Electronics World

JUNE, 1962

50 CENTS

SPECIAL TEST EQUIPMENT ISSUE

Directory of Test Equipment Kits • Lissajous Patterns • Oscilloscope Directory

Nuclear Radiation Gages • Test Equipment for Communications Servicing

Instrumenting the Service Shop • Dosimeters • Automated Testing • Oxygen Analyzers

Cover Story—Technicians in the Computer Industry

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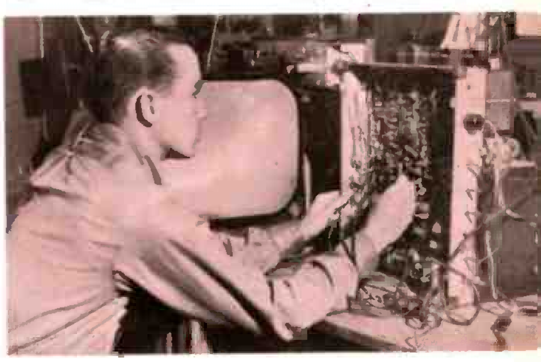

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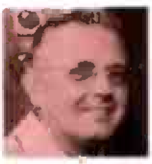
Thousands of NRI graduates throughout the U.S. and Canada are proof that it is practical and profitable to train at home for a career in Electronics. NRI graduates can be found in every field of Electronics: inspectors, maintenance men, lab technicians, testers, broadcast and mobile radio operators, TV and Radio service technicians; or in essential research and development posts with military and government agencies. Hundreds of letters received from NRI graduates tell us what they do and earn. Here are excerpts from some of them:

"The Finest Job I Ever Had," Thomas Bilak, Jr., Cayuga, N. Y., says of his position with G.E. Advanced Electronic Center. "Thanks to NRI, I have a job which I enjoy and pays well."

"I Owe My Success to NRI" says Cecil E. Wallace, Dallas, Texas. He holds a First Class FCC License, is a Recording Engineer at station KRLD-TV.



Marine Radio Operator is the job of E. P. Searcy, Jr., New Orleans, La. He has also worked as a TV Transmitter engineer. He says, "I can recommend NRI training very highly."

From Factory Laborer to His Own Business with sales of $158,000 in one year. That's the success William F. Kline of Cincinnati, Ohio, has had since taking NRI training.

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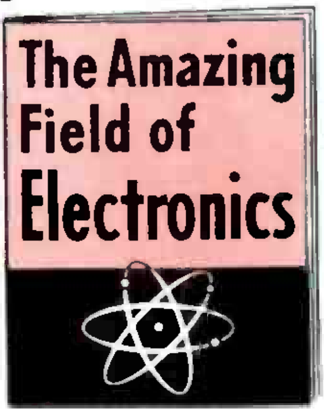

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3 DON'T LOOK FOR SERVICE "BARGAINS."

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4 CALL YOUR TV EXPERT AT THE FIRST SIGN OF TROUBLE.

Don't wait for your set to go completely dead. Failure of one TV part sets up a chain reaction—other parts are damaged and repair costs pile up. Early attention prevents this and also makes it easier—and less expensive—to find and cure the trouble. To keep your repair costs low, call your TV technician when trouble *starts!*

5 TRUST YOUR INDEPENDENT TV TECHNICIAN.

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MONTHLY FEATURES

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...for the Record

By **W. A. STOCKLIN**
Editor

THIS ISSUE

As YOU read this, the Annual Electronic Parts Distributors Show is just getting underway at the Conrad Hilton Hotel in Chicago. Each year this industry-wide event has been growing in stature with new features added to make it a worthwhile occasion for everyone involved.

As in past years, the Show Corporation Committee has worked tirelessly to insure that those attending the Show derive maximum benefit from the event. Seminars, business sessions, and free time for conferences with manufacturers and their representatives are to be the order of the day.

And in keeping with our annual tradition at Parts Show time, we are again bringing you a Special Features Issue which this year includes outstanding articles on test equipment of all types for a variety of applications in industry, the laboratory, and the shop.

To bring you up to date on the newest and best of the test equipment available to professionals we have assembled 10 outstanding features designed to provide the broadest coverage of test equipment that space permits. This issue has been in the works for over four months and represents a wide variety of material of interest to *every* technician.

We have included in this issue a gatefold carrying some 48 Lissajous patterns all of which can be put to immediate practical use by the technician. In conjunction with this chart, we are running a four-page directory of oscilloscopes which presents complete electrical and mechanical specifications on a wide range of commercially available instruments.

In another section of this issue we have presented what we believe to be the most complete and extensive tabulation of test equipment available in kit form ever compiled. Over 200 models of standard and specialized test gear have been included, along with pertinent specifications and prices, for personal as well as professional applications.

And for those interested in industrial electronics, nuclear radiation gages — one of the new workhorses of industry — are discussed in considerable detail as to their types and applications in this month's lead article. Another device, whose applications range from use in premature infants' wards in hospitals to the space helmets of astronauts — is covered in the article on oxygen analyzers.

Nor have we forgotten the radio and TV service technician. For while there will always be a very small number of technicians who seem to get by with the "spit-and-touch" servicing techniques of yesteryear, the enlightened and progressive technician is aware that something better is needed if he is to handle his job expeditiously and in a professional manner.

For these men, John Frye has prepared a three-in-one article on basic test equipment which all of our readers should find helpful. In a carefully thought-out presentation, Mr. Frye has outlined the test equipment needed by all types of service organizations—from the one-man shop to elaborate setups involving the servicing of everything from TV sets to two-way radio gear and industrial controls.

And, speaking of two-way radio, *General Electric's* "Tex" Smiley has written a comprehensive analysis of the test equipment needs of the communications technician. Based on his experience as national service manager for *G-E's* Communication Products Dept., the article offers a lot of down-to-earth advice for both beginning and experienced technicians in this field. We think you will find his ideas worthwhile and helpful.

Another subject of importance to technicians is that of automation and its effect on the future of their profession. The article "Automated Testing: Men & Machines" takes a long, hard look at the future both from the standpoint of the growth of automation and that of the men who will command, service, and oversee the machines.

In addition to these special articles and features for practicing technicians, readers will find an interesting and varied selection of informational articles on a number of other subjects. For example, those interested in the employment potential for the qualified technician in the computer industry will want to read the article "Technicians in the Computer Industry" by *IBM's* Director of Personnel. Audiophiles will be interested in Edgar Villchur's study of "Distortion in Loudspeakers" and his analysis of the causes of distortion as well as its magnitude.

In this issue we have tried to bring you the best articles by the best authors we could find to help you with your professional test equipment problems and other matters of vital interest to your career. We hope we have succeeded.

We also hope to see many of you at the 1962 Electronic Parts Distributors Show in Chicago — one of the major events on our industry's calendar. ▲

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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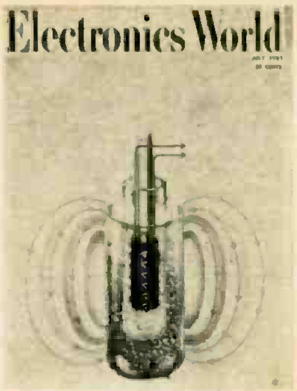

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MARINE RADIO SERVICE INSTRUMENTS
You don't have to spend thousands of dollars on test equipment in order to get into marine radio work. The author, who has years of experience behind him, offers a sensible appraisal of the equipment needed to do a professional job in this area.

TRANSISTORIZED CB EQUIPMENT
A boon to the mobile CB operator—now several companies are offering completely transistorized Citizens Band equipment. This new gear delivers several watts of r.f. output and operates close to the maximum legal power ratings. Here is a rundown on some of the equipment now on the market.

ELECTROMETERS
When the impedance of conventional v.t.v.m.'s is too low for certain measurements in industrial electronics, electrometers are taking over such jobs as measuring the output voltage of quartz crystals, the contact potential of dissimilar metals, static charges on plastics, and other critical parameters. Here's how they do it.

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Details and applications of an important industrial instrument that can record 50 or more channels of data and produce an almost instantaneous and permanent record of the results.

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Those of you who have been looking for a high-quality, low-distortion preamp will want to build this unit. It offers feedback volume controls and tone controls for flexibility and outstanding performance.

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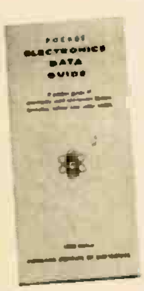

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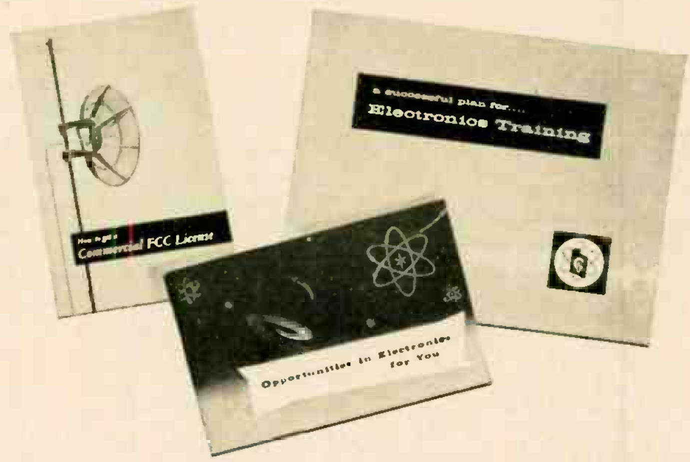

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LETTERS FROM OUR READERS

MUSIC-POWER EDITORIAL

To the Editors:

Your editorial in the February issue of ELECTRONICS WORLD wins you the title of "Mr. Missionary." It is high time that someone approaches the problem of calling a spade a spade.

I feel that this is only a start and I, personally, would like to see you expand this effort to cover all phases of this field from microphone or pick-up right through to the speaker systems.

This latter, the speaker system, is badly in need of an honest approach. It seems that the present method of rating power-handling capacity is that point at which the entire system disintegrates into a mushroom cloud. Don't get me started on the subject of frequency range.

GERRY MCL. COLE
Argos Products Company
Chicago, Illinois

To the Editors:

Your editorial on page 6 of the February issue entitled "Hirsch-Houck Lab Reports" was a welcome one, containing highly valid comments on amplifier power ratings and reflecting great credit on the magazine as an honest purveyor of unbiased information to the reader. The problem of amplifier power ratings is of especial interest to us as makers of electronic-organ kits, for the sound of our organs is always heard through standard high-fidelity amplifiers which the organ owner owns or purchases from an independent source. We have had to explain, time and time again, that organs produce essentially steady tone and not the generally low power level with occasional peaks produced by the music ordinarily heard *via* records and radio. The organ, furthermore, produces frequencies as low as 32.7 cps at full power—and many is the organ owner who cannot understand why his "30-watt" amplifier overloads under these circumstances at volumes which seem considerably lower than he can obtain with recorded orchestral music. A typical example is the one you cite, where a "50-watt" amplifier would be useful for only 15 watts of "organ power."

I believe this is an outgrowth of the endless rat race for bigger sales through making things look bigger. Remember when a TV CR tube about 10 inches in diameter was advertised in a receiver as a 10-inch tube? Now they talk about square inches, which is a bigger number but means little or nothing more. Is the usual stereo amplifier advertised as "30 watts per channel?" No; it is a "60-watt" amplifier. And in our own field, some organs having 44 keys per manual are advertised as having "88 keys." Nobody is lying. But this method of inflating the figures gives a meaningful picture of the actualities only to the person with enough knowledge to break the figures down.

It's time someone stood fast and refused to go along with this nonsense. You and *Hirsch-Houck* have done just that with amplifier power figures. And my hat is off to *Pilot,* whose 248 amplifier is reported in the same issue, for advertising a 30-watt-per-channel amplifier as exactly that—and not as 60 or 80 watts "music power," whatever that may mean to the average reader. This may give *Pilot* a slight handicap in the numbers race with ignorant customers (those who don't read ELECTRONICS WORLD). But an extra few bucks is something you can't take with you; a reputation for integrity you can!

RICHARD H. DORF
President, The Schober Organ Corp.
New York, N. Y.

Our editorial pointed out that, although there is some validity to the music-power measurement technique, we are sticking to the stricter, easy-to-duplicate continuous sine-wave power method of measurement.—Editors.

* * *

TRANSIENT RESPONSE OF DUAL CHAMBER

To the Editors:

I have received some correspondence from readers of my article "Double-Chamber Speaker Enclosure," which appeared in the December 1961 issue, concerning the transient performance of the enclosure described.

In previous articles on reflex enclosures, I have explained my own viewpoint about the highly emotional arguments involving transient response of loudspeaker systems. Very briefly, I don't think that transient distortion (or, for that matter, reasonable amounts of even-order harmonic distortion) are subjectively objectionable in the very low bass range—say, below 65 cps. The muddiness, boominess, garble, hash, fuzz, etc. which are all too evident in many loudspeaker systems in the bass range are almost always due to troubles in the region between 80 and 200 cps.

There is almost universal confusion regarding the frequency range of this type of distortion because it is a common tendency, even among professional and experienced audio people, to subjectively judge bass frequencies about an octave lower than they actually are. In music, the vital bass line very seldom dips below 60 cps, even on the organ. Therefore, muddiness in the bass is usually caused by irregularities in a speaker's performance in the 80-200 cps range, or even higher. The initial attack

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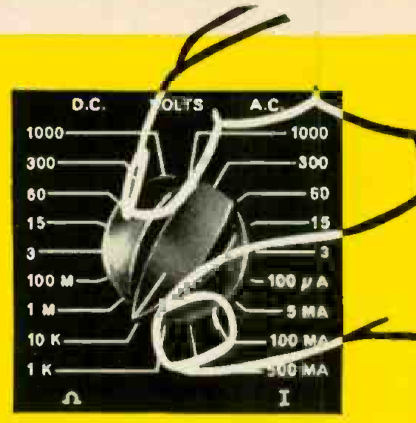

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of a bass viol string or tympani effectively lies much higher than the fundamental, and a speaker which goes all to pieces when overdriven at 350 cps may then very well betray its deficiencies by altering the sound of the lower-pitched drum.

Assuming that a reflex enclosure is large enough in volume to suit the characteristics of the speaker installed, and that it is not tuned higher than 65 cps, I submit that it cannot and does not degrade the audible transient response of the speaker whether it is tuned for optimum results or not. For years I have been suggesting a simple little test to people who are convinced that reflex enclosures introduce boom or hangover; cover the reflex port with a block of wood and note that the troubles are still there. The enclosure may be too small, it may not be sufficiently rigid, there may be strong standing waves in the listening room, but the effect of the Helmholtz resonator tuned to some frequency below 65 cps is *not* to add boom and hangover.

Once the enclosure *is* tuned for best results with a given speaker, distortion and transient response are measurably improved. But trying to tune a reflex enclosure by ear, or with "click-bong" tests and the like, is both frustrating and completely futile.

Unfortunately, I don't have tone-burst tests of the double-chamber enclosure available at present. However, the characteristics of the system are such that some reasonably valid guesses can be made.

With a good, high-efficiency speaker installed (such as those recommended in the article) the attack and decay characteristics of the system would be the same as those of the given speaker in an infinite baffle down to about 70 cps. A slight improvement in transient response should be noted in the region from 50-65 cps, while a little evidence of ringing would probably exist in the frequency range from 30-45 cps.

GEORGE L. AUGSPURGER
Chicago, Illinois

* * *

TV AUDIO TAKE-OFF

To the Editors:

I read the article "A Transistorized TV Compensator" on page 64 of your March issue, and received the impression that Mr. Wagner is taking a far more complicated and expensive method than is necessary to feed good audio from many TV (or radio) receivers into a hi-fi system.

A large number of receivers use a bypassed cathode resistor for the audio-output stage. I have never found a set where removal of the bypass capacitor reduced the volume by an amount which could not be easily compensated for by a small increase in volume-control setting. The unbypassed cathode resistor and output tube then provides a cathode-follower-type source of audio at low impedance and, of course, requires no external compensation as in Mr. Wagner's circuit. Operating results into conventional preamps and amplifiers have been very satisfactory. If the amplifier does not have an input blocking capacitor, then such a component should be added. Also, the cathode circuit of the audio driver stage can be used if there is enough signal level.

C. W. MARTEL
Manager, Tech. Info. Service
Raytheon Company
Waltham, Mass.

* * *

TRANSISTORIZED MULTIPLEX ADAPTER

To the Editors:

We are quite pleased with your presentation of the article entitled "Transistorized FM-Multiplex Stereo Adapter" by Larry Blaser in your March issue. There was only one omission of a point noted on the returned author's proofs that is fairly critical. Silver mica capacitors (.01 μf.) must be used across the 19-kc. coils T_2 and T_3 otherwise the unit will drift. One saving factor is that the *Miller Coil* data with the transformers specify the use of silver mica capacitors in their diagram.

WILLIAM O. HAMLIN
Technical Editor
Fairchild Semiconductor
Mountain View, Calif. ▲

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Electronics World LAB TESTED

Product Test Report

AUDIO PRODUCTS TESTED BY HIRSCH-HOUCK LABS

Sherwood Model SR-3 "Ravinia" Speaker System
Shure M33 Stereo Phono Cartridge
Cabinart "Mark I" Speaker System

Sherwood Model SR-3 "Ravinia" Speaker System

For copy of manufacturer's brochure, circle No. 58 on coupon (page 108).

THE *Sherwood* Model SR-3 "Ravinia" is a compact three-way speaker system.

Although it resembles so-called "bookshelf" speakers in styling, its dimensions of 15" x 26¼" x 13" make it more suitable for conventional floor mounting. Its woofer is a 12" high-compliance unit, in a ducted-port enclosure. Frequencies from 600 cps to 3500 cps are handled by an 8" cone speaker, with a closed back to isolate it from the back pressure generated by the woofer. High frequencies are radiated by a 3" cone tweeter, which acts as a ring radiator because of a 1" diameter metal plug in its center. The built-in crossover network has 12 db/octave slopes. There are individual level controls for the middle- and high-frequency speakers.

The instruction booklet accompanying the speaker system rates its response at 45 to 17,500 cps ± 2 db. We measured its frequency response by taking pressure-response measurements at eight different locations in a fairly large room. The data was averaged to obtain a single composite response curve. Harmonic distortion was measured at low frequencies, where it becomes significantly large. The power input to the nominal 16-ohm speaker impedance was maintained at 10 watts below 1000 cps and 1 watt above 1000 cps, to avoid damage to the high-frequency speakers which are usually not designed to handle large continuous power levels. Transient response was tested by applying tone-burst signals throughout the speaker's range.

The SR-3 proved to be an outstandingly fine speaker system. Its low-frequency response extended considerably below the rated 45 cps. due to the loading effects of the test room. The mid-range response, with the level control at the indicated normal setting, was elevated about 6 or 7 db above the response at other frequencies. The effective acoustic crossover frequencies appeared to be about 300 and 2500 cps. At high frequencies, the response was remarkably flat, within ± 1.5 db from 2800 cps to over 15,000 cps. Our microphone response limits the upper frequency of measurement to 15,000 cps, but the data indicates that the SR-3 is quite flat out to considerably higher frequencies. If the mid-range level is adjusted slightly, the over-all response of this speaker system is ± 5 db from 27 cps to beyond 15,000 cps. This is about as good as we have ever measured on a speaker system.

Tone-burst tests showed a fair amount of ringing at frequencies below 300 cps, neither better nor worse than we have observed on most speakers. At high frequencies the transient response was excellent, with little or no overshoot or ringing.

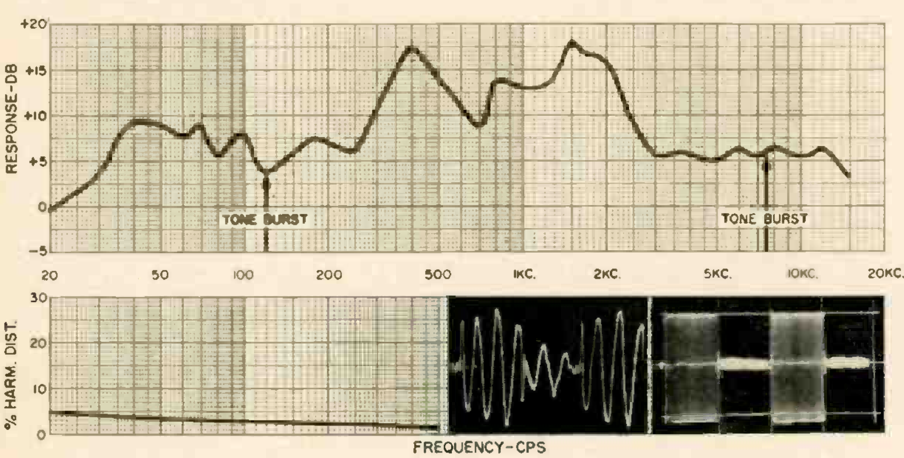
The low-frequency harmonic distortion measurements produced surprising results. Unlike most speakers, the woofer of the SR-3 did not "let go" or lose its coupling to the room at any frequency down to 20 cps. Even at our 10-watt input level, far higher than normal listening levels, the distortion rose slowly from 1.5% at 500 cps to only 5% at 20 cps.

The first SR-3 we tested had an inoperative tweeter, so we tested another unit from 1000 cps upward and plotted a composite response curve. The two speakers apparently were very closely matched in all respects, with less than 0.5 db difference in output level at 1000 cps.

Listening tests confirmed the excellent performance of this speaker in every respect. We set the mid-range level to a point which approximated flattest over-all response. The middles and highs sounded smooth and natural. The high-frequency sound in particular was almost indistinguishable from that of a good electrostatic speaker, with good dispersion and no peaks. Like any truly good woofer, the low-frequency driver of the SR-3 was unobtrusive. In fact, the absence of a resonant peak makes this speaker sound deficient at the low end, compared to some more spectacular (but inferior) systems. A listening check with an audio oscillator produced unmistakable sensations of strong acoustic pressure in the 30-cps region, which rattled objects in the room but was barely audible due to the low harmonic content. On musical programs with real bass, the sound from the SR-3 is frequently an octave lower than that from other speakers which, superficially, seem to have stronger bass.

The only flaw we could find in this speaker system was the tendency for the grille-cloth panel to buzz or rattle when reproducing low frequencies at high levels. A better method of securing the panel would be desirable.

In conclusion, we found the *Sherwood* "Ravinia" to be an outstandingly fine, compact speaker system. It has unusually flat frequency response, good transient response, and very low distortion. What is more, it sounds as good as it measures. The system sells for $139.50 in hand-rubbed walnut finish. ▲



Shure M33 Stereo Phono Cartridge

For copy of manufacturer's brochure, circle No. 59 on coupon (page 108).

MUCH attention has been given to the problem of groove wear in stereo records. Of course, record wear is not a new phenomenon, but it is accentuated by the small stylus tip radii used in stereo cartridges. Even the conventional 0.7-mil stylus exerts extremely high pressures on the vinyl groove walls. Some cartridges use 0.5-mil or 0.6-mil styli to improve high-

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SPECIFICATIONS

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 to 330 KC, flat within —6 DB from 20 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. 99 MMF
Aux. vert. input jack	2.7 Meg. shunted by approx. 15 MMF
Through hi-imped. probe	27 Meg. shunted by 9 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

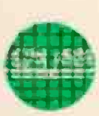
MAXIMUM AC INPUT VOLTAGE:

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.

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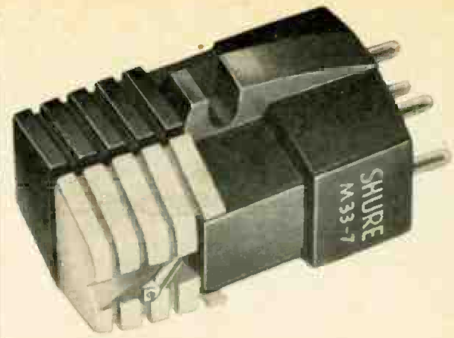

frequency tracing in the inner grooves. With a 0.5-mil stylus tracking forces must be very low to keep record wear at acceptable levels. Low tracking forces, in turn, require a highly compliant stylus for proper tracking.

The new *Shure* M33 series of stereo cartridges have a rated compliance of 20×10^{-6} cm./dyne in both lateral and vertical planes, ranking them among the most compliant cartridges on the market. Their styli are instantly replaceable without tools and are protected by a plastic finger grip which minimizes the chances of damage while handling the stylus.

The cartridge is available in two versions, the M33-5 with a 0.5-mil diamond stylus and the M33-7 with a 0.7-mil diamond stylus. The two are identical in all other respects. The 0.5-mil stylus gives superior high-frequency tracing, particularly in the inner grooves of a record, but may rattle around in the 1-mil grooves of a mono LP record. For this reason, the 0.7-mil stylus may be advisable for someone with a large collection of mono LP's. Incidentally, the cartridge will play 78-rpm records when fitted with the N78 diamond stylus, having a 2.7-mil radius. A tracking force of 3 to 6 grams is recommended with this stylus, but the other advantages of the cartridge are retained.

Like the earlier *Shure* "Dynetic" cartridges, the M33 employs the moving-magnet principle. The coils are encapsulated in the plastic cartridge body, and the replaceable stylus assembly includes not only the stylus jewel, but the tiny magnet which generates the electrical output of the cartridge.

Shure specifications rate the frequency response of the M33 at 20 to 20,000 cps, with a typical output of 6 millivolts per channel at 1000 cps. The recommended load impedance is 47,000 ohms per channel. The channel separation is rated at greater than 22.5 db at 1000 cps. Vertical and lateral compliance are both 20×10^{-6} cm./dyne. The recommended optimum tracking force is 2 grams, with a 3-gram maximum. The cartridge mounts in any standard arm or plug-in shell on ½" centers.

We tested the M33-5 with the *CBS Labs* STR-100 test record. To eliminate any possible preamplifier equalization errors, the cartridge output was measured directly on a v.t.v.m. Before making measurements, the minimum tracking force was determined by playing the *Cook* 60 and the *Fairchild* 101 records. The *Cook* record has extremely large recorded levels at 32 cps, while the

(*Continued on page* 20)

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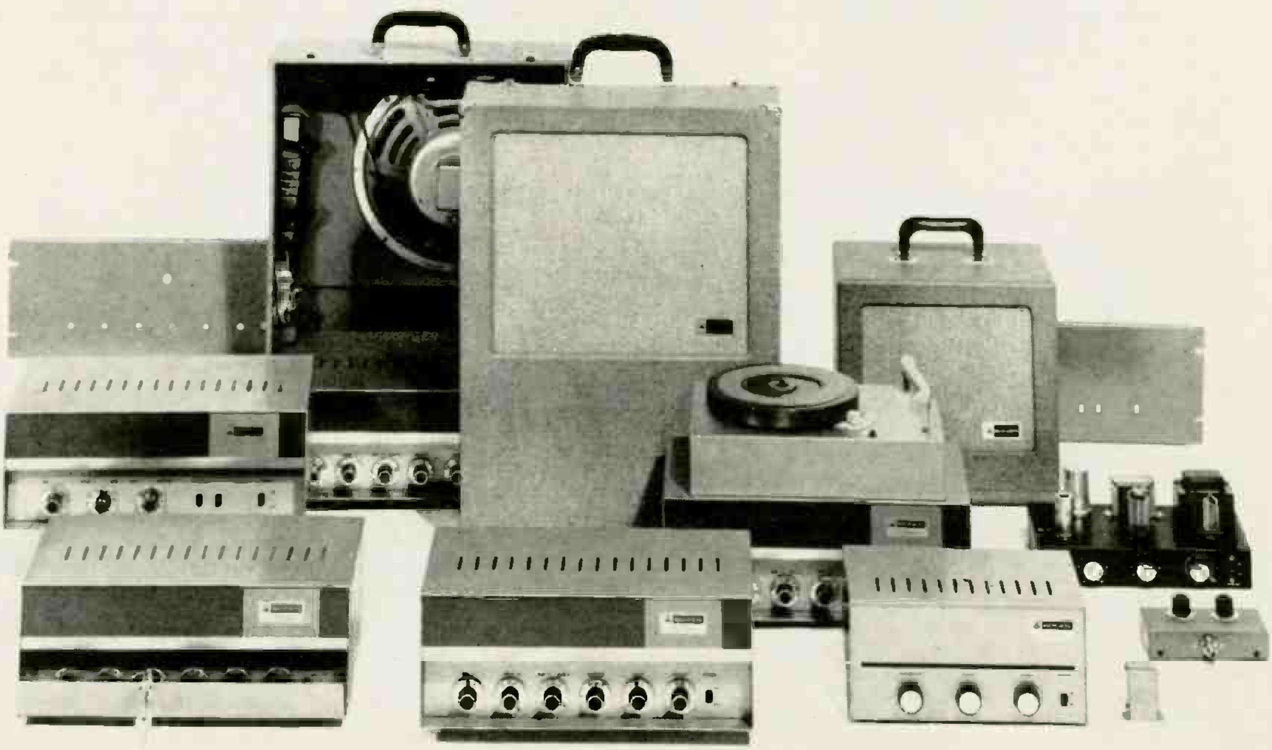

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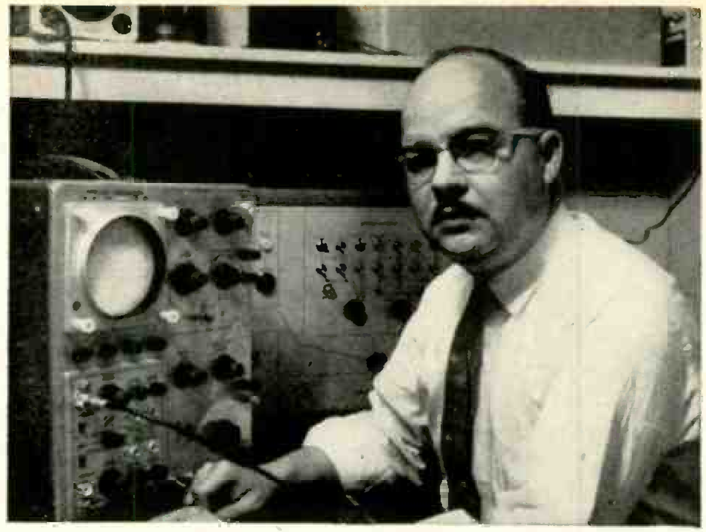

CREI graduate Mearl Martin, Jr. has progressed from Junior Technician to licensed Senior Engineer. He is now Field Support Manager, Marketing Division of Tektronix, Inc., Portland, Oregon.

