Electronics World

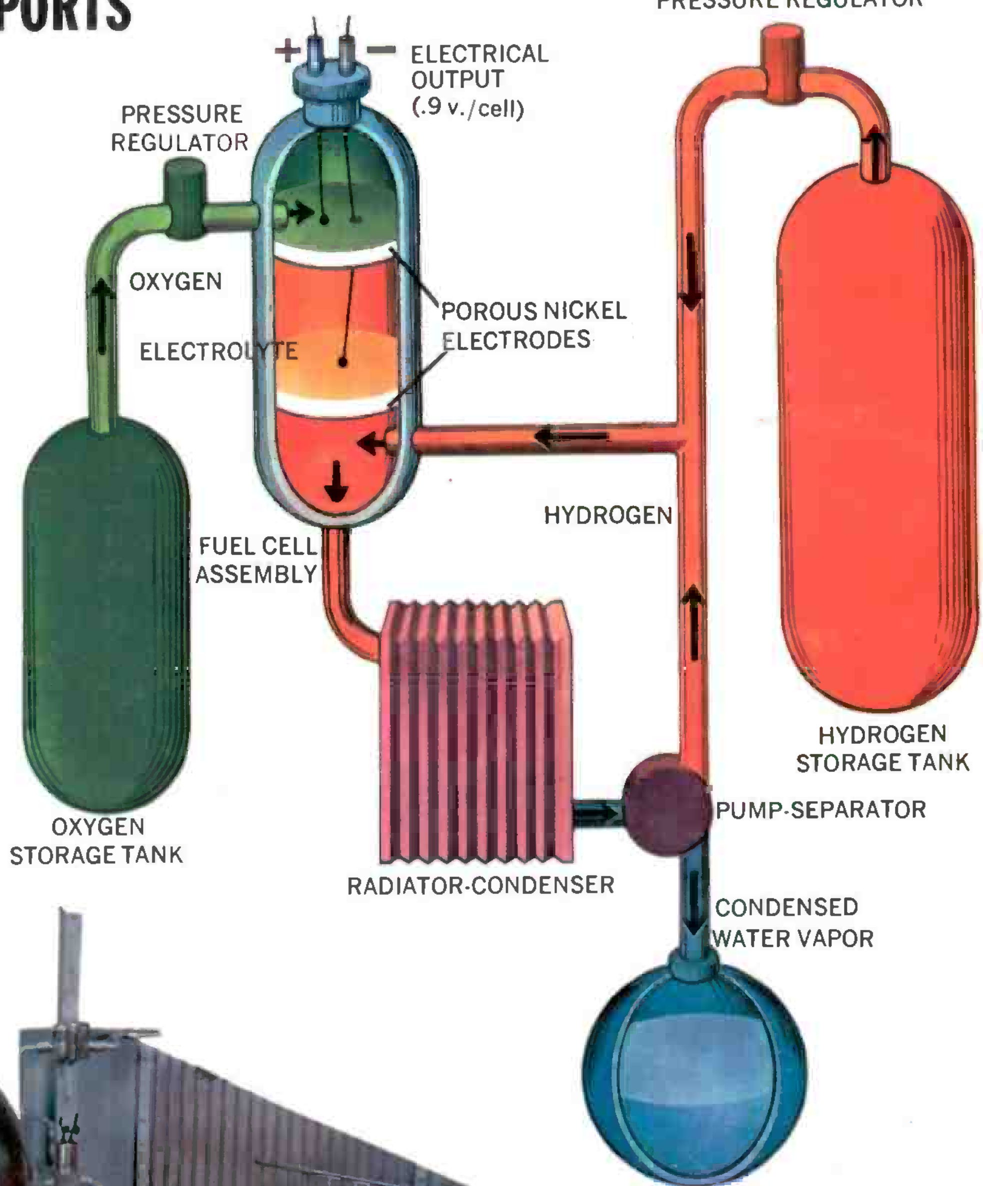
SEPTEMBER, 1962
50 CENTS

BROADCASTER'S VIEWPOINT ON FM STEREO MULTIPLEXING

TECHNICIANS WITH PASSPORTS

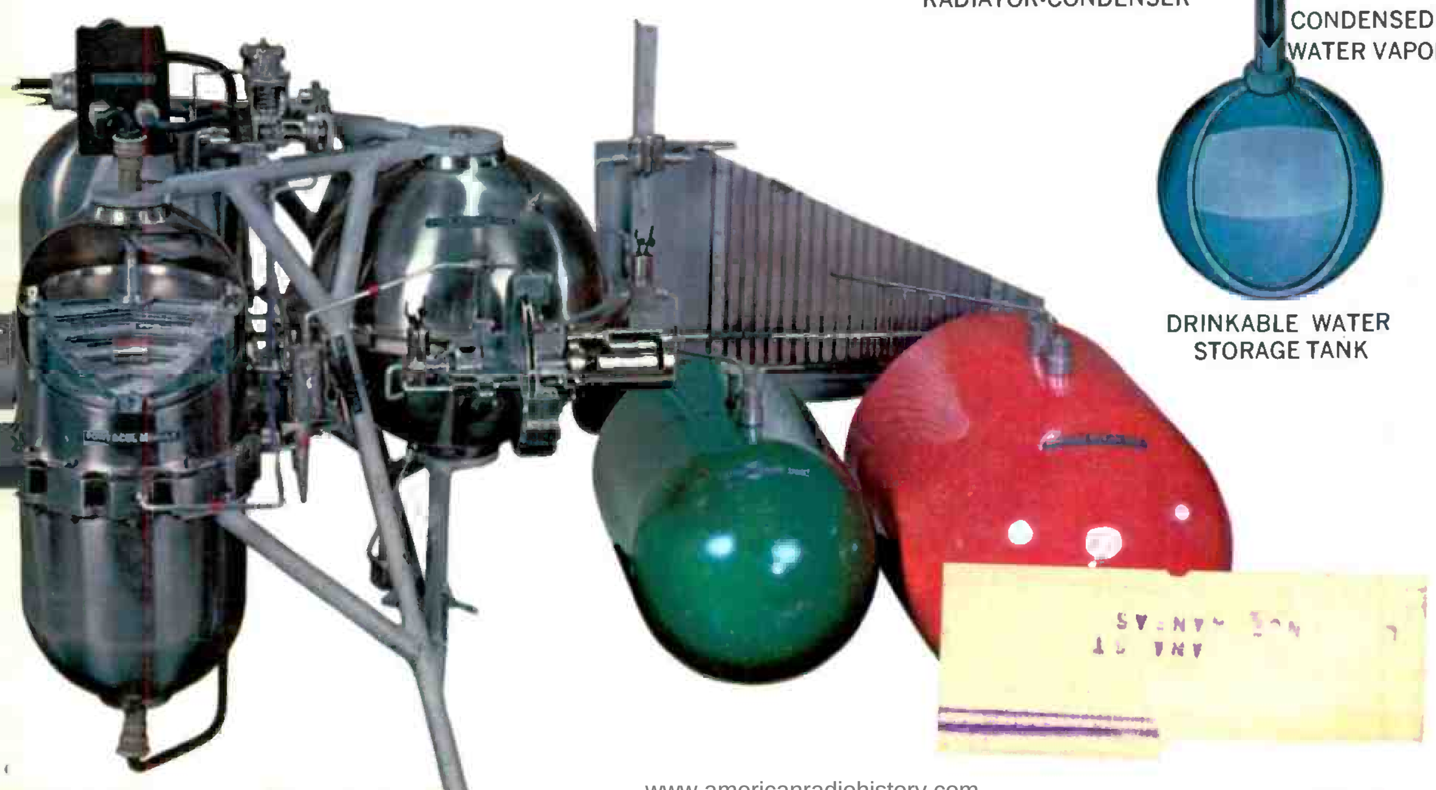
"S" METERS FOR CB

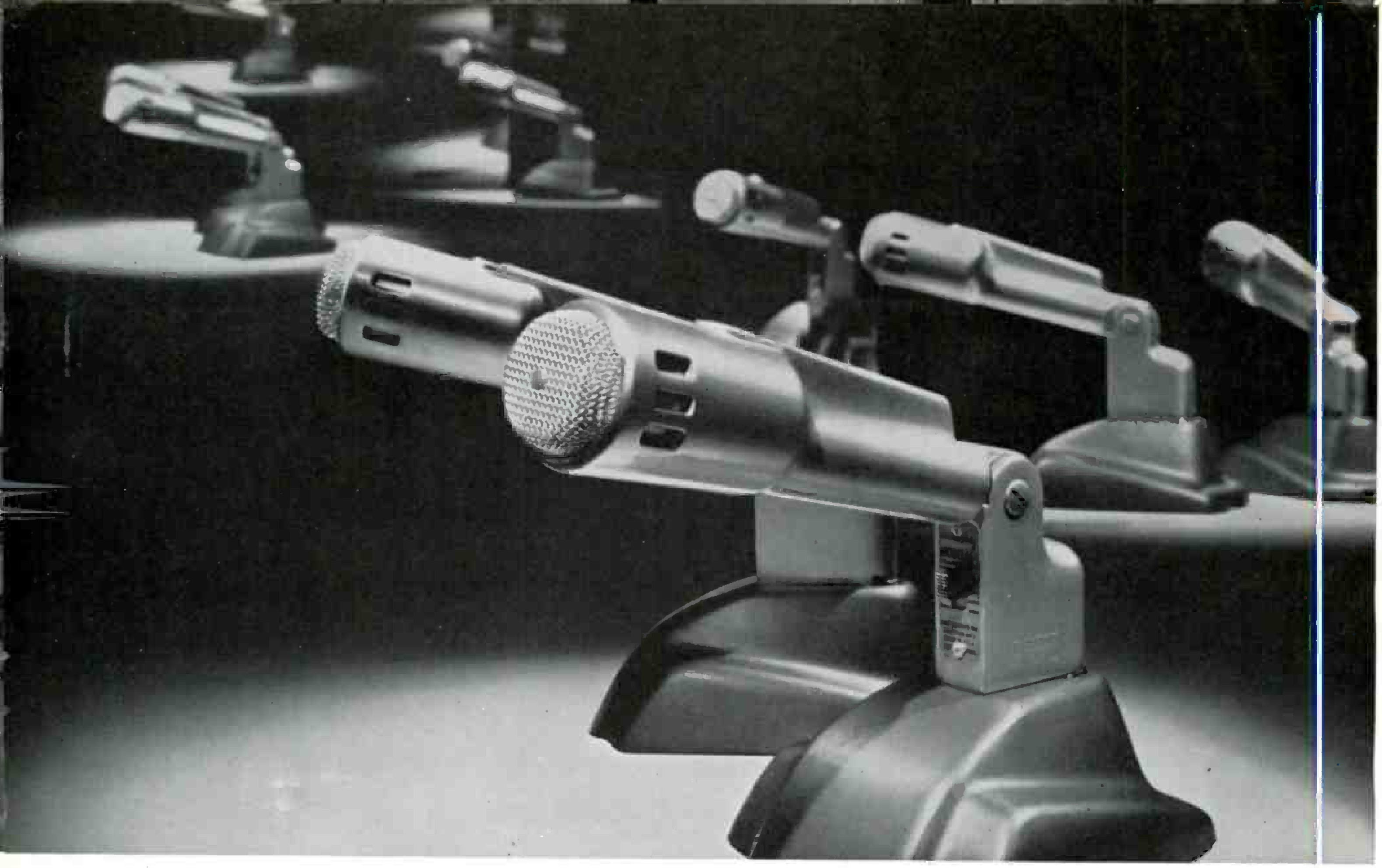
DIGITAL VOLTMETERS— Designs & Applications



FUEL CELLS

These new exotic power sources will operate all electronic and life-support equipment in "Gemini", our first 2-man spacecraft and in "Apollo", our moon ship. The cells are the most efficient non-nuclear devices for generating electricity. Ultimately, we may have fuel-cell-powered submarines and automobiles.





matched dynamic microphones take guesswork out of stereo recording

Now, whether you buy E-V microphones singly, or in pairs . . . E-V uniform quality assures custom-matched performance for stereo recording.

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CIRCLE NO. 112 ON READER SERVICE CARD

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Here it is, the scope that technicians, engineers and servicemen from coast to coast have been demanding. A portable wide band scope that can be used on the job anywhere, yet has the highest laboratory specifications for shop or lab. Cumbersome color TV sets, remote audio and organ installations and computers are just a few of the jobs that make owning a scope of this type so essential. Why consider a narrow band scope, when for only a few dollars more, this professional wide band sensitive scope equips you for any job.

• The PS120 provides features never before offered. Only two major controls make the PS120 as easy to use as a voltmeter. Even its smart good looks were designed for functional efficiency. New forward thrust design, creating its own shadow mask, and full width calibrated graph increase sharpness of wave form patterns. A permanent chromed steel carrying handle instead of untidy leather strap and a concealed compartment under panel for leads, jacks and AC line cord make the PS120 the first truly portable scope combining neatness with top efficiency.

• Electrical specifications and operational ease will surpass your fondest expectations. Imagine a wide band scope that accurately reproduces any waveform from 20 cycles to 12 megacycles. And the PS120 is as sensitive as narrow band scope . . . all the way. Vertical amplifier sensitivity is .035 volts RMS. The PS120 has no narrow band positions which cause other scopes to register erroneous waveforms unexpectedly. Another Sencore first is the Automatic Range Indication on Vertical Input Control which enables the direct reading of peak-to-peak voltages. Simply adjust to one inch height and read P-to-P volts present. Standby position on power switch, another first, adds hours of life to CRT and other tubes. A sensitive wide band oscilloscope like the PS120 has become an absolute necessity for trouble shooting Color TV and other modern circuits and no other scope is as fast or easy to use.

S P E C I F I C A T I O N S

WIDE FREQUENCY RESPONSE:

Vertical Amplifier—flat within ½ DB from 20 cycles to 5.5 MC, down −3 DB at 7.5 MC, usable up to 12 MC.

Horizontal Amplifier—flat within −3 DB from 45 cycles to 330 KC, flat within −6 DB from 20 cycle to 500 KC.

HIGH DEFLECTION SENSITIVITY:

		RMS	P/P
Vertical Amplifier—	Vert. input cable	.035V/IN.	0.1V/IN.
	Aux. vert. jack	.035V/IN.	0.1V/IN.
	Through Lo-Cap probe	.35V/IN.	1.0V/IN.
Horizontal Amplifier—		.51V/IN.	1.44V/IN.

HIGH INPUT RESISTANCE AND LOW CAPACITY:

Vert. input cable	2.7 Meg. shunted by approx. 85 MMF
Aux. vert. input jack	2.7 Meg. shunted by approx. 20 MMF
Through low cap. probe	27 Meg. shunted by 8.6 MMF
Horiz. input jack	330 K to 4 Meg.

HORIZONTAL SWEEP OSCILLATOR:

Frequency range—	4 ranges, 15 cycles—150 KC
Sync Range—	15 cycles to 8 MC–usable to 12 MC

MAXIMUM AC INPUT VOLTAGE:

Vertical input cable— Aux. vert. jack— Lo-Cap probe—	1000 VPP (in presence of 600 VDC)
Horiz. input jack—	approx. 15 VPP (in presence of 400 VDC)

POWER REQUIREMENTS:

Voltage—	105-125 volts, 50-60 cycle
Power consumption—	On pos. 82 watts Stby. pos. 10 watts

SIZE: 7″ wide x 9″ high x 11¼″ deep—weight 12 lbs.

The PS120 is a must for color TV servicing. For example, with its extended vertical amplifier frequency response, 3.58 MC signals can be seen individually.

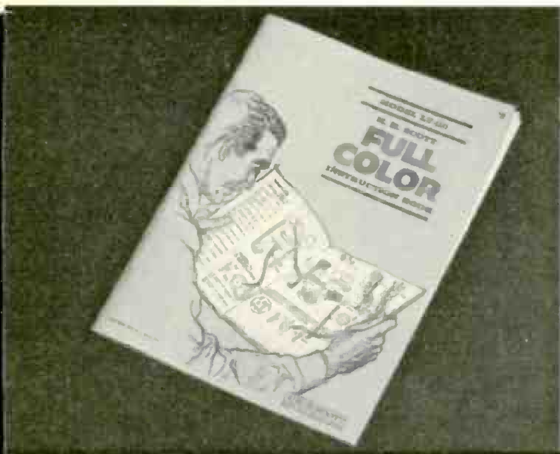
S E N C O R E
ADDISON 2, ILLINOIS

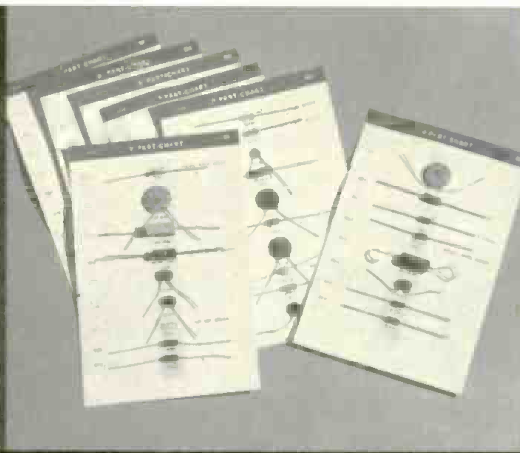
ELECTRONICS WORLD is published monthly by Ziff-Davis Publishing Company at 434 South Wabash Avenue, Chicago 5, Illinois. Subscription rates: one year United States and Possessions $5.00; Canada and Pan American Union countries $5.50; all other foreign countries $6.00. Second Class Postage Paid at Chicago, 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. September, 1962; Vol. 68, No. 3.

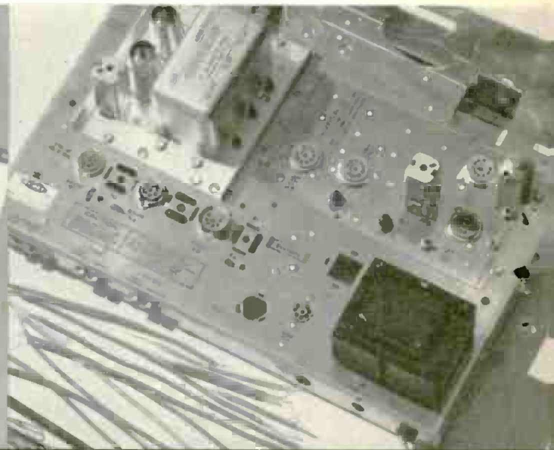
 CIRCLE NO. 139 ON READER SERVICE PAGE

Here's why Audio Magazine says Scott® Kits are

"Simplest to build..." and have "Engineering of the highest calibre" *



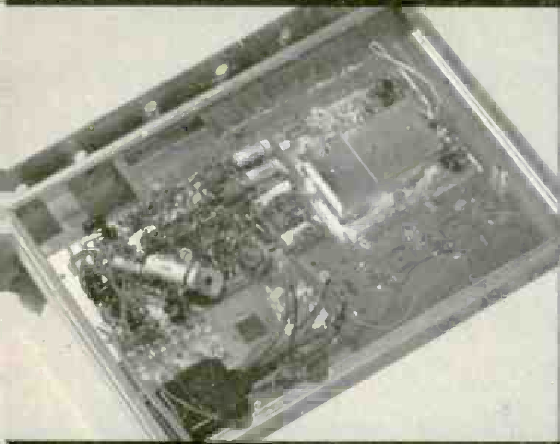


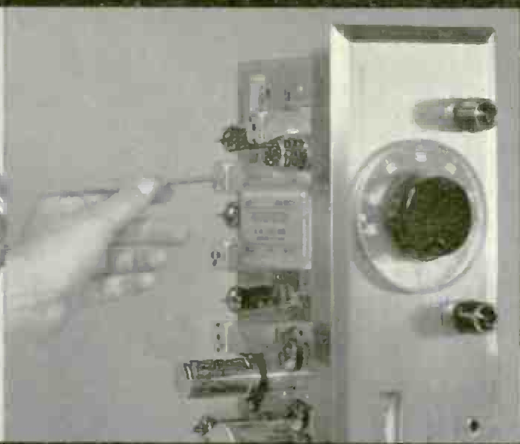


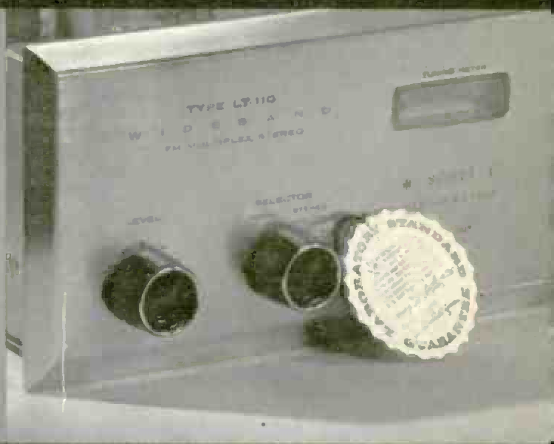
The exclusive Scott full color instruction book shows every part and every wire in natural color and in proper position. To make the instruction book even clearer, each of the full color illustrations shows only a few assembly steps. There are no oversized sheets to confuse you.

Each full color illustration is accompanied by its own Part Chart . . . another Scott exclusive. The actual parts described in the illustration are placed in the exact sequence in which they are used. You can't possibly make a mistake.

Much of the uninteresting mechanical assembly is completed when you open your Scott Kit-Pak. All the terminal strips and tube sockets are already permanently riveted to the chassis. To insure accuracy all wires are pre-cut and pre-stripped to proper length.







There are certain areas in every professional high fidelity component where wiring is critical and difficult. FM front ends and multiplex sections are an example. In Scott Kits these sections are wired at the factory, and thoroughly tested by Scott experts, assuring you a completed kit meeting stringent factory standards.

Tuners are aligned with the unique Scott Ez-A-Line method using the meter on the tuner itself. This assures perfect alignment without expensive signal generators. Amplifier kits require no laboratory instruments for perfect balancing.

The new Scott Warrantee Performance Plan guarantees that your kit will work perfectly when completed. If you have followed all recommended procedures and your kit fails to work Scott guarantees to put your kit in working order at the factory at minimum cost.

When you finish your kit you'll be delighted by its handsome good looks. And when you turn your Scott Kit system on you'll know for yourself why the expert editors of leading high fidelity magazines like Audio say . . . "only the most sophisticated engineering thinking could design a kit as simple and foolproof as this . . ." *

*Audio — February 1961, Pages 54-56

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H. H. Scott Inc., Dept. 160-09
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Please rush me without charge your full color brochure on the complete line of Scott FM stereo tuner, stereo amplifier and speaker kits. A sample 36 page full-color Scott Kit Instruction book will be included if you enclose 50¢ in coin or stamps.

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Address.................................

City......................State...........

If any of your friends would like a copy of the new Scott Kit brochure send us their names and addresses.

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CIRCLE NO. 138 ON READER SERVICE PAGE

SEPTEMBER 1962 / VOL. 68 NO. 3

Electronics World

CONTENTS

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COMING NEXT MONTH

Special Feature

Transistors or Tubes for Hi-Fi?—Five of the country's leading high-fidelity component design engineers offer their own answers in an open debate—an EW Symposium conducted exclusively for our readers. Such well-known engineers as Robert E. Furst of Harman-Kardon, Inc.; Richard Medal of Allied Radio Corp.; Fred L. Mergner of Fisher Radio Corp.; Ed Miller of Sherwood Electronics Lab.; and Daniel R. von Recklinghausen of H. H. Scott, Inc. give their reasons for championing tubes or transistors. Don't miss this timely and important survey of things to come in the high-fidelity audio field. Know whether the era of transistorized component hi-fi is approaching rapidly or is a thing of the future!

"TELSTAR" COMMUNICATIONS

With International TV a reality—this article provides the technical details on one of this decade's most interesting and ingenious applications of electronics. The full-color cover shows how the signals are being transmitted between the U.S., France, and England.

TRANSISTOR RADIO SERVICE WITH A V.T.V.M.

Still looking for a service method that is rapid and reliable? Deciding that the v.t.v.m. is the single instrument for providing the greatest variety of useful tests, author develops his technique around it.

FLOW MEASUREMENT—ELECTRONIC TECHNIQUES AND DEVICES

In their more spectacular applications, flow meters monitor fuel flow to the rocket motors in missiles and control the flow of blood during artificial-heart-lung operations. Since electronic technicians are more likely to encounter flow meters as part of complex industrial control systems, they should have a speaking acquaintance with electro-mechanical and all-electronic types—both of which are covered in this article.

DESIGN FOR A HIGH-GAIN V.H.F.-U.H.F. ATTIC ANTENNA

You can pull in weak signals nicely on all TV channels, u.h.f. as well as v.h.f., and FM transmission too, with a single antenna. What is more, you can assemble it of wire and wood and then hide it in your attic. A simplified adaptation of the log-periodic concept provides exceptional pick up from 54 to 890 mc. with superior directivity.

NON-DIRECTIONAL STEREO EFFECTS

Stereo reproduction contributes much more to musical fidelity than is generally acknowledged . . . it reduces tone cancellation and enhances reverberation effects as well as resulting in less distortion. Charles J. Hirsch of RCA explains why this should be true and describes a number of simple, easily reproduced experiments and listening tests so "skeptics" can sell themselves on the idea.

All these and many more interesting and informative articles will be yours in the October issue of ELECTRONICS WORLD . . . on sale September 25th

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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.

What Does F.C.C. Mean To You?

What is the F.C.C.?

F. C. C. stands for Federal Communications Commission. This is an agency of the Federal Government, created by Congress to regulate all wire and radio communication and radio and television broadcasting in the United States.

What is an F.C.C. Operator License?

The F. C. C. requires that only qualified persons be allowed to install, maintain, and operate electronic communications equipment, including radio and television broadcast transmitters. To determine who is qualified to take on such responsibility, the F. C. C. gives technical examinations. Operator licenses are awarded to those who pass these examinations. There are different types and classes of operator licenses, based on the type and difficulty of the examination passed.

What are the Different Types of Operator Licenses?

The F. C. C. grants three different types (or groups) of operator licenses—commercial radiotelePHONE, commercial radioteleGRAPH, and amateur.

COMMERCIAL RADIOTELE*PHONE* operator licenses are those required of technicians and engineers responsible for the proper operation of electronic equipment involved in the transmission of voice, music, or pictures. For example, a person who installs or maintains two-way mobile radio systems or radio and television broadcast equipment must hold a radiotelePHONE license. (A knowledge of Morse code is NOT required to obtain such a license.)

COMMERCIAL RADIOTELE*GRAPH* operator licenses are those required of the operators and maintenance men working with communications equipment which involves the use of Morse code. For example, a radio operator on board a merchant ship must hold a radioteleGRAPH license. (The ability to send and receive Morse is required to obtain such a license.)

AMATEUR operator licenses are those required of radio "hams"—people who are radio hobbyists and experimenters. (A knowledge of Morse code is necessary to be a "ham".)

What are the Different Classes of RadiotelePHONE licenses?

Each type (or group) of license is divided into different *classes*. There are *three* classes of radiotelephone licenses, as follows:

(1) Third Class Radiotelephone License. No previous license or on-the-job experience is required to qualify for the examination for this license. The examination consists of F.C.C. Elements I and II covering radio laws, F.C.C. regulations, and basic operating practices.

(2) Second Class Radiotelephone License. No on-the-job experience is required for this examination. However, the applicant must have already passed examination Elements I and II. The *second class* radiotelephone examination consists of F. C. C. Element III. It is mostly technical and covers basic radiotelephone theory (including electrical calculations), vacuum tubes, transistors, amplifiers, oscillators, power supplies, amplitude modulation, frequency modulation, measuring instruments, transmitters, receivers, antennas and transmission lines, etc.

(3) First Class Radiotelephone License. No on-the-job experience is required to qualify for this examination. However, the applicant must have already passed examination Elements I, II, and III. (If the applicant wishes, he may take all four elements at the same sitting, but this is not the general practice.) The *first class* radiotelephone examination consists of F. C. C. Element IV. It is mostly technical covering advanced radiotelephone theory and basic television theory. This examination covers generally the same subject matter as the second class examination, but the questions are more difficult and involve more mathematics.

Which License Qualifies for Which Jobs?

The THIRD CLASS radiotelephone license is of value primarily in that it qualifies you to take the second class examination. The scope of authority covered by a third class license is extremely limited.

The SECOND CLASS radiotelephone license qualifies you to install, maintain, and operate most all radiotelephone equipment except commercial broadcast station equipment.

The FIRST CLASS radiotelephone license qualifies you to install, maintain, and operate every type of radiotelephone equipment (except amateur, of course) including all radio and television stations in the United States, and in its Territories and Possessions. This is the highest class of radiotelephone license available.

How Long Does it Take to Prepare for F.C.C. Exams?

The time required to prepare for FCC examinations naturally varies with the individual, depending on his background and aptitude. Grantham training prepares the student to pass FCC exams in a minimum of time.

In the Grantham *correspondence course*, the average beginner should prepare for his *second class* radiotelephone license after from 300 to 350 hours of study. This same student should then prepare for his *first class* license in approximately 75 additional hours of study.

In the Grantham *resident course*, the time normally required to complete the course and get your license is as follows:

In the M thru F DAY course, you should get your first class radiotelephone license at the end of the 12th week of classes.

In the M-W-F EVENING course, you should get your first class radiotelephone license at the end of the 20th week of classes.

In the Tu-Th EVENING course, you should get your first class radiotelephone license at the end of the 30th week of classes.

The Grantham course is designed specifically to prepare you to pass FCC examinations. All the instruction is presented with the FCC examinations in mind. In every lesson test and pre-examination you are given constant practice in answering FCC-type questions.

Why Choose Grantham Training?

The Grantham Communications Electronics Course is planned primarily to lead to an F.C.C. license, but it does this by TEACHING electronics. This course can prepare you *quickly* to pass F. C. C. examinations because it presents the necessary principles of electronics in a simple "easy to grasp" manner. Each new idea is tied in with familiar ideas. Each new principle is presented first in simple, everyday language. Then after you understand the "what and why" of a certain principle, you are taught the technical language associated with that principle. You learn more electronics in less time, because we make the subject easy and interesting.

Is the Grantham Course a "Memory Course"?

No doubt you've heard rumors about "memory courses" or "cram courses" offering "all the exact FCC questions". Ask anyone who has an FCC license if the necessary material can be memorized. Even if you had the exact exam questions and answers, it would be much more difficult to memorize this "meaningless" material than to learn to understand the subject. Choose the school that teaches you to thoroughly understand—choose Grantham School of Electronics.

Is the Grantham Course Merely a "Coaching Service"?

Some schools and individuals offer a "coaching service" in FCC license preparation. The weakness of the "coaching service" method is that it presumes the student already has a knowledge of technical radio and approaches the subject on a "question and answer" basis. On the other hand, the Grantham course "begins at the beginning" and progresses in logical order from one point to another. Every subject is covered simply and in detail. The emphasis is on making the subject easy to understand. With each lesson, you receive an FCC-type test so you can discover daily just which points you do not understand and clear them up as you go along.

Advanced Resident Training

The Grantham F.C.C. License Course is Section I of our Electronics Series. Successful completion of this course is a prerequisite for enrollment in Section II which deals with more advanced material. However, it is not necessary for the student to take Section II unless he wishes to advance beyond the level of a first class F.C.C. License.

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Over the years, people have come to respect membership in the National Home Study Council as a hallmark of quality. No school can be a member of the Council unless it has met the rigid standards set up by the Council's Accrediting Commission. This means that all schools, such as Grantham Schools, Inc., which display the seal of the National Home Study Council have demonstrated their integrity and adherence to high ethical standards. It means that they offer quality instruction at reasonable tuition rates. It means that these schools believe in, and are specialists in, the home study method of instruction.

For further details concerning F.C.C. licenses and our training, send for our FREE booklet, "Grantham Training". Clip the coupon below and mail it to the School nearest you.

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...for the Record

By **W. A. STOCKLIN**
Editor

Educational TV

RECENTLY we drove out to the Northedge Elementary School at Bethpage, Long Island, N.Y., to watch a demonstration of an experimental closed-circuit educational TV system by *Adler Electronics, Inc.* What made the demonstration unusual was that the program originated at the Plainedge High School, and was transmitted to us and to seven other elementary schools in the district by way of an on-the-air 2000-mc. microwave link. Ordinary v.h.f. TV receivers, tuned to an unused channel, picked the program up through the school's distribution system after the microwave signal had been converted down to v.h.f.

The *Adler* system employed a frequency in a microwave band currently being used occasionally for some TV studio-to-transmitter links and remote pickups. The band can provide twenty 6-mc. TV channels of broadcast quality. The simplicity and low power should make the system far less expensive to interconnect schools that are some distance apart than would a wired or coax-cable link.

A large group of school administrators, audio-visual specialists, broadcasters, Health, Education and Welfare officials, and members of the FCC watched on four TV sets a 20-minute film on elementary French. It was a strange and stimulating experience for us. After a few minutes, we forgot that we were watching a TV program and we felt that the gifted teacher was talking directly to us. Quite a few members of the audience, who have been out of elementary school for a long time, responded to the teacher as the class would do. And when the film was over, we all applauded the film, and the quality of the demonstration. We feel that the applause was also for the effectiveness of television as an educational medium.

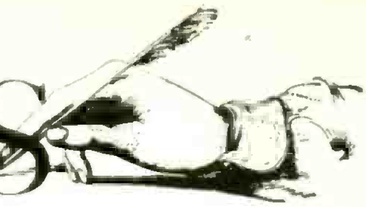
When TV was first proposed for in-school use, there were some who worried that it would take jobs away from instructors. This fear has proved to be completely unfounded and not a single teacher has been displaced by TV. Instead, the classroom teacher has found in television a powerful partner that is helping to do a better job than the teacher could do alone. Our school enrollments are growing by leaps and bounds and the number of qualified teachers is simply not meeting the need. Hence, our educators require all the help they can get to train our children—and educational TV is one answer. With ETV, one gifted teacher can reach far more students, special films and demonstrations can be seen by a large number of students, the views of the world's great scientists and leaders can be brought into the classroom.

Today, there are over 60 educational TV broadcasting stations and 400 closed-circuit TV systems in use for in-school programming. There is also a National Educational Television network and an active program for transmitting ETV to a large number of schools in the mid-West from an airborne TV station. Some educational TV stations operate on the regular v.h.f. TV channels, a larger number operate on the u.h.f. TV channels. Practically all the larger cities, except Los Angeles and Cleveland, should have one ETV channel by the end of the year. In all, there are some 274 ETV channels presently available.

Although these figures are impressive, the present facilities barely begin to fill the need for this important new service. This is true since most schools would like to have available not just a single channel but a number of channels, each with a different program. Only in this way can ETV be fully utilized for the various grades and various levels. ETV stations not only help the teacher during the day, but many are serving their local communities with non-commercial broadcasting after school hours.

More and more demands are being made for spectrum space both by the proponents of educational, non-commercial TV broadcasts and by commercial TV broadcasters. Some months ago, in our April issue, we indicated in our editorial that we felt that a move to u.h.f. by television broadcasters was inevitable. We still feel this way in spite of some mail we have had from v.h.f. broadcasters who don't agree with us. With both educational and commercial TV broadcasters looking for space, we feel that any proposal that holds out a promise of more channels and more effective use of the TV spectrum is a good one. It will be good for viewers who want a greater choice of programs to watch as well as for educators who want television to become an even more useful teaching tool than it is at present. ▲

LETTERS FROM OUR READERS



COLLEGE-STATION TRANSMITTER

To the Editors:

In regard to the article in the April issue of ELECTRONICS WORLD concerning the transistorized low-power transmitter for college stations, the FCC requires that, in addition to having the transmitter at a low power, you must show that it is not violating the field-strength requirements.

According to a recent FCC publication: "The responsibility of assuring the electromagnetic energy radiated from carrier-current (or other low-power communications) systems does not exceed the maximum permissible field strength, and does not cause interference to authorized radio service lies with the owner and operator of the system. The amount of radiation can only be determined through the use of a standard field-strength meter operated by an engineer experienced in this work. Installation and operation of a . . . system should not be undertaken unless means are available for taking such measurements."

Anyone interested in operation in the broadcast band under the various laws pertaining to unlicensed broadcasting should consult OCE Bulletin No. 12, "Operation in the Broadcast Band Without a License," available from the FCC without charge. The front side of this bulletin gives a general description of the requirements and interpretations, and the back side has reprints of the applicable parts of the FCC Rules and Regulations.

MICHAEL SHAPIRO
KMRX Radio
Purdue Residence Network
West Lafayette, Indiana

° ° °

BELL-TRANSFORMER INTERFERENCE

To the Editors:

I read with interest the discussion in John Frye's "Mac's Electronics Service" in your May issue. The interference-causing bell transformer is more common than you might think. I've had to run down at least five of them in half as many years.

A good many of these transformers are built with a bi-metal circuit breaker installed inside. If for any reason the current drawn exceeds the transformer rating, this breaker will heat and open, then cool and close again, on and on until the load is removed. I've never found a transformer that was actually defective. In every case but one it was a new transformer that was simply not big enough to carry the load. The exception was an older transformer used in a doorbell circuit. The doorbell wiring was shorted.

Considering the inductance of the windings in these transformers, coupled with the capacitance of the wiring used in bells and thermostats, the circuits usually resonate nicely just below or right in the broadcast band. They have nice harmonics right up into the u.h.f. region too.

About the most successful method of finding these rascals is to first locate the general area of the offender with an auto radio tuned to the low end of the broadcast band. Then connect a 2.5-mhy. r.f. choke, a 1N34 crystal diode, and a set of headphones in series. Then it is simply a matter of going from house to house and holding the r.f. choke near the electric meter. When you get to the right house, you'll hear the interference loud and clear in the phones. Then all you have to do is find the transformer. I found one in a doorbell circuit that hadn't been used in years. The entire shorted circuit was in an attic behind some wallboard that had been used to finish the room when it was converted to a spare bedroom. Try talking a homemaker into letting you tear down her walls sometime.

STEVE BROOMELL
Chief Engineer, KATI
Casper, Wyoming

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TRANSISTOR MULTIPLEX ADAPTER

To the Editors:

The transistor multiplex adapter described in the March issue of ELECTRONICS WORLD is a very good system. I constructed the unit and have been using it for about five weeks now. In constructing it, I used a printed-circuit board 3-7/16" x 4". The component layout is different than Mr. Blaser's and it is easier to wire than his would be. I made a layout according to the photo and did not like it, so I did it over and used less space. I used ½-watt resistors in order to cut the cost of parts by a few dollars.

I've added an indicator system to it which is also transistorized. It has an NE-2 neon indicator and is also on a printed-circuit board. I made it 1" x 3-7/16" with external connections for the multiplex signal, NE-2, and 65 d.c. volts. The unit requires two transistors and

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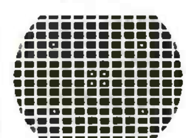
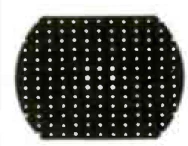


Enables you to troubleshoot and signal trace color circuits in color TV sets, or facilitate installation.



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operates with 1.2 ma. total current.

I would consider supplying the printed-circuit board for both units if any of your readers should request them. I would need approximately thirty days to make the first board, as I would have to make a photo mask for etching so that the labor could be cut to a minimum. I would estimate between eight to ten dollars with the board drilled and ready for component installation. If the customer wants to drill the holes, then the cost would be about five dollars. A sketch showing component layout would be included.

WALLACE A. ROOS
6246 Southbrook
Houston 17, Texas

• • •

INHALING TEFLON FUMES

To the Editors:

Your article on page 94 of the April 1962 issue ("A Solder Remover," utilizing a piece of Teflon tubing) reminded me of a bulletin which states that Teflon, when heated above 400° C, gives off a very toxic gas, perfluoroisobutane. Most soldering guns will heat their tips well above the safe temperature level of Teflon.

DON G. SILVER
Pisgah Forest, N. C.

To the Editors:

This gas (perfluoroisobutane) has been known to cause death, even in small quantities. A technician died from the amount inhaled from a cigarette which was placed on a Teflon part.

BERNARD F. JOHNSEN
Levittown, New York

The number of published warnings on the hazards of Teflon is only equalled by the number of subsequent retractions. The widely circulated "cigarette tale" has never been traced to its source despite many efforts. Teflon just begins to give off infinitesimal but harmless amounts of perfluoroisobutylene (the correct term for the gas) at the very high temperature of 400° C—which is 752° F. Toxic quantities do not develop until much higher temperatures are reached and maintained. Teflon is the coating material used on currently popular "greaseless, no-stick" frying pans, which are often heated to high temperatures. These utensils have been judged to be completely safe.

Dr. John A. Zapp, Jr., Director of the Haskell Laboratory for Toxicology and Industrial Medicine, has published a paper covering his extensive research on this matter. We don't have the room to run it, but extensive excerpts are available from E. I. DuPont De Nemours & Company, Public Relations Department, *Wilmington 98, Delaware, in a booklet entitled "The Anatomy of a Rumor."—Editors.* ▲

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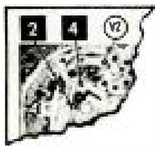

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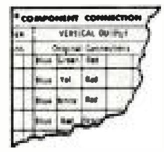
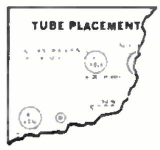
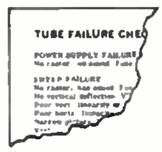


Exact Terminal Connections are indicated—no need for trial-and-error methods—a real time-saving feature.

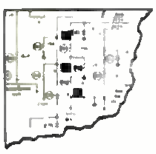
Field Servicing Notes spell out locations of adjustments for speedy "in home" servicing. Saves time spent in hunting for hidden adjustments.



Tube Location Guide enables you to locate and replace proper tubes in seconds—a big time-saver on most repair jobs.



Tube Failure Check Charts spell out probable tubes responsible for failure—no need to waste time studying circuitry.



Clear Parts Symbols with values and associated information are shown plainly on the schematic—no time wasted in cross-reference "look-up."

Waveform actual photos are shown on schematic for quick comparison of patterns on your scope. No time wasted in guesswork.

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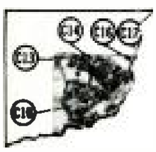
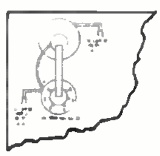
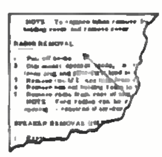


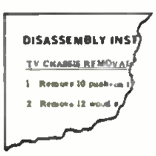
Full Photo Coverage of the actual equipment makes identification of all components and wiring easy—you can see everything.



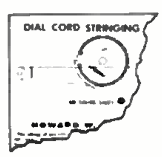
Terminal Identification saves you time; transformer and coil terminals quickly identified by color code or basing diagram shown on schematic.



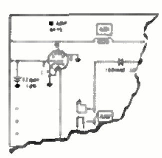
Auto Radio Removal instructions show you step-by-step procedure for removal of even the most complicated models—a big time-saver.



Disassembly Instructions, step-by-step, help you remove difficult chassis, sub-chassis, and assemblies in minutes.



Dial Cord Stringing instructions save you up to an hour or more of time and headaches on a single job.



Alternate Tuner Data—separate schematics, alignment data and parts lists are provided—no time wasted interpreting various tuner versions.

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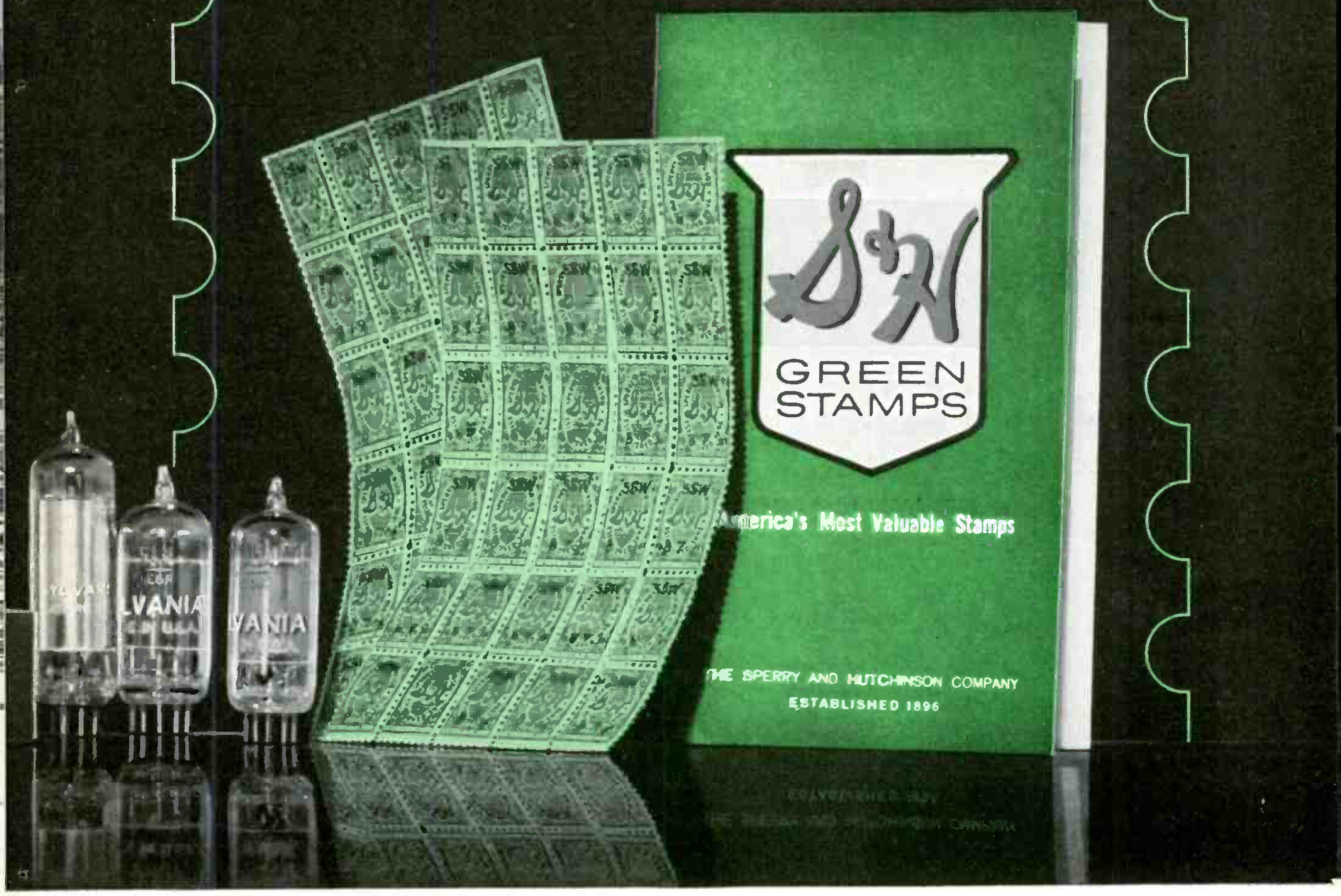

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Eico MX-99 Multiplex Adapter

For copy of manufacturer's brochure, circle No. 57 on coupon (page 19).

THE *Eico* MX-99 multiplex adapter features novel circuitry as well as operating conveniences not often found in low-priced adapters. The MX-99 circuit is basically a matrixing type, in which the difference (L−R) signal is combined with the sum (L+R) signal to produce left- and right-channel outputs. Unlike ordinary matrixing adapters, it does not use filters to separate the main and sub-channel information before they are processed.

One of the chief limitations of matrixing-type multiplex adapters is the inevitable phase shift in practical filters. This causes a reduction in channel separation at higher modulating frequencies. Also, the relative phases of the sum and difference signals must be precisely controlled for good separation. *Eico* engineers took advantage of the fact that the total composite detected signal, including both main and sub-channels, may be demodulated to produce only the (L−R) information. The only requirement for this is that the demodulating waveform have zero average value (no even-order harmonics). The omission of a 23- to 53-kc. bandpass filter, used in other matrixing adapters to separate the sub-channel before demodulation, eliminates the phase shift and loss of separation occurring at this stage.

The MX-99 has an input amplifier with a very high input impedance to minimize loading of the tuner detector circuit. A 19-kc. tuned amplifier isolates the pilot carrier, which is then detected in a full-wave diode circuit. The d.c. component of the detected output, after amplification, operates a neon indicator lamp to show that a station is transmitting in stereo. The a.c. component, largely 38 kc., synchronizes a 38-kc. oscillator. This oscillator may be switched off when listening to mono broadcasts, although this is not necessary.

