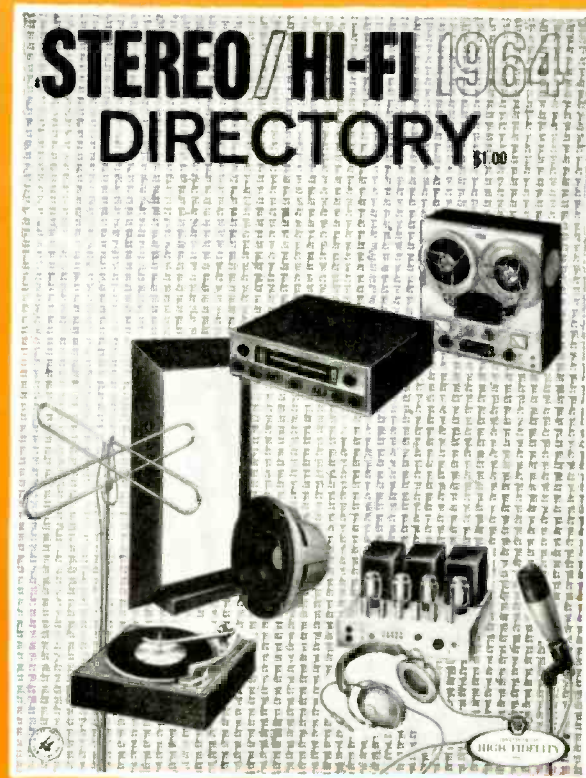

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the SHRUNKEN RASTER: A PUZZLER

By ART WIDMANN

Careful study of symptoms cut short a time-consuming problem.

THE SET had a black border about two inches wide around the picture. The first impression was "tired seleniums," but the chassis, a *Sylvania* 1-502-2, used a pair of 5U4's. The schematic showed a "B+" supply of 125 volts and a "B−" of 120 volts, with various taps in the negative supply.

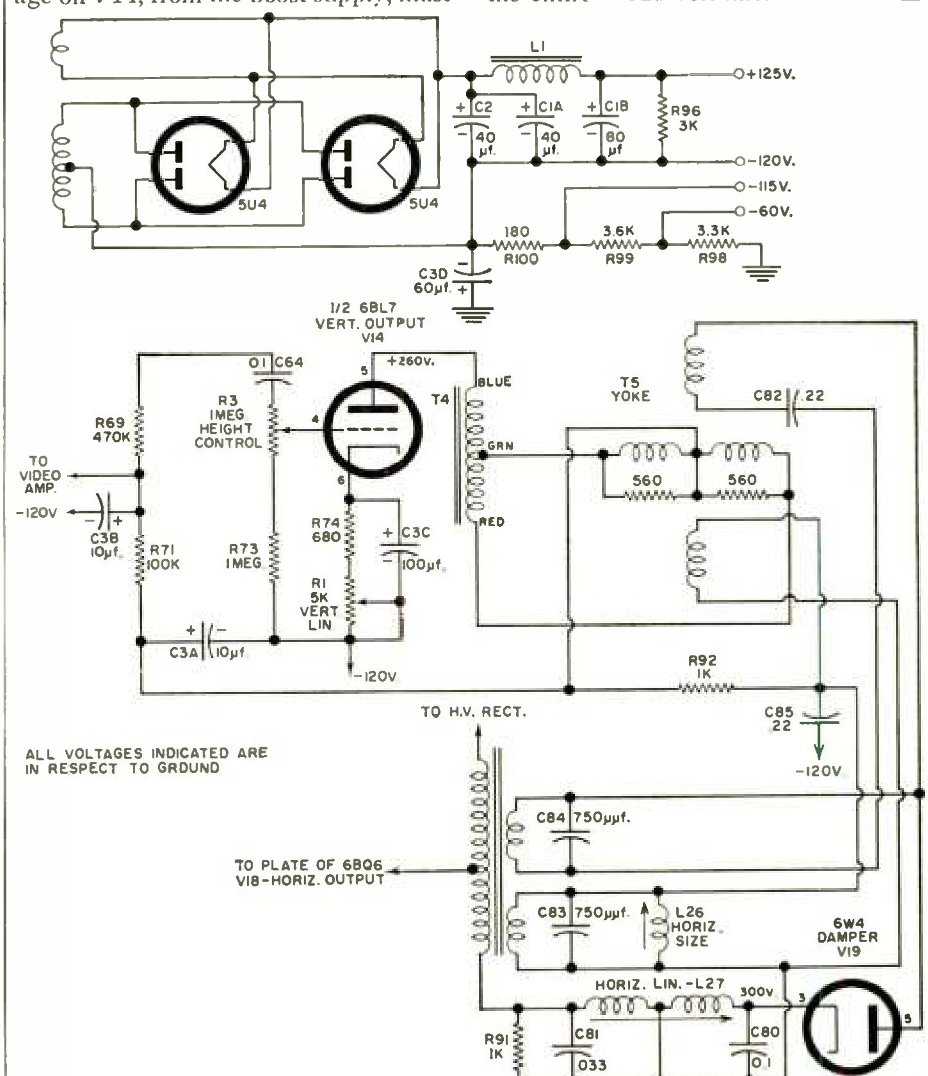
"B+" checked slightly high but "B−" was about 20 volts low. Boost voltage (pin 3 of V19) was only 250—50 volts low. A new damper made no difference. "Leakage to ground on the negative supply," I thought as I disconnected *C3D*—but the filter was good. The −115 and −60 volt lines were low but in proportion, indicating the drain was on the −120 line. That was unfortunate: the line went to a dozen different places.

I leaned back and tried to think of an easier way. Another look at the shrunken raster showed slight vertical foldover. This was not surprising since plate voltage on *V*14, from the boost supply, must also be low. Increasing height or vertical linearity, however, had a strange effect. The raster assumed a keystone shape and faded completely at maximum height. Was the yoke shorting? Boost voltage had dropped even more.

When I pushed V14 out of its socket, normal width and boost returned. I took one more reading and replaced the faulty part. Can you guess what was wrong?

The solution: With *V*14 removed and the height control at maximum, there was a positive reading at pin 4. *C*64 was leaking. This was masked with the tube in place as the stage developed some grid bias of its own. The keystone effect? *V*14 loaded the boost supply—and varied it at the vertical rate. It also loaded the −120 line, applied to its cathode.

This case shows the value of checking all symptoms. A "minor" one, slight foldover, was the clue to a quick solution. It spared a painstaking check through the entire −120 volt line. ▲



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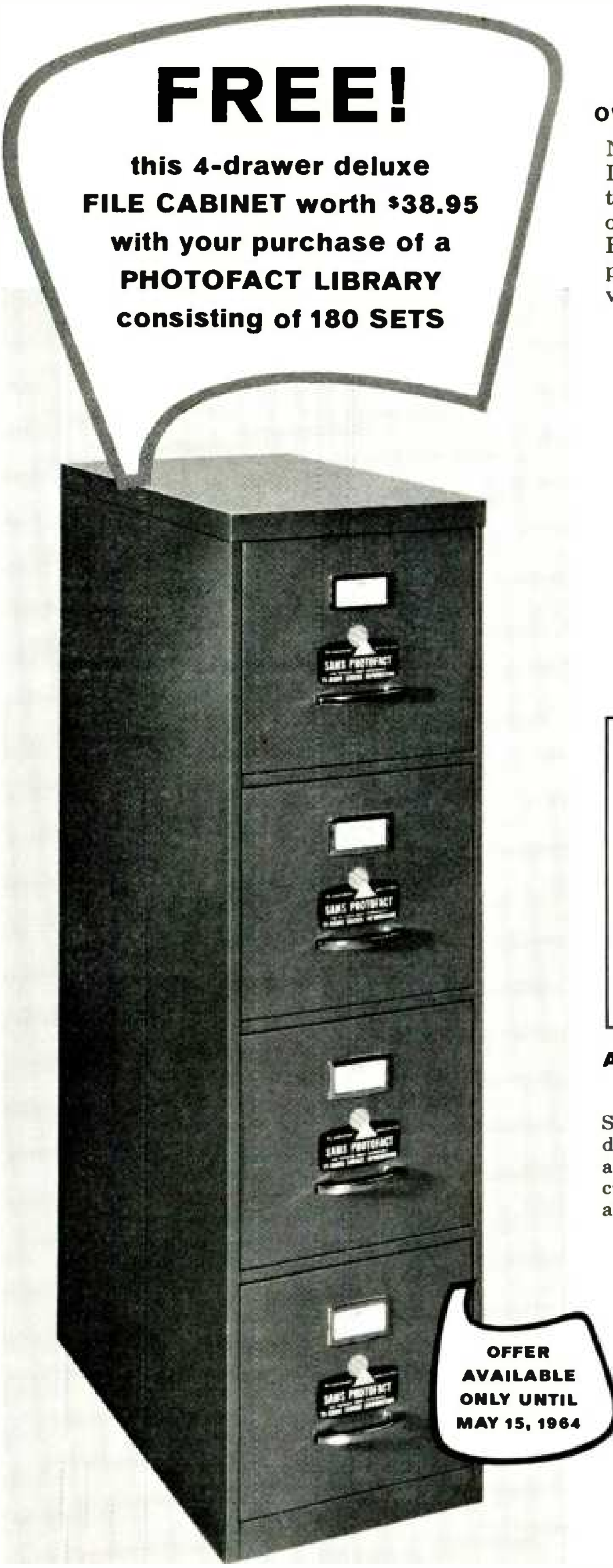

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Jet Communications

(*Continued from page 30*)

techniques. Interchangeable power supplies provide for operation from either 115-v.a.c. or 28-v.d.c. sources. Remote control for frequency selection with either single-channel simplex or double-channel 6-mc. spread is provided. The transmitter is provided with metering circuits for tune-up and test.