LET'S LOOK AT THE FACTS. There's something wonderful about knowing how a circuit works or what a filter capacitor does. If you've ever fixed a TV set, built a radio or used a voltmeter, you've tasted the thrills of electronics.

This excitement may have led you to a job in electronics. But the glamour fades if you are stuck in the same job year after year. You'll be bored with routine and unhappy about prospects for future earnings. You'll discover, as have many men, that simply working in electronics does not assure a good future.

If electronics is the "field of opportunity," how is this possible? No question about it, electronics offers many opportunities, *but only to qualified men*. In any career field, it is how much you know that counts. This is particularly true in the fast moving field of electronics. The man without thorough technical education doesn't advance. Even men with intensive military technical training find their careers can be limited in civilian electronics.

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(*Continued from page* 16)

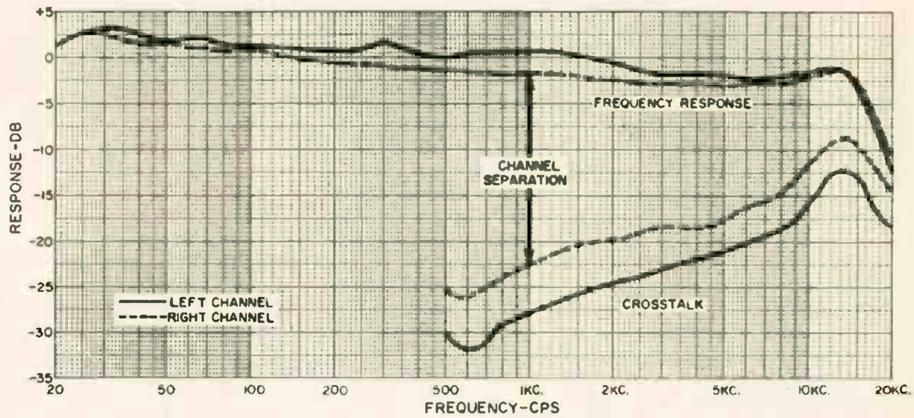
Fairchild record has 1000-cps bands at 30 cm./sec. velocity. Both are far greater than typical maximum levels found on stereo records. The M33-5 tracked the *Cook* record at 1.2 grams and the *Fairchild* record at 2 grams. The former tracking-pressure figure was used for subsequent tests.

The measured frequency response was within ± 2.5 db from 20 to 15,000 cps. There was about 2-db difference between channel levels at middle frequencies and less at the extremes. The channel separation was 21 to 28 db at 1000 cps, decreasing to 7 to 10 db at 15,000 cps.

Both frequency response and crosstalk curves were smooth and free from sharp resonances. The average output was about 7.5 millivolts per channel at 5 cm./sec. velocity. The cartridge has exceptionally effective shielding against magnetically induced hum, ranking in the top two or three cartridges in this respect. Needle talk is also very low and practically inaudible.

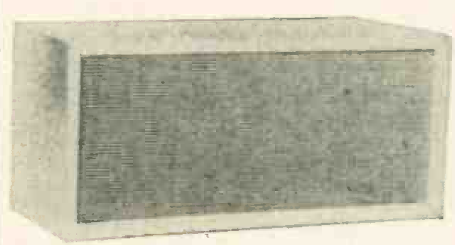
In listening tests, we found that the cartridge would track any stereo record in our collection at 0.5 gram, in an *Empire* 980 arm. It should be possible to operate this cartridge at not more than 1 gram in any good arm having low friction bearings. The listening quality is easy and smooth, although not overly brilliant. ("Brilliance" is frequently the result of a high-frequency response peak.) It is a truly musical and transparent sound cartridge, one of the best we have heard.

The *Shure* M33, with either the 0.5-mil or 0.7-mil stylus, sells for $36.50. ▲



Cabinart "Mark I" Speaker System

For copy of manufacturer's brochure, circle No. 60 *on coupon* (*page* 108).



THE *Cabinart* "Mark I" is a true bookshelf speaker system, measuring 23" wide by 11" high by 9½" deep and weighing 27 pounds. It contains a single 8" speaker, with a 1" diameter voice coil rated at 8-ohms impedance. The enclosure is a ducted-port type, with a port at each end and the speaker in the center. The inside of the enclosure is treated with 1" acoustic insulation to damp internal reflections.

The enclosure is made of a pressed wood material, solidly glued together (except for the rear panel, which is screwed in place). The front is covered by an acoustically open plastic cane grille cloth. The cabinet is unfinished, but its smooth surfaces and flecked appearance are quite attractive. It can, of course, be painted as desired by the user.

One of the most interesting features of the unit is its price, which is $18.00 ($30.00 in oiled walnut). Few speaker systems sell for less than 2 or 3 times this price, even in kit form. The manufacturer rates the system as having a frequency response from 45 to 13,000 cps, with a nominal power handling rating of 10 to 15 watts.

In listening tests, the unit sounded surprisingly good. It was obvious that the low-end response was a long way from reaching 45 cps, and comparison with other speaker systems indicated a lack of extended highs as well. Nevertheless, the over-all sound was clean and reasonably well balanced. It tended to be a trifle "thin" sounding, but moderate bass boost was able to build up the low end without any undesirable side effects.

Our indoor frequency response measurements involved taking 12 complete frequency response measurements in as many different microphone positions and averaging them. The results showed a ±7 db variation from 90 to 10,000 cps, which is very respectable response for this type of measurement. This helps to explain the smooth and pleasing sound of this speaker, despite its restricted frequency range. At the low-frequency end there was a distinct peak at 150 cps, below which the response fell off at 12 db/octave. Harmonic distortion began to rise significantly below 100 cps. The useful lower limit of this speaker's response is about 90 cps, although at low levels it can be assisted somewhat by

(*Continued on page* 70)

What sets the stage for scientific discovery?

H. E. D. Scovil, pioneer developer of the solid state microwave maser, explains a point at a symposium at Bell Telephone Laboratories.

There is no one answer. But surely discovery is more likely when people are stimulated to think in new ways. And nothing more powerfully stimulates scientists and engineers than up-to-the-minute discussion of the latest developments.

Bell Laboratories scientists and engineers make a point of exchanging information on their latest advances not only among themselves but with the great world-wide professional community to which they belong. Last year, for example, Bell Laboratories specialists delivered over 1200 talks to technical societies and universities. The stimulating exchange of new ideas plays an indispensable role at the world center of communications research and development.

Bell Telephone Laboratories

By WALTER H. BUCHSBAUM / Industrial Consultant, ELECTRONICS WORLD

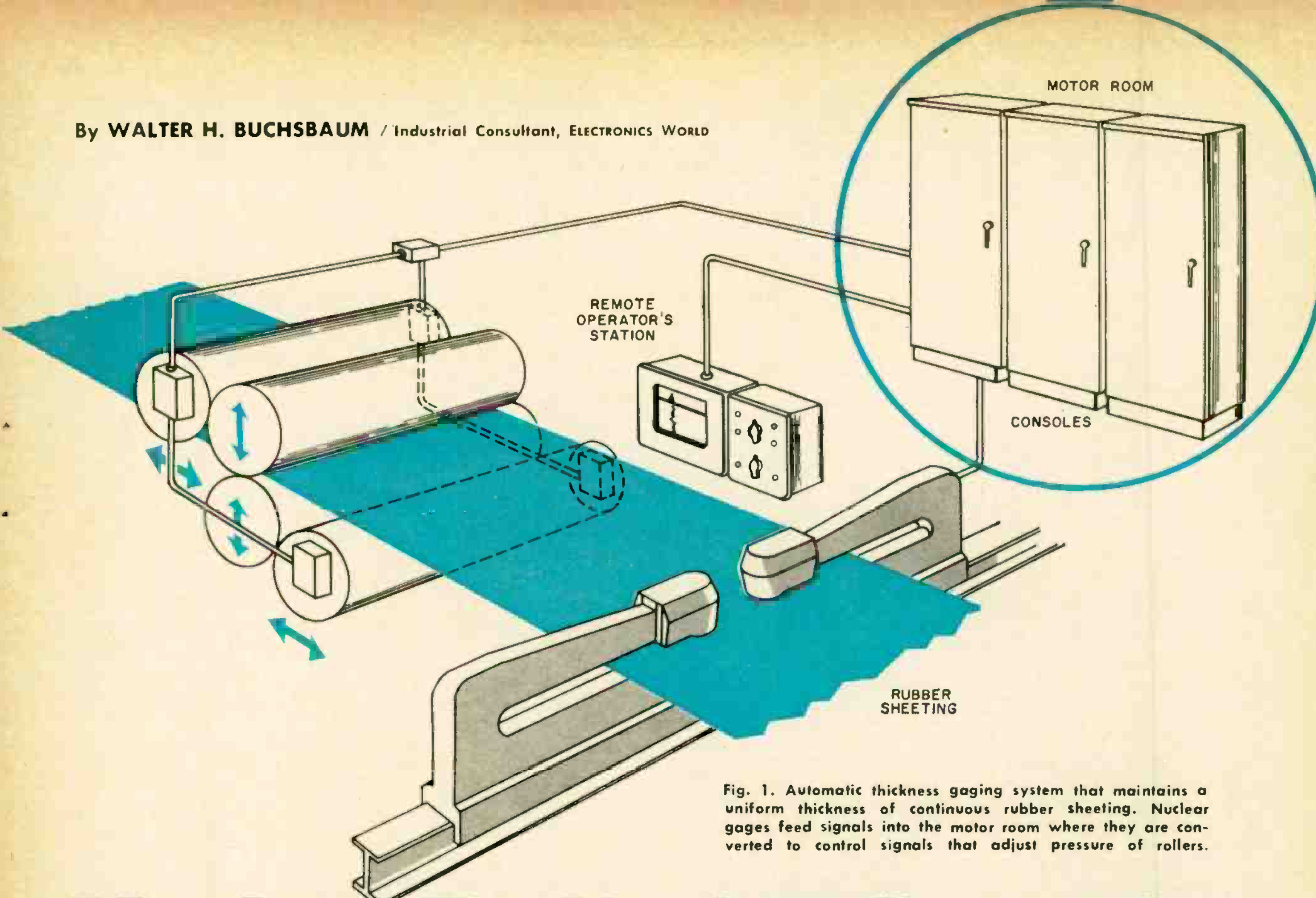


Fig. 1. Automatic thickness gaging system that maintains a uniform thickness of continuous rubber sheeting. Nuclear gages feed signals into the motor room where they are converted to control signals that adjust pressure of rollers.

Nuclear Radiation Gages for Industry

Radioactive isotopes are used in conjunction with electronic circuits for measurement and control of many industrial processes. Here are techniques in use to check thickness and liquid level.

NUCLEAR radiation has teamed up with electronics to take over a very important operation in many industrial processes. We are referring to the rapidly growing application of nuclear radiation gages in industry. These devices provide the yardstick, the calipers, or the micrometers for measuring and, together with electronic circuitry, generate the correction signals for the machine tools to maintain fixed measurements. Radiation gages can be found checking the level of beer in cans, the stuffing of cigarettes, the thickness of wet paper, the coating of paint on metal, the stretching of rubber, and the flow of gases.

While the basic detection unit is really a nuclear device, its output is an electrical signal and the major portion of such equipment consists of familiar electronic devices like amplifiers, recorders, and servo systems. It is not surprising, then, that the maintenance and repair of nuclear radiation gages is the province of electronics men who have had some training in the handling of nuclear devices. One of the reasons for this seemingly incongruous assignment is that nothing can ordinarily go wrong with the nuclear portion of the gage, but the electronic parts are subject to the same faults as any ordinary electronic device. Adjustments and calibrations are always confined to the electronic portions since the radiation source and its detector are fixed.

Such gages need a source of radiation and a detector to measure the amount of radiated energy. Radioactive isotopes of certain elements are used as sources and these are obtained as incidental and often undesired byproducts of a nuclear reactor. These isotopes are elements whose atomic structure has been altered during the nuclear chain reaction so that they themselves become sources of nuclear radiation. Typical materials used as sources for industrial work include strontium-90, krypton-85, cesium-137, and cobalt-60.

Radioactive isotopes emit three types of radiation of various relative strengths. The *alpha* radiation, consisting of high-speed helium nuclei, is not generally used for gaging since

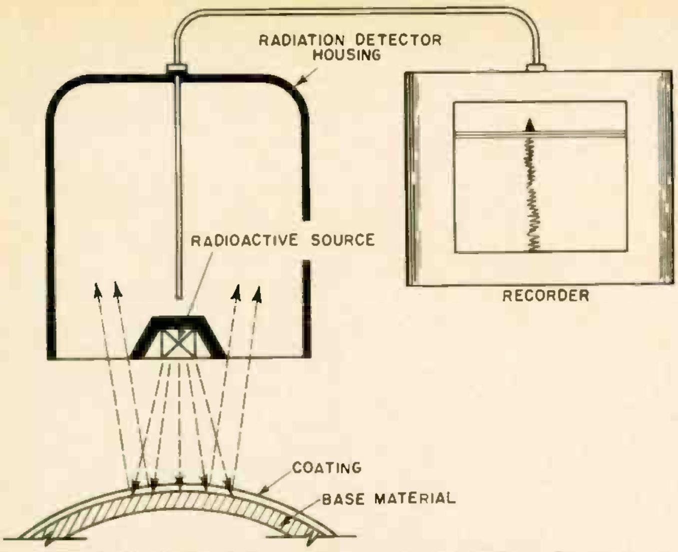


Fig. 2. Nuclear radiation gage employing reflection principle.

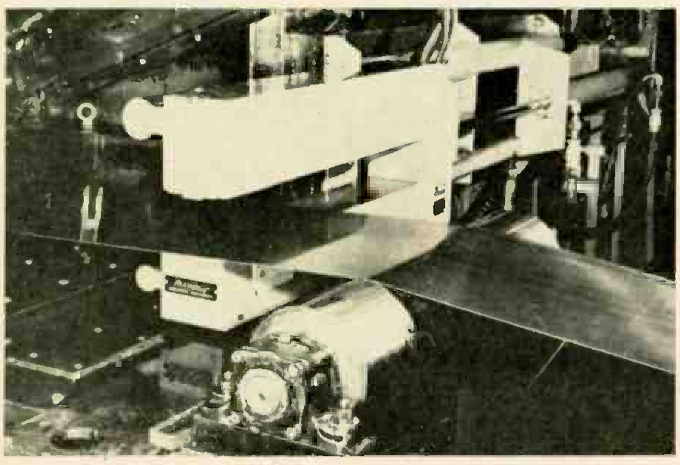


Fig. 3. Transmission gage installed in steel rolling mill.

the particles are too large to penetrate dense materials in sufficient numbers. *Beta* radiation, which is really a stream of high-speed electrons, is used in a few radiation gages for certain specialized applications, but the most widely used type of radiation involves *gamma* "rays." *Gamma* radiation is essentially electromagnetic energy somewhat similar to but at a higher frequency than x-rays. Like x-rays, *gamma* radiation will expose photographic film and illuminate phosphor when the radiation has sufficient energy.

For industrial gages radiation sources which emit a constant "stream" of the desired radiation for a long time are selected. The activity time is expressed in terms of the "half-life" of a material. This is the time required for the amount of radiation to be reduced to half the original amount. As an example, cesium-138 has a half-life of 33 years. This means that the rate of radiation decay from maximum to half is spread over that length of time. This very gradual decay permits extreme accuracy and stability in designing and calibrating the gage. Other materials have different half-life periods, with some as short as 36 hours for bromide-82, 8 days for iodine-131, and 5.3 years for cobalt-60. Bromide or iodine are obviously not suitable for radiation gaging sources, but are actually used as radioactive tracers in biological and medical experiments.

For industrial radiation gaging the radioactive material must be securely mounted and adequately shielded. For this reason, such material is not normally visible. Although emitting energy and apparently "alive," a piece of radioactive strontium, cobalt, or cesium looks disappointingly like any lump of dull gray ore. Its emitted energy can only be measured by special devices such as the Geiger-Mueller tube, the scintillation detector, the electroscope, or the cloud chamber. The latter two devices are not suitable as radiation gages and are only useful for laboratory experiments. However, the Geiger-Mueller tube and scintillation detectors are rapidly becoming accepted industrial instruments.

The Geiger-Mueller tube is, essentially, a gas-filled tube with a cathode and an anode at a high voltage. As *beta* or *gamma* radiation enters the gas it ionizes individual gas particles and this increases the anode current. The stronger the radiation, the more current pulses the tube will put out. *Beta* radiation, consisting of high-speed electrons, is attenuated by glass, hence Mylar windows are used in G-M tubes intended for *beta* radiation detection. *Gamma* energy passes through glass with relatively little attenuation.

Scintillation counters utilize the effect of radiation on phosphor or certain crystals. The slight illumination caused in the phosphor is detected and amplified by a photomultiplier tube which is mounted as an integral part of the detector unit. A typical crystal used for *gamma* detection is thallium-activated sodium iodine. Just as in the G-M tube, the output basically consists of a number of current pulses which are then integrated into a control voltage.

For industrial radiation gages the output of both the G-M tube and the scintillation detector must be amplified and the amplifiers handling this job must be ultra stable. In some instances transistorized amplifiers are used. These are often mounted in temperature-controlled miniature ovens which are usually a part of the detector head assembly.

Neglecting the varieties of radiation sources and detectors, radiation gages can be divided into two categories as shown in Figs. 2 and 5. They are either of the transmission or the reflection type. In the former the radiation passes through the measured material and the amount of absorption is determined. The thickness of any material is directly proportional to the amount of radiation energy it will attenuate or absorb. The reflection-type gage also depends on absorption but here the absorption is combined with the reflectivity of the base material. Reflection gages are normally used only when one side of the material is accessible, or when the base material is not too "transparent" to radiation as would be the case when the thickness of a plastic coating on a steel container is to be measured.

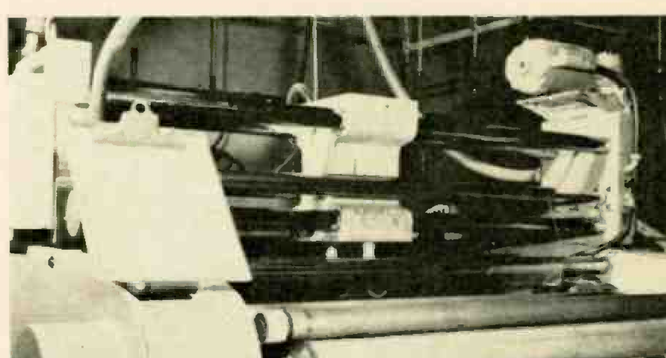


Fig. 4. Traversing thickness gage used in plastic production.

Radiation Safety

Of great concern to anyone using any nuclear device is the effect of radiation on the human body. While the amount of radiation involved in most applications is very small, the effects of radiation are known to be cumulative and, therefore, even small doses can be dangerous over a period of time.

For this reason all radiation sources are licensed and super-

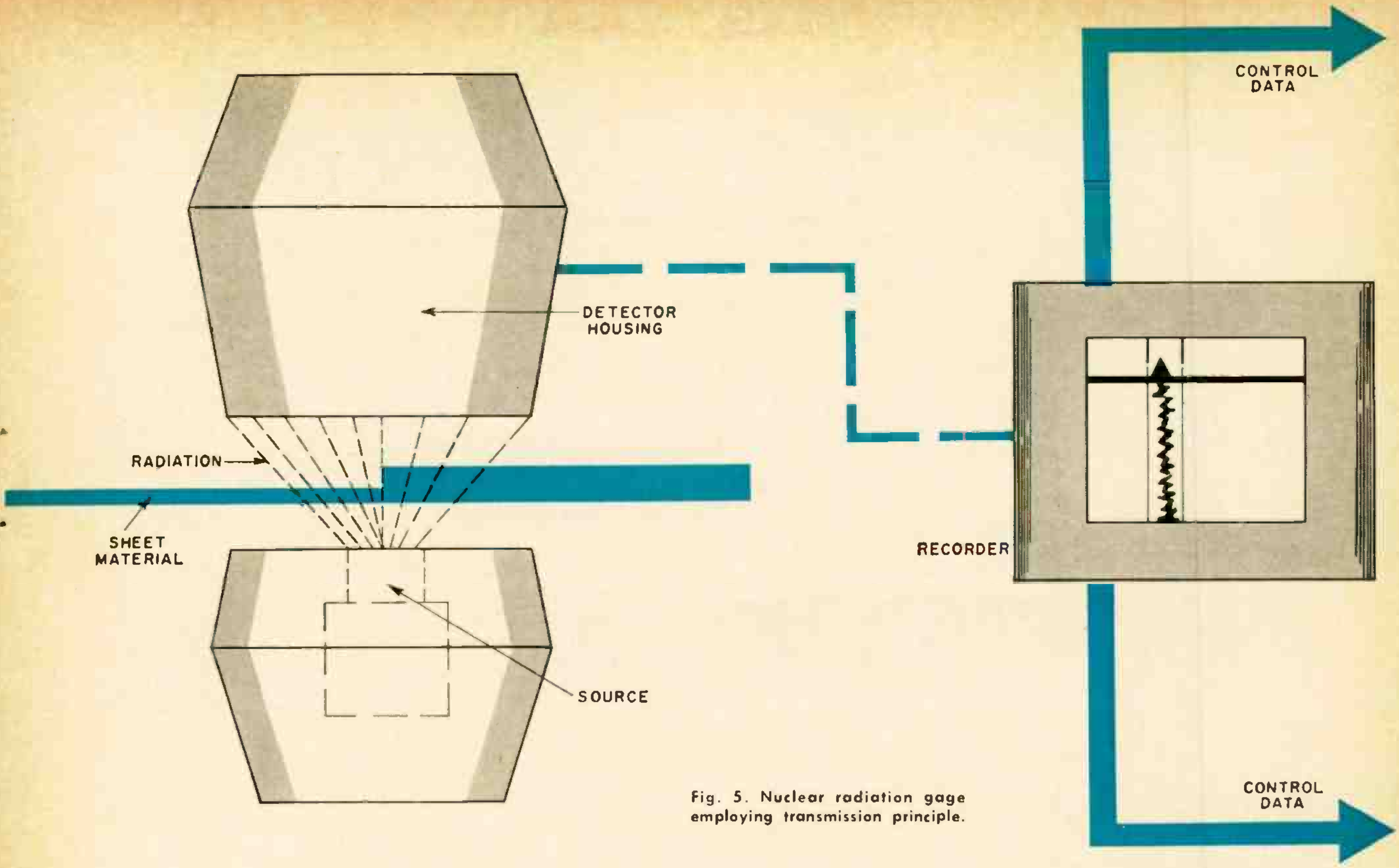
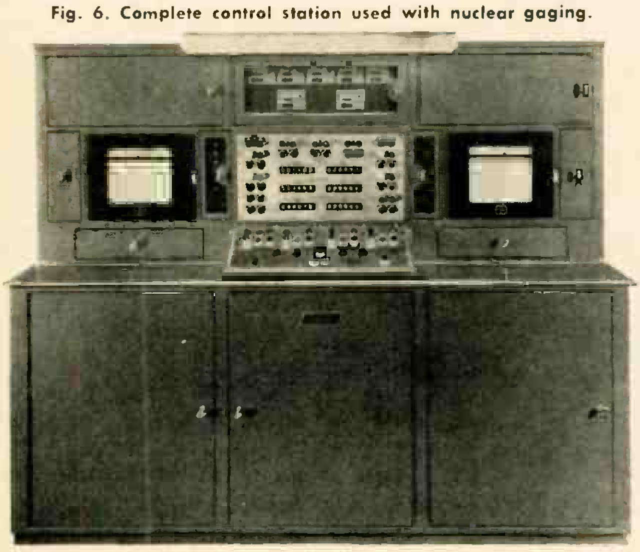


Fig. 5. Nuclear radiation gage employing transmission principle.

vised by the Atomic Energy Commission. All such devices are carefully designed to prevent dangerous exposure. In addition to being completely and effectively shielded, the small aperture through which the radiation to be measured emerges is guarded by a heavy shutter. This shutter is electrically actuated and closes automatically when power is removed. Thus even the tiny amount of radiation used for gaging is only present when the source is mounted in place and the entire unit is turned on.

Many people believe that anything which has been exposed to radiation becomes radioactive itself. This is untrue. Extensive irradiation can change some physical properties of certain materials, but they do not in themselves become radioactive. As a matter of fact, most of the sources used in radiation gages are relatively weak and perfectly safe in their shielded containers. There is no need for film badges or radiation monitoring equipment in plants where radiation gages are being used.

Fig. 6. Complete control station used with nuclear gaging.



Radiation gaging is still a relatively new technique but its applications are growing steadily. We can cite only a few typical examples here to indicate how this equipment is used but there are many other applications—some already in use and others projected.

Typical Applications

Fig. 3 shows a typical installation of a transmission-type gage in a steel rolling mill. Source and detector are mounted above each other and the continuous strip of steel moves between them. When the steel is of the desired thickness, the amplified output voltage of the detector is adjusted to maintain the roller pressure and take-up reel speed. When the steel gets too thin, the output voltage increases because the radiation picked up by the detector gets stronger. The increase in voltage is translated into a reduction of the roller pressure. Similarly, when the steel gets too thick, less radiation is detected and the reduction in output voltage signals an increase in roller pressure.

It is obvious from this brief description of the operation that a lot more electronic equipment is required than just the detector and its amplifier shown in the photograph of Fig. 3. Usually the automatic control action is monitored by a pen recorder which provides a detailed record of the variations in thickness for each roll of strip steel. In many plants this information is also included in the operator's console which contains manual controls to adjust for the desired thickness and shut off the machine. Because such an installation is automated, it is possible for one operator to monitor several strip rollers and a typical operator's console often looks almost as complicated as a pilot's control panel.

The use of thickness controls is not restricted to steel fabrication as evidenced by the photograph of Fig. 4 which shows an installation in the processing of Saran, a very thin plastic. Here the source and detector assembly travel back and forth over the width of the plastic sheet as the sheet passes between them.

A typical control station for a complete radiation thickness

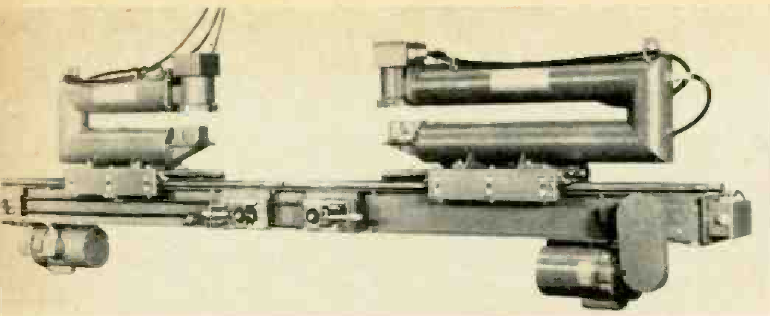


Fig. 7. A set of dual traversing type thickness gages.

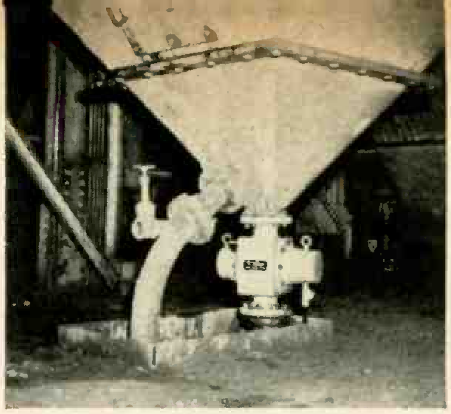


Fig. 9. Fluid density radiation gage.

gage set up is shown in Fig. 6. Six numerical read-outs and two pen recorders, together with a number of push-buttons, allow the operator to monitor and control the entire process. The bottom of the cabinet houses the power supplies and control equipment.