The total composite signal is taken from the plate of the input amplifier and passed through a phase splitter. The outputs of the inverter, which are 180 degrees apart in phase, are combined in a balanced diode ring modulator with the 38-kc. oscillator signal to produce the (L−R) information. This, in turn, is combined with the (L+R) and −(L+R) outputs from the phase splitter to produce L and −R signals. De-emphasis is also applied to both sum and difference signals at the point of combination. The −R signal is inverted by another stage, after which the L and R channels are filtered to remove any 19-kc. pilot carrier. Low-impedance cathode-follower outputs drive the associated amplifier.

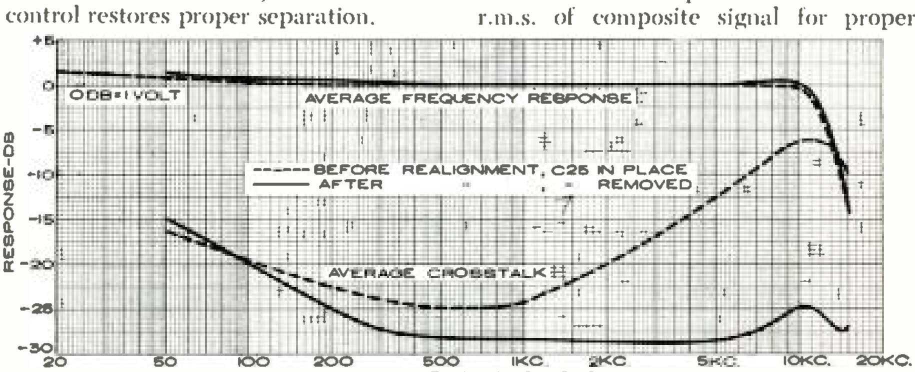
The channel separation is adjusted by a front-panel control which varies the level of the difference signal before combination with the sum signal. If there should be a phase error in the injected 38-kc. carrier, a re-adjustment of this control restores proper separation.

We tested a kit-built *Eico* MX-99 (construction time: 10 hours) with stereo composite signals derived from an *H. H. Scott* Model 830 multiplex signal generator. The frequency response was very flat up to 10 kc., falling steeply above that frequency. This was due to the 19-kc. traps in the output circuits. Most of the reduction in output occurred above 12 kc., so it was not particularly audible.

As originally constructed, the channel separation was about 25 db at 1 kc., decreasing to 16 db at 50 cps. The separation fell off to about 5 to 8 db at 10 kc., and there was little or none at higher frequencies. In an addendum to the manual for the MX-99, it is pointed out that the input circuit is compensated for phase shift and loss of high-frequency response in *Eico* tuners, as well as other relatively narrow-band tuners. If the MX-99 is to be used with a wide-band tuner, a capacitor (C_{25}) in the input is to be clipped out. We first went through the recommended alignment procedure to attempt to improve the separation. This is a rather tricky operation, which we would not recommend for the average user. Finally, we resorted to using the multiplex signal generator to align the MX-99 and obtained an improvement of 3 or 4 db in mid-range separation. This is not enough improvement, in our opinion, to warrant disturbing the factory-aligned coils.

Removing the compensating capacitor made a dramatic improvement in high-frequency separation. From about 300 cps to 5000 cps the separation exceeded 25 db (typically 28-29 db). At 10 kc. it was 21 db on one channel and 28 db on the other. At 15 kc. it was 10 to 12 db, which is more than adequate.

The MX-99 required about 1 volt r.m.s. of composite signal for proper



synchronization of the 38-kc. oscillator. Careful peaking of the 38-kc. transformer T_3 improved the sensitivity so that it would synchronize on a .25-volt signal. If the signal (at maximum modulation) exceeded 1.5 to 2 volts, excessive distortion occurred in the adapter circuits. This limits the application of the MX-99 to tuners with detector outputs between 1 and 2 volts at maximum modulation. Presumably *Eico* tuners are designed to meet this requirement. The adapter gain was 6 db, delivering 2 volts output from a 1-volt input signal. Its internal hum was 47 db below 2 volts.

We found that the required setting of the separation control varied considerably as the unit warmed up. At first, a setting of 2 to 3 was optimum, changing to 5 after warmup. This is the indicated "normal" setting. Separation was also strongly affected by very low pilot carrier levels. This signal level is below the point one would consider normal operation. The unit does, however, have a front-panel separation control which can be re-adjusted for maximum separation even under these conditions.

We performed listening tests by modulating our multiplex signal generator from stereo disc programs to simulate the output of an ideal tuner. It sounded quite good, with little evidence of the limited separation and loss of response at high frequencies, even in its original, unmodified condition. Adjustment of the separation control is rather difficult unless a station is known to be transmitting on one channel only, but this is a problem common to any multiplex adapter having such a control.

The *Eico* MX-99 sells for $39.95 in kit form or $64.95, factory-wired. ▲

Fisher FM-100-B Multiplex Tuner

For copy of manufacturer's brochure, circle No. 58 *on coupon (page* 19).

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(*Continued on page* 20)

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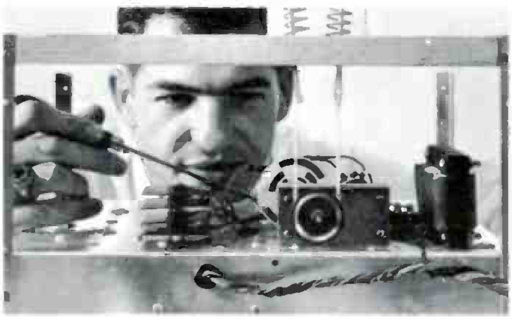

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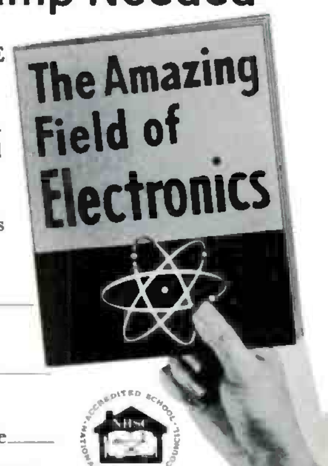

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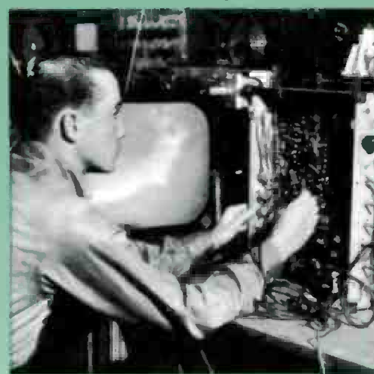

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17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60

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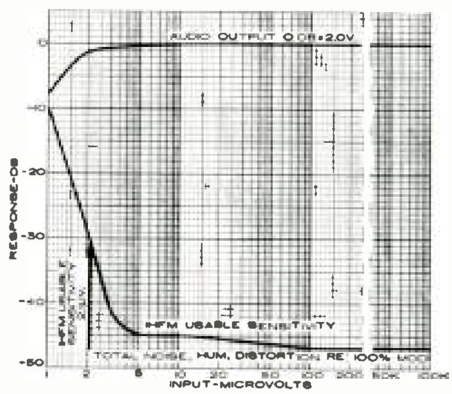
EW Lab Tested *(Continued from page 16)*

hold level cuts off the oscillator and restores the tuner to normal operation.

The "Stereo Beacon" feature uses the rectified 19-kc. pilot carrier of an FM stereo transmission to operate a relay which connects the tuner output jacks to the left- and right-channel outputs of the built-in multiplex decoder. A green light on the panel indicates that a stereo broadcast is being received. If there is no pilot carrier, the two outputs are paralleled and taken from a separate, de-



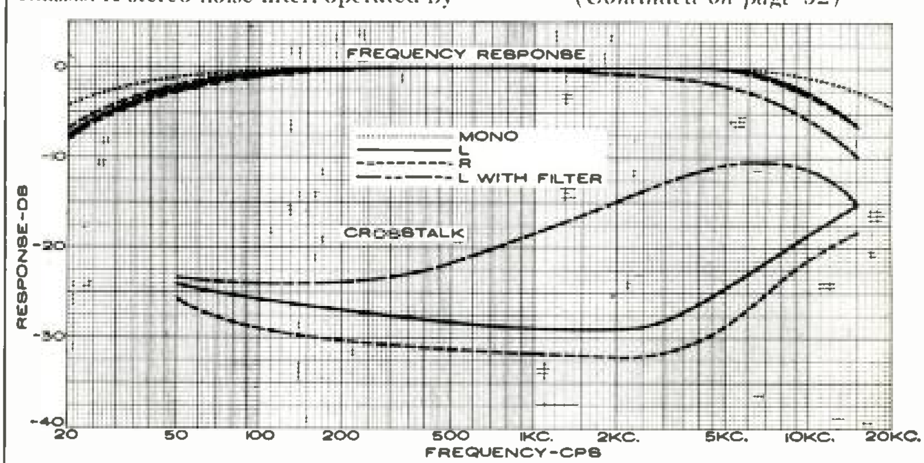
emphasized output ahead of the multiplex circuits.

The multiplex portion of the FM-100-B is basically of the switching type, using three dual-triodes, two four-diode modulators, and a pair of diodes which prevent the "Stereo Beacon" from triggering on inter-station noise. There is a factory-set separation control on the chassis. A stereo noise filter, operated by a front-panel switch, mixes the two channels at high frequencies, reducing the effect of sub-carrier noise modulation, at some sacrifice in channel separation.

The front panel of the tuner, finished in brushed brass to match the other *Fisher* products, has four controls. The "Selector" sets the tuner for mono, automatic stereo/mono, or stereo noise-filter operation. A "Muting" control, which may be switched off, sets the threshold above which the muting circuits allow signals to pass. The a.c. power switch is combined with a sensitivity switch which reduces sensitivity approximately seven times to prevent overload from strong local signals. Finally, the tuning control operates a velvet-smooth fly-wheel dial with a legible, linear scale. An illuminated tuning meter reads maximum when the station is tuned in correctly. On the rear apron of the chassis are individual channel-level setting controls.

Considered as an FM tuner alone, the unit proved to be an outstanding performer. Its limiting action was extremely sharp, with full limiting occurring at less than 5-μv. input. The IHFM usable sensitivity, rated at 1.8 μv., measured 2.1 μv. This is within the normal limits of measurement error. The same comment applies to most of its other specifications, including capture ratio (3 db measured *vs* 2.2 db rated). FM harmonic distortion at 100% modulation (0.47% *vs* 0.4%), and FM hum level

(Continued on page 92)



NOW with TRANSISTOR POWER supply

INTERNATIONAL MODEL 100 A EXECUTIVE TRANSCEIVER

International's new Model 100 A is the latest in the outstanding line of Executive transceivers. The advanced design Executive features a *transistor power supply, new perforated metal cabinet,* and a *new rugged microphone* . . . all of which contribute to a more reliable mobile operation.

The Model 100 A . . . the finest of its kind, also features:
• Crystal filter for improved receiving • Twelve crystal controlled transmit positions • Two crystal controlled receive positions • Dual conversion superheterodyne receiver tuning 23 channels • Built-in calibration circuit • N R squelch • Provision for connecting external speaker and s/meter • Push-to-talk operation • Transistor power supply operates from 6/12 vdc or 115 vac

Model 100 A, complete with 1 transmit crystal, 1 receive crystal, and microphone.......... $199.50

External Speaker and S/Meter

The perfect companion for the International Executive Model 100. Utilizes a high impedance vacuum tube volt meter circuit. Connects to socket on rear of transceiver. S/meter reads in three ranges. Brown cabinet, brown and silver panel matches Executive transceiver.

Complete with interconnecting cable.......... $49.50

Executive Speech Clipper/Filter Amplifier

A microphone amplifier designed to increase average modulation . . . limits modulations peaks . . . filters audio frequencies above 2500 cycles. Permits arms-length microphone operation. Power requirements: 12 vac or 12 vdc.

Complete with interconnecting cable.......... $36.50

12.6 VAC, 2 Ampere Power Unit

Base station power unit for Speech Clipper/Amplifier. Operates from 115 vac. Provides 12.6 vac at 2 amperes.

Complete with mounting chassis, power cord, fuse, switch.......... $12.50

Citizens Band licensees with International equipped stations know the unquestioned superiority and advantages of Executive transceivers and their system engineered accessories.

See your authorized International dealer today.

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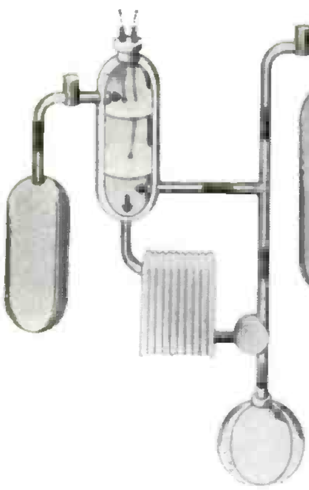
CIRCLE NO. 119 ON READER SERVICE PAGE

New exotic power sources will supply all electrical needs of space vehicles. These cells produce electricity directly from chemical reactions with efficiencies far greater than any other non-nuclear power system.

By KEN GILMORE

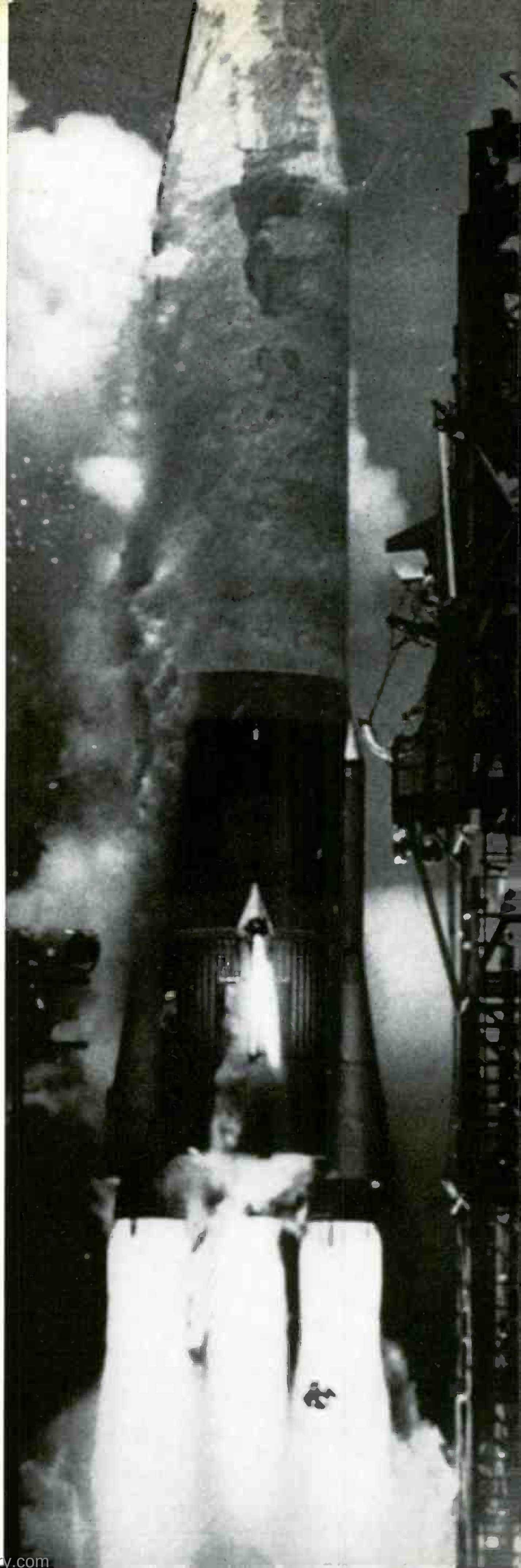


fuel cells

WHEN the "Gemini" space craft with its two-man crew orbits the earth sometime in 1963, the electric power to operate its elaborate electronic and life-support equipment will come from an exotic new source: a newly developed fuel cell. The "Apollo" space ship, our entry in the moon sweepstakes, will also draw fuel-cell power.

The Navy, meanwhile, is financing development work on a fuel-cell-powered submarine. Like an atomic sub, it could stay submerged practically indefinitely, but would be far quieter and harder to detect. Furthermore, it would cost much less to operate.

Fuel cells will soon be pouring their power into devices designed for the civilian market, too. *Allis Chalmers Company* has announced plans to market a fork-lift truck driven by the potent power makers. (The company demonstrated a prototype fuel-cell-powered tractor more than two years ago.) And, although no one is ready yet to make predictions as to *when* fuel cells may appear in automobiles and trucks, their ad-



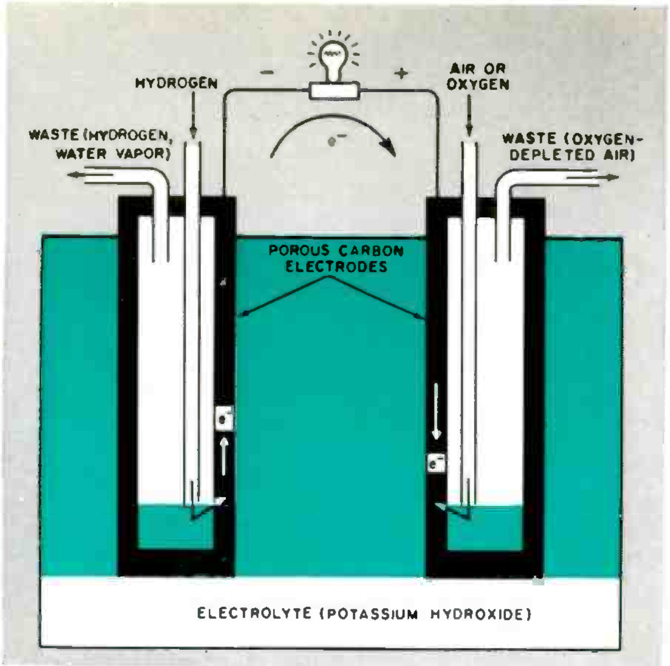


Fig. 1. Basic hydrogen-oxygen fuel cell consists of two porous carbon electrodes submerged in electrolyte and supplied with gases.

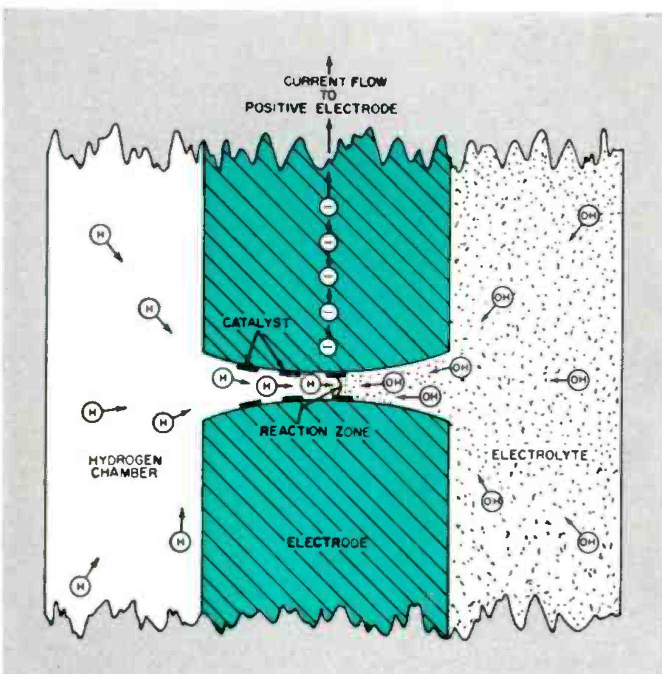


Fig. 2. Hydrogen and hydroxide react in pores of electrode, producing surplus electrons that flow toward the positive electrode.

vantages lead many engineers and scientists in the field to believe that most of us may ultimately drive fuel-cell-powered cars.

Fuel cells, in fact, could bring about the biggest electrical revolution since the dynamo launched the electrical age in the closing years of the last century. The reason: they generate far more electricity per pound of fuel than any other non-nuclear method of power production. The most modern turbine electric generating plants, for example, strain to operate at 40% efficiency, that is, to turn 40% of the energy stored in the fuel into usable electrical power. Automobiles run at about 20% efficiency, motor boats at 10%. Present-day prototype fuel cells, on the other hand, wring 50 to 85% of the potential power out of every pound of fuel.

Even though the excitement about them is relatively new, fuel cells themselves are not. Sir William Grove, an Englishman, built the first primitive model in 1839. A half century later, two of his countrymen, Ludwig Mond and Carl Langer, developed a more advanced model, dubbed it a fuel cell. But the electric dynamo was just coming into its own at that time and it captured the attention of scientists and engineers. Fuel to run the machine was plentiful, efficiency wasn't important, and the dynamo appeared simpler and was easier to build.

Poor efficiency has plagued the dynamo through the years, though, and there's not much engineers can do about it. The trouble comes from the fact that in the process of releasing the energy of the fuel, we throw most of it away. We extract the fuel's energy by burning it. The heat is converted to mechanical energy by a turbine or some other heat engine, the engine drives a dynamo which generates electricity. Energy is wasted at every step.

The fuel cell eliminates the efficiency problems of the dynamo by skipping the heat cycle entirely: it transforms the potential energy stored in the chemical bonds of the fuel directly into electrical energy without the wasteful intermediate heat step. Theoretically, the fuel cell could have 100% efficiency. Certain practical limitations, internal I^2R losses, for example, make it unlikely that we will ever reach this point, but even today's relatively crude devices have little trouble achieving efficiency at least twice as good as the nearest competitors, and, what is more, they're getting better all the time.

Battery with a Gas Tank

In drawing electrical energy directly from fuel through a chemical reaction, the fuel cell is similar to its close relative, the storage battery. But it is also different in important ways. In a battery, the "fuel" is built in, in the form of expendable or rechargeable electrodes. The fuel cell, on the other hand, has its fuel fed in continuously from the outside. Because of this feature, it has been called a "battery with a gas tank."

The basic principle on which the fuel cell operates is simple. Hydrogen and oxygen combine to produce water. During the process, they release electrical energy which can be tapped off to do useful work. Fig. 1 shows the basic principle of the hydrogen-oxygen cell, one of the types in the most advanced state of development. It consists of two hollow porous carbon electrodes immersed in a potassium hydroxide solution. Hydrogen is pumped into one electrode, oxygen into the other. A potential appears across the electrodes and if a load is connected between them, current flows.

How it Works

Hydrogen molecules consisting of two hydrogen atoms enter the negative electrode, flow into the tiny pores (10^{-5} to 10^{-4} cm. in diameter), come into contact with a catalyst which splits them into two separate hydrogen atoms. See Fig. 2. The atoms then migrate along the surface of the

Fuel cell at Esso Research Center being prepared for testing.

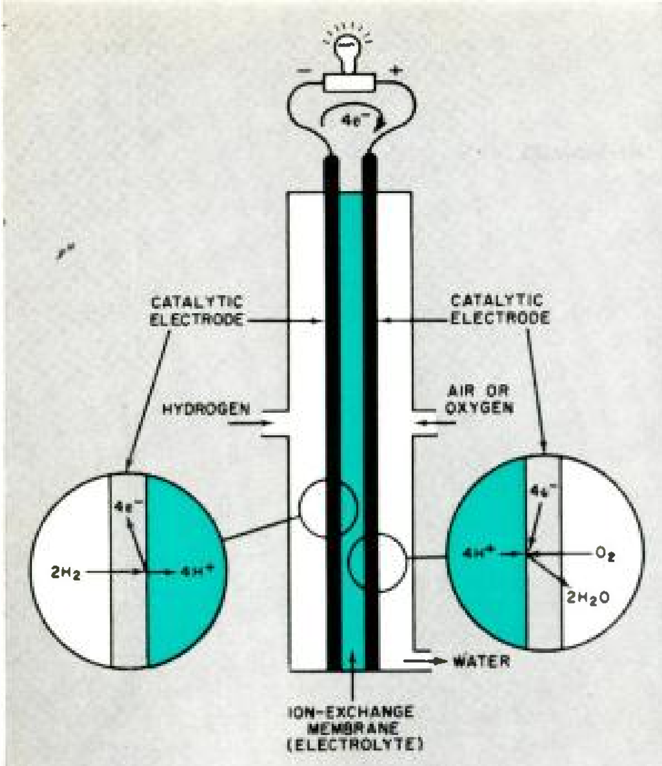


Fig. 3. The ion-membrane fuel cell employs electrolyte in solid form in order to solve problem of contact stability.

pores to the reaction zone. At the same time, hydroxyl (OH^-) ions from the potassium hydroxide electrolyte have migrated toward the reaction zone also. At this point, the hydrogen and hydroxyl ions combine to form water and, in the process, release electrons.

These electrons are attracted by the potential on the positive electrode, and flow through the load toward it, doing useful work on the way. At the positive electrode, atoms of oxygen have flowed into the pores where they combine with one water molecule from the electrolyte plus the two electrons which have just arrived from the negative electrode. This reaction forms perhydroxyl (O_2H) and a hydroxyl (OH^-) ion to replace those being used on the negative electrode. The hydroxyl ion now migrates through the electrolyte to the negative electrode to start the chain all over again.

Actually, at ambient temperatures, these reactions take place very slowly. Consequently, many early fuel cells—and some present-day ones—operated at high temperatures to speed up the process and produce more electricity. Another way to encourage rapid reaction is to supply the proper catalytic agent.

Catalytic Agents

Catalysis has always been something of a "black art," dimly understood and imperfectly applied. But research in recent years has led to a more basic understanding of the field. Consequently, fuel-cell engineers have been able to find catalysts—usually fine particles of platinum or palladium coating the carbon pores—which speed up the ordinary low-temperature reaction by as much as a million times. Using such catalysts, low-temperature cells can be built to deliver practical amounts of power.

But there have been massive problems of chemical engineering—just now being solved—which have kept the fuel cell from being a practical power generator.

Some Problems

In order to deliver usable amounts of power, for example, a cell had to be designed in which large amounts of gases and electrolyte could come together in a cell of practical size. The porous carbon electrode, used in a cell designed

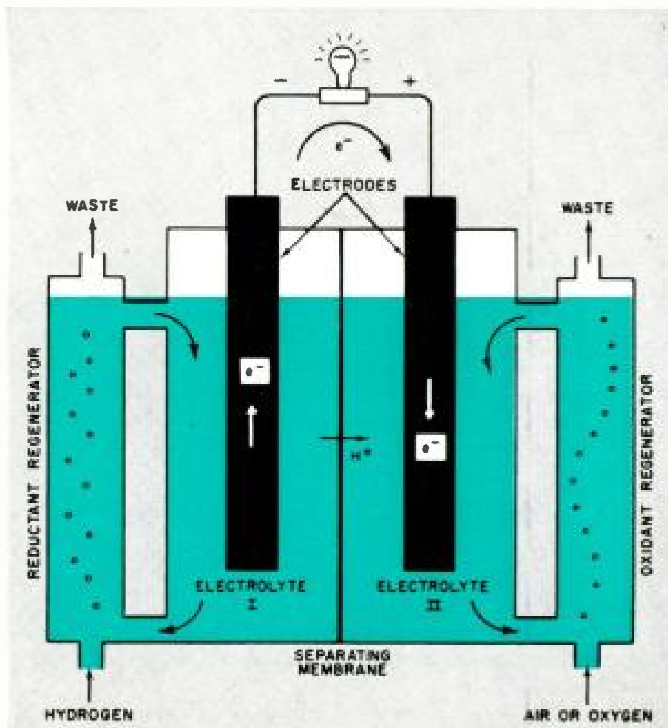


Fig. 4. "Redox" cell has two electrolytes separated by membrane.

by *Union Carbide (Eveready)* is one approach to this problem. Dr. D.M. Gage, technical manager of Electrochemical Products, showed the author a two-ounce bottle of carbon pellets which could almost be concealed in a fist. "The carbon in this bottle," he said, "contains a surface area equivalent to seven football fields." Electrodes built of such carbon provides tremendous amounts of reaction surface even in small cells.

Perhaps the biggest problem to bedevil fuel-cell designers is polarization—chemical changes at the surface of the electrodes which tend to block off any further reaction. Many apparently attractive fuel-cell combinations are completely worthless because no one can figure out a way to stop excessive polarization. In the hydrogen-oxygen cell, the

COVER STORY

THIS month's cover shows a simplified schematic representation of a fuel-cell power plant designed by Pratt & Whitney Aircraft for use in space flights. A photo of a model of the actual power plant is also shown. The system will provide the full electrical requirements of the spacecraft. Moreover, the exhaust product is potable water—useful for all space crew needs, including drinking.

Oxygen and hydrogen gas are supplied under modest pressure to the fuel-cell assembly. Here a number of porous nickel electrodes (only two are shown in the drawing for simplicity) are submerged in a solution of potassium hydroxide. Chemical reactions occur within the cell, producing electricity, water vapor, and heat. By using a number of cells in series, a higher output voltage may be obtained. This voltage is then used to power an external load. An excess of hydrogen removes the water vapor and heat and transports it to the radiator-condenser where the heat is rejected and the water vapor condenses to form water droplets. These are removed by a pump-separator and the water is stored in a tank for later use. The pump recirculates the exhaust hydrogen and returns it to the inlet connection of the cell assembly.

Experience gained from space programs such as this should accelerate the evolution of an economical fuel-cell power plant using readily available fuels and adaptable to a wide variety of industrial applications.

(Cover illustration: George Kelvin. Photo courtesy: Pratt & Whitney Aircraft.)

principal polarizing agent is the perhydroxyl mentioned above. If unchecked, it will soon coat the positive electrode and stop all further reaction. To combat it, scientists built into the electrode catalysts which tend to decompose the perhydroxyl as fast as it forms.

Another difficulty: elimination of water formed during the reaction. It tends to dilute the electrolyte. Sometimes a large amount of hydrogen must be circulated through a condenser where the water is removed. Sometimes, the electrolyte itself must be pumped through an external evaporator to get rid of the excess water and maintain electrolyte concentration. Either of these methods, of course, involves undesirable extra mechanical equipment.

Despite these and many other engineering problems, though, researchers have succeeded in building workable cells. *Union Carbide*, for example, built and delivered to the Signal Corps in August 1957, a 1-kilowatt unit for evaluation at the Army's electronics proving grounds at Fort Huachuca, Arizona. It was used to power the "Silent Sentry," a portable radar designed for battlefield use. The normal gasoline-powered generator used to operate field equipment is noisy enough to give away the unit's position, so the Army was looking for a completely silent power source. More recently, *Union Carbide* has built an improved version which delivers up to 100 amperes per square foot of electrode surface. It has performed well for a two-year test period. The company's researchers say present units are even better, although exact performance figures are secret.

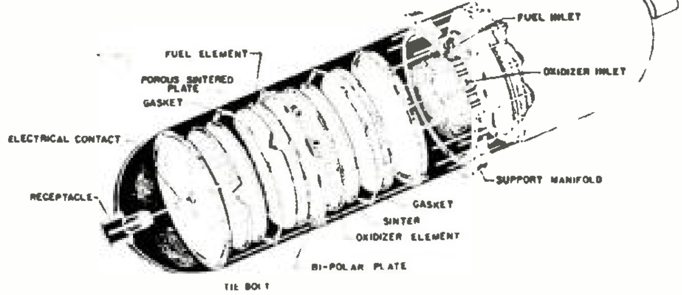
Soldier at right is shown loading a new fuel supply. Metal hydrides in the tank generate hydrogen to power the cell. This unit supplies enough power for the portable radar set at left.

Higher Temperature, Higher Output

The low temperature, low pressure (roughly 100 to 170 degrees F at atmospheric pressure) units are relatively simple in mechanical construction, but are limited in output power capabilities. The chemical reaction, and consequently power output, is increased substantially if a cell is operated at higher pressures and temperatures.

One of the pioneer fuel-cell scientists, Francis T. Bacon of Cambridge University, has been working on such a cell since the early 1930's. The Bacon cell, which uses porous nickel electrodes, operates at temperatures up to 500 degrees F and pressures of some 800 pounds per square inch. Under these conditions, it produces current densities up to six times those available from the low-temperature cells. Bacon cells have generated as much as 150 watts per pound of weight. Because of this high power-to-weight ratio—lead-acid storage batteries used in automobiles and planes put out 10 watts per pound—several companies are looking into the possibility of using the Bacon cell for electrical power in airplanes. The weight savings could be significant. One problem: the cell doesn't begin to produce much power until heated to about 300 degrees F, so engineers would have to devise a fast, light, reliable heater before they would be practical. Once operating, the cell generates enough heat to maintain proper operating temperature.

Pratt & Whitney fuel-cell assembly consists of a number of porous fuel and oxidizer element plates through which gases pass.

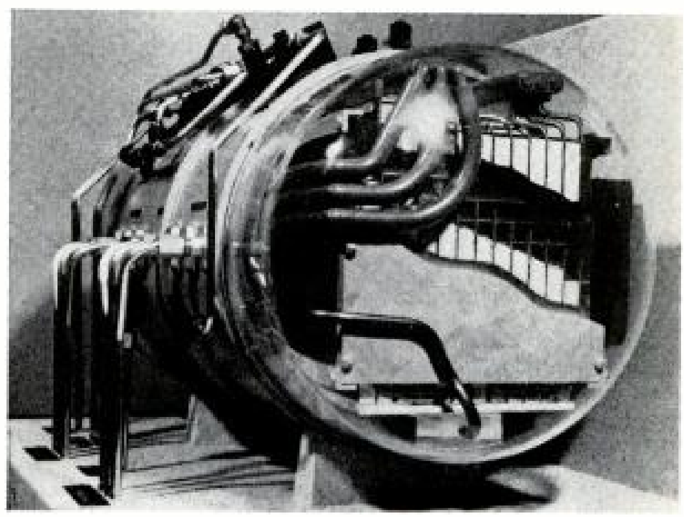


The Bacon cell has advanced so far that space planners have chosen it as the electrical power source for the "Apollo" manned moon vehicle. A model of the type which will be used, built by *Pratt & Whitney*, is shown on the cover.

Ion-Exchange Membrane

Another approach to fuel-cell construction which has reached an advanced stage is the ion-exchange membrane cell built by *General Electric Company* (Fig. 3). The principle of operation is similar to that of the standard hydrogen-oxygen cell. The main difference is that the electrolyte has been replaced by a solid membrane through which the ions can migrate. The cell is compact and water formed during the process is easily eliminated: it simply drips out of the bottom. The unit uses less auxiliary equipment—pumps and so on—than any other cell, and has no moving parts.

General Electric cells have already been built in several prototype models which have been tested by the military. One 55-pound unit produces 200 watts of power, enough to operate the Army's PPS-4 ground surveillance radar. Seventy-two pounds of fuel will operate the unit for a week. It would take a half-ton of freshly charged lead-acid storage batteries to do the same work. The unit produces 20 amperes per square foot of electrode surface—a kilowatt per cubic foot. Another *G-E* cell was sent into space on a test flight in October 1960 and operated satisfactorily.



Cut-away mockup of G-E fuel-cell power source that can provide electricity and drinking water for astronauts. The type of supply shown will be used in NASA's two-man spacecraft "Gemini."

Pure-Fuel Problem

One of the problems associated with most hydrogen-oxygen fuel cells is the fact that gases of high purity are required. Impure hydrogen will speed up the polarization process and poison the cell—sometimes quickly.

One approach to avoiding the need for ultra-pure gases is the "Redox" cell—*red*uction and *ox*idation—shown in Fig. 4.

(*Continued on page* 83)

FM STEREO: *a broadcaster's viewpoint*

By D. RIDGELY BOLGIANO
Director, Engineering Services Div.
Drexel Hill Associates, WDHA-FM

Technical problems for the broadcaster and the listener and how they can be overcome. Included is a simple scope method of monitoring that checks the channel identification and separation.

MOST articles on FM stereophonic broadcasting have been written primarily from the viewpoint of the listener. However, it may be of interest, not only to the listener but to the service technician, hi-fi salesman, or installer as well, to learn how the stereo broadcaster feels about FM stereo.

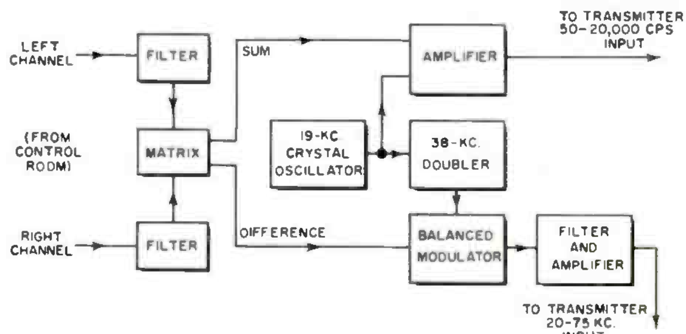
We at WDHA-FM (105.5 mc., Dover, N.J.) believed, when we first went on the air early in 1961, that FM stereo was not too far away. Therefore, we selected and designed all our equipment for eventual conversion to stereophonic broadcasting. We installed stereo phonograph cartridges and purchased stereo records for our library. The stereo cartridges permitted us to play all of our records without fear of ruining them for later stereo usage. We installed a complete dual-channel control board console (the *Gates* "Dualux"), wherein both channels are identical rather than one being employed for monitoring as is frequently the case in AM, TV, or mono FM stations. And we made sure that our transmitter had provisions for accepting modulating frequencies as high as 75 kc. even though we did not at that time know just what system would be approved by the FCC.

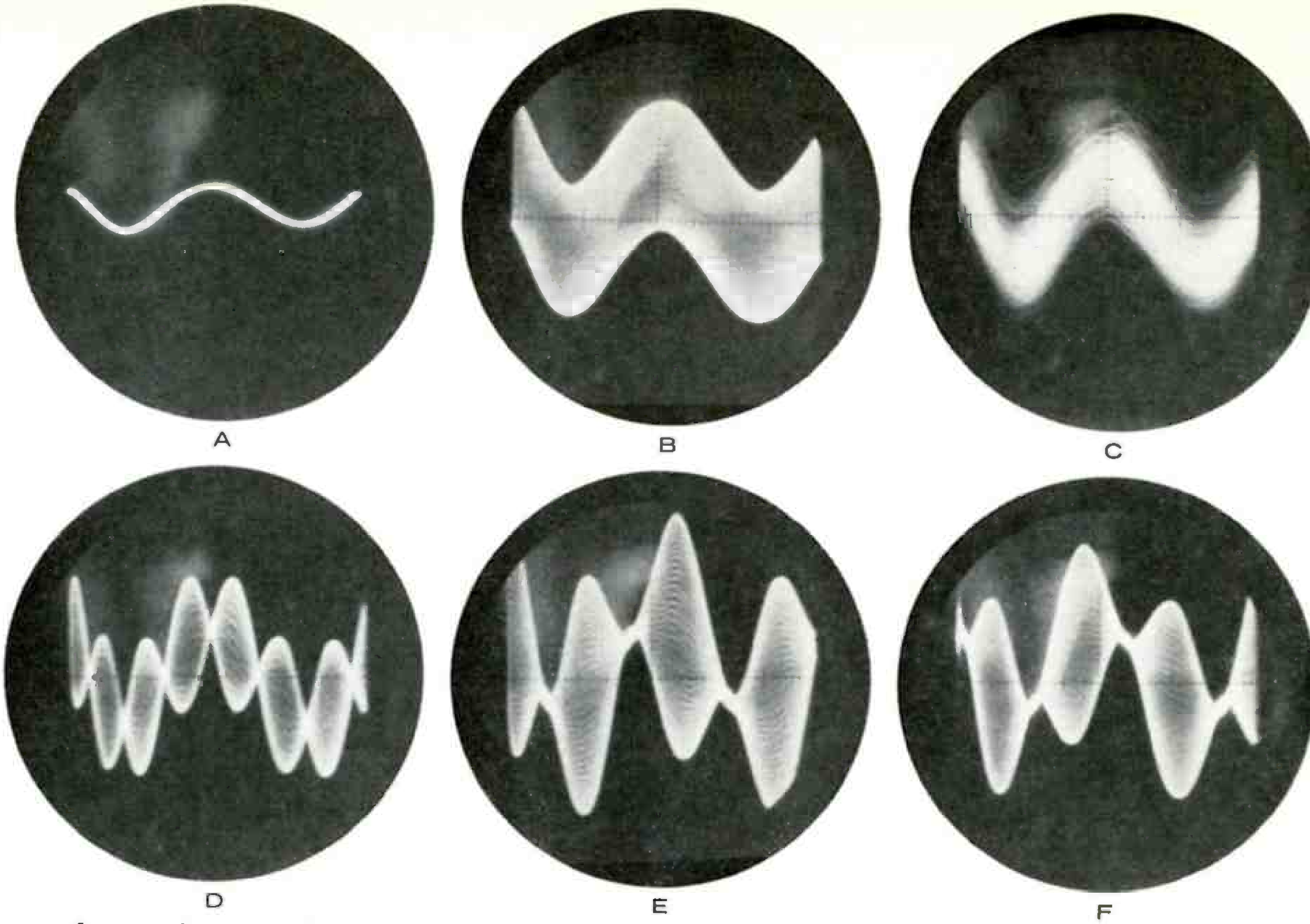
It was only a couple of months later that the FCC approved the *Zenith-General Electric* system of stereo broadcasting. We immediately checked with each of the manufacturers of broadcast equipment. Several were building prototypes, some of which eventually made it on the air. We tentatively selected one which seemed to be in the forefront. After several months of observing some of the early equipment troubles, however, we decided that if we were to go on the air with stereo quickly, it was up to us. We commissioned the Engineering Services Division of *Drexel Hill Associates*, the parent company of Radio Station WDHA-FM, to build a stereo generator using the station facilities to their best advantage. Those listeners in the New York-New Jersey-Connecticut area may remember the many times when we tested between one and six o'clock in the morning before we had the system perfected.

We employed the matrix method of generating our stereo signal, as shown in Fig. 1. The two audio signals enter the generator through two filters (see Fig. 2) which not only filter out all audio above 15 kc. (any frequencies above 15 kc. would cause sideband interference) but also provide identical pre-emphasis in each channel. The filtered left and right signals are then matrixed to provide sum and difference signals. A crystal oscillator with a ± 1 cps tolerance is used to generate a 19-kc. pilot subcarrier which is amplified and mixed with the sum audio signal for insertion into one of the inputs of our transmitter. (The transmitter itself has two inputs: one with a flat frequency response from 50 to 20,000 cps. the other with flat response from 20-75 kc.) The 19-kc. signal is also fed to a frequency-doubler circuit to provide a 38-kc. output which, after amplification, is fed into one input of a balanced modulator.

When two signals are applied to a non-linear element (such as a diode) as in the usual amplitude-modulation system, four signals come out: the original two plus the sum and difference of their frequencies. We used a double balanced modulator which accepts two signals at two inputs and provides two

Fig. 1. Basic block diagram of the stereo generator employed at WDHA-FM. Matrix method of generating signals is utilized.





Scope waveforms produced during monitoring of stereo broadcast. (A) 19-kc. pilot subcarrier with no audio modulation. (B) A mono signal, right and left channels are identical. (C) Complex audio signal with little or no separation. (D) Subchannel only signal or the signal that would be produced if a mono record were played with the phase reversed on one channel. (E) Waveform produced with modulation mainly on the right-hand channel. (F) Waveform produced with modulation mainly on the left-hand channel. For clarity, the pilot subcarrier amplitude has been increased in these waveforms and in the ones shown on the following page.

different signals as outputs. The output signals consist of only the sum and difference frequencies. Thus if there is no signal on one or the other of the two balanced modulator inputs, then there is no output. As we use it to generate a stereo signal, a steady 38-kc. signal is fed in to one input while the amplitude difference of the left and right channels is fed to the other input. Thus if there is no difference between the left and right channels (such as if we were to play a monophonic record with our stereo pickup), there would be no difference signal into the balanced modulator and thus no output from the balanced modulator. The output of the balanced modulator is then filtered, amplified, and connected to the 20-75 kc. input of the transmitter.

High-Quality Stereo Broadcasting

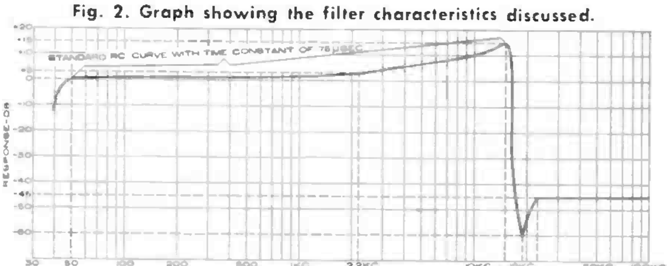
Aside from the usual requirements of high-fidelity monophonic broadcasting, such as minimum distortion and flat frequency-amplitude response, we have found three criteria which we had to meet in order that our listeners would receive a top-notch stereophonic signal with really good separation (35-40 db).

1. The ratio of main channel to subchannel modulation for a left-only or right-only signal should be close to unity.

2. The same ratio should be maintained for all audio frequencies from 50 to 15,000 kc.

3. The 38-kc. sidebands should be in-phase with the 19-kc. pilot carrier.

Fig. 2. Graph showing the filter characteristics discussed.



A fourth item, which will not stop the listener from enjoying FM stereo, but which has caused much head scratching by many broadcasters, is the determination of which of the two almost identical channels is right and which is left. This is true since the distinction is purely arbitrary and not inherent in the system itself. We have even found some stations which merely assumed that the receiver manufacturer had chosen correctly and decided which was left and right on the basis of which speaker the sound came from in the home of the chief engineer. An absolute method for distinguishing right from left by the technically minded listener will be described later in this article.

The first criterion is implied in the FCC rules although it is not completely and clearly specified. You can get good stereo without it on matrix-type receivers. However, for time-division type receivers, which appear to be getting very popular, the closer a station can maintain a unity ratio, the greater the separation will be from the two receiver outputs. We have a volume control in our subchannel circuits and so can vary the ratio at will, although we try to keep as close as possible to unity, employing the monitoring method described later.

The second criterion is more a function of original design, although it does mean that if a two-input transmitter is used the transmitter exciter must be kept in as good alignment as possible. We originally obtained our equal ratios by making each section of the system flat rather than by putting in massive correction at the transmitter inputs to make up for section deficiencies. Maintaining this criterion implies, of course, that you will have stereo at all audio frequencies and not just one or two. While the FCC has set down quite stringent requirements already, in terms of amplitude and phase delay differences, it behooves the alert station to do much better.

The third criterion is specified by the FCC by stating, in effect, that all zero crossings which can occur simultaneously must do so. We adjust the phase of the 19-kc. signal just before it is mixed with the sum audio. Maintaining this phase relationship seems to have been one of the most difficult problems faced by many broadcast stations and the difficulty seems to have stemmed primarily from a lack of monitoring of the phase relationship.

One must be careful when adjusting the phase relationship. If the 38-kc. sidebands and the pilot subcarrier are 45 degrees apart, there will be a total lack of separation. If they are 90 degrees apart, you have just as good separation as when they are in-phase except that the channels will be reversed even though none of the audio wiring has been touched. If, under these conditions, the right and left audio lines from the control room are reversed, as far as anyone can tell by any measurement the transmitter signals are exactly in-phase. This is also true of receivers and is sometimes the cause when, during alignment, the audio output channels seem to be reversed from what they had been previously or from what they are actually labeled.

Scope Monitoring Method

We have found a very easy method of monitoring our stereophonic transmissions. This method may also be used by the technically minded listener at home to actually measure quantitatively just how much separation a stereo station is broadcasting. We use the same method in our own control rooms to continuously monitor the transmitted signal.

The technique depends upon the fact that while the signal may be generated by matrix methods, it is also a time-division signal. That is, the left and right channels are fed to the transmitter alternately 38,000 times per second. The only purpose of matrixes, balanced modulators, and such is to provide a somewhat roundabout method for generating the alternating signals. Since each channel is "on" for only one-half cycle, coming out of the transmitter for one seventy-six thousandth of a second there is left channel only and then for the next seventy-sixth thousandth of a second there is right channel. Since the 38-kc. sidebands are in-phase with the 19-kc. pilot carrier, the left and right channels appear primarily within each 90-degree quadrant of the pilot 19-kc. sine-wave signal as in Fig. 3A.

This may be observed very easily on an oscilloscope by connecting the vertical input to the multiplex output of a good tuner (or directly to the output of the ratio detector which is usually the same thing) and connecting the sync input of the scope to a source of 19 or 38 kc. The best source, since it is nicely synchronized, is the 38-kc. oscillator in many multiplex adapters. By adjusting the oscilloscope sweep frequency so that only one or two cycles of the 19-kc. sine wave appear and adjusting the sync control so that the pattern stands still (providing the sync is coming from an adapter oscillator synchronized with the transmitted pilot), patterns such as those shown on the previous page will be seen.