The companion *Collins* 51X-2 receiver is an 880-channel unit providing for reception of navigation and communication signals over the range of 108.0 to 151.95 mc. in 50-kc. steps. Frequency synthesis is employed. Where only communications is desired, the unit is available with a range of 118.0 to 151.95 mc. providing 680 channels in 50-kc. steps using 38 crystals. Size and weight are the same as the companion 17L-7 transmitter.

The use of solid-state devices is especially advantageous in jet communications because of lighter weight, smaller size, and lower power consumption. Numerous equipments of this type are presently being installed on the latest jet transports, including the *Boeing* 727, the *Douglas* DC-8, and the *Grumman* "Gulfstream" turbo-prop plane. Typical solid-state units are designed as transceivers to minimize space requirements. The *Collins* 618M-1C, shown in Fig. 4, is such a transceiver with a coverage from 116.0 to 149.95 mc. with 25-kc. spacing.

Modern high-frequency equipment is represented by the *Collins* 61ST transceiver. Employing 14 tubes and 100 transistors, this versatile unit provides 28,000 discrete channels in the range of 2.0 to 29.999 mc. Frequency synthesis, using a master oscillator adjustable to WWV, results in a frequency stability of 0.8 part-per-millionth per month. Capable of SSB (upper or lower sideband) or straight AM, the transmitter provides 400-watts p.e.p. on SSB and 110-watts carrier on AM. Selectivity of the receiver portion of the unit is 2.7 kc. at 6-db down points on SSB and 5.5 kc. at 6-db down points on AM. The unit is shown in Fig. 5.

All aviation radio air-to-ground communications equipment uses AM modulation. This may seem odd, in view of the widespread use of FM in other communications services. However, the advantages of FM are not nearly as important in airborne equipment, and the compatibility of communication and navigation facilities on v.h.f. makes AM the obvious choice. In h.f. communications, the use of SSB or very-narrow-band AM eliminates the possibility of FM.

Problems Encountered

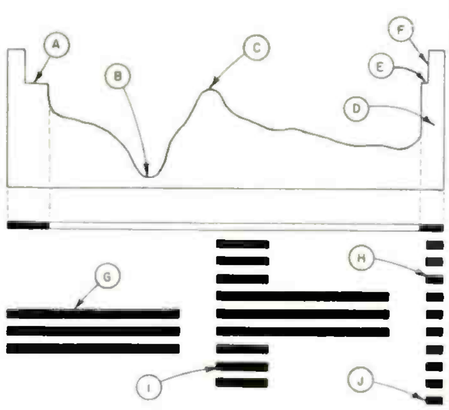
Because of the large amount of electronic equipment on board the jet transport, extreme care must be taken with the isolation of various units, the shielding of internal wiring, and the design of equipment. Radio frequency interference frequently plagues the installer of equipment and may take hours to run down. Reception of image frequencies from TV and, rarely, from other services can be a problem in some equipment. Careful engineering, careful wiring design, and the use of filters, where necessary, largely reduce the problems.

Many of today's jet transports fly in area (positive-controlled) air space. When flying in such areas, they must always be under IFR (instrument flight rules) conditions and carry special equipment for IFR weather and radar identification. As a result, radio communications are vital to their operations. Without radio, we could have no jet transport facilities. It is no wonder that more time, more money, and more ingenuity are being spent on equipment for the aviation services, although in terms of numbers of mobile units in use, it is one of the smaller of the communication services of the country. ▲

TELEVISION WAVEFORM QUIZ

By ROBERT P. BALIN

THE television video signal is made up of an assortment of pulses that are visible on both an oscilloscope and on the screen of a television receiver. A technician should be able to identify them.



Shown in the sketch is the last line of a field of video, and below it is the familiar pulse-cross pattern.

See if you can match the names of the various pulses with their location in the pattern and waveform.

1. Black picture element 1.___
2. Leading edge of horizontal sync pulse 2.___
3. Trailing equalizing pulse 3.___
4. Horizontal blanking pedestal 4.___
5. White picture element 5.___
6. Leading equalizing pulse 6.___
7. Front porch 7.___
8. Vertical serrated sync pulses 8.___
9. Horizontal sync pulse 9.___
10. Back porch 10.___

(*Answers on page* 109)

MAKING SPECIAL RESISTORS

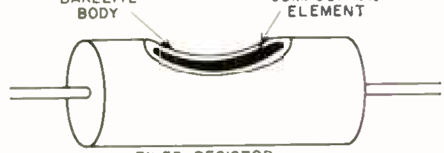
By ROBERT JONES

Making an odd-value resistor with 1% tolerance from an ordinary 10% tolerance type.

CONVENTIONAL molded carbon composition resistors can be reworked to make some odd value of resistance whose tolerance is determined by the measuring instrument used. Only those resistors having a value of 10% or less *below* the final desired value should be used as the cutting process involved reduces the cross-section area thus physically weakening the resistor.

Cutting is done by securing the resistor against turning or slipping. If a vise is used, be careful of the applied pressure as the resistor can easily be damaged.

Using a file, gently cut through the plastic cover of the resistor until the resistance element is exposed. While keeping tabs on the resistance value, gently file the resistance element. Be very careful when making the change to the resistance element, as little can be done to lower the resistance value and it is very easy to increase the value beyond the desired and useful tolerance.



Standard-value resistor is modified by filing the resistance element to the desired value then coating with a cement.

Once the resistance has reached the desired value, clean the resistor and cover the cut with a cement such as "Q-Dope," made by *General Cement Co.* The resistance value will change slightly as the cement dries. When dry, the resistor may have increased its value by a small constant, different for each type of cement. For "Q-Dope," this will be about 0.36% higher. Since the change is constant for the type of cement used, the resistor can be cut for some lesser value so it will have the desired value when finished. For example, to make a 950-ohm, 1%-tolerance resistor, use a conventional 910-ohm one in conjunction with a 1% tolerance bridge, file it 0.36% less in value (946.58 ohms), then coat it with "Q-Dope." Power rating should be reduced by 50% since part of the resistor has been cut away.

Finished resistors having 1% stability or better can easily be made from ½-, 1-, and 2-watt sizes. ▲

Phasemeter for Audio

(*Continued from page 46*)

the parts for each input channel are laid out symmetrically on each side of the chassis. The 6BN6 combining tube and the meter-calibrating potentiometers occupy the center of the chassis.

Since it is desirable that the two input channels be as electrically equal as possible, it is necessary to match all critical components. Capacitors and tubes should be new and from the same manufacturer's lot. Resistors used in similar circuit locations must be matched as closely as possible. For example, the plate and cathode resistors, *R5* and *R37*, *R7* and *R39*, *R6* and *R38* for tubes *V1* and *V4* respectively, are matched. Voltage divider resistors, *R10* and *R41*, *R11* and *R42*, should also be matched. If the balancing potentiometer, *R3*, at the initial checkout of the completed instrument does not have sufficient range to supply the desired voltage to grid one of *V1*, random substitutions of resistor *R2* are made until the desired voltage from *R3* is obtained. Similar changes in *R34* in the B channel may also be required. The necessity for matching corresponding resistors for *V2* and *V5*, and *V3* and *V6* is apparent from inspection of the schematic. The matching of resistors is readily done with a bridge of the accuracy found in the *Heath* IT-11 or *Eico* 950-K capacitor-resistor checkers. The matched pairs are placed in separate labeled envelopes for later use.

No particular problems are encountered in the wiring of the 6BN6 tube and associated components. The 0°-18° and 0°-180° full-scale adjusting potentiometers, *R70* and *R71*, are located on top of the chassis for ease of adjustment. The 20-kc. adjust variable capacitor, *C20*, may be adjusted through a hole drilled in the chassis bottom coverplate.

The power supply transformer *T1*, 0A2 regulator tubes *V8* and *V9*, and electrolytic capacitor cans for *C22*, *C23*, and *C24*, and decoupling capacitors *C7*, *C15*, and *C21* are placed on the rear of the chassis. The back panel of the cabinet is not used as it restricts the cooling of the instrument.

A recalibrated scale is used on the 100-μa. meter. Disassembly of the meter is readily accomplished by prying out the snap fasteners around the back of the meter.