Still another installation involving thickness gaging is shown in Fig. 1. This system is used for automatically controlling the thickness of continuous rubber sheeting. Fig. 1 shows that the control voltages from the detectors are fed to the motor room where they are converted into control signals for the main calender which governs the thickness of the rubber sheet. When the two controlled rollers are moved

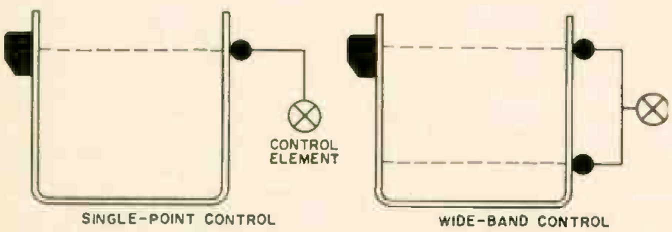


Fig. 8. One radiation source may be used with one or two detectors whose output is applied to a control element. The control element starts or stops the flow of liquid to container.

inward toward the vertically moving rollers, these press on the rubber sheeting reducing its thickness. When the controlled rollers move outward, the other rollers move away from the sheet, increasing its thickness.

A combination of C-frame-mounted thickness gages, which can also traverse across extra-wide sheets is shown in Fig. 7. Each gage moves independently back and forth across the material to provide a close, continuous indication of sheet thickness.

Other Uses

In the processing and chemical industries radiation gages are used to measure density, degrees Baumé, or specific solids or liquids flowing in a pipe. Such an installation is shown in Fig. 9 where the gage is mounted around a pipe and measures the density of the coal sludge passing through. In this instance it is necessary to allow for the absorption of radiation due to the pipe itself, but that remains constant and is compensated in the initial control voltage adjustments. Similar installations can be found in chemical plants of all types where liquid material must be controlled as to viscosity or content of various solids.

Still another area of application for radiation gages is the "inventorying" of storage bins or tanks to determine the level of filling. The principles involved here are the same whether the storage tank is an open bin, as shown in Fig. 8, or whether we are concerned with beer cans or the fuel tanks of a rocket, plane, or ship. One of the more sophisticated fuel-indicating systems is intended for aircraft fuel tanks where a number of *gamma* sources are arranged to radiate to a centrally located detector. As shown in Fig. 10, this arrangement insures that tilting of the aircraft in flight will not affect the accuracy of the fuel gage indication. In this type of system very weak

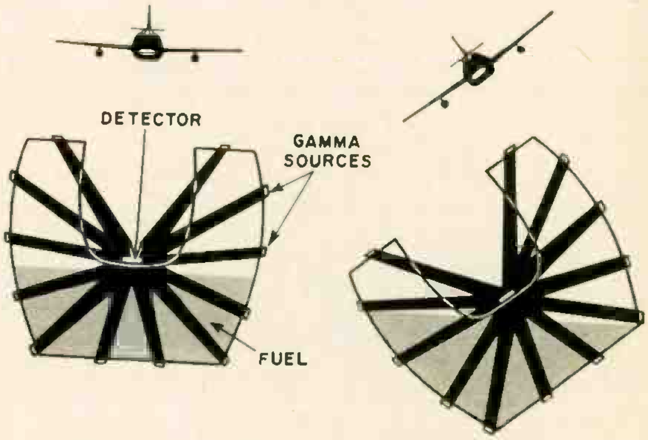


Fig. 10. Aircraft fuel level is measured in any position.

sources are used, eliminating the need for extensive shielding because of their very low radiation level. The sources are so small that they can be housed inside ordinary rivets or screws.

We have cited only a few typical applications for radiation gages although many others are undoubtedly already in the planning and design stages.

Conclusion

At a time when nuclear weapons threaten our entire civilization, it is cheering to see that some of the technology which has created this Sword of Damocles is also contributing to peaceful industrial applications. In describing radiation gages we have highlighted only one rather narrow application of nuclear energy to industry. There are many other services which radioactive materials perform. One, which is somewhat like radiation gaging, is the use of industrial x-ray machines which employ radioactive material as the source of illumination. A photographic plate or film is exposed by the radiation according to the amount of energy absorbed by the material under examination. The result is a regular x-ray picture.

Still another application involves the use of radioactive tracers. This technique is used in processes where the degree of mixture, the relative volume, or the path of a particular liquid is controlled. A minute amount of short-lived radioactive tracer material is injected into the material to be controlled and then traced with radiation detectors. These detectors are of the same two types previously described and are always combined with amplifiers, recorders, and meters—using well-known electronic circuits. These techniques are not limited to industry but also find wide application in biological and medical research and diagnosis.

Radiation gaging, as described here, forms a very important link and serves as an excellent sensing device in automation systems. Its wedding to electronic devices represents a permanent union since only by electronic means can the weak radiation signals be amplified and converted into control voltages. It is another example of how electronics, combined with another technology, has produced a new and valuable tool. ▲

By EDGAR VILLCHUR
Acoustic Research, Inc.

DISTORTION in LOUDSPEAKERS

How much distortion does a hi-fi speaker produce? What causes it and what are the techniques for measuring it?

LOUDSPEAKERS are still probably the weakest link in the chain of reproducing components. Speakers are subject to many faults, including raggedness of frequency response, limited range, and hangover. One of the worst speaker defects is harmonic distortion. Levels of distortion which would automatically disqualify any other component from a "high-fidelity" classification are commonly found in loudspeakers. Yet loudspeaker distortion is a subject about which very little is written. Distortion data on speakers, with one or two exceptions, is not published by their manufacturers.

There are several reasons for this. One is that the distortion percentages for speakers are so high. The technically oriented high-fidelity public that reads spec sheets is used to amplifier harmonic distortion figures of the order of small fractions of one per-cent. Discovery by an audiophile that his favorite speaker showed distortion percentages (over part of its frequency range) one hundred times greater might leave him in a state of shock.

Another and more valid reason is that absolute percentages in speaker distortion do not have the same significance as in amplifiers. Speaker distortion is likely to occur at separate frequencies or frequency ranges and to show up only when there is music in the frequency range concerned. Amplifier distortion is usually less discriminating. Further, the highest values of speaker distortion are almost always in the low bass, where the speaker's response to the fundamental may be very much attenuated. A particular speaker may, for example, have 50 per-cent distortion at 30 cycles at a given input level. If the total output in response to that frequency input is very low, then the distortion products that are contributed to the final sound will be attenuated in proportion.

Whatever the mitigating circumstances surrounding high values of speaker distortion, comparing a low-distortion speaker to one with high distortion leaves no doubt in the listener's mind as to the primary importance of this element to natural musical reproduction.

Distortion Levels in Speakers

It is not difficult to take a rough glimpse at the magnitudes of distortion associated with loudspeakers if one has an audio signal generator, a microphone, and an oscilloscope. A sweep test record may be substituted for the signal generator if a very good record playback system is available. The combination of microphone output and scope sensitivity must be sufficient to provide a good-sized pattern on the scope screen; the higher the low-frequency output of the microphone and the greater the sensitivity of the scope the better. If the microphone-oscilloscope combination does not provide a trace of adequate size with a direct connection, a preamplifier will have to be inserted between the two units.

Fig. 1 illustrates the hook-up required, with test points for scope monitoring indicated. If we sweep the system between 30 and 60 cycles, at a sound level corresponding to good but not overpowering volume, we should see perfect sine waves on the screen when the scope is connected across the output of the generator or of the amplifier. When we connect the oscilloscope to the microphone, however, things may be expected to change radically. At best the screen pattern at the lower frequencies will, on careful examination, show imperfections; at worst it will look like the top of a broken beer bottle.

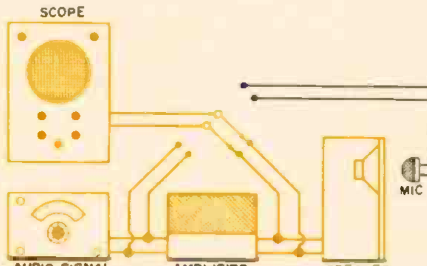


Fig. 1. Block diagram of test setup used.

The above test was applied to a random group of current speakers, taking them as they were mounted on a dealer's display shelves. Each speaker was driven to the same peak-to-peak level of total sound at 30 and at 40 cycles input. A photograph of the oscilloscope trace of microphone output was taken with a *Polaroid* 'scope camera. Electrical input power to the speakers required to produce the reference sound level varied from 2 to 20 watts, depending on speaker efficiency and on frequency.

Fig. 2 shows oscilloscope traces representing the acoustical output waveforms of seven speakers in the $85 to $250 price range. The wide variation in distortion characteristics is obvious. (These test results were made possible through the cooperation of John Waugh, Jr., of *Minute Man Radio Co., Inc.* in Cambridge, Mass. to whom the author wishes to express his thanks.)

The sine-wave distortion in these photos is not a mere technical failing, but is a major factor in the quality of speaker reproduction, particularly in those cases where speaker response to low-frequency input contained harmonic output of appreciable amplitude relative to mid-band response. One strange effect of the distortion is to make the bass appear louder and crisper, albeit wooden and nasal. Comparison with undistorted reproduction (or with the original instru-

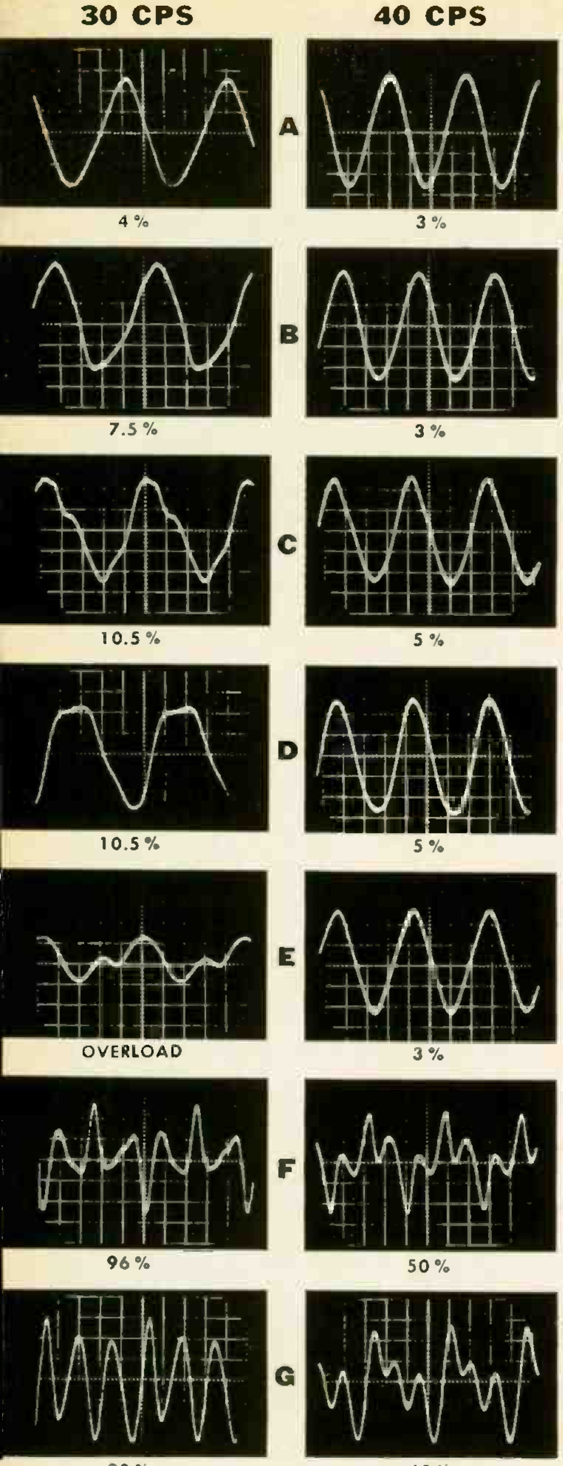


Fig. 2. Here are oscilloscope photographs showing the acoustical output of seven different loudspeakers on a dealer's shelf, all at the same peak-to-peak output sound level, when driven by 30-cps and 40-cps sine-wave input. The speakers employed were in the $85 to $250 price range. The numbers below the oscilloscope photos are the distortion-meter readings that were obtained. Note that the output of speaker G at 30-cps input is an almost pure 90-cps tone. (The Hewlett-Packard distortion analyzer measures the percentage r.m.s. ratio of harmonics to the total signal. Harmonic distortion is also sometimes expressed as the percentage ratio of harmonics to the fundamental only, a method that would substantially increase the values for F and G.)

ments) will, of course, reveal the essentially unnatural quality of this distorted bass.

This measuring technique is not a rigorous one, but it is sufficiently accurate to demonstrate the orders of magnitude of loudspeaker bass harmonic distortion, particularly when different speakers are substituted in turn in the test setup. The results shown in Fig. 2 are consistent with what little published material can be found on the subject. In 1956 the *Audio League*, an organization devoted to the testing of audio products (now defunct and succeeded by *Hirsch-Houck Labs*), wrote:

"Speaker systems that will develop much less than 30 per-cent distortion at 30 cycles (at the test levels employed by the *Audio League*) are few and far between."

In the same year, a Master's thesis ("The Effect of Negative Source Resistance on Loudspeaker Performance" by George D. Ramig) at Worcester Polytechnic Institute reported on a series of studies on fifteen loudspeakers, which included measurements of bass harmonic distortion. Covering the frequency range down to 50 cycles and keeping the sound level the same for each speaker, the measured distortion at the lowest frequency varied from 2 per-cent for the most distortion-free speaker to 43 percent for the one with the highest distortion. Input power ranged up to 20 watts, depending on speaker efficiency. It may be assumed that these distortion figures would have been doubled at 30 cycles.

Distortion in the mid-range and treble is lower in percentage value and requires more careful measuring techniques, although its effects are just as raucous from the point of view of quality. It is not as liable to appear in the form of easily identifiable waveform aberrations on an oscilloscope screen.

Causes of Speaker Distortion

Speaker distortion at bass frequencies has two main causes, both of them related to large voice-coil excursions. Cone excursions over the bass range, for constant power output, must quadruple with each lower octave.

These two causes are the non-linearity of cone suspensions (spider and rim suspension) and the non-uniformity of the magnetic field over the path of voice-coil travel. At higher frequencies mechanical resonances of different parts of the speaker's mechanical system become the more significant factors.

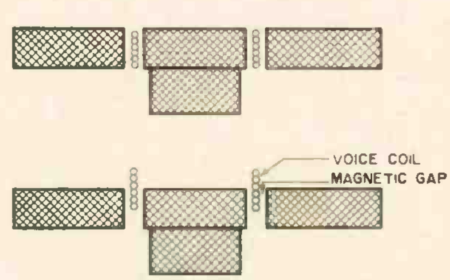


Fig. 3. Only half of the voice-coil turns remain in the magnetic field of the gap.

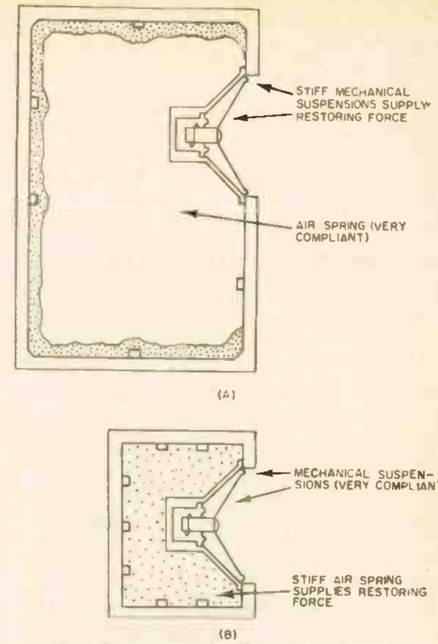


Fig. 4. Substitution of an air-spring for mechanical-suspension stiffness in the acoustic-suspension system, shown in (B), in order to reduce speaker distortion.

The non-linearity exhibited by speaker mechanical suspensions is a characteristic possessed in some degree by all elastic materials. As the suspensions are stretched by the impelling force of the moving voice-coil their elastic stiffness increases, that is, they begin to "bind." Beyond a certain point they could not yield at all without tearing.

This means that the cone will travel less towards the ends of its excursion—the peaks and troughs of the waveform—than the input signal dictates. Increased mechanical impedance in the face of a given applied force results in decreased mechanical response. The process is similar to clipping in amplifiers. Since the same sort of thing takes place at each side of the excursion the distorted waveform tends to be symmetrical, which predicts odd-harmonic distortion. The most prominent harmonic component in speaker distortion is usually the third, and so the common reference to speaker bass distortion as "doubling" is not an apt expression. "Tripling" would be more accurate in most cases.

The second cause of distortion on large excursions—non-uniformity of the magnetic field over the voice-coil path—also operates to distort the signal peaks symmetrically. When the voice-coil shown in Fig. 3 has moved forward, only half of its turns are immersed in the magnetic field of the gap (actually, fringing of the field alleviates the situation somewhat). The force on the voice-coil is considerably weakened, even though the signal itself has not called for any slackening of this force. Again cone travel is reduced at the extreme positions, and again third-harmonic distortion tends to predominate.

It will be noted that some of the waveforms in Fig. 2 are asymmetrical, indicating even- rather than odd-harmonic distortion. This means either that the mechanical suspensions begin to stiffen for one direction of cone travel before they do for the other, or that the voice-coil is not centered longitudinally in the magnetic field.

Designing Against Distortion

There are two general approaches to reducing speaker distortion in the bass range. One is to employ design which reduces the cone excursion required for a given bass output, and the second is to create a speaker capable of making the necessary large excursions in a linear manner.

The first and older of these two methods employs an acoustical coupling device—either a horn or an acoustical resonator—between the speaker diaphragm and the air of the room. The efficiency of coupling between the cone and the room is thereby improved; a given level of bass energy can be radiated with smaller cone movements. Cone suspensions are not stretched as much and the voice-coil is not driven so far out of the gap, so that distortion is reduced, sometimes drastically. A variation on this theme is the use of many large speakers for increased cone area, also for the purpose of increasing speaker-to-room coupling.

Unfortunately, a horn ceases to load its driver below the bass cut-off frequency, a point inversely related to the horn rate of flare. The area of the horn mouth must also be very large to avoid resonances and horn coloration. The solution to both of these problems involves large physical size for the horn structure.

Acoustical resonators of different types have been used, but by far the best known is the bass-reflex design employing a classical Helmholtz resonator (as opposed to the air column or organ pipe type of acoustical resonator). A detailed discussion of the operation of the bass-reflex cabinet is not appropriate here, but it is sufficient to say that in a properly tuned and damped bass-reflex system small motions of the cone in the bass range produce large in-phase motions of the mass of air in the port. A given cone excursion is therefore associated with increased bass energy radiated from the system. As in the case of the horn, coupling efficiency between cone and room is increased.

The main problems associated with bass-reflex design are those that are to be expected when anti-resonance is used as a design element. Resonant elements must be carefully tamed and controlled. Speaker and enclosure must be accurately matched, or the increase in coupling will occur at particular bass frequencies rather than evenly over the bass range.

Test setup that was employed for qualitative display of speaker distortion.

The second general approach referred to—designing a direct-radiator speaker which does not use a coupling aid to reduce excursion requirements, but is capable of executing the necessary large excursions with linearity—requires attention to the suspension system itself.

Various configurations of suspension devices have been used to allow large stretching without undue stiffening at the end of the stretch. These suspensions have had to perform a second function over and above centering the voice-coil and cone. They have had to provide the speaker with elastic restoring force, an indispensable element in speaker design.

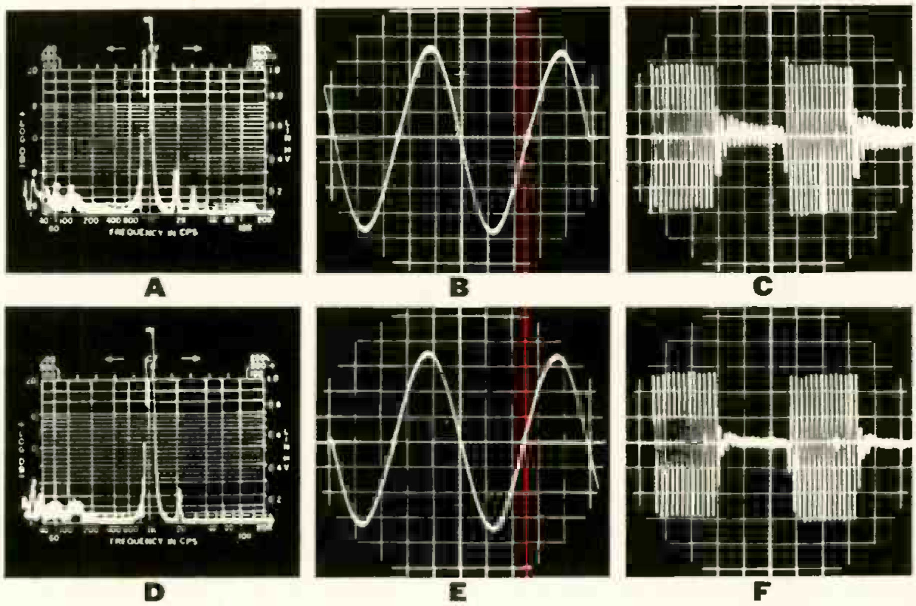
With the specific aim of substantially eliminating suspension non-linearity, the acoustic suspension system[1] employed a new approach to providing cone restoring force. As shown in Fig. 4, the volume of air enclosed by the cabinet walls is used as an air spring, substituting for the mechanical suspensions as a source of elastic restoring force. The mechanical suspensions cannot be dispensed with because they must still perform their centering function, but they can be made so limp that the problem of suspension non-linearity is eliminated as a practical consideration.

The air spring itself is almost ideally linear in the degree of compression to which it is subjected. With the acoustic suspension system, then, we can expect

[1]U.S. Patent 2,775,309, E. M. Villchur, assignor to Acoustic Research, Inc.

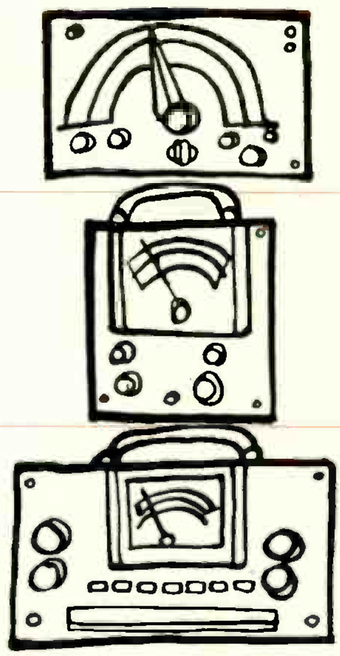
(*Continued on page* 68)

Fig. 5. (A) Display of treble distortion of rejected tweeter on panoramic analyzer. The large blip at 1000 cps is the fundamental; smaller blips to the right show each harmonic of the distortion content. Hash on the left is noise. (B) Sine-wave 'scope trace does not reveal the distortion, but a 10.6-kc. tone burst (C) shows a little overshoot as well as some ringing between bursts. Parts (D), (E), and (F) shows the same series of 'scope displays but for an acceptable tweeter of the same model.



INSTRUMENTING THE SERVICE SHOP

By JOHN T. FRYE



A plan for progressive acquisition of equipment takes into account your immediate needs, financial status, shop size, growth, and specialization.

EVERYONE knows good advice is hard to obtain, but did you ever stop to think it is equally hard to give? Worthwhile counsel must be carefully and thoughtfully distilled from a mash of personal experience, an understanding of the recipient's ability and needs, and a deep feeling of responsibility for any advice given. Consider how these factors apply to suggesting instrument purchases for an electronic repair shop. Nothing will take the place of experience. Only a man who has melted many yards of solder really knows which instruments are indispensable, which helpful and time-saving, and which needed only rarely.

Electronic test instruments vary widely in their complexity and sophistication. Napoleon said, "The tools to him that can handle them." Obviously there is little point in a technician's buying an instrument too complicated for him to use, no matter how helpful that instrument might be in more skilled hands. For example, a technician with limited knowledge would get much more benefit from a good general-purpose oscilloscope than he would from a complicated professional laboratory instrument that would require an hour of manual-thumbing and head-scratching on his part even to set it up for a simple test.

And the individual needs of the technician are important. His capital must cover such items as rent, utilities, taxes, parts stock, service literature, hand tools, truck, and advertising. If his capital is limited—and it usually is—some of these demands obviously must be placed before instruments. There is no need for instruments without a shop to house them. Other demands will vie with instruments for the use of the capital. For example, will a new instrument or increased advertising produce more net profit? The type of service work a man intends to do greatly affects his instrument requirements. Does he plan to specialize in color TV, high-fidelity, auto radio, industrial electronics? Each service field has special instrument needs.

At first the writer's feeling of responsibility made him hesitant to make *general* recommendations about instrument purchases. As has been pointed out, much depends on the technical background, financial status, and specialized interest of the person at whom the advice is aimed; and general advice cannot take these matters into account.

It was decided, however, to assume first an interested reader who had a good basic knowledge of electronics but was short on actual experience. This particular reader would want to purchase first the minimum of instruments needed to open a small, one-man shop. As he gained knowledge, experience, and working capital, he would want to increase his service equipment, one piece at a time, making sure in each instance to add the next most helpful instrument to his collection. Eventually he might hire more men and take on some specialties—which involves more instruments.

It is hoped that aiming the article at this progressing service technician will permit the reader to step on the advice escalator at whatever level he finds himself and continue upward. Suggested instruments are arranged in various tables tied in with the text. Prices given in these tables are intended to be approximately representative for good-quality instruments, completely assembled and tested. Equivalent instruments can be had in kit form, in most instances, for roughly one-third less. Instruments with added features and refinements—many very worthwhile—will cost more.

Basic Shop Instruments

The first instrument needed is a *volt-ohmmeter* (Table 1).

If a good instrument is purchased and properly treated, it will provide reliable readings year after year and can be used as a standard in judging and calibrating other pieces of equipment. A typical, good v.o.m. will have a sensitivity of 20,000 ohms-per-volt on d.c. measurements and 1000 to 5000 ohms-per-volt on a.c. Six to eight ranges will have full-scale values from 1-3 volts up to 5000-7000 volts. Three to five ohmmeter scales will permit resistance measurement up to at least 20 megohms. Direct currents from 50 or 100 microamperes up to 10 or 15 amperes can be read. "Output" measurements that range from −15 or −20 db up to +40 or +60 db can be taken through a built-in d.c. blocking capacitor. Guaranteed accuracy will probably be a conservative 3% of full-scale on d.c. and 5% on a.c., but you can expect better. For more money, you can buy such extra features as increased sensitivity, expanded range, greater guaranteed accuracy, mirrored scales, and overload protection.

The second instrument should be an *r.f.-a.f. signal generator*. A satisfactory one will cover from 100 kc. to at least 50 mc. on fundamental frequencies. Each band will be spread out on the dial so the pointer can be easily set within 1% of a desired frequency marking. The frequency generated should be within 1% of the dial reading, and there should be provision for recalibrating both ends of every band. Double shielding and a good stepped attenuator should permit the output to be smoothly varied from around .1 volt down to a signal that can barely be detected with a sensitive receiver. A separately controlled audio oscillator should provide a low-distortion fixed-frequency sine-wave output around 400 cycles that can be used separately or employed to modulate the r.f. output of the signal generator. More money will buy metered output, crystal-controlled calibrating frequencies, a variable-frequency audio oscillator, extended r.f. range, and greater r.f. amplitude.

A *tube tester* should be the next purchase, even though some technicians consider this more of a sales aid than a service instrument and prefer to rely on tube substituting. True, a bad tube undetected by a tube tester will occasionally be revealed by substituting a good tube. On the other hand, tube substitution often fails to reveal marginal tubes; it is time consuming; and it requires a huge tube stock. Replacing weak and faulty tubes is as lucrative as any work a technician performs; so the instrument is a good business investment.

I do not, however, recommend buying too expensive a tube tester at the beginning. Settle for a rugged, portable, up-to-date instrument capable of spotting at least 95% of the defective tubes. The price of detecting that other 5% is very steep, and the tricky tubes can still be flushed out by tube substitution. A suitable instrument will test either the emission or G_m of a tube, or both. It will test practically all tubes encountered in present-day radio or TV sets; and, with the aid of an adapter, it will test picture tubes. Later, when you have more money to spend, you will want to buy a better tube tester for the shop and use the older one on service calls. For more money—in some instances much more money—you can have such features as greater variety and thoroughness of tests, automatic card-indexed set-up, testing of transmitter and industrial tube types, semiconductor and transistor testing, and protection against obsolescence.

What to Seek in a Scope

The fourth instrument should be a *general-purpose oscilloscope*. An absolute necessity in TV service, it can pinch-hit as an a.c. voltmeter, a signal tracer, a distortion analyzer, or a frequency meter until you are ready to acquire these instruments. Here are *minimum* specifications for a satisfactory scope and accessories:

Screen: 3". Vertical Amplifier: 50 mv. r.m.s. per-inch deflection; frequency response flat from 10 cycles to 1.5 megacycles. Horizontal Amplifier: .75 volt-per-inch sensitivity; frequency response 10-200,000 cycles. Sweep Oscillator: 15-75,000 cycles and very nearly linear throughout its range. Shielding: CR tube shielded from magnetic deflection. (Accessories: *demodulator probe* and *low-capacity probe*.)

Later a more expensive scope will be purchased for color and other work, but this first instrument should certainly not be the cheapest you can find. A good instrument will be kept and used a great deal even after the new scope is purchased; furthermore, only experience obtained with a good scope will fully reveal to you the many possible uses of this most versatile of all service instruments.