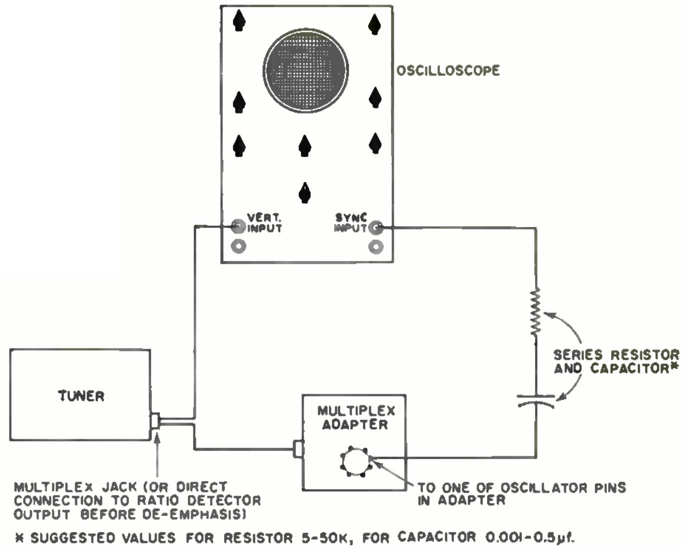


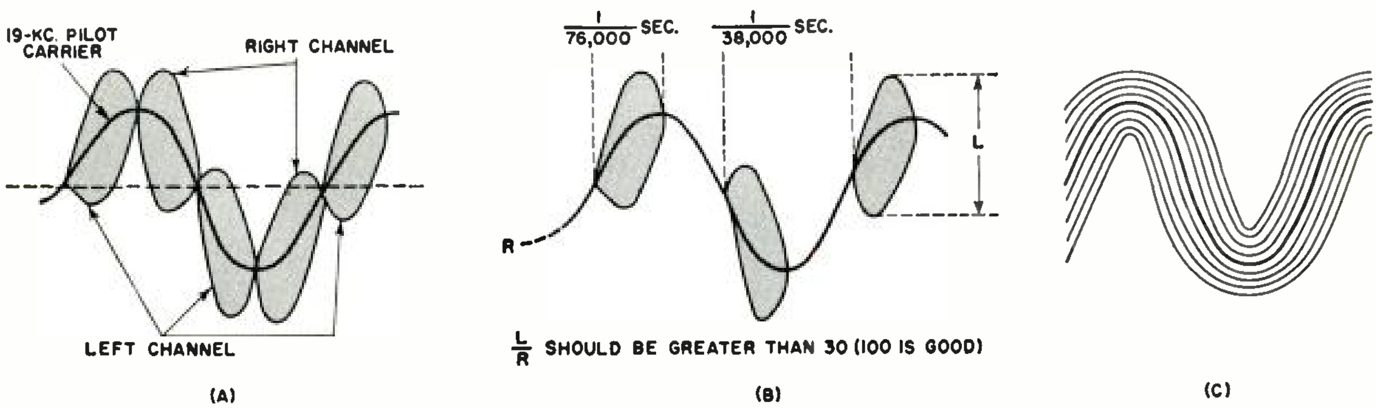
Fig. 4. Scope method of identifying channels, checking separation.

If an announcer speaks over only one channel, the right one for instance, it will be noticed on the oscilloscope that there is modulation only in the even quadrants of the 19-kc. sine-wave. The left-hand channel appears in the odd-numbered quadrants as in Fig. 3B. If the announcer is in the center or a mono recording is played, it will be noticed that the whole sine-wave just moves up and down over its entire length as in Fig. 3C. By observing the pattern for awhile, most people are able to readily see, for instance, just how much separation a recording contains. This method of monitoring FM stereo is absolute in the sense that all four of the criteria mentioned earlier may be measured quantitatively from this pattern and no filter measurements need be made first. It is assumed that the tuner has been properly aligned.

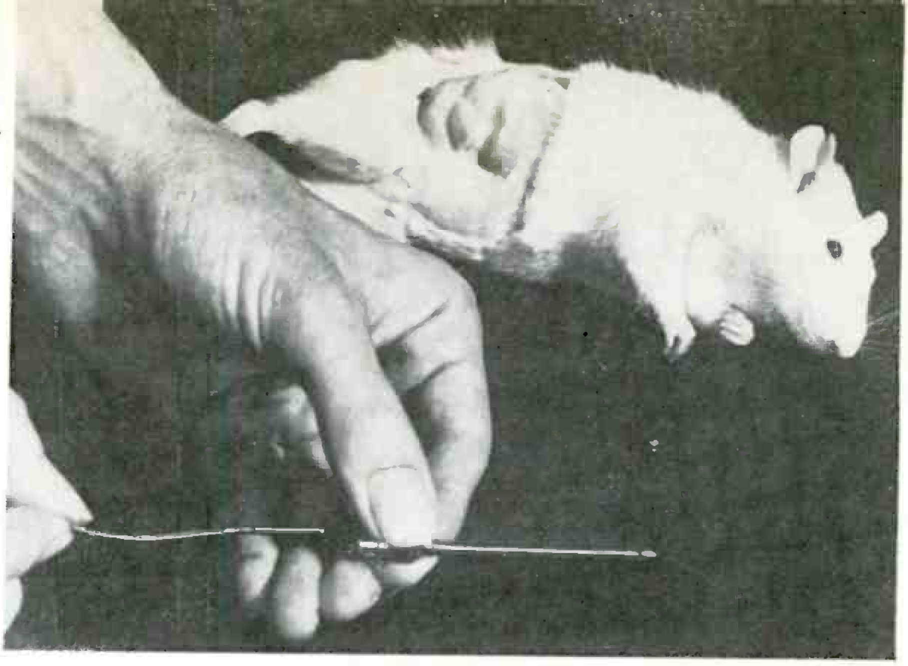
If when a signal is transmitted on only the left-hand channel, the ratio is taken between the amplitude of the modulation in the even quadrants (right channel) and the odd quadrants (left channel), it will be found that the ratio is a measure of the separation mentioned earlier. We hesitate to say that this is actually the amount of separation, since it is only so if the phase is correct. However, we could say that it is a measure of separation capability. Thus it is this ratio which should be at least 30 to 1 as observed on the oscilloscope and will range up to around 100 to 1 (40 db) for really good separation.

(*Continued on page* 103)

Fig. 3. (A) Scope display of stereo signal with good separation. The pilot carrier is seen only when there is no modulation. (B) With signal only on left channel, this is the scope display produced. (C) Scope display with a mono or center-only signal.



RECENT DEVELOPMENTS IN ELECTRONICS



Microminiature Counter Tube

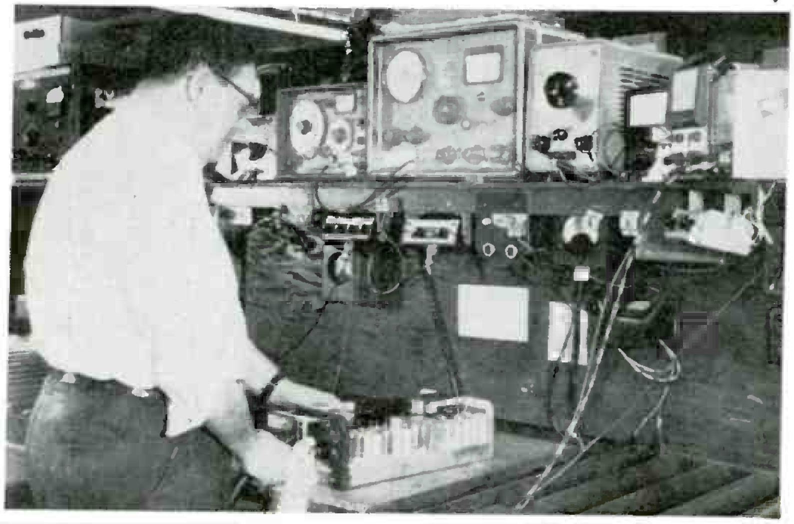
An ultra-tiny G-M counter tube is shown being inserted into a hypodermic needle, prior to being introduced in the cancer tumor of the anesthetized experimental animal. These counter tubes are small enough to be implanted directly into blood vessels, body cavities, or solid tissues without causing tissue damage. With a number of such counters connected to data-recording equipment, hospital research teams can monitor the uptake or excretion of radioactive tracer compounds. The equipment was developed by EON Corp. at the request of a Columbia-Presbyterian Medical Center research team.

Radar Tracking Antenna

A new radar antenna for missile-tracking ships is lifted atop a test tower on Sperry Gyroscope Co.'s new mile-long radar range at Manorville, N.Y. The 30-foot dish is part of an instrumentation radar that is said to be the largest precision radar yet designed for shipboard use.

Two-Way Radio Shake Test

A reliability test specialist readies a mobile radio unit for a factory version of "the twist" at RCA's plant in Meadow Lands, Pa. Placed on a vibrating table, the equipment is given a ride that simulates the bumps and jars of highway travel it will encounter when installed in a taxicab, truck, or other vehicle for two-way communications.



Instant Radio Station

Military communications are keeping pace with the split-second requirements of the space age. The "instant radio station" shown is truck-contained and truck-transported. The station can be put on the air within minutes after its arrival in the field. Developed by the National Co., the station was recently shipped to the U.S. Air Force for use in a trans-European communications link.

Thermoelectric Refrigerator ▶

The world's first thermoelectric refrigerator for home use is shown at the right. The unit provides two cubic feet of food storage space, including space in the doors for bottles and a compartment for ice-cube making and storage. The refrigerator, soon to be made available for sale by Norge dealers, chills without using moving parts, compressor, or refrigerant fluid. Instead, it employs thermoelectric cooling, the temperature change occurring at the junction of two dissimilar metals when a direct current is passed through them.

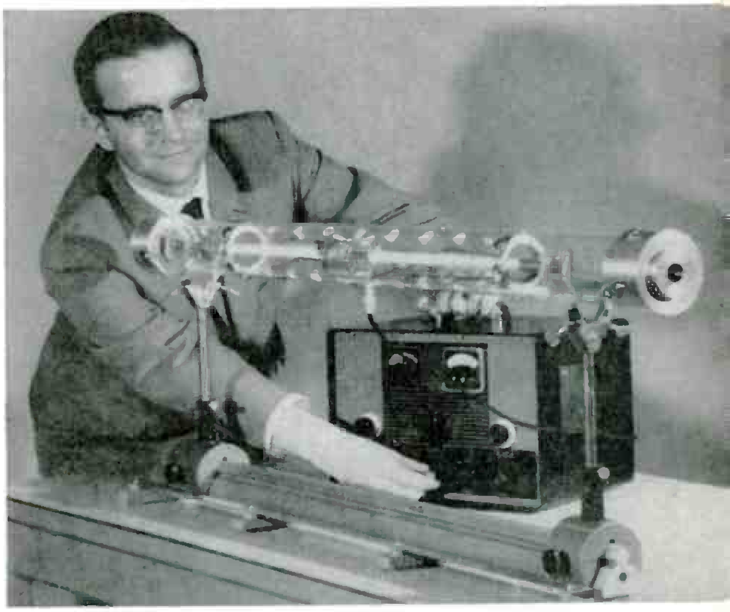
◀ Closed-Circuit TV for Traffic Control

An Indianapolis police patrolman is shown using an integrated radio-television network to coordinate traffic for this year's 500-mile race. A TV camera, part of a Motorola closed-circuit television system, is installed to check on traffic moving in and out of the Indianapolis Motor Speedway. The camera, atop a city-owned "snorkel" truck, may be raised 40 feet above the ground to get a good view of the most heavily travelled approach road. All camera control functions are handled remotely from one of the monitor posts, so that the camera can be aimed in any direction and zoom lens can be used to provide close-up views of traffic a mile from the camera. The TV system is used along with two-way radio for over-all coordination.

Wireless Portable TV Camera

A wireless TV camera weighing 20 pounds with its companion 40-pound back-pack was used for the first time during the CBS TV coverage of Scott Carpenter's orbital space flight in "Aurora 7." The Japanese-built camera uses a standard 3" image orthicon camera tube that can be fitted with a zoom or any other standard lens. The back-pack contains a complete microwave relay transmitter and a rechargeable battery. The picture is of broadcast quality. The unit can be up to 1500 feet away from the relay receiver.

▼



▲

Helium-Neon Laser

A rugged, helium-neon laser, warranted for 1000 hours of continuous operation, is being introduced by Raytheon. The new unit is expected to find wide use in industrial and institutional research laboratories. Output is 1.5 milliwatts; beam dispersion is eight minutes of arc. Price of the unit is $7400, complete with r.f. power supply, magnetic shielding, and image converter.

OSCILLOSCOPE VOLTAGE CALIBRATOR

By JOSEPH WIEDEMAN

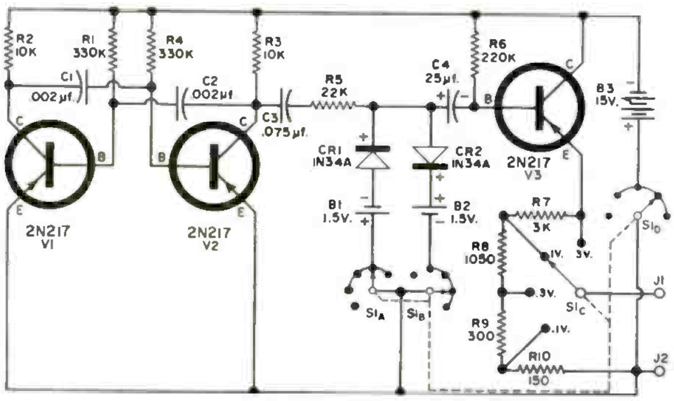
Construction of a square-wave generator that makes it possible to use a scope for accurate peak-to-peak voltage measurements.

Actual size of voltage calibrator. Jacks at top are spaced ¾" to accommodate standard insulated double banana plug.

ONE of the more useful accessories for an oscilloscope is a voltage calibrator. It is used to calibrate the scope's vertical amplifier and makes it possible to accurately measure the amplitude of a displayed waveform by comparing it with the calibrator's known output.

This calibrator is a low-frequency square-wave generator with peak-to-peak outputs of 0.1, 0.3, 1.0, and 3.0 volts. The accuracy of the output voltage is determined by the tolerance of the resistors in the output voltage divider (R_7-R_{10}). The stability of the output depends on the voltage of the cells (B_1, B_2) used in the clipper circuit. Mercury cells were selected as voltage references because of their constant-voltage output during their life. When their life has been spent, their output voltage falls abruptly.

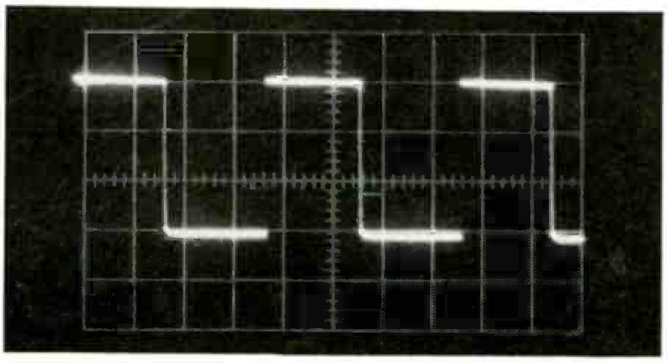
This instrument can also be used to calibrate voltmeters. However, bear in mind that most voltmeters indicate the r.m.s. value of a sine wave which is .707 times the peak of the sine wave. When checking a voltmeter, remember that the calibrator's output is a square wave. *The r.m.s. value of a square wave is its peak amplitude, that is, a three-volt peak-to-peak square wave has an r.m.s. value of 1.5 volts.*



R_1, R_4—330,000 ohm, ½ w. res.
R_2, R_3—10,000 ohm, ½ w. res.
R_5—22,000 ohm, ½ w. res.
R_6—220,000 ohm, ½ w. res.
R_7—3000 ohm, ½ w. res. ± 5% (see text)
R_8—1050 ohm, ½ w. res. ± 5% (see text)
R_9—300 ohm, ½ w. res. ± 5% (see text)
R_{10}—150 ohm, ½ w. res. ± 5% (see text)
C_1, C_2—.002 µf., 50 v. capacitor
C_3—.075 µf., 50 v. capacitor
C_4—25 µf., 15 v. elec. capacitor
S_1—4-pole, 5-pos. non-shorting rotary switch
CR_1, CR_2—1N34A diode
B_1, B_2—1.5-volt bias cell (Mallory BC-3)
B_3—15-volt battery (see text)
V_1, V_2, V_3—"p-n-p" transistor (RCA 2N217)

Fig. 1. C_3 removes d.c. level from square wave generated by V_1 and V_2. CR_1 and CR_2 limit the signal to V_3 to 3 v. p.p.

Fig. 2. Waveform of 3-volt signal at output terminals J_1, J_2.



The Circuit

There are three parts to the circuit. An astable multivibrator produces a square wave with a non-critical frequency of approximately 500 cps. A double-diode clipper limits the voltage level of the signal from the multivibrator to V_3 to 3 volts (p-p). V_3, an emitter follower, isolates the multivibrator and clipper from the load.

Since the collector-to-emitter voltage of a saturated transistor is about 0.25 volt, the multivibrator output has a peak-to-peak amplitude equal to the supply voltage minus 0.25 volt. Since only a small portion of this output is passed by the clipper stage, the actual amplitude of the signal before clipping is unimportant. B_3 can be 6 to 20 volts.

Capacitor C_3 removes the d.c. level from the signal before it is fed to the clippers. The clipper stage consists of two mercury bias cells and two semiconductor diodes: the latter function as voltage-controlled switches. Diode CR_1 conducts when the voltage at its cathode exceeds −1.5 volts and diode CR_2 conducts when the voltage at its anode exceeds +1.5 volts. Thus the signal at the base of V_3 is limited to 3 volts. V_3's emitter-load resistors (R_7-R_{10}) form a four-step attenuator.

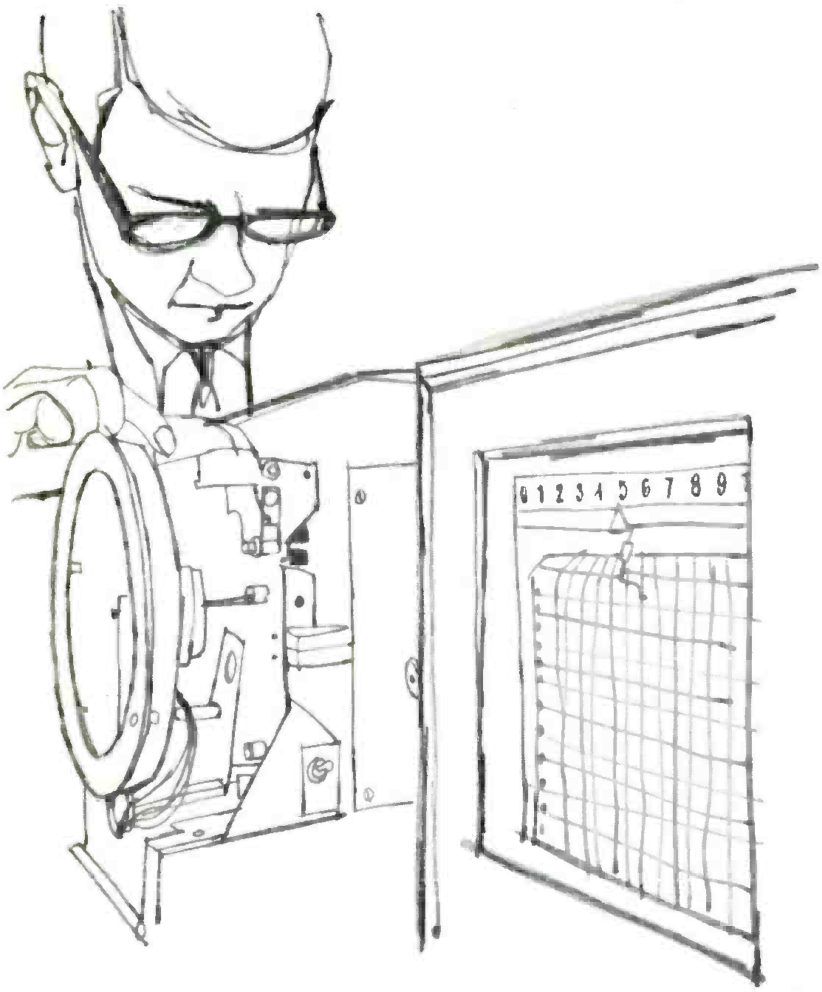
Construction

The author's calibrator was built in a 3¼" x 2⅛" x 1⅝" aluminum "Minibox." The components were mounted on a piece of 3/32"-thick fiberglass 1¾" wide x 2¼" long. Since extreme miniaturization was not of prime importance, transistor sockets and standard components were used. For really compact construction, the transistors could be wired directly

(*Continued on page* 77)

SELF-BALANCING POTENTIOMETERS

By ROBERT MEEM



Electronics technicians who fill industrial jobs encounter few devices more frequently than these.

VISIT almost any industrial plant and you are likely to find a battery of recorders, such as the instrument shown in Fig. 2, keeping track of temperature, humidity, pressure, *p*H, tension, viscosity, or whatever other variables may be of interest to the process at hand.

Few devices are more valuable or more necessary to modern industrial operations. Few are more likely to be encountered by electronics technicians in industrial roles. They provide a history of process performance which is essential for duplicating previous results, studying process efficiency, correcting unfavorable conditions, and planning future operations. Trends are readily detected from the record of past and present conditions, so that corrective measures can be taken at an early stage.

Instruments of this kind will record any variable that can produce an electrical signal—and just about any variable can. In operation, a pen is positioned on a horizontal carriage in response to the input voltage, and its position is recorded continuously as a chart revolves beneath it. At speeds of ¾-inch to 2 inches per hour, a single rolled chart will hold a continuous record of about 30 days of operation. Other recorders use circular charts which revolve beneath the pen, much as a phonograph record revolves under the needle. These charts are usually designed for 24-hour coverage and are replaced each day.

While simple galvanometers are adequate for most noncontinuous measurements, they are almost useless for continuous recording, since they are too delicate to move a recording pen over a chart without seriously affecting their sensitivity. For this reason, industrial recorders contain synchronous motors, which are powerful enough to drive the pen easily and which, through the use of amplifiers, respond to minute changes in the input signal. A typical instrument with a full-scale range of 10 millivolts will be sensitive to a change in input signal of less than 2 microvolts.

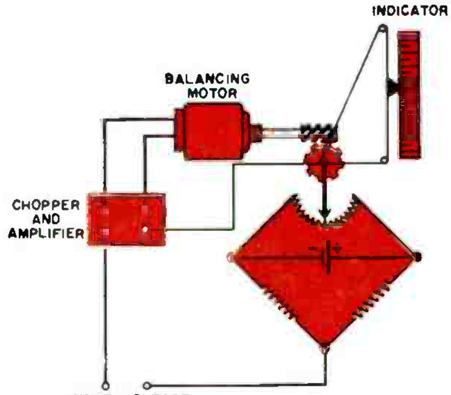


Fig. 1. How the self-balancing potentiometer works. Functional blocks are shown.

Basic Elements

A unit called a self-balancing potentiometer is the heart of a pen recorder. Potentiometer, in this connection, refers to a circuit for balancing an input voltage against an internal reference voltage. It has little to do with the familiar "pot" or variable resistor widely used in radio and television circuits.

The elements of a self-balancing potentiometer are shown in Fig. 1. The input voltage may be supplied by a ther-

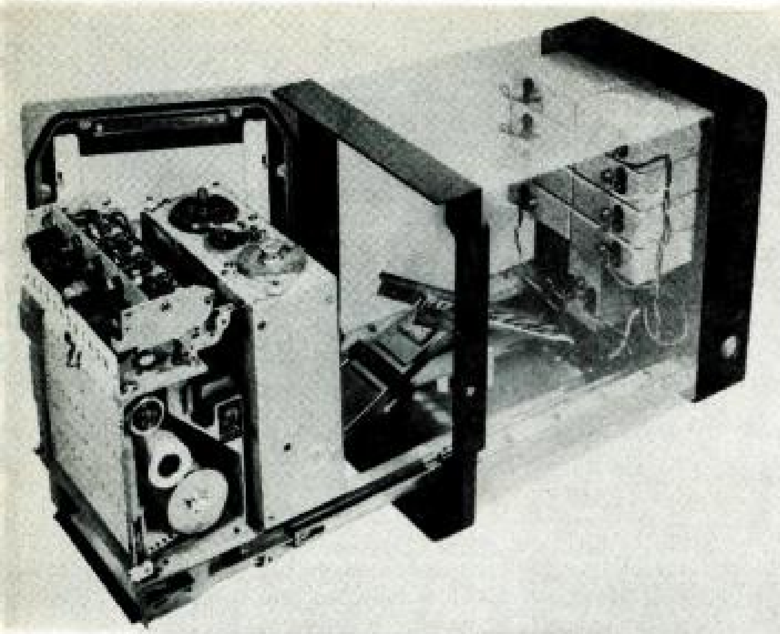


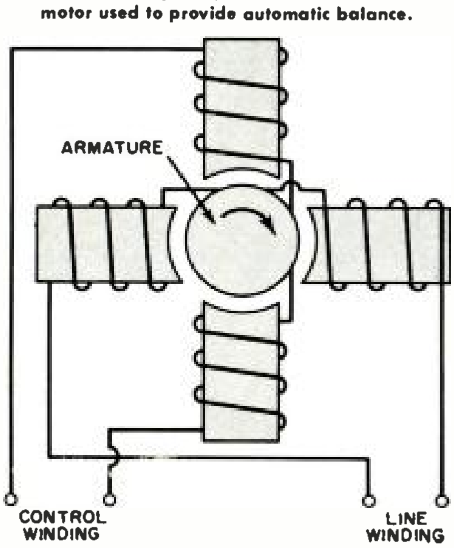
Fig. 2. A self-balancing potentiometer by Minneapolis-Honeywell, opened for detail. Drive mechanism is at the front (left). Behind it (to the right) is the amplifier enclosure. Modules at the rear (extreme right) are power-supply and control units.

mocouple or any number of other devices. It is introduced to the amplifier through a bridge arrangement which is powered by a dry-cell battery. Within the range of the instrument, there will be a setting of the slidewire contact at which the battery voltage picked off by the contact will exactly balance the input voltage, so that no current will flow through the input circuit.

At any other setting, there will be current which is amplified and used to power the motor, which in turn drives the slidewire contact to a new position. The motor will stop only when it has moved the contact to the proper balance point. Thus, the instrument works on the null-balance principle.

Since most inputs are d.c., a chopper is used to convert them to a.c. before amplification. In this way, drift problems associated with d.c. amplifiers are avoided. It is obvious that the unbalance voltage—that is, the difference between the input signal and the reference voltage—may be either positive or negative, depending on whether the input signal is increasing or decreasing. The polarity is of the utmost importance; if it were disregarded, the motor might turn in the wrong direction and never succeed in balancing the bridge. To prevent this, the chopper — which resembles the vibrator used in an auto radio—is polarized by attaching a small, permanent magnet to its vibrating reed. The reed is driven back and forth by an electromagnet powered by the line voltage. Thus the output of the chopper will always maintain a constant phase relation to the a.c. line voltage.

Fig. 3. Two-phase, reversible induction motor used to provide automatic balance.



The amplifier is conventional. In the *Leeds and Northrup* "Speedomax H" recorder, for example, two type 12AX7 twin triodes provide four stages of voltage amplification. A single type 12BH7 twin triode is used for power amplification.

The balancing motor (which will be described in detail below) drives the slidewire contact by means of a worm gear. It may have either a ratio of 100:1 for 5-second response, or 16-2/3:1 for 1-second response. Faster response is usually unnecessary and would be entirely useless where the slow chart speed would offset any advantage that might otherwise be gained.

The pen is moved back and forth by an arrangement not unlike the dial cord found on some radios. The pen is connected to the cord, and the cord is wrapped around the gear wheel which is driven by the worm gear. Whenever the gear wheel turns, therefore, the pen also moves.

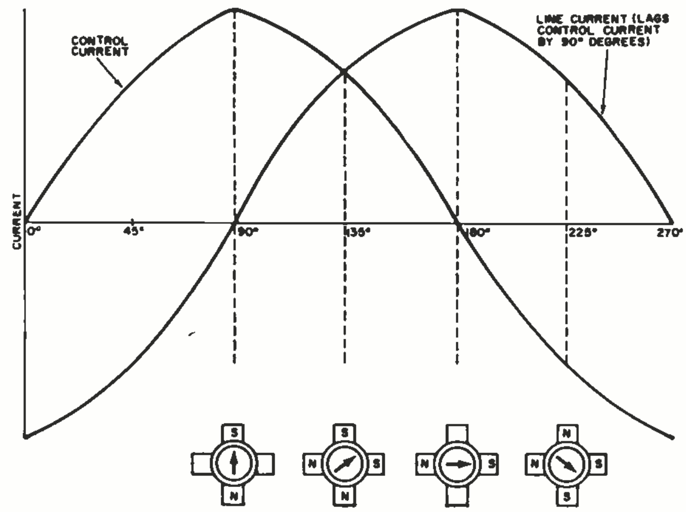


Fig. 4. Relationship between line and control currents, showing the instantaneous position of the rotor at various moments.

Balancing Motor

The function of the balancing motor is to position the recording pen according to changes in the input voltage. To do this, it must be able to rotate in either direction, in response to increases or decreases in that voltage. This is accomplished by means of a two-phase, reversible induction motor, shown in Fig. 3.

The motor has four poles and two sets of stator windings. The *line windings,* which carry the line current, are on the horizontal poles. The *control windings,* which carry the current resulting from the amplified unbalance voltage, are on the vertical poles. A necessary condition for the operation of the motor is that there be a 90-degree phase difference between the line current and the control current. When this phase difference exists, the poles will become magnetized in turn and will produce continuous rotation of the armature, as illustrated in Fig. 4.

When the control current leads the line current, as in this instance, the armature will rotate in a clockwise direction. If the control current should lag the line current by 90 degrees, however, counterclockwise rotation would result. Thus, with a constant line current, the direction of the armature rotation can be reversed by shifting the phase of the control current 180 degrees.

The method of obtaining the necessary phase shift in the control current is shown in Fig. 5. The type 12BH7 in the power-amplifier stage is connected so that the plate voltage for the two triodes is supplied from opposite ends of a center-tapped, high-voltage power transformer. The control winding of the balancing motor is connected to the transformer center-tap and to the junction of the two cathodes. A capacitor is shunted across the winding of the proper value to balance inductance, so that impedance is almost purely resistive.

The three possible conditions are illustrated in Fig. 6. When the system is balanced, no signal voltage is applied to the grids of the power-amplifier triodes. The plate of triode 1 goes positive on one half of the cycle, and current flows through the motor control winding. At the same time, the plate of triode 2 goes negative and no current flows through it on that half cycle.

During the next half cycle, the plate voltages are reversed. No current is drawn by triode 1, but current flows through triode 2 and, of course, through the control winding. The result is a pulsating direct current (Fig. 6A) with 120 pulses-per-second. Since this yields a fundamental frequency of 120 cycles while the motor is designed for 60 cycles, the rotor will not move.

When the system is not in balance, the unbalance voltage (E_G) will be converted to a.c., amplified, and applied to the grids of the power amplifier. Depending on whether the unbalance voltage is positive or negative, the grid voltage will always be in-phase with the plate voltage of either triode 1 or triode 2.

In the first instance, we assume that the grid voltage is in-phase with the plate voltage of triode 1. On the half cycle when the plate voltage is positive the grid will also be positive, and the output will be greater than when the grid voltage was zero. At the same time, however, the plate of triode 2 will be negative and the latter will not conduct. On the next half cycle, the plate of triode 1 will be negative. The plate of triode 2 will be positive, but its grid will be negative, so little or no current will flow.

The result of this situation is shown in Fig. 6B. It is apparent that, despite the irregularity of the waveform, the basic frequency in this case will be 60 cycles. This control

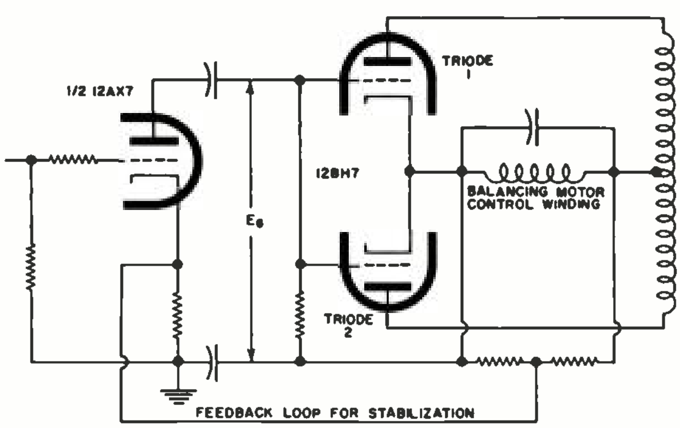


Fig. 5. The output section of the amplifier. The control winding of balancing motor is incorporated in this circuit.

current leads the line current by 90 degrees, and the rotor of the balancing motor will revolve in a clockwise direction.

Fig. 6C shows the comparable situation when the grid voltage is in-phase with the plate of triode 2. On the first half cycle, triode 1 will not conduct because its grid will be negative. On the next half cycle, the plate and grid of triode 2 will be in-phase and will produce a large output. The resulting 60-cycle wave will be 180 degrees out-of-phase with the wave shown in Fig. 6B. Since it lags the line current by 90 degrees, the direction of the motor will be reversed, as explained above.

Whether the control current is supplied by triode 1 or 2, it is essential that it be 90 degrees out-of-phase with the current in the motor line winding. This is accomplished primarily by placing a 2.3-microfarad capacitor in series with the line winding. There is some mechanical lag in the chopper circuit and some phase shift in the power output stage, however, and while the result of these various effects is a phase difference of about 90 degrees, it may be necessary

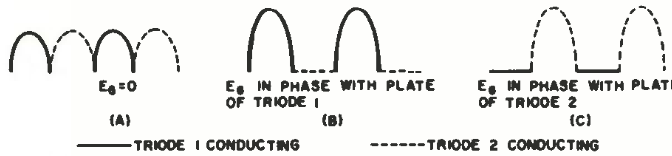


Fig. 6. Output-current waveforms of the amplifier in Fig. 5 for the three possible conditions of input voltage in Fig. 1.

to make small adjustments to obtain proper phase relation.

Other Features

When a dry cell is used as the source of power for the bridge, its output will vary with age, and this may cause inaccuracy. This factor is overcome by inserting a rheostat in series with the battery and periodically reducing the resistance in the circuit so that the output to the bridge remains substantially constant.

A standard cell having a constant voltage of 1.0195 volts is incorporated in many circuits and connected so that, when a switch is thrown, it will oppose the bridge voltage through a resistive network. The rheostat is then adjusted until there is no current flow. In many instruments the calibration is automatic. The standard cell is switched into the circuit at regular intervals, and the rheostat is driven to the null position by the same balancing motor that operates the slidewire contact. When the rheostat is at one extreme leaving more resistance in the line, the dry cell is replaced.

Some instruments employ a zener-diode voltage supply (Fig. 7) instead of a dry cell. Zener diodes have the unique property that, when connected in the reverse direction, the voltage remains constant despite changes in current drain. Since their characteristics do not change with use, periodic calibration is unnecessary.

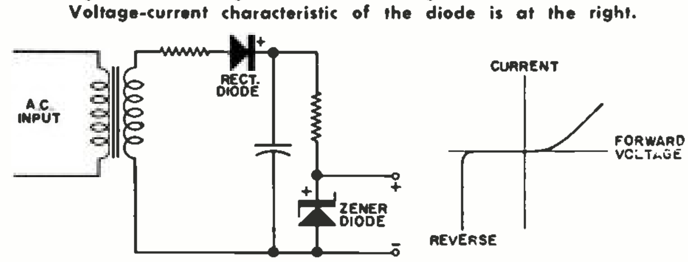
Not all instruments use a slidewire device to achieve balance. A bridge made by the *Foxboro Company*, for example, operates on a.c. and employs a center-tapped variable capacitor as the balancing mechanism. The unbalance signal is amplified in the usual manner and drives the rotor of the capacitor to a balance position.

The *Minneapolis-Honeywell* recorder (Fig. 2) uses a strain gage as the balance mechanism. Four pre-stressed, looped, wire strands enclosed in an *I*-shaped frame form the variable resistance legs of a Wheatstone-bridge circuit. Their resistance varies in proportion to the tension applied to them, in accordance with the principle of the strain gage.

When the horizontal torsion pivot to which the wires are fastened is at zero position, the wires are under equal torsion and have equal resistance. Any movement of the balancing motor causes a torsional movement of the pivot, however, so as to increase the tension and thus the resistance on two of the wires and reduce it on the other two. This changes the electrical resistance of the wires and continues to change it until the bridge is electrically rebalanced. At this point the motor will stop turning.

Movement of the wires, which act like rubber bands, is extremely slight but precisely proportional to the degree of shaft rotation. The pen carriage is linked to the balancing motor, and the same movement that balances the bridge also positions the pen. This strain-gage arrangement has the advantages of infinite resolution and low mechanical wear. ▲

Fig. 7. Establishing the reference voltage with a zener diode. Voltage-current characteristic of the diode is at the right.



"S" meters for CB

ONE OF the most popular Citizens Band accessories is the signal-strength indicator, or "S" meter. When properly used it is an excellent operating aid. More often than not, however, it is misunderstood and therefore maligned.

The purpose of an "S" meter is to provide a *relative* indication of signal strength. The key word here is "relative."

Operation & Limitations

The most common form of "S" meter operates in conjunction with the receiver automatic volume control (a.v.c.) circuit. As the incoming signal strength increases, the rectified output from the detector also increases. This negative voltage is fed through an audio filter (to produce near-pure d.c.) back to the control grids of the preceding amplifying stages to reduce their gain (Fig. 1A).

The a.v.c. voltage will increase with larger incoming signal strengths, but not linearly. If the input signal doubles, the a.v.c. may increase one unit, for example. If the incoming signal doubles again, the a.v.c. increase may only be 9/10ths of a unit. There is very good reason for this effect. As the grids are made more negative, they amplify less, therefore the detector produces smaller increases in a.v.c. voltage. This is also the reason that the typical "S" meter calibration gets progressively more "cramped" toward the high end of the scale. The meter calibration is made to approximate the non-linear characteristics of the receiver amplifiers.

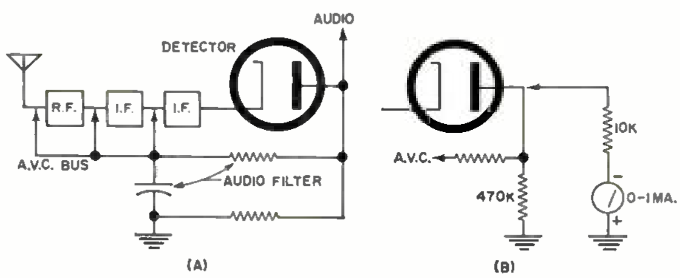
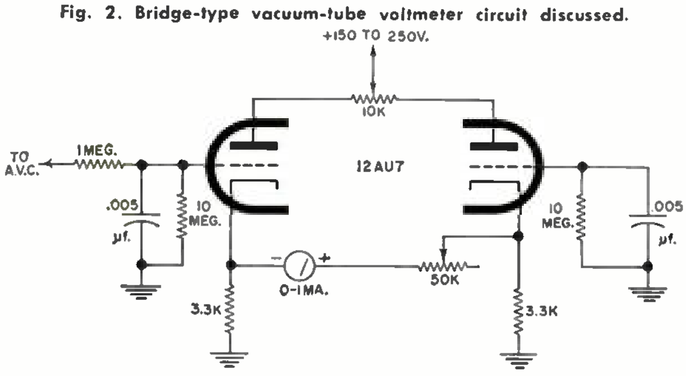


Fig. 1. (A) Basic a.v.c. circuit. (B) Simple tuning indicator.

Fig. 2. Bridge-type vacuum-tube voltmeter circuit discussed.



If you consider for a moment the a.v.c. loop in a typical radio receiver, you will see why the "S" meter readings can only be relative. If, for example, the receiver gain drops (due to component aging or alignment changes), the a.v.c. voltage will decrease for a given signal strength. Under these conditions, an S9 signal may indicate only S7. Another non-linearity in the loop is the detector output, which follows a square-law function for weak signals. Further, the printed "S" meter calibration can only approximate the receiver a.v.c. characteristics. Various tube curves can modify this characteristic radically.

A weak or somewhat insensitive "S" meter can still be valuable, however. For instance, it will tell you if Joe or Sam has the stronger signal or which of their antennas "puts out" the best. It will show you when your CB beam antenna is pointed in the right direction by indicating the highest signal reading. The "S" meter can be used as an alignment indicator simply by peaking all receiver adjustments for a maximum reading.

When designing a receiver, the manufacturer does have a target value for the "S" meter readings. The standard has generally been to consider an S9 reading as 100 microvolts impressed across the antenna terminals. If this voltage drops by half, it represents a reduction of 6 db and the "S" meter reading should drop one "S" unit.

Ham radio operators, using receivers with this calibration and reasonable accuracy, report dissatisfaction with the readings. "The 'S' meter says S8, but you sure sound louder," is often heard. For this reason the trend has been to use so-called "soft S" units, that is, 50 microvolts representing S9 and divisions representing 3-db to 5-db voltage changes (1.4 to 1.8 rather than 2 times). This results in much more lively readings and therefore is sometimes called a "courteous S meter."

Basic Circuits

Since a source of voltage that depends on the incoming signal is present in the receiver, it is logical to make an "S" meter that measures this voltage. The simplest circuit for this purpose is shown in Fig. 1B. It is a simple voltmeter which uses the a.v.c. voltage to deflect the meter. However, this system shunts the detector load resistor (470,000 ohms) with a 10,000-ohm resistor and places a heavy load on the circuit. The net result is a drastic reduction in a.v.c. voltage which permits stronger signals to overload the receiver. Even if an ultra-sensitive meter (50 µa. or so) is used, it will still result in degraded receiver performance to some extent.

This problem of circuit loading is present whenever power must be removed from the circuit to actuate the meter. An example is the common volt-ohm-milliammeter which produces inaccurate readings in very high resistance circuits. When loading is a problem, as in the a.v.c. circuit, a vacuum-tube voltmeter is generally used. Fig. 2 shows a typical

By DONALD L. STONER, 11W1507

Survey of circuits used for signal-strength indication and suggestions for incorporating them into a Citizens Band rig.

v.t.v.m. circuit. Here 11 megohms is connected across the a.v.c. circuit, rather than 10,000 ohms. The amount of loading, therefore, is insignificant. The circuit operates in the following manner. If the two triode sections are equal and resistors are the exact values shown, equal currents flow in both tube sections. This results in the same cathode voltage for both sections. With no cathode-to-cathode potential difference, no current flows through the meter. This condition represents meter zero. However, this ideal condition is seldom achieved in practice and a "Zero" potentiometer is required. This control, the 10,000-ohm pot in Fig. 2, varies the plate voltage on each section and is set to produce equal cathode voltages as indicated by a zero meter reading. An additional potentiometer is included in series with the meter for controlling full-scale deflection. Disc capacitors bypass both grids to prevent rectification and erratic readings due to pickup of stray r.f. fields.

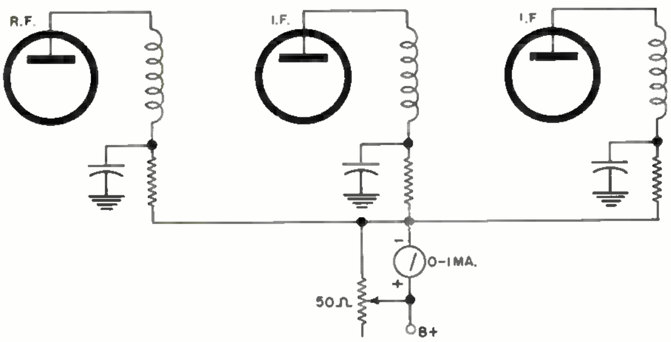


Fig. 3. Tuning indicator that measures plate current flow.

One important feature of this circuit should be particularly stressed and that is the self-balancing aspect. If, for example, the "B+" voltage changes, the current in each triode section changes equally and the cathode-to-cathode voltage remains constant. Further, as the tube ages, both sections lose gain about equally and the balance is maintained.

Typical "S" Meter Circuits

Because of the competitive nature of the Citizens Band business, cost-conscious manufacturers hesitate to add an extra tube to actuate the "S" meter. It is possible to incorporate the "S" meter in the amplifier section of the transceiver by utilizing the effect of the a.v.c. on the tubes. One of the least complicated circuits is shown in Fig. 3. Here the meter is inserted in series with the "B+" circuit and indicates the current consumption of the amplifiers. As the a.v.c. increases, due to a stronger signal, the negative voltage present on the control grids decreases the current flow in the tubes and the meter. A potentiometer in parallel with the meter is used to zero the pointer. This circuit is difficult to install in most transceivers because the "B+" circuit is "strung around" and must be traced down.

A similar system, which is easier to install in existing equipment, is shown in Fig. 4A. In this circuit the meter is connected as a simple voltmeter across the cathode resistor of one of the i.f. tubes. In this case, the load is a low resistance and the meter does not load the voltage developed across the cathode resistor. The series resistor *R* is made variable to act as a zero adjustment. The value of this resistor is determined by the amount of voltage present. A 10,000-ohm pot would probably be suitable.

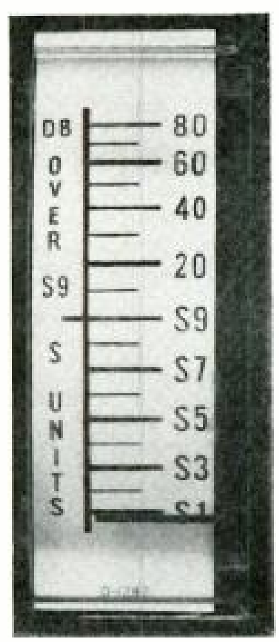
The "S" meter circuits just described are known as backward-reading types. The amplifier characteristic is to draw maximum current with minimum a.v.c. voltage. Increasing the a.v.c. decreases the current flow through the meter. If a conventional meter were used in the preceding circuits (Figs. 3 and 4A), it would read backwards, that is, S1 would be at the right side and over S9 would be at the left.

There are two solutions to this problem. One of these is to obtain a special meter in which the de-energized or resting position is at the right end of the scale. When full current flows through this meter (representing minimum a.v.c.), the needle moves to the left. The resistance in shunt (Fig. 3) and in series (Fig. 4A) sets the needle position to "zero" at the left side of the scale. Another method of overcoming the backward reading is to mount the "S" meter upside down and, of course, use a suitable "right side up" scale.

Both of the schemes require special, and therefore more expensive, meters. They have a further disadvantage that the meter can never be made to read full-scale. You will recall that full-scale (strongest signal) in the backward reading system represents minimum current through the meter. However, the current flow in the tubes is never completely cut off. This cannot occur for there would then be no r.f. signal to produce an a.v.c. voltage.

To avoid all the preceding problems, the "S" meter circuit shown in Fig. 4B is most commonly used in CB equipment. It uses the varying current in one of the i.f. amplifier tubes to deflect the meter. However, the meter is connected in a bridge configuration, although at first glance it appears to be the simple voltmeter discussed earlier.

As before, current flows through the tube and returns to the power source. In this circuit, the plate current flows through R_1, a 200-ohm resistor. A 1000-ohm resistor and the meter are connected as a voltmeter to measure the potential drop across R_1. Let's say, for the purposes of an explanation, that the tube is biased to draw 5 ma. (plate current, path *A*) with no incoming signal. This current flows through R_1 and results in exactly a 1-volt drop across the 200-ohm resistor. A second current path exists through the meter and R_2, a 1000-ohm resistor. According to Ohm's Law, 1 volt impressed on 1000 ohms results in a current flow of 1 ma. (path *B*). If a 0-1 ma. meter movement is used it will deflect to full-scale with no signal. However,



Vertical-scale "S" meter employed on some National Co. communications receivers.