Meter-Scale Construction

The phase scale used on the 100-μa. *Weston* model 1941, ±2% meter was constructed by the author as follows: The original 100-μa. scale was removed from the meter and fastened to a sheet of drafting paper. The center of the circle formed by the scale arc was located and a second arc of twice the original radius drawn in pencil on the drafting paper. Lines were extended from the center point through the 0- and 100-μa. calibration marks on the original meter scale to the new arc. These were labeled 0 (360) and 180, respectively. Additional lines were extended for each 10-μa. mark on the original scale. The distances between the extended lines on the new arc correspond to 18° for each segment of the arc. The segments were then divided into nine parts corresponding to 2° of phase, for the small segments. The lines on the new arc for 0°, 10°, 20°, 30°, etc. were lengthened slightly and labeled at 0 (360), 30 (330), 60 (300), etc. for the full-scale width. Since the calibrating marks are made at twice the final size of the meter face, slight errors in marking are of less consequence. The desired wording on the meter face was shown in pencil and the drawing given to a professional draftsman for inking. The finished drawing was then photographed at exactly half scale on process film and prints made on low shrinkage photographic paper. The new scale was cemented directly over the original scale, the edges trimmed, and the scale re-installed in the meter.

Alignment

The first step is to adjust the cathode-coupled clippers. Apply 1.1-1.4 volts of a 500-cycle sine wave to the "A In" terminal. Connect an oscilloscope to the output of *V1*, pin 6 (see Fig. 4), and adjust *R3* until clipping just starts on both the top and the bottom of the sine wave. It will be necessary to vary the input voltage slightly to obtain the best presentation of the scope screen. If symmetrical clipping cannot be obtained, it may be necessary to replace *R2* with another resistor as described elsewhere in this article. Reduce the input voltage to .10-.13 volt, connect the scope to the output of *V2*, pin 6, and adjust for symmetrical clipping by varying the setting of *R14* and the input voltage. The Schmitt trigger may be adjusted by observing the position of the pips on the waveform from *V2*. The slight change in the intensity of the trace is caused by feedback from the operation of the Schmitt. The pips should be made to fall just above and below the zero reference line by adjusting *R24*. A second method of adjusting the Schmitt is to connect the scope to the output of *V3*, pin 6. Reduce the input voltage to a very low level, about 10 mv., and adjust *R24* for triggering on the lowest possible input. The B-channel clippers and Schmitt are adjusted exactly in the same manner as the A channel, since both channels are symmetrical.

The next step is the adjustment of the meter ranges. Apply about 10 volts of 500 cycles to both the A and B channels. Set "F. S. Adjust," *R68* on the front panel, to mid-range, the "Addition" switch, *S3*, to 180°, the "Range" switch, *S4*, to 180°, and adjust *R71* on the chassis for full-scale meter deflection, 180°. To adjust the 0-18° range, it is necessary to apply 18° of phase shift to one of the input channels. The phase-shifting circuit shown in Fig. 3B may be connected to the B channel and the reference signal to the A input. Set the phase-shift switch to 21.8° and vary the input frequency from the audio generator so that exactly 18° of shift is indicated on the 0-180° range. The required frequency is about 375 cycles. Move the "Range" switch, *S4*, to 0-18° and adjust *R70* for exactly full scale.

The 20-kc. adjustment is made as follows: Apply 10 volts of a 20-kc. sine wave to both A and B channels. Set the "Addition" switch to 180°, the "Range" switch to 0-180°, and adjust trimmer, *C20*, through the hole in the bottom of the chassis until the meter reads exactly 180°.

A final touch-up adjustment may be made by applying 500 cycles to both inputs and alternately switching the voltage input from 0.3 to 10 volts. If the meter pointer moves slightly on either the 0° or the 180° ranges, carefully adjust *R3* and *R35*, respectively, until changes in voltage input have no effect on the meter reading. This requires only a very slight movement of adjusting potentiometers *R3* and *R35*. The instrument is now ready for use and should remain in adjustment for some time. As noted in the section on operation, the 6BN6 cathode resistor, "F. S. Adjust," *R68* on the front panel, may require resetting as the instrument warms up.

Phasemeter readings at four phase angles were compared with results obtained with two high-quality commercial phasemeters of different design and with an oscilloscope. The phase-shift standard (Fig. 3B) at an input frequency of 500 cycles was used to obtain the required phase delay. The results from the subject phasemeter compare favorably with the average readings of the commercial instruments.

Operation

After a warm-up period of several minutes, a signal source between 0.5- and 60-volts r.m.s. and at any audio frequency is connected to both the A and B input channels of the instrument. The "Addition" switch, *S3*, is set at 180° and the "F. S. Adjust" control *R68*, set to obtain a meter reading of exactly 180°. This setting remains quite constant once the instrument is warmed up. The installation of a check switch for temporarily connecting the two channels was considered. However, leakage through the switch in the "off" position at high frequencies could decrease the accuracy of the instrument. The input to both channels is disconnected, switch S3 returned to 0 , and the instrument is ready for use.

If the reference signal is connected to the A channel and the unknown signal to the B channel, the operation of the direction circuit is as follows: With the rotary "Direction" switch, S1, counterclockwise, push-button switch, S2, is depressed and the meter pointer moves toward the input with the leading phase shift. If insufficient movement occurs, the rotary switch is moved one position clockwise. This switch should not be rotated any more than is necessary to obtain a definite movement of the meter pointer, as at some frequencies, incorrect indication of the leading phase will be obtained. The action of the direction circuit is to slightly retard the phase angle of the A channel only. Referring to Fig. 1A, the dashed line near the reference frequencies indicates the new position of the reference signal. In the case of a lagging input signal E_r, to the B channel, depression of the direction button shifts the A channel reference frequency in the direction of E_r, decreasing the phase difference between the two channels and causing the meter pointer to move to the left, *i.e.*, in the direction of the A channel input terminals that are, in this example, the leading phase angle input. The effect with a leading unknown input is to increase the phase difference between the two signals causing the pointer to move to the right, *i.e.*, in the direction of the leading input terminals.

In using the phasemeter, the author confines the limits of possible phase shift to plus or minus 180°. If phase shift is considered always positive, *i.e.*, 0 to 360°, the meter is calibrated in the reverse direction for angles from 180° to 360°. In this latter range, the direction circuit operates in the reverse direction, pointing to the terminals with lagging phase.

Before the advent of dual-speaker systems with crossover networks and of stereo with multiple speakers, the phasing of the various frequencies was of little consequence. Currently used high-fidelity systems cannot give superior sound reproduction unless phase is controlled. The author recently listened to a high-quality stereo system with a 15-inch cone speaker and several high-frequency units in each of two stereo enclosures. Reversing the phasing switch on the preamplifier when listening to a program rich in bass resulted in a muffling of the sound and the loss of directional effect.

Phase shift within amplifiers may occur, particularly at low and high frequencies. For purposes of illustration, two amplifiers, not stereo, were evaluated with the phasemeter (see Fig. 6).

Amplifier A, a high-quality unit, was compared to amplifier B, a low-cost pre-amplifier-amplifier unit set with the controls flat. A 16-ohm resistor was connected across the amplifier outputs. Drastic changes in phase occur with unit B at the high and low end compared to the relative flatness of unit A. Obviously these two amplifiers could not be used successfully in a dual-channel stereo system.

Another example of phase shift occurs in crossover networks supplying bass and midrange speaker systems. The crossover system checked with the phasemeter was constructed with oil-filled capacitors and heavy wire in the inductances. The circuit is a constant-resistance design with 12-db attenuation per octave. During these tests, amplifier output was 5 watts and 16-ohm resistors were used on the crossover outputs. It will be noted in Fig. 7 that the phase changes markedly with frequency. The phase shift on both the high- and low-pass networks is very close to $+90°$ and $-90°$ at the 3-db crossover point. There is a constant phase difference approaching the theoretical 180° over the entire frequency range, consequently the speaker connections should be adjusted so that the cone movement of both units is in the same direction at the crossover frequency.

A third example of the use of the phasemeter in equipment evaluation is shown in Fig. 8. In matrixing-type multiplex converters the (L+R) signal is often routed through a 15-kc. low-pass filter. The particular filter used in this test was down 3 db at 19 kc. and indicated a phase shift at the higher frequencies. The 23-kc. to 53-kc. bandpass filter used in the (L−R) channel of multiplex converters showed appreciable phase shift above and below the 38-kc. suppressed-carrier frequency. Since the outputs from the 15-kc. low-pass and the 23-kc. to 53-kc. bandpass filters are combined in the detector matrixing system of the converter, phase shifts of the direction and amount such as shown in Fig. 8 do not lead to distortion-free reproduction. ▲

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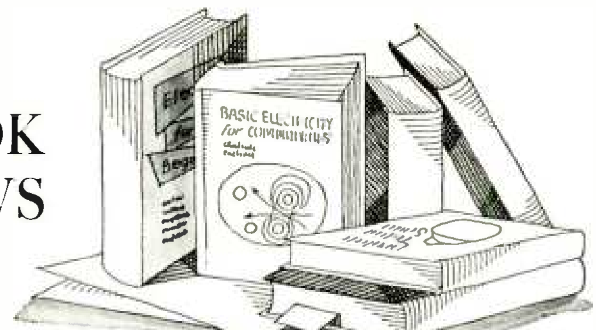
BOOK REVIEWS



"TRANSISTORS" by *Federal Electric Corporation.* Published by *Prentice-Hall, Inc.* 430 pages. Price $12.00.