One more purchase must be made before you are ready to open the doors of your little shop: a *sweep generator*. You cannot claim to do TV service unless you can examine and align the i.f. section of the receiver, and using a sweep generator is the only practical way of doing that. The same sweep generator will also allow you to align FM receivers and examine the frequency response of video amplifiers, if it has the following specifications:

The output range on fundamentals should be a continuous 3-220 megacycles. The sweep width must be smoothly variable from 0 to at least 12 mc. Generator output should be nearly constant over a sweep width of at least six megacycles, especially in the vicinity of the 21- and 41-megacycle intermediate frequencies. Horizontal retrace blanking and a phase-controlled horizontal sweep for the scope should be provided. Both variable and crystal-controlled marker generators should be built into the sweep unit. The output cable should be terminated with an impedance-matching arrangement. Such a generator will be adequate for anything except precise tuner alignment; but since few technicians attempt tuner overhaul, this will be an instrument you will keep. Get a reliable one.

Worthwhile Additions

A service business can be started and operated for some time with the five instruments mentioned if the technician has sufficient electronic know-how to take maximum advantage of their possibilities. As soon as he can afford it, though, he should buy a good *vacuum-tube voltmeter* (Table 2). This instrument probably will have a constant input resistance of 10 megohms with an extra isolating megohm in the d.c. probe. The d.c. and a.c. ranges will approximate those of the v.o.m. Resistance ranges will likely extend upward to 1000 megohms. A *high-voltage probe* will extend the d.c. voltage range

BASIC SHOP INSTRUMENTS	
V.O.M.	$ 50.00
R.F.-A.F. Generator	80.00
Tube Tester	125.00
Oscilloscope (general-purpose)	130.00
Demodulator Probe	7.50
Low-Capacity Probe	7.50
Sweep Generator	195.00

1.

MUCH NEEDED INSTRUMENTS	
V.T.V.M.	$ 80.00
High-Voltage Probe	12.00
R.F. Probe	10.00
Transistor Tester	50.00
Signal Tracer	50.00
Capacitor Checker	90.00
Sine- and Square-Wave Generator	50.00

2.

TIME-SAVING INSTRUMENTS	
Flyback Transformer & Yoke Tester	$ 55.00
TV Field-Strength Meter	135.00
CRT Substitute	55.00
Grid-Dip Oscillator	50.00
TV Bias Supply	13.00
Capacitor & Resistor Substitution Box	20.00

3.

SPECIAL INSTRUMENTS	
(High-Fidelity)	
A.C. V.T.V.M.	$ 70.00
Distortion Analyzer	170.00
Test Tapes and Records	30.00
(Color Television)	
Wideband Oscilloscope	$275.00
Bar and Dot Generator	190.00
Degaussing Coil	12.00
(Auto Radio & Communications)	
Battery Substitute	$ 50.00
Special Frequency Meter	600.00
FM Deviation Meter	300.00
(Industrial Servicing)	
"Snap-Around" Ammeter	$ 40.00
Stroboscope	170.00
Wavemeter	25.00
(Deluxe Equipment)	
Special TV Analyzer	$300.00
NTSC Standard Color Bar & Dot Generator	525.00

4.

to 30,000 volts, and an *r.f. probe* will extend the a.c. range to 250 megacycles.

In spite of the fact the writer suggested buying the v.o.m. first, he prophesies the technician will get much more use out of the v.t.v.m. The v.t.v.m. can take d.c. readings on circuits containing r.f. with very little loading or detuning of these circuits. Its a.c. frequency response is greater. Positive or negative voltages can be read with the same probe simply by throwing a switch. It is much less likely to be damaged by overload. *BUT* the inherent long-time accuracy of a v.t.v.m. is inferior to that of a v.o.m., and you need the latter to check and recalibrate the former. The situation is like that of your wrist watch and an electric clock. The wrist watch is the timepiece you consult dozens of times a day, but you still need the clock to set the watch and occasionally check on its accuracy. Furthermore, the v.o.m. is self-contained and independent of line voltage. It can be used on a rooftop or inside a car parked at the curb.

The rapid advance of transistors demands the seventh instrument be a *transistor tester*. You can tell if a tube is burned out by looking at it or feeling it, but not so with a transistor. You need a reliable instrument to decide if a semiconductor is good or bad. A minimum transistor tester should check both diodes and transistors, in circuit or out. Front-to-back ratios of diodes will be indicated, and transistors will be tested for current gain, leakage, shorts, and opens. More expensive testers will check other operating parameters of transistors.

Number eight choice is a *signal tracer*. This instrument has a.f. and r.f. input probes that permit the operator to pick off a modulated signal at any point in a radio from the antenna terminal to the speaker voice coil and hear the signal coming out the speaker of the tracer. Some tracers have facilities for connecting a scope or meter across the output. A noise-testing arrangement applies a high voltage of limited current across the probes. If a coil, capacitor, or other part that is breaking down is placed between these probes, the fluctuating current produces a signal that is amplified and heard as characteristic noise in the speaker. Simplified and miniaturized versions of the signal tracer are built into a small probe with the demodulated and amplified signal being heard in an earphone. The signal tracer is a great time-saver in running down distortion, noise, dead stages, or intermittent conditions in both tube and transistor radios; and it is also helpful in TV servicing.

A *capacitor checker* receives the ninth nod. Only resistors outnumber capacitors in radio and TV receivers, and the various afflictions besetting capacitors account for a large proportion of receiver failures. A good capacitor checker will allow you to determine quickly the condition of practically any type of capacitor in or out of the circuit. Attached to a capacitor in a receiver, it will reveal if that capacitor is the cause of intermittent behavior. Anything that shortens time squandered on "intermittents"—the technician's personal gremlin—is a welcome addition to the service bench.

A *sine- and square-wave generator* is invaluable in working with audio and video amplifiers; so let's make it number ten. This instrument should produce sine waves of negligible distortion from 20 to at least 50,000 cycles with nearly uniform output across the entire range. Good square waves should be produced over a goodly portion of this range. The sine-wave output should be smoothly variable from 0-10 volts r.m.s. In conjunction with the scope and v.t.v.m., this generator can be used to check unknown frequencies, determine inductance values, measure impedance, find transformer ratios, and perform many other valuable tests.

This completes the major instrumentation of the general shop, but there are many other pieces of service equipment designed to save the increasingly valuable time of the technician (Table 3). *Flyback transformer and yoke tester, TV field-strength meter, portable CRT substitution units, grid-dip oscillator, TV bias supply, capacitor and resistor substitution boxes*—these are some of the instruments you will find in any shop that claims to be really well equipped.

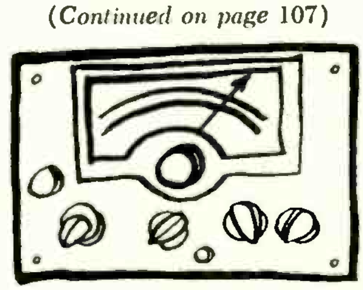
Special Instruments

The sine- and square-wave generator and the scope are the mainstays of a technician specializing in hi-fi servicing, but he should also have an *a.c. v.t.v.m.* (Table 4). This instrument will have full-scale ranges from .01 to 300 volts r.m.s., and it will have a virtually flat frequency response from 20 to at least 50,000 cycles. With it the technician can measure accurately very small audio and noise signals far beyond the frequency limits of the human ear and even beyond the limits of a conventional v.t.v.m. Hi-fi bugs have critical ears for distortion and the technician needs a *distortion analyzer* to help locate and identify causes of subtle distortion. The analyzer can be of either the harmonic or intermodulation type. *Test tapes* and *test records* round out the list of specialized hi-fi test equipment.

The man who expects to do much color TV service work—and who doesn't?—must invest considerably more money in equipment. First, he needs a *wide-band oscilloscope* whose vertical-amplifier frequency response holds up well beyond 4 megacycles. The instrument should also have an extended sweep-oscillator range and built-in peak-to-peak calibrating voltages. Input attenuators must be carefully compensated so as not to display frequency discrimination. For convergence and work with chroma circuits, he must have a *dot and color-bar generator*. The bar generator will preferably be one of the *keyed* or *side-lock* type rather than the *continuous rainbow* type. If the dot generator also produces horizontal and vertical lines, so much the better. Both generators can be had in a single instrument. The color technician will also need a *degaussing coil*.

A *battery substitute* that produces metered, heavy-current, variable d.c. voltages from 0 up to 20 volts is needed for auto-radio service. An instrument furnished with a second, extra-

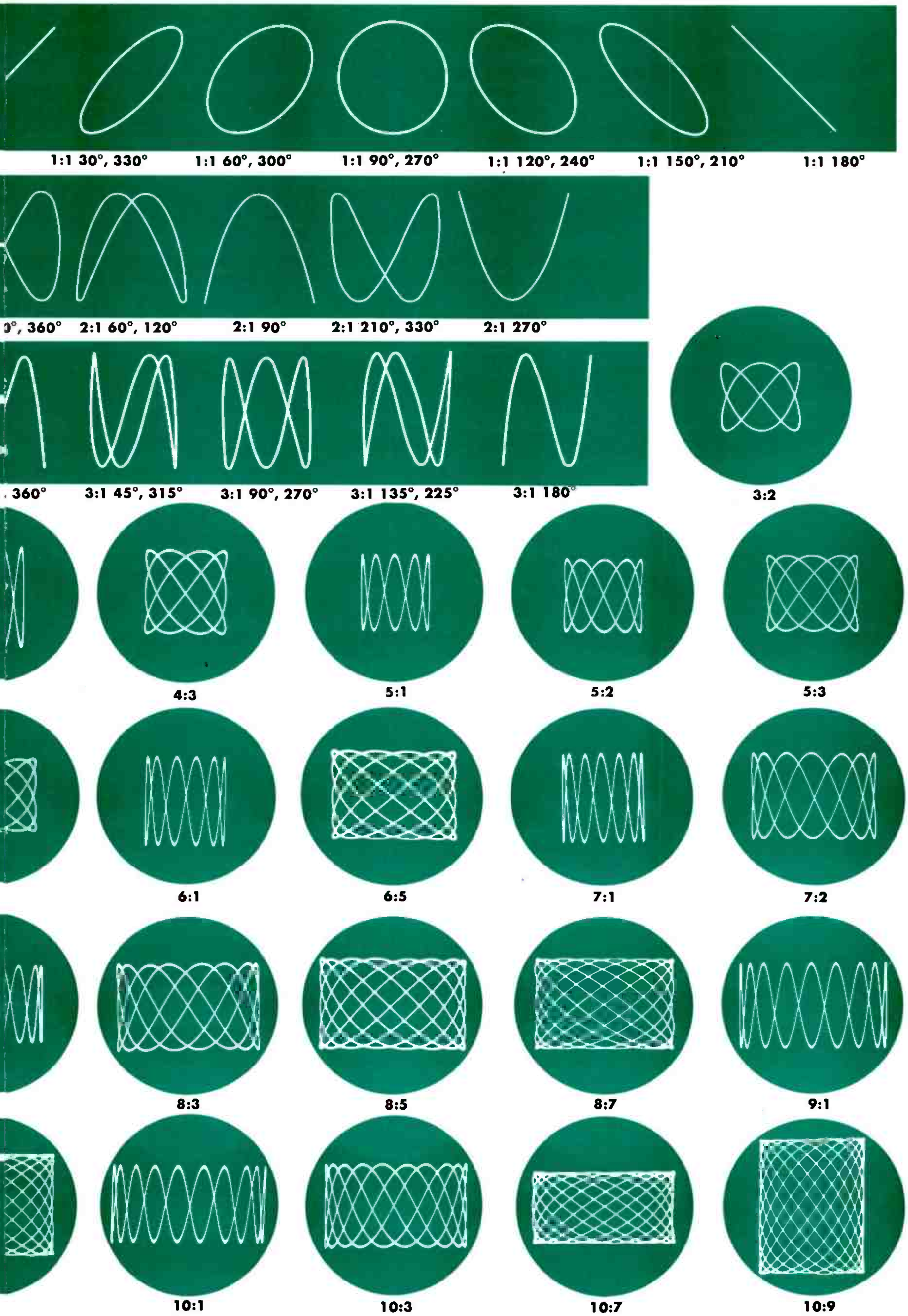
(*Continued on page* 107)



1962 OSCILLOSCOPE DIRECTORY

This condensed list of the primary specifications and capabilities of over seventy oscilloscopes, currently in production, is based on a broad survey recently completed by Electronics World.

Model	Vertical Channel: Frequency Response	Vertical Channel: Sensitivity	Vertical Channel: Input Z (meg.-μμf.)	Horizontal Channel: Frequency Response	Horizontal Channel: Sensitivity	Horizontal Channel: Input Z (meg.-μμf.)	Sweep	CRT Size	Price	Remarks
DU MONT, ALLEN B. LABS, 750 Bloomfield Ave., Clifton, N.J.										
304-A	d.c.-coupled down no more than 10% @ 100 kc.; a.c.-coupled down no more than 10% @ 10 cps & 100 kc. and no more than 50% @ 300 kc.	.025 d.c. volt/in.	2-50	Same as vertical channel	1.2 d.c.v./full scale	2.2-50	2 cps-30 kc. with sweep expansion 1 μsec./in.	5"		Rack mount 304-AR; 12 μsec. rise time
401-B	d.c.-500 kc.	10 mv./cm.	1-47	d.c.-500 kc.	10 mv./cm.	1-47	200 msec./cm.-5 μsec./cm.	5"		Rack mount 401BR; 5X sweep expand; .8 μsec. rise time
403-B	150 kc.-500 kc.	50 μv./cm.	1-47	d.c.-coupled, d.c.-500 kc.	10 mv./cm.	1-47	15 sec./cm.-1 μsec./cm.	5"		Rack mount 403BR; 5X sweep expand; .7 μsec. rise time
411	flat from d.c. to down not more than 30% @ 100 kc. on 2 mv.-50 v. positions	100 μv./cm.	Balanced 4-30	d.c. to down not more than 30% @ 100 kc.	.3 p-p v./cm.	2-50	1 sec./cm.-1 μsec./cm.	5"		Rack mount 411R; dual-beam vertical amplifiers are identical; 5X sweep expand; 3.3 μsec. rise time
425	d.c.-35 mc.	5 mv./cm.					2 sec./cm.-.05 μsec./cm.	5"		Rack mount 425R; 5X sweep expand; 10 nsec. rise time
4201: Y Preamp for 425. vertical channel: freq. resp., d.c.-3 mc. down 3 db; sensitivity 50 mv./cm.; input Z, 1 meg., 25 μμf.										10 nsec. rise time
4202: Dual-trace preamp for 425. vertical channel: freq. resp., d.c.-33 mc.; sensitivity 50 mv./cm.; input Z, 1 meg., 23 μμf.										11 nsec. rise time
4202: Y preamp for 425. vertical channel: freq. resp., d.c.-21 mc. down 3 db; sensitivity 5 mv./cm.; input Z, 1 meg., 23 μμf.										17 nsec. rise time
4204: X input for 425. horizontal channel: freq. resp., d.c.-4 mc. down 3 db ± 1 db; sensitivity 2 v./cm; input. Z, 1 meg., 23 μμf.										90 nsec. rise time
430	d.c.-10 kc.	10 mv./cm.	1-47	d.c.-10 kc.	10 mv./cm.	1-47	2 sec./cm.-50 μsec./cm.	5"		5X sweep expand; 35 μsec. rise time
440	d.c.-5 mc.	50 mv./cm.	1-47	d.c.-500 kc.	10 mv./cm.	1-47	20 msec./cm.-1 μsec./cm.	5"		Rack mount 440R; 5X sweep expand; .08 μsec. rise time
766: 76-01: Y amp. 74-03 timebase	d.c.-25 mc. down 3 db ± 1 db	5 mv./cm.					2 sec. /cm.-.05 μsec./cm.	6 X 10 cm.		Transistorized scope; 5X sweep expand; 14 nsec. rise time. Model 765 field version; 676 rack mount type
76-02: Dual-trace amp. for 766. vertical channel: freq. resp. d.c.-25 mc. down 3 db ± 1 db; sensitivity 5 mv./cm.										14 nsec. rise time
HEWLETT–PACKARD CO., 1501 Page Mill Rd., Palo Alto, California										
120A	d.c.-200 kc.	10 mv./cm.	1-50	d.c.-200 kc.	.1 v./cm.	1-100	200 msec./cm.-5 μsec./cm.	5"	$ 450	5X sweep expand
120B	d.c.-450 kc.	10 mv./cm.	1-50	d.c.-300 kc.	.1 v./cm.	1-100	200 msec./cm.-5 μsec./cm.	5"	$ 475	5X sweep expand
122A	Same as 120 except dual trace								$ 675	
130B	d.c.-300 kc.	1 mv./cm.	cabinet 2-25 rack 2-125	d.c.-300 kc.	1 mv./cm.	same as vertical	5 sec./cm.-1 μsec./cm.	5"	$ 650	5X sweep expand
150A	main vertical amp d.c.-more than 10 mc.			d.c.-over 500 kc.	200 mv./cm.	1-31	5 sec./cm.-1 μsec./cm.	5"	$1300	5X, 10X, 50X, 100X sweep expand; .035 μsec. rise time
151B: High-gain amp. for 150A. vertical channel: freq. resp. d.c.-10 mc.; sensitivity 5 mv./cm.; input Z, 1 meg., 31 μμf.; .035 μsec. rise time.									$ 200	
152B: Dual-channel amp. for 150A. vertical channel: freq. resp. d.c.-10 mc.; sensitivity .05 v./cm.; input Z, 1 meg., 30 μμf.; .035 μsec. rise time both inputs to 1 channel.									$ 250	
153A: Differential amp. for 150A. vertical channel: freq. resp. d.c.-500 kc.; sensitivity 1 mv./cm.; input Z, balanced 2 meg., 17 μμf.; single-ended 1 meg., 35 μμf.									$ 150	
154A Voltage-current amp. for 150A	current, 50 cps-8 mc.; voltage, d.c.-10 mc.	1 ma./cm. .05 v./cm.	current channel .01Ω-1μhy. voltage channel 1 meg.-30 μμf.						$ 430	
160B	main vertical amp d.c.-15 mc.			d.c.-1 mc.	.1 v./cm.	1-30	5 sec./cm.-.1 μsec./cm.	5"	$1850	*
	*1X, 2X, 5X, 10X, 20X, 50X, 100X sweep expand; 166B time mark gen. $130; 166C display scanner $300; 166D sweep delay gen. $325.									


1:1 30°, 330°
1:1 60°, 300°
1:1 90°, 270°
1:1 120°, 240°
1:1 150°, 210°
1:1 180°
0°, 360°
2:1 60°, 120°
2:1 90°
2:1 210°, 330°
2:1 270°
360°
3:1 45°, 315°
3:1 90°, 270°
3:1 135°, 225°
3:1 180°
3:2
4:3
5:1
5:2
5:3
6:1
6:5
7:1
7:2
8:3
8:5
8:7
9:1
10:1
10:3
10:7
10:9

Oscilloscope LISSAJOUS Patterns

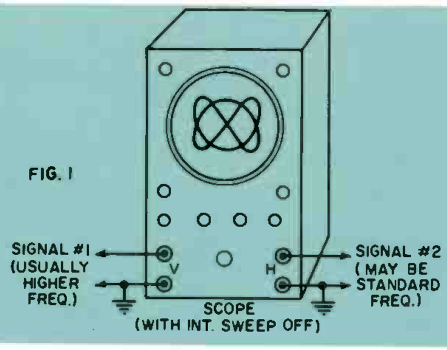


FIG. 1

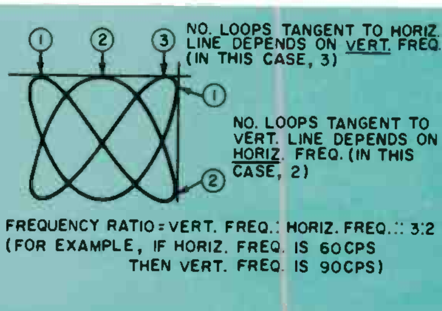


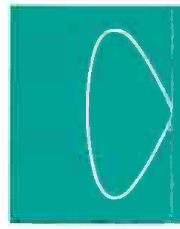
FIG. 2

One of the most useful techniques of measuring frequency and phase is by means of Lissajous figures on a cathode-ray oscilloscope. To obtain these patterns, the scope's internal saw-tooth sweep is turned off and a known standard signal is applied directly to the horizontal input. The unknown signal is then applied to the vertical input (Fig. 1). The scope gain controls are adjusted for equal horizontal and vertical deflection. When either of the signals is adjusted so that there is an integral relation between the two frequencies, a stationary pattern will be seen on the scope screen. By examining the pattern it is possible to determine the ratio between the two frequencies as well as their phase relation.

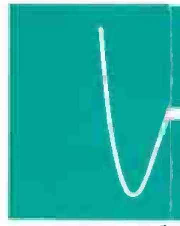
For example, assume that the pattern shown in Fig. 2 is produced. To "read" this pattern, visualize a square surrounding the figure or position the pattern so that the ruled lines on the scope's graticule form a square around the figure. Then count the number of loops in the pattern that touch one of the horizontal sides of the square. This number depends on the signal applied to the scope's vertical channel. Next, count the number of loops that touch one of the vertical sides of the square. This number depends on the signal applied to the scope's horizontal channel. The ratio between the two numbers is the frequency ratio. In the example shown, this frequency ratio is 3:2, so that if the horizontal frequency is exactly 60 cps, then the vertical frequency is exactly 90 cps.

All the Lissajous patterns shown here were produced with two sine-wave signal generators. The same principle of pattern formation applies when other waveshapes are used, but the points of tangency may be a little more difficult to count. Beneath each pattern is shown the frequency ratio (the first number applies to the vertical signal) and the phase relation in degrees in the simpler patterns. If the frequencies are interchanged, for example, 2:3 rather than 3:2, then the pattern is simply rotated by 90 degrees. In some cases, scope gain controls have been re-adjusted in order to make it somewhat simpler to count the number of loops in the pattern.

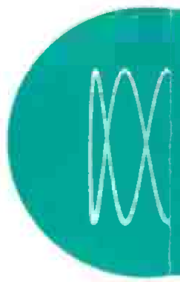
1:1 0°, 360°



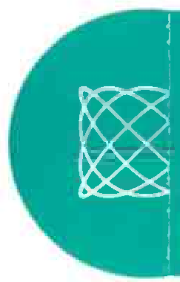
2:1 0°, 18



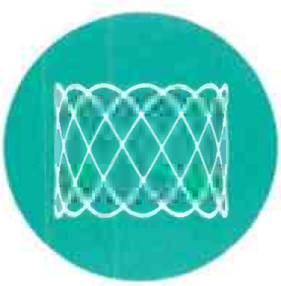
3:1 0°



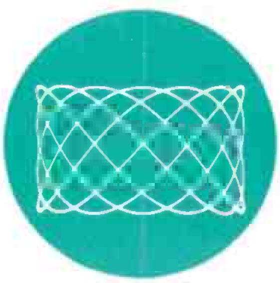
4:1



5:4

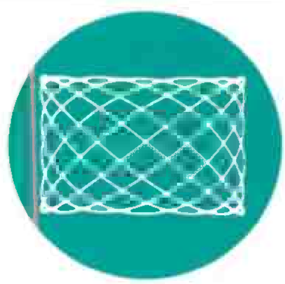


7:3

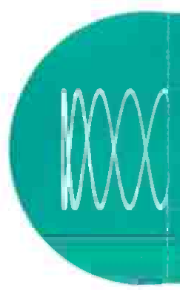


7:4

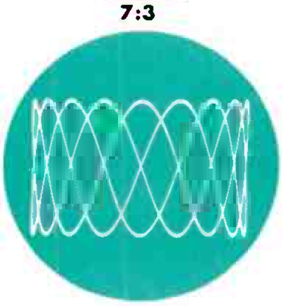
7:5



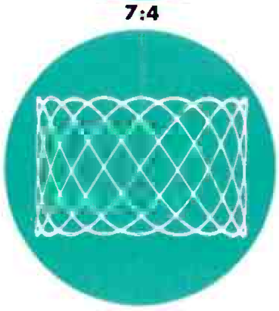
7:6



8:1

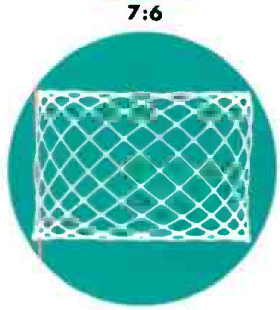


9:2

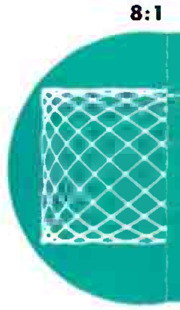


9:4

9:5



9:7



9:8

Waveforms from "Encyclopedia on Cathode-Ray Oscilloscopes and Their Uses" by Rider & Uslan (Published by John F. Rider Publisher, Inc.)

Model	Vertical Channel: Frequency Response	Vertical Channel: Sensitivity	Vertical Channel: Input Z (meg.-µµf.)	Horizontal Channel: Frequency Response	Horizontal Channel: Sensitivity	Horizontal Channel: Input Z (meg.-µµf.)	Sweep	CRT Size	Price	Remarks
162A: Dual-trace amp. for 160B. vertical channel: freq. resp. d.c.-14 mc.; sensitivity .02 v./cm.; input Z, 1 meg., 25 µµf. *Alternate-sweep switching or chopped. .025 µsec. rise time.									$ 350	*
162F: Fast-rise amp. for 160B. vertical channel: freq. resp. d.c.-15 mc.; sensitivity .05 v./cm.; input Z, 1 meg., 25 µµf.									$ 145	23 nsec. rise time
170A	main vertical amp d.c.-30 mc.			same as 160B	same as 160B	1-30		5"	$2150	Same accessories as 160B
185A (with 187B dual-trace amp.)	greater than 800 mc. @ 3 db point; less than .5 nsec. rise time for any input signal; d.c.-1000 mc. @ 3 db point; less than .4 nsec. rise time	10 mv./cm.	.1-2				.1 nsec./cm.-1 µsec./cm.	5"	$2000 +187B-$1000	Sampling scope; 2X, 5X, 10X, 20X, 50X, 100X sweep expand
185B with 187B dual-trace amp. vertical channel: freq. resp. d.c.-800 mc.; sensitivity 10 mv./cm.; input Z, .1 meg., 2 µµf.							10 nsec./cm.-10 µsec./cm.	5"	$2300 +187B-$1000	Sampling scope; 1X, 2X, 5X, 10X, 20X, 50X, 100X sweep expand
HICKOK ELECTRICAL INSTRUMENT CO., 10514 Dupont Ave., Cleveland 8, Ohio										
675A	d.c.-4.5 mc. ± 3 db	20 r.m.s. mv./in.		1 cps-450 kc. ± 3 db	250 r.m.s. mv./in.		10 cps-100 kc.	5"	$ 290.90	10X sweep expand
770	d.c.-5 mc. ± 3 db wideband; d.c.-2.5 mc. narrow band	35 r.m.s. mv./in. wideband; 10 r.m.s. mv./in. narrow band	2.2-50	d.c.-500 kc. ± 3 db	75 r.m.s. mv./in.	2.2-50	2 cps-30 kc.	5"	$ 470	6X sweep expand; .07 µsec. rise time
ITT INDUSTRIAL PRODUCTS DIV., 15191 Bledsoe St., San Fernando, Calif.										
1735D 2135D	series yoke conn. —3 db @ 200 kc.; par. yoke conn. —3 db @ 270 kc.	series yoke conn. 10 p-p mv./in.; par. yoke conn. 20 p-p mv./in.	2-35	—3 db @ 200 kc.	10 p-p mv./in.	2-50	1 sec./in.-10 µsec./in.	17" or 21" mag. defl.	$1980 $2095	
1740D 2140	series yoke conn. —3 db @ 85 kc.; par. yoke conn. —3 db @ 100 kc.	series yoke conn. 1 p-p mv./in.; par. yoke conn. 2 p-p mv./in.	2-35	—3 db @ 100 kc.	1 p-p mv./in.	2-50	1 sec./in. 10 µsec./in.	17" or 21" mag. defl.	$2210 $2300	
1770A	—3 db @ 110 kc.	1 in./volt	.25-15	—3 db @ 110 kc.	1 in./volt	.25-15		17"	$1595	Magnetic deflection
1770H	—3 db @ 110 kc.	10 in./volt	.25-15	—3 db @ 110 kc.	10 in./volt	.25-15		17"	$1720	Magnetic deflection
JACKSON ELECTRICAL INSTRUMENT CO., 124 McDonough St., Dayton, Ohio										
CRO-2	20 cps-4.5 mc. ± 1 db	.018 r.m.s. v./in.					20 cps-50 kc.	5"	$ 225	
600	20 cps-4.9 mc. ± 1 db	20 mv./in.		20 cps-200 kc. ± 2 db			10 cps-100 kc.	5"	$ 355	
PACKARD BELL ELECTRONICS, P.O. Box 337, Newbury Park, Calif.										
5Mc-2P/R	d.c.-5 mc. ± 3 db	a.c.-coupled 2.5 cps-20 kc. 1 mv./cm.	1-30	d.c.-200 kc. ± 3 db	.2 v./cm.		1 sec./cm.-1 µsec./cm.	3"	$ 570	Dual-gun scope; 1X, 2X, 5X, and 10X sweep expand; .07 µsec. rise time
RADIO CORPORATION OF AMERICA, Harrison, N.J.										
WO-91A	3 cps-4.5 mc. wideband ± 1 db; 3 cps-1.5 mc. high sensitivity; 3.5 cps-1.5 mc. flat within —6 db	.15 p-p v./in. wideband; .05 p-p v./in. high sensitivity	1-40	3 cps-500 kc.; flat within —6 db	.18 r.m.s. v./in.	2.2-30	10 cps-100 kc.	5"	$ 239.50	Sensitivity and input impedance with "V Input" conn.; rise time .1 µsec. (4.5 mc. pos.); 5 µsec. (1.5 µsec. pos.)
SIMPSON ELECTRIC CO., 5200 W. Kinzie St., Chicago 44, Ill.										
458	wideband flat within ± 1 db to 4.5 mc.; narrow band flat within ± 2 db 10 cps-300 kc.	wideband 30 r.m.s. mv./in.; narrow band 20 r.m.s. mv./in.					up to 200 kc.	7"	$ 395	
466	15 cps-100 kc. flat within ± 1 db; 6 db down @ 250 kc.	30 r.m.s. mv./in.	.5-35 @ att. X100	15 cps-20 kc. flat within ± 1 db; 6 db down @ 100 kc.	.7 r.m.s. v./in.		15 cps-80 kc.	5"	$ 149.95	
2610	d.c.-8 mc. ± 1.5 db	2.5 r.m.s. mv./in. without delay line	1-30	2 cps-1 mc. ± 1.5 db	2.5 r.m.s. v./in.	1-45	3 cps-500 kc.	5"	$ 575	Four calibrated sweeps 5, 50, 500, 5000 µsec.; rise time .1 µsec. in transient pos.
TEKTRONIX, INC., P.O. Box 500, Beaverton, Oregon										
310A	d.c.-4 mc.	a.c.-coupled .01 v./div.	1-40		1.5 v./div.		.2 sec./div.-5 µsec./div.	3"	$ 625	5X sweep expand; 90 nsec. rise time
316	d.c.-10 mc.	a.c.-coupled .01 v./div.	1-40	d.c.-500 kc.	1.4 v./div.		2 sec./div.-.2 µsec./div.	3"	$ 750	Rack mount RM16; 5X sweep expand; 35 nsec. rise time