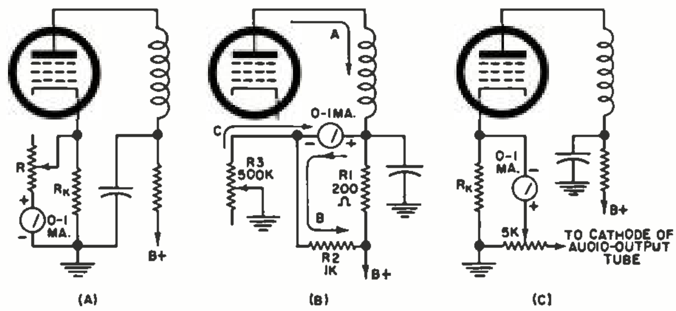


Fig. 4. (A) Metering cathode voltage of one of the a.v.c.-controlled i.f. tubes. (B) Bridge circuit tuning indicator. (C) Simple circuit that can be installed in a CB receiver.

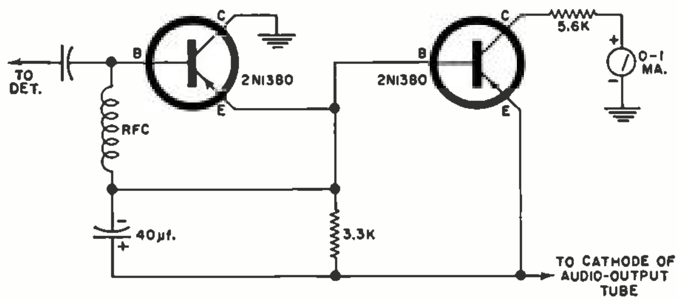


Fig. 5. Transistorized "S" meter. Neither the transistors used nor the input circuit employed is critical in this application. The circuit is connected to the second detector by twisting a few turns of insulated wire around the last i.f. transformer to provide capacitance coupling. This avoids any retuning of the i.f. transformer. The value of the r.f. choke used is not critical; it is probably in the order of 1 millihenry.

this is the undesirable backward-reading condition described earlier.

To correct this situation, a third resistor, R_3, is employed to introduce yet another current path. This path (*C*) forces an equal and opposite current through the meter causing it to move back down scale. Thus resistor R_3 becomes the zero adjustment. If adjustment of full-scale readings were desired, it could be accomplished by varying either R_1 or R_2. When a signal comes in, the plate current through the tube is reduced. This reduces the amount of current in path *B* and the bridge is no longer balanced. Current *C* now deflects the meter to produce the signal-strength reading.

This circuit also has a few disadvantages. Obviously "B+" variations, in addition to tube aging, will cause the zero to wander around over a period of time. However, it is relatively inexpensive and reasonably accurate.

The easiest circuit to install in an existing CB rig is the one shown in Fig. 4C. This circuit is also a bridge configuration with the tube and cathode resistor forming one arm and the audio tube and potentiometer forming the other. Because there is a tube in each leg of the bridge, it exhibits the self-balancing feature discussed previously in connection with Fig. 2 and, in many respects, it is quite similar.

To install this circuit in your transceiver, locate a suitable position on the front panel for the meter and space on the rear apron for the zero-set potentiometer. Also locate the i.f. amplifier (commonly a 6BA6 or 6BJ6) that is connected to the a.v.c. line and the audio beam power output tube (often a 6AQ5 or 6BQ5). Connect the two outside lugs of the potentiometer across the cathode resistor and the center lug to the meter plus terminal. The negative meter terminal should be connected to the cathode of the i.f. amplifier tube. If the meter reads excessively high on strong signals, a resistor can be inserted in series with the meter leads. Excellent meters with "S" meter calibrations are available for this application.

Unfortunately, this circuit is not without its limitations. It requires a source of cathode voltage which varies with the a.v.c. potential. Several popular transceivers employ circuitry in which the cathodes of the i.f. amplifier stages are all grounded. Some of these are the *Apelco* AR-9, *Globe* CB-100, *Gonset* G11 and G12, and the *Hallicrafters* CB-1. The circuit shown cannot be used with these units.

Transistorized Circuits

A "universal" transistorized "S" meter, which will work with any CB rig except the superregenerative type was recently announced by a California company (Model SM-1, *Cover Engineering*, 430 W. 40th Street, San Bernardino, California). The transistor feature is logical as it is rather wasteful to consume 2 or more watts of power to deflect a meter which requires only one-thousandth of a watt to move it to full-scale.

Transistorized "S" meters also introduce several unique problems which have prevented their use until now. For example, transistors are sensitive to heat which usually causes zero to wander around. In addition, transistors are low-impedance devices, while the a.v.c. bus in a typical CB rig exhibits an extremely high impedance. These problems have been largely overcome in this unusual "S" meter. The circuit is shown in Fig. 5. It consists of a common-collector class B transistor detector driving a d.c. amplifier. The input is not the customary a.v.c. connection, but rather a small amount of i.f. at the second detector is sampled and rectified. Due to the action of the transistor, this causes current to flow in the emitter load resistor. The voltage developed across this resistance is applied to the base-emitter junction of the d.c. amplifier. The amplified signal, which is proportional to the signal strength, is used to deflect the meter. A series resistance limits the full-scale deflection. A special meter, with compression characteristics, is used to provide the customary "S" meter calibration.

Leakage current in the detector stage is minimized by connecting an r.f. choke between the base and emitter. The choke acts as a relatively high impedance for r.f. but has a low d.c. resistance, thereby preventing I_{co} multiplication. A negative-ground type of circuit is used to be compatible with vacuum-tube circuitry. The "B+" voltage is obtained from the cathode of the audio-output tube.

In addition to the "S" meter function, this unit is designed to act as an output r.f. and modulation monitor when transmitting. A small pickup wire is placed near the final tank coil. The r.f. output is rectified by the device and a meter deflection is produced. The exact value of the reading obtained on the meter may be adjusted by varying the coupling to the final tank circuit.

The information contained in this article has been compiled to acquaint you with the basic operation of "S" meter circuits as they apply to Citizens Band equipment. Obviously it is impossible to show all of the many possible variations. However, with the information supplied, you should be able to find a circuit suitable for installation in your particular equipment. ▲

"S" meter dial employed on Hallicrafters ham communications sets.

TECHNICIANS WITH PASS-PORTS

By FREDERICK J. DEGLER
Federal Electric Corp.
Service Div. of ITT Corp.

Varied field assignments in all parts of the world offer adventure, learning, a sense of achievement, broad experience, immediate reward, and a foundation for a career.

IN A FEW decades, electronics has become a key factor in transforming virtually every facet of our civilization, including such areas as science, business, industry, and the arts. Our military establishment and our economy depend on it heavily. This remarkably varied field, in turn, relies ever more heavily on skilled technicians flexible enough to adapt to the range of functions that grows out of the variety.

It is hard to find a better illustration of this point than a company, like *Federal Electric,* which installs, services, and manages electronic equipment and systems, military and civilian, in more than 30 countries throughout the free world. Of a total staff that involves more than 5000 persons, nearly half are considered electronics technicians, or were.

Some of these are radar technicians or "radicians." Others are versed in carrier systems. Many become involved with microwave technique. Other areas of interest include tropospheric scatter systems, pulse-system navigational aids, aircraft guidance, and emergency maintenance. In any of these areas, the individual may deal with planning and installation, operation, maintenance, or the instruction of other personnel in taking over operation and upkeep.

The technician may work in this country. He may also find himself in Canada, Greenland, Alaska, Africa, Thailand, Indonesia, Scotland, Spain, Greece, Chile, New Zealand, on a Pacific island, somewhere in Western Europe, or at the South Pole. More interesting than this variety is the fact that one man may find himself, over the years, at a number of these places and he will probably hold, at one time or another, several of the various positions mentioned.

What sort of individual can meet such requirements? What does he need in the way of training, experience, and temperament? Can he lead any sort of settled life? What is his future? No single answer applies to all cases. Before we discuss general possibilities, the author's history with the organization may shed some light on what happens in this field.

One Man's Story

My background is not unusual. Before becoming a technician, I had completed more than three years of college. Then, in 1957, came the opportunity to become part of a forward-propagation, tropospheric-scatter system in Alaska being developed to provide channels for telephone and telegraph traffic in that remote region. Along with 24 others, I was given a course in voice and telegraph systems, microwave theory, and the principles of tropo. The training included actual work on equipment at sites where laboratory-type problems were presented.

After two years, I was assigned a succession of jobs that included teaching pulse-system navigational aids in Washington, D.C.; directing emergency maintenance on Air Force equipment in Virginia; supervising a radar and microwave installation in Newfoundland; rescuing a collapsing radome off the coast of Greenland; and installing an AF ground-to-air transmitting and receiving site on Cape Cod. I then unpacked my bags to become a field service administrator of several of the company's projects.

Now I have a home of my own, a wife, and young children.

Federal Electric Corporation of Paramus, New Jersey, is the world-wide service affiliate of International Telephone and Telegraph Corporation. It is concerned with installation, maintenance, operation, engineering, support, and system management in the electronics and communications fields. Its customers include the military services, government agencies at all levels, and industrial and commercial concerns, in this country and abroad.

Major projects operated and maintained by FEC are the DEW Line (Distant Early Warning), Point Arguello and West-Coast based range ship facilities of PMR (Pacific Missile Range), and the activitation of "Titan" Missile Base T-4 at Larson A. F. Base, Washington. It also plays a key role in several military tropospheric-scatter systems in Europe and the Far East.

(Below) Technicians stationed on the Greenland ice cap repair wiring in a weather-instrument system, which uses radar and a variety of data recording devices. The installation is part of the DEW line.

(Above, left) A pair of "radicians" operate a control console, which is also part of the DEW line. The tour of console duty runs for four hours. It is followed by another four-hour span in communications and electronic maintenance, putting some variety into the working day.

(Above, right) A student group in Vietnam learns the right way to climb when making cable repairs from an FEC field man. For these eager young men, such activity may involve fewer problems than their other studies. They are being trained in basic telephone system techniques.

(Left) Installing or repairing a heater on an antenna feed horn about 50 feet above ground is a normal maintenance chore. The technician used a ladder to reach the dish, but then had to shinny out on the arm. Tropospheric scatter systems around the world use antennas like these.

At my own request, I am bound for assignment in Nepal. The State Department's Agency for International Development is helping this small nation build a communications network internally and also to connect with major cities in India. Under contract to AID, our job is to teach the Nepalese how to operate and maintain approximately 40 single-sideband units and power generators. Many natives of this country do not know what "communications" means in the sense that we take for granted today. We will help unlock the wonders of the 20th century to a developing nation. There are many valid motives for seeking work of this kind. As for me, I can think of nothing more challenging or rewarding than a role in helping a people to improve their condition and strengthening the position of our country by winning friends abroad.

It is most unlikely that I will touch all bases myself with *FEC*. However, associates of mine are operating instrument calibration and repair depots in France, manning Project Mercury tracking stations, conducting telemetry check-out and study programs for NASA, and working with tacan, loran, and other systems aboard ships and at hundreds of fixed locations around the world.

Responsible Positions

You don't have to be engaged in such activities for very long before you learn that there are never enough *good* technicians. They are among the most sought-after men in the industry. Far from being run-of-the-mill hired hands, they are entrusted with important responsibilities. They must know what they are doing, because delays and errors on projects of wide scope are expensive. They must be able to work independently, because they will often be in situations where there is no one to whom they can call for help. They must be able to deal with other people successfully, because the company's hope for future contracts with a particular customer often depends on the impression they make on current ones—and the customer may be a private firm, some arm of our own government, or a foreign state.

They make key decisions. Take a field engineer in charge of an installation team. He has worked up to that position by experience as a member on such teams. First he selects his assistant. Then he goes through the installation contract, which calls for his company to provide a certain amount of the equipment, hardware, and other material to be used. He checks this list thoroughly to make sure that particular materials meet the stated requirements. Compatibility with the conditions of the specific installation must be evaluated; availability must be determined; and, where availability may be a problem, satisfactory equivalents must be recommended. This brings him into contact with many suppliers.

Weather, shipping time, manpower allocation, and expenditures must be assessed; for, although he draws upon his company's entire technical and field resources for advice, ultimate responsibility for proper completion of the job rests on his shoulders. Due to factors that could not be foreseen, he may have to revise plans in the field. Once on his own here, he is directly responsible for equipment purchases.

Information Feedback

Changes based on the unexpected are important to his company. He will record these carefully and bring such information back with him when his job is done; this data can be most significant in planning future installations.

When the equipment is in working order, he is not yet done. Demonstrating performance and operation to the customer and his personnel are also his responsibility. The impression he makes with these people on behalf of his firm and their ultimate satisfaction with the installation, though intangibles, are important values to be brought back when he returns. These may mean as much to his government as to his employer.

Obviously, the sort of individual who can handle such duties is not the glorified, carefree hobo seeking superficial excitement. A taste for adventure is valuable, but a sense of responsibility is as indispensable as technical background. Let's consider the type of man who succeeds here in somewhat more detail.

Previous Background

Most FEC field men have had at least a year of college, which is not always in electronics, but is often in some related aspect of science. However, those with solid learning in good technical training institutes or previous experience in some of the specialties involved also find acceptance. A background confined merely to training or experience in consumer service would not generally be adequate. Since a great deal of the work involves military equipment, specialized training and experience in the Armed Forces is useful. Many men enter the company directly after the completion of tours of duty with one of the military services.

A civilian interested in such employment stands his best chance of making the grade if he applies while he already holds a position elsewhere. This is another way of saying that "job hoppers" are not welcomed with open arms. W. T. Duffy, FEC employment manager, reports that this type seldom works out. However, as we shall see later, this does not exclude an applicant with legitimate, short-term objectives.

Personal Details

To check on desirability, a background investigation is made that includes previous employment, credit, and other records. Evidence of a good reputation in the community, maturity (apart from age), and stability are helpful.

As to age itself, there is a surprising spread. One would expect to find nothing but young men roaming the world adventurously. As a matter of fact, not only are there field men in their forties and even their fifties, but the members of this group are not exclusively hold-overs who started in earlier years. Many members of the Armed Forces, having retired after careers as electronics specialists, supplement their retirement income and get a look at the world by going into such employment.

The man with a wife and children may not consider the situation stable enough for him—although we will consider an opposite view shortly—but the employer does not confine hiring to bachelors only. In some locations where a wife or children cannot be accommodated, single men are preferred for assignment. But consider this startling figure for techni-
and 70 per-cent are married. The author himself tends to
cians stationed at outposts on the DEW Line: between 60
prefer married men when he makes up a team because they seem to deliver more reliability in the field.

Temperament and Outlook

Liking and getting along with other people is important. A man may be stationed with a sizable group of men, but they can be his chief or exclusive contacts for some time. He must fit in. Often they will include military personnel or nationals of other countries. If he looks down on different people as inferior people, he is of no help either to his employer or his government. The State Department is concerned with wise choices for these unofficial ambassadors in many cases. Also, a man who gets along with others is most likely to get along with himself. This capacity comes in handy in some relatively solitary assignments.

Living Conditions

When associated with a military installation, here or abroad, as is often the case, the technician can generally count on substantial living and recreational facilities. For example, food abroad may be quite attractive. The author fondly remembers the Danish cooking, under the supervision of native chefs, in one location. As a rule, facilities for military officers will also be available to technicians abroad, who rate as people of some importance.

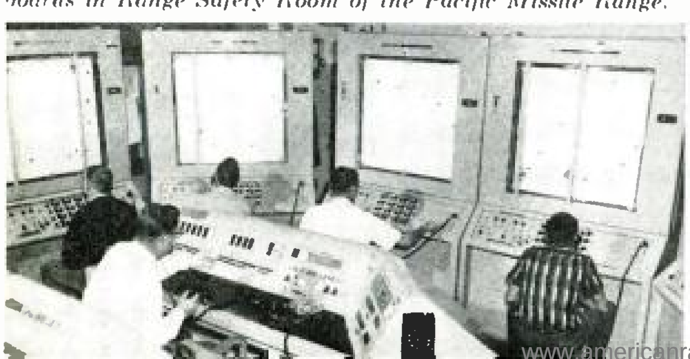
People in foreign lands also attribute considerable prestige to those who are bringing them modern facilities they need. You may find yourself getting an invitation from a local potentate in a far eastern land to join him on a tiger hunt.

However, it isn't always that easy. You may be where you can't simply push a button to turn on the electric light and the nearest movie may be a day's travel. Being able to rely

(Continued on page 58)

(Above) Operation and maintenance of photo optic gear used in missile tracking. Locale is Point Arguello, California.

(Below) Light work: operation of consoles and display boards in Range Safety Room of the Pacific Missile Range.



(Left) The technician's life does not consist exclusively of work. These men, assigned in Nepal, are enjoying a tiger hunt aboard an unusual vehicle. They accepted the invitation of a local VIP.

(Below) Another activity for the earthbound. These technicians are manning a console at a Project Mercury tracking station. Also part of PMR, this installation is at Point Arguello, Calif.

U.H.F. CONVERSIONS ARE PROFITABLE

With activity in the ultra-high band on the way, service technicians may have a billion-dollar potential in installations for older sets.

By LON CANTOR / Blonder-Tongue Laboratories

WITH FINAL enactment of the all-channel TV receiver law, the long-awaited upswing in utilization of u.h.f. TV channels at last seems destined for realization. There are already available 1543 individual u.h.f. assignments, less than 10 per-cent of them in use. This is almost three times the number of v.h.f. channels in operation.

The business potential for service technicians is impressive. There are more than 50 million TV receivers in use today, few of which can receive u.h.f., but they can be adapted to do so, either with tuner strips or top-of-the-set converters. Average cost of a complete job, including antenna, converter, and labor, will be about $40.00. Thus TV technicians can look forward to as much as $2-billion worth of increased business.

With well-circulated accounts concerning the special problems of u.h.f., technicians may tend to expect much more difficulty than will actually be encountered. Thus, before considering what conversion will involve, a glance at the nature of the u.h.f. spectrum is worthwhile.

Comparison with V.H.F.

It includes channels 14 through 83 in the range from 470 to 890 megacycles. As with v.h.f., each channel occupies a 6-mc. band, but these 70 channels run consecutively through their range with no gaps between any two.

The lowest ultra-high frequency used is more than twice that of the highest very-high frequency, 216 mc. Since transmission frequency influences propagation behavior, u.h.f. involves different problems, but not necessarily more of them.

Generally speaking, the higher the frequency, the less will signal tend to follow the curvature of the earth. This tends to limit u.h.f. reception to line-of-sight distances even more than is the case with v.h.f.

This problem can be overcome, to a degree, by increasing the height of transmitting and receiving antennas. The MPATI (Midwest Program on Airborne Television Instruction) provides an interesting application of this principle. Because transmission is from a plane flying at 23,000 feet, telecasts can be received more than 200 miles from Montpelier, Indiana, over which the plane circles in a 12-mile radius.

Another problem is that u.h.f. signals tend to be absorbed readily by hills and buildings. Opponents of u.h.f. have said this would make it impractical for metropolitan and other areas. In cooperation with the City of New York, the FCC has set up an experimental station on channel 31 to evaluate this and other problems. The mammoth "canyon areas" of this city are considered to represent a severe test.

Results so far are encouraging. The median field strength measured at channel 31 was 98 dbu. (0 dbu, or 0 dbmv, is 1000 microvolts or 1 millivolt across 75 ohms.) This compares with 93 dbu for channel 7 and 91 dbu for channel 2. However, these readings were taken outdoors, on roofs. Indoors, the increased "building loss" caused the channel 31 signal to be somewhat weaker: 71 dbu compared with 72 dbu at channel 7 and 73 dbu at channel 2.

This slight difference does not indicate that u.h.f. is significantly inferior with indoor antennas. Indeed, a counterbalancing element is the fact that u.h.f. is less susceptible to man-made interference than v.h.f. There is also evidence that ghosting is less of a practical problem, despite the fact that, theoretically, signals tend to bounce more as frequency goes up. Although the u.h.f. channel bandwidth is still 6 mc., it is a smaller percentage of the transmission frequency than is the case on v.h.f. Why this should help minimize interference and ghosts requires an explanation to which we will not devote space here. Nevertheless, it is important to recognize the practical significance of the phenomenon, especially in metropolitan areas.

There is some evidence that outdoor antennas will be required more frequently than in v.h.f. reception, and they will

Fig. 1. Two compact, easily built, indoor antennas, made of twinlead (A) or wire (B).

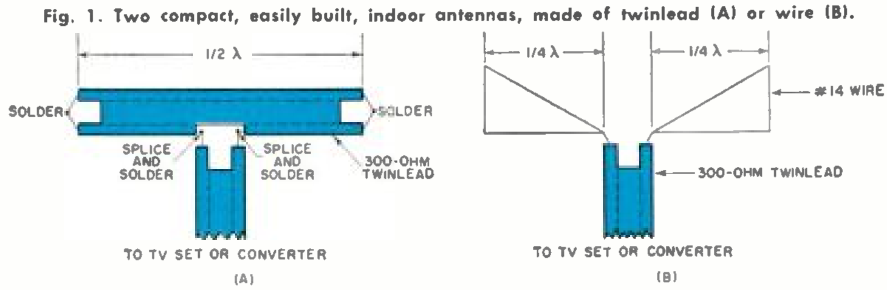
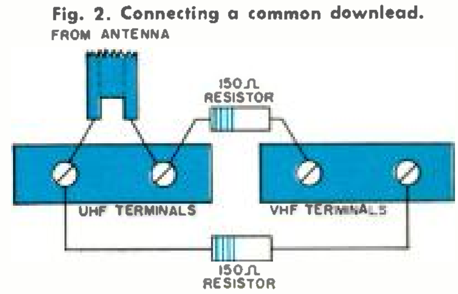


Fig. 2. Connecting a common downlead.



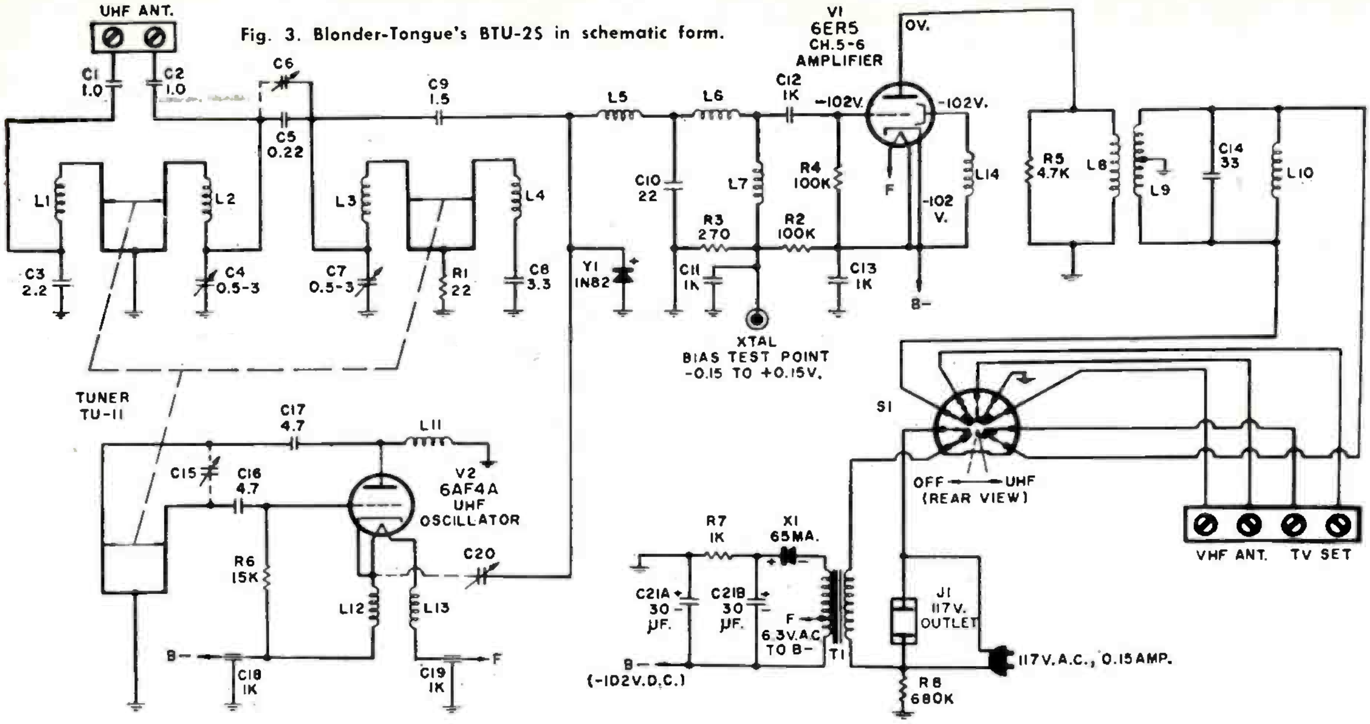


Fig. 3. Blonder-Tongue's BTU-2S in schematic form.

have to be installed with more attention to good practice.

Another point: the thermal noise figure of a TV receiver has great bearing on the amount of signal needed to provide a good picture. Therefore, if a receiver installed in a poor signal position has a poor noise figure, preceding it with a low-noise u.h.f. preamplifier will provide considerable improvement.

Choosing an Antenna

For areas within about 15 miles of the transmitter, an indoor antenna will usually suffice, and one will often work reliably at greater distances. In general, indoor units will work in most but not all areas where indoor v.h.f. antennas are satisfactory. Also, partly because of their smaller size, they do not present the esthetic problems encountered with ungainly rabbit-ear and other v.h.f. types.

If a commercial indoor type is not readily available, it's a simple matter to make one up. Fig. 1A can be put together quickly from 300-ohm twinlead; Fig. 1B is made with #14 wire. Either lends itself to ready concealment behind the set or other furnishings.

To determine the wavelength, in inches, we use the following formula: $\lambda = 3\text{x}10^8/.0254F$, where λ is the wavelength in inches and F is the frequency in cycles. Since the center frequency of channel 31 is 575 mc., a wavelength would be 20.5 inches. The half-wave section in Fig. 1A would then be 10.25 inches and the quarter-wave sections of Fig. 1B, slightly more than 5 inches each. These figures should be reduced about 5% to allow for end effect but, in practice, there will be little difference. Dimensions tend to be uncritical because these devices, rather than being sharply selective with respect to frequency, tend to be broad-band.

In fact, in an area where more than one u.h.f. station is active, and available signal is good, you may prefer to base your calculations on the mean of the u.h.f. spectrum, 650 mc. This would make the half-wave and quarter-wave sections in Fig. 1A and Fig. 1B respectively 8.7 and 4.35 inches long. Efficiency would be reasonable for all u.h.f. channels.

While performance is comparable to that of the familiar v.h.f. rabbit-ears, positioning is far more important. You will find dramatic differences in the reception at one point in a room as compared to another. In fact, while "building loss" usually results in the *average* indoor u.h.f. signal being weaker than the *average* v.h.f. signal, careful positioning of the antenna often produces excellent results where indoor v.h.f. signals are not usable. However, this may require some patient probing.

If you are within about 25 miles from the transmitter and the installation in question already uses an outdoor v.h.f. antenna, another approach is possible. Most v.h.f. types will pick up a certain amount of u.h.f. signal. However, you will have to split the output of the downlead between the regular v.h.f. terminals on the TV receiver and the u.h.f. terminals (if any) or the input of the added converter.

One way of doing this is with the arrangement of Fig. 2, using two 150-ohm resistors. This will introduce some loss to either pair of terminals, with both u.h.f. and v.h.f. signals being delivered to both connections, since the method is not frequency-selective. If the available u.h.f. signal can tolerate the loss better than the v.h.f. signals, the antenna connection can be transferred directly to the v.h.f. terminal strip.

If necessary, a special frequency-selective, u.h.f./v.h.f. coupler can be used to avoid losses. One such, the *Blonder-Tongue* A107, is shown in Fig. 4. Acting as a crossover network, it sends almost all u.h.f. signal to one of its output connections and almost all v.h.f. signal to the other.

As the installation site gets farther from the transmitter, separate outdoor antennas for u.h.f. will have to be used. The common, broad-band, bow-tie types have proved themselves in use. In fringe areas, it may be necessary to stack them. For the most difficult locations, low-noise preamplifiers or boosters, preferably the mast-mounted types, may be necessary. The cost of a good unit is not low, but the user is paying for the difference between acceptable reception and none at all.

Installation Pointers

Mounting a u.h.f. antenna to a mast is no great problem: use the same technique you follow with v.h.f. The small size will make the job easier. Running a satisfactory lead-in, however, can be a problem. Cable losses increase with frequency. At u.h.f., even a relatively short cable that is improperly run can introduce enough loss to cancel out much of the advantage of using an outdoor antenna.

The choice of antenna wire is itself significant. Ordinary flat, 300-ohm twinlead is acceptable only if it is used entirely inside, as with a conventional indoor antenna or an attic

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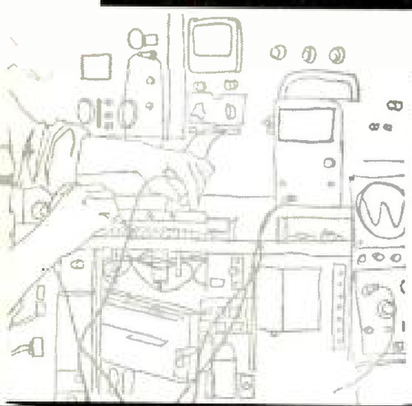

MAC'S ELECTRONICS SERVICE

By JOHN T. FRYE

It's Not the Heat

IT WAS sizzling outside, but the air conditioner kept the service department quite comfortable. That's why Mac knew it couldn't be the effect of the heat when he heard Barney, his assistant, chuckling to himself.

"What's so hilarious?" Mac asked.

"Oh this little heat indicator I brought along to show you reminded me of an experience related by Bruce, the technician with whom I had lunch today. Last winter he had a service call to fix a hi-fi set in a very swanky home. When he discovered the hi-fi unit was about the size of a baby grand piano, he decided to fix it there instead of trying to take it to the shop.

"The room in which the hi-fi was installed had very beautiful and obviously expensive wall-to-wall carpeting; so before he pulled the chassis he spread a newspaper out on the carpet. The woman customer watched anxiously while he took out the chassis and turned it upside down on this newspaper; then, apparently satisfied he knew what he was doing and would be careful, she went to the kitchen and started preparing a meal for guests she was expecting that evening.

"Bruce said he noticed a slight scorched odor while he was running voltage checks on the hi-fi chassis, and he thought to himself the woman must be burning something out in the kitchen. It did not take him too long to locate a shorted capacitor and replace it, but when he turned the chassis over he was horrified to see that the top of the rectifier tube on which the chassis had been resting had slipped off the newspaper and had burned a spot about the size of a half-dollar in the nap of the rug.

"The woman was nearly hysterical when she saw this, and Bruce could just picture himself laying out a large sum to replace the floor covering; however, in desperation, he decided to make a temporary repair. He asked the woman for a pair of tweezers and some *Elmer's Glue*. Then he carefully plucked little bits of wool from the rug in out-of-the-way corners and painstakingly glued them to the burned spot, taking care to match the floral pattern exactly. When he finished, the woman could not find the charred area at all; and she refused to let him call a rug man.

"Now, several months later, the temporary repair is still holding up. Bruce knows because he did not lose the customer and has been back on other calls; but he says the experience certainly taught him to be more careful and made him more eager than ever to take sets to the shop for repair. But every time I think of old Bruce down there on his hands and knees plucking out those little tufts of wool, touching glue to the bottom of each tuft, and then carefully transplanting it in the charred spot—and sweating blood all the time—I get the giggles. The things a poor radio and TV service technician has to go through!"

"Yes, and you might add: 'the imagination and resourcefulness he needs in other fields besides his own!' But where's this 'heat indicator' you were bragging about showing me?"

"Patience. You see it all started when I wanted to know how much a blower would cool off the transmitting tubes in my ham rig. A glass thermometer wouldn't work because I couldn't read the actual glass envelope temperature with it. In fact, with the TVI shields in place, I couldn't even see such a thermometer down inside the final amplifier compartment. That's when my mind turned to thermocouples. Some time back someone gave me a length of #30 iron-constantan (type J) thermocouple wire, and I wondered if I couldn't use this. I had a fuzzy notion all I had to do was twist the ends of the wires together and connect a microammeter across the other ends. The meter would then read the current produced by heat applied to the junction of the two wires."

"It's not that simple?"

"Not by a long shot. I wrote *Minneapolis-Honeywell Company* for help, and they were kind enough to send me several catalogues on thermocouple accessories they make, together with some articles on how thermocouples work. A true thermocouple consists of two dissimilar metal wires connected at *both* ends. The connection at one end is called the 'measuring junction,' and that at the other the 'reference junction.' When these two junctions are at different temperatures, a potential is developed between the conductors that directly relates *to this difference in temperature*. Notice if the measuring junction is in the higher temperature, as is usually the case, the potential developed will go down if the temperature of this junction is lowered *or* the temperature of the reference junction is raised."

"I'd guess, then, the reference junction would have to be held at some certain value to give meaning to the potentials developed by heat applied to the measuring junction."

"And you'd guess right. The reference junction is usually assumed to be at 32° F. In practice it would be a great nuisance to have to keep this junction at the temperature of melting ice; so some means must be used to bring the e.m.f. developed at the reference junction under existing conditions to a value equalling that which would be generated if the junction were maintained at 32° F. Voltage drop across a temperature-sensitive resistor does the trick in most pyrometers. This voltage, added to that actually produced across the reference junction, produces a sum equal to what the reference junction would have produced if it had been at freezing. Am I losing you?"

"I don't think so. As the change in ambient temperature causes the voltage across the reference junction to decrease, the voltage across the temperature-sensitive resistor increases, and *vice versa*. That allows the instrument calibration to be independent of room temperature."

"You're smarter than I thought," Barney admitted grudgingly; "but have you considered we can't just twist the two wires together at the reference junction? Meter terminals, binding posts, etc., will be between the two ends. Fortunately, what we thermoelectricity engineers call the Law of Intermediate Metals takes care of this. The laws says we can introduce all the different metals we want between the two ends of the wires without creating any effect on the e.m.f. generated across those wires *as long as all the junctions of the different metals are at the same temperature*. In that case it is just as though there were only one junction.

"What did you do with all this information, make a thermocouple?"

"On the contrary, I quickly gave that up. For one thing, it's necessary to measure the tiny voltage developed—for remember it's the voltage that is directly related to the temperature—without consuming current. In practice, this is done by bucking out the developed voltage with an adjustable

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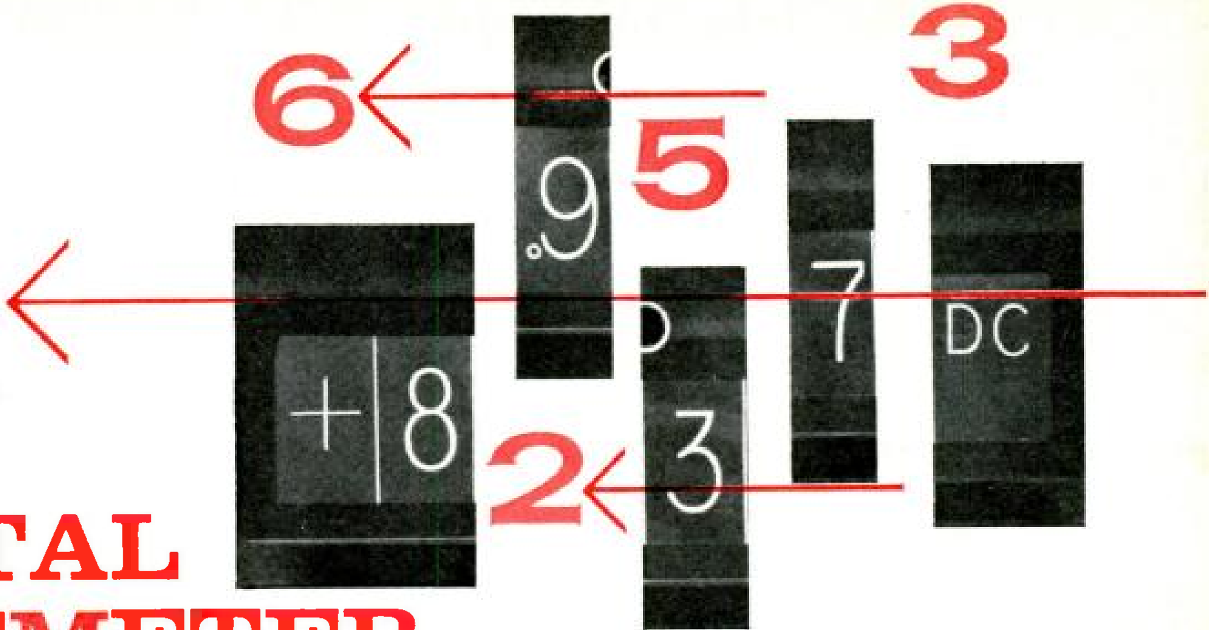


By JOHN R. COLLINS

the DIGITAL VOLTMETER

Faster and easier to read than pointer meters, digital voltmeters have made lab accuracy of up to ±0.01% available for field and production-line measurements.

IN RECENT years, digital voltmeters (Fig. 2) have found increasing use in place of conventional pointer instruments. One very good reason for their popularity is the fact that a voltage can be read faster and more accurately in numerical form than from the position of a pointer on a calibrated scale. In addition, most d.v.m.'s (digital voltmeters) provide accuracy to three or more significant figures; many also select the range and indicate polarity automatically.

By using a d.v.m., a relatively inexperienced operator can make a voltage measurement in a fraction of a second whereas a skilled technician with a precision laboratory potentiometer might take several minutes.

Because of their cost, it is not likely that d.v.m.'s will entirely replace conventional pointer meters. Most are priced over $1000, and many cost in excess of $10,000. Since they have more parts than pointer meters they require more maintenance. For many industrial and military uses, however, d.v.m.'s are almost indispensable. They are especially suited to the rigorous demands of production line testing and quality control, automatic missile checkout, aircraft electrical system testing, and industrial process monitoring. Since the data is obtained in digital form, it is convenient to use automatic recorders and transmission systems.

Several kinds of d.v.m.'s have been developed, based on quite different operating principles. Some of the more familiar circuits will be described.

Voltage Comparison Method

One of the more accurate ways to measure voltage is by means of a potentiometer, in which the unknown voltage is balanced against a known voltage. The method is not unlike the way in which an apothecary's scale is balanced. The item to be weighed is placed in one pan, while known weights are added to the other pan until they are balanced.

The voltage-comparison d.v.m. illustrated in Fig. 1 is the electrical equivalent of an apothecary's scale. The unknown voltage is introduced on one side of the chopper which serves as a voltage comparator. It is opposed by a voltage derived from an internal reference on the other side of the chopper. Although the figure shows a potentiometer pick-off from the reference, the reference voltage is actually impressed across an arrangement of precision resistors. In this way, discrete, calibrated voltages are provided which can be switched into the circuit as needed.

If the input voltage is not the same as the opposing voltage, the difference is chopper-modulated to produce a square-wave error signal. These error pulses are amplified and used to switch voltage into or out of the circuit. The pulses are either "up" or "down," depending on whether the input is greater or less than the opposing voltage, and their direction determines whether voltage is added or subtracted.

The switches are programmed to reach the balance or null position in as few steps as possible. Programming involves a system of binary logic in which large voltages are first applied to find the largest voltage equal to or less than the input. If it is less than the input (as is the usual case), successively smaller voltages are then added until balance is achieved. At the null position, the output of the chopper is zero.

The "on-off" switch arrangement at the balance point determines the read-out. Each possible combination is wired to the read-out assembly in such a way that the corresponding voltage will be displayed in lighted numerals. Special tubes called "Nixies" are often used for the read-out. These contain digits formed from individual wires which glow brilliantly when a voltage is applied to them.

Instruments of this type are sometimes called successive-approximation voltmeters from the way in which balance is achieved. Their accuracy is limited only by the precision of the calibrated voltage units and the resolution, which in well-

Fig. 1. Block diagram of voltage-comparison digital voltmeter.

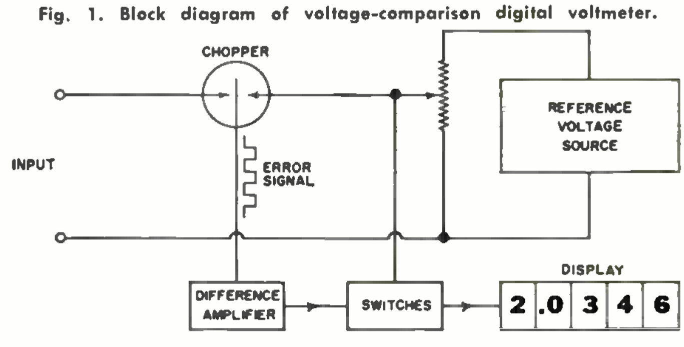


Fig. 2. Dymec Model 2401A is capable of five-place accuracy.

designed instruments are very great. The reference voltage may be supplied either by standard cells or from a source regulated by zener diodes. Attenuators limit the input voltage so that voltages greater than the reference can be measured.

The speed of a voltage-comparison d.v.m. is determined by how fast trial voltages are switched into the circuit and by the number of steps needed to reach the null position. Several switching devices are in general use. These include unidirectional rotary switches, called stepping switches, which are driven by an electromagnet. They advance one step each time the electromagnetic coil is energized by an amplifier error pulse.

Other d.v.m.'s use fast-switching contact relays, called mercury-wetted switches, in which electrical contact is made through a pool of mercury. They are extremely reliable and trouble-free.

All-electronic d.v.m.'s utilize semiconductors for switching and are especially fast. Some fully transistorized models are able to make a voltage measurement in 2 milliseconds and as many as 100 independent measurements per second.

Accuracy of 0.01% is not uncommon for a voltage-comparison type d.v.m.

Integrating D.V.M.'s

A different approach to the problem is shown in Fig. 3. This integrating d.v.m. has two sections—a voltage-to-frequency converter and a counter. The first section incorporates an operational amplifier with feedback capacitor which is designed to integrate the voltage applied to the input over a selected time interval. It is characteristic of an integrating amplifier that if the input voltage remains essentially constant, the output voltage will increase from approximately zero to a value that depends both on the size of the input voltage and the duration of the integration. The relationship between the input and output voltages is illustrated in Fig. 4. It is obvious that a larger input voltage will cause the output to rise more steeply.

The amplifier output connects to both a positive- and a negative-level detector which feed into separate pulse generators. This arrangement makes it possible to accommodate inputs of either polarity.

When a signal appears at the input, the amplifier produces a saw-tooth output, whose slope depends on the magnitude of the input voltage. This output pulse will be either positive-going or negative-going, depending on the polarity of the input. When the saw-tooth voltage reaches a predetermined trigger level, either positive or negative, the corresponding pulse generator is activated and produces a pulse which is fed back to the input.

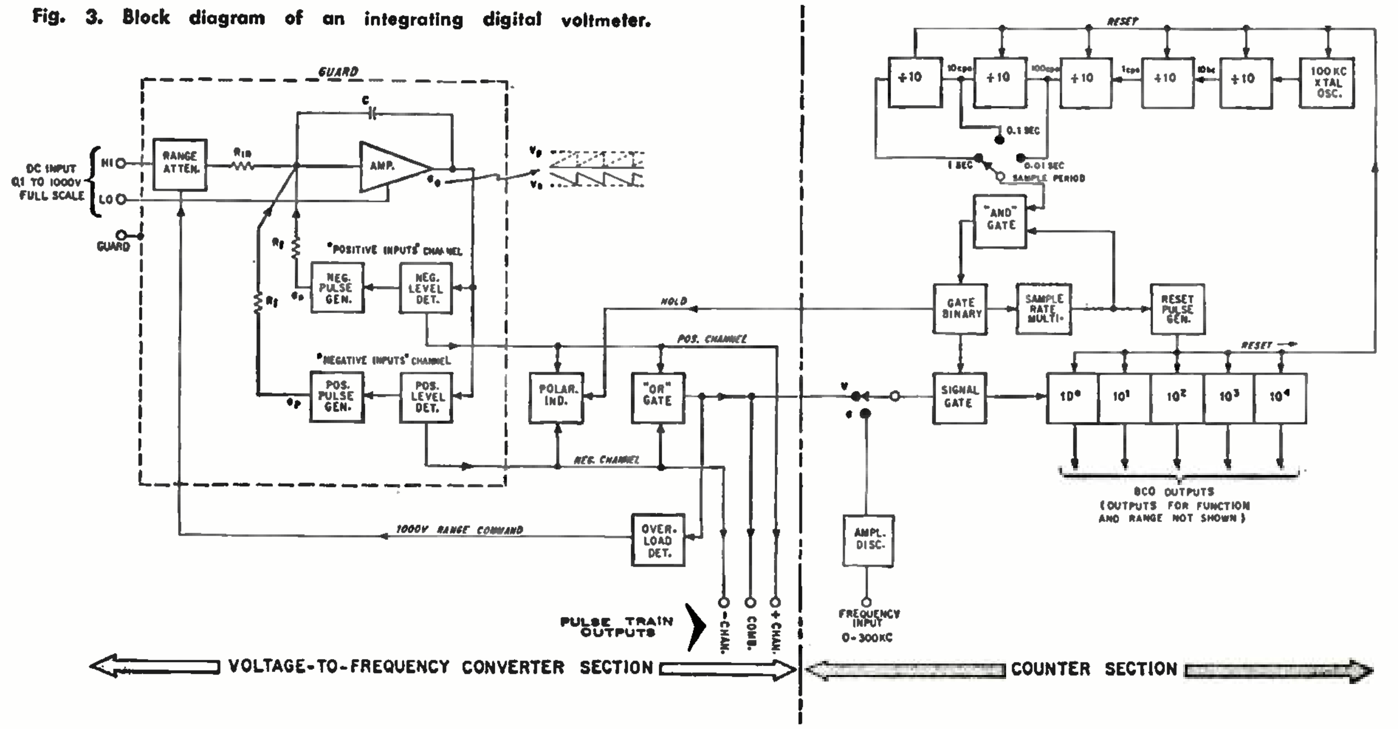
The polarity of the feedback pulse is opposite to that of the input signal and it causes the amplifier output to be abruptly forced back from the trigger level. As the input signal continues to be applied, however, the amplifier output again rises until it has reached the trigger level, and the process is repeated.

It is obvious that a large input voltage will cause the output to reach the trigger level faster than a smaller input voltage. The number of times a level detector is triggered in a given interval is thus an accurate indication of the size of the input voltage.

The function of the counter is to count the number of times a level detector is triggered during a preselected time interval. In a typical instrument, the measurment period is 0.1 second. An input of 1 volt will produce output pulses at a rate of 100,000 per second, or a total of 10,000 pulses during the 0.1-second interval. This would appear at the read-out, with decimal point properly placed, as +1.0000.

In operation, each time a level detector is triggered, a pulse passes through the *or* gate to the counter. The polarity of the input voltage is determined by sensing whether the pulse

Fig. 3. Block diagram of an integrating digital voltmeter.



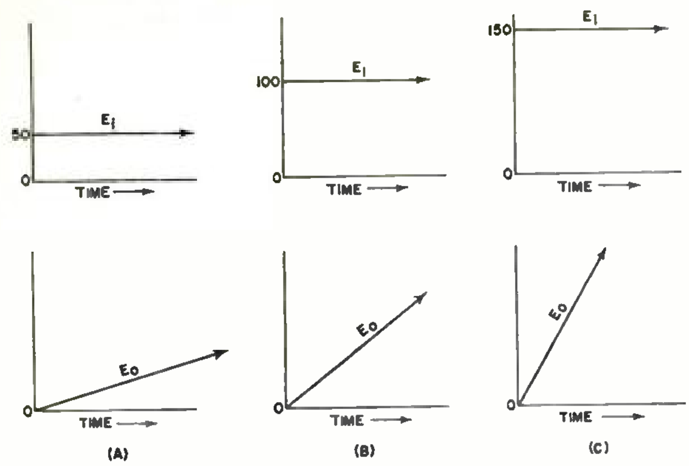


Fig. 4. Relationship of E_O to E_I of integrating amplifier. Rate of change of output is proportional to input magnitude.