This "Self-Instructional Programmed Manual," as *Federal* chooses to call it, is a unique experiment in home-study at the user's individual pace and in small progressive steps. The company has used this material in a programmed course for electronics technicians with outstanding results.

The text is divided into seven "Parts" devoted to major subjects which, in turn, are made up of "Sets." Each "Set" constitutes the minimum recommended amount of work for one learning period and contains one major idea or circuit description. The "Sets" are composed of "Frames" which are the working parts of the course, containing bits of information.

The scope is from basic principles of physics, through transistor theory and circuitry up to and including logic and switching circuits—the basis of all digital computers.

° ° °

"ELECTRONIC TESTS AND MEASUREMENTS" by Robert G. Middleton. Published by *Howard W. Sams & Co., Inc.* 283 pages. Price $6.95.

Written for the electronics technician or those with a background in basic electronics, this volume covers test and measurement technology as applied to any type of electronics circuitry.

While the early chapters deal with methods of measuring resistance, voltage, and current, this is "review" material. The text then treats complex component and circuit tests using bridges, generators, calibrators to analyze reactive and linear or non-linear loads, zener action, negative resistance, harmonic content, and high-frequency circuits.

Actual measurement techniques are outlined in detail while step-by-step instructions cover instrument and circuit hookups.

° ° °

"MICROELECTRONICS" edited by Edward Keonjian. Published by *McGraw-Hill Book Company, Inc.* 375 pages. Price $12.50.

This volume represents an integrated and comprehensive treatment of the field of microelectronics prepared by a team of well-known specialists each of whom has played an important role in this field.

In addition to presenting broad basic information, there is a wealth of practical material necessary for the design and manufacture of microelectronic circuits and equipment.

The book is divided into six chapters, the first two of which are introductory and include a microelectronic glossary, basic criteria, etc.; the balance of the book deals with discrete component parts, thin-film technology, and semiconductor integrated devices. Over 300 references have been compiled to enable those wanting additional information on specialized segments of the field to locate the literature.

° ° °

"DESIGN AND OPERATION OF DIGITAL COMPUTERS" by Dr. Gerhard Haas. Published by *Howard W. Sams & Co., Inc.* 267 pages. Price $6.95.

Designed as either a reference work or an instruction manual for classroom and home-study, this volume deals with basic elements, components, and circuits of digital computers.

The text material is divided into four main parts covering electronic computer classifications, a synopsis of electronic computing, and the coordination of a program-controlled computer; numerical systems; digital computer components; and operation of such units.

The treatment is, of necessity, mathematical and a working knowledge of algebraic techniques would be helpful. The text carries an extensive bibliography which will be useful to the serious student and those seeking additional information.

° ° °

"PULSE FUNDAMENTALS" by John M. Doyle. Published by *Prentice-Hall, Inc.* 482 pages. Price $16.00.

Electronics technicians and engineers will find this book useful as it describes in detail, then analyzes, the circuits and techniques used in radar, telemetering, pulse communications, industrial instrumentation, and television.

Among the subjects covered are linear waveshaping, electronic switches, pulse amplifiers, clippers, clampers, gates, multivibrators, blocking oscillators, delay lines, counters, and pulse modulation techniques.

Mathematics are used only where necessary and a working knowledge of basic algebra is the only prerequisite. The required electronic fundamentals are reviewed briefly in the early chapters of this volume for those readers who need brushing up on vacuum-tube and transistor theory.

° ° °

"UNDERSTANDING AND USING CITIZENS BAND RADIO" prepared and published by *Allied Radio Corporation*. 108 pages. Price 50 cents.

This handy and up-to-date pocket manual for the CB user or potential CB licensee covers how to obtain a license, CB equipment, antennas, how to use the equipment, operating procedures, servicing hints, a list of FCC field officers, and the "10" signals used in CB communicating.

The text is lavishly illustrated with line drawings, schematics, and photographs of typical CB equipment and accessories.

° ° °

"BASIC JUNCTION DEVICES AND CIRCUITS" by Roy H. Mattson. Published by *John Wiley & Sons, Inc.* 454 pages. Price $9.75.

This book is designed to provide engineers and designers with a thoroughgoing working knowledge of transistor fundamentals and applications. The author covers semiconductor materials, *p-n* junction diodes, triode-junction transistors, and other semiconductor devices and circuits—with circuits comprising the major part of the book.

There are 13 chapters and appendices. Subject matter covered includes a chapter on basics, semiconductor materials, junction devices, a review of circuits, the transistor, small-signal equivalent circuit considerations, operating point, the transistor as a switch, small-signal amplifier and feedback amplifier design, power amplifier design, and switching applications. The appendices are the rules of matrix algebra, quantities, and a selected reference listing. ▲

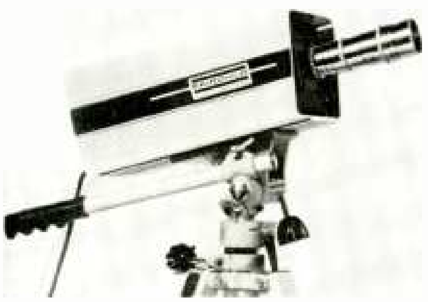
NEW PRODUCTS & LITERATURE

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

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

SINGLE-UNIT CCTV CAMERA

1 **Du Mont Laboratories, Divisions of Fairchild Camera & Instrument Corp.** has announced a single-unit CCTV camera which has been specifically designed for unattended operation in such applications as bank ledger transmission and signature verification, plant security surveillance, data transmission, remote monitoring of dangerous processes, and similar industrial and commercial uses.



The Type TC 350 camera offers a nominal horizontal resolution of 775 lines, transistorization of video circuits, and a selling price which the company claims to be almost $1000 below that of cameras of comparable quality and performance.

The circuit features 2:1 interlace and uses a 7735-A vidicon. The unit is housed in a cast aluminum cabinet, is fan cooled, and utilizes modular PC boards for fast servicing.

MAGNETIC TAPE VIEWER

2 **3M Company** is now offering a precision instrument, the magnetic tape viewer No. 600, which can be used to check recorder head alignment, track placement, pulse definition, inter-block spacing, and dropout areas in computer and instrumentation work.

The device makes visible the data recorded on the magnetic tape without damaging the tape. The viewer itself carries a six months guarantee against defective materials or workmanship.

TRANSISTORIZED IGNITION SYSTEM

3 **Workman Electronic Products, Inc.** is now offering a low-cost transistorized auto ignition system as the "Trans-It." The unit is a two-transistor circuit housed in an aluminum case that is waterproof and shockproof. No special additional coil is needed.

According to the company, high voltage is maintained as rpm is increased. It is designed to be used on any car with a 12-volt, negative-ground system. It is catalogued as BX14. For six-volt cars, Model BX14A is available.

NEW ANTENNA LINE

4 **Zenith Sales Corporation** has entered the antenna business with a full line of v.h.f. and u.h.f. TV, FM, and FM-stereo antennas, including hardware and accessories, for outdoor and indoor use.

The "Gold Seal" line consists of outdoor antennas, including a series of harmonically resonant all-channel log-periodic types for color TV reception, black-and-white, and FM or FM stereo. These range from a 4-element array for local use up to 50 miles from the transmitter to a 17-element array for super-fringe locations up to 175 miles from the transmitter. These log-periodic antennas were developed in the Antenna Laboratory, Department of Electrical Engineering, University of Illinois.

Other units include broadband yagis, v.h.f. antennas, v.h.f. in-line, deluxe in-line, and folded in-line conical antennas, stacked bow-ties for u.h.f., among others, plus an extensive line of indoor antennas.

IN-CIRCUIT TESTER

5 **American Electronic Laboratories** has added the Model 245 in-circuit tester to its line of completely integrated semiconductor testers.

The new unit is designed for the quantitative troubleshooting of diodes, rectifiers, and transistors, either in or out of the circuit. The tester is portable and is powered by standard Type "C" flashlight batteries.

The Model 245 measures beta, resistance between semiconductor electrodes independent of semiconductor loading, shorts and opens in diodes and rectifiers, transistors for I_{cbo}, and diodes and rectifiers for reverse leakage.