(Continued)

	Vertical Channel			Horizontal Channel						
Model	Frequency Response	Sensitivity	Input Z (meg.-$\mu\mu$f.)	Frequency Response	Sensitivity	Input Z (meg.-$\mu\mu$f.)	Sweep	CRT Size	Price	Remarks
317	d.c.-10 mc.	a.c.-coupled .01 v./div.	1-40	d.c.-500 kc.	1.4 v./div.		2 sec./div.-.2 μsec./div.	3"	$ 800	Rack mount RM17; 5X sweep expand; 35 nsec. rise time
321	d.c.-5 mc.	.01 v./div.	1-40	d.c.-1 mc.	1.5 v./div.	.1-20	.5 sec./div.-.5 μsec./div.	3"	$ 785	Transistorized, operates a.c., d.c., batteries; 5X sweep expand; .07 μsec. rise time
502	d.c-100 kc. to d.c.-1mc.	200 μv./cm.-.2 v./cm.	1-47	for single-beam applications, same as vert.			5 sec./cm.-1 μsec./cm.	5"	$ 825	Dual beam; ident. vert. amps; 2X, 5X, 10X, 20X sweep expand
503	d.c.-450 kc.	1 mv./cm.	1-47	d.c.-450 kc.	1 mv./cm.	1-47	5 sec./cm.-1 μsec./cm.	5"	$ 625	Rack mount RM503; X-Y unit for curve plotting; 2X, 5X, 10X, 20X, 50X sweep expand
504	d.c.-450 kc.	5 mv./cm.	1-47				5 sec./cm.-1 μsec./cm.	5"	$ 525	Rack mount RM504
515A	d.c.-15 mc.	.05 v./cm.	1-36	d.c.-500 kc.	1.4 v./cm.		2 sec./cm.-.2 μsec./cm.	5"	$ 800	Rack mount RM15; 5X sweep expand; 23 nsec. rise time
516	d.c.-15 mc.	.05 v./div.	1-20	d.c.-500 kc.	1.4 v./div.	1-20	2 sec./div.-.2 μsec./div.	5"	$1000	Dual trace; 5X sweep expand; 23 nsec. rise time
517A		.05 v./cm.					20 μsec./cm.-10 nsec./cm. @ 24 kv.; 10 μsec./cm.-5 nsec./cm. @ 12 kv.	5"	$3500	High speed unit; 7 nsec. rise time
519	d.c.-1 gc.	10 v./cm.					1000 nsec./cm.-2 nsec./cm.	5"	$3800	.35 nsec. rise time
531A	d.c.-15 mc. with K, L, C-A plug-ins; d.c.-14 mc. with A, B, G plug-ins; d.c.-11 mc. H plug-in; d.c.-350 kc. D plug-in; .06 cps-20 kc. E plug-in; d.c.-10 mc. with Z plug-in	.05 v./cm. with A, B, K, L, C-A, G, Z plug-ins; 50 μv./cm. with E plug-in; 5 mv./cm. with H plug-in; 1 mv./cm. with D plug-in	Plug-ins A, B, D, G, H 1-47 C-A, K, L 1-20 E, 10-50 Z, 1-24	d.c.-240 kc.	.2 v./cm.	1-47	5 sec./cm.-.1 μsec./cm.	5"	$ 995 without plug-ins	Rack mount RM31A; 5X sweep expand
533A	uses A-Z plug-ins; same specs as for 531A	same as 531A	same as 531A	d.c.-500 kc.	.1 v./cm.	1-45	5 sec./cm.-.1 μsec./cm.	5"	$1100	Rack mount RM33A; 2X, 5X, 10X, 20X, 50X, 100X sweep expand; plug-ins as 531A
535A	same as 531A	same as 531A	same as 531A	same as 531A	same as 531A	same as 531A	time base B: 1 sec./cm.-2 μsec./cm.	5"	$1400	Rack mount RM35A; time base A sweep delay 1 μsec.-10 sec., derived from time base B
532	d.c.-5 mc. with A, B, C-A, G, K, L, Z plug-ins; d.c.-2 mc. with 0 plug-in; .06 cps-60 kc. with E plug-in	same as 531A	same as 531A	d.c.-300 kc.	.2 v./cm.	1-40	1 sec./cm.-1 μsec./cm.	5"	$ 875	Rack mount RM32; 5X sweep expand
536	d.c.-10 mc. with A, B, C-A, G plug-ins; d.c.11 mc. with K, L plug-ins; d.c.-2 mc. with 0 plug-in; .06 cps-60 kc. with E plug-in; d.c.-9.5 mc. with H plug-in; d.c.-9 mc., Z plug-in	same as 531A	same as 531A	same as for vert. channel plug-ins	same as 531A	same as 531A	time base gen. T: 2 sec./div.-.2 μsec./div.	5"	$1050	X-Y unit for curve tracing; 5X sweep expand
541A	d.c.-30 mc. with K, L plug-ins; d.c.-24 mc. with C-A plug-in; d.c.-15 mc. with H plug-in; d.c.-20 mc. with A, B, G plug-ins; d.c.-350 kc. with 0 plug-in; .06 cps-20 kc. with E plug-in; d.c.-13 mc. with Z plug-in	.05 v./cm. A, B, C-A, G, K, L, & Z plug-ins; 1 mv./cm.-0; 5 mv./cm.-H; .5 mv./cm.-E	plug-ins A, B, 0, G, H 1-47; plug-ins K, L, C-A, 1-20; plug-in E, 10-50 plug-in Z, 1-24	d.c.-240 kc.	.2 v./cm.	1-47	5 sec./cm.-.1 μsec./cm.	5"	$1200	5X sweep expand
543A	same as 541A	same as 541A	same as 541A	d.c.-500 kc.	.1 v./cm.	1-45	5 sec./cm.-.1 μsec./cm.	5"	$1275	2X, 5X, 10X, 20X, 50X, 100X sweep expand
545A	same as 541A	same as 541A	same as 541A	same as 541A	same as 541A	same as 541A	time base B: 1 sec./cm.-2 μsec./cm.	5"	$1200	Time base A sweep delay 1 μsec.-10 sec.; derived from time base B

Model	Vertical Channel: Frequency Response	Vertical Channel: Sensitivity	Vertical Channel: Input Z (meg.-µµf.)	Horizontal Channel: Frequency Response	Horizontal Channel: Sensitivity	Horizontal Channel: Input Z (meg.-µµf.)	Sweep	CRT Size	Price	Remarks
551	range—plug-in: .06 cps-20 kc., E; d.c.-350 kc., D; d.c.-13 mc., Z; d.c.-14 mc., H; d.c.-18 mc., A, B, G; d.c.-22 mc., C-A; d.c.-25 mc., L; d.c.-30 mc., K	.05 v./cm. plug-ins A, B, C-A, G, H, K, L, Z; plug-in D 1 mv./cm.; plug-in E 50 µv./cm.	same as 541A	d.c.-400 kc.	.2 v./cm.	.1-40	5 sec./cm.-1 µsec./cm.	5"	$1800	Dual-beam unit; 5X sweep expand
555	range—plug-in; .06 cps-20 kc., E; d.c.-350 kc., D; d.c.-13 mc., Z; d.c.-15 mc., H; d.c.-20 mc., A, B, G; d.c.-24 mc., C-A; d.c.-30 mc., K, L.	.05 v./cm. A, B, C-A, G, K, L, Z; 50 µv./cm., E; 1 mv./cm., D; 5 mv./cm., H	same as 541A	d.c.-240 kc.	.2 v./cm.	1-47	5 sec./cm.-.1 µsec./cm. sweep can be delayed .5 µsec.-50 sec.	5"	$2600	Dual beam unit with sweep delay; 5X sweep expand
581	same as 555 with A-Z plug-ins & type 81 adapter; with type 80 plug-in d.c.-100 mc.	same as 555 with A-Z plug-ins & type 81 adapter; with type 80 plug-in .1 v./cm.	same as 555; with type 80 plug-in .1-10	d.c.-240 kc.	.2 v./cm.	1-47	2 sec./cm.-5 nsec./cm.	5"	$1375	Rise time type 80 plug-in 3.5 nsec.; 5X sweep expand
585	same as 581	same as 581	same as 581	same as 581	same as 581	same as 581	var. sweep delay 1 µsec.-10 sec.	5"	$1675	Has second time base gen. for sweep delay

Plug-Ins: A, wideband d.c., 25 nsec. rise time, $90; B, wideband, high-gain, 25 nsec. rise time, $135; C-A, dual-trace d.c., 23 nsec. rise time, $250; D, high-gain d.c. differential, $155; E, low-level a.c. differential, $175; G, wideband d.c. differential, 18-35 nsec. rise time, $185; H, wideband, high-gain d.c., 23-70 nsec. rise time, $185; K, fast-rise d.c., 12-70 nsec. rise time, $135; L, fast-rise, high-gain, 15-70 nsec. rise time, $200; N, sampling, .6 nsec. rise time, $600; T, time-base generator, .4 nsec. rise time, $235; Z, differential comparator, $525.

Model	Vertical Channel: Frequency Response	Vertical Channel: Sensitivity	Vertical Channel: Input Z (meg.-µµf.)	Horizontal Channel: Frequency Response	Horizontal Channel: Sensitivity	Horizontal Channel: Input Z (meg.-µµf.)	Sweep	CRT Size	Price	Remarks
560	type 50 vert. amp.: 15 cps-200 kc.; type 59, d.c.-400 kc.; type 60, d.c.-1 mc.; type 63 diff. amp. d.c.-300 kc.; type 72 dual-trace d.c.-650 kc.; type 75 wideband amp d.c.-4 mc.	1 mv./cm.; 1 v./cm./.05 v./cm./50:1 rejection ratio; 10 mv./cm.; .05 v./cm. respectively	type 50 none; type 59 .250 meg. balance 1-47				type 51 time base 5 ms./cm. type 67 time base 5 sec./cm.-1 µsec./cm.	5"	560—$325 50—$115 51—$135 59—$ 50 60—$ 99.50 63—$ 125 67—$ 150 72—$ 250 75—$ 175	Type 72 dual trace amp. 30 kc. switching rate; 1X-20X magnifier on 51 time-base unit; 5X sweep expand on 67 time-base unit
561	same plug-ins as 560 plus units No. 70-79							5"	$ 425	

WATERMAN PRODUCTS CO., 2445 Emerald St., Philadelphia, Pa.

Model	Vertical Channel: Frequency Response	Vertical Channel: Sensitivity	Vertical Channel: Input Z (meg.-µµf.)	Horizontal Channel: Frequency Response	Horizontal Channel: Sensitivity	Horizontal Channel: Input Z (meg.-µµf.)	Sweep	CRT Size	Price	Remarks
Mark I	d.c.-75 kc.	6 r.m.s. v./div.	.5-100	20 cps-75 kc.	.15 r.m.s. v./div.	.5-100	20 cps- 20 kc.	3"	$ 89.95	
Mark II	d.c.-100 kc.	36 r.m.s. mv./div.	1-90	20 cps-75 kc.	150 r.m.s. mv./div.	.5-40	20 cps- 20 kc.	3"	$ 149.50	
S-11-A	d.c.-200 kc. ± 2 db	100 r.m.s. mv./in.	.5-35	d.c.-200 kc.	100 r.m.s. mv./in.	10-10	3 cps-50 kc.	3"	$ 149.50	2 µsec. rise time
S-14-A	d.c-155 kc. ± 2 db	12 r.m.s. mv./in.	1-25	d.c.-155 kc.	42 r.m.s. mv./in.	1-35	.5 cps-50 kc.	3"	$ 249.00	1.8 µsec. rise time
S-14-B	d.c.-700 kc. ± 2 db	50 r.m.s. mv./in.	1-25	d.c.-200 kc.	150 r.m.s. mv./in.	1-25	.5 cps-50 kc.	3"	$ 239.00	.35 µsec. rise time
S-14-C	d.c.-700 kc. ± 2 db	70 r.m.s. mv./in.	1-25	d.c.-700 kc.	700 r.m.s. mv./in.	10-15	.5 cps-50 kc.	3"	$ 289.00	.35 µsec. rise time
S-15-A	d.c.-155 kc.	10 r.m.s. mv./in.	1-25	d.c.-140 kc.	1 r.m.s. v./in.	1-25	.5 cps-50 kc.	3"	$ 399.00	1.8 µsec. rise time; two separate scopes in one unit
S-16-A	d.c.-5 mc. + ½-3 db	2.5 r.m.s. mv./cm.	1-40	3 cps-180 kc.	10 r.m.s. mv./in.	1-120	5 cps-50 kc.	5"	$ 245.00	.07 µsec. rise time
S-17-A	d.c.-230 kc. + ½ — 6 db	d.c. 10 mv./div.	1-53	3 cps-170 kc.	400 p-p mv./in.	1-85	1 sec./div.-10 µsec./div.	3"	$ 295.00	2 µsec. rise time

Notes on the Tables

Among the most important factors to be considered when selecting an oscilloscope are the vertical-channel sensitivity and the passband. The former must be great enough to provide a useful display of the lowest amplitude signal to be observed. The latter has to be sufficiently broad to display the highest frequency signal to be studied without modifying its waveshape. The rise time should be fast enough to give an undistorted display of the fastest pulse and sweep speeds must be commensurate with this.

Dual-channel oscilloscopes are especially suited for performing over-all system checks as the input waveform can be compared directly with the output waveform. A dual-channel scope can be used to determine phase shift by measuring the time (distance) between zero-axis crossings of the same waveshape slopes. However, the relative phase of two signals can also be compared with a single-channel scope by using Lissajous patterns.

All the specifications listed here are based on information supplied by the manufacturers. Further details and prices (where applicable) can be obtained by writing directly to the firms in question.

Only the d.c. frequency response of the vertical and horizontal channels is listed. In those cases where separate a.c. and d.c. sensitivities were mentioned by a manufacturer, we showed the a.c., the higher of the two.

With regard to sweep speeds, we noted in the remarks column the amount of sweep expansion that is available. Vernier-control provision for extending the time of the slowest sweep is not taken into account.

Special-purpose oscilloscopes, such as tube and transistor-characteristic-curve tracers; TV vectorscopes and waveform monitors; and strain-gage oscilloscopes, were not included.

Kit oscilloscopes are not included here; they are listed in the directory of kit test equipment elsewhere in this issue.

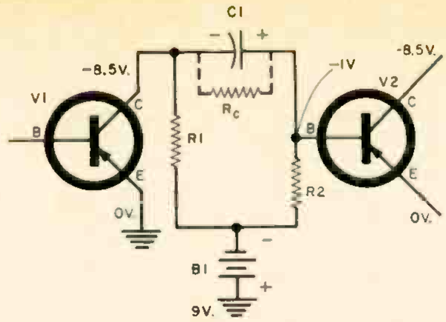


Fig. 1. Leakage in electrolytics used for inter-stage coupling is critical.

Leaky Electrolytics in Transistor Circuits

THE DEVELOPMENT of leakage in electrolytic capacitors and the problems that arise from this characteristic are not new to electronics technicians. In transistor circuits, however, the difficulties created are somewhat more complex than is usually the case in tube circuits and the symptoms are also more elusive.

A principal cause for the additional woe is the fact that normal transistor-circuit configurations involve impedances considerably lower than those encountered in tube circuits. Thus the values of coupling capacitors must be considerably higher. When low-frequency circuits are involved, such as audio stages in transistor radios and other equipment, the high values are obtained by using electrolytic capacitors in coupling applications. To conserve space, miniature, low-voltage electrolytics are employed frequently, and these are quite likely to develop leakage or have some leakage to begin with. In practice, leakage resistance often means more in determining the behavior of a circuit than capacitance. The fact is worth noting when troubleshooting, replacing capacitors, or constructing.

To illustrate the point, consider the circuit of Fig. 1. The collector of each transistor has a potential fairly close to that of the 9-volt battery, in this case about -8.5 volts for the *p-n-p* units. The base of V_2 is biased to approximately -1 volt, primarily by the action of R_2. To maintain this bias, d.c. leakage resistance (R_c) of C_1 should be quite high, being somewhere in the vicinity of 1 megohm for a good unit.

Now suppose that leakage resistance R_c is lower or drops to 250,000 ohms, for example. There is a path for the -8.5-volt potential at the collector of V_1 to the base of V_2 through R_c. This will shift bias, bringing it closer to -2 volts.

The operating point of the V_2 stage will definitely shift. A good possibility is that distortion and clipping of peaks will occur. The cause may be obscure to an unwary technician. Even when the change in voltage reading is sufficient to arouse suspicion, attention may be directed to the transistor itself or the value of R_2. If distortion in the audio output is not sufficient to be readily evident, the trouble may be even more confusing. The complaint may be that battery life in the equipment is noticeably shorter than it used to be. This would occur because the V_2 collector is drawing greater-than-normal current. The audio stages in a transistor radio generally account for most of the drain on the battery. On the basis of the symptom, a more familiar cause of short battery life, like leakage in an "on-off" switch, might be considered.

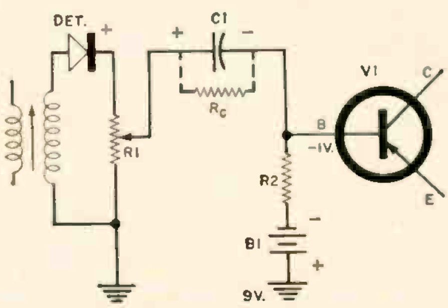


Fig. 2. In this circuit, effect of leakage may be opposite to that in Fig. 1.

There are other possibilities, another common one being shown in Fig. 2. Detected audio signal is coupled from volume control R_1 to the base of transistor V_1. The d.c. potential at R_1 is more positive than that at the base of V_1 in this case. If C_1 develops shunt leakage resistance, V_1 bias would shift in the direction opposite to that in the previous example, say to about -0.5 volt. Again, distortion may result, and output may be weaker.

Let us suppose, however, that output from the second detector was also used to supply a.v.c. voltage for preceding stages in the receiver. The drop due to leakage resistance would upset normal action of the entire a.v.c. circuit. In most cases, this would reduce the a.v.c. effect, with the result that enough signal would get through to cause overloading on strong transmissions. (In some configurations—as when *n-p-n* and *p-n-p* transistors are both used—the opposite effect might occur!)

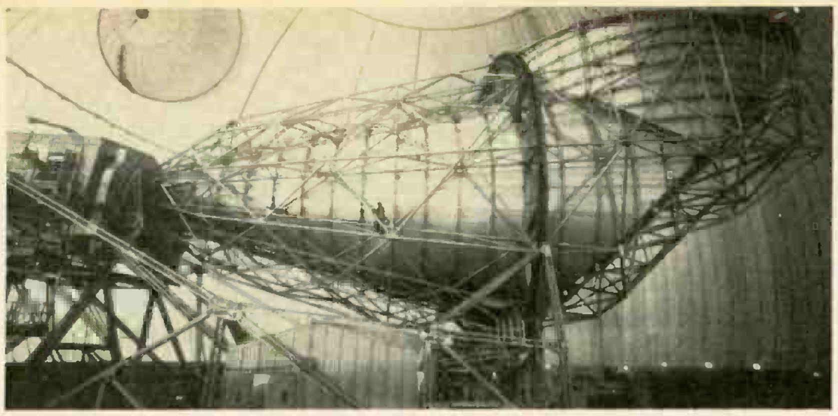
The nature of the symptoms are such that the technician would do well to keep the possibilities in mind whenever a circuit using electrolytics for coupling applications is involved—which is often. For test purposes, it is helpful to know that a good, well-formed bantam electrolytic has a normal leakage current in the range from 2 to 6 microamperes. Variations will depend on capacitance value and applied voltage. Also helpful is the fact that, when the component becomes even slightly defective, this current is likely to increase many times.

When a fresh electrolytic is selected for replacement use or being inserted in a new circuit, it is not likely to be well formed. Recommended practice is to apply a forming voltage to the component before installing it in its circuit to build it up. This rule, which also applies to electrolytics used in tube circuits, is frequently ignored: forming takes place as the capacitor is used normally in its equipment. During the earliest portion of the forming cycle, however, extremely heavy leakage current is drawn. Although this period is brief, it can permit a transistor to draw enough current in the capacitor applications shown here to produce damage. Since transistors are expensive components, the practice of pre-forming should be observed carefully.

While *p-n-p* circuits have been used for illustration, the points made here apply equally to *n-p-n* stages, except for changed voltage polarities. ▲

By WARREN J. SMITH

Frequently used for coupling in low-impedance circuits, electrolytics can baffle the unwary with obscure and misleading symptoms when defective.



◄ **Horn Antenna for Satellite**

Huge horn antenna recently completed at Andover, Maine for the Bell System's Project "Telstar." Engineers will carry out experiments in broadband communications by way of the active satellite, scheduled for launching this spring. The horn will both transmit signals to and receive signals from the satellite, a "space radio relay tower." Workman standing on the framework reveals the size of the 177-foot-long structure.

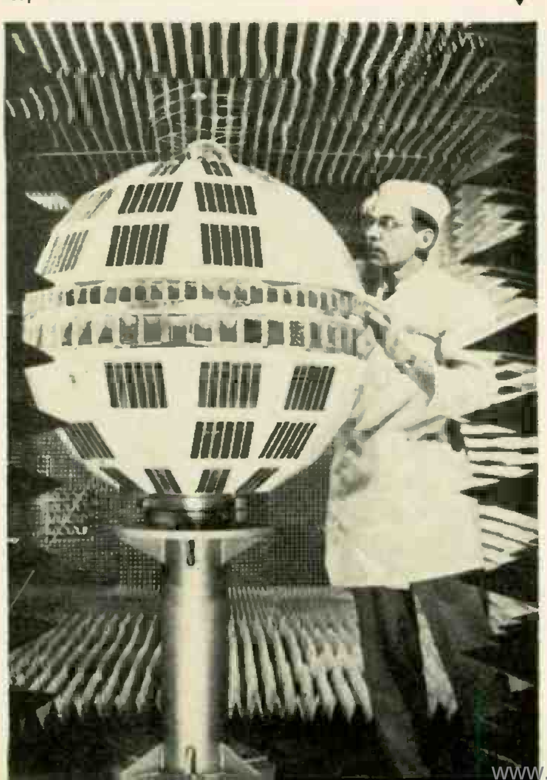
RECENT DEVELOPMENTS in ELECTRONICS

Alaskan Telephone Link ►

The first direct distance dialing telephone network in Alaska was placed in operation by Western Electric recently for use by the U.S. Air Force. The system interconnects all Air Force installations throughout the vast reaches of the 49th state into a long-distance dial telephone system for command and tactical functions. The major automatic switching centers are located at four sites of the 3000-mile "White Alice" communications network. The two technicians shown in the photo are checking over some of the equipment at one of the sites.

Communications Satellite

In a room lined with pyramids of foam plastic that absorb radio energy, Bell Labs engineer is inspecting a model of the "Telstar" experimental communications satellite. The room simulates the radio environment of space so that the broadband antennas circling the satellite and the beacon antenna atop the satellite can be tested. ▼

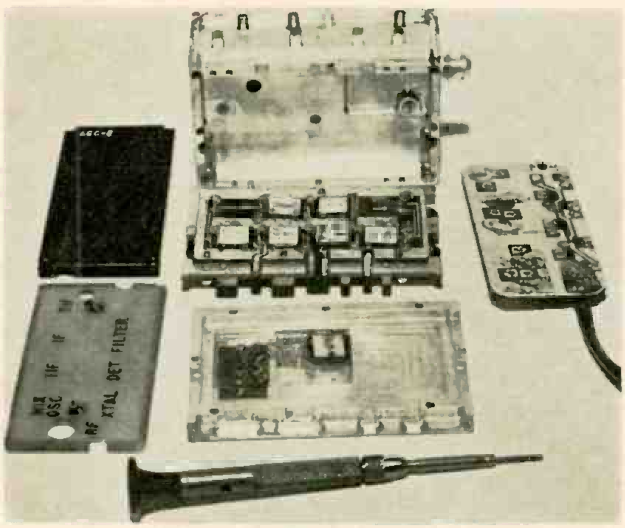


▲ **New Optical Maser**

A Minneapolis-Honeywell scientist is observing the pink glow caused by exciting helium and neon gas in a glass tube that forms part of a new c.w. optical maser. This maser, believed to be only the fourth such operating device yet announced, incorporates several unique features, including a high degree of mechanical stability and interlocking micrometers for precise alignment. Devices of this type show promise for use in long-range communications and for precise measurement of velocity.

◄ Luxury Liner Control Room

The control room of Philips' television and audio installations aboard the new luxury liner SS "France" is shown at the left. Pictured are the chief engineer and his two assistants who monitor the 3-network sound system and 2-network TV system. The sound system develops a total power of 12,000 watts over about 1500 loudspeakers, including several stereo installations. Closed-circuit and off-the-air TV equipment permits programs from either the ship or from European and American TV stations to be viewed on some 450 TV sets.



Molecularized Receiver ▲

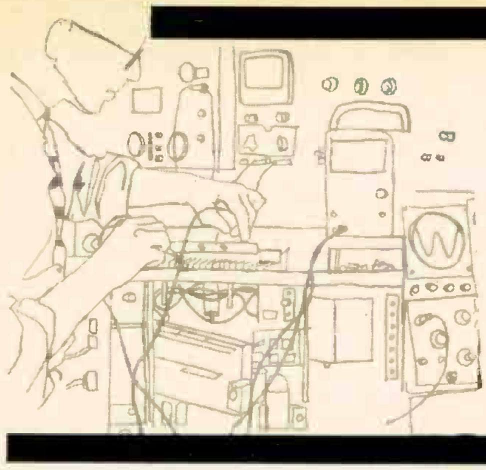
A unique radio receiver made up of molecular electronic building blocks was demonstrated recently by Westinghouse and the Air Force. Solid blocks of specially fabricated materials perform the functions usually handled by separate electronic components. The receiver weighs less than ½ lb. and has a volume of 9 cu. in., while a comparable receiver built by conventional methods weighs over 5 lbs. and occupies 148 cu. in. of space.

▲ Transistorized Autopilot

A transistorized computer for a unique new light-plane autopilot was unveiled recently by Minneapolis-Honeywell. The computer was described as having the ability to virtually "think for itself." For example, if one engine fails, the autopilot automatically senses this change and compensates by smoothly banking the aircraft to maintain the intended flight path. The complete autopilot system retails at about $5500 plus installation.

◄ Automatic Transistor Tester

This test set, which automatically tests eight parameters of a transistor in eight seconds and records the information on punch cards, was built by Delco Radio for use in its power transistor reliability program in connection with the "Minuteman" missile. The device checks its own results after testing a rack of 20 transistors. If a transistor is out of limits, or if some part of the device itself fails, the machine turns itself off. The tester checks collector voltage, collector current, emitter voltage, saturation voltage, base current, low and high collector currents, emitter-to-base voltage, and floating potential.



MAC'S ELECTRONICS SERVICE

By **JOHN T. FRYE**

Polyoptic Sealing & Power Supplies

MAC, perched on a stool in front of the service bench, was reading some mimeographed sheets when Barney returned from a service call.

"I never thought last winter I'd ever be too warm again," the youth confessed; "but I believe I am. How about turning on the air-conditioner?"

"Go ahead: and while you're cooling down, let's talk a little about 'polyoptic sealing.' "

"If you insist," Barney agreed, loosening his tie and collar: "but why we should discuss the hunting of seals with polyps is beyond me."