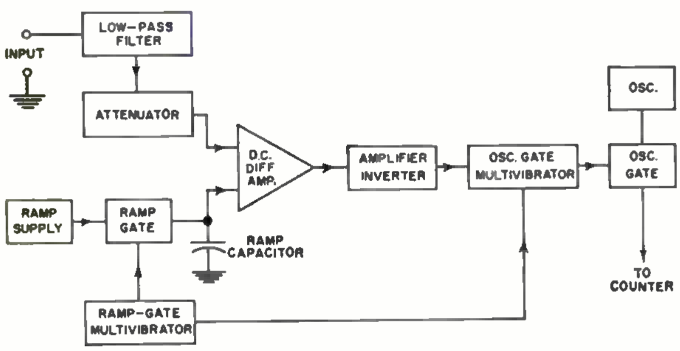


Fig. 5. Block diagram showing the essential functional elements of a voltage-to-time, or ramp-type digital voltmeter.

came from the positive- or the negative-level detector. While it is true that the counter shows the number of pulses rather than the input voltage, the instrument is so designed that the count will be the same as the voltage, as described above. This is done by controlling the height and duration of the opposing pulses produced by the pulse generators. In this way, for example, an input voltage of 299.79 millivolts will produce 29,979 counts over the selected time interval (Fig. 2). The decimal point is placed automatically.

The instrument shown in Figs. 2 and 3 has an overload detector and automatic range changer. Overload is indicated when a pulse rate in excess of 300 kc. is detected. The input attenuator is then automatically set at the 1000-volt range.

Voltage ranges as low as 0.1 volt can be selected at fixed sampling periods of 0.01, 0.1, or 1 second. The voltage reading thus obtained corresponds to the average value of the input voltage over the specific time interval. This method of averaging effectively cancels superimposed noise and a.c. hum pickup.

Ramp D.V.M.'s

A somewhat similar d.v.m. is the ramp type; its operation is based on voltage-to-time conversion. Essentially, this instrument measures the time required for an internally generated voltage (ramp) to build up on a capacitor from zero to the value the input voltage has after passing through an input filter and attenuator.

The principal features of the ramp d.v.m. are shown in Fig. 5. After being filtered and attenuated, the input voltage reaches the input of a d.c. differential amplifier. Measurement starts when the ramp-gate multivibrator opens the ramp gate and, at the same instant, triggers the oscillator gate multivibrator. The oscillator gate multivibrator opens the oscillator gate, and the counter begins totalizing the output of the oscillator.

With the ramp gate open, the ramp supply voltage (usually 150 volts) starts charging the ramp capacitor through a series resistor. The values of the resistor and the ramp capacitor are selected to produce a wedge-shaped voltage that increases with time.

The differential amplifier has two input grids to accommodate both the input and the ramp voltage. Its output is limited until the ramp voltage equals and then becomes greater than the attenuated input voltage, at which instant it produces a distinct voltage step. This voltage step is further amplified and inverted to provide a negative-going pulse to the oscillator gate multivibrator. This causes the multivibrator to close the oscillator gate, and the measurement is ended. In a typical instrument, an oscillator frequency of 50 kc. is used, and about 0.2 second is needed to make a single measurement.

As in the case of the integrating d.v.m. previously described, the read-out of the counter is an accurate reflection of the input voltage. The relationship between the input voltage and the number of counts is arranged by choosing the proper resistor and capacitor values for the ramp voltage circuit and the oscillator frequency.

The low-pass filter removes any a.c. superimposed on the d.c. input voltage. The attenuator is made up of four series resistors which provide 1:1, 10:1, 100:1 and 1000:1 attenuation. A stepping switch which can be controlled either manually or automatically selects the proper attenuation. When on automatic, the instrument, which has a 3-digit read-out, checks the range by monitoring the output of the tens and hundreds counters. If there is no output from the tens counter, the range is too high, since the ramp voltage equals the attenuated input voltage before 100 counts have been registered. If there is an output from the hundreds counter, the range is too low, since the upper limit of the counter has been exceeded before the ramp voltage has reached the level of the attenuated input voltage. Thus, the range is correct only when there is an output from the tens counter and none from the hundreds counter.

Fig. 6. A typical ratiometer. It indicates the ratio of the test voltage A to internally generated reference voltage B.

Special Problems

While noise is a universal problem in voltage measurement, it is especially troublesome in the case of digital instruments. Pointer voltmeters with conventional d'Arsonval movements have a certain amount of inertia which makes them relatively insensitive to noise, transients, and hum pickup. Digital voltmeters, being electronic, have no inertia and therefore tend to reflect the instantaneous voltage at the moment the measurement is made. While this may be an advantage in some respects, it is usually true that the instantaneous value is not the best reflection of the operating condition. It was noted above that an integrating voltmeter

(*Continued on page* 82)

Relay Electronics

By RUSSELL D. SHATTUCK

The variety of useful "circuits" you can design with relays is endless. The many shown here only scratch the surface.

AS A RULE, the electronics technician or the experimenter doesn't expect a relay to be anything more than an electrically operated switch. Most users never get beyond this basic application because they don't give the component credit for much sense. Actually a relay can be the active element in practically any circuit a tube or transistor can handle. The former can't compete when it comes to response, being confined to operation at rather low frequencies, but very fast rise times can be achieved.

A number of circuits built around these mundane devices are shown here. In each, the *Potter & Brumfield* RS5D relay with 10,000-ohm winding has been employed. This is a basic s.p.d.t. type. With suitable changes, practically any other relay could be substituted. To accommodate different needs, there is a wide variety of current- and voltage-sensitive types of different sensitivities available.

The basic feature important to each illustrated application is that the device actuates on a certain pull-in current or voltage and releases at a certain drop-out current or voltage. Drop-out value is ordinarily about one-third of pull-in value.

There are two common uses of a relay that are widely known. One is the control of a large amount of power by a small amount of power. The other is remote operation of a circuit either for isolation or convenience. The circuit of Fig. 1 illustrates both of these functions. Manual closing of the switch in the low-voltage supply to the relay causes the latter to pull in, applying the higher voltage to load R_L. The latter may be some distance from the relay switch.

Note that the input voltage and current to the relay are considerably lower than the voltage and current (to the load) being controlled. This is analogous to a conventional tube circuit in which a small input voltage produces a much greater output at the plate. Fig. 1 may thus be considered an amplifier. In this case, voltage gain is 4.6, current gain 800, and power gain 3680.

Measuring with Relays

The common denominator of the four configurations in Fig. 3 is that they all belong to the general class of voltmeters, despite application differences. The general circuit (Fig. 3A) relies on the repeatability of the pull-in current or voltage of the relay. The unknown voltage is connected with *R* set at its maximum value. *R* is then reduced until the relay closes and operates the indicator (light, bell, or other). A dial on the potentiometer shaft can be calibrated in volts.

The switch is an added convenience for opening the relay without having to disconnect test leads or change the setting of *R* to reduce the test voltage. With the relay mentioned earlier and the value shown for the potentiometer, the useful measuring range would be from about 25 to 250 volts. By choosing a relay with different characteristics and a pot of another value, either or both ends of the usable range could be shifted in either direction. Battery voltage and the indicator are simply chosen to suit each other.

The precision voltmeter (Fig. 3B) depends on the fact that a VR tube (a zener diode may be used instead) does not conduct until a certain, critical voltage is applied across its terminals. Then it conducts with a fixed voltage drop. Control *R* is used to set the range of measurement.

With a VR105 tube, the latter will fire with about 118 volts across it but won't conduct enough current to operate the relay. After firing, the voltage drop across the tube goes to 105 volts and remains there. If *R* is set to zero resistance and the unknown voltage is at least 105 volts plus the value needed to pull in the relay (totalling 140 volts with the relay specified), the latter closes, operating the indicator. If *R* is set to equal the relay's resistance, indication will begin at 155 volts.

Precision results because an accurately known, fixed voltage is subtracted from the unknown voltage before measurement is made. With the reading range thus limited, close calibration is possible (*i.e.*, a relatively narrow range of voltage variation is spread out over the rotation of the potentiometer dial). The larger the fixed voltage subtracted in relation to the total voltage applied, the more accurate is the final measurement. The principle is the same one used in conventional suppressed-zero, expanded-scale voltmeters designed

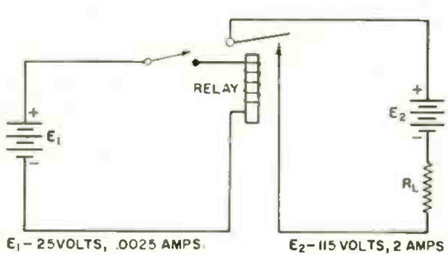


Fig. 1. The relay used as an "amplifier."

Fig. 2. A light flasher—which is really a simple, low-frequency, pulse generator.

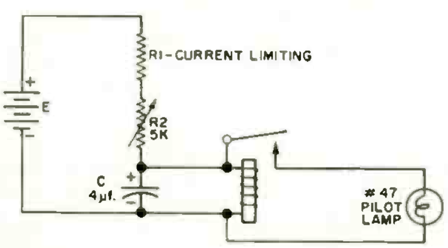
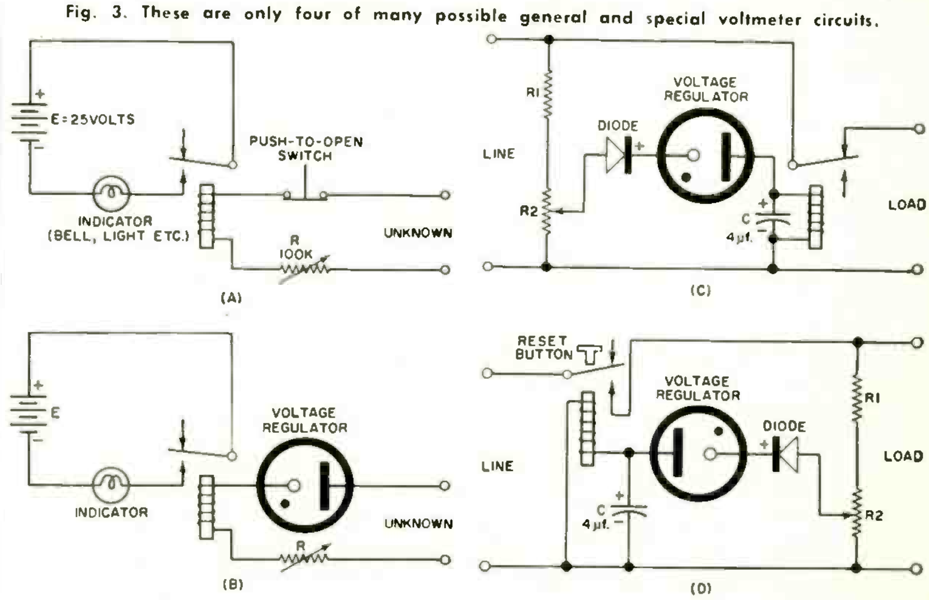


Fig. 3. These are only four of many possible general and special voltmeter circuits.



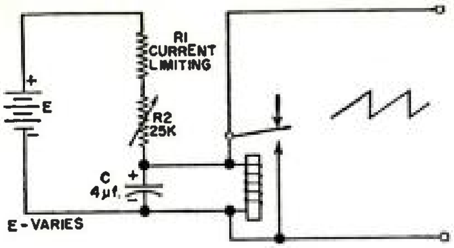


Fig. 4. Generating a saw-tooth output.

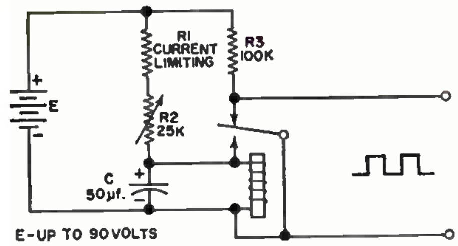


Fig. 5. Perhaps you prefer square waves.

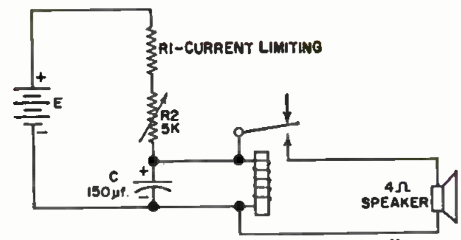


Fig. 6. The metronome. It is actually a special case of the timer or counter.

to be highly accurate over a limited range of interest—a category in which the circuit of Fig. 3B may be included.

The arrangement is obviously useless at levels lower than the sum of the voltage drops across the VR tube or other regulating element, the relay, and any fixed series resistance. The lower limit can be changed by choosing relays of various sensitivity and VR tubes or zener diodes of appropriate characteristics. The upper voltage limit can be shifted by changing the value of R.

Circuit Protection

The over-voltage relay (Fig. 3C) is also, in effect, a voltmeter, but its application is different. The purpose is to disconnect a load from a power source if the applied voltage becomes too high. The relay contacts are thus used to accomplish this at the desired level instead of operating an indicator. The added diode and capacitor are necessary only if the unit is to be operated on a.c. With a d.c. supply, however, the diode would also be useful in blocking voltage if the applied polarity is incorrect. The VR tube or zener diode is optional, depending on the specific case.

Part of the source voltage is tapped off through R_1 and R_2 and applied to the relay. R_2 sets the pull-in voltage at the desired level. When it is reached, the contacts open to disconnect the load, which remains disconnected as long as line voltage remains too high. Use of the regulating element, as described in the preceding circuit, reduces the range over which the relay operates and thus improves accuracy. It also provides another advantage. Without it, line voltage would have to be reduced to about one third its normal value to drop out the relay and re-connect the load. With it, drop-out can be made to occur in the normal voltage range. A re-set switch would, of course, accomplish a similar purpose.

The values of R_1 and R_2 are chosen to provide the desired adjustment range. Capacitor C permits control of the time response of the circuit, even from a d.c. supply. A larger value prevents pulses or short transients from triggering the relay. A smaller value permits more rapid response to changes. Excessive reduction, however, will cause the relay to chatter if the circuit is used on a.c.

The under-voltage relay (Fig. 3D) is similar in operation but different in function. Certain devices, like some motors, can be damaged when supplied with insufficient voltage. They draw more current from the source and overheat.

Line voltage in this circuit is connected to the load as long as the relay remains pulled in, but power is removed at drop-out. In the preceding circuit, the contacts are wired to produce the opposite effect. To establish the drop-out point, the re-set button is depressed (or the armature is pushed in) with the line voltage kept low. The latter is then increased until the voltage across the load is at least the required minimum. R_2 is adjusted so that the relay will be held by this load voltage. Relay voltage is then reduced by careful re-adjustment of R_2 to the point where any further reduction would release relay contacts. As for the functions and values of components shown, the same considerations apply that were discussed in connection with the over-voltage relay.

Generating Pulses

The light flasher of Fig. 2 operates by charging capacitor C through its series resistance until the pull-in voltage of the relay is reached. On closing, the relay applies voltage to the bulb, lighting it, and also permits the capacitor to discharge through it to open the relay. This cycle repeats itself. The flash frequency depends on the time-constant of the circuit, which is established by the values of E, R_1, R_2, C, and the characteristics of the relay.

The value of R_1, which is important, is selected so that, even when R_2 is set to minimum position, maximum voltage and current applied to the bulb will not exceed its ratings. It saves lamps when some enthusiast tries to speed up the flashing rate too much. Addition of a rectifier diode and experimentation with component values would enable operation with larger bulbs from an a.c. source.

The sweep or saw-tooth generator (Fig. 4) differs from the light flasher mainly in the way output is taken from the capacitor. This output may be used to provide low-frequency sweep on an oscilloscope, with application to the horizontal plates of the CR tube feasible. Here the current-limiting resistor is used to prevent short-circuiting the power supply, which would occur at the same time the capacitor is shorted by closing of the relay contacts, if R_2 is set to zero.

Values shown, used with a relay like the one specified earlier, would produce a sweep-frequency range between about 1 and 20 cps, extending the usable range of the average scope downward for special applications. E need simply be greater than the triggering voltage required, and its level will determine the value of R_1. Sweep linearity could be improved considerably by doubling the value of C, but the range of operating frequencies would also be lowered.

This circuit has another use with an oscilloscope. Since the amplitude of the saw-tooth pulse is always the firing voltage of the relay, it could be used as a scope calibrator that would not be affected by variations in the supply voltage.

With another resistor and a slight change in wiring of the relay contacts, we have the low-frequency, square-wave generator of Fig. 5. Amplitude of the output is nearly that of the battery voltage, with the relay armature alternately sampling the battery voltage and shorting the output. R_3 prevents a short across the battery when the positive electrode is sampled and also helps to equalize pulse width of the positive and negative half-cycles. Trimming of values can adjust such inequality. If you want to lock in the output on your scope, you can take off a sync signal from across capacitor C.

A Timing Circuit

The metronome of Fig. 6 goes back to the basic light flasher (*Continued on page* 72)

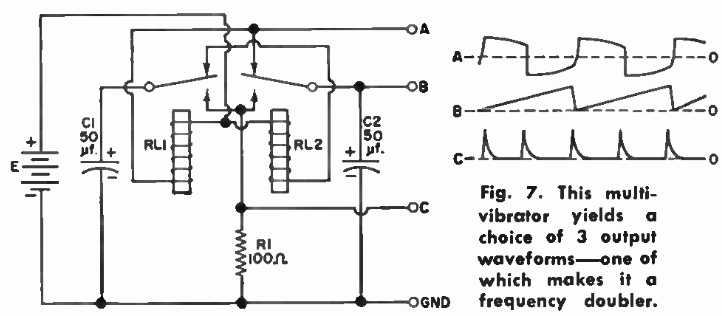


Fig. 7. This multivibrator yields a choice of 3 output waveforms—one of which makes it a frequency doubler.

8 TUBE TV DESIGN

Muntz' new 19-inch set—compact, low-cost, and light-weight—is aimed at the urban market. Compactrons and other innovations make the streamlined design practical.

IT HAPPENS every few years. TV set makers get the notion that a cut in selling price—which means a corresponding cut in the contents—is just what the industry needs.

When this philosophy has taken over in the past, it has brought trouble with it. "Stripped" sets, with much of the performance and reliability ripped out, have left owners and technicians with a collective headache and a bad taste that lingered long after the manufacturers decided to reverse their position. We seem on the verge of another cost-cutting round today, but there is an encouraging variation on the old theme. Design standards, far from being tossed aside, are the starting point.

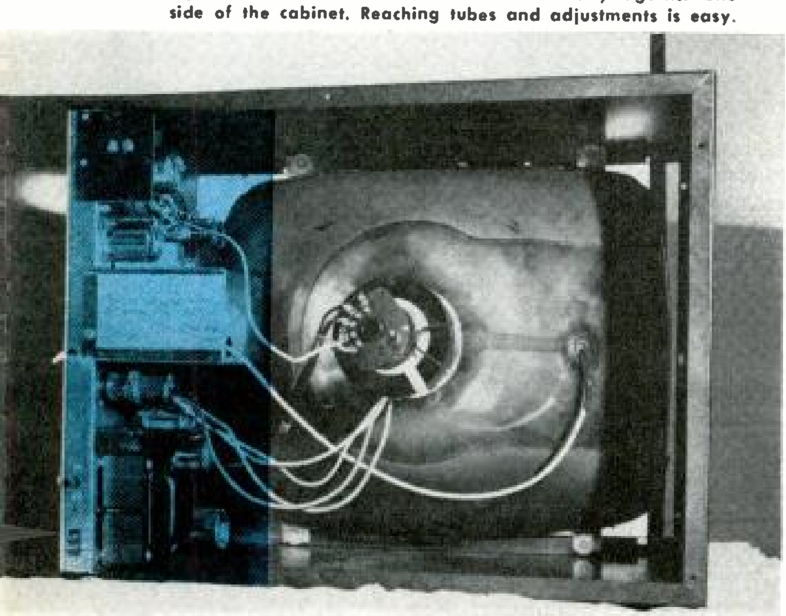
In our July 1962 issue ("New Motorola TV Design," p. 36), we examined a large-screen set in which an attempt had been made to retain deluxe features while lowering the price. Design objectives in the *Muntz* "Metropolitan" are different, but also sensible. Similar techniques are sometimes used. Streamlined circuitry as well as new tube designs both play their part.

The manufacturer of the "Metropolitan," or the "Met," takes pride in the fact that the circuit uses only eight tubes. Actually, he is stretching things a little, but not much. He is overlooking a couple of tubes in the tuner. On the other hand, he includes the CRT in his tally. But that matters little. The immediate question, give or take a tube, is "What can you do with that approximate number?"

Well, what did the designers *try* to do? Their intention in this 19-inch receiver is frankly stated. The name tells a good part of the story. The set is not being pushed with fringe viewers far out from transmitting sites. But why should urban TV fans, surrounded with good signal, have to pay for, say, sensitivity they do not need? The intended customer is this city dweller. The receiver is made to retail for under $100. And *Muntz* hopes to capture a sizable portion of the second-set market.

The drastic reduction in the tube complement is made possible, to a large extent, by the generous use of compactrons, multi-function tubes pioneered by *General Electric*. In fact, no less than six of them are used in the "Met" chassis. Thus the number of tube functions or stages is not slashed as drastically as would first appear. The cut has been helped by substituting semiconductors for tubes just about anywhere function will permit.

Fig. 1. The smallish chassis stands vertically against one side of the cabinet. Reaching tubes and adjustments is easy.



What About Performance?

The reader may wonder what he can expect from this circuit in actual use. The most important question will doubtless involve sensitivity, especially in a TV receiver that uses a single video i.f. stage. The manufacturer has chosen to render this characteristic in terms that will be understood by any layman rather than in absolute quantities. He states that field tests demonstrate satisfactory reception within a 50-mile radius of the transmitter with standard outdoor antennas, such as the single, in-line type. Indoor antennas of the common rabbit-ear type provide adequate performance for most locations within 30 miles of the transmitter.

The Circuit

The power supply (upper left in Fig. 3) includes an isolation transformer with a 6-volt filament winding, followed by a single, half-wave semiconductor rectifier, whose filtered output is 145 volts.

The two-tube tuner, not shown, is the "Silver-Sealed" switch type manufactured by *Sarkes Tarzian*, using shadow-grid tubes. The r.f. amplifier is a 6FS5, with a 6FG7 serving as oscillator and mixer. An interesting feature of this front end is the fact that switch contacts are completely sealed. This enhances reliability by keeping dust out and minimizing oxidation of contacts.

Tuner output is capacitively coupled to the single-stage i.f. strip, which uses one half of a dual-pentode compactron, the 6J11 (V_2). Output of the double-tuned stage feeds a

1N64 diode detector for video that is quite conventional, employing series and shunt peaking and incorporating a tweet filter.

The a.g.c. voltage is derived from the detector load, as is often the case, but its development and application are not entirely conventional. This voltage is stabilized by an assist from voltage developed at the grid of the sync separator (V_{4A}), applied to the a.g.c. loop through R_{15}. Finally, a.g.c. is applied only to the r.f. amplifier in the front end.

Detected video then proceeds to the remaining pentode section of V_2, which serves as the video amplifier. Here we encounter a problem that can be anticipated easily. With the low level of "B+" available from the cost-saving power supply used, it is difficult to obtain enough signal amplitude at the output of the video amplifier to drive a conventional CRT.

The solution is reminiscent of the one employed in the *Motorola* design, described in our July issue. The electron gun of the 19P4 picture tube, a new design, is of the type employing a low cut-off voltage—approximately 25 volts. Video signal is applied to its cathode, to which the brightness control, R_{26}, is also connected. The grid, pin 2, is connected to the vertical retrace-blanking network at point *A* in the vertical-output stage, V_3. The first anode, pin 10, is operated at about 27 volts, which is obtained from the voltage source of the V_3 screen grid. Required focus voltage is near zero. Thus the best connection for pin 6 may be chassis ground. If sharper focus is sought, connection of the electrode to pin 2 or 10 may be tried.

The 19P4 also reverses the trend toward wide-angle picture tubes. It is a 92-degree type with a short neck. With requirements for deflection sensitivity thus reduced, less is demanded of the vertical- and horizontal-output systems. This fact, plus the use of new power-output tube types that can handle relatively high current, helps solve the problem of obtaining adequate operation with the low "B+" available. Picture tubes of this general design seem to be in for

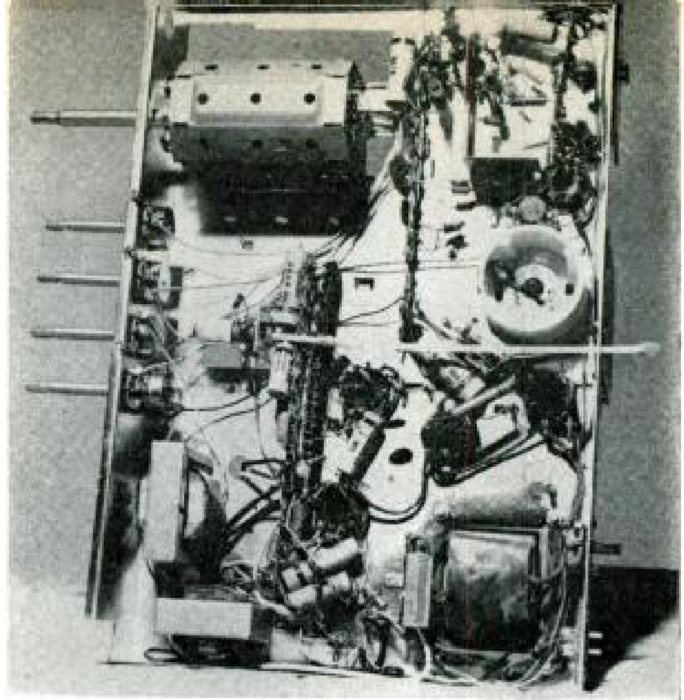


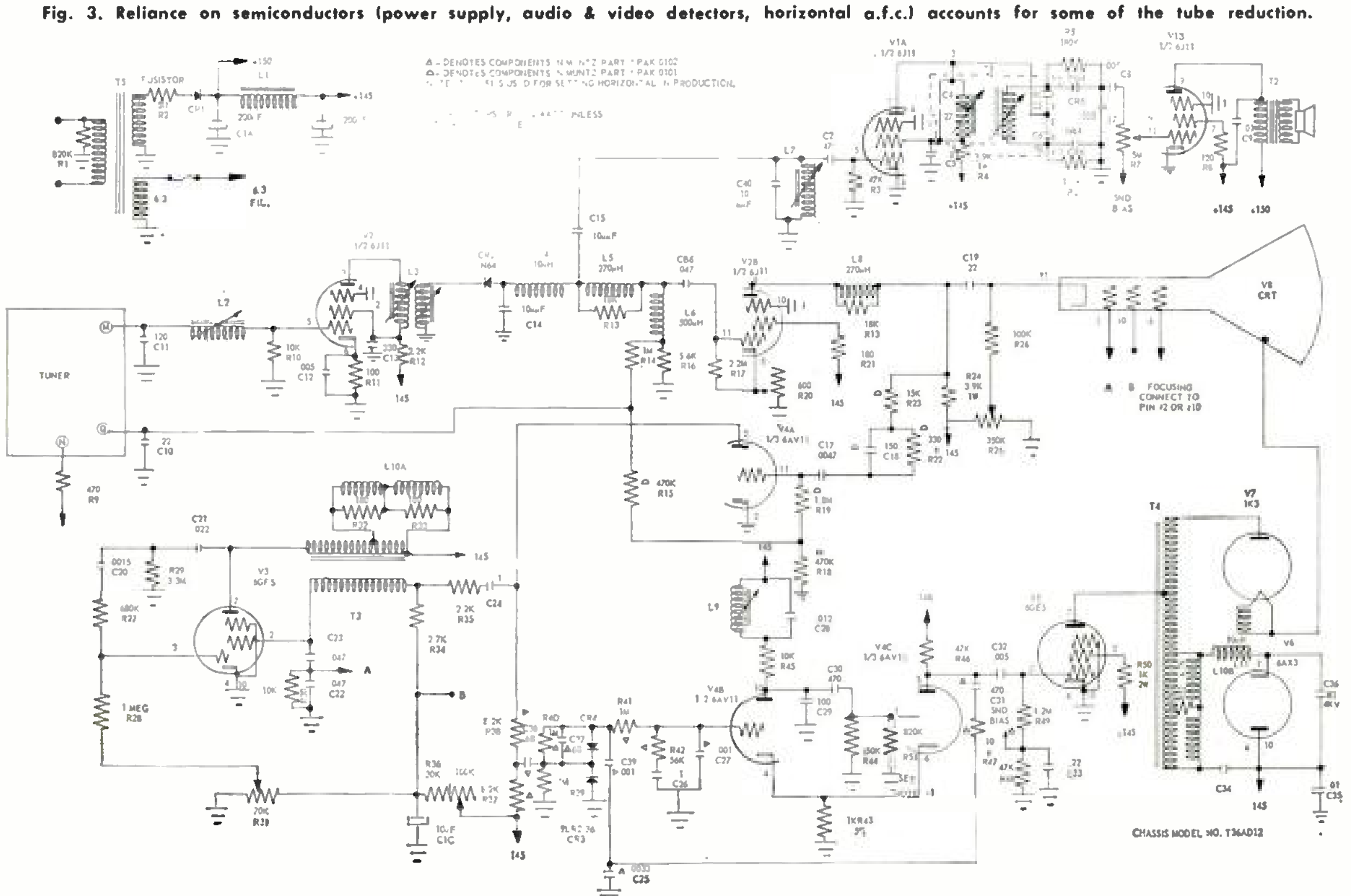
Fig. 2. Despite its size, the chassis allows plenty of access to reach parts and make repairs, as the underside view shows.

increased use in step with interest now developing in power supplies using a half-wave rectifier with no voltage step-up.

Returning to the video detector, we find another output applied to the sound i.f. stage, V_{1A}, through C_{15}. V_1, another 6J11 twin pentode, comprises the entire tube complement for the audio section, just as V_2 does for the video section. In part, this reduction is obtained by using semiconductors for the second detector. The Foster-Seeley discriminator used involves CR_5 and CR_6. Output of the circuit is then applied to the second pentode of V_1, which serves as the sound-output stage, through the volume control. Another interesting short-

(*Continued on page* 90)

Fig. 3. Reliance on semiconductors (power supply, audio & video detectors, horizontal a.f.c.) accounts for some of the tube reduction.



LOUDSPEAKER INTERCOM SYSTEMS

By RAY A. SHIVER

Principles of operation and features provided by this widely used method of voice communication for the home and industry.

LOUDSPEAKER intercom systems are used extensively in home and industry for rapid, effective voice communication. They vary in size and complexity from the simple two-station system with one master and one remote unit up to the large multiple master and remote systems such as would be found in a complex industrial installation.

The principle of operation is the same for all types of systems, whether they be simple or complex. Basically, the voice is used to actuate a microphone or a PM speaker, the output of which is amplified by an audio amplifier which, in turn, operates a loudspeaker at some remote point. In order to be an intercommunicating system, some means must be provided for a return signal to permit a two-way exchange of information. This is generally accomplished by switching the amplifier input and output to provide both an incoming and an outgoing signal. In this manner one amplifier can be used and each speaker can be employed alternately as a microphone for the outgoing signal and as a loudspeaker for the incoming signal. Most systems use this switching principle (a few special cases will be covered in a later section) in some form and it can be very simple or complex, depending on the special features desired.

Simple Two-Station Unit

Fig. 1 illustrates the operation of a simple two-station system consisting of one master and one remote (or "slave") station. The audio amplifier can actually be any type of amplifier capable of driving the loudspeakers to the desired listening level. Amplifiers employing vacuum tubes and transistors are commonly used.

The circuitry is generally designed to limit the operation range to the voice frequencies (about 300 to 5000 cps) which permits the use of compact components. Often a.c.-d.c. circuitry is employed in the lower powered units which permits a further reduction in size by eliminating a power transformer. For ordinary home or office use a fraction of a watt of output power will usually suffice. An industrial plant with a high noise level may require a unit with several watts of output power and special loudspeakers to insure effective intercommunication.

Referring to the circuit of Fig. 1A, S_1 is the talk-listen switch and is shown in the "listen" position which permits the local loudspeaker LS_1 to receive the incoming signal from the remote speaker LS_2. The local speaker is connected to the amplifier output by means of switch contacts 1A and 2A. The remote speaker, which in this case is being used as a microphone, is connected to the amplifier input by means of switch contacts 1B and 2B.

In Fig. 1B, the situation is just the reverse. Switch contacts 1A and 3A connect the amplifier output to the remote speaker for the outgoing signal and contacts 1B and 3B connect the local speaker to the amplifier input thereby permitting it to be used as the microphone. The talk-listen switch is normally spring-loaded in the "talk" position so that it automatically returns to the "listen" position when finger pressure is removed from the knob.

The impedance of loudspeakers used for intercom systems is generally 45 ohms. This permits longer wire runs between stations with a minimum signal loss due to wire resistance, as would be the case with a 4- or 8-ohm speaker. It also permits several remote stations to be paralleled without dropping the total impedance to a value which would create a serious mismatch to the amplifier output.

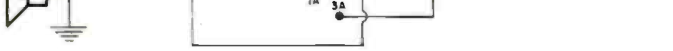
However, when the speaker is being used as a microphone, some means must be devised to step up the impedance to a value suitable for the high input impedance of vacuum-tube amplifiers. This is accomplished by adding a microphone-to-grid transformer at the input of the amplifier. It should be well shielded with a high permeability material to prevent magnetic coupling with other components on the chassis, especially power transformers where they are used.

Systems with Privacy Features

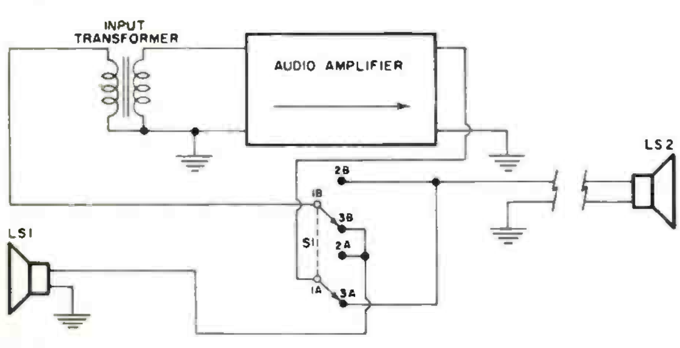
The system described thus far is "non-private," that is, the person operating the master unit can listen in to the remote station at will. Obviously, this is not always desirable, especially in schools and commercial applications. In order to prevent this, some modification must be made to our simple system.

Fig. 2 shows how this can be accomplished. Note that the remote station now requires three wires instead of two. The dotted lines between switch contacts 2B and the remote speaker line show the modification necessary for private operation. With this connection removed there is no longer an electrical path between the remote station and the amplifier input when the talk-listen switch is in the "listen" position. Note, however, that when the switch is in the "talk" position, the unit will function normally. All that remains to complete the private system is to provide a means for the remote station to answer a call. This is done with a privacy switch at the remote unit and a third wire which bypasses the talk-listen switch at the master unit and connects directly to the input

Fig. 1 Simple 2-station system during (A) "listen" and (B) "talk."



(A)



(B)

of the amplifier that is utilized in the intercom system.

As can be seen from the diagram, the privacy switch disconnects the remote speaker from the normal station line and connects it to the privacy line when returning a call. This switch is generally spring-loaded like the talk-listen switch in the master unit. In this manner privacy has been gained for the remote station, but not without cost.

The disadvantage of a private system is that the operation at the remote unit is no longer "hands free" but requires manual operation of a switch in order to return a call from the master unit. This could be a serious disadvantage if the remote speaker were located, for example, at a loading dock which would require a worker to leave his job and perhaps

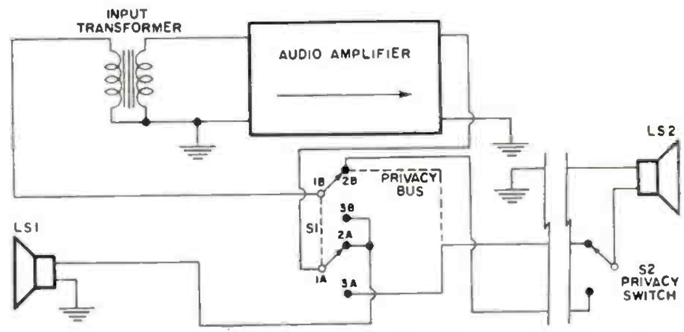


Fig. 2. For privacy feature a three-wire interconnection is used.

walk a considerable distance in order to answer a call. For this reason, this type of operation is usually confined to desk-top installations.

Balanced & Unbalanced Line Systems

It may have been noticed in the systems we have described thus far that one side of the input and output transformers is returned to ground, providing a common path between the two. This is an unbalanced system and is quite extensively used in master units for systems where only one master station and one or more remotes are used. This type of circuitry simplifies construction since only half the switching needed for balanced-line operation is required. However, this system does not exhibit the noise-concealing properties of a balanced-line system and for this reason shielded lines are generally required if extraneous noise pickup and hum are to be kept to a minimum. This is especially important with units utilizing the privacy feature since the privacy line is unterminated and makes an effective antenna if not well shielded. Multiple master operation is not recommended for this type of system because of its inherent high level of crosstalk.

Balanced-line construction is generally employed in systems where two or more master units are used and they are required to communicate with each other. Wiring for such systems usually consists of multiple conductor twisted-pair cable that requires no shielding. Since there is no common connection between input and output circuits of the amplifiers in such a system, crosstalk is greatly reduced or eliminated entirely.

Call-In Systems

The addition of the privacy feature to the system of Fig. 2 really accomplishes a two-fold purpose. In addition to maintaining privacy, switch S_2 in the remote unit may also be used to initiate a call to the master station. This is not possible in the system of Fig. 1 unless the remote station were monitored continuously which, ordinarily, is not desirable.

This type of call-in system is known as "voice call-in" and is quite commonly used in unbalanced-line systems. It should be pointed out that if the non-private connection is left in the circuit between switch contacts 2B and the remote speaker line, the call-in feature will still be retained if the unit is equipped with a standby switch.

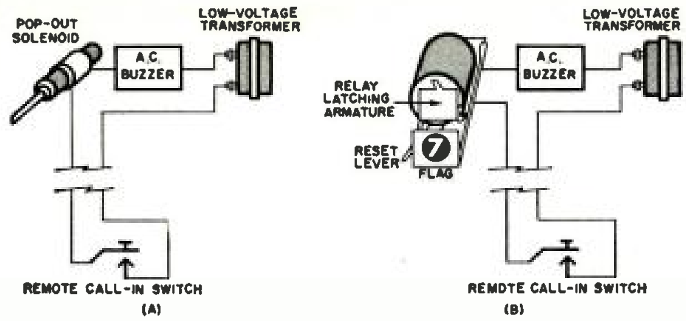


Fig. 3. (A) Pop-out solenoid and (B) relay drop-flag annunciators.

One disadvantage of voice call-in is that the calling party must identify his station in systems consisting of several remotes in order for the called party to select the proper station for returning the call. If the called party does not happen to be present when a call is initiated, he has no way of knowing, upon his return, that he has received a call nor the identity of the calling party. This problem can be eliminated by the use of an annunciator call-in system. Two types are generally employed: the pop-out or the drop-flag. The pop-out system uses a small solenoid for each station. This pops out when energized thus identifying the calling party. In order to re-set the unit, a plunger must be pushed in manually. In the drop-flag type a relay trips a small identifying flag. To re-set this unit, the flag is simply pushed up until it latches in the original position. Lamps are sometimes used as call-in indicators but they are less reliable due to bulb failure. Fig. 3 is a diagram of each type of annunciator call-in. An audible buzzer is generally used with each type of system to attract the attention of the called party.

Selective Systems

In Fig. 2 we have advanced our simple system to include privacy and remote-call origination. We may now wish to add several more remote stations to expand our communications network. This can be accomplished by the addition of a station-selector switch, S_3 in Fig. 4. The addition of this switch will allow us to select any one of several stations as desired.

For a balanced-line system, the switch would have to have two poles and twice the number of contacts since both sides of the line would be switched. As shown in Fig. 4, in the unbalanced system the privacy and call-in line can be extended to each additional remote station by simply paralleling the lines at the master station. Ordinarily the remote stations all have to be set up as either private or non-private since the manner in which the switch is connected at the master station will affect all remote stations equally.

Station-selector switches can be of the rotary wafer type, push-button, or slide-switch types. The first two are preferable since they have self-wiping contacts and give long, trouble-free service. Push-button switches have the advantage of providing more convenient station selection since in the rotary type it is often necessary to step through several switch positions in order to arrive at the desired station.

Intermixed System: Masters & Remotes

In the system of Fig. 4 it is evident that remote stations A, B, and C can establish communication with the master station but not with each other. There are many cases where such a system would be entirely adequate. In a typical example, let us suppose it has been established that station A has need for contacting stations B and C. We must now replace station A with a master unit if this is to be accomplished.

Now both master stations can converse with remote stations B and C but additional switching must be provided if the master units want to communicate with each other. This involves the addition of another position on the talk-listen switch and, basically, converts the master to a remote station when not in use. This is shown in the schematic diagram of Fig. 5 for a balanced-line system. Note the increased complexity of switching involved to provide this facility in a balanced-line system. The additional switch position, usually designated "off" or "standby," disconnects the speaker from the amplifier in the master station and connects it to the pair of terminals marked "X" in the diagram. This pair of terminals is called the "home line" for the unit and offers a direct connection to the speaker in the master unit when the talk-listen switch is in the "off" position. Thus the master stations can communicate with each other as well as with the remote stations. However, it can be seen that in a system of this type the privacy and voice call-in feature cannot be extended to the remote stations since the speakers in the master stations are disconnected from their respective amplifiers when the units are in the "standby" position. In fact, the amplifiers are usually turned off by an extra set of contacts on the talk-listen switch which breaks the "B+" lead when the switch is in the standby position. This will provide minimum power consumption and heating when the unit is not in actual use.

A system of this type is generally used where the need is for a limited number of master stations and the bulk of the system consists of remote units. If a call-in system is employed, one of the annunciator types is generally used.

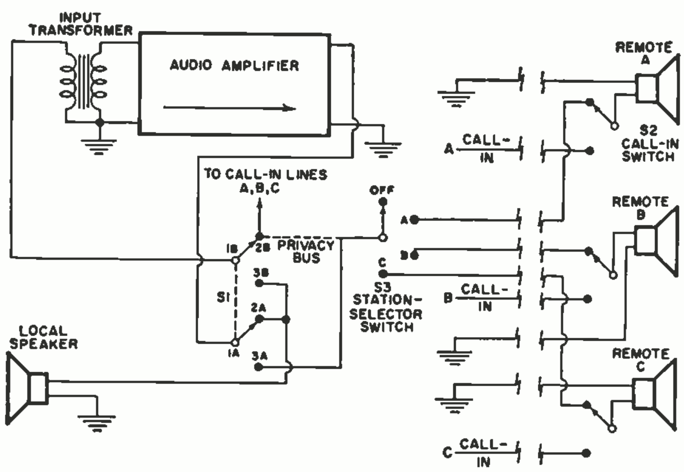


Fig. 4. The addition of a station-selector switching arrangement.

Master-to-Master System

The all-master type of system is designed for use where each station in the system must be able to contact every other station. The basic switching system is shown in Fig. 6. Note that the home-line switching is similar to Fig. 5 except that only a two-position switch is used. The normal "listen" position, utilizing the amplifier, is not needed in an all-master system. Instead, an "off" position is used as "listen."

Referring to Fig. 6, when the unit is in the "talk" position, operation is quite straightforward. When the master switch is in the "listen" position, the amplifier is disconnected and the home-line terminals are connected to the local speaker. Note that the level control is only in the circuit when the master is in the "listen" position. This permits one setting of the control for desired loudness at a master station to serve for all incoming calls if the gain of all the master amplifiers in the system is approximately equal, which is generally the case.

One important feature of the all-master system is the 100 per-cent trunkage feature. This is an old telephone term meaning there can be half the number of simultaneous conversations going as there are units in the system. Two units, of course, are required to make one conversation path. This feature can be very worthwhile in a system subject to heavy usage.

In a system of this type it is not possible for a station to be monitored by another station as long as the talk-listen switch is kept in the "listen" position. However, when two stations are in use it is possible for a third station to monitor one or both sides of the conversation by selecting one or, alternatively, selecting both of the home-lines of the busy stations. This is not ordinarily a problem and the system may be considered a private system for all practical purposes.

Some special applications may require absolute privacy, however, and in this case an additional feature is required to prevent the possibility of eavesdropping. One solution commonly used is a lock-out relay system. This requires a relay for each line in the system at each master station. The circuit is so designed that when two stations are using the line, both stations are removed from service at all of the remaining stations. A busy lamp is usually provided which indicates that the stations are in use and temporarily unavailable.

In some applications it is necessary for a key station to have instant access to all stations. A busy override switch is provided for the key station in such a case. This permits the key master station to disable the lock-out privacy circuit if necessary.

Systems for "Hands-Free" Operation

All of the systems described thus far have one common disadvantage, *i.e.*, a switch has to be manually operated at one or both ends of the line in order to alternate the conversation path. Two ways in which the disadvantage can be overcome will be discussed in this section. One method involves the use of a "vox" or voice-operated switching system. A block diagram of such a system is shown in Fig. 7. Note that the loudspeaker has been removed from the master station and placed some distance away. This is necessary to minimize acoustic feedback between the speaker and the vox microphone.

Basically, the operation of the system is as follows: A station is selected by the station-selector switch in the normal manner. From this point on the operation is "hands-free." At the instant the audio signal reaches the vox microphone, the plate relay operates and places the unit in the "talk" position. The relay replaces the manually operated talk-listen switch in the other units. As long as the operator keeps talking, the relay remains energized in the outgoing position. When the vox microphone no longer receives a signal, the relay de-energizes, returning the unit to the "listen" position.

An adjustable time-delay is usually provided for the vox circuit in order that the relay remains closed between words to prevent chattering. As indicated in the diagram, the audio

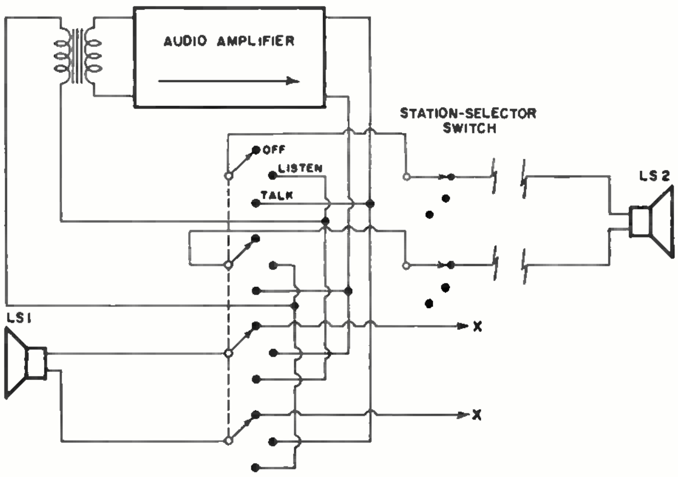


Fig. 5. System permitting master to be operated as a remote.

signal from the vox amplifier is also used to operate the intercom amplifier to provide the outgoing signal. When the unit is in the "listen" position, the incoming signal is amplified in the normal manner through the intercom amplifier and applied to the speaker. Thus it can be seen that the voice actually does the switching from the "listen" to "talk" position.

It can be appreciated that such a system would not work well under conditions of high ambient noise levels since this would introduce false triggering of the vox amplifier. Therefore, such systems are somewhat limited in application. Also the speaker for the incoming signal must be placed some distance away from the master unit for the same reason and thus it is sometimes difficult to obtain an adequate listening level.

The simultaneous system diagrammed in Fig. 8 overcomes many of the disadvantages of the vox system. However, two amplifiers are generally required in this type of unit. Basically, the system consists of two separate amplifying systems arranged as shown in Fig. 8A. This eliminates the need for manually operated switching but, like the vox unit, is subject to acoustic feedback problems which preclude high operating levels. Its use is more or less confined to bank drive-in windows and similar applications. Fig. 8B shows how the same system can be applied to one amplifier. Although this simplifies the circuitry, it multiplies the number of possible acoustic feedback paths and is, therefore, capable of only low operating levels.