REGULATED POWER SUPPLIES

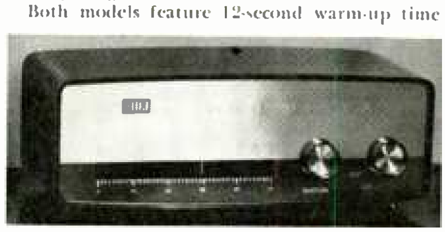
6 **Kepco, Inc.** has released its new ABC 10-0.75M (0-10 volt, 0-0.75 amp) regulated power supply which provides 0.05% regulation and stability, adjustable current limiting, short-circuit protection, low ripple (0.25 mv.), and low output impedance, plus such features as remote error sensing and constant-current operation.

The supply is housed in a half rack package and may be rack mounted as a single unit or combined with another supply on a common rack panel.

ALL-CHANNEL U.H.F. CONVERTER

7 **Jerrold Electronics Corporation** has two all-channel u.h.f. converters on the market, the "Super-Vista" for weak signal areas and the "Vista" for strong signal areas. Both are "top-of-the-set" converters and have all-channel frequency range of 470-890 mc.

Both models feature 12-second warm-up time



and no-drift circuitry. Slide-rule tuning makes channel selection easy. Gain is 8-12 db over the entire u.h.f. band. Both units measure 11" long x 6" wide x 4" high.

TUBE/TRANSISTOR TESTER

8 **Eico Electronic Instrument Co. Inc.** is marketing the Model 667 dynamic conductance tube and transistor tester in both kit and wired versions.

The instrument combines a mutual conductance test with a peak emission test to give a single reading of tube quality. It will also spot bad transistors by gain and leakage tests.

The tester is designed to handle almost every domestic and foreign receiving tube made including 5- and 7-pin nuvistors, 9-pin novars, 12-pin Compactrons, 7-, 9-, and 10-pin miniatures, 5-, 6-, 7-, and 8-pin subminiatures, octals, and loctals.

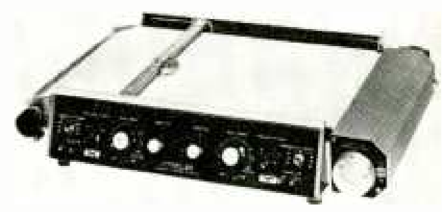
The Model 667 weighs only 20 pounds and is cased in a heavy-duty grey wrinkle steel case with matching steel cover and carrying handle. It measures 12" x 15" x 4½". Up-to-date roll charts will be available periodically.

ROLL-CHART ACCESSORIES

9 **F. L. Moseley Co.** is now offering four new roll-chart accessories for use with its Model 2D series X-Y recorders and Model 231 chart readers.

These new Type Q accessories allow the use of 120-foot continuous roll chart paper in a variety of operating modes to provide fast paper change and easy chart storage.

Types Q1 and Q2 are manually operated "hand crank" and "pull through-tear off" accessories while the Type Q3 has a variable-speed



motor drive for automatic advance of the chart paper at speeds of 2, 4, 8 16, 24 and 32 inches per minute. The Type Q1 is for automatic frame advance.

SHRINKABLE TUBING

10 **Pennsylvania Fluorocarbon Co.** is now offering a new, lower cost shrinkable tubing of Teflon FEP that shrinks instantly at 300° F and lower to permit inserted objects to have a surface of Teflon with a continuous service temperature of 400° F.

The transparent, flame resistant tubing, called "Penntube II-SMT" permits the encapsulation of parts, soldered joints, components, and fittings of plastic, metal or wood. The shrinking process does not affect the electrical, mechanical, or chemical properties of the Teflon.

PORTABLE PHONE SCRAMBLER

11 **Delcon Corp.** has introduced a portable telephone accessory that electronically scrambles the spoken word into totally unintelligible sound patterns.

The Model 105E is a 26-ounce, transistorized unit which provides total privacy. The scrambler which actually re-broadcasts the garbled speech into the telephone mouthpiece requires no connections to the telephone. The self-powered unit measures 2" x 9". Two identical units are required for sending and reception at the terminal phones.

"ADD-ON-CIRCUITS"

12 **International Crystal Mfg. Co., Inc.** is now marketing a new line of "Add-On-Circuits" which may be assembled to construct receivers, converters, transmitters, and other electronic equipment.

Amateurs, experimenters, and hobbyists can select from a variety of completely wired circuits including oscillators, preamplifiers, detectors, i.f. amplifiers, and frequency multipliers. The company can also supply companion matching cases for assembling individual units. Cases are presently available from 4 to 16 inches in length.

LOW-TEMPERATURE SOLDER

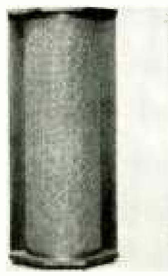
13 **Jensen Tools** has announced availability of its Formula 121, a low melting-temperature solder for aluminum and its alloys. The solder requires no flux whatsoever and parts to be soldered are simply heated and then "tinned" by rubbing the solder stick lightly on the surface of the aluminum. The solder may also be used on magnesium and its alloys.

The new solder is furnished in triangular sticks 15" long and about 3/16" on a side.

HI-FI — AUDIO PRODUCTS

COLUMNAR SPEAKER SYSTEM

14 **Leonhardt Engineering Company** is now marketing a unique columnar speaker system as the "Concert Master" LH-500. The design permits a full 180-degree dispersion of sound over a frequency range 25-20,000 cps. Input impedance is 8 ohms while the system will handle 20 watts average program material and 45 watts peak.



The system is 36¾" high, 16" wide, and 12" deep. The standard finish is oiled walnut but other finishes can be supplied on a special order basis.

TEST TAPE FOR RECORDERS

15 **Burgess Battery Company's Magnetic Tape Division** has just introduced a popularly priced test tape for use in testing home recorders.

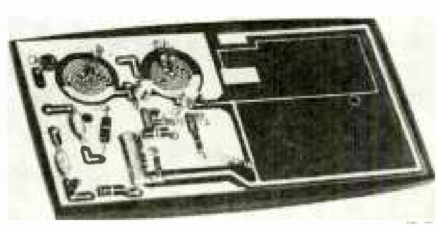
The tape permits checking the recorder for volume control, sound level, frequency response, fidelity and balance, timing, tape quality as well as providing instructions on various recording techniques and tape editing and splicing.

The tape is recorded on two sides: side A at 7.5 ips and side B at 3.75 ips. The tape itself is cellulose acetate base, 1.5-mil, quarter-inch all-purpose plastic.

FM/FM STEREO ANTENNA

16 **Antronics, Inc.** is in production on the "Multitron," a compact, electronic antenna system specifically designed to overcome the special problems of FM and FM-stereo reception.

Minimum gain is 20 db over a tuned dipole at any FM frequency. A printed-circuit, multi-element receptor with tuned coupling provides

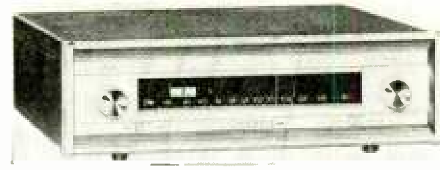


full bandwidth. The fixed-tuned printed transformer never needs adjustment, while critical circuit values are printed as distributed constants, replacing conventional components. Output matching is provided for 72- and 300-ohm tuners.

The unit is housed in a modern plastic cabinet which is available in either white or black.

FM-STEREO TUNER

17 **Sherwood Electronic Laboratories, Inc.** has added another tuner to its line of audio equipment as the S-3000 V, an FM-stereo tuner.



The new instrument uses a d'Arsonval meter as a tuning indicator with zero-center when the station is tuned in exactly. Sensitivity is 1.8 μv. (IHF) for −30 db noise and distortion. A 2.4-db capture effect eliminates background noise while FM interchannel hush suppresses between-station noise when tuning. The tuner has a stereo indicator light as well as an 8-inch professionally calibrated expanded dial scale.

SPUN-ALUMINUM SPEAKER

18 **Utah Electronics Corporation** is now offering the Model WP4A speaker featuring a spun-aluminum cone which is impervious to moisture and exposure to sunlight. Designed for a wide variety of outdoor speaker applications, this 4" speaker has a 3.2-ohm voice coil and will handle 4 watts.

INTERCOM/MUSIC SYSTEM

19 **Fasco Industries, Inc.** is currently introducing a transistorized intercom and music system specifically designed for motel and similar installations.

The new unit has a capacity of up to twenty stations and provides simple, foolproof communication between the office and guest rooms. Music from a quality AM-FM radio receiver may be included in the system. Since the talk-listen circuits are controlled from the guest rooms, complete privacy is assured. The office station indicates desire to talk by push-button audible signalling.

The entire system operates from a low-voltage chime transformer that powers an all-transistor amplifier, insuring complete safety and long life at low operating cost.

AMPLIFIER/TUNER LINE

20 **Omega Electronics Corporation** has announced its new "Laboratory Series" of all-transistor stereo amplifiers and FM-stereo tuners. In this series the amplifiers and tuners are hand assembled with special attention being given to component matching and accurate wiring and testing.

The amplifier (Series 1800) has a power rating of 35 watts per channel for stereo and 70 watts mono. Distortion is less than 0.5% at full range while frequency coverage is 18-20,000 cps −0.2 db at full output. Hum and noise is rated 75 db below full output at 10 mv. sensitivity.