"That's not *exactly* what the phrase means. You probably know two flat glass plates will stick together. I don't mean just when they're wetted. I'm talking about two highly polished perfectly mated pieces of glass that stick together when completely dry because of intermolecular bonding. They're held together by mutual attraction of molecules on the two surfaces. Applying this principle to the sealing of the glass envelope of a vacuum tube to the glass base or button carrying the elements is called 'polyoptic sealing.' "

"Why?"

"A French firm, *Compagnie Generale de Telegraphie Sans Fil (CSF)*, was a pioneer in the sealing method, which they call a system *de scellement par poli-optique,* or, roughly translated 'sealing by optical polishing.' The term *poli-optique* was corrupted in this country to 'polyoptic.' "

"How come you dig all this?"

"I ran across a story about it in 'Tung-Sol Tips' published by the *Tung-Sol Electric Company* two or three months ago. I was interested and wrote the company for more information. The *Chatham Electronics Division* of *Tung-Sol* has been investigating the method under an evaluation type of contract from the Signal Corps since 1956, and they have an agreement with *CSF* to obtain technical information and manufacturing know-how."

"You mean they just stick the envelope on the button and that's it?"

"No, the two mated glass surfaces form a temporary seal that will hold a vacuum of 2×10^{-3} millimeters of mercury. This vacuum is applied to the tube in a sealing furnace where it is vacuum-baked at 400° C. A graphite ring is placed around the button stem and heated by induction to 950° C. Fifteen seconds of this creates enough localized heat to fuse the glass surfaces together and make a permanent seal."

"How is a tube usually sealed?"

"By a method called flame-sealing in which a high-temperature gas jet heats the mating surfaces of the button and envelope so as to fuse them together. This has several disadvantages: the high temperature during sealing and annealing often oxidizes the tube elements; the emissive coating binder may be broken down by the heat; impurities in the heating gas can contaminate the tube elements; carbon dioxide, water vapor, and oxygen liberated from the melting glass in the sealing zone may be absorbed by the carefully cleaned surfaces of the elements; and high temperature at the seal may vaporize metallic impurities onto the cathode surface. The tube cannot be evacuated until after this sealing process has been completed.

"Practically all these disadvantages disappear in polyoptic sealing because (1) the envelope is evacuated before heat is applied, and (2) not so much heat is necessary. Oxidation cannot take place in the vacuum. There are no gas fumes to contaminate. Few contaminating products and vapors are released in the brief 15 seconds during which the glass is soft, and these are swept into the exhaust system before they can do any harm. There is no distortion of the element mount due to softening of the glass adjacent to the pins."

"But how do they know these things are really important?"

"That is what first caught my interest. They manufactured two lots of 1258 thyratrons, one with conventional flame-sealing, the other with polyoptic sealing. Only 60% of the flame-sealed tubes passed inspection, while 85% of the polyoptic-sealed tubes were okay. Next both lots were subjected to a 2000-hour life test. Not a single flame-sealed tube survived the test, while better than 60% of the polyoptics were still going at the end of 2000 hours."

"What kind of a tube is the 1258? Seems to me 2000 hours is not a very long life for a tube."

"It is for a 1258. This zero-bias miniature hydrogen thyratron, designed primarily for use as a pulse modulator in low-power radar transmitters, was selected because experience has shown extraordinary care is necessary during sealing to produce a reliable product, and even then the production yield is erratic. It has a guaranteed life of 500 hours and an average life of about twice this; so you can see 2000 hours is a real Methuselah age for a 1258.

"I want to point out not all tubes are going to be polyoptic sealed—at least not right away. Lapping those two mating surfaces and testing the laps with interference bands produced by a monochromatic helium light source is tedious and expensive. However, in industrial and military tubes where reliability is very important, the very substantial improvement is certainly worth the extra cost; and maybe high-speed inexpensive methods of producing polyoptic seals will be devised. Not to change the subject, how did you make out with that service call you were on?"

"I darned near pulled a boo-boo," Barney confessed. "The lab technician who called from that tire and rubber company on the West Side said their laboratory vibration testing machine was blowing fuses. He explained he thought he had spotted the trouble by just checking resistors. When he put his ohmmeter across a 30,000-ohm resistor in the high voltage power supply, he got variable readings between 1000 and 5000 ohms. After he explained the resistor was wire-wound, I thought I had better take a look.

"Sure enough, it was the bleeder resistor of the high-voltage power supply for the power amplifier, which used six 807's in a push-pull-parallel arrangement. This amplifier translated the signal from a variable-frequency 5-2000 cycle sine-wave generator into power to drive the vibrating mechanism. The power supply itself was a conventional full-wave affair putting out about 800 volts of well-filtered d.c. It used a pair of 866's, a swinging choke, a smoothing choke, and two 15-μf. oil-filled capacitors.

"I explained as tactfully as I could that low resistance measured across a bleeder resistor does not necessarily indicate a bad resistor. More often it means there is a low-resistance path somewhere along the high-voltage line. First I disconnected the power supply from the amplifier. This made no change in the low resistance across the bleeder; so I knew the trouble was in the supply. Next I disconnected the bleeder resistor. It checked 30,000 ohms exactly; so I reconnected it.

"About this time I felt a pair of resentful eyes boring into my back, and I turned around to find they belonged to the plant electrician. He was obviously mad because he thought I was muscling in on his job. Mostly for the electrician's benefit, I explained to the lab technician

(*Continued on page* 82)

the DOSIMETER

By ROBERT GARY

A pocket-sized device for measuring total accumulated radiation. Its operating principles, construction, and its care are discussed.

NUCLEAR radiation, as most readers know, can be detected only by photographic and electronic means. Three different detection methods are used to protect personnel who work in radioactive environments: the first is the wearing of photographic film badges, the second is the carrying of pocket ionization chambers, and the third involves the use of the dosimeter.

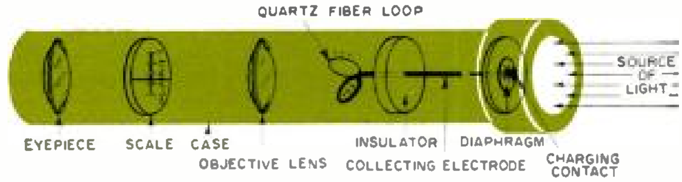


Fig. 1. The dosimeter is basically an electroscope to which has been added an optical system and a calibrated scale.

The dosimeter is rapidly becoming the most popular of the three because it is the only device that tells the wearer directly, at any time, how much radiation he has been exposed to. Dosimeters are recommended emergency equipment in fallout shelters, and for Civil Defense workers, and others who might be exposed to radiation. Dosimeters are also widely used wherever *gamma* and x-ray radiation are encountered in laboratories and industry. In order to calibrate, charge, and test a dosimeter, only a basic understanding of its operating principles is necessary.

How it Works

Fig. 1 shows a cylinder with a well-insulated, positively charged wire in the center. If a small metal-coated, quartz-fiber loop is attached to the center wire, the fiber will deflect toward the outer shell because the like charges of the quartz fiber loop and the positively charged wire repel each other. The unlike charges of the fiber loop and the outer shell attract. The higher the voltage between the center wire and the outer cylinder, the farther the fiber will deflect away from the center wire. *Gamma* or x-ray radiation will ionize the air surrounding the center wire thus allowing some of the charge to leak off to the outer shell. The amount of deflection and the position of the quartz fiber loop is directly proportional to the charge.

This is the principle of the electroscope which forms the heart of the dosimeter. Many high school students have seen the operation of the electroscope in their physics lab work, but the electroscope used in the dosimeter is much smaller and more compact.

A typical dosimeter looks like a ball-point pen. The view of its internal construction in Fig. 1 shows that the electroscope is only one part of the dosimeter. In order to translate the position of the fiber into a unit of radiation intensity, a small portion of the fiber is optically enlarged and projected on a calibrated scale. The optical portion of the dosimeter is essentially a pocket microscope and requires that one hold the dosimeter up to a light source to obtain a reading. Daylight through a window is satisfactory.

Dosimeters are available for different exposure levels but the most widely used type has a range of 0 to 200 milliroentgens. This dosage is not lethal but if one is exposed to 200 mr. in a period of a day or so, further exposure should be avoided and medical aid sought.

In many industrial and research institutions personnel are instructed to wear two dosimeters so that one can be used to check the other.

Charging a Dosimeter

The dosimeter requires a charger to establish a potential

(*Continued on page* 79)

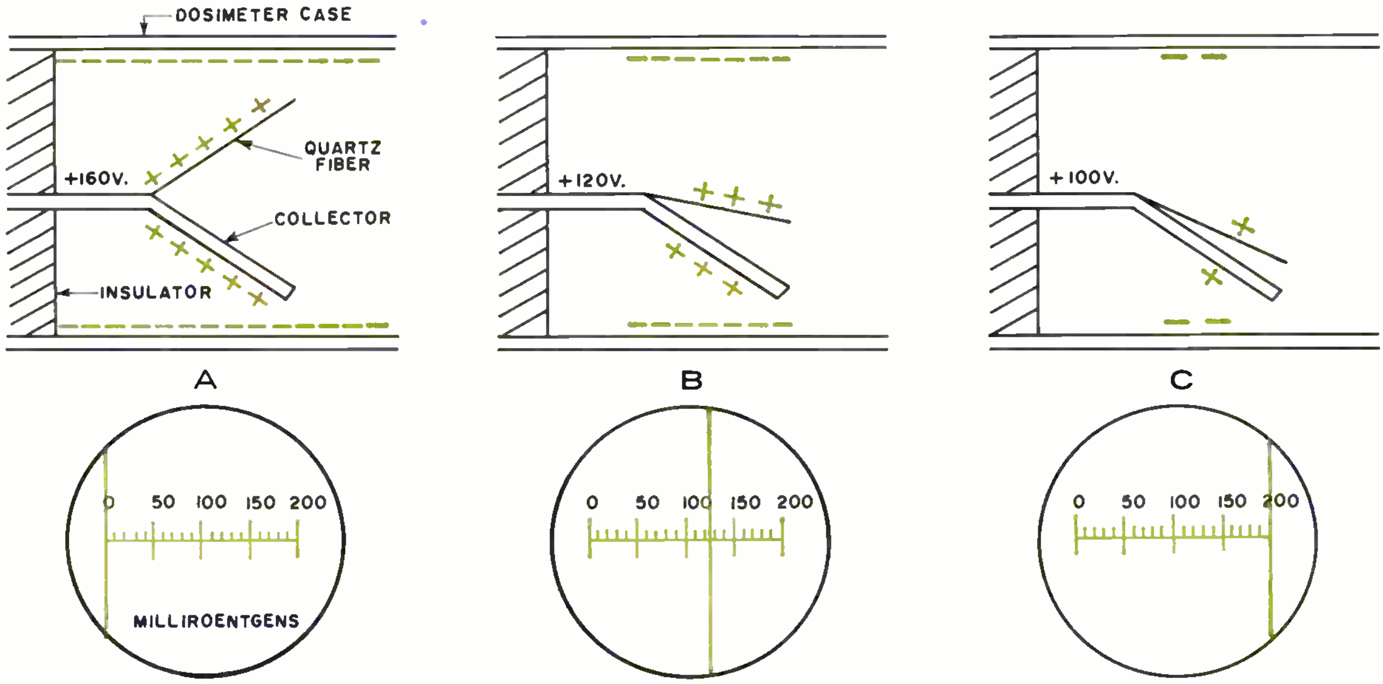


Fig. 2. Fully charged dosimeter at left indicates 0 mr. Radiation reduces charge and increases scale indication to 200 mr.

Test Equipment for Communications Servicing

By TEX SMILEY
National Service Manager, Communication Products Dept., General Electric Co.

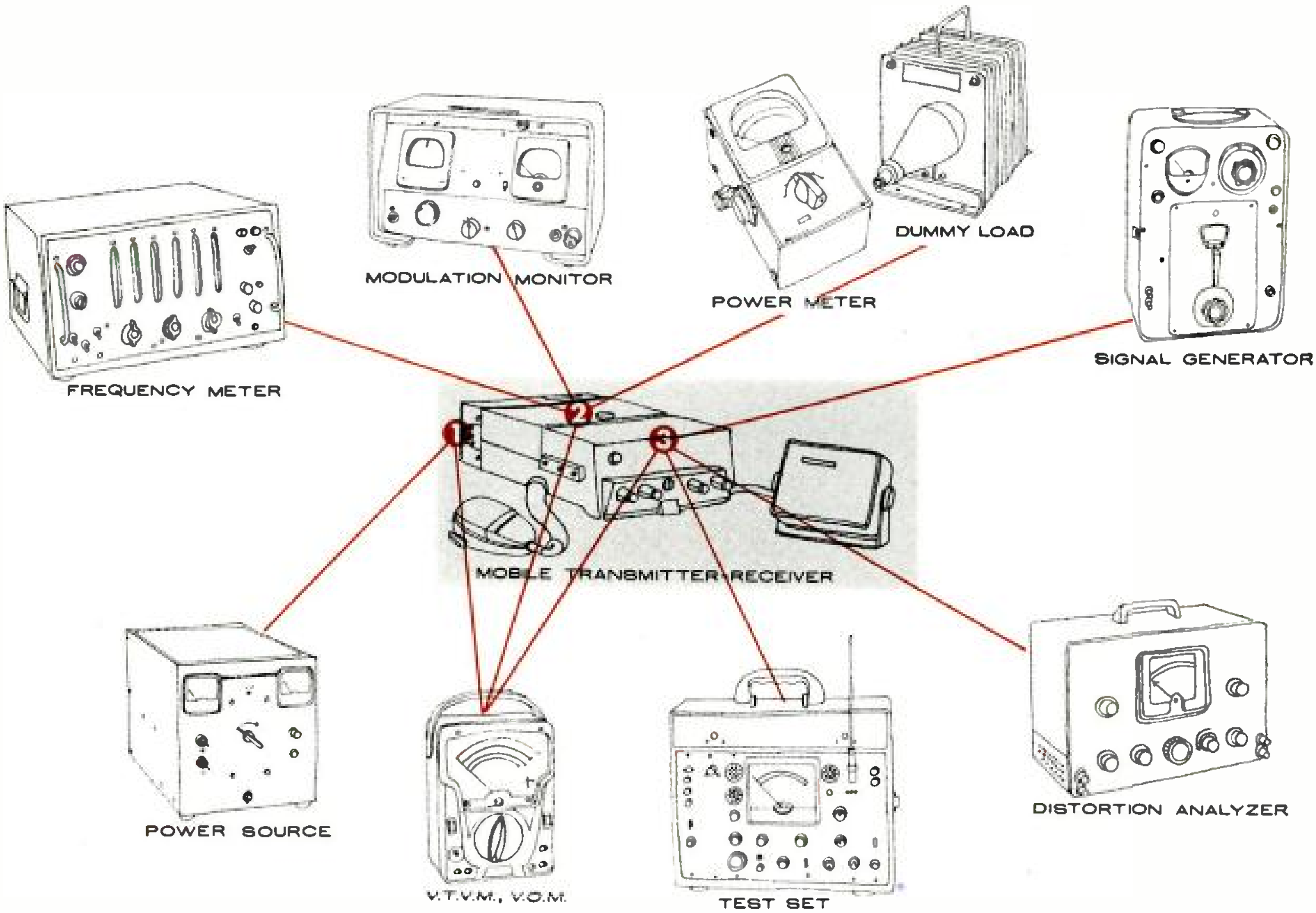


Fig. 1. Test equipment needed to service the power supply (1), the transmitter (2), and the receiver (3) of an FM mobile unit.

THE USER of two-way radio communications equipment has one concern—to be able to communicate with other stations in his system when he wants. The job of the mobile communications technician is to keep the equipment in top-notch working order so that this goal is achieved. To do this job properly, the right type of test equipment is required.

The variety of available test equipment often makes it difficult for the communications technician to select wisely. The choices should be made on the basis of: (1) the location and type of service to be rendered by the two-way radio service station; (2) the requirements of the Federal Communications Commission; and (3) the cost of the test equipment.

Many service organizations encounter communications systems on all commonly used bands and, consequently, must choose test equipment which will operate over these ranges. Certainly, the r.f. test equipment must be capable of operating on the three most used bands of approximately (1) 25-50 mc.; (2) 150-174 mc.; and (3) 450-470 mc. There are other operational fixed and Government frequencies used in communications, such as those in certain portions of the 150-mc. band and 72 mc., which service technicians may also encounter. If it is known that equipment which operates on these frequencies is to be serviced, then certainly the required test instruments should be on hand.

Type of Service Rendered

The fact that there are numerous manufacturers of mobile radio equipment shouldn't cause the technician too much trouble when it comes to selecting his test equipment. This is true since a well-designed two-way radio unit should be able to be tested with standard instruments. However, the type of service the technician wishes to offer his customers is an important factor.

Since most two-way communications equipment is mobile, that is, it is designed to be used in vehicles, it is often possible to arrange to have the radio-equipped vehicles driven to the communications service station for radio repair. Most

Summary of the equipment requirements for the technician who is interested in going into two-way mobile radio servicing.

communications service stations have established price differentials for this type of service as compared to service performed at the user's location. The decision to service two-way radios in the field will, to some degree, dictate the type of test equipment purchased, although the communications base station equipment obviously must be serviced at its location. Rack-mounted test equipment may satisfy every need in the shop, but will be of little use when it is necessary to service a two-way unit mounted in a vehicle working 20 miles from the service shop. In cases where a specially equipped service vehicle is employed, this problem is minimized.

FCC Requirements

The mobile communications technician must also consider Governmental requirements when choosing his test equipment. Although the Federal Communications Commission will not put its stamp of approval on items of test equipment, it does require that the service technician be licensed and have access to test equipment that will guarantee his capability for maintaining each system he services within FCC rules and regulations.

Since these regulations are stringent, the test equipment must have greater accuracy than the equipment being measured. For example, frequency tolerance of land mobile communications transmitters under split-channel operation is .0005%. To assure accuracy, the frequency meter used to measure this tolerance should be at least twice as good and preferably better. A typical frequency accuracy of .0001% is presently available with suitable test equipment. Considering possible further splits in certain channel allocations, instruments with a frequency tolerance of even .0001% may not be suitable in future years.

Test Equipment Costs

The cost of mobile communications test equipment varies widely. The decision to purchase more or less expensive equipment should be based upon need and on the specific type of equipment. For example, highly accurate frequency meters are expensive while such items as v.t.v.m.'s or v.o.m.'s are relatively inexpensive and may even be put together from kits—a further price saving.

It is possible to become "test-equipment poor" by purchasing beyond service needs. On the other hand, inadequate test equipment can turn out to be a poor investment. The phrase "you pay for good test equipment whether you have it or not" applies since poor test equipment will result in lost time, repeat repair work, and customer complaints.

Fig. 1 indicates those items of test equipment most often needed to service FM mobile communications equipment. As mentioned earlier, the specific items purchased will depend on the needs and wants of the service station.

Frequency Meters

Recently the FCC relaxed its requirements in certain services so that frequency measurement of communications transmitters is now required only once each year. This does not mean, of course, that this is the extent of the use for the frequency meter. A service station operator may have a number of systems under service contracts or under his responsibility. These systems may contain many mobile units, each requiring its annual check. For example, a one-man service station may have 200 to 400 mobile units plus 10 to 15 base stations under his care while larger stations may have to oversee thousands of units. In any case, the job of measuring the frequency of each unit can become a laborious and time-consuming assignment. Obviously, a frequency meter which will allow him to perform this service in the shortest possible time can result in increased income for the technician through hours saved. Also, routine maintenance often requires the use of a frequency meter.

Since this unit is usually a rather expensive test instrument, it should be chosen carefully. Meters are available in a price range from approximately $4000 for the larger direct-reading counter instruments down to about $400 for the crystal-controlled heterodyne units. Factors such as size, weight, portability, ease of operation, frequency ranges, accuracy, and stability, as well as cost, should be weighed before a purchase is made.

Larger stations often have frequency meters for both the laboratory and the field service truck when large numbers of units are serviced out of the shop. It must be remembered that the meter which permits fastest frequency checks in the laboratory could lose its value when the time comes for it to be hand-carried to a mountain top to set a base-station frequency.

Modulation Monitor

"Wide-band" operation of land mobile communications equipment will continue throughout 1962; however, this 15-kc. deviation operation will be prohibited on most channels as of January 1, 1963. At that time, government regulations will require that all systems be limited to 5-kc. deviation usually referred to as "narrow band."

Not only should the modulation monitor selected be capable of accurately taking these measurements on all desired bands, but in cases in which tone applications are used, it is very

Photographs showing a pair of typical service-bench setups for handling mobile two-way radio equipment.

desirable that deviation readings below 1 kc. be taken with accuracy. This latter requirement makes it imperative that the technician evaluate his choice carefully to guarantee accurate readings irrespective of extraneous noise in the unit itself or in the working area.

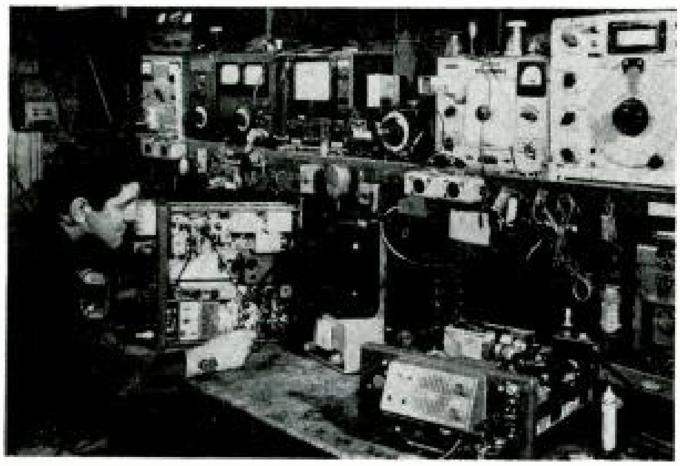
Several models of frequency meters incorporate modulation monitors in the same instrument. Other modulation monitors are self-contained, using direct meters or scope traces to indicate average deviation or peak-to-peak readings. Portability and ease of operation are again important considerations.

Power Meter and Dummy Load

There are those who consider a power meter (wattmeter) a luxury item and hesitate to invest money in such an instrument. Most technicians have learned, however, that there is no more accurate or faster means of measuring the output of a mobile transmitter than with a properly calibrated power meter. Obviously, the meter selected must be capable of covering frequency and power ranges used in mobile communications. Some of the available instruments accomplish this by means of plug-in elements, others by means of selector switches. Most meters allow both forward and reflected power to be measured, hence antenna matching may be checked.

Many manufacturers offer power meters terminating the r.f. output power into a 50-ohm resistive load of various wattages. Prices of such instruments range from less than $100 to several hundred dollars, depending upon the frequencies and power to be measured.

A proper termination for the communications transmitter must be made before final tuning can be completed and the output measured. The antenna itself may be used, however this may cause interference to the system. This can be eliminated by the use of a properly matched dummy load. Important considerations here are proper impedance values, adequate power rating, and the ability to dissipate heat. Loads are available for all ranges to handle output from the smallest pocket transmitter to the largest base-station transmitter.



Another fully equipped service bench for mobile two-way radios.

V.O.M. or V.T.V.M.

Apparently, the v.o.m. or v.t.v.m. used by the technician is a very personal choice. Of the dozens which are on the market, many will meet the needs of the communications service station. The primary requirements include at least 20,000 ohms/d.c. volt sensitivity; adequate selection of voltage, resistance, and current scales; a large easy-to-read meter face; easy operation; and good portability. Accuracy and durability under extreme conditions should also be considered. Although less expensive meters will sometimes do the job, including those that may be assembled from kits, the technician should be critical in his selection.

R.F. Generator

There are many technicians who have been servicing receivers in two-way communications systems for some time without the benefit of a frequency-modulated r.f. signal generator. The convenience of the r.f. souce makes it a vital part of the complement of test equipment in most service shops. A good r.f. signal generator is fairly expensive, but when balanced against savings of time, trouble, and effort, it soon pays for itself.

Naturally, the generator must be capable of producing signals of adequate output (at least 100 mv.) over all frequencies of the communications bands. Its internal and external modulation must be extremely stable under the quickest warm-up period. The attenuator must have smooth operation and it should be calibrated with accuracy to small fractions of a millivolt. With all this, it must also be portable and able to withstand wide temperature changes and mechanical shock. The technician can expect to pay at least $400 for a suitable r.f. signal generator.

Distortion Meter

Although the 20-db quieting method of measuring sensitivity has definite application as a quick check of the receiver, a more useful 12-db SINAD check may be made by a method that takes distortion into account. The distortion meter is useful for this and other receiver tests. In addition to accuracy and portability, the meter must provide for ease of operation since much switching is done during the testing process. The wide range of prices of instruments on the market, including some equipment in kit form, makes it possible for the technician to choose a good distortion meter at moderate cost.

Power Source

Although it is possible to service mobile radio equipment using the vehicle's power supply, there will be many instances when the technician will want to have the unit on his workbench for modifications or extended repair work. During these times, he will require a power source. A storage battery can be used and, with an appropriate charger, is being used in many service stations. However, the disadvantages are obvious, although the pure d.c. output of such a bench supply has advantages when making precise measurements. Many service shops use battery sources in addition to good power supplies to keep ripple to a minimum as well as to duplicate the vehicle supply as closely as possible. In some cases, an automobile generator has been used, driven by an electric motor feeding into a battery supply.

The choice will again be based largely on cost and need. In any event, the supply should have a variable output incorporating the necessary current and voltage ranges with a well-filtered and regulated output. Many such supplies are available, ranging in price from under $150 up to $1000 depending on the options included.

Other Equipment

In addition to the items already discussed, many communications technicians include a portable test set especially designed for this type of receiver servicing. Such a unit may contain an i.f. frequency generator, a peaking generator, multimeter, audio oscillator, dummy control head, transistor checker, and dummy load—all in one package. Designed for field use in emergency situations, these test sets assist in isolating problems quickly while the radio is connected in its operating position.

Several other pieces of test equipment might be added in order to provide for other than the usual repair and maintenance situations. Most service stations will have a v.t.v.m. if a v.o.m. is used for field checks of voltage, an audio oscillator, an additional regulated power supply, an oscilloscope, and a grid-dip meter. A visit to one of the larger service stations would reveal many more items of personal preference.

Finally, the communications technician must have the usual complement of test-bench cables, control heads, microphones, and speakers for the equipment being serviced, plus the usual assortment of hand tools. Special tools may be needed to work on transistorized, printed-circuit equipment.

From all this you can see that a sizable investment will be required to adequately equip a communications service station. However, the technician who attempts to undertake the duties involved in communications service will find that there is no substitute for accurate, reliable, and properly calibrated test gear. Money wisely spent in the initial investment will pay dividends many times over during the lifetime of quality test equipment. ▲

IN-HOME TELEVISION SERVICE TECHNIQUES

By PAUL B. ZBAR / Director of Electronic Technology, Voorhees Technical Institute

You may prefer shop work, but the trend is hard to buck. To come out ahead, you must know how far limitations will let you go and what methods to use.

MANY TECHNICIANS limit TV service performed in the customer's home to tube replacement and minor service adjustments. These feel that any work requiring removal of the chassis from the cabinet for instrument checking can be done more efficiently and more economically in a well-equipped shop. While the view has merit, the practice tends to arouse customer suspicion and opposition. As a result, the technician may lose the particular job and, even when he doesn't, he may eventually lose the customer.

In contrast to this view is the policy of other independent technicians and of many, major factory-service companies. The latter will often boast proudly: "Our men know their product. They will service your receiver in the home, if at all possible." And their boast is not an idle one. Their technicians, trained and skilled in the proper methods, are instructed to service the receiver in the home. In most instances, they are successful. Where they cannot find the trouble within a limited, realistically determined time interval, it is then not too difficult to get the customer's permission for pulling the chassis: they have demonstrated an honest attempt at home repair.

This growing trend, which has won customer approval, is difficult to buck. It obliges the independent technician to re-evaluate his methods to meet the challenge of competition. A technician's ability to remain in business is often determined by his capacity to upgrade or re-adjust his skills, and such an adjustment may be necessary if he is to troubleshoot in the home efficiently and economically.

It is not practical for a technician to take his complete shop equipment with him on a home call. Because he is usually limited to a single instrument, which will be a v.o.m. or v.t.v.m., it is easy to jump to the conclusion that a correspondingly simple technique is involved. On the contrary, the very limitation calls for a high degree of technical skill and know-how. The man must learn to use the instrument for more than the basic measurements he is accustomed to making with it. He will want to make dynamic checks at major and minor test points in the receiver. For example, a v.o.m. or v.t.v.m. can be used as a substitute for an oscilloscope in a signal-tracing process that may quickly localize trouble to a particular stage.

This is not intended to suggest that the meter replaces the other instruments of the trade. In the shop, there is no substitute for a full complement of equipment. With such instruments, the technician will find the troubles he could not hope to locate in the home. But, while he is in the home, he will wish to make the meter go as far as possible. In order to achieve that, the technician must be certain that he understands his instrument and its operation as well as he can.