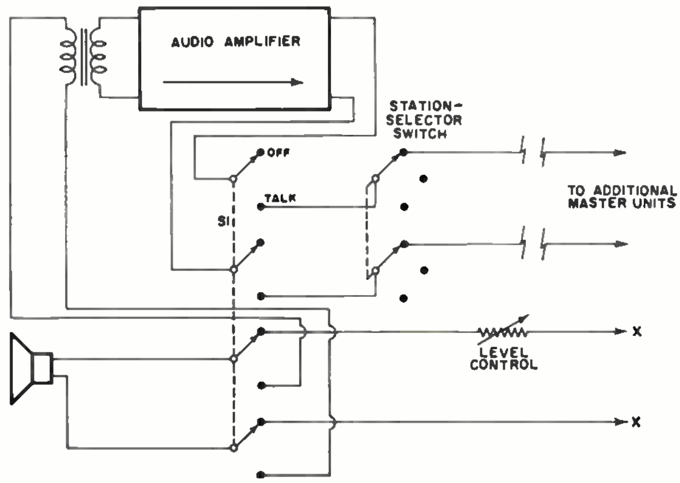


Fig. 6. Switching circuit used for all-master type operation.

Industrial Applications

Intercom systems for industrial use often require special components and techniques to insure effective intercommunication. High noise levels are a frequently encountered problem. For interfering noise containing mostly low-frequency components (such as might be caused by large machinery, motors, or compressors), loudspeakers with a natural low cut-off frequency of from 200 to 300 cps will help minimize such noise without affecting the voice frequencies. Small re-entrant horn speakers are suitable for this purpose since they attenuate frequencies below a few hundred cycles and are very effective in the voice range. Since they are of all-metal construction they have the added advantage of being virtually waterproof and can be used outdoors without weather protection.

Noises in the high-frequency region can often be effectively reduced by the use of a low-pass filter designed to cut off at about 3000 cps. This does not noticeably affect the voice range but often helps reduce high-frequency noise.

Noise that falls in the range of voice frequencies or "white noise" (noise that is of random frequency and thus cannot be filtered) presents a peculiar problem that, unfortunately, cannot be solved by any simple means. In such cases speaker location is of prime importance in order to insure maximum efficiency. Generally the speaker should be placed as close as possible to the operating position in order that the voice level may override the interfering signal. In severe cases, a handset containing a close-talking microphone is substituted for the

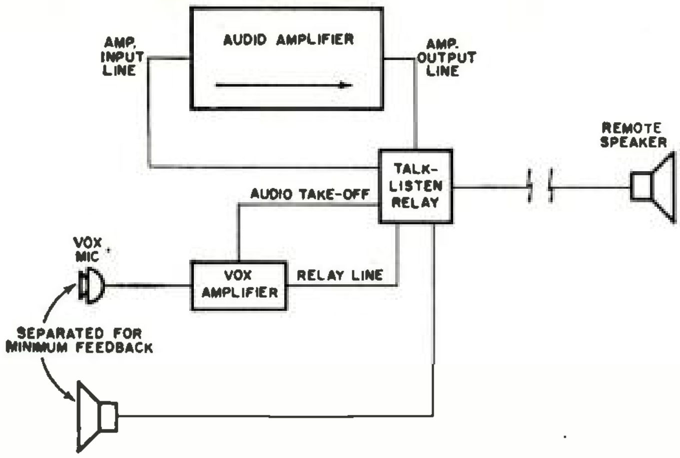


Fig. 7. The use of a "vox" (voice-operated switching) circuit.

loudspeaker. A loud ringing bell or horn is used to signal the called party.

Operation in an explosive environment poses another requirement for an intercom system. Components for such a system must be enclosed in special cases or containers that are air-tight. Systems of this type may be found in chemical plants, in the presence of explosives or explosive gases, and in hospital operating rooms.

Another special feature often desired in industrial systems is high-level voice paging. One line can be selected at one or all master stations to drive a booster amplifier which provides the power for the paging speakers. This is diagrammed in Fig. 9. The pad is usually necessary to drop the level from the intercom amplifier to a value that will not overdrive the booster amplifier. Such a circuit, of course, is one-way only since it is not possible to receive through the booster amplifier used.

Other special features often in demand are foot-operated talk-listen switches for "hands-free" operation, handsets instead of loudspeakers for additional privacy, combination intercom and background music systems which provide for dual usage of the intercom speakers, and all-call facilities which permit all stations to be monitored or called simultaneously. There is literally no end to the combination of special features and circuitry that can be provided to meet the requirements of just about any loudspeaker intercommunications system.

Systems for Home Use, Wireless Systems

Intercom systems designed for home use have several unique features not generally found in commercial units. Several master stations may be required in a home system but, due to the limited service involved, usually one amplifier is provided for the complete system. This permits only one master unit to be in service at a time or, in other words, it is a "one trunk system." Applications requiring more than one trunk would dictate the use of a commercial-type system.

Since the off-duty time of a home system is much greater than the in-service time, the amplifier can be disabled when not in use. For this reason filament-type vacuum tubes or transistors are generally used in the circuitry. This permits instant service without waiting for a warm-up period and conserves power and component life when the system is not in use.

Master stations in most systems of this type can be set for either private or non-private operation. Remote stations, as a rule, are non-private although in some systems they may be wired for voice call-in. Where voice call-in is not used, a push-button is usually available for the remote unit to permit signaling the master by a buzzer or bell.

For ordinary home use a fraction of a watt of audio power is usually adequate for a good listening level hence amplifiers can be of very compact construction and, in most cases, will be flush mounted in an ordinary stud wall constructed of 2 by 4's.

In some cases where existing construction makes a wired system impractical, a wireless intercom system may be considered. Only the existing electrical wiring is required for a system of this type. Low-frequency r.f. energy is used as the communications medium and this is coupled to the electrical wiring.

Basically a unit of this type is a low-powered r.f. transmitter and receiver operating in the range from about 75 to 350 kc. Multi-purpose tubes are generally employed much as they are in transceiver circuitry. Utilizing this type of construction, along with the small amount of r.f. energy required (usually only a few milliwatts), the unit can be quite compact—often no larger than a comparable wired unit.

Multi-channel units are available with up to twelve individual communications channels. To minimize crosstalk between adjacent channels they are usually spaced at least 25-kc. apart.

Operating characteristics for this system can be compared to the all-master wired system. Voice call-in, 100 per-cent

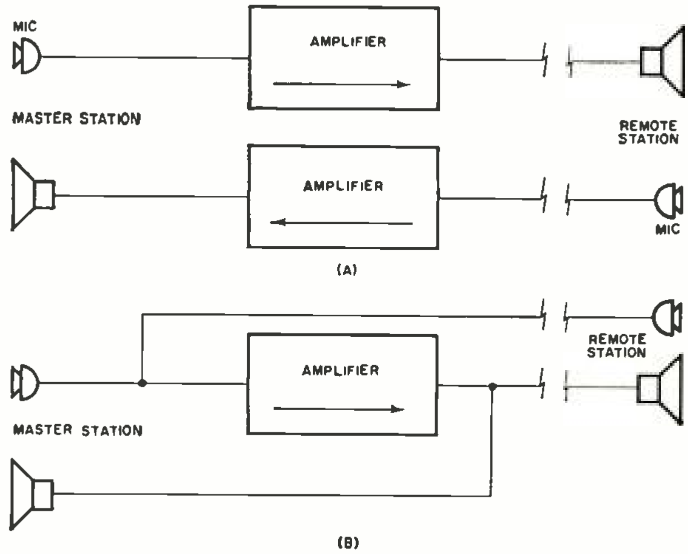
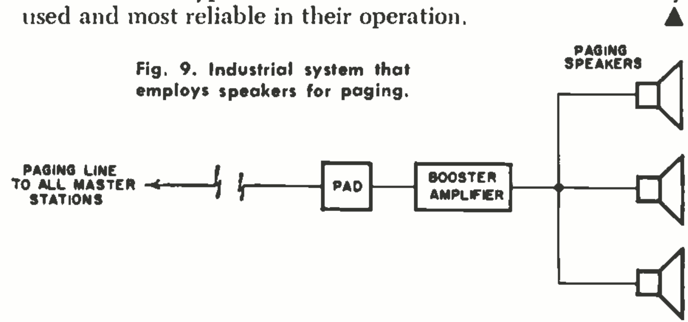


Fig. 8. Simultaneous system overcomes drawbacks of "vox" system.

trunkage, and privacy are all included. Difficulties are sometimes encountered with r.f. carrier intercom systems when they are operated on power lines that are common with large motors or transformers. The large shunt capacity often associated with these devices tends to bypass the r.f. signal to ground and, in some cases, will not permit reliable operation. In addition, they do not work too well on polyphase power distribution systems since the signal is shunted in the same manner when attempting to cross from one power leg to another. For these reasons, wireless systems cannot be used interchangeably with wired systems but are capable of reliable service when used under the proper conditions.

Although all possible combinations and types of systems cannot be covered in a single article, the author has tried to suggest the basic types and the various features available. Intercoms of the types described include those most commonly used and most reliable in their operation. ▲

Fig. 9. Industrial system that employs speakers for paging.



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Technicians with Passports

(Continued from page 41)

on yourself for leisure activities is very helpful. Hobbies make a difference. Anything from hi-fi to flying goes. An avid reader has an advantage. In fact, the company encourages and assists financially those who undertake correspondence studies to improve their store of knowledge.

Rough conditions, sometimes encountered, may extend to the job itself. On some assignments, you may work at a console, sitting down. At another, you may have to climb an antenna tower in a storm to make a repair. In fact, along with conventional aptitude and information tests, you will have to take a physical when you look for a job. This does not mean only musclemen need apply. But the more daring jobs will go only to those who can meet certain qualifications.

Reluctance to deal with certain jobs or living conditions need not eliminate a candidate from field work. The company considers individual preferences and abilities in making up assignments. In fact, many positions are filled by those who indicate interest in specific projects or in trying specific jobs.

Family Problems

What does the married man do when he has to travel? If he has no children, he can take his wife with him on most but not all assignments. He must find living quarters on his own, but he can determine availability, probable facilities, and costs within the company. If he has very young children, he can find many an assignment on which they can be taken along too. Where children are of school age, providing for their education may be difficult and will also involve additional expense.

Goals, Present & Future

Why does a man go into such a career? Eagerness for new experience is an obvious motive. Money is not a dishonest one. Average stateside income is $6000 a year plus $3100 for living expenses. The overseas average is $7200 plus $3830 for expenses. "Radicians" on the DEW Line make about $10,000 a year. In addition, they receive free housing, food, transportation, and arctic clothing.

Since living expenses, without a family, are generally lower overseas than in this country, a technician who goes abroad alone can put aside quite a bit of capital. Many, in fact, take on an assignment for such short-range purposes as accumulating enough to continue education, get married, buy a home, or pay the bills for an expensive illness in the family. A single assignment may last anywhere from a few months to a couple of years. The employer is chiefly concerned that you complete the assignment, whose scheduled length will be reported to you honestly in advance. At its termination, you may pack up or request another assignment.

Many men feel that, whether they stay with *FEC* or move on elsewhere, work of this kind is an excellent career investment. Consider Chris Schlachter. He studied mechanical engineering for two years, is 30 years old, has been with the company for four years. In that time, he has had over twenty assignments, ranging in length from one day to one year. The sort of experience he has acquired, he feels, enables him to make special contributions in a number of different positions. He may consider teaching in the future. If so, along with his formal background, he will be able to impart practical knowledge that few others can offer. On the other hand, he might end up in design work. He has learned much about equipment requirements and shortcomings, at first hand, that never occur to the engineer in the laboratory. There is much to offer here.

Many men continue in field work indefinitely, as a matter of preference. What they have to offer in the way of experience makes up for much of the activity that younger men can contribute. As they marry and raise families, a greater number of technicians look for job stability. Of these, a certain number will find it elsewhere, bringing to their new positions a variety of valuable experiences acquired in field work. Although *FEC* cannot absorb all of its men who wish to settle down, it manages to relocate a substantial number of these within the company or with affiliated firms. It is at least as alert to the special contribution such individuals can make in other roles as are outside firms.

Careers after Field Work

What positions are open to former field men? *FEC* experience here is indicative. L. P. Feldkamp, operations supervisor, points out that there are openings in supervision, management, administration, and other staff jobs—like his own—which are primarily based at the home office. Since these involve planning of field assignments elsewhere, prior field experience is an asset. Other men may end up in research and development or manufacturing, where they make recommendations for equipment or test and evaluate equipment, from the field man's point of view. Again, their experience for this function is uniquely suitable. They may be placed with design and manufacturing subdivisions in the *ITT* family.

For any prospect, the roving field job holds the promise of immediate rewards and the experience on which a long career can be built. ▲

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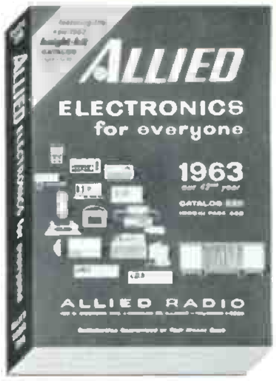

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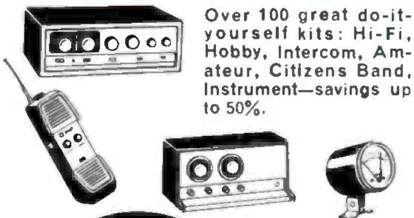

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RC-COUPLED HIGH-FREQUENCY AMPLIFIERS

A new concept in transistor circuit design promises simplified circuitry, lower cost, along with better performance for wide-band high-frequency amplifiers.

By W. A. RHEINFELDER / Applications Engineer, Motorola Semiconductor Products Inc.

A NEW transistor circuit-design technique using the recently discovered principle of emitter tuning[1] may have a pronounced effect on the design of high-frequency receivers in the near future. Particularly useful for wide-band r.f. applications in the h.f., v.h.f., and u.h.f. ranges, the new circuit technique involves the insertion of a high "Q" resonant circuit in the transistor emitter lead, thereby removing degeneration due to the internal emitter junction inductance.[2] This results in an extremely high transconductance which produces high gain even with small load resistors in simple wide-band *RC*-coupled amplifier designs. Moreover, it leads to improved circuit stability, reduces the number of circuit components, and greatly enhances the possibilities for microminiaturization.

A typical *RC*-coupled amplifier stage using the emitter tuning principle is shown in Fig. 1. The circuit has a center frequency of 100 megacycles and the only elements involved in tuning are the internal emitter inductance plus the external lead inductance in series with the external trimmer capacitor. The choke in the emitter circuit effectively isolates the emitter resistor from the tuned circuit and prevents it from lowering the circuit "Q." Thus the actual transconductance of the transistor approaches the intrinsic g_m of the emitter junction which is substantially higher than the published specification for this parameter.

In many single-stage amplifiers the load is connected directly in the transistor collector circuit to eliminate the necessity for capacitance coupling. In such cases the radio-frequency choke in the collector lead of Fig. 1 can be omitted. It is used in this experimental circuit solely for the purpose of maintaining a steady d.c. operating condition while experimentally varying the value of the load resistor.

Removal of the emitter-inductance degenerative effect through its use as a part of a series-tuned circuit substantially raises the input resistance of the transistor and reduces its output resistance. This serves to reduce the mismatch ratio between cascaded *RC*-coupled stages although exact matching for optimum power transfer cannot be obtained. However, considering the fact that a 4:1 mismatch causes a loss of only 2 db in power gain the resulting mismatch at high frequencies is not serious.

The performance characteristics of the single-stage circuit using types 2N700 and 2N834 mesa transistors are shown in Fig. 2. From these graphs it can be seen that the circuit provides excellent wide-band amplification. With the 2N700, for example, a 200-ohm load resistor, *R*, yields approximately 12 db of power gain at 60% relative bandwidth. By way of comparison, the same transistor in a much more complex and expensive "conventional" circuit would provide a maximum gain of only 10 db for the same bandwidth.

An additional advantage of this circuit results from the fact that the cascading of stages is simple since the loss due to mismatching is relatively small. The measurements for Fig. 2 were taken at an emitter current of 5 ma. with a supply voltage of 13.6 volts. Both gain and bandwidth can be varied by changing the emitter current.

Typical Cascaded Amplifier

A typical three-stage amplifier is diagrammed in Fig. 3. To simulate additional cascaded stages the source and load re-

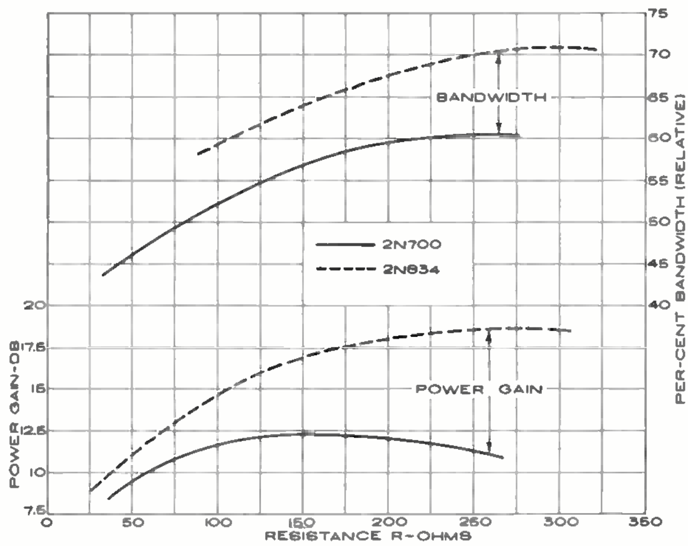


Fig. 2. Gain and bandwidth for the two transistor types.

Transistor	I_E	R_1	R_2	Power Gain (unloaded)	Power Gain (loaded)	Bandwidth	Input Z
2N700	5 ma.	11k ohms	150 ohms	39 db	36 db	35 mc.	150 ohms
2N834	5 ma.	18k ohms	110 ohms	35 db	29.3 db	33 mc.	75 ohms

Table 1. Performance of 3-stage amplifier shown in Fig. 3.

Fig. 1. Single-stage amplifier. R_1 consists of a 50-ohm generator resistance plus a series resistance equal to the difference between the transistor input resistance and the resistance of the r.f. generator.

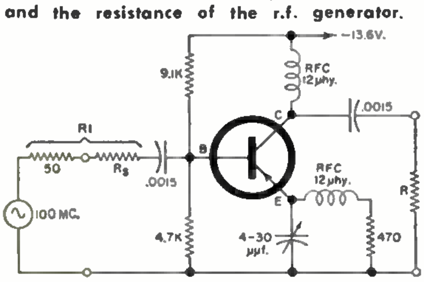
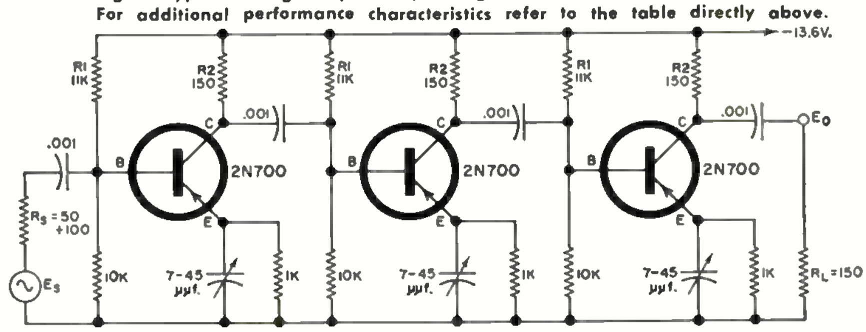


Fig. 3. Typical 3-stage amplifier operating at 70 mc. with bandwidth of 35 mc. For additional performance characteristics refer to the table directly above.



sistances have the same values as in the cascade. (The input impedance of the 2N700 transistor is approximately 150 ohms.)

Performance of the three-stage amplifier circuit with both 2N700 germanium transistors and the 2N834 silicon mesa is given Table 1.

Since the amplifier was designed for wide-band applications (approximately 35 megacycles at a center frequency of 70 megacycles), maximum "Q" for the tuned emitter circuit is not required. As a result, no r.f. chokes are needed, although the emitter resistors have been increased to 1000 ohms to reduce their shunting effect.

It is evident from the table that the 2N700 germanium transistor provides higher gain in this circuit than the 2N834 silicon unit. This is due to the lower input resistance of the silicon transistor which increases the mismatch ratio. In practical applications, where the amplifier might work into a high-impedance load, the difference in gain between the germanium and silicon units would be substantially reduced.

By way of comparison, a conventional 3-stage circuit using four tuned *LC* circuits and a far more complex circuit configuration might yield a typical power gain of 30-45 db with 2N700 transistors.[3] The much simpler circuit of Fig. 3, therefore, has much to recommend it in numerous applications. ▲

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2. *"Effects of Lead Inductance on High Frequency Transistors," Motorola Applications Report #64.*
3. *"A 70-Mc. Wide Band Amplifier," Motorola Applications Memo #500.*

Motorola Applications Reports and Memos are available from the Technical Information Center, Motorola Semiconductor Products Inc., 5005 East McDowell Road, Phoenix 8, Arizona.

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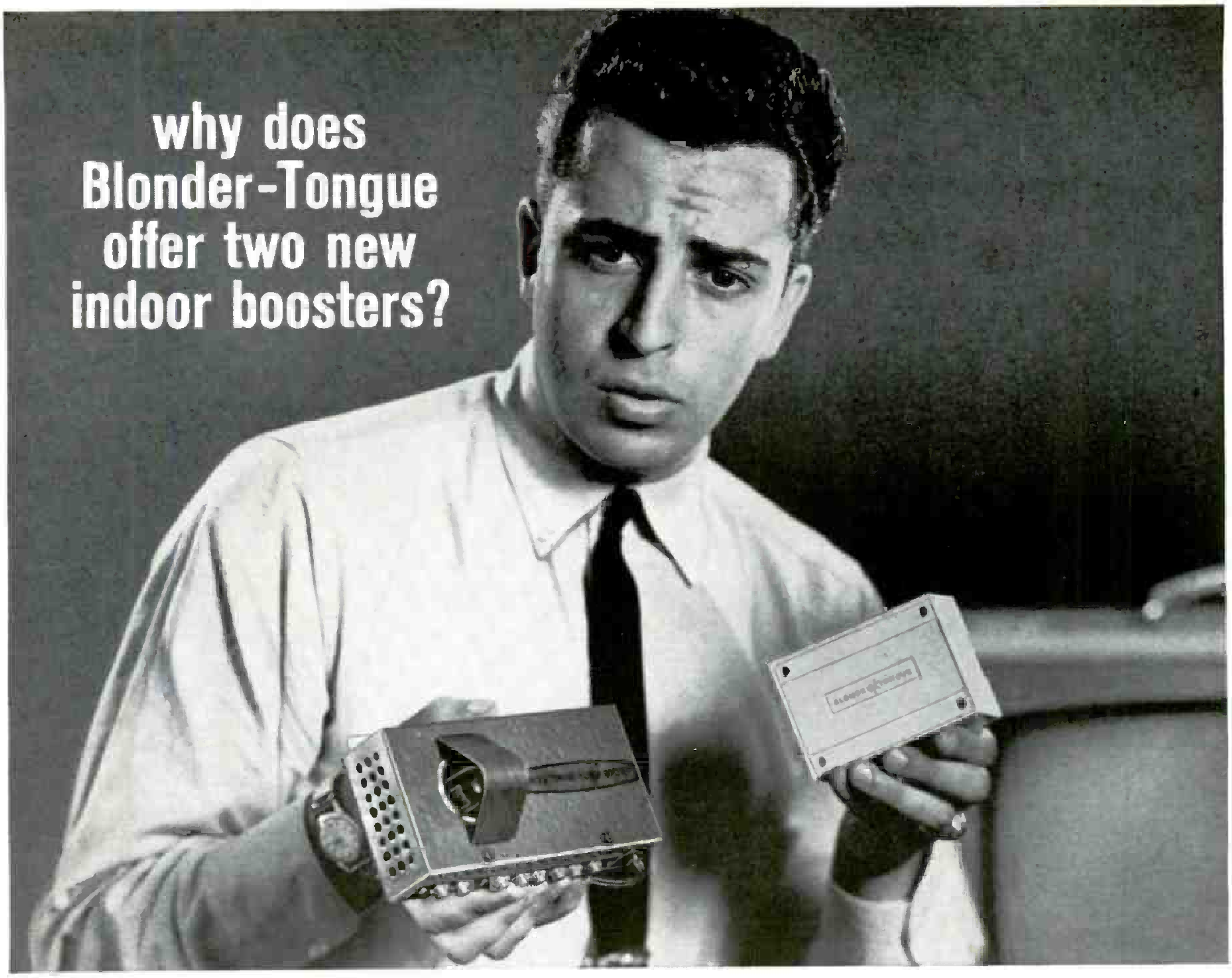

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 CIRCLE NO. 102 ON READER SERVICE PAGE

SWITCHED-RESISTOR CONTROLS

Close-tracking stereo controls, accurate linear and tapped pots may be made with fixed resistors and a rotary switch. / By ROBERT K. RE

ARE YOU tired of looking through component catalogues for those special tapped volume controls, high-linearity potentiometers, and close-tracking dual volume controls for stereo amplifiers? The use of "switched-resistors" can solve most of these special problems quickly and inexpensively. All parts required are readily available and economical. Switched-resistors, shown in Fig. 1A, are merely individual resistors that are controlled by switches to simulate variable resistors.

Applications

The Baxandall feedback tone circuit, which has appeared in many articles in this and other publications, requires a 500,000-ohm linear-taper pot with a tap at 250,000 ohms. The only unit available was one with a tap at 225,000 ohms. Using the switched-resistor technique, this tapped resistor was easily obtained. Another circuit using a tapped resistor control for a compensated loudness control, shown in Fig. 1B, posed quite a problem until the switched-resistor technique was applied.

Stereo sound systems require identical dual controls to provide balanced outputs from the amplifiers. Tracking and tolerance errors of most controls available today are about 5-10%. With switched-resistor methods, the tolerance, tracking, and linearity characteristics can be tailor-made to almost any desired value. Using switched-resistors, the flat positions on tone circuits can be found easily and recorded for future reference. Thus previous settings can be recalled for best sound reproduction from each input.

Some variable resistors have a switch that attaches to the rear of the unit. These are usually s.p.s.t. or d.p.s.t. Using the switched-resistor technique, one or more extra wafers are added to produce the desired switching functions. Sequential switching, as the resistor value is varied, is entirely possible, if desired. Perhaps one needs a four-gang pot with a three-pole, single-throw switch in a particular application. This item is not generally listed in the catalogues and is an unusual requirement. It can, however, be made quite easily with switches and resistors.

Potentiometers are usually replaced when they get noisy or become inoperative. Using switched-resistors, the noisy or defective resistor can be replaced at low cost; no need to purchase a whole new unit. Low noise levels are a "must" for good sound systems; however, the typical potentiometer may become relatively noisy. Low-noise variable resistors can be made using low-noise resistors and switches with double-wiping contacts.

High-wattage potentiometers are usually wirewound units and these, as we know, have an effect on the frequency response because of their inductance. Using carbon resistors (or other non-inductive resistors), high-wattage variables can be assembled which will have little effect on the frequency response of the unit. Dual units can be made to control different power levels with one knob. The wattage of each resistor is determined by the power levels involved. Normally the method of determining the wattage of each resistor is as follows: (1) Determine the maximum applied voltage across the switched-resistors; (2) Compute the current that will flow through the whole string of resistors; (3) Using Ohm's law, compute the power dissipated in each resistor; and (4) If the power level is, say, one watt, use a 2-watt unit for a safety factor. Higher wattage units will give an even greater safety factor.

Circuit design need not be compromised if a special value of variable resistor or taper is required. Thus a 13,000-ohm reverse audio-taper pot is easily constructed. The level changes between steps can be made to conform to decibels, decade, or linear voltage changes by proper choice of the resistor values. The resolution is limited by the number of switch positions used.

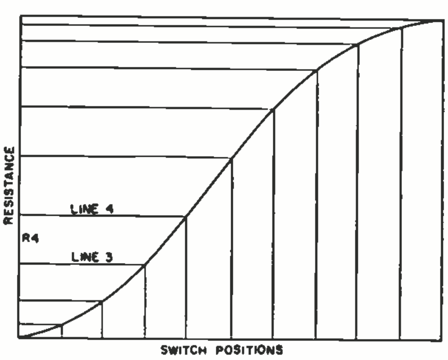


Fig. 2. Graphical method of construction.

Construction

Linear potentiometers are made by taking the total resistance value and dividing by the number of switch positions minus one. Thus a switch with 11 positions and ten 1000-ohm resistors will make a 10,000-ohm linear switched-resistor.

Graphical methods of construction are as follows (see Fig. 2). (1) Draw a graph of resistance (ordinate) as a function of degrees rotation or switch positions (abscissa); (2) At each switch position or degree index, draw vertical lines up to the resistance curve; (3) At the intersection of each vertical line and the resistance curve, draw horizontal lines to the resistance scale on the left. The actual resistance value is found by subtracting one resistance value from the other. thus the fourth resistor value equals Line 4 resistance minus Line 3 resistance (see Fig. 2).; (4) Reversing the order of resistor positions on the switch will reverse the taper of the switched-resistor control (this assumes that clockwise rotation produces increasing resistance for the normal unit).

To illustrate the mathematical method, let us design a 50,000-ohm, 5% tolerance pot with a 24-position switch.

Table 1. Resistors used for a 50,000-ohm, 5%, 24-position potentiometer control.

Step	Computed Values	5% EIA Values
1	12.5 k	12 k
2	9.38 k	9.1 k
3	7.04 k	6.8 k
4	5.28 k	5.1 k
5	3.96 k	3.9 k
6	2.97 k	2.7 k
7	2.23 k	2.2 k
8	1.67 k	1.6 k
9	1.25 k	1.2 k
10	938	910
11	704	680
12	528	510
13	396	390
14	297	270
15	223	220
16	167	160
17	125	120
18	93.8	91
19	70.4	68
20	52.8	51
21	39.6	39
22	29.7	27
23	22.3	22
Total Res.	51.0 k-ohms	48.2 k-ohms

Note: values rounded off to three places

Fig. 1. (A) Basic switched-resistor circuit. (B) Special tapped loudness control.

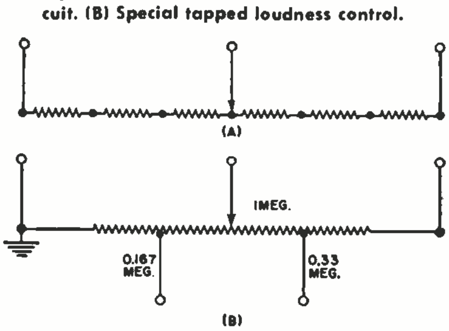
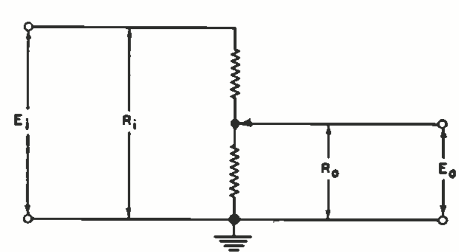


Fig. 3. Circuit constants used in formulas.



CIRCLE NO. 133 ON READER SERVICE PAGE →

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Skew, another hidden defect, produces cross-talk and loss of recording level. Golden Tone's oxide formulation and base are balanced to prevent cupping or curling, an effect which can also prevent tape to head intimacy. Golden Tone's oxide surface is Micropolished. This patented Soundcraft process removes any surface irregularity, prevents drop-outs, protects high frequency response and minimizes head wear.

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*DuPont T.M.

GOLDEN TONE BY REEVES SOUNDCRAFT CORP.

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The level changes per step are to be equal and should be 2.5 db. This will allow us a 60-db range of control over the input signal. Equations 1, 2, and 3 show that the resistance ratio is proportional to the voltage ratio, if the current is constant. The loading of the succeeding circuit will change the current, but usually not enough to seriously affect the attenuation ratio. With reference to Fig. 3 the following equations apply:

$$Attenuation\ (db) = 20\ log\ (E_o/E_i) \quad (1)$$

where: E_o = output voltage and E_i = input voltage, but

$$E = I \times R \quad (2)$$

therefore,

$$Attenuation\ (db) = 20\ log\ (R_o/R_i) \quad (3)$$

where: R_o = resistance from slider to ground and R_i = total resistance of the unit. If full output (maximum resistance from the slider to ground) is assumed as 0-db attenuation, then the first step must attenuate −2.5 db. Thus, using Eq. 3:

$$-2.5\ db = 20\ log\ (R_o/R_i)$$

or,

$$log\ (R_o/R_i) = -2.5\ db/20 = -0.125$$

The number whose log is −0.125 is 0.75, therefore:

$$R_o/R_i = 0.75$$

or,

$$R_o = 0.75 \times R_i \quad (4)$$

Thus, $R_o = 0.75 \times 50{,}000$ ohms = 37,500 ohms. This means that the first resistor equals:

$$R_i - R_o = 50{,}000 - 37{,}500 = 12{,}500$$ ohms.

The value of the next resistor can be found by using the first value of R_o as the new R_i in Eq. 4, and subtracting the new value of R_o from the new value of R_i. Thus the second resistor equals:

$$R_o = 0.75 \times 37{,}500 = 28{,}100 \text{ ohms}$$

$$Second\ resistor = 37{,}500 - 28{,}120 = 9380 \text{ ohms.}$$

The other resistors are calculated in a similar manner. However, a simple method will produce the same results quickly. Just multiply the value of the first resistor (12,500 ohms) by 0.75 to find the value of the second resistor. Multiply the value of the second resistor by 0.75 to find the value of the third resistor, and so on. Table 1 lists the values obtained and the 5% EIA values chosen to construct the control. The exact values are shifted to the closest EIA value. If one resistor is shifted down to the closest EIA value, shift all of them down so that the relative ratio among them is about the same as before.

Either the graphical or mathematical method can be used to determine the resistor values. Curves of most any resistance-rotation characteristic can be duplicated quickly using this method. Normally ½- or ¼-watt resistors are sufficient if more than ten resistors are used for the control. Thus ten ¼-watt resistors will make a variable resistor with a 2.5-watt rating. Increasing the wattage rating of each resistor will produce less noise, less resistor drift with time, and insure longer life. ▲

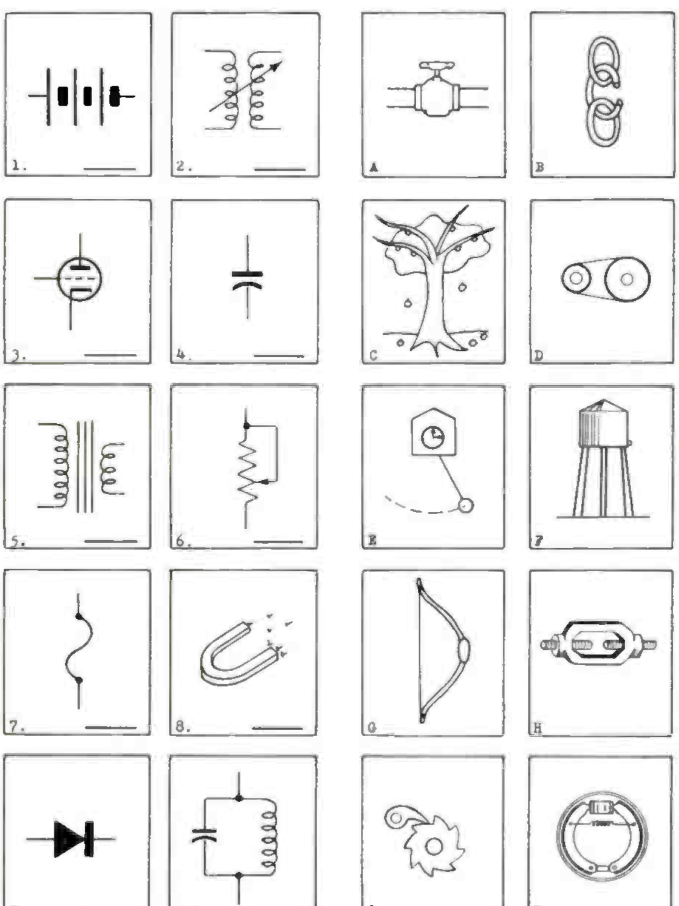
ELECTRONIC ANALOGIES

By ROBERT P. BALIN

ELECTRO-mechanical analogies are very important in understanding many principles of electronics. What makes them valid, or possible at all, are some of the most important fundamental principles of physics.

See if you can match the electronic components and the mechanical devices shown below on the basis of their functions and operating principles. Then turn the page for the correct answers and their explanations. ▲

1-F. A battery is a reservoir of electrical energy which can be supplied to an electric circuit at a voltage or electrical pressure determined by the chemical composition of an individual cell. A tank can store water which it can supply at a pressure determined by the height of the tank above ground.
2-H. A transformer with variable coupling between the primary and secondary windings is like a turnbuckle, the coupling device used to adjust the tension of a guy wire between, for example, an antenna mast and the ground.
3-A. A vacuum tube is often called a valve because it can control the flow of electrons through it just as a gate valve controls the flow of water in a pipe.
4-G. A capacitor stores electrical energy when it is charged. A bow stores mechanical energy when the string is stretched.
5-D. A stepdown transformer can take electrical power supplied at a high voltage and low current and step it down to a lower voltage but at a higher current so that the input and output power are equal. A belt drive transfers mechanical power from a pulley operating at high speed and low torque to a shaft rotating at a low speed, but having a higher torque.
6-J. A rheostat is an adjustable resistance in which an electric current produces heat. A brake shoe provides a variable resistance in the form of friction to the motion of a brake drum, and in so doing, also produces heat.
7-B. A fuse in a circuit has a lower current rating than any other component in the circuit, and therefore burns open first when there is an overload. It acts, therefore, like the weakest link in a chain.
8-C. A magnet attracts nails with its magnetic field in the same way that the earth's gravitational field pulls apples to the ground.
9-I. A rectifier permits electron flow in only one direction. A ratchet and pawl mechanism permits rotation of a shaft in only one direction.
10-E. A resonant circuit will oscillate at a frequency determined by the rate at which the kinetic electrical energy stored in the magnetic field around the inductor can be converted into a flow of electrons to charge the capacitor with potential electrical energy. In a pendulum the swing bob exchanges the potential energy that it has while being momentarily stationary at the extreme ends of its swing into the kinetic energy that it has while moving swiftly at the bottom of its swing. The frequency of its oscillation is determined by the length of the pendulum.



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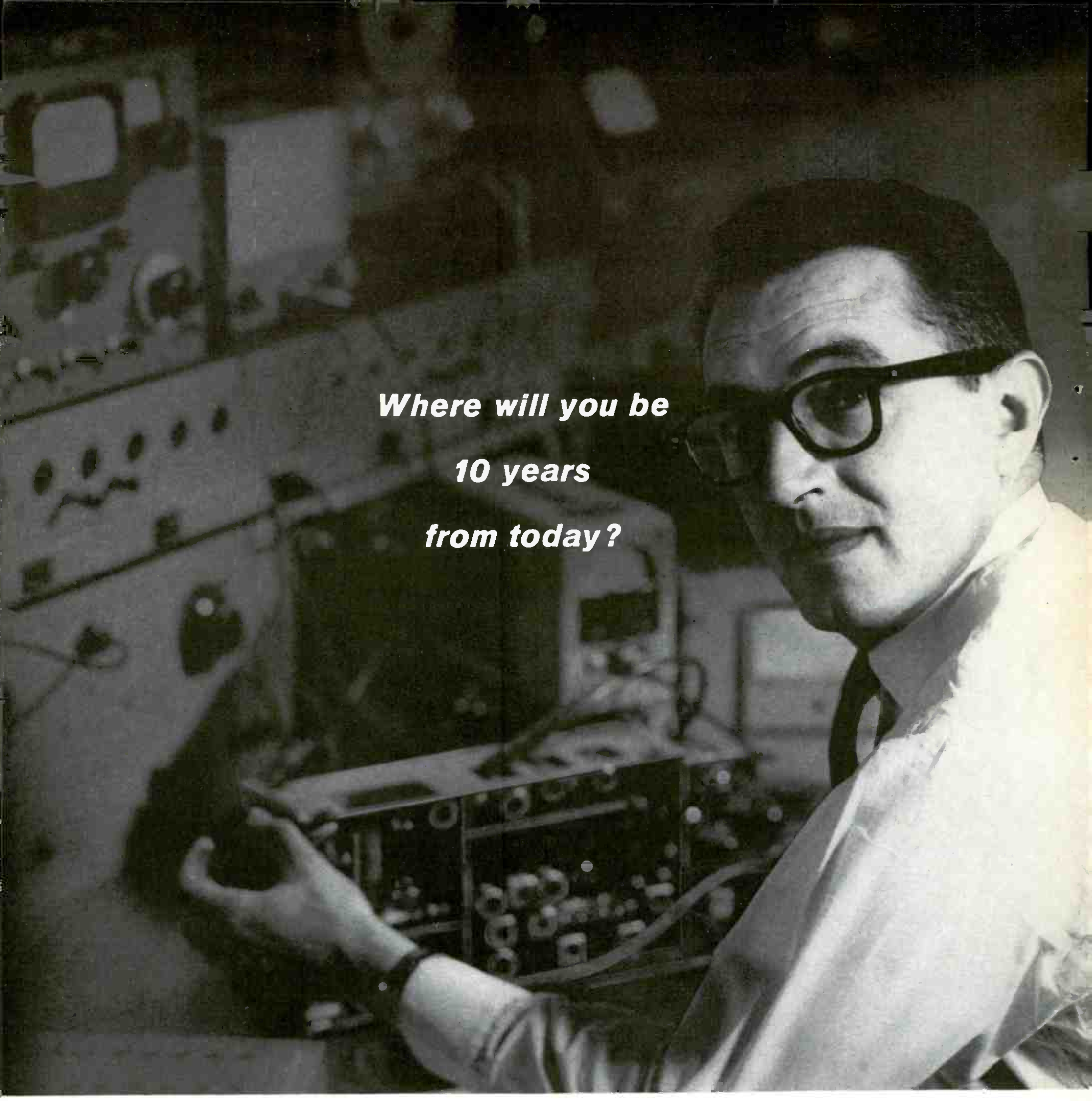

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TV Serviceman, Electronic Tester	Electronics and Television Receivers (V-3)	2 yrs. High School with Algebra, Physics or Science
Transistor Circuits Specialist	Transistors	Radio background
Junior & Senior Detail Draftsman	Electronic Drafting (V-11, V-12)	2 yrs. High School with Algebra, Physics or Science
Color TV Service Technician	Color Television	Television background
Hi-Fi Service Technician	Audio Hi-Fidelity	Radio background
Technical Writer	Technical Writing	Electronics background
Cameraman, TV Film Editor, Video Technician, Director	TV Studio Production (S-1)	High School Grad
Console Operator, Junior Programmer	Computer Programming (C-1)	College Grad or Industry sponsored
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The Most Trusted Name In Electronics

Relay Electronics

(Continued from page 49)

(Fig. 2). Chief difference is use of a speaker as the output load, for audible indication, instead of a bulb. Although a 4-ohm speaker is shown, voice-coil impedance is of little consequence. Operating frequency with the values shown is adjustable from 15 to 300 pulses per minute, encompassing the full range of conventional metronomes with room to spare at either extreme.

The circuit has also been employed in a sports-car rally computer (a device used to gage average speed) by substituting a counter for the speaker. Accuracy was commendable. In such an application, stability of the voltage supply is important.

Especially interesting as a multiple-output, low-frequency generator, the multivibrator of Fig. 7 is also good for getting a laugh with its audible clip-clop. When power is applied, both relays try to close but, because of slight differences between the two sides of the circuit (as with tube multivibrators), one closes before the other can. The faster relay drops out when the capacitor in series with it is fully charged, and applies current to the other relay and its series capacitor. Pull-in of the second relay switches the first capacitor's connection so that the latter can discharge. This cycle of operation repeats as long as power is applied.

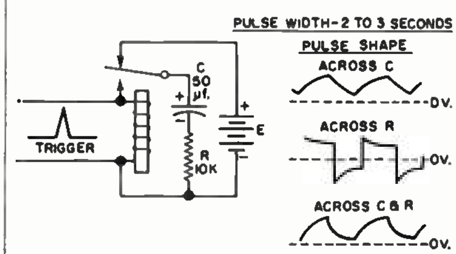


Fig. 8. Another multi-output generator. It is also an excellent pulse stretcher.

Specifically, assume RL_2 closes first. Its coil is in series with C_1 through the contacts of RL_1, so the capacitor charges. When C_1 is fully charged, current ceases to flow in the series circuit and there is no voltage drop across the coil of RL_2. The latter can no longer hold. When it switches, it puts C_2 in series with the supply through the winding of RL_1. The charging current through C_2 produces a sufficient drop across RL_1 to pull in the latter, which connects C_1 to ground through R_1 so that the capacitor can discharge. The purpose of the resistor is to limit discharge current.

Operating frequency can be set by varying E. With the values shown, a range from 28 to 46 volts will produce output from 52 to 27 cycles per minute. If output is taken between point A and ground, a fairly good square wave is obtained. Point B yields a good sawtooth. The voltage across the resistor (point C) is a series of spikes at twice the frequency of the other two waveforms. Some juggling of component values may be needed to get good waveform symmetry.

The one-shot circuit (Fig. 8) is extremely versatile. The width of the output pulse can be varied by manipulating the values of R and/or C. Thus the configuration can serve as a pulse stretcher: a pulse too narrow to operate a counter, power relay, or other device can be lengthened.

If a d.p.d.t. relay is used in place of the s.p.d.t. type shown, the circuit can be made an excellent square-wave generator or scope calibrator. A stable voltage source would be needed in the latter application, of course. The circuit can also act as a frequency divider if trigger amplitude, shape and width of the pulse, and frequency are kept nearly constant.

Adjustable Fusing

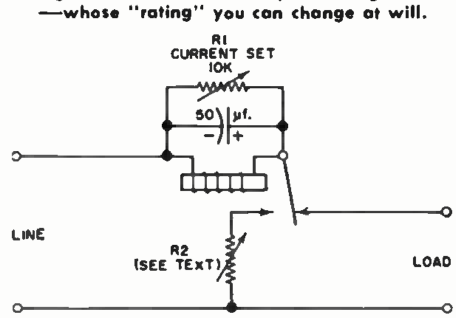
The over-current relay of Fig. 9 is an excellent, stable, and quick-acting cut-out. In many applications, such as when even a slight overload is not to be tolerated, it is preferable to a fuse. The relay "measures" load current in terms of the voltage drop across R_1, which is in series with the load. When this current becomes too high, the relay begins to pull in, removing power from the source.

However, in disconnecting power from the load, the relay cuts off its own driving power. Thus, without the capacitor, the relay would never complete its cycle. The charge on the capacitor across the relay coil is enough to carry the armature all the way to the pulled-in position. Once contact is made here, holding current is maintained through R_2. The value of the latter, not very critical, is simply selected or adjusted to limit coil current to a safe value.

Since the network serves as a versatile fuse whose rating can be changed at will, it can be very useful in variable-voltage supplies. Dial scales can be made for the shafts of R_1 and R_2 to permit convenient adjustment to various loads.

The value of the capacitor may also be determined by the use to which the supply is put. If the latter is employed

Fig. 9. How to make a quick-acting fuse —whose "rating" you can change at will.



with transistor circuits, the relay should open as quickly as possible and the capacitor should therefore be small. If power is being applied to a motor, however, the surge of starting current would open a fast-acting relay, so a large capacitor would be used to introduce time delay. Note that this circuit does not automatically re-connect the load when the overload has passed.

Only a fraction of the unusual and interesting possibilities are presented here, and even those have been presented in their simplest forms without elaborating the full list of applications and variations. With less simple relays (more contacts, two coils), possibilities become endless. Nevertheless, the examples chosen may open the door for many technicians. If you have a practical problem requiring an active element that consumes very little standby power, you should consider the possibility of adapting a relay. Just remember that it has more intelligence than it usually gets credit for. ▲

INCREASING STORAGE-BIN CAPACITY

By ROBERT K. RE

IF YOU have the problem of storing components and hardware items in a storage bin with an insufficient number of compartments for the items you wish to house, why not try this helpful method of increasing your storage-bin capacity.