The company's Series 1850 FM-stereo tuner has an IHF sensitivity of 1.6 mv. with 0.3% maximum distortion. Stereo channel separation is 36 db and frequency response is 0.5 db from 15-30,000 cps. A transistor-operated tuning indicator facilitates fast, precise tuning.

FM WIRELESS MIKE

21 **Kinematix, Inc.** is marketing an FM wireless microphone which weighs only 7½ ounces and can be concealed in a cigarette package. Known as the "Imp II," the unit is designed to work with any FM receiver, including portables, tuners, consoles, or FM car radios.

The unit may be used with its own built-in pinhead mike (which will pick up voices at a distance of 35 feet) or with any low-impedance microphone. A number of accessories are available for use with the system. The unit comes complete with its own leather case and carries FCC "type approval."

TRANSISTORIZED INTERCOM

22 **Texas Communications** is now offering a fully transistorized intercom system which has been designed specifically for camping safety and communications.

The "Camper 88" consists of two units, a master and a remote, styled in tan and gray. The system is ruggedly built for outdoor applications. The master unit, designed for installation in a pickup truck, may continuously monitor the remote unit if desired. The remote unit may call but not monitor the master unit.

The system includes both units, all necessary wires and connecting cable, special shock mounts, and adjustable mounting brackets.

TRANSISTORIZED P.A. AMPLIFIER

23 B & K Manufacturing Company is introducing a new line of all-transistor public-address amplifiers available in 15-, 30-, and 60-watt ratings.

The 30- and 60-watt models include a unique anti-feedback feature which enables the operator to tune out the unwanted feedback frequency, increase the amplifier gain, and obtain greater sound levels without acoustic feedback. These units have three microphone channels for the separate or simultaneous use of one, two, or three microphones—either high or low impedance. Two inputs for tuner, tape recorder, or other auxiliary equipment are provided.

The 15-watt model is a dual-power a.c. and d.c. unit designed for portable, mobile, and general-purpose applications. It operates on 117-volt a.c. or 12-volt d.c. with automatic polarization of the power supply for safety.

STEREO TAPE RECORDER

24 Roberts Electronics, Inc. has added the Model 330 to its line of tape recorders as a moderately priced stereo unit.

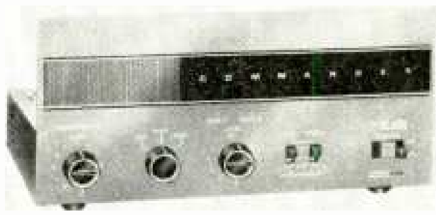
The Model 330 offers sound-on-sound recording, multiple sound-on-sound with channel transfer switch, multiple stereo headset outputs, inputs and outputs that allow for custom installation without modification, two vu meters, internal monitoring, and an output for third-head monitoring. A special transistorized preamp booster allows direct monitoring of the recorded tape signal during recording. It is available as an accessory.

The recorder weighs 27 pounds and records at 7.5 and 3.75 ips with a 15-ips accessory kit available. Two stereo speakers are included along with two high-impedance microphone inputs; two high impedance, high-level phono-radio inputs; two high-impedance preamp outputs; and two external loudspeaker jacks.

12-WATT P.A. AMPLIFIER

25 Harman-Kardon, Inc.'s Commercial Sound Division has recently introduced a compact 12-watt public address amplifier as the "Commander" Model CA-12.

The CA-12 has a channel for high- or low-impedance microphone, with an on-chassis socket



for a plug-in low-impedance matching transformer. Two music channels are arranged on a fader-type control for smooth transition. They accommodate such program sources as a tuner, crystal or ceramic phono, tape playback machine, or recorder. Push-pull output is used for cooler and more conservative operation.

Individual bass and treble tone controls offer a variety of system response characteristics to cope with acoustical feedback, booming or hissing microphone, poorly baffled speakers, or poor quality program material.

CB-HAM-COMMUNICATIONS

COMPACT BUSINESS RADIO

26 Sonar Radio Corporation has added a business-radio unit to its line of two-way radio equipment. The BR-20 offer 11 watts AM and

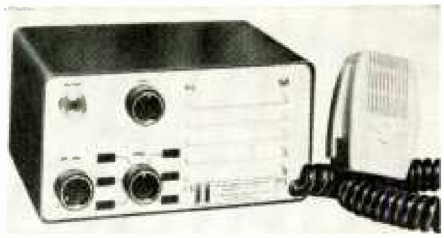
is designed for either mobile or desk use. The instrument comes complete with mounting bracket, two crystals, a ceramic microphone, microphone hanger, and a.c. and d.c. cord sets. Frequency range of the radio is 25-50 mc., receiver sensitivity is 8 μv. for 10 db signal-to-noise, and audio output is 3 watts. Transmitter audio frequency response is 200-3000 cps and output impedance is 50 ohms. Emission is 8A3.

The unit measures 4¾" high x 9½" wide x 11¼" deep and weighs 10 lbs.

MARINE RADIOTELEPHONE

27 Astromarine Products Corp. is in production on the "Ensign," a transistorized marine radiotelephone with a peak audio output of 3 watts with nominal current drain of only 0.01 ampere. This low current drain permits dry battery operation for boats without storage batteries. Of the six operating channels, one is reserved for the International Calling and Distress frequency while the other five channels are for use of telephone frequencies assigned to ship-shore service, for intership communications, and for communications with authorities for weather and navigational assistance.

The unit measures 4" high x 7¾" wide x 6" deep and weighs less than 5 pounds. It comes



complete with all crystals installed, a mounting bracket, cables, ground-plane 8-foot fiberglass whip antenna, mounting base, and push-to-talk hand microphone.

DEPTH SOUNDER

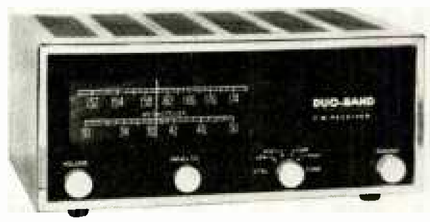
28 Raytheon Company is now offering a low-priced depth sounder with a built-in noise-rejection feature as the DE-720 "Fathometer." Suitable for inshore and inland waterways cruising in either fresh or salt water, the new unit has a calibrated six-inch dial with widely spaced markings at every foot to indicate precise depths to 60 feet. Sufficient power is designed into the unit to provide second-revolution readings beyond 60 feet.

The instrument is housed in a high-impact, corrosion-proof plastic case and has an aluminum yoke to permit tilting to any angle for easy viewing.

FM MONITOR RECEIVER

29 Utica Communications Corp. has developed a new FM receiver for monitoring business, police, fire, taxi, trucking and mobile telephone frequencies.

The "Duo-Band" receives both the low band (30-50 mc.) and the high band (152-174 mc.). It



features a dual-conversion superhet circuit, squelch, tuned r.f. stage, and crystal-controlled second oscillator. It is temperature-compensated for control of drift.

The monitor is available in a durable chrome-steel cabinet measuring 5½" x 13" x 8¼". It operates from 110-120 volt, 60-cycle a.c. An accessory speaker in a matching chrome steel cabinet is available extra.

COMPACT SSB TRANSMITTER

30 Hammarlund Manufacturing Company has announced a new compact, crystal-lattice SSB transmitter as the HX-50. Conservatively rated at 130 watts two-tone p.e.p. and c.w. input, the unit covers all amateur bands 80 through 10 meters. In addition it provides for optional 160-meter operation by means of a kit or factory-wired assembly.

Other features of the transmitter include carrier and unwanted sideband suppression of 50 db or better, 3rd and 5th order distortion down more than 30 db; all necessary crystals, full coverage of 10 meters; built-in antenna changeover; VOX; and keying relay.

The HX-50 measures 17½" wide x 9½" deep x 9⅛" high and is designed for 105- to 125-volt a.c. operation.

8-CHANNEL CB UNIT

31 Polytronics Labs, Inc. is marketing an 8-channel CB transceiver as the "Poly-Comm" N-8. Built for rugged performance, the N-8 has three i.f. stages plus a 6-mc. i.f. stage (16 tuned circuits) to provide a better than 60-db adjacent-channel rejection. The unit is designed for mobile-to-mobile as well as base-to-mobile use. All-electronic circuitry eliminates mechanical

relays. Power consumption is 85 watts a.c. The unit measures 11" x 7½" x 5" and weighs 12¾ pounds. It is offered in a white case with white knobs with face panels available in five colors.

BASE STATION UNIT

32 Aeronautical Electronics, Inc. is marketing a compact 35-watt v.h.f.-FM set for base station use. Designed especially for the typical business radio user, this unit has up to four-channel capability and provision for plug-in addition of the firm's tone-actuated "Unicall" for protection against unwanted calls on the same frequency.

Housed in a matte-black finished cabinet, the

station requires no more desk space than a sheet of letterhead paper. The set is designed for 115/230-volt, 50/60-cycle operation.