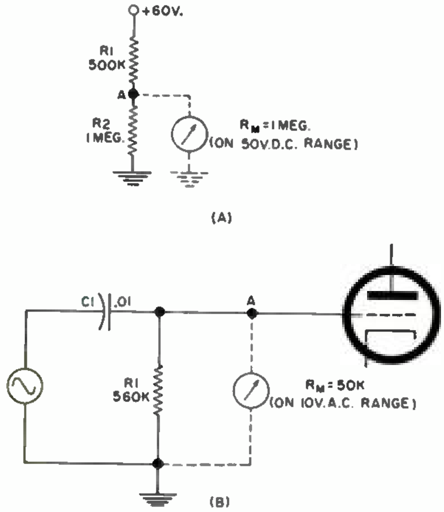


Fig. 1. Loading effect of v.o.m. on low d.c. range (A) in high-impedance circuit. For a.c. (B), frequency is also a factor.

The V.O.M. and the V.T.V.M.

According to conservative estimates, the experienced technician is getting only about 50 per-cent use out of these instruments because his testing is limited to "static" d.c. voltage checks and resistance readings. Even here, moreover, he experiences difficulty in interpreting these readings properly. The use of the d.c. function for dynamic tests and of the "output" function for signal tracing are certainly as important as the static checks. Yet these are seldom employed.

In interpreting d.c. measurements, the impedance of the circuit under test and the sensitivity of the meter must both be considered. Sensitivity, in this sense, relates to the input resistance of the instrument. In the case of the v.o.m., this varies from one range to another rather than being constant. The greater the sensitivity (the higher the ohms-

Fig. 2. With a detector probe, your meter checks signal up to v.h.f. frequencies.

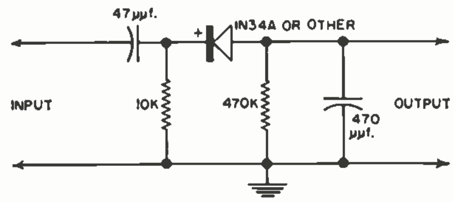


Fig. 3. This detector-probe circuit can be used with either a v.o.m. or v.t.v.m.

Fig. 4. H.v. probe by Precision extends d.c. range of common v.t.v.m. Choose a probe to match the input of your meter.

Fig. 5. Versatile Don Bosco tracing probe, shown with some accessories, combines many facilities in one unit.

volt rating), the smaller is the loading effect in the circuit. Also the loading effect is reduced as higher ranges are used.

This point is illustrated in Fig. 1A. Without the meter, the d.c. voltage at point *A*, the junction of R_1 and R_2, is evidently 40 volts. A v.o.m. rated at 20,000 ohms/volt on its 50-volt range has an input resistance of 1 megohm. If this meter is used to measure the voltage from point *A* to ground, 30 volts will be the normal reading obtained, rather than 40. The reason for this discrepancy is that the 1-megohm input resistance of the meter is in parallel with R_2, upsetting values in the resistive divider between the source voltage and ground. From point *A* to ground, there will now be 500,000 ohms instead of 1 megohm. The meter has loaded the circuit. If the measurement were made on the 250-volt range, however, where input resistance of the same v.o.m. is 5 megohms, the reading would be 37.5 volts.

It is therefore apparent that, when a v.o.m. is used to measure d.c. in high-impedance circuits, the highest practical range should be used. It is also clear why a fairly high sensitivity of 20,000 ohms/volt on d.c. has become standard for instruments used in TV service, with less sensitive instruments avoided. In fact, some are on the market with a rating of 100,000 ohms/volt. Finally, a technician who knows of this effect and takes it into account when checking high-impedance circuits is not likely to be misled by a reading that superficially appears below normal because of the meter load.

Pitfalls in A.C. Readings

As in the case of d.c., the higher a.c. ranges of a v.o.m. should be used wherever possible for measurements in high-impedance circuits. Moreover, a meter with high input resistance in this function is also desirable to minimize circuit loading. The rating should not be less than 5000 ohms/volt.

However, other factors are involved. One of these is the frequency of the signal. Assume signal amplitude at the grid of the triode in Fig. 1B is to be checked. A 600-cps sine wave at 6 volts is being applied from the source through the a.c. divider consisting of C_1 and R_1. Since the reactance of the capacitor at this frequency is negligible compared to the value of the resistor, essentially the full 6 volts would appear at point *A*. Now suppose we set a meter with 5000 ohms/volt sensitivity on a.c. to its 10-volt range. With the meter's 50-k input resistance shunted across R_1, quite a bit of the signal would now be dropped across the reactance of C_1. Meter indication is a bit above 4 volts.

The situation appears to be similar to that involved in d.c. measurement, with error being somewhat greater due to the lower input resistance of the meter. But more is involved. Let us assume that, in the same circuit (Fig. 1B), frequency of the input signal is 250 cps at 6 volts. Since the reactance of C_1 is greater at this frequency, there will be a small loss through the coupling capacitor. Nevertheless, the signal at point *A* will be only slightly below 6 volts, not a significant difference. When the meter is put in parallel with R_1, however, conditions in the divider are changed so drastically that the meter reads less than half expected value.

Another complicating factor appears when an attempt is made to measure non-sinusoidal voltages. Consider the 60-cycle, trapezoidal waveform found at the control grid of the vertical-output tube in a TV receiver. Its amplitude, conventionally given as a peak-to-peak value, may be about 100 volts. In the service shop with an oscilloscope, this voltage can be measured quite accurately. A v.o.m. on its a.c. ranges is *calibrated* for r.m.s. value (of sinusoidal voltages only), but its rectifier system is generally designed to respond to average values. The calibration will thus fail to be accurate on the waveform being checked here. In practice, the 5000 ohms/volt a.c. instrument might read about 10 volts at the control grid of the vertical-output tube. This is a relative rather than an absolute measurement. With other signals, impedance, frequency, and waveshape may produce a combined effect that is somewhat different but just as drastic.

At this point, a technician may well ask, "Of what use are such a.c. measurements in TV servicing?" The answer is that *relative* a.c. measurements are very useful in signal tracing without regard to amplitude accuracy. They will demonstrate the presence or absence of signal at a test point. When the problem involves a discontinuity, such as a complete loss of vertical sweep, or sync signals, or video information, such tracing is particularly valuable.

The v.t.v.m. has certain advantages over the v.o.m. Thus the d.c. input resistance of the former is relatively high, usually about 11 megohms, and is also constant for all ranges. Low d.c. voltages may be measured in circuits of relatively high impedance on low-voltage ranges without appreciable loading. In the circuit of Fig. 1A, for example, effect of the meter on the voltage read at point *A* would be too negligible to notice. Input resistance of the v.t.v.m. on a.c. would also be higher than that of a v.o.m. on low-voltage ranges.

In addition many v.t.v.m.'s, although calibrated to read r.m.s. voltage on sinusoidal waveforms, are actually designed to respond to peak-to-peak values, although not with close accuracy on all waveshapes. In the previously cited example of the 100-volt, peak-to-peak signal at the grid of the vertical-output tube, the reading on the r.m.s. scale might be about 25 or 30 volts. If the instrument has a peak-to-peak scale, the reading here might be 85 volts or somewhat higher.

This comparison should not be taken to mean that the v.t.v.m. is preferable to the v.o.m. for in-home checks. Both instruments are comparable for resistance measurements. The v.t.v.m. is not designed for current readings at all, whereas this function, as we shall see, can be useful. The v.o.m. is more flexible in that it does not rely on external power. With better long-term reliability, it does not have to be re-checked and recalibrated constantly. Whichever of these instruments the technician chooses, a little experience is all that is needed for him to become familiar with the readings he can expect in the checks recommended here.

Tests and Accessories

With either the v.t.v.m. or the v.o.m., signals that can be measured directly with the a.c. scales are generally limited to the audio range and a good portion of the spectrum above it; but r.f. and i.f. signals, which are of definite interest, cannot be checked reliably. However a special probe, such as a demodulator probe, can extend the range for tracing. Very often, especially in the case of a v.t.v.m., the manufacturer makes such a probe available, like the one in Fig. 2.

If there is no special one, it is still possible to make the necessary r.f. measurements, with either v.t.v.m. or v.o.m., through an easily assembled detector probe. The circuit for the latter, in Fig. 3, provides a negative d.c. output, developed from rectified signal. When used with a v.t.v.m., the grounded probe output connection goes to the common input of the instrument, the ungrounded output lead goes to the d.c. input, and the meter function is set to "−d.c. volts." Special adapters may be required or desirable for convenient use, depending on the input connections to the v.t.v.m.

In the case of the v.o.m., the ground lead of the probe is connected to the "+" or d.c. jack and the "hot" probe lead to the "−" or common jack. With most of the crystal diodes that may be used in such probes, the technician should avoid measuring r.f. greater than 25 volts, but such amplitudes are seldom encountered.

Even with this range-extending probe, signal amplitude in the earlier, low-level stages of the TV receiver may be such that observation in the conventional way is questionable. If the technician is using a v.o.m., he can employ a technique that the author has found quite successful: probe leads are connected to the current terminals of the instrument (polarity must be observed). Indication can be obtained on the lowest current range, which will be in the order of 50 to 100 microamperes, full scale, although it is wise to try a higher range first to protect the movement. In this way, the meter is being used as a very sensitive voltmeter. Although exact readings are not possible, remember that relative indication and the presence or absence of signal are our chief concern. The method is successful, for example, in isolating a discontinuity in an i.f. amplifier.

The high-voltage probe is another the technician will need to carry. The manufacturer of the meter markets such probes to match his own instruments, and the probe for a v.o.m. will differ from that for a v.t.v.m. because each is designed for a different input resistance in the instrument. This accessory extends the d.c. range of the meter for measurements in the high-voltage section of the receiver. One is shown in Fig. 4.

The meter itself and the pair of probes comprise the basic complement of test equipment for service in the home. Some technicians may wish to consider a special, multi-purpose probe, shown in Fig. 5, in place of the demodulator. Although it is compact, it comes with a variety of interchangeable input and output adapters and connectors, including demodulation facilities, for observing different types of signals. It also houses a high-gain transistor amplifier, powered by a small, internal cell, that is helpful with low-level signals. In a shop, it may be used as a scope preamplifier. On home calls, it can give audible indication with an accessory earpiece or visible indication when plugged into the meter.

In addition to the meter facilities already noted, many instruments include a calibrated decibel scale that is useful for checking gain or loss in audio-amplifier stages. A function for reading capacitance may also be included. The only additional facility required here is generally a 60-cycle a.c. source, available directly from a wall outlet or from the filament supply of a TV receiver, for application to the capacitor under test and the meter. Where this is provided, the manufacturer specifies the circuit arrangement for the test and either provides a scale for direct reading of capacitance values or an auxiliary, printed table.

In general, the instrument includes a sufficient number of scales in each function to assure simple, accurate readings. As a rule—when circuit loading is not a factor—it is desirable to use a scale on which the measurement being made will fall between 20 per-cent and 80 per-cent of maximum reading.

Major, Dynamic Test Points

Signal tracing is the heart of the logical troubleshooting procedures used by experienced TV service technicians. With the facilities discussed, a technician can perform extensive tracing and other troubleshooting despite the absence of the many important instruments that he needs in shop work. He can localize and pinpoint specifically many defects, making repairs on the spot. Details of his procedure will follow his own practices on the bench, except that he is relying on a single indicating instrument. Before examining a circuit in detail, however, he will observe the symptoms and, based on this observation, make checks at one key point or more to determine broadly which section of the receiver he will inspect more closely.

When servicing in the home, the sin-

(Continued on page 80)

NO.	TEST POINT	A.C. VOLTS Peak-to-Peak V.T.V.M.	A.C. VOLTS V.O.M.	D.C. VOLTS V.T.V.M.	D.C. VOLTS V.O.M.
1.	Output of Pix Detector*	1.5 to 4	.14 to .5	−1.25 to −5.5	−1.2 to −5.2
2.	Grid or Cathode of CRT*	27 to 160	6 to 50	——	——
3.	I.F. A.G.C. Line*	——	——	−1.8 to −8.7	−2.8 to −8
4.	Common Sync Output*	21 to 90	1.5 to 11	——	——
5.	Output of A.F.C. Detector	——	——	−2.5 to −15	−.2 to −11
6.	Control Grid of Horizontal Amplifier	55 to 170	11 to 57	−9 to −50	−8 to −50
7.	Control Grid of Vertical Amplifier	38 to 120	4.5 to 17	——	——
8.	Bias Network of Ratio Detector*	——	——	−11 to −48	−10 to −44
9.	Low Voltage "B+"	——	——	+235 to +325	+235 to +325
10.	Control Grid of Mixer (1st Detector)	——	——	−.4 to −3.8	−.02 to −3.6

*Taken with receiver tuned to broadcast signal.

▲ Table 1. Key points for meter checks that are employed in the recommended home-call technique, with the normal ranges of a.c. and d.c. readings on the v.t.v.m or v.o.m. Refer to the functional blocks in Fig. 6.

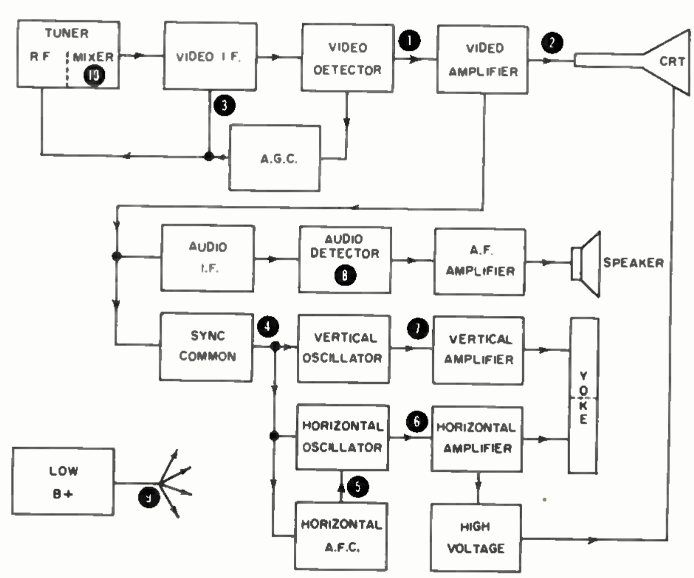


Fig. 6. Numbers identifying key test points on this block diagram of a typical TV receiver are coordinated with the listings in Table 1. Refer to the latter for set-up and range of normal readings.

Technicians in the Computer Industry

By D. N. JONES / Director of Personnel, General Products Division, IBM

New and changing technology has increased demand for and status of technically trained persons working in industry. Here is how IBM sees the technician's role.

> **ABOUT IBM-ENDICOTT**
>
> *Endicott, New York was selected as the site of manufacturing facilities in 1914 when IBM was still known as the Computing-Tabulating-Recording Company. Today, the general products division of IBM operates the manufacturing facilities and development engineering laboratory there with some 8500 employees.*
>
> *Endicott is the anchor area for the division which is responsible for development and production of intermediate-size computers. Thus Endicott designers and manufacturing people are responsible for the IBM 1401 system. Central Processing Units of the system and its printer are produced in the plant; and systems are checked out on the plant's final test line. All printed-circuit cards presently used in IBM machines sold in the U.S. are also produced in Endicott.*

FRANCIS J. Villante was a young man just graduated from Broome Technical Community College in 1956 when he and a dozen others joined *IBM* as electronics technicians. Today, Frank Villante, with his training and experience, has the equivalent of an engineering degree. He is now designing electronic test equipment, and has several electronics technicians working for him.

In the years between 1956 and 1962 Frank Villante was caught up in the fast pace of the electronics industry. He witnessed the last of the production lines for vacuum-tube and electromechanical systems in Endicott. He was there when solid-state technology was something new to engineers and technicians alike, and had to go to school with engineers to learn the theory of new components and the circuitry they made possible. As the demand for test equipment surged, Frank Villante was called upon more and more to lay out circuit designs.

It soon became apparent that Frank Villante was fully capable of handling engineering assignments, so he was promoted to engineering status. There are certain areas in which he finds himself less informed than graduate engineers, especially in math. But Frank Villante fully intends to bridge as many of the gaps as possible in the immediate future.

This isn't the story of one man. Actually it's the story of the electronics industry where opportunity has been the keynote for engineers and technicians alike. In the past ten years, few industries have experienced the tremendous strides in technology that have taken place in electronics. Nowhere is this more apparent than in the computer branch of electronics where change is now an accepted fact of life.

Often when writers comment about the role of the technician in industry, they are quick to point out that the advent of automation and remotely controlled equipment has increased the importance of the electronics technician. This may be true in many industries. But for those of us involved with electronic data processing equipment, it is not the whole truth. Changing technology has had a much greater impact.

For twenty years before World War II, data processing products were essentially electromechanical. For about ten years after the war, vacuum-tube technology was implemented in the first practical computer systems for commercial use. Then by 1958, solid-state technology revolutionized the size, speed, capacity, and power of computers. This technology has hardly been exploited for a full five years and now the entire industry is alive with talk of the next technology involving: thin films, chips, and vacuum deposition.

This dynamic environment is the principal reason for the importance of qualified electronics technicians in a facility such as *IBM*'s development laboratory and plant in Endicott, N.Y.

Here technicians are active in circuit technology, electrical analysis, instrumentation, test equipment design, manufacturing research, automation engineering, and final test. Some are assigned to help develop and maintain complex automated production equipment such as the automatic wire-wrap machine. But most are involved with development of new circuit configurations, analysis of components, and design of faster and more reliable test equipment.

Qualifications

Department managers in both development laboratories and plants usually specify graduates of two-year technical school programs when looking for electronics technicians. This is the customary prerequisite in hiring an electronics technician. While electronics training in the armed services is valuable experience, personnel interviewers have found that a two-year technical course better qualifies an electronics technician. It gives a man sufficient background to undertake a variety of assignments. Formal training is a big help, too, when a man has the opportunity to further his education.

With two years of technical school, a technician can be employed in breadboarding circuits, drafting, assembly of test equipment, and troubleshooting both machines and production equipment. Service experience is invariably limited to assembly work and troubleshooting. And this tends to be centered on a certain type of equipment. Thus many ex-service technicians are not

A

B

A. *Joseph Titti sets up a testing device in the electrical analysis department. Joe's work is meant to evaluate components and their behavior so that the computer designers will be able to select the proper components with best performance for their particular circuit needs.*

B. *Stephen Hundiak (left) and Frank Olsen put transistor analyzer through its paces during last stages of building the equipment. Sample batches of transistors received at plant will be run through analyzer. Such statistical technique is first step in quality control.*

usually equipped for the variety of electronic work required of the technician in our particular industry.

In contrast to the technical-school graduates are the employees retrained by industry for technical tasks, such as final test of main frames and computer systems. When the need for vacuum tube and electromechanical production dropped off, many employees were sent to company courses to qualify for the tasks required in production of solid-state equipment.

In the Endicott facilities, for instance, a full-time school program on computer technology was established. The computer technology course lasted from 12 to at least 20 weeks and each individual had to score well on aptitude and achievement tests before becoming eligible for the five-day-a-week program.

Obviously such a course does not compare with a two-year technical school program. Of necessity it must be specifically oriented to company products and technology. Such a course, in itself, does not enable a man to compete directly with technical-school graduates. It does qualify him to work on final test lines and to perform certain maintenance and service tasks. Such a man will have to fill in with additional study in order to qualify for circuit layout, drafting, and test-equipment assembly. This is why an employee completing the computer technology course is seldom ranked with fully trained technicians.

On the Job

Many people would like us to say that in the computer industry there is an established ratio of technicians to engineers, such as 1 to 4. But the truth is that the ratio varies from department to department depending on present work assignments. In the test equipment area in Endicott there is a higher ratio of technicians. And in the development laboratories of the electrical analysis department, technicians actually outnumber engineers and physicists. The ratio invariably depends on the amount of bench work required in relation to the engineering effort. Thus no facility-wide nor even industry-wide proportion is really valid. It is obvious, however, from what we do see that there is a goodly proportion of technicians needed throughout industry.

Technicians are assigned to departments and specific tasks on the basis of their experience and training. Most departments have technicians of varying specialties. These specialties include electronics, mechanics, chemistry, hydraulics, and math. Exposure to a variety of problems within a department provides many opportunities to extend experience and training.

After joining a new organization, technicians usually attend orientation sessions either part or full time. Then they are assigned to an engineering group as draftsmen. Here they take rough drawings, sketches, and notes and create clear, precise, and detailed drawings of a product, machine, or process.

As a technician becomes more familiar with the environment, he is asked to help with the building of models. From drawings he wires panels, assembles components, solders connections. As he builds he tests the assembly. At this point, the technician often detects things that were overlooked in the idea and drawing stages. It may be that in the physical construction, adequate room has not been allowed for components originally specified. The technician must know enough to detect trouble spots early and permit engineers time to provide an alternative.

A technician should be able to build breadboard circuits or mechanical assemblies with little or no assistance. In fact, his shop experience is often quite valuable in getting things done in the most efficient way. Engineers should be free to tackle more complex problems which require mathematical analysis. The technician can find no better way to prove his value than by making decisions about shop equipment, construction limitations, and machine capabilities on his own.

Testing of prototype machines is an important task for technicians. Under the direction of an engineer he must locate trouble spots by testing and analysis. Faulty components must be identified, reason for failure determined, and replacement procured. Debugging or test running is time-consuming work which demands skilled technicians.

Electrical analysis work is a standard requirement in development work. It provides complete performance and environmental descriptions of components for design decisions. Analysis of components never really ends since improved products are continually made available. How well designers can take advantage of these improvements depends on how well the electrical analysis lab can describe components. In this department, technicians are called on to perform two distinct tasks. Test equipment must be designed, built, and proved. Then the components must be run through specific tests as technicians monitor the equipment and collect data for later analysis.

Technicians are called upon to help set up production machines and processes in the plant. When complex equipment is involved, this work may take many weeks of installation, assembly, troubleshooting, and test runs. In certain cases a skilled technician is called upon to operate the machine, since it is important to keep the machine operating and only a skilled technician is really capable of repairing it. An automatic wired-panel tester is thus operated by a technician so that he can detect trouble early and make adjustments without having to call for assistance.

Opportunities

After investing in formal training, few of us are satisfied with positions which offer little chance for advancement. Thus the technician with even a fair amount of ambition wants to know what the chance of advancement is. He may decide that dramatic advancement is not worth the sacrifice in time and study. But it is encouraging to know that advancement is possible.

What are the opportunities for technicians in the electronic data processing industry? Skilled technicians are very much in demand. At the same time it should be recognized that this demand fluctuates from month to month, as well as from place to place. In the long run, however, job opportunities for technicians look quite promising.

Presently the *IBM* facilities in Endicott employ approximately 500 qualified technicians. As more sophisticated technologies are employed in the design of data processing equipment the need for technicians will undoubtedly increase throughout *IBM* and throughout the industry. And more sophisticated production facilities will demand highly skilled technicians for operation and maintenance.

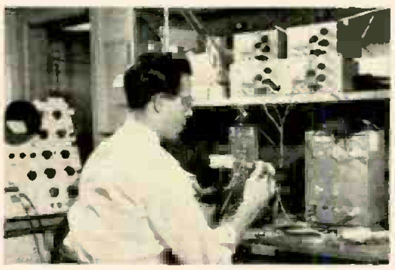
Indications are that the electronic data processing industry is still in its growth period. Some experts in the field

(*Continued on page* 84)

COVER PHOTO:

THIS month's cover shows Michael J. Nugent, Jr., a systems technician trainee, checking out a part of the central processing unit of an IBM 1401 computer. The man has been trained by the company to conduct final testing on the equipment. In the photo he is using the oscilloscope in a series of specified procedures devised to analyze malfunctions, diagnose troubles, and effect repairs. His work here is concerned only with the main frame or central processing unit. Later the main frame will be attached to the peripheral equipment and become a complete computer system.

(Photo: Courtesy of IBM)



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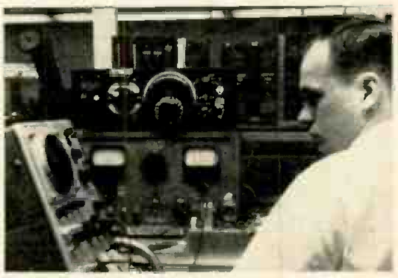
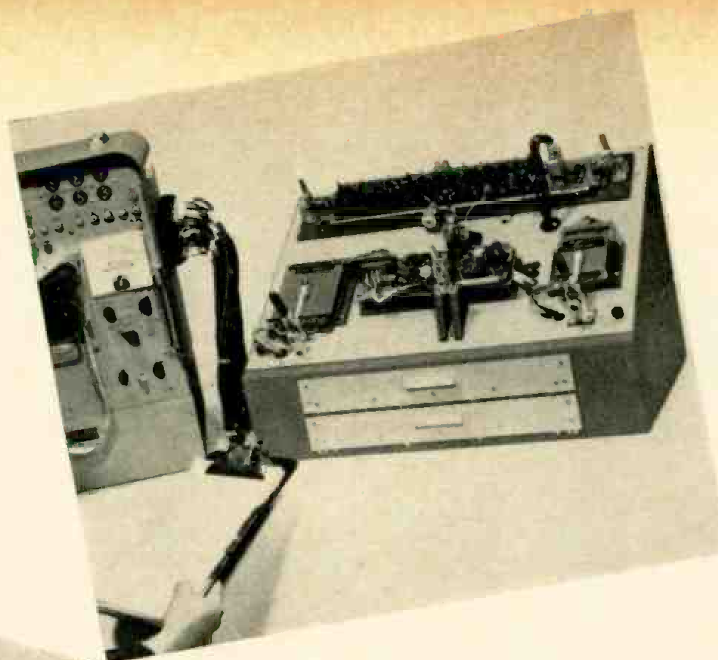


D

C. *James Ortloff breadboards a section of circuitry for new test equipment. Visual inspection is of little use in making computers and generalized types of test equipment require too much time to use. Instead specialized and sophisticated test gear is commonly employed.*

D. *In the manufacturing research laboratory, Richard Bolcavage has just built an amplifier that will be employed to test the output of a bridge oscillator. Knowing how to use a variety of test instruments is a real necessity for electronics technicians like Dick.*



By **STEPHEN D. LAVOIE** / President, Lavoie Laboratories, Inc.

Automated Testing / Men & Machines

A new apparatus and its technique invade another area where human operators were once used exclusively. It foreshadows profound changes in technology and the role of manpower.

IMPRESSIVELY as it sweeps human agency aside, automation is often held to be confined within certain limits beyond which it cannot go. This may be true, but notions as to where the barriers stand and how large an area they encompass are undergoing profound alteration. Correspondingly, ideas as to what automation means to people are also being changed.

Since this is happening in too many ways to discuss all at once, consider a single area of activity. Entirely automatic production of electronic components, sub-assemblies, and even entire equipments, once requiring many manual operations and countless manhours, has been a reality for some time, while simultaneously improving quality and cutting costs. But the line was once drawn after *production*. Man's surveillance then took over to check the finished product, and discover defects.

Today that function too has been invaded. Automatic equipment—like the *Lavoie* Model LA-303 "Robotester" in Fig. 1—can troubleshoot faster and more accurately than men in many applications. It makes tests possible that cannot be practically performed by manpower.

The basic unit can handle up to 250 individual test points through the sockets on the side panel (to the right in Fig. 2), but is adaptable to many times that number of tests. It can measure resistances, voltages, and—*via* built-in frequency standards and an optional impedance module—it can test capacitance, inductance, or combination networks by checking reactance or complex impedance.

Once the machine has been programmed by a punched tape, it will go on its way making test after test, for different properties and to various tolerances, at a greater rate than one per second. It will clearly indicate acceptance, rejection, or deviation on each test and, when it must reject on a test, can stop itself at that point. A human operator may then take action on the reject and reset the "Robotester" to complete its test sequence through a "proceed" loop (Fig. 1) activated from a front-panel control. On the other hand, an optional printer—toward the lower right in the block diagram of Fig. 1—can record all relevant data for later analysis and key the equipment to continue, replacing another human function.

Part of the tape drum assembly, 96 brushes make contact with a grounded belt through holes punched in the program tape to activate individual tests. Contact operates various relays that set up for resistance, voltage, or other tests through the integral bridge-circuit module; set the tolerance limit (1, 5, 10, or 20%) individually for each test; determine through the selector sockets and pins at what points in the equipment under inspection each check is to be made; and operate the reject relays whenever a tolerance limit is exceeded.

Aside from the tape drum, the instrument's front panel consists principally of indicators. Four Nixie tubes at the top left of Fig. 2 (three digits and a decimal multiplier) indicate the value that should be read on the test. The Nixies at the upper right identify the point in the equipment that is being examined. An array of indicators below light up to show desired tolerance, type of test (d.c. or a.c. voltage, resistance, impedance, etc.), whether the test has been passed or the reading is "over" or "under," and the like. A voltohmmeter at the right may be used by an operator to obtain more exact readings when the LA-303 has been stopped by a reject. Yet this array may be ignored when the printer is used.

Other available accessories include a keyboard tape perforator for programming that works ten times faster than manual punching; a reperforator that can duplicate test tapes rapidly and automatically; a "Robotroller" that, on command from the main unit, can insert a variety of other variables or stimuli for complex system check-outs; and multipliers that can increase the number of possible test points to 1000 or more. In addition, special jigs can be made to accommodate a variety of equipments to be tested. To the right in the photo at the top of page 52, we see a jig into which printed boards are inserted for "Robotester" inspection.

Who Uses the Testers?