Simply store two or more items in the same bin but pick two dissimilar components—such as grommets and terminal strips or bolts and washers. This procedure can increase the storage capacity of most parts bins without resorting to makeshift dividers. Thus each drawer can be filled and fully utilized. ▲

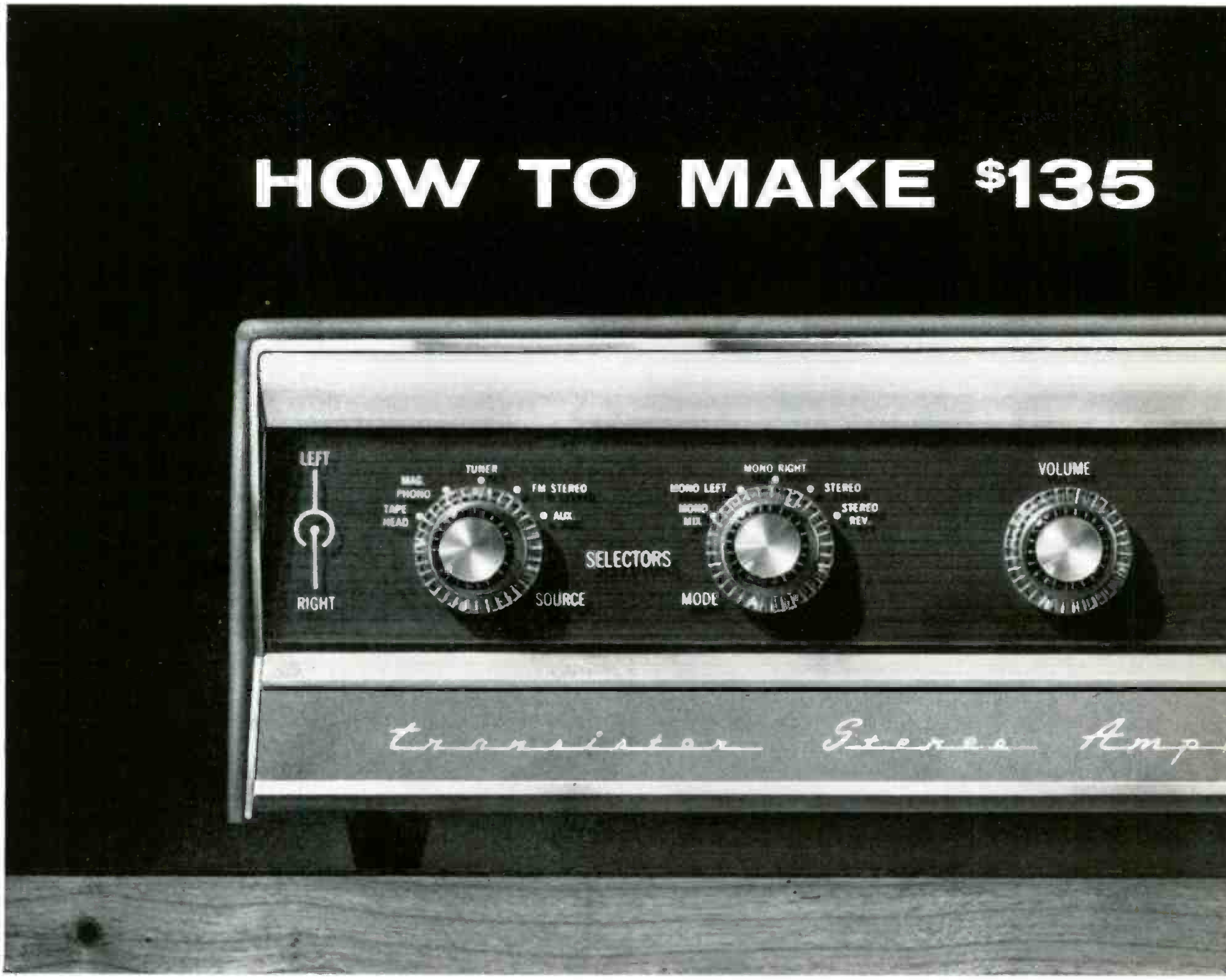
HI-FI GROUP IN GERMANY

WORD has been received from Frankfurt (Main), Germany that, following the lead of the Institute of High Fidelity Manufacturers Inc. in the United States, a similar association has been established to be known as Deutsches High-Fidelity Institut e.V. (or "dhfi") with headquarters at Russelsheimer Strasse 22, Frankfurt.

Like its U.S. counterpart, the association is dedicated to improving the quality standards of high-fidelity reproduction of phonograph records, magnetic tapes, and radio broadcasts. Full membership is limited to manufacturers or importers of hi-fi equipment with associate memberships open to interested parties on a paying basis.

Among the founders of the new Institute are: Braun AG (Frankfurt), Dynacord, Straubing (Donau), Elbau, Bogen (Lower Bavaria), Electroacustic GmbH (Kiel), Garrard-Audioson GmbH (Frankfurt), Klein & Hummel (Stuttgart), Shure Brothers, Inc. (Evanston & Dusseldorf), Dietrich Hahn (advertising consultant, Dusseldorf), and Ernst Pfau (technical writer, Asperg).

Herbert Ticho of Garrard-Audioson and Dieter Ludenia of Electroacustic were elected members of the executive committee and Manfred Walter of Braun the chairman. ▲



70 Watts, Heath Rating; 100 Watts IHFM Music Power

"Startling Realism . . . Superb Dynamic Range . . . Smooth, full power delivery . . . Fast, effortless transient response . . . Professional . . . Convenient . . . Takes full advantage of the state of transistor art . . . Simple assembly" . . . these are but a few of the enthusiastic comments of those who have heard and seen the new Heathkit AA-21 Transistor Stereo Amplifier.

Rated at 35 watts per channel by Heath standards or 50 watts per channel by IHFM music power standards, this Heathkit combination stereo preamplifier, power amplifier delivers full power over a range of 13 cycles to 25,000 cycles, ±1 db! No compromise in dynamic range, no faltering power at the important high and low extremes of response . . . just the most satisfying solid sound you have ever heard. Its other specifications are equally impressive . . . completely factual and guaranteed!

Featuring 28 transistors and 10 diodes, the latest, most advanced in RCA semi-conductor technology, the Heathkit AA-21 not only offers record-setting performance, but also provides operational characteristics unique with transistors . . . cool operation with low power line requirements . . . steady performance under wide, external temperature variations . . . complete freedom from annoying microphonics . . . instant operation.

More than two years in development, this pace-setting unit features transformerless output circuitry plus multiple feed-back loops for flat response and finest fidelity. All controls are front-panel mounted for operating convenience, with a 5-position, dual concentric input selector which permits "mixing" inputs for tape recording purposes, etc., a 5-position "mode" selector, plus dual concentric volume, bass and treble controls. A hinged lower front panel covers all input level controls, the tape-monitor input switch, a speaker phase reversal switch, and a loudness switch which converts the volume control to a loudness control for compensated low-volume levels. The right-hand section of the lower front panel is a unique On-Off switch . . . touch to turn on, touch to turn off. All input and output connections are conveniently located on the rear chassis panel. Circuit safety is assured through the use of 5 new, fast-acting, bi-metal circuit breakers . . . no more annoying fuse-fussing.

Kit assembly is fast and simple through the use of 5 circuit boards which eliminate most of the conventional, time-consuming point-to-point wiring. The preamplifier circuits are "capsulized" to reduce wiring . . . 6 epoxy-covered modules contain 70 resistors and capacitors, all factory wired and sealed, ready for easy mounting on the preamplifier circuit boards.

Styling is in the Heathkit deluxe motif of luggage-tan vinyl-clad steel with polished, anodized aluminum trim, plastic upper front panel, extruded aluminum lower panel with matching vinyl inset, and soft, refracted panel-lighting.

Designed to set a new standard of value, this finest of all stereo amplifiers carries a surprisingly low price tag . . . order yours now for early enjoyment.

Kit AA-21, 28 lbs., no money down, $13 mo. **$134.95**
Assembled AAW-21, no money down, $21 mo. **$219.95**

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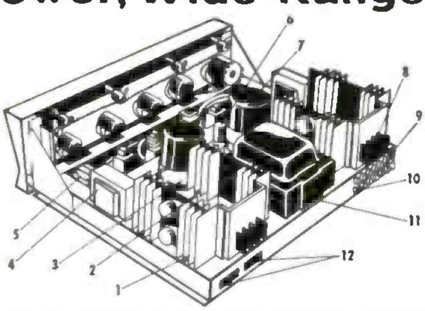

1. Eight germanium power output transistors mounted on four finned heat sinks. 2. Output circuit breakers. 3. Two power amplifier circuit boards containing four transistors and six diodes. 4. Two driver transformers. 5. Two preamplifier circuit boards containing six epoxy-sealed component modules and ten transistors. 6. Two germanium driver transistors plus four electronic filter transistors. 7. Two 3,000 mfd filter condensers and four power supply diodes. 8. Two output terminal boards. 9. Stereo input jacks. 10. Tape recorder output jacks. 11. Power transformer. 12. AC power outlets. All primary and secondary controls accessible at front panel area!

SPECIFICATIONS—Power output per channel: (Heath rating), 35 watts/8 ohm load—26 watts/16 ohm load—18 watts/4 ohm load: (IHFM music power output): 50 watts/8 ohm load—34 watts/16 ohm load—25 watts/4 ohm load @ 0.7% THD, 1 KC). **Power response:** ±1 db from 13 cps to 25 kc @ rated output: ±3 db from 8 cps to 40 kc @ rated output. **Harmonic distortion (at rated output):** Less than 1% @ 20 cps, 0.5% @ 1 kc, 2.0% @ 20 kc. **Intermodulation distortion (at rated output):** Less than 1%, 60 & 6,000 cps signal mixed 4:1. **Hum and noise:** Tapehead, 40 db below rated output; Mag phono, 45 db below rated output; Aux. inputs, 60 db below rated output; Tape monitor, 70 db below rated output. **Channel separation:** 40 db min. @ 20 kc, 55 db min. @ 1 kc, 50 db min. @ 20 cps. **Input sensitivity:** (For 35 watts output per channel, 8-ohm load) Tapehead, 2 mv; Mag. phono, 3 mv; Tuner, .25 v; FM Stereo, .25 v; Aux., .25 v; Tape Monitor, .90v. **Input impedance:** Tapehead, 60 K ohm; Mag. phono, 30 K ohm; Tuner, 100 K ohm; FM Stereo; 100 K ohm; Aux., 100 K ohm; Tape Monitor, 47 K ohm. **Outputs:** 4, 8, & 16 ohm and low impedance tape recorder outputs. **Controls:** 5-pos. Selector (dual-concentric), 5-pos. Mode switch, dual-concentric Volume, Bass & Treble controls, Tape monitor sw., Loudness sw., Phase sw., Input level controls (all inputs except Tape Head & Tape Monitor inputs), Push-Push on/off switch. **Semiconductor complement:** 28 Transistors, 10 diodes. **Power requirements:** 105-125 volts, 50-60 cycles AC. 35 watts idling, no signal; 200 watts, full power out. @ 120 volts with no load on AC receptacles. **Power outlets:** 2 AC receptacles, 1 switched, 1 unswitched. **Dimensions:** 15¼" W x 5" H x 14" D.

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Radio & TV News

Events in the Service Industry

AN ITEM caught our eye while we were glancing through one of the New York City newspapers a few weeks ago. The heading trumpeted, "Three Accused in TV Repair Price Gouge." Since we have a little something to do with the TV service business, we stopped turning pages and read carefully. Three Brooklyn men were accused "of organizing and operating a virtual syndicate of price-gouging radio-TV repairmen who preyed on unsuspecting customers." The trio was described as using "tactics reminiscent of bootleg barons by dividing the territory into zones, with a lieutenant in command of each sector."

We glanced up quickly to make sure that the doors were locked and the windows barred against invaders, then read on: "Specifically charged with conspiring to fix prices, the three allegedly cheated set owners by arbitrarily boosting repair prices at least 25 per-cent." We sighed in relief. But another emotion began developing. Reading further, we learned that the Maffia-type organization engaged in this sinister activity was the Brooklyn Radio and Television Servicemen's Association, "the parent body that recruited others to join up and agree to a fixed scale of repair prices."

In the next paragraph, we learned just how serious their crime was. Basic charge for a service call in the home had been down as low as $2 in Brooklyn. These ruthless mobsters were pushing it up to $3.95 and even $4.95. Reader, if you are hovering somewhere between befuddlement and rising indignation, you know how we felt. There was obviously more to the matter than the reporter, aroused by the lurid possibilities in his material, was conveying.

How To Fail Without Trying

Among the three names cited in the paper—there is no point in giving them here; these men have enough on their hands—we recognized one who has been in the service business and active in associations for years. His reputation for honesty among his fellows is enviable. We couldn't make quick contact with him, so we reached one of the other two officers mentioned.

As we give them to you here, the details we learned are far better organized than they were as they came from the informant, who was quite understandably agitated. He is a young man with a background in electronics who, after completing an honorable tour of duty with the Armed Forces, decided to settle down in Brooklyn. He hoped to build a future by opening his own service shop. Doing a decent job was not enough, however. In a highly competitive area, he found himself bucking others who were desperately offering house call fees of $2 *and even less*. He got together with a couple of other service dealers who shared his concern (the other two officers of the Brooklyn group cited in the "conspiracy").

The first step, they reasoned, was to form an association that would enable all similarly concerned service dealers to unite for deciding what to do and then taking action. Each volunteered to canvas shops in a particular portion of the area involved for the purpose of getting men to a meeting (*i.e.*; "dividing the territory into zones, with a lieutenant in command of each").

They found ready acceptance. Turning out a good crowd was no problem. Everyone had the same gripes. Controlling the crowd was another matter.

Oh, For Some Experience!

Our informant, relatively new to service, had had no previous background in association work. In fact, none of the names we mentioned to him, of individuals once active in his area, rang a bell. Unaware of pitfalls, he and his fellows found matters getting out of hand. Everyone had his own ideas and was pushing his own action. One individual who knew a printer, carried away by the urgent need to get a better house-call fee, had signs printed up for shop display carrying the new price and the name of the association. Although unauthorized by the group, these signs were bought up eagerly by many of those at the meeting.

When the complaint of price fixing was made to the Attorney General, he had no choice but to act on it. Evidentally aware that he was dealing with misguided businessmen rather than criminals, he seemed willing to work out a consent judgment without harsh punishment against the Brooklyn officers. Against legal advice, the association decided to fight the action. It feels the reputation of service is at stake.

We do not have the end of this story yet, but morals can be drawn from what has happened already. How badly these men needed the guidance of others who had experience in such matters! How sadly lacking such wiser heads are now in this area they abandoned after valiant but vain struggling! How desperate the plight of the service industry is where attempts to establish a successful association failed! Is this a warning to others elsewhere? ▲

Scope Voltage Calibrator

(*Continued from page 32*)

to lugs and quarter-watt resistors and subminiature capacitors could be used. Because of the low operating frequency, lead dress and parts placement are not critical. A four-pole, five-position, non-shorting rotary switch is used for the attenuator/power switch, S_1. In its extreme counterclockwise position, S_1 turns the calibrator off by disconnecting the collector supply voltage and both bias cells. The reason for disconnecting *each* cell with a separate switch section is that there would be a small amount of leakage if the positive side of B_1 and the negative side of B_2 were connected together by only one switch section.

Since practically no current is drawn by the clipper stage, *Mallory* type BC-3 subminiature bias cells were selected; each is mounted in a *Mallory* GB-17 clip. Care should be taken not to short these cells during construction for even the briefest moment.

S_1 should be wired as a subassembly. The attenuator network (R_1-R_{10}) consists of selected 5% half-watt resistors. From these the author selected resistors within 1% of the desired value by using an impedance bridge. If a bridge is not available, resistors with a 1% tolerance should be bought.

If you substitute transistors with a different *beta* than 2N217's, it may be necessary to use different value base-bias resistors (R_1, R_4) to get the multivibrator to start. If *n-p-n* transistors are used, it will be necessary to reverse the polarity of the collector supply voltage.

The calibrator is small enough to be wired directly inside an oscilloscope. If it is, the circuit board should be lengthened slightly and a simple half-wave rectifier and capacitor filter added to eliminate B_3. Operating power can be taken from the scope filament circuit. B_1 and B_2, of course, would be retained and S_1 would have to be mounted on the front panel of the scope. ▲

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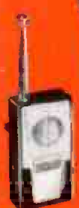

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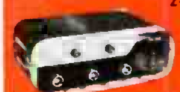

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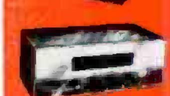

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CIRCLE NO. 123 ON READER SERVICE PAGE

The Digital Voltmeter

(Continued from page 47)

overcomes this condition by providing an output equal to the average voltage over a selected period. In many other instruments, however, it is necessary to use carefully designed filters to minimize noise voltage.

The *RC* elements in a filter tend to increase the time-constant of the circuit, and it is necessary to utilize them judiciously, especially where the d.v.m. is incorporated in an automatic test installation where it is switched rapidly from one test point to the next. Some instruments provide a selection of filters which can be switched into the circuit as needed. This permits the use of a minimum of filtering for quiet circuits, with greater filtering available for noisy circuits.

Filters are placed at the voltmeter input and thus become charged to the full value of the test voltage when a measurement is made. Since an *RC* network does not discharge at once, it is likely that a charge may still be retained when the next measurement is made. In making a series of measurements, the d.v.m. may be switched from a high-voltage point to a low-voltage point, transferring the stored voltage to the new test position. In the case of a tube grid or a transistor, this may upset the circuit enough to cause damage. It is good practice, therefore, to ground the probe briefly between measurements. In automatic installations, provision should be made to do this mechanically.

Related Instruments

Although d.v.m.'s are basically d.c. instruments, many are equipped to read a.c. as well, through the use of an a.c.-to-d.c. converter. The a.c. voltage is first rectified and then measured in the usual manner. Since rectifiers are linear over only a part of their range, however, it is customary to interpose an a.c. amplifier between the input attenuator and the rectifier to raise the voltage to the proper level. The amplifier also serves as a high impedance input device and thus minimizes the loading effect on the circuit under test.

Digital ohmmeters (d.o.m.'s) are essentially automated Wheatstone bridges. A voltage comparator detects any unbalance of the bridge, and the unbalance signal is amplified and used to vary the setting of a digital rheostat in one arm of the bridge. Some conventional d.v.m.'s are equipped with an ohms-to-d.c. converter. This device permits resistance measurements to be made by passing a selected constant current through the unknown resistance and thus develop a proportional d.c. voltage. This voltage is then measured by the d.v.m. in the usual way.

Digital ratiometers (d.r.m.'s) are similar to d.v.m.'s (Fig. 6) except that they measure the ratio of the input voltage to a reference voltage, rather than its absolute value. In most instances, the reference is an external supply voltage. A typical use of a d.r.m. is for measuring the position of the pick-off on potentiometer instruments. The reference in this instance is the voltage impressed across the potentiometer, and the input is the voltage at the pick-off. The ratio of the two voltages thus furnishes an accurate picture of the position of the pick-off in relation to the top and bottom of the potentiometer.

D.r.m.'s are suited for applications where an unknown voltage is obtained from a d.c. excitation voltage.

Digital ratiometers are useful in connection with pressure transducers, liquid level indicators, or for any instruments where variables are measured by the position of a potentiometer pick-off. They may also be used for read-out in analog computers. Since both the reference and the input voltages are supplied from the same source, the effects of fluctuations in the supply voltage are largely balanced out. ▲

REMOVING INSULATION

By RICHARD A. GENAILLE, K4ZGM

ONE OF the most annoying and frustrating chores around the shop is the removal of enamel or Formvar (vinyl acetal) insulation from copper wire. This type of insulation can usually be burned off while tinning the wire providing the wire diameter is quite small and sufficient heat is available to do the job. For the larger diameter wires such as are used for winding transmitter coils and transformers and for antenna work, the removal of insulation can prove to be a chore. One usually resorts to scraping the insulation material with a sharp knife.

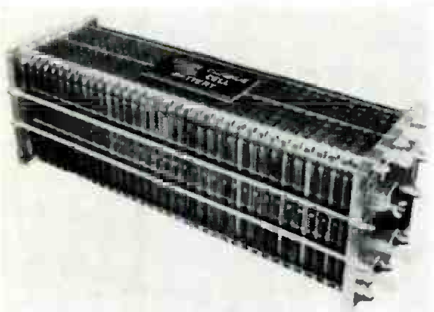
The author recently had occasion to tin a large number of #16 Formvar insulated wires and found that the non-flamable Paint and Varnish Remover No. 2779 sold by Sears, Roebuck and Co. did an excellent job of softening up the insulation to the point where it could be wiped off easily with an old piece of rag. The paint remover was poured into a small jar to the depth of about 1½" and the ends of the wires dropped into the jar and left overnight. The next morning the insulation was removed very neatly from the ends of the wires by wiping. If it is not convenient to suspend the wires to be cleaned in a jar or other receptacle, the paint remover may be applied with a paint brush. While the author allowed a number of hours for the removal process, the paint remover to do its job, the removal process can be accomplished in approximately 20 or 30 minutes. ▲

Fuel Cells

(*Continued from page 26*)

The fuel and oxygen are not consumed in the electrodes, but in two special regenerating tanks. The hydrogen enters the regenerator and reduces—adds electrons to—the electrolyte. Oxygen on the other side oxidizes—takes electrons from—the electrolyte on that side. The two solutions are separated from each other by a membrane, at which the reaction takes place. Ions migrate across the membrane, just as they do across the electrolyte solution in the regular cell, and maintain the reaction.

Although the Redox cell is inherently less efficient than the regular design, it has many attractive features. Polarization is less of a problem, it has lower internal losses, potentially higher current densities, and the ability to operate on impure hydrogen.

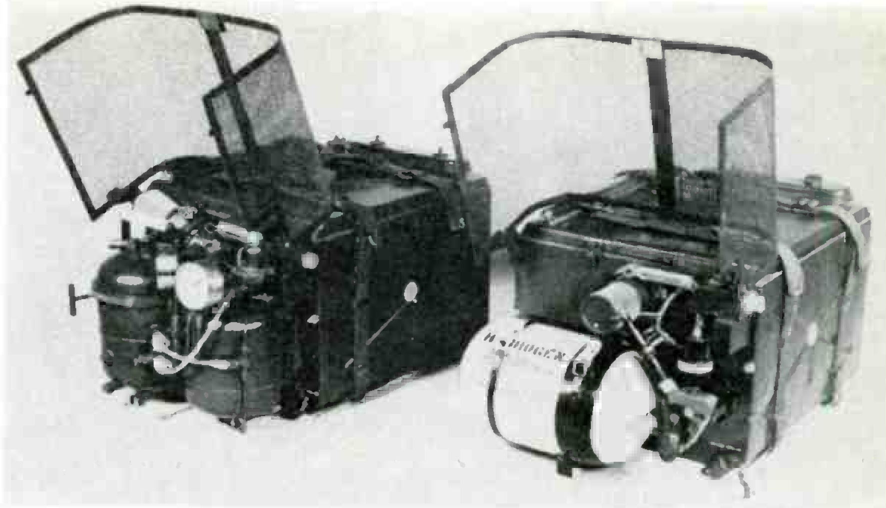


This fuel-cell battery, built by Union Carbide, contains 35 cells in series. It delivers 600 watts of power at 28 volts d.c.

Hydrogen-fueled cells are by far the most advanced at this time and will be the first to go into practical operation. But hydrogen is still expensive, even though it is getting cheaper all the time. For this reason, hydrogen-powered cells will be used only where the convenience of the cell makes the extra cost of fuel justifiable. The "Apollo" and "Gemini" are good examples of this philosophy.

Inexpensive Fuels

Really large-scale use of fuel cells will have to wait for further advances in the technology of cells that operate on cheap fuels. Work on these advanced units is proceeding rapidly. For the most part, present models are high-temperature units, operating in the vicinity of 1000 degrees F. The heat "cracks" the hydrocarbon fuel—methane, propane, vaporized kerosene, or gasoline—into hydrogen and carbon monoxide. Since any water-based solution would vaporize at these temperatures except under extreme pressure, the electrolyte is usually a molten salt, such as potassium carbonate, held in a sponge-like matrix of magnesium oxide. The hydrogen and carbon monoxide react with the electrolyte to form water and carbon dioxide and release electrons. Oxygen at the



These fuel-cell field power supplies are identical except that the one at the left manufactures its own hydrogen fuel from chemicals contained in the two tanks. The power supply shown at the right operates on a small container of hydrogen gas.

positive electrode attracts the electrons for a reaction similar to that which takes place in the hydrogen-oxygen cell. Such cells so far have produced no more than 500 watts per cubic foot—half the output of the *Union Carbide* cell—but undoubtedly this will be raised.

Low-temperature hydrocarbon cells—which would be far easier to manufacture—have also been built. Proper catalysts allow the same reaction to take place at much lower temperatures. *Esso Research Laboratories* has announced the development of a cell which operates at temperatures as low as 150 degrees F on ethane, propane, or ethylene. Its output is low, but the production of a low-temperature hydrocarbon cell which operates at all is a significant step forward.

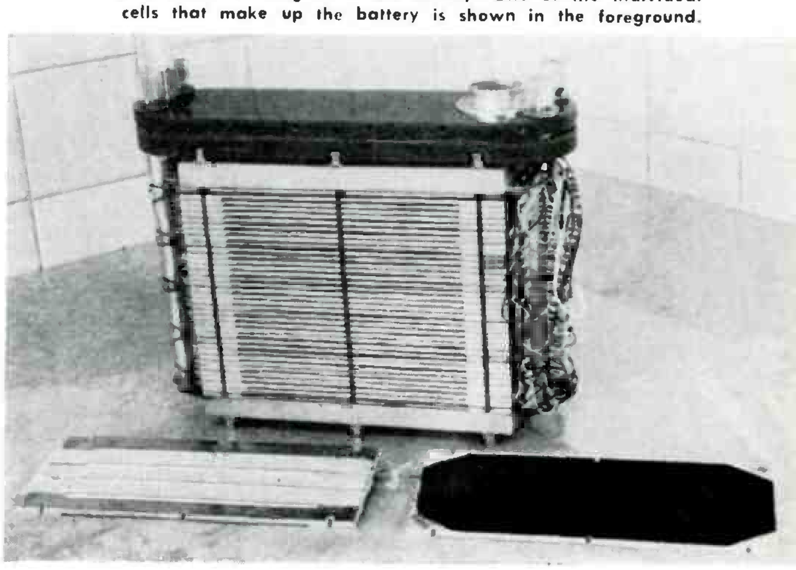
More Exotic Cells

In the search for ever-cheaper fuels and more efficient operation, some workers in the field have turned to biological fuel cells. Ideally, the electrolyte would contain organic matter—corncobs, sawdust, even sewage—and bacteria suspended in seawater. The bacteria produce an enzyme which acts as a catalyst for the electrochemical oxidation of the fuel, in a way similar to the reaction in a regular cell.

General Scientific Corporation of Washington demonstrated such a unit at a press conference several months ago, used it to power a small radio. Dr. Frederick D. Sisler of *General Scientific* said that bacteria could be put to work making electricity, using chemicals found in the sea as fuel. No figures as to operating characteristics or exact principles and no data on materials and fuels were released, however.

Electro-Optical Systems, Inc. of Pasadena, California and *Sonotone Corporation* of Elmsford, New York are working jointly on another kind of biological cell. The *EOS-Sonotone* unit is understood to operate on sugar and various proteins and to use synthetic enzymes rather than bacteria. But no further de-

A G-E ion-exchange fuel-cell battery. One of the individual cells that make up the battery is shown in the foreground.



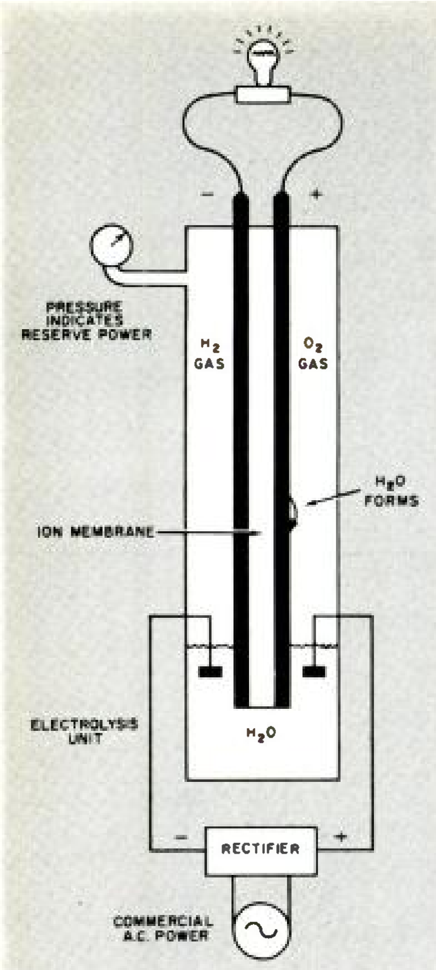


Fig. 5. Use of a fuel cell as automatic emergency power supply. Normally, the electrodes connected to the rectifier separate water into hydrogen and oxygen. These gases are stored in reservoirs on both sides of the membrane, where they generate power used for light. If the line power fails, the cell continues to operate the lights without interruption. When enough water has been electrolyzed into gas, the water level falls below the electrodes attached to the rectifier and the process stops. As power is drawn from the cell, the gases are changed back into water, the level rises, the electrolysis process is initiated again.

tails have been released. If biological cells ever become practical, they would be ideal for use in extended space journies. Garbage, human waste, and other useless substances could be used as fuel.

Future Power

Whatever the final form, though, there is little doubt that fuel cells will occupy an important place in future power generation. Military and space use will, of course, come first since utility, not cost, is the prime requisite in both fields. But with the development of the hydrocarbon cell, civilian uses will be close behind. The comeback of the electric car and truck, whispered about for some time now, looks more likely with the advent of the fuel cell.

The efficient electricity maker is a natural for automotive power. Cars could be designed with an electric motor in each wheel, eliminating transmissions, drive shafts, and, of course, the engine and all its complications. The fuel cell car wouldn't even need brakes. A load resistor thrown across the wheel motors would make them act as generators, slowing the car. Electric trains now use this type of dynamic braking. Then, too, fuel cells would produce no noxious exhaust—the only output of the cell is water—and would use no fuel while stopped at traffic lights. And, of course, they'd be some four times as efficient—and thus far cheaper to run—than today's autos.

Finally, since the cells wouldn't have to be lumped in one place like a gasoline engine, car designers would be free to design for superior roominess, riding qualities, and streamlining, distributing the cells around the body in convenient places. Troubleshooting in such a car would be done with a v.o.m.

Large-scale power generation—although it would be more efficient with fuel cells and thus cheaper—will face more serious problems. The low-voltage, d.c. current produced by the cells is perfect for autos, but not for our present a.c.-oriented power distribution system. Some simple, cheap method of changing cell output to high-voltage a.c. would have to be found.

In the meantime, one possible use for fuel cells might be to help nuclear electric plants run efficiently. To perform near maximum efficiency, nuclear plants must operate "wide open." Fuel costs per kilowatt hour rise sharply as plant output decreases. But electric usage varies substantially through the day and year.

Future nuclear plants might be adjusted to run at a rate just high enough to produce the total power needed over a long term. During periods of low consumption, excess power would be used to generate hydrogen and oxygen from water. In peak load periods, the gases would run fuel cells to meet the power demand.

The most important fuel-cell application ultimately may be the self-contained home power plant for either regular or emergency use. *Esso Research* and other firms have this in mind as a long-range possibility. Such a small "black box" in the basement would furnish power for lights, appliances, heating, air-conditioning, and so on. *Esso* engineers have gone so far as to estimate that the energy costs for an average six-room home might be cut from the present \$380 a year to \$125.

Fuel cells are, of course, only one of the exotic power sources being developed for future use. Others—magnetohydrodynamic, thermoelectric, and thermionic generators—all have their strong points, but none of them rivals the efficiency of the fuel cell. ▲

Mac's Electronics Service

(*Continued from page 44*)

calibrated voltage fed from a potentiometer. A meter is used just to indicate equilibrium of the two voltages. The millivolts, and consequently the measured temperature, is read from the dial of the potentiometer. Lacking equipment of that kind, I settled for this little gadget that indicates relative temperatures nicely and even gives a rough indication of actual temperatures between 100° F and 1000° F."

Barney pointed to a little black box lying on the bench with a small meter with a 0-10 scale in the top of it and a short length of brown thermocouple wire coming out of a small hole in the case.

"This is actually the antenna-current indicating unit from the war surplus 274-N transmitter," he explained. "The meter itself has rather special characteristics intended to give a roughly linear presentation of r.f. current when used with the r.f.-heated thermocouple inside the case. Shaded poles of the meter cause it to read full-scale with 5.5 ma. of d.c. and half-scale with only 1 ma. Best of all the meter has only three ohms of resistance. That means you get a good pointer deflection with only a millivolt or so across its terminals—something you couldn't get with the high-resistance microammeters I first tried to use.

"Actually all I did was whack off eighteen inches of that iron-constantan wire—the shorter the length the more sensitive the meter—and connect it to the meter terminals and twist the wires together at the other end to form a measuring junction. Notice I can make the pointer go up almost half a unit on the scale simply by pinching this junction; yet 350° F in Mom's oven only makes it read half-scale, and the heat of our soldering tip can't quite pin the needle. I used the oven thermometer to make this graph of approximate temperatures indicated by meter readings. Of course the graph only holds good while the ambient temperature of the meter terminals is at room temperature of around 72° F, but in ordinary usage it will be near that. However, I make no claims about the accuracy of the gadget. That's why I call it a 'heat indicator' instead of a thermometer. It does, though, show relative temperatures quite easily and told me quickly the blower lowered the bulb temperature of my transmitting tubes substantially. Notice how that meter pointer moves as I slide the measuring junction around on the bulb of this 60-watt lamp."

The pointer jumped up to 3.5 on the scale when the junction was touched to the end of the bulb and then went on up to 5 when the junction was slid around to a hot spot on the side opposite the filament.

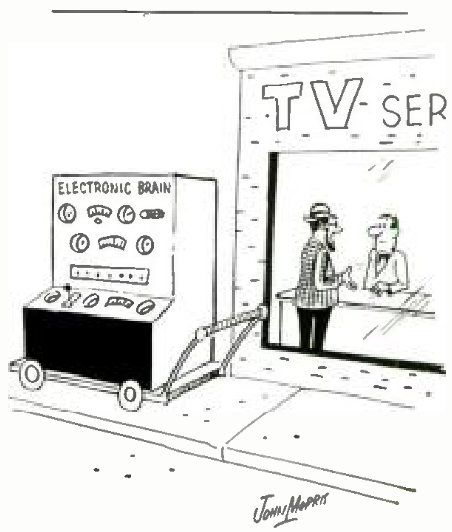
"If Bruce had used this on the rectifier tube, he could have guessed it would burn the carpet," Mac observed; "but he could have learned the same thing another way. Watch this." He picked up a crayon and made a gray-green mark on top of a rectifier tube in the TV chassis operating on the end of the bench. In a second or so the mark changed to a deep purple.

"What kind of a crazy mixed-up crayon is that?" Barney demanded.

"It's a 'Thermochrom' crayon manufactured by *Curtiss-Wright Corporation*. When a mark applied to a heated surface changes color in 1 to 2 seconds as this did, the temperature of the surface is within 5° C of the temperature indicated on the crayon. In this case, that's 150° C or 300° F. If the color changes more slowly, the temperature tested is not up to the change-temperature of the crayon. An almost instantaneous change means the temperature is higher than the change-temperature. Eighteen 'Thermochrom' crayons provide temperature measurement from 150° F to 1240° F.

"The same company also manufactures 'DetectoTemp' paints that work on the same principle, but thirty-six of these paints cover a range of 104° F to 2462° F. Applied to a cool surface, they will reveal developing hot spots as the temperature rises. Some of the paints hold the changed color. That means a critical component such as a transistor, transformer, tube, or motor armature can be painted and from then on will reveal if it is ever overheated. Both crayons and paints are used a lot in industry and research."

"I don't doubt it," Barney said as he studied the inside-outside thermometer on the wall; "but don't you suppose we could have picked a better day to discuss a hot subject like this? It's just a hundred degrees out there!" ▲



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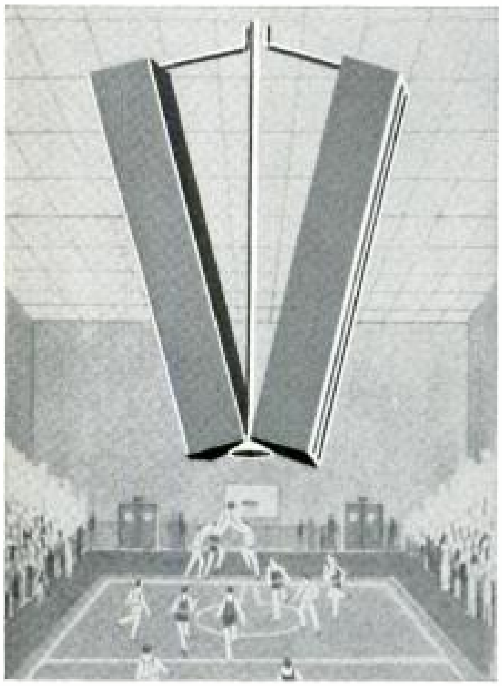
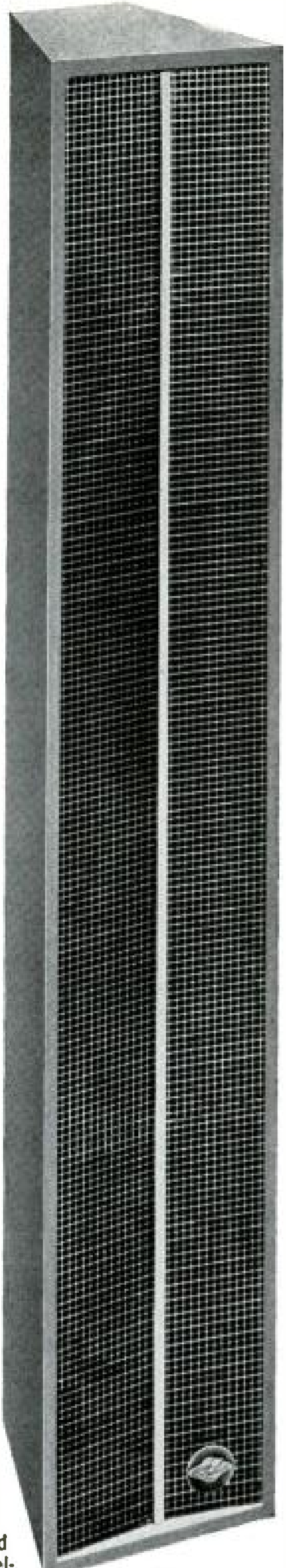
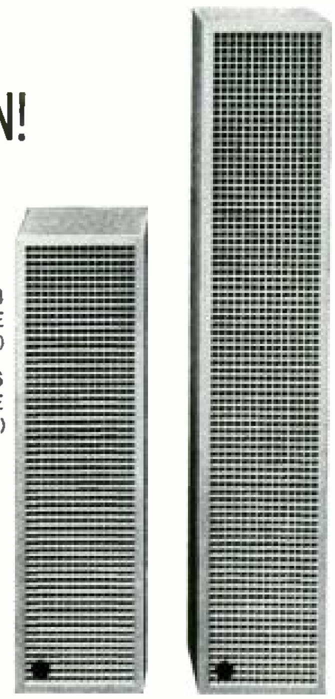




MODEL CS-4 UNILINE (Right)

MODEL UCS-6 UNILINE (Far Right)



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U.H.F. Conversions

(*Continued from page* 43)

installation. When it becomes wet or dirty, however, signal loss can increase by as much as six times. For this reason, an installation that works well initially can deteriorate in a very short time. In a weak-signal area, flat twinlead is an invitation to call-backs.

Hollow, tubular twinlead also has drawbacks. Although it has low loss at first, it can become filled with rain water. If it is used at all, then, care must be taken to run it so that no ends opening into the hollow center portion face upward and to provide weep holes at the lowest portion of the line. However, the best practice is to use one of the heavy new polyfoam cables, such as *Amphenol* 214-105, *Belden* 8325 or 8275, or *RCA* 933014. These are rugged and durable.

Fig. 4. Frequency-selective u.h.f.-v.h.f. splitters, like the Blonder-Tongue A107, minimize losses with a single downlead.

The rules for running v.h.f. downlead also apply to u.h.f. The difference is that you will have to toe the mark to get good results, since you can't get away with flouting good practice so readily. For example, keeping the wiring away from metal surfaces as much as possible becomes very important. Never splice u.h.f. cable. Keep lengths as short as possible, but don't run the lead near other wires. Use as few stand-off insulators as will support the cable properly, as each stand-off increases losses. When signal is very weak, use only the type of stand-off insulator that does not encircle the lead with metal.

Adapting the Receiver

Of approximately 55 million TV sets in the field today, less than 10 per-cent are equipped with u.h.f. tuners. The rest must be adapted, in either of two ways. On receivers whose tuners use separate strips for each channel, an individual u.h.f. strip may be inserted in place of one for an unused v.h.f. channel. These strips will become more readily available as u.h.f. becomes more popular. Although this is the least expensive method when one u.h.f. channel becomes available, it has drawbacks.

One u.h.f. strip enables the set to receive only a single u.h.f. channel, to which it is tuned. It makes no provision for future transmitters that may come into the area. Also, it provides no amplification of the received signal which may be necessary or desirable in many areas. Furthermore, installation is relatively difficult in terms of labor. In virtually all cases, the chassis must be pulled from its cabinet and sometimes it must be taken to the shop. Many cases may require alignment for complete success. This can build up the labor bill and introduce the possibility that the customer can blame the technician for other receiver faults.

For these reasons, most sets in newly opened u.h.f. areas are being equipped with tunable, all-channel converters. This unit, one type of which is shown in Fig. 5, normally sits on top of the v.h.f. receiver like a radio. It accepts u.h.f. signal from the antenna, converts it to a v.h.f. signal that can be handled by the TV set, and applies the signal to the latter.

The conventional converter contains a local oscillator, operating in the u.h.f. band (V_2 in Fig. 3), which is tuned 82 mc. below the frequency of the channel being received. Since 82 mc. is the dividing line between channels 5 and 6 on the v.h.f. band and the bandwidth of the converter output is fairly broad, converter output may be received by tuning the TV receiver to either of the two channels noted. One or the other will not be active in a given area. Adjustment of the fine-tuning control on the TV set or the tuning control on the converter will assure reception with the proper bandwidth, on either channel 5 or channel 6.

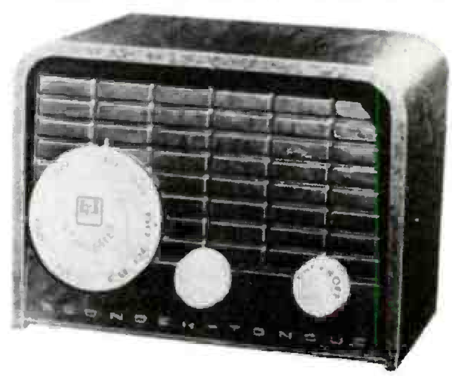


Fig. 5. This all-channel, top-of-the-set converter (the BTU-2S) also amplifies.

This method sounds simpler than it is. Since u.h.f. oscillators are not easy to design and produce, only a few manufacturers have been able to market converters that are reliable and durable. In poor signal areas, reception can be improved with a converter that also amplifies. The schematic in Fig. 3, which includes an amplifier stage (V_1), is for the BTU-2S converter shown in Fig. 5. A similar, less expensive converter, Model 99R, omits the amplifier stage for installations where the boost is not needed.

Most reliable converter manufacturers maintain factory service facilities, since very few service shops have either the equipment or the know-how to repair the tuning section or to perform alignment. However, converters are subject to a variety of easily cured ills. Thus the average technician can repair 80 or 90 per-cent of the troubles he will encounter with nothing more than a v.t.v.m., provided he does not disturb alignment.

Most troubles will be solved by tube replacement. When this is done, even though it involves the oscillator tube, there is no need to attempt re-alignment. The worst effect of a tube change is that there will be some shift in tracking on the u.h.f. band, which may not be very perceptible. In any case, this can be compensated in tuning of the converter or by adjusting the fine-tuning control of the TV receiver. Bandwidth and frequency response will not be affected. Be careful not to re-adjust or move any coils, contact strips, or trimmer capacitors.

Other common sources of trouble are the diode (Y_1), the rectifier (X_1), or a poor contact. Signal voltage from the oscillator is injected into the mixing diode through a wire "whisker," which extends from Y_1 to the oscillator. This "whisker" controls the amount of injection voltage. Since the wrong injection voltage can affect bandwidth and sensitivity, causing buzz in the sound or smear in the picture, be sure not to disturb its position.

If a diode has been replaced, carefully set the "whisker" to its original condition. The correct position, which will produce neither smear nor buzz on any u.h.f. channel, can be found by trial and error.

Another problem is that u.h.f. oscillators do not work on low line voltage. If reception tends to cut out, do not attempt other troubleshooting until you have checked to see that rectifier output is at least 90 volts and filament voltage at least 5.9 volts. With these hints and conventional troubleshooting methods, the need to use the manufacturer's service facilities should not arise often. ▲

Calendar of Events

AUGUST 23-26
NATESA Annual Convention. Pick-Congress Hotel, Chicago. Details from Frank J. Moch, Executive Director, 5908 S. Troy St., Chicago 29, Ill.

AUGUST 29-SEPTEMBER 1
1962 Congress on Information Processing. Sponsored by International Federation of Information Processing Societies. Munich, Germany. Program information from Dr. E.L. Harder, Westinghouse Electric Corp., East Pittsburgh, Pa.

AUGUST 28-30
Fourth EIA Conference on Maintainability of Electronic Equipment. Sponsored by Engineering Dept. of EIA in cooperation with the Dept. of Defense. University of Colorado, Boulder. Details from EIA, 1721 DeSales St., N.W., Washington.

AUGUST 31-SEPTEMBER 9
World's Fair of Music & Sound. McCormick Place, Chicago. All phases of music and sound. Open to public.

SEPTEMBER 3-7
International Symposium on Information Theory. Sponsored by the PGIT, Benelux Section & Belgian Societies. Free University of Brussels, Brussels, Belgium. Program details from F.L. Stumpers, Philips Research Labs., Eindhoven, Netherlands.

SEPTEMBER 5-7
Symposium on Measurement of Thermal Radiation Properties of Solids. Sponsored by Aeronautical Systems Division USAF, NBS, NASA. Biltmore Hotel, Dayton, Ohio. Details from C. Robert Andrews, Chairman of Arrangements, University of Dayton, Dayton 9, Ohio.

SEPTEMBER 13-14
Sixth National Symposium on Engineering Writing & Speech. Sponsored by PGEWS of IRE. Mayflower Hotel, Washington, D.C. Program details from J.E. Durkovic, c/o ARINC, 1700 K Street, N.W., Washington.

Tenth Annual Engineering Management Conference. Sponsored by IRE, AIChE, AICE, AIEE, AIIE, AIME, ASCE, ASME. Roosevelt Hotel, New Orleans. Program details from J. S. Cave, AT&T, 195 Broadway, New York 7, New York.

OCTOBER 1-3
Eighth National Communications Symposium. Sponsored by PGCS, Rome-Utica Section of IRE. Hotel Utica & Municipal Auditorium, Utica, New York. Program details from George Baldwin, Paris Road, R.D. #2, Clinton, New York.

OCTOBER 2-4
Eleventh Annual Symposium on Space Electronics and Telemetry. Sponsored by PGSET. Hotel Fontainebleau, Miami Beach, Fla. Program details from Otto A. Hoberg, George C. Marshall Space Flight Center, NASA Redstone Arsenal, Ala. ▲

8-Tube TV Design

(*Continued from page* 51)

cut is found in the latter stage. The audio-output cathode is grounded and bias, applied to the grid, is tapped off from the grid network of horizontal-output stage of V_5.

Sync separator V_{1A} is a conventional triode stage, except that the tube section used is one third of a 6AV11, whose envelope also houses two other triodes.

A single-pentode 6GF5, V_4, serves as combined oscillator and output tube in the vertical circuit. Tube economy is maintained here by using a special transformer with a tertiary winding. It provides the inductive coupling required, in the proper phase, between plate and screen, to sustain oscillation. The network between plate and grid, pins 3 and 7, shapes the output waveform for application to the vertical-deflection coils, L_{10A}. The hold control, R_{31}, is off the grid. The size control is R_{37}. Sync is maintained by applying pulses to the screen grid through the tertiary winding, from the sync separator plate.

Output from the separator is also applied to the horizontal phase detector, which consists of a pair of selenium diodes, CR_3 and CR_4. These bring the number of semiconductors to six. The a.f.c. voltage is applied to a conventional horizontal multivibrator—whose two triode sections are the remainder of the 6AV11, also serving as sync separator.