MANUFACTURERS' LITERATURE

GLASS TRIMMER DATA

33 **Corning Electronic Components** has available a revised 14-page illustrated booklet covering physical and electrical data on metallized glass trimmer capacitors having high "Q" and low temperature coefficients.

In addition to discussing the design and construction details and properties of standard trimmers, the booklet covers three types of inductors.

SPEAKER BROCHURE

34 **Jensen Manufacturing Company** has published a two-color brochure (MX) which pictures and describes the firm's line of ultra-compact, miniature high-fidelity speaker systems.

In addition to supplying technical details on the units, the brochure suggests a variety of placements for the small systems.

ANTENNAS & ACCESSORIES

35 **Delta Electronics, Inc.** has issued a 4-page brochure covering its line of transportable antennas and other special custom-made products including operating impedance bridges, two-channel receiving multicouplers, and transistorized monitor amplifiers. Full technical details are given for each item.

POWER SUPPLY DATA

36 **High Voltage Engineering Corporation** is offering a four-page illustrated folder containing a complete description of the new Series 7 high-voltage d.c. power supplies.

The line includes eighteen models based on the unique insulated core transformers (ICT) developed by the company. Full details, selected design and operating characteristics, and a listing of typical applications is provided.

INDUCTOR CATALOGUE SHEET

37 **Nytronics, Inc.** has issued a new catalogue sheet which describes in detail the firm's line of ultra-reliable shielded subminiature r.f. inductors with inductances from 0.1 μhy. to 180,000 μhy. in 76 values.

In addition to tabulating the specifications on these "Wee-Ductors," the sheet provides pertinent mechanical details as well.

INSTRUMENT CATALOGUE

38 **Cole-Parmer Instrument & Equipment Co.** has issued a comprehensive catalogue covering a line of up-to-date instruments and equipment for general research, clinical study, production, quality control, and pilot-plant operation.

Sub-divisions of the catalogue deal with thermistor-based instrumentation, chemically resistant liquid transfer, metering and vacuum pumps, precision temperature and heat-treating equipment, and clinical instrumentation.

RECORDING SYSTEMS

39 **Brush Instruments** has issued a 20-page condensed catalogue (No. 1200) that describes the firm's complete line of recording systems for industrial, military, and scientific applications.

Fully illustrated, the two-color booklet includes descriptions and specifications for the company's direct-writing, light-beam, and direct-recording systems. Also described are associated signal-conditioning amplifiers, preamplifiers, and enclosures.

COMPUTER GLOSSARY

40 **TRW Computer Division, Thompson Ramo Wooldridge Inc.** is offering copies of its 12-page computer and process control glossary. Included in this new brochure are definitions of more than 200 terms commonly used in the computer and process industries.

INDUSTRIAL TRANSFORMERS

41 **Triad Distributor Division** has available a new 48-page catalogue covering its line of transformers for military and industrial applications.

Complete specifications, dimensions, and prices for more than 1150 transformers are included.

SOLID-STATE DEVICES

42 **Sylvania Electric Products Inc.** has published a 28-page booklet describing solid-state microwave devices which contain ferrite materials. The publication discusses magnetism, ferrites, isolator theory, isolator design and applications, rotators, circulators, and other devices. The company makes more than 80 types of solid-state microwave products, most of which contain ferrite devices.

ALTERNATOR REPORT

43 **The Leece-Neville Company** is offering an 8-page report entitled "Let's Take the Guesswork Out of Alternators" which emphasizes that most alternator faults arise because of improper selection of equipment or improper maintenance.

The booklet points out how to determine the right size alternator for any vehicle, the most common charging-system symptoms, what they mean and what to do about them.

SSB TRANSMITTER BOOKLET

44 **Westinghouse Electronics Division** has published a new booklet covering its 50-kilowatt SSB transmitter for high-frequency communications. The four-page, two-color booklet describes and illustrates features of the type MST transmitter and gives technical characteristics of the compact, self-contained unit.

MAGNETIC VOLTAGE REGULATORS

45 **Raytheon Company** is now offering copies of its four-page consolidated data folder covering its magnetic voltage regulators. The publication lists 40 tubeless units with outputs stabilized to within ±1% for input changes of up to 15 percent. Standard models listed range from 10 va. to 3000 va. Component and apparatus styles are illustrated and described with their complete electrical and mechanical specifications. Models listed include line voltage, filament voltage, plate and filament voltage, and ferroresonant a.c. voltage regulators.

MICROWAVE EQUIPMENT

46 **General Radio Company** is offering copies of a new 20-page illustrated brochure which describes an extensive line of v.h.f.-u.h.f. instruments and components. Featured are coaxial connectors and adapters, slotted lines, admittance meter, transfer-function and immittance bridge, v.h.f.-u.h.f. sweep generators, modulators, detectors, oscillators, and many other microwave designs.

Special attention is paid to the company's new slotted-line recording system for automatic plotting of v.s.w.r. and the Type 900 line of precision coaxial elements.

RELAY CATALOGUE

47 **Potter & Brumfield** presents pertinent data and prices on 50 standard relays, including recently announced new types in more than 550 different contact arrangements and coil voltages, in its newly revised 12-page stock catalogue.

A four-page insert describes the firm's full standard line of mercury-wetted contact relays.

TRAVELING-WAVE TUBE DATA

48 **Sylvania Electric Products Inc.** has released a booklet describing its 100-watt continuous-wave traveling-wave tube, Type SYT-4369. The booklet describes the construction of the tube, lists data on typical r.f. performance, and provides full mechanical and electrical characteristics.

ULTRAMINIATURE ELECTROLYTICS

49 **Aerovox Corporation** provides complete specifications on its line of Type CRE ultraminiature aluminum-cased electrolytics in Bulletin NPJ-124 just released. Operating temperature range, d.c. leakage current, working voltage, and surge voltage data are included.

A complete listing of catalogue numbers, available from distributors, is provided with essential microfarad ratings and sizes.

OSCILLOSCOPE LITERATURE

50 **RD Instruments Division, Hickok Electrical Instrument Company** has issued an 8-page technical brochure which covers in detail its Model 1805A d.c. to 30-mc. oscilloscope.

The brochure includes technical specifications, a simplified block diagram, and descriptions of eight plug-in preamplifiers for use with the Model 1805A.

V.H.F. VOLTMETER

51 **Ballantine Laboratories** is offering a single-page technical bulletin describing its Model 340 v.h.f. voltmeter designed for accurate true-r.m.s. measurements from 300 microvolts to 3 volts over a frequency range of 0.1 mc. to over 1000 mc.

TRANSFORMER CATALOGUE

52 **Freed Transformer Company, Inc.** has announced publication of a new transformer catalogue which also includes information on the firm's line of standard filters—bandpass, low-pass, and high-pass types as well as subminiatures, telegraph tone and telemetering filters.

INSTRUMENT KNOBS

53 **The Buckeye Stamping Company** has published a four-page data sheet which pictures and describes a new series of instrument knobs, the "Standard" (SS) and "Prestige" (PS) series.

The publication includes a photo of each type, pertinent mechanical specifications, and ordering information.

MICROPHONE CATALOGUE

54 **The Turner Microphone Company** is now offering copies of its new General Catalogue No. 1008, a 16-page, 4-color book covering a complete line of cardioid, mobile, home recording, professional recording, broadcast, p.a., and general-purpose microphones. All are illustrated. The publication also carries details on a line of microphone stands, accessories, and interiors.

OPTICAL DIAMETER GAGE

55 **Weston Instruments and Electronics Division** has issued a four-page technical bulletin describing the Daystrom transistorized microlimit optical diameter gage. Operation, features, and general specifications on the Model 5111 are detailed. The gage is used for continuous, non-contact dimensional measurement and automatic control of products manufactured in continuous form.

SCR DESIGNER'S HANDBOOK

Westinghouse Electric Corporation has just published a 384-page handbook on silicon controlled rectifier characteristics, applications, and design considerations.

Produced especially for design engineers and technical supporting personnel, the manual contains much technical information and data which previously had only been available to designers by special request. In addition, it contains material relating to the firm's new SCR's, including the gate controlled switch.

A special detailed 116-page section covers applications of SCR's in various circuits, including design details and performance data.

Copies of the SCR Handbook can be ordered from the company's Printing Division, Box 398, Trafford, Pa. at $2.00 each. ▲

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Answers to "Television Waveform Quiz"
(Appearing on page 95)

1. C	4. D	7. E
2. F	5. B	8. G
3. I	6. H	9. J
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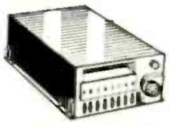
FAMOUS BC-645 TRANSCEIVER

BRAND NEW! 15 Tubes 435 to 500 MC
Can be modified for 2-way communication, voice or code, on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.
Shipping weight 25 lbs. **SPECIAL!** ... **$19.50**

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

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

ARC-3 RECEIVER!



Complete with All Tubes Exc. Used ... **$21.50**
Like NEW ... $33.50
Crystal-controlled 17-tube superhet, tunes from 100 to 156 MC., AM., on any 8 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

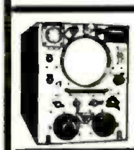
ARC-3 TRANSMITTER

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

ASB-5 'SCOPE INDICATOR

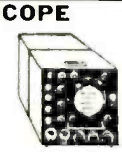
BRAND NEW, including all tubes, **together with SBP1 'Scope Tube.** Originally used in Navy Aircraft RADAR equipment. Easily converted for AC operation.
VALUE $250.00!
OUR LOW PRICE ... $16.95

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

SCHEMATIC DIAGRAMS For most equipment on this page, each **65¢**

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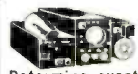
- All packing and shipping is made directly from our own warehouse in NYC to give you substantial savings in handling costs!

LORAN APN-4



FINE QUALITY NAVIGATIONAL EQUIPMENT
Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes, Exc. Used. **$69.50**

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.

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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.

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC	$12.95	$14.95
BC-454	Receiver 3-6 Mc	12.45	17.95
BC-455	Receiver 6-9 Mc	11.50	13.95
1.5 to 3 Mc. Receiver Brand New			$17.95

110 Volt AC Power Supply Kit for all 274-N and ARC-5 Receivers. Complete with metal case. Instructions ... **$8.95**
Factory wired, tested, ready to operate ... $12.50
SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. **Only** ... **49¢**

2.1 to 3 Mc Transmitter, Brand New ... $12.95
BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal. BRAND NEW ... **$9.75**
Like New ... $7.95
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ALL ACCESSORIES AVAILABLE FOR ABOVE

ARC-5/T-23 TRANSMITTER 100-150 Mc., includes tubes: 2-832A, 2-1625. BRAND NEW, with tubes ... **$21.50**
Excellent Used, less tubes ... $5.95

ARC-5/R-28 RECEIVER. 2-meter superhet, 100 to 156 Mc in 4 crystal channels, complete with 10 tubes
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Telephone: CO 7-4605
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LATEST TYPE COMMAND BROADCAST RECEIVER!

Like NEW, with Tubes **$34.50**
Model R-22 Broadcast Receiver, 550 to 1600 Kc. with control box and flexible mechanical tuning cable. 6 Tubes. 28 VDC operation.
110V AC Power Supply for above: Kit $8.95; Wired $12.50

AN/ART-13 100-WATT XMTR

11 CHANNELS
200-1500 Kc
2 to 18.1 Mc

$79.50 EXC. USED
complete with Tubes

Famous Collins Autotune Aircraft Transmitter, AM, CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PP811s modulate 813 in final up to 90% class "B." A Real "HOT" Ham buy at our low price!
AN/ART-13 XMTR, as above, in LIKE NEW condition, with all tubes and crystal ... **$89.50**

0-16 Low Freq. Osc. Coil for ART-13 ... 7.95
24V Dynamotor for ART-13 ... 11.95
We carry a complete line of spare parts for above.

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Talk as far as 17 miles! Dependable 2-way communication at low cost! Ideal for home, farm, field. Up to six phones can be used on one line. Each phone complete with ringer. Originally cost govt. $65.00 each. Excellent Condition, checked out, perfect working order, complete with all parts. Each ... **$12.95**

AN/APR-4 RECEIVER only, 38 to 4000 Mc in 5 tuning unit ranges. High precision lab instrument. Input 115 V 60 cy. Like New ... $89.50
Tuning Units TN16, 17, 18 each ... $39.50
Tuning Unit TN19, Brand New ... $89.50
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BC-348 SUPERHET RECEIVER 200 to 500 Kc and 1.5 to 1800 Mc. Voice Tone, CW. Self-contained dynamotor for 24 V DC. Exc. Used. Checked out ... $89.50
AC Power Supply ... $14.50

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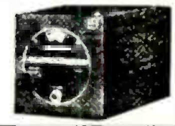
Hot Special! 2000 to 6000 Kc AM Receiver, 2-band, complete with all tubes, 200 Kc Xtal Calibrators, and 12 V Dynamotor. Fine for 80-meter Ham band, Marine, etc. Provides for CW, MVC, AVC, Speaker Jack and two Headphone Jacks. Shpg. Wt. 50 lbs. Brand New, only ... $39.50

BC1206-C BEACON RECEIVER



195 to 420 Kc, made by Setchel-Carlson. Works on 24-28 volts DC. 135 Kc. IF. Complete with 5 tubes. Size 4" x 4" x 6". Wt. 4 lbs. BRAND NEW ... **$9.95**
Like New, with tubes ... $7.95
Like New, less tubes ... $3.95

SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New ... **$29.50**

DYNAMOTOR VALUES: Type	Input	Output		Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V	.05A	2.45	4.45
DM-33A	28V 5A	575V	.16A		
	28V 7A	540V	.25A	2.95	4.45
DM-34D	12V 2A	220V	.080A	4.15	5.50
DM-36	28V 1.4A	220V	.080A	1.95	2.95
DM-37	25.5V 9.2A	625V	.225A	2.95	4.22
DM-43	28V 23A	925V	.220A		
		460V	.185A	—	7.95
DM-53A	28V 1.4A	220V	.080A	3.75	5.45
PE-73C	28V 20A	1000V	.350A	8.95	14.95
PE-86	28V 1.25A	250V	.050A	2.75	3.85

DM-37 DYNAMOTOR. Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each $3.25

MICROPHONES Checked Out, Perfect

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

HEADPHONES Checked Out, Perfect

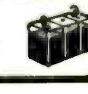
Model	Description	EXC. USED	BRAND NEW
HS-23	High Impedance	$2.79	$4.95
HS-33	Low Impedance	3.15	5.45
HS-30	Low Imp. (featherwt.)	.90	1.65
H-16/U	High Imp. (2 units)	3.75	7.95

TELEPHONICS—600 ohm Low Impedance HEADSETS, BRAND NEW, PER PAIR ... $3.95
CD-307A Cords, with PL55 plug and JK26 Jack ... .99
Earphone Cushions for above—pair ... .50

2 VOLT BATTERY "PACKAGE"

1—2V, 20 Amp. Hr. Willard Storage Battery, Model 20-2, 3" x 4" x 5½" high ... $2.79
1—2V, 7 prong Synchronous Plug-in Vibrator ... 1.49
1—Quart Bottle Electrolyte (for 2 cells) ... 1.45
ALL BRAND NEW! Combination Price ... $5.45

WILLARD 6-VOLT MIDGET STORAGE BATTERY



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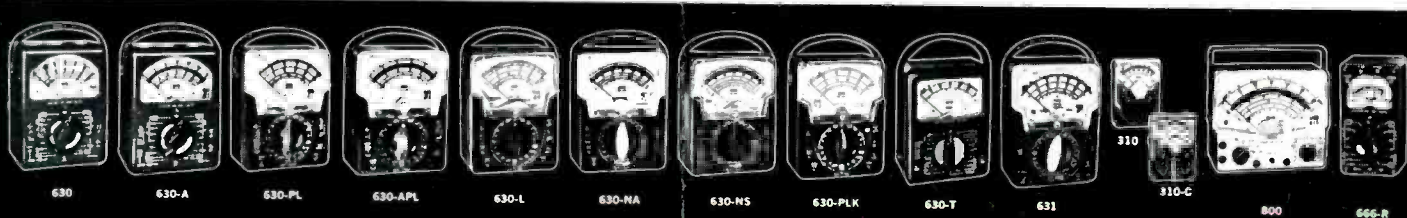

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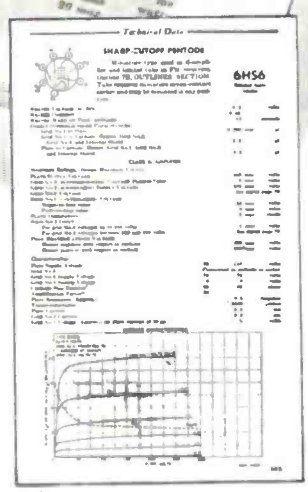

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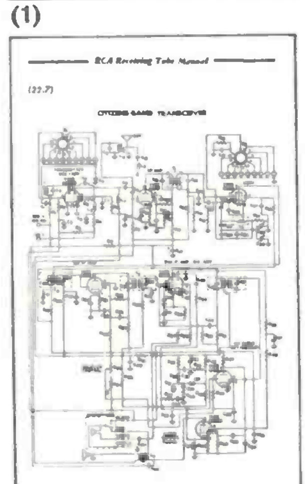

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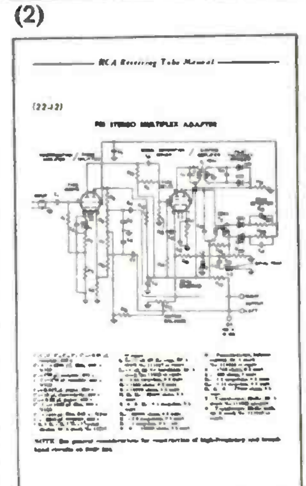

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