With low screen voltage, the 6GE5 horizontal-output tube, V_5, provides adequate output for the 92-degree deflection system. Helping to keep demand from this stage down is the fact that second-anode voltage developed by V_5 for the 19-inch, low-drive CRT is only 14,000 volts.

Service & Reliability

The hand-wired chassis is small enough to mount vertically along one side of the cabinet (Fig. 1). In this position, tubes and adjustments are readily available. Despite small size, the reduced tube complement permits plenty of working room under the chassis (Fig. 2). The sealed tuner has already been mentioned. Another significant contribution to reliability is the fact that, with filament power drastically reduced, the entire set consumes only 80 watts. Aside from operating economy, this results in a well laid-out chassis that runs cool. This should be no small factor in prolonging component life.

As to electrical safety, we tend to expect hot-chassis hazards in semiconductor power supplies like the one found here. An isolation transformer eliminates the problem. Its use was probably made practical by the need for a 6-volt filament source to heat available compactron types. ▲

<u>But you don't want to be caught without them</u>! You see, Delco Radio has <u>new sounds</u> planned for the 1963 General Motors cars—and <u>new parts</u> to make them possible. These are <u>vital</u> parts that you, as an electronic service dealer, will <u>need</u> to make the most of your business. So why wait? Get ready <u>now</u> for the new models by calling your United Delco representative.

DIVISION OF GENERAL MOTORS **DELCO RADIO** KOKOMO, INDIANA

EW Lab Tested
(*Continued from page* 20)

(better than −60 db *vs* −54 db rated). The output level was approximately 2 volts per channel. Drift was negligibly small. Due to the low output impedance, even large capacitive loads caused negligible loss of high-frequency response.

The frequency response was not quite as flat as the rated 20-20,000 cps ± 1 db. We measured a drop of about 4 db at both extremes of this range on mono, with the −1 db points occurring at 50 cps and 10,000 cps. In the stereo mode, the roll-off at the frequency extremes was slightly greater due, in part, to a built-in filter intended to reduce the 19-kc. pilot carrier in the output.

Stereo channel separation was about 30 db from 100 cps to 5000 cps, decreasing somewhat at higher and lower frequencies. The stereo noise filter, in addition to introducing some additional loss of high-frequency response, greatly reduced the channel separation.

In listening tests, the FM-100-B performed very well. The stereo quality was first-rate. Even the stereo filter, which made a worthwhile reduction of background noise on signals of marginal strength, did not seriously degrade the stereo performance. We did find one annoying effect, however. When listening to some moderately weak stereo broadcasts, fluctuations in level caused by airplanes flying nearby caused the "Stereo Beacon" relay to chatter. Switching to mono reception solved this problem.

The *Fisher* FM-100-B tuner sells for $229.50, without cabinet. ▲

Roanwell Stereo Phones

For copy of manufacturer's brochure, circle No. 59 *on coupon (page* 19).

THE *Roanwell Corporation* is a well-known manufacturer of microphones, headphones, handsets, and similar devices for commercial and military applications. They have now entered the high-fidelity market with a set of stereo headphones.

The phones are housed in plastic, shaped to follow the contours of the human ear. They are marked for left and right ears, but this is almost superfluous since putting them on backwards produces a sensation not unlike wearing one's shoes on the wrong feet. On the other hand, when properly worn, these headphones fit tightly yet very comfortably. Their vinyl ear cushions, which are foam-filled, make an excellent seal and external sounds are almost completely excluded. They adjust easily to fit anyone, and the vinyl headband can hardly be felt.

We received no specifications with the phones, but measurements indicated that their impedance (measured with the phones paralleled) is about 8.5 ohms, rising to 10 ohms at 15,000 cps. (Each phone has a nominal impedance of 20 ohms.) In listening tests, frequencies from 30 to 15,000 cps were clearly audible, with no significant peaks anywhere in that range. There was a peak at 17,500 cps, large enough to be audible in spite of our limited hearing at that frequency. The low-frequency reproduction was clean, without signs of distortion or muddiness.

These phones are very efficient. Connected to 8-ohm amplifier outputs, we reached ear-shattering levels at gain settings which produced a mere whisper from loudspeakers of moderate efficiency. We were impressed with their ability to operate at very high levels without unpleasant distortion. Subjectively, they can provide tremendous impact and realism when operated in this manner.

We also appreciated the fact that the phones are equipped with a long cord (about 14 feet), allowing the wearer some freedom of motion while using them. The cord has four color-coded wires, to which the user must fit plugs of his choice. The phones will be marketed by the *Heath Co.* at $37.50. ▲

Sencore PS120 Oscilloscope

For copy of manufacturer's brochure, circle No. 60 *on coupon (page* 19).

THERE are a good many technicians, including those engaged in radio-TV servicing, who swear by the scope and wouldn't attempt to go into a TV set's sync circuits without one. On the other hand, there still remains an even larger group of such technicians that are a little afraid of this most useful instrument. These men have bought a scope which is now gathering dust on their shelves or they have never invested in one at all. In an effort to make the scope especially palatable to these technicians, Sencore has re-

cently brought out a unit that looks and is about as easy to operate as a v.t.v.m.

To one who has lugged around many a 5-inch scope, the compactness (8½" high, 7" wide, 11" deep), light weight (only 12 pounds), and convenience of the Sencore PS120 with its 3" CRT is a welcome change. There are no dangling leads either, thanks to the built-in compartment that holds the input leads and low-C probe. The small size allows it to fit easily on a shelf or on the bench itself without its getting in the way. A large rectangular graticule makes the waveforms seen on the scope look larger than they actually are.

The scope is a wide-band instrument with a rated vertical response within ½ db from 20 cps all the way up to 6 mc. for color-TV work. Its maximum deflection sensitivity is 35 mv. r.m.s. for 1-inch deflection. Four sweep ranges are provided with sweep frequencies from 15 cps to 150 kc. Although at first glance, it appears that some operating controls have been omitted in order to simplify the scope, this is not true. Instead, by using two large dual concentric-knob controls, a row of six knobless pots, and by putting a couple of slide switches and input terminals behind the lead compartment front panel, everything has been taken care of.

The circuit of the PS120 is fairly conventional. Vertical signal comes into the scope through a frequency-compensated voltage divider to a cathode-follower. The signal is then amplified by two pentode stages and then by a push-pull triode output stage which feeds the vertical plates of the CRT. Frequency compensation is used throughout to maintain wide-band response. The sweep generator is a multivibrator whose output is applied to a push-pull triode output stage that connects to the horizontal plates of the CRT. Two rectifiers complete the circuit line-up.

We tried out the scope on the bench using a number of different input signals and found that it displayed all of these readily with a minimum of control adjustments. The control ranges were well centered, sync was positive and non-critical, and there was no evidence of hum modulation on the high-gain vertical channel. We did notice a little hum modulation in the horizontal channel however, and this had the effect of slightly spreading out the trace horizontally. We learned from the manufacturer that in some of the early production models there was some horizontal pickup by the CRT itself. This was remedied however by use of a Mumetal shield around a portion of the tube.

Our first measurement was of the maximum vertical sensitivity. This turned out to be 33 mv. r.m.s. for 1-inch deflection, slightly better than rated. The attenuation of the probe and the coarse vertical attenuator were then checked and found to be accurately 10:1. Since the fine vertical attenuator is calibrated for peak-to-peak measurements, we then proceeded to check the readings obtained from one end of this calibrated control to the other. We found that all readings were within +3 and −10 per-cent of their precise values. This kind of accuracy is certainly satisfactory for most service-type work. If it is desired to center the range of reading to improve its accuracy, then the gain of the vertical amplifier can be changed by an internal calibration adjustment.

Our next step was to check the frequency response of the vertical channel of the scope. Using the low-C probe supplied with the scope, we found the response to be flat from 20 cps up to 5 mc., dropping to −3 db at 7.5 mc. Interestingly, we were still seeing an indication of r.f. signal on the screen up as high as 12 mc. although we could not see individual cycles. We then connected our generator directly to the vertical input terminal of the scope. Our response now extended out flat to 3 mc. and was −3 db at 6.25 mc. Finally, using the direct probe, we found the response to be flat from 20 cps up to 2 mc., and then a gradual roll-off reaching — 3 db at 5 mc. This kind of response was the result of the shunt capacity of the input lead loading down the generator. The figures obtained certainly bear out the manufacturer's claim of a wide-band scope which is entirely suitable for color-TV work.

In summary, the Sencore PS120 (available at $124.50) turned out to be a compact, convenient, easy-to-use instrument having high gain and wide bandwidth—a worthwhile addition to any service bench.....................*E.W.*

Pictured below is a mobile communications laboratory designed by Electronics Communications, Inc. for the purpose of demonstrating, checking, and testing CB equipment. Dubbed the "Mobilab," the unit is completely self-contained.

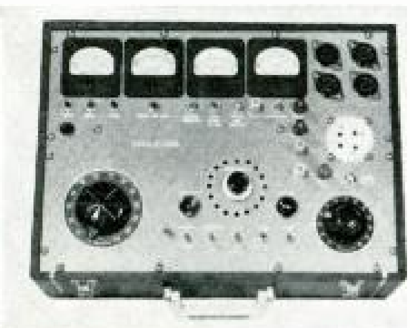
New Products and Literature for Electronics Technicians

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 19.

INDUSTRIAL TUBE TESTER

1 **Alectric Manufacturing Company** is marketing a thyratron and rectifier tube tester for industrial applications.

The Model JB-16D will handle all common industrial tubes from .1 through 16 amps. There



are four meters for measuring anode volts, grid volts, arc-drop volts, and filament volts. The instrument operates on 105-130 volts a.c., 60 cycles. It is housed in a portable case with hinged cover. Space is provided for the load resistor, plug, and cord.

HIGH-VOLTAGE CAPACITORS

2 **Mallory Capacitor Company** has expanded its tantalum foil capacitor line to include higher voltage ratings. Units with 200, 250, and 300 volt ratings will be added in tantalum smooth-foil construction.

The 85° C Type TAF capacitor will be available in five MIL case sizes, either polar or non-polar, in ratings up to 300 volts. For 125° C applications, the Type TAG capacitors, either polar or non-polar, will be available in four MIL case sizes at 200 volt ratings. A fifth MIL case size is available in lower ratings.

U.H.F. CONVERSION KIT

3 **Admiral Sales Corporation** has demonstrated a special u.h.f. field conversion kit for use with its recently introduced 1963 23-inch TV models.

This continuous tuner will permit the tuning of all u.h.f. channels. It comes complete with built-in antenna and is offered in two models, the UHF100 for the company's sets with full-range fine tuning and the UHF200 for receivers with automatic preset fine tuning.

The tuner has vernier tuning for receiving channels 14 to 83. It has plug-in connectors and can be installed without soldering.

COMPLEMENTARY TRANSISTORS

4 **Motorola Semiconductor Products Inc.** has introduced two pairs of low-cost complementary "p-n-p" and "n-p-n" mesa transistors especially suited for high-speed current-mode switching applications.

The new transistors, types 2N2256-2N2259, feature typical gain-bandwidth products of 320 mc. with turn-on and turn-off times on the order of 3 to 4 nanoseconds.

These new components are expected to be of particular interest to logic design engineers who want to capitalize on the advantages offered by non-saturated switching.

TV SAFETY SHIELDING

5 **General Electric Company's Cathode-Ray Tube Department** has developed an entirely new method of providing a safety shield across the viewing surface of a TV picture tube.

The new shielding, known as "Lamilite," consists of a thin coating of tough plastic which in effect is similar to the safety coating used on photoflash tubes. In addition to providing increased safety, the new material reduces reflection. According to the company, use of the new plastic shield can reduce the weight of a typical 19" TV picture tube installation as much as four pounds.

FOUR-CHANNEL EVENT RECORDER

6 **Rustrak Instrument Company** has added a low-cost miniature event recorder to its line of industrial and laboratory test equipment.

The Model 92 can provide facts on a wide variety of operations such as work-time or downtime of machinery, productivity of machines or personnel, continuity of production, need for maintenance, or quality control.

Weighing 3½ pounds and measuring 3½" wide x 5½" high x 4" deep, the instrument is housed in rugged die-cast aluminum case, coated with durable vinyl paint.

VOLT-TO-FREQUENCY CONVERTER

7 **Weston Instruments Division** is marketing a new solid-state converter which accepts d.c. signals of ± 0 to 20 millivolts for conversion to proportional frequencies.

The Model 180 operates as an inexpensive digital voltmeter when used with an electronic counter. Linearity is ± 0.1 per-cent. In its 0 to 20 mv. input range the instrument is ideally suited for transducer input. Higher ranges may be obtained with input attenuators. Input may be either positive or negative, polarity being displayed on the front panel by indicator lamps. Output frequency is 10,000 cps at 20 mv. Input impedance is 100,000 ohms.

TV PROJECTOR

8 **TelePrompTer Corporation** has introduced a large-screen TV projector weighing only 70 pounds and priced at less than half the cost of other big picture equipment.

The "Amphicon 190" is only 20 inches high and 21⅝" deep. It is designed especially for

classroom, club, industrial, and custom home markets. It provides pictures up to 12 feet in width. Brightness is eight footlamberts and highlight illumination four footcandles on an 8-foot-wide picture. The optical system uses a 12" mirror, 10" corrective plate, and has a relative aperture of f0.8.

PORTABLE FREQUENCY STANDARD

9 **Stancor Electronics, Inc.** has announced the availability of a portable, reliable frequency standard for the alignment of two-way radio networks including transmitters, relay stations, receivers, or transceivers.

The Model SC-101 was designed to meet the need for a lightweight, self-powered instrument for on-location applications. The battery-powered unit operates at any of ten pre-selected frequencies within the range of 10 to 480 mc. and at temperatures from −22 degrees F to +104 degrees F.

The instrument weighs 2.6 pounds and measures 7¾" x 4" x 4½".

12-AMPERE RECTIFIERS

10 **Sarkes Tarzian, Inc.** is now offering a new line of hermetically sealed rectifiers with d.c. load current ratings of 12 amperes maximum. The new line is designated Series 2.

Peak inverse ratings of 100 to 600 volts are offered in 100-volt increments. Mounting is simplified by a choice of base polarity.

DIGITAL PHASE CONVERTER

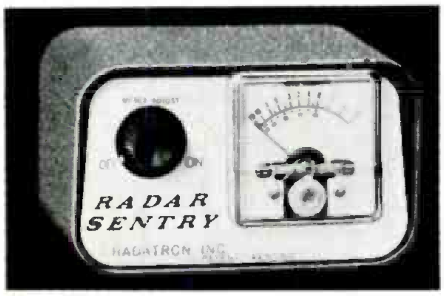
11 **ControlDyne, Inc.** has developed a new instrument for the accurate measurement of the phase angle between two a.c. signals. Known as the Model TE-103 digital phase converter, the instrument is offered in two versions. The "A" model will operate with input signals of 20 volts r.m.s. minimum and 400 and 800 cps at 150,000 ohms input impedance while the "B" model operates in the range of 500 millivolt

input signal from essentially d.c. to 10 kc. at one-megohm input impedance. Accuracy is ± .01% with the unit working into a suitable electronic counter.

The instrument is offered in either shelf or rack mountings.

FIELD-STRENGTH METER

12 **Radatron, Inc.** is marketing a miniature, transistorized microwave receiver which is designed for numerous laboratory and field ap-



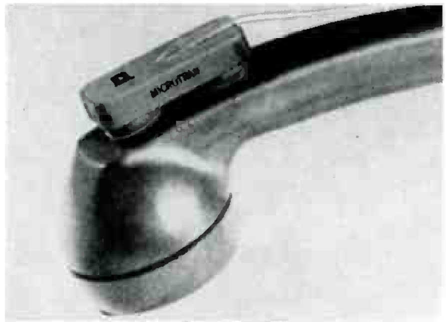
plications as a troubleshooting and testing instrument.

The "Radar Sentry" can be used by organizations employing microwave and radar equipment. The unit weighs only 13 ounces and measures approximately 3⅝" x 2¼" x 3¼". It is completely portable, being powered by two 1000-hour self-testing mercury batteries.

It is capable of receiving c.w. signals and all other types of modulation through a frequency range from 1000 mc. in the "L" band up through 11,000 mc. in the "X" band. Detection of radiation is indicated by an audible 800-cycle tone.

TELEPHONE PICKUP COIL

13 **Microtran Company, Inc.** has introduced a hum-bucking telephone pickup coil for use with high-impedance-input tape recorders,



amplifiers, and dictating machines when used in transcribing telephone conversations.

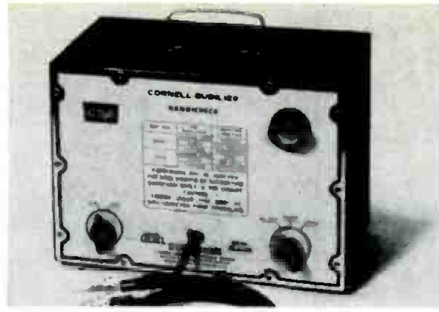
To eliminate the high stray hum pickup levels usually encountered, the new unit has been designed with symmetrical hum-cancelling pickup coils. The coil is housed in a gray plastic case which measures 2½" x ⅞" x ⅝". It comes complete with a 5-foot cable.

IN-CIRCUIT CAPACITOR TESTER

14 **Cornell-Dubilier Electronics** has released the Model BF-90 "Handicheck," an in-circuit capacitor checker for service applications.

The unit will detect open, shorted, or intermittent capacitors and will, in most cases, give an indication of the capacitor's condition for values ranging between 30 $\mu\mu$f. and 2000 μf.

Housed in a portable metal case, the unit



weighs 6 pounds, 12 ounces. Power is 110-125 volts, 50 or 60 cycles.

PRE-TINNED SOLDERING TIPS

15 **Electronic Ideas, Inc.** is now offering a complete line of pre-tinned soldering tips designed to be used with the firm's "Sidco" pencil-type soldering irons.

The tips are threaded for use with the firm's soldering tips and are made in both regular and iron-clad models, including conical, bent conical, and chisel shapes. A pre-tinned de-soldering tiplet is also available.

HI-FI—AUDIO PRODUCTS

SIREN/AMPLIFIER

16 **University Loudspeakers, Inc.** is now offering a new combination electronic siren and p.a. amplifier system, the "Vanguard I."

The unit is fully transistorized and push-button operated. The instrument is self contained and measures a mere 7"x 8"x 2½". It features a command panel of push-buttons designed to serve both as function and "on" buttons for maximum speed of operation. The panel is self-illuminated for greater convenience and to minimize possibility of error.

The siren/amplifier has been especially designed for CD, police, fire departments, etc. for instantaneous mobile operation during emergencies.

FM REBROADCAST RECEIVER

17 **Vitro Electronics** has recently introduced a crystal-controlled commercial-type stereo/mono FM rebroadcast receiver which eliminates the need for telephone lines or conventional hi-fi receivers.

Designed specifically for FM network applica-

tions, the "Nems-Clarke" Type FMR-101 has an r.f. section designed to produce a noise figure of 3 db and a sensitivity of 2 μv. for 30 db quieting. A specially designed filter network provides an i.f. bandwidth of 200 kc. with a shape factor of 2.7 to 1. The receiver is a single superhet with an i.f. of 10.7 mc.

Completely transistorized and nuvistorized, the FMR-101 has a solid-state power supply. It measures 19"x 3½"x 14½" and weighs 18 pounds.

STEREO PROGRAM INDICATOR

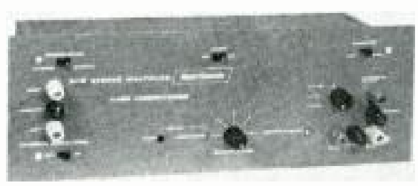
18 **Sherwood Electronic Laboratories, Inc.** is marketing the new Model SL-1 "Stereo-lite" which provides instant identification of FM stations broadcasting stereo programs. Special sensing circuitry prevents false indications due to noise impulses.

The unit measures 2½"x 2¼"x 7½" with its circuitry designed to operate with any present FM tuner on the market. Sensitivity is adjustable and adequate to operate satisfactorily with any FM tuner. The indicator is an NE-2H neon lamp while there are two parallel jacks for FM tuner input and multiplex adapter output.

MULTIPLEX SIGNAL GENERATOR

19 **Karg Laboratories, Inc.** has recently introduced the Model MX-1G FM multiplex stereo signal generator which is being offered as either a cabinet unit or for rack mounting.

The instrument generates the FCC-specified stereo signal for use in design, production test-

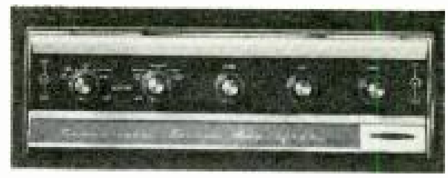


ing, and alignment of FM stereo adapters and receivers. The circuit features a unique stereo modulator design, crystal-controlled pilot and carrier signal, integral audio frequency oscillator, plus versatile switching provisions for the rapid testing of sync stability, channel separation, channel balance, and distortion.

TRANSISTORIZED STEREO AMP

20 **Heath Company** is now offering a fully transistorized 70-watt stereo amplifier, the Model AA-21, in kit form. Frequency response is 13-25,000 cps ± 1 db at 35 watts per channel or 50 watts per channel (IHFM).

This amplifier-preamp unit uses 28 transistors and 10 diodes to deliver full power over the frequency range. All controls are front-panel mounted and include a 5-position dual concentric input selector, a 5-position mode selector, and dual concentric volume, bass, and treble controls. A hinged lower front-panel conceals the tape-monitor input switch, speaker phase re-



versal switch, loudness switch, and all input level controls.

The kit features 5 circuit boards which eliminate most of the conventional point-to-point wiring. The preamplifier circuits are encapsulated in six epoxy-covered modules containing 70 resistors and capacitors, all factory wired and sealed. A completely assembled version of this instrument is available as the Model AAW-21.

ELECTRONIC PIANO

21 **The Wurlitzer Company** has recently introduced a transistorized electronic piano with battery pack.

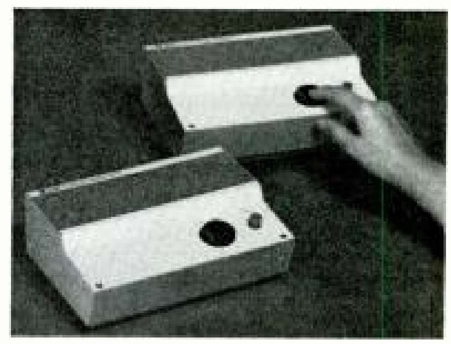
The 64-note portable Model 140 weighs 81 pounds and is finished in sandstone beige with matching bench. A portable cover snaps over the music panel and keyboard and provides storage for the legs. When packed for traveling, the piano measures approximately 39"x 21"x 8".

Earphones may be plugged into a jack on the front panel to redirect the sound from the speaker to the earphones so that only the player can hear, permitting silent practice sessions.

WIRELESS INTERCOM

22 **Allied Radio Corp.** is offering a new completely transistorized wireless intercom system in kit form as the No. 83 Y 991.

The two-station system operates by simply plugging into any a.c. outlet or d.c. power source.



Each station is a master, employing a large press-to-talk button which can be locked on when a unit is used as a monitor or electronic baby sitter. A special noise silencing "squelch" circuit cuts power-line interference and provides static-free standby operation.

The units are housed in eggshell white and Oxford grey cabinets measuring 3"x 8¼"x 5¾".

PROFESSIONAL TAPE RECORDER

23 **Vega Electronics Corporation** has introduced an all-transistorized professional magnetic tape recorder for critical applications.

The instrument is offered in two standard speeds, 7.5 and 3.75 ips with the frequency response at 7.5 ips 50 to 18,000 cps ±2 db. Wow is .03%, flutter is .08% for a combined wow and flutter equal to .09% at 7.5 ips. Start-stop action

is so fast it can cleanly split syllables, according to the company.

The Model V-30 is a two-channel audio frequency recorder-reproducer for quarter-inch magnetic tape. The transport and electronics are available separately if desired.

HEAVY-DUTY MICROPHONE

24 Astatic Corporation has added a heavy-duty industrial model to its line of microphones as the Model 551.

The microphone is unbreakable and sealed. It can be taken apart for cleaning without breaking the seal. The microphone offers a selection of high or low impedances, the choice being made by simply changing one wire on the terminal strip inside the unit. The mike features a shielded transformer for very low hum pickup and high signal-to-hum ratio; leaf-type switch; and coiled cables that stretch to 8 feet and recoil to 15 inches.

AUDIO/P.A. AMPLIFIER

25 McMartin Industries, Inc. has recently introduced an 8-watt continuous-duty amplifier especially designed for background music and p.a. applications.

The Model LT-80 provides frequency coverage of 30-15,000 cps ±1 db and has 4, 8, 16, 150 ohms and 600 ohm/70.7 volt outputs. Inputs are for microphone, program (10,000-ohm bridge), phono, and 600 ohms.

The unit is transistorized (8 transistors and 2 silicon rectifiers) and measures 9"x 7"x 4½".

HEAVY-DUTY COMPACT SPEAKER

26 Atlas Sound Division is now offering a compact, heavy-duty speaker especially designed for applications requiring ruggedness and reliability. The flange-mounting speaker can be installed flush with cabinet panels, ceiling bulkheads, or in any limited mounting area.

The speaker is weatherproof and incorporates a protective bell opening screen that provides additional structural strength as well as protection. The mounting hole circle is 6⅝" and the outside diameter of the flange is 7¼". Over-all length is 6⅛". Power is 25 watts at voice frequency, frequency response is 300 to 10,000 cps and impedance is 8 ohms.

CB-HAM-COMMUNICATIONS

10-CHANNEL CB UNIT

27 Webster Manufacturing has recently introduced a 10-channel CB unit designed for command installations in offices and for industrial applications.

Known as the "Band Spanner 440," the unit's ten channels insure command-post operations by giving a central executive office the opportunity to monitor secondary channels being used by various operations within an organization. A full-band tunable receiver permits the user to switch instantly and listen to traffic on all 23 CB channels.

The receiver employs an r.f. stage and two i.f. amplification stages. Other features include automatic noise limiter, squelch control, and a.v.c. A meter built into the instrument panel gives visual indication of output and modulation.

TELEMETRY RECEIVER

28 Regency Electronics Inc. is in production on an all-transistor, miniature, double-superheterodyne FM receiver for use in the v.h.f. telemetry band, 225-245 mc.

The STR-2500 Series measures 4½" high x 5¾" wide, and 11-15/32" deep and weighs 7 pounds. The units are of modular construction and are designed for shipboard application in tracking and scoring systems for guided missiles.

The receiver consists of three main sections: the main unitized chassis; the main amplifier plug-in unit containing the 1st and 2nd i.f., a.f.c. discriminator, output signal amplifier boards, and plug-in r.f. section; and the power-supply assembly. The r.f. section may be either crystal-controlled or variable tuned, and either type can be quickly interchanged from the front panel.

CRANK-UP TOWER

29 Rohn Manufacturing Company is now marketing a new "crank-up" tower specifically designed for amateur radio applications.

The No. 6 "crank-up" version is available in heights from 18 to 54 feet. The tower features a sturdy winch and cable which lifts the various sections easily and safely. It is completely hot-dipped galvanized and features all of the advantages of the firm's No. 6 tower. It is currently available in 18, 26, 37, and 54 foot heights.

R.F. INDICATOR PROBE

30 Dare, Inc. has recently released an r.f. indicator probe especially designed for use in such applications as tuning Citizens Band transmitters, receivers, and antennas as well as for TV receiver servicing.

The probe includes a precision 200-μa. indicating meter which provides a high degree of sensitivity for the required measurements.

TRANSISTORIZED CB UNIT

31 Vocaline Company of America has added a 6-channel transistorized unit to its CB radio line as the "Commaire ED-276."

The circuit features receiver fine tuning on the fixed channel positions to improve performance under extreme range conditions. There is also a combination panel meter for relative field strength, r.f. power, and frequency spotting.

The double-conversion superhet receiver uses ceramic transfilters for improved selectivity.

Squelch and r.f. gain are combined in a single control. A back-lighted dial covers all 23 channels.

The over-all size of this new instrument is 5⅜ inches high by 9⅝ inches deep. It comes complete with mike and coiled cord.

LOW-COST HAM TRANSMITTER

32 World Radio Laboratories has added a low-cost transmitter to its line of equipment for the radio amateur.

The "Meteor SB-175" transmitter provides complete coverage of the 80-40-20-15-10 meter bands with double sideband/AM/c.w. operation. There is straight-through final amplifier operation on all bands. A specially designed pi-network matches 50 ohms on all bands and will handle feedline standing waves of 2:1.

The unit measures 5" high x 8" deep x 11⅞" wide. It is housed in a modern wrap-around cabinet in coppertone and black.

NEW CB SET

33 Pearce-Simpson, Inc. has added a rugged, compact, and lightweight CB unit to its line of two-way radio communications gear.

Known as the "Companion," the new unit features a transistorized dual power supply of 12 volts d.c. and 115 volts a.c. The circuit includes five crystal-controlled, pretuned channels plus a tunable receiver and front panel transmitter crystal socket for all additional channels. A squelch circuit and noise limiter are included.

The new unit measures 8¾" wide x 5" high, x 12¼" long and comes with a universal mounting bracket.

SSB EXCITER

34 **Manson Laboratories, Inc.** is now offering its newly developed SSB exciter, the Model 508.

The unit is continuously tunable from 2 mc. to 32 mc. with frequency stability of one part in 10^8 per day. Spurious signals are at least 60 db below p.e.p. and second-harmonic radiation is at least 40 db below p.e.p. output while all other harmonics are at least 50 db below p.e.p. output.

Incorporated in the exciter is a 35-mc. direct-

reading solid-state frequency counter which is self-checking and system-checking. The exciter is also available with tuning in 100-cycle steps.

CB TRANSCEIVER

35 **Globe Electronics** is currently marketing a new CB transceiver, the "Star," which has received type acceptance from the CSA, the Canadian equivalent of the FCC.

The unit features new dual conversion and superheterodyne circuitry which is said to eliminate adjacent-channel interference and provide greater signal clarity and range. The circuit uses one triple-purpose tube, three dual-purpose tubes, six single tubes, and four silicon rectifiers.

Adaptable to five channels, the instrument is delivered with one set of crystals.

INDUSTRIAL TWO-WAY RADIO

36 **E. F. Johnson Co.** has just released a new high-performance two-way industrial radio which highlights moderate cost.

The "Messenger 202" transmits and receives in the 25-50 mc. band and is FCC type-accepted for use in the industrial, public safety, and land transportation radio services. The unit measures

7" x 5⅝" x 11⅜". The front panel is of functional modern design, grey and black in color and trimmed in chrome.

MANUFACTURERS' LITERATURE

TUNING FORK OSCILLATORS

37 **Accutronics, Inc.** has recently issued a short-form catalogue covering its complete line of tuning fork oscillators. The four-page publication is of particular interest to engineering personnel who need low-frequency oscillators.

Along with complete electrical and mechanical specifications, the brochure carries a listing of the firm's representatives in various sections of the country.

COMPONENTS FOR INDUSTRY

38 **Waldom Electronics, Inc.** has issued a 32-page catalogue of parts for industrial applications. Featured are over 1700 items of solderless terminals and connectors. In addition, the publication offers a complete selection of "Shakeproof" products, electronic hardware, instrument and equipment knobs and dials, instrument cases, terminal strips, standard and printed-circuit tube sockets, jack covers, and planetary drives.

AUDIO EQUIPMENT CATALOGUE

39 **Eric Electronics Corp.** is now offering a six-page catalogue introducing its Series 3000 line of high-fidelity and stereo components. The fully illustrated catalogue lists features and specifications on the firm's tuners, amplifiers, integrated receivers, and all-new stereo multiplex equipment.

EDUCATIONAL TV DATA

40 **Sylvania Commercial Electronics** has issued a 28-page booklet designed to provide educators and school administrators with a comprehensive, non-technical introduction to educational TV.

The fully illustrated booklet, titled "Television in Education," sums up the significant accomplishments of educational television, explains the various means by which open and closed circuit TV is transmitted and received, describes equipment requirements, and outlines the considerations for planning and installation.

SERVICE DATA LISTING

41 **Supreme Publications** is offering a free 48-page listing of the technical service data it is prepared to supply. The radio material covers receivers dating back to 1926 and up to present 1962 models while the TV data goes back to 1950 sets and up to current models. Details on ordering specific schematics are also included with the listing.

DIGITAL-DISPLAY GENERATOR

42 **Microdot Inc.** has issued a four-page data sheet covering its Model 412 FM signal generator. The brochure FMSG-1 contains operation theory and procedure as well as complete specifications on the unit. Photographs of the unit plus block diagrams on its applications are also included.

VARIABLE-VOLTAGE CONTROLS

43 **The Superior Electric Company** is now offering copies of its Bulletin CSR462 which describes in considerable detail its "Solidstat" solid-state, semiconductor-type variable-voltage controls.

The booklet illustrates various applications and provides data on the electrical characteristics of the models in the current line.

ILLUMINATED CONTROLS

44 **Illuminated Controls Incorporated** is now offering a full-color, illustrated brochure on its line of matrix-modular switching for the monitoring of commercial and military equipment.

Independently operated momentary or alternate action push-button switches are illustrated providing four colors for four visual conditions and also a single color indication. A section of the brochure covers illuminated control panels using the new "Isolume" concept which illustrates conditions during the monitoring of equipment.

SSB COMMUNICATIONS BROCHURE

45 **Adler Electronics, Inc.** has issued a six-page brochure describing the AN/TSC-18, 19, and 20 transportable single-sideband communications systems. The units are designed for air and ground communication centrals in applications involving long-range high frequency and multi-channel voice teletypewriter, among other uses.

COMPUTER-GRADE ELECTROLYTICS

46 **Sangamo Electric Company** has issued a 12-page booklet covering its line of computer-grade electrolytic capacitors. In addition to an extensive listing of sizes and ratings, the publication includes up-to-date design and application data.

Bulletin 2231A contains graphs, charts, and pertinent ordering information.

ULTRASONIC DRILL DATA

47 **Gulton Industries, Inc.** has issued a new bulletin on its "Glennite Hi-T" ultrasonic impact drills. These instruments are especially suited for use in the electronics, ceramic, optical, and similar industries requiring precision machining of brittle hard-to-cut materials.

The bulletin contains a list of these materials and photographs indicating the range of cut shapes which the drill can produce. Details on the various drills are also included in Bulletin V7d.

TERMINAL BLOCK CATALOGUE

48 **The Rowan Controller Co.** has available a 24-page catalogue which provides complete information on the firm's line of terminal blocks, terminal strips, special connectors, and accessories.

The various items in the line are illustrated and complete specifications and application data provided.

GOLD-BONDED GERMANIUM DIODES

49 **Clevite Transistor** has issued a single-page data sheet describing a new series of milliminiature gold-bonded germanium diodes. The new series, CID205 through CID209, consists of five basic types able to perform the functions of virtually all existing subminiature types.

Bulletin TB230-1A lists all electrical and mechanical specifications on these new units.

COMMUNICATIONS EQUIPMENT

50 **Manson Laboratories, Incorporated** has released short-form catalogue No. 1000 covering its line of communications equipment.

Fully illustrated, this 8-page book provides full specifications and descriptions of the firm's line including h.f. and u.h.f. systems, exciters, receivers, amplifiers, stabilization kits, crystal frequency synthesizers, frequency standards, precise oscillators, crystal ovens, multipliers, and dividers.

TRANSISTOR TESTER DATA

51 **RD Instruments Division** has available a new 6-page technical brochure which describes the Model 1880 dynamic beta transistor tester made by its parent company, **The Hickok Electrical Instrument Co.**

Brochure RD1880 describes the tester in detail and provides technical specifications, simplified schematic diagrams, and circuit descriptions of the a.c. beta, d.c. beta, and leakage tests.

SWITCHING TRANSISTORS

52 **RCA Commercial Engineering** has issued a six-page brochure covering the reliability of its 2N706, 2N706A, USA2N706, and 2N708 double-diffused "n-p-n" silicon planar very-high-speed switching transistors.

Bulletin No. 62S3 provides data establishing stability, electrical uniformity, and long operating life, MIL-S-19500 environmental and mechanical testing results, and frequency distribution analyses.

ANTENNAS AND ACCESSORIES

53 **Master Mobile Mounts, Inc.** has issued a comprehensive 20-page catalogue covering an extensive line of antennas for CB, CD, mobile, v.h.f., and ground-plane applications.

In addition to picturing and describing each antenna in detail, the catalogue includes hundreds of accessory items for communications radio antenna systems, as well as crystals, a field-strength meter, and antenna mounts of various types.

TAPE-HEAD TIPS

54 **Nortronics** is offering copies of its new booklet "Magnetic Tape Heads—Care, Wear and Replacement." The publication carries full replacement head listing, detailed information on tape recording principles, and proper care of tape heads. ▲

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PARTY record with catalog, $1.00. Pioneer, Box #38E, Station F, Toledo 10, Ohio.

FM Stereo

(Continued from page 29)

Next, let us turn our attention away from the transmitter that is producing the FM stereo signal and consider some of the problems that may arise at the receiving location.

Reception Problems

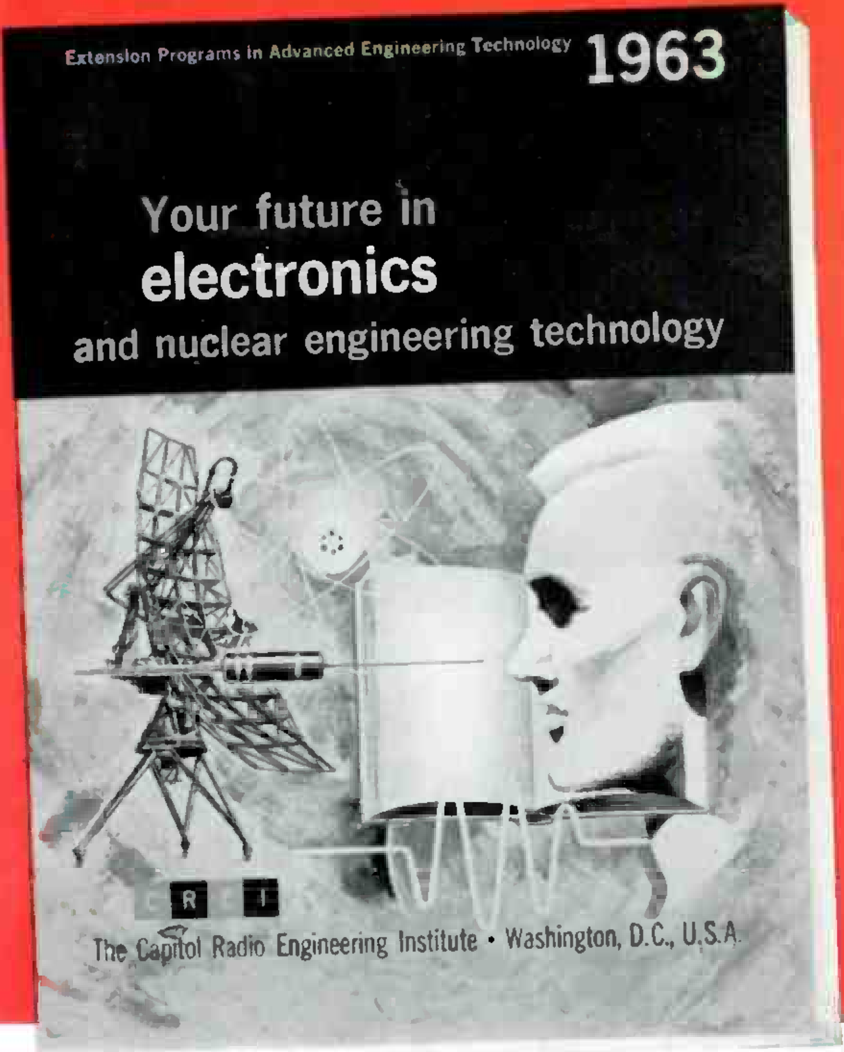
It has been observed in our own monitoring away from the station itself that FM stereo has many of the same problems as television, especially ghosting. If a non-directional or bi-directional antenna is used for receiving FM stereo, simultaneous reception of a signal reflected by an object (such as a hill) only a mile away can completely destroy separation by making the receiver receive the right and left channels simultaneously. This will usually be accompanied by distortion of the signal. On the other hand, a monophonic signal may be received perfectly. So, as a recommendation to FM stereo listeners, it is wise to avoid turnstiles and other relatively non-directional antennas when receiving FM stereo. If you do not receive a good stereo signal from an FM station which you know is broadcasting a good stereo signal and you suspect that the troubles may be caused by reflections, try connecting an oscilloscope to the tuner multiplex jack. You don't even need to have a sync signal to be able to see the odd peaks and jags which will occur in the 19-kc. sine-wave. When the antenna has been adjusted for a good clean sine-wave which looks like the one in the photos, you should be able to reconnect your adapter and enjoy a distortion-free signal with good separation.

If you still have trouble, here are a couple of suggestions which may help you. First, tune in a stereo station which occasionally transmits a signal, such as voice announcements, on only one channel. Tune in the signal as best you can, then disconnect the audio to the channel being used by the announcer. If everything is working perfectly, you should now hear nothing. If you do hear sound, first rotate your antenna for minimum signal and then adjust your tuner frequency dial for minimum signal. As you do either you will first hear no signal (because you are not tuned to the station), then you will hear a signal (probably distorted), then a null (this is the point you want), then a signal again (probably distorted), and finally no signal as you tune away from the station frequency.

The same effects occur as you rotate the antenna. Leave the tuner tuned and the antenna aimed for the null. Now turn on the other channel audio and you should be "in business" and ready to enjoy the FM-stereo broadcast. ▲

INDEX OF ADVERTISERS SEPTEMBER 1962

Printed in U.S.A.



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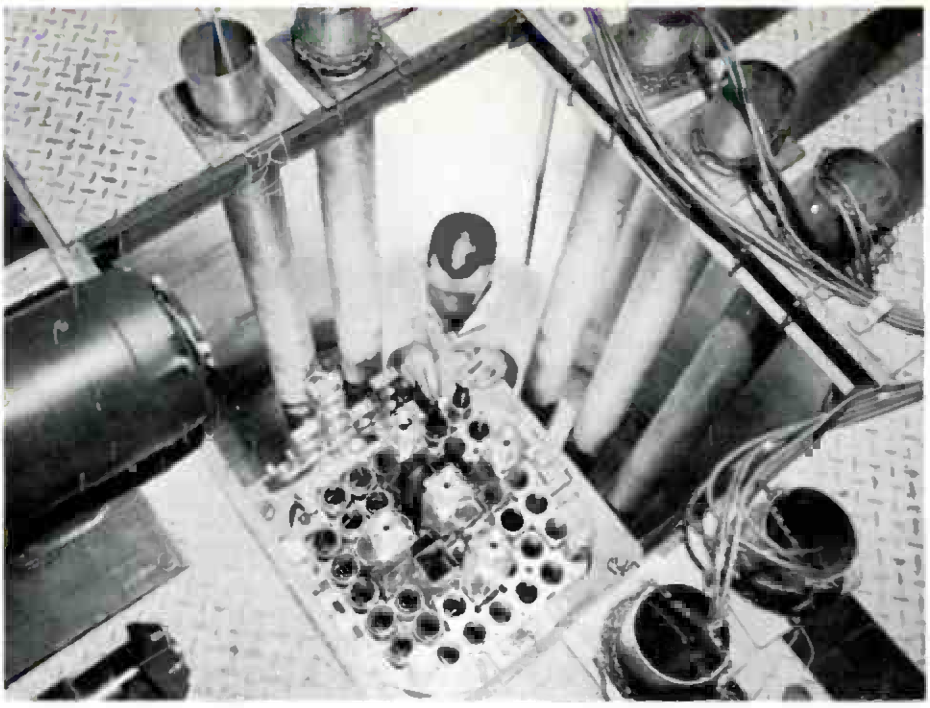

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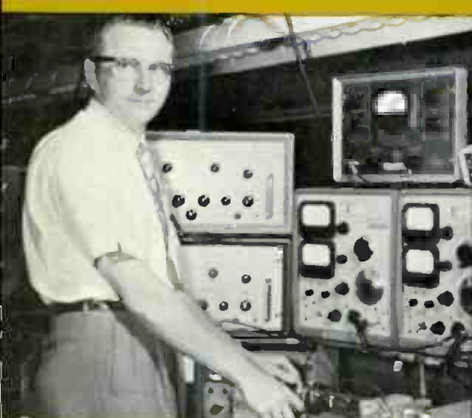
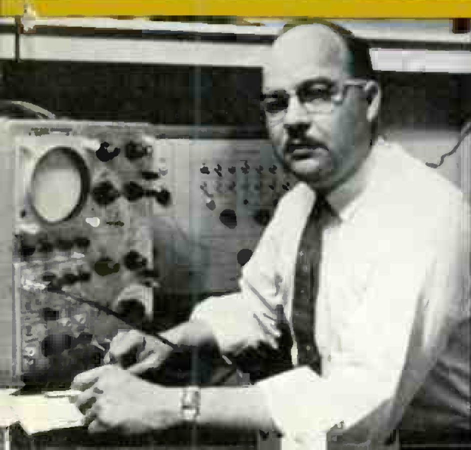


RICHARD S. CONWAY (CREI grad 1960) is Supervisor, Electronic Test Department, Wilcox Electric Co., Kansas City, Mo.



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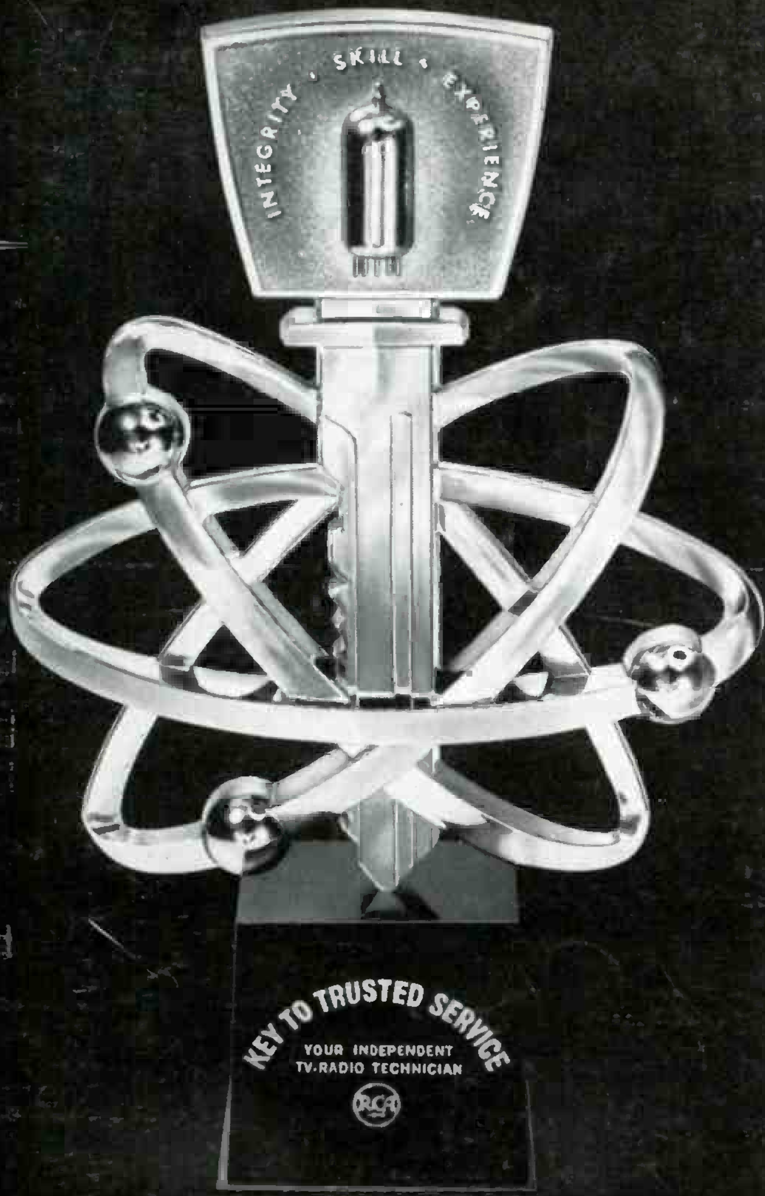

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