The types of electronic establishments that make use of such automatic test equipment as we consider here run the gamut of the industry. By and large, the range can be broken down into equipment manufacturers, service agencies, and military agencies. At one extreme, some manufacturers are automatically checking the quality of individual components as they come in prior to use. At the other extreme, the technique is being used to check an elaborate wired communication network that has many times the capacity of ordinary systems. This giant network is so complex that it has been broken down into thousands of circuit cards. There are more than 500 basic card types, with some types being used hundreds of times over. In this system, automatic testing has been instituted for a simple reason: a full check by a personnel team would take several years.

In between the extremes noted, the automatic tester is being used to make static and dynamic tests (inserting test signals, for example, in the latter) on modules, sub-assemblies, and completed equipment. It has found use in conjunction with computers, aircraft missiles, and TV receivers. It has been put to work rapidly scanning large numbers of tubes to eliminate many manhours of individual testing.

For many users, service and maintenance applications develop easily from the initial role in production testing. Since a defect is reflected in one or more changed readings in the circuit, the original program tape prepared for initial checking can be employed for troubleshooting. In this way, a thorough inspection of the defective unit is achieved in less time than a skilled test technician would take to isolate the single trouble that has necessitated service. In the meantime, other unnoticed deviations are exposed.

Military applications account for a substantial portion of use, but some of the biggest names in non-military electronics rely on automatic testers. Applications and relevant statistics are highly impressive, but the most interesting ones are confidential matters. Even in non-military use, the companies involved, for competitive reasons, are reluctant to divulge full details. In one case, a manufacturer was able to underbid a competitor on a contract by 15% because he tested automatically. Another estimates an annual savings of $285,000 on check-out costs. Included in the latter figure is the subsequent cost of correcting errors that would slip past human inspection.

Reasons for Use

Automatic test equipment has not found immediate, universal acceptance everywhere. The concept is new and initial equipment costs are considerable. Thus there are some situations where it has made greater inroads than others. In military applications, for example, maximum reliability is more important than cost considerations, and automatic testing has shown itself to be far more dependable than human agency, especially with complex equipment. Once the testers are in use, however, other advantages become evident. Saved test time is translated into lower costs. More reliable products result. Some tests, on sophisticated equipment, simply cannot be performed in any other practical way.

Another factor that has induced many installations to acquire "Robotesters" is the present shortage of skilled technicians. It is difficult or often impossible to obtain the men who would otherwise be needed to conduct complex tests. Once more, this has been a particular problem with the military. It takes considerable time to train a man to the point where his skills are sufficient for satisfactory work on sophisticated electronic gear. Often very little time remains in his tour of service, after training, during which the service can benefit from his qualifications. Thus the military has found it practical to take a lead in servicing applications.

Future Possibilities

Although changes in technology already realized by automatic testing have been profound, the equipment may be considered to exist only in its primitive form at present. Possibilities not yet tried, not even dreamed of yet, are so sweeping and various as to tax the imagination. They can be suggested, however, by taking note of applications that have already been touched upon.

At *Lavoie Laboratories*, "Robotesters" are being used to check the production of complex laboratory oscillo-

(*Continued on page* 71)

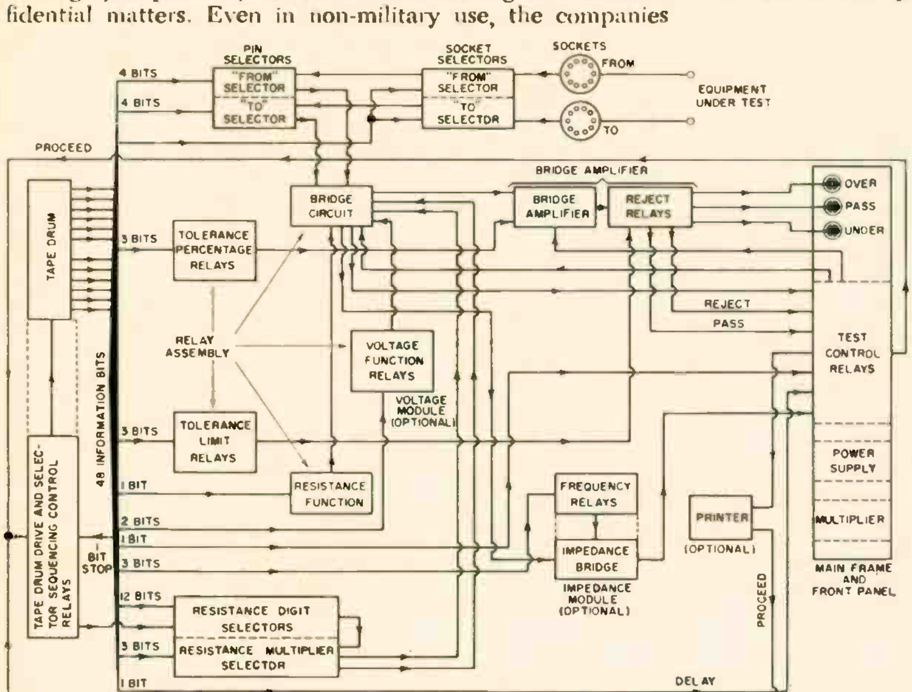


Fig. 1. Blocks connected by broken lines in this functional diagram of the LA-303 Robotester constitute separately removable modules. Some may be used optionally.

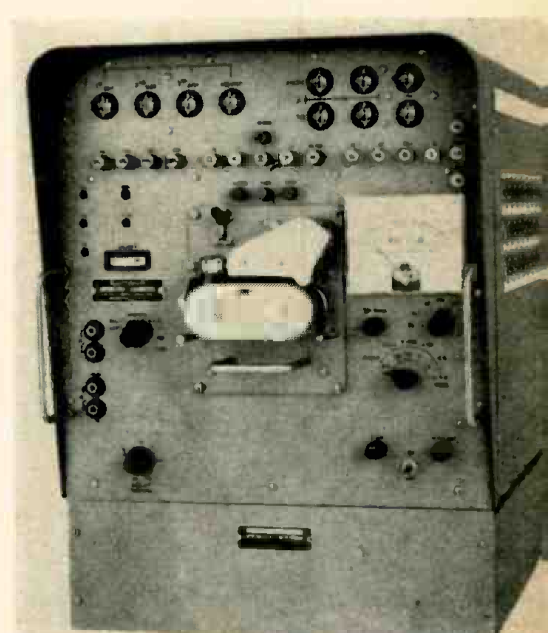
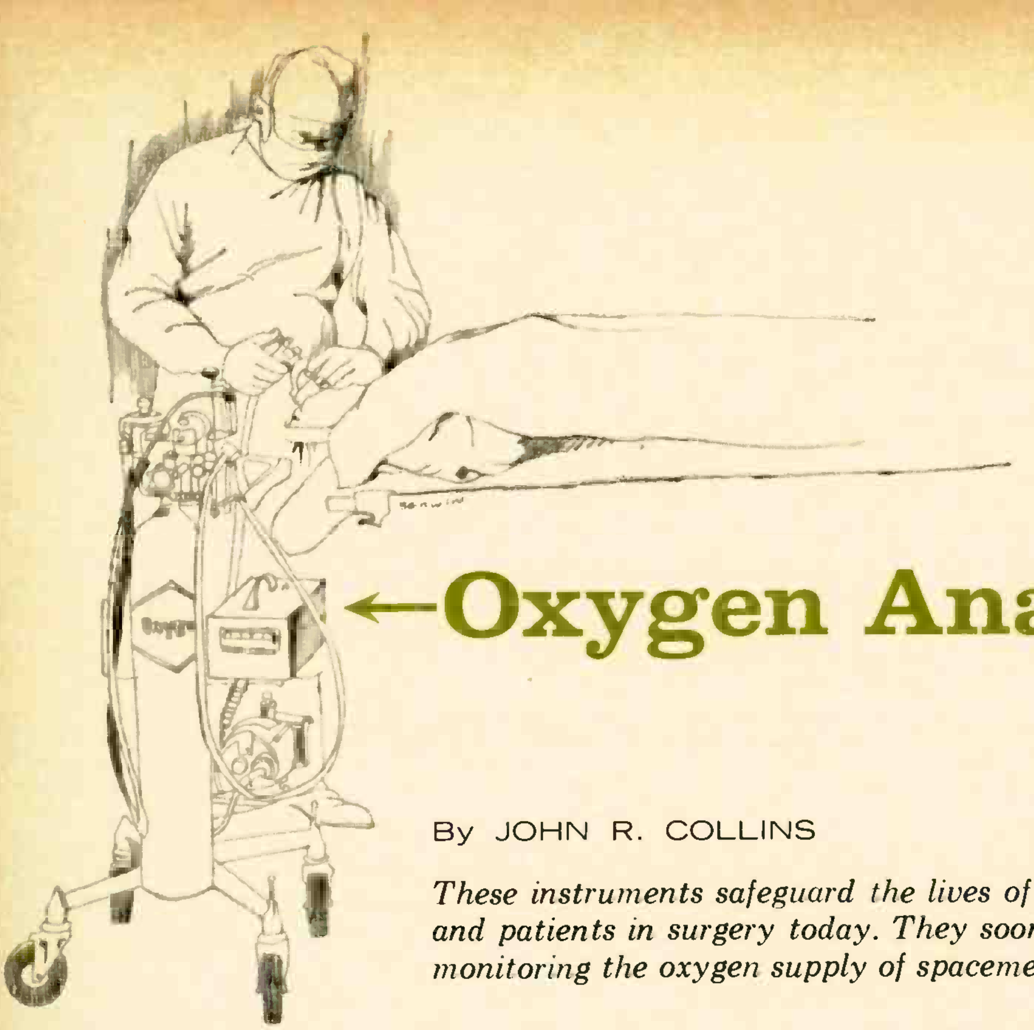


Fig. 2. Results of complex tests can be read on the Robotester's indicator array.



←Oxygen Analyzers

By JOHN R. COLLINS

These instruments safeguard the lives of premature infants and patients in surgery today. They soon will be monitoring the oxygen supply of spacemen on moon flights.

WHEN AN astronaut blasts off for a journey into space, he carries in his helmet a tiny instrument to monitor his vital oxygen supply. When a Navy bathysphere plunges to the ocean floor, it carries a device to measure the dissolved oxygen content of the ocean water. Similar oxygen sensors monitor the oxygen/carbon dioxide ratio in space capsules and environmental test chambers.

The instruments used for these purposes are called *oxygen analyzers*. While many of their other applications may not be as spectacular, they are no less important. Nurses in hospitals use portable analyzers to measure the oxygen in incubators for premature infants and in oxygen tents, since too strong or too weak a concentration might have serious after-effects. Technicians in canneries and frozen food plants monitor the oxygen content of their products to prevent spoilage. Engineers responsible for fuel lines and tanks carrying combustible gases depend on oxygen detectors to warn of air seepage which represents an explosion hazard. Industrial furnace and kiln operators monitor the oxygen content of the fuel supply and exhaust gases for most economical service.

Electronic technicians who switch to the field of industrial electronics are likely to encounter different types of oxygen analyzers which have been developed to meet the needs of industry, defense, and medicine. Not all instruments work on the same principle; several properties of oxygen have been exploited to permit its detection and measurement.

Paramagnetic Oxygen Analyzers

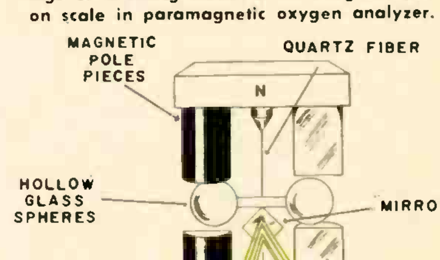
It is fortunate that oxygen is strongly *paramagnetic* (attracted by a magnetic field); this characteristic sets it apart from other common gases, which are almost all slightly *diamagnetic* (repelled by a magnetic field). The paramagnetic properties of oxygen form the basis of operation for an important group of analyzers.

A basic instrument for detecting and measuring oxygen by means of paramagnetism is shown in Fig. 1. It consists essentially of two sets of magnetic poles and a glass dumbbell assembly on which a small mirror is mounted. The dumbbell (shown in detail in Fig. 2) is suspended on a taut quartz fiber between the pole pieces and is free to revolve when a force is exerted against it. A narrow light beam is directed against the mirror and is reflected on a translucent calibrated scale.

The assembly is mounted in a chamber into which the gas to be tested is introduced through a tube. If the test gas contains no oxygen, the dumbbell assembly remains in the same position and the light beam is reflected to the zero point on the calibrated scale. If the test gas contains oxygen, however, the oxygen will be strongly attracted into the gap between the magnet pole pieces and will tend to force out the hollow glass spheres in order to occupy that space. As Fig. 1 shows, the left-hand set of poles is flattened on the far side and the right-hand set of poles is flattened on the near side. This results in a non-uniform magnetic field which causes the left and right spheres to be pushed in opposite directions, so that the assembly rotates on the quartz fiber.

The rotation of the dumbbell assembly is proportional to the force exerted against it, which, in turn, is proportional to the oxygen concentration in the test gas. The small mirror turns with the assembly and reflects a spot of light on a number on the translucent scale.

Fig. 1. Rotating mirror throws light beam on scale in paramagnetic oxygen analyzer.



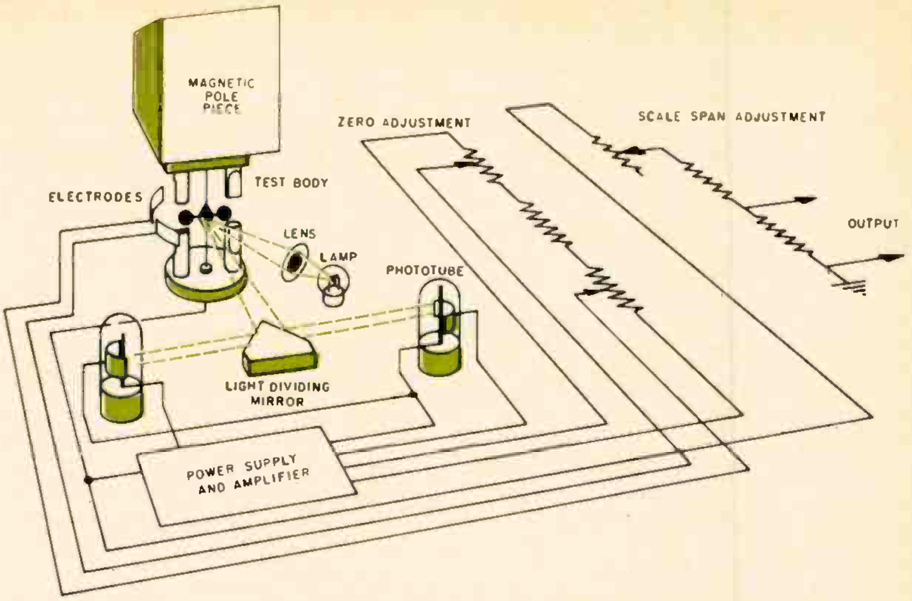


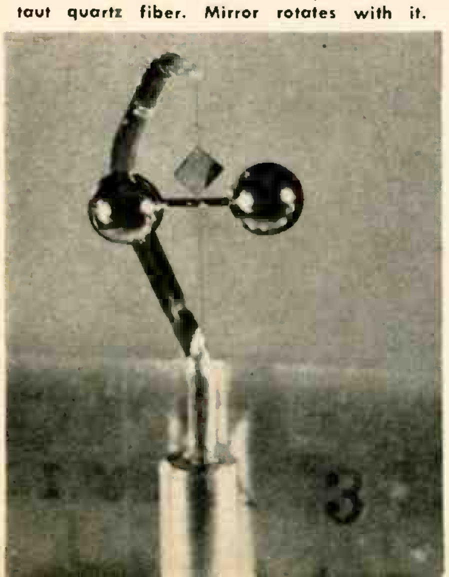
Fig. 3. Null-type paramagnetic oxygen analyzer is more accurate and designed for continuous operation. Electrostatic force opposes force exerted by oxygen on dumbbells.

An instrument incorporating an assembly of this kind is shown in Fig. 4. Permanent magnets furnish the magnetic field, so power is needed only for the light beam. This is supplied by flashlight batteries, making the instrument readily portable. Models are available providing full-scale deflection with either 25% or 100% oxygen content, with accuracy of 2% of full scale. Instruments of this kind are especially useful where measurements must be made intermittently at several locations, as in checking the oxygen concentration in hospital oxygen tents and incubators.

Null-Type Instruments

Greater accuracy is possible with null-type instruments based on the same principle, in which the rotational force exerted by the oxygen against the dumbbell assembly is exactly balanced by an electrostatic force applied in opposition. The dumbbell assembly, then, is maintained in its initial zero position, and the light reflected on the translucent screen serves simply as a null detector.

Fig. 2. Dumbbell assembly is suspended on a taut quartz fiber. Mirror rotates with it.



Although the principle is simple, the mechanical construction is somewhat complicated. The glass spheres are coated with a conductive material, and two electrodes are erected on either side of the dumbbell assembly, one carrying a positive and the other a negative charge. A voltage source is connected to the dumbbell assembly through a potentiometer, so that any desired charge can be placed on the coated surface of the glass spheres.

When a gas containing oxygen enters the test chamber, the dumbbell assembly rotates in the usual way, and one of the coated spheres is brought closer to the positive electrode and farther away from the negative electrode. Like charges repel one another, so if a positive charge is placed on the coated sphere, an electrostatic force will be set up which will tend to overcome the effect of the magnetic field. By adjusting the potentiometer, the charge on the sphere can be controlled precisely, so that the assembly is returned to the zero or null position.

Since the force with which the dumbbell assembly is expelled from the magnet gap is proportional to the concentration of oxygen, it is apparent that the voltage needed to return the assembly to its original position will also be proportional to the oxygen concentration. The applied voltage depends on the setting of the potentiometer. The potentiometer dial is calibrated so that oxygen concentration can be read directly. It has 1000 divisions that enable very accurate measurements to be made.

Null-type instruments can be adapted for contiouous industrial use by adding a self-balancing arrangement, as shown in Fig. 3. The light beam is reflected from the mirror to a light-dividing mirror which splits it between two photocells. When the assembly is in the null position, the light falling on each photocell is the same and no voltage is applied to the coated surface of the glass spheres. However, when the assembly rotates from the null position (because of the presence of oxygen), the phototubes are unequally illuminated and the difference in their output voltages is amplified and applied to the coated spheres. The unbalanced condition continues until the electrostatic force exerted between the coated spheres and the charged electrodes has returned the assembly to the null position.

The voltage applied to the coated spheres is also applied to the output circuit of the instrument and provides an indication of the oxygen content of the gases being analyzed. Any standard recorder can be attached for a permanent record of the fluctuation of the oxygen concentration.

For accurate results, it is important that the test gas should flow through the chamber at a constant rate and pressure, since these factors will obviously influence the concentration of oxygen in the chamber at any given instant.

Thermomagnetic Analyzers

While oxygen at room temperature is strongly paramagnetic, this property declines rapidly as the temperature is raised. The difference between the hot and cold paramagnetism of oxygen forms the basis for a valuable class of thermal oxygen analyzers.

An elementary thermal instrument is shown in Fig. 5. It consists of a conventional Wheatstone bridge made up of two ordinary resistors and two temperature sensitive elements which serve as arms of the bridge and as heaters. One sensitive element is used as a reference and the other as the measuring element. A permanent magnet sets up a strong magnetic field about the measuring element. Power to supply the bridge and to heat the sensitive elements is furnished by a transformer. A galvanometer in the center leg of the bridge detects imbalance.

The two sensitive elements are installed in chambers opening into the tube through which the test gas passes. The test gas thus circulates continuously around both the reference and the measuring element, and this circulation provides a degree of cooling. If no oxygen is present, the effect is the same for each element and the bridge remains balanced.

When oxygen is present, it is attracted into the magnetic field surrounding the measuring element. As soon as it becomes hot from proximity to that element, however, it loses its paramagnetism and is forced out and replaced by cool oxygen. The measuring element is thus cooled more than the reference element, since it is subject to both thermal and magnetic convection. Its resistance changes proportionally and the bridge becomes unbalanced, causing current equivalent to the oxygen concentration to flow through the galvanometer.

A more elaborate thermomagnetic analyzer utilizes two complete bridge circuits, one operating on the test gas and the other on ordinary air. This arrangement permits the effects of variations in barometric or static pressure, which might seriously affect the accuracy of the system, to be eliminated. Pressure changes would have an equal effect on both bridges, and the circuits are connected so that the variations cancel. A single magnet is also used for both bridges, so that variations in its field strength due to aging and temperature changes will affect both bridges equally. The magnet is movable and can be swung away from the cells to permit zeroing of the instrument. This assures that convection due to magnetism will not influence the adjustment.

Instruments of this kind may be sensitive to better than ±0.05% oxygen and accurate to 1.5% of full-scale span. In order to maintain this high degree of accuracy, extreme care must be taken in handling the assembly. The sensitive elements must never be touched, since even the lightest touch will probably damage them permanently. Individual elements are not interchangeable. If a single element is damaged, all four elements must be removed and returned with the resistor panel to the factory for recalibration.

Polarographic Oxygen Sensor

The need for a rugged device to monitor oxygen supplies for space exploration and oceanographic studies was largely responsible for the development of the miniature oxygen sensor shown in Fig. 6. Its operation is based on a well-known laboratory technique, called *polarography*, in which oxygen (and other elements, if desired) can be detected and measured by means of the current produced when the oxygen gains electrons through contact with a negative electrode. The process of acquiring a negative charge in this manner is called *reduction*, and the oxygen is said to have been *reduced*. Laboratory apparatus for polarographic work is quite delicate, however, so the problem was to develop a unit that would be small and rugged but still perform the same job.

The sensor assembly illustrated contains a platinum cathode and a silver anode which are electrolytically connected by a gelled solution of potassium chloride. The cathode is centered in a cylindrical body and supported on an insulated post. The anode is recessed in the area around the cathode. A piece of Teflon, one-mil thick, is stretched taut over these elements, forming a thin membrance in direct contact with the cathode. The assembly can be used either in the atmosphere or in liquids.

A potential of approximately 0.6 volt is applied between the anode and cathode of the cell. No current will flow, however, unless there is an element present capable of being reduced at that voltage. Oxygen is the most common gas reducible in that range. If it is present, either in the atmosphere or in a liquid in which the sensor is immersed, it will permeate through the membrane and come into contact with the cathode. The subsequent transfer of electrons from the cathode to the oxygen will result in a measurable current flow, proportional to the oxygen concentration.

Units of this kind are sensitive to temperature changes, so a thermistor is incorporated in the circuit to provide essentially flat output over a wide temperature range. They are extremely rugged, being designed to withstand acceleration up to 50 g's. Types styled for face masks weigh as little as 10 grams. ▲

Fig. 4. Beckman Model D2 analyzer has two oxygen concentration ranges: 0-25%, 0-100%.

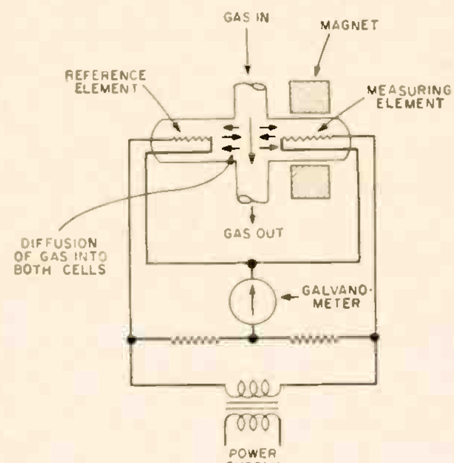


Fig. 5. Temperature difference in thermomagnetic oxygen analyzer unbalances bridge.

Fig. 6. Polarographic oxygen sensor is rugged; used in space and oceanographic work.

1962 Directory of Kit Test Equipment

A complete listing of over 200 test equipment kits. The specifications reveal engineering design sophistication that is justifying their wider acceptance by industry.

KIT TEST equipment, once associated with hobbyists and radio and TV service shops, is finding new applications in an expanding industrial market. The use of kits by manufacturers engaged in non-military electronic work is extensive, an industry-wide survey recently completed by ELECTRONICS WORLD disclosed. Test equipment kits are accurate and reliable instruments for product testing, checking, research, and inspection required in everyday factory operations. In this directory, kits have been divided into 29 categories, according to function, and range in price from $5.95 for a resistance substitution box to $395 for a laboratory oscilloscope.

At the end of World War II kits filled the immediate needs of men starting a service business with limited capital; before the war the cheapest factory-assembled scope sold for about $150. Kits were also the answer to the new post-war experimenter in need of equipment for a home lab. Now, kit test equipment is making inroads into industry in the test and service departments of production-line radio, TV, hi-fi, and industrial electronic equipment manufacturers, service organizations, and schools. In some areas kits are finding their way into laboratories. They have made these advances for three reasons: design standards and accuracy are high—the equivalent of their factory-assembled counterparts; cost is low—the price differential between kits and factory-assembled equipment is substantial; and technicians can assemble them during their idle moments when they're drawing their regular salaries. *General Electric*, who has accepted kit v.t.v.m.'s and distortion analyzers for its two-way-radio service stations, feels that kits would still be cheaper than factory-assembled instruments if they were assembled by technicians whose hourly pay rate were added to the kit cost.

A more interesting reason for using a kit in a special application is that its circuit can be modified during construction to adapt it to a special test or laboratory application. If an assembly-line test position requires the measurement of only d.c. circuit voltages, an inexpensive v.t.v.m. could be *partially* assembled for just this purpose. The same is true of an oscilloscope; only those circuits required to display one particular waveform need be completed.

Today, kits bear little resemblance to the first five-inch scope that sold for $39.95 in 1947. For the technician/experimenter they are the most economical way to equip a home lab—building them still provides pleasure and the satisfaction and pride of having "done it yourself."

If you have never assembled a kit, be assured that their construction manuals are as clear and well written as the manuals for "consumer market" kits. Calibration procedures are simple and accurate and for a nominal fee the manufacturer will check out a kit that does not operate, calibrate it, and put it in top working order. ▲

R.F. SIGNAL GENERATORS

Mfgr.	Model	Freq. Range (fundamentals)	No. of Bands	Cal. Harmonics Freq.	Cal. Harmonics No. of Bands	Output Voltage	Output Z	Modulation Freq. (cps)	Provision for Ext. Mod.	Audio Output	Audio Output Volts	Price	Remarks
ALLIED	83Y145	160 kc.-112 mc.	5	none	—	.1	—	400	yes	yes	10	$19.95	
CONAR	280	170 kc.-60 mc.	6	none	—	—	—	400	no	yes	—	$21.50	
EICO	315	75 kc.-50 mc.	5	13-150 mc.	2	.1	—	400	yes	yes	—	$39.95	
	320	150 kc.-34 mc.	5	22-102 mc.	2	.1	—	400	no	yes	1.5-2	$19.95	Model 322 with 5 cal. bands $23.95
	324	150 kc.-145 mc.	6	111-435 mc.	1	.1	50Ω	400	yes	yes	10	$26.95	
EMC	501	115 kc.-110 mc.	6	—	—	.1	—	400	yes	no	—	$24.90	
HEATH	FMO-1	90, 100, 107 mc.	3	—	—	—	—	400	no	yes	—	$34.95	three switch-selected freq. var. 10.7 mc. sweep, 200 kc. to over 1 mc., 10.7 mc. crystal mark, 100 kc. submarker
	LG-1	100 kc.-31 mc.	5	—	—	.1	50Ω	400	yes	no	—	$48.95	panel meter indicates output voltage or percent modulation
	RF-1	100 kc.-110 mc.	6	110-220 mc.	1	.1	50Ω	400	yes	yes	10	$27.95	
	SG-8	160 kc.-110 mc.	6	110-220 mc.	1	.1	—	400	yes	yes	2-3	$19.50	
LAFAYETTE	KT-208	250 kc.-120 mc.	5	—	—	—	—	400	yes	—	—	$19.95	also a signal tracer
OLSON	KB-141	250 kc.-120 mc.	5	—	—	—	—	400	yes	—	—	$19.95	also a signal tracer
PRECISE	610K	300 kc.-110 mc.	5	60-330 mc.	2	—	—	60, 400	—	—	—	$27.50	available with precalibrated r.f. head as 610KA, $34.95
RADIO SHACK	TK100	100 kc.-330 mc.	6	—	—	1.0	—	20-20,000	yes	20-20,000 cps	2.5	$49.95	meter indicates r.f., a.f. output; r.f., a.f. volts; db in 3 ranges; 0-1, 10, 100 v. a.c.
	R94L026	160 kc.-110 mc.	5	—	—	.1	50Ω	400	yes	—	—	$22.50	

OSCILLOSCOPES

Mfgr.	Model	Vertical Channel Freq. Resp.	Vertical Channel Sensitivity	Vertical Channel Input Z (meg.—$\mu\mu$f.)	Horizontal Channel Freq. Resp.	Horizontal Channel Sensitivity	Horizontal Channel Input Z (meg.—$\mu\mu$f.)	Sweep	CRT Size	Price	Remarks
ALLIED	83YU144	5 cps-5 mc. ± 3 db	25 r.m.s. mv./in.	3.4-12	down 4 db @ 1 mc.	600 r.m.s. mv./in.	—	15 cps-600 kc.	5"	$ 69.95	
	83YZ945	—	—	—	d.c.-750 kc.	1 v./cm.-10 v./cm.	—	.5 sec./cm.-50 nsec./cm.	5"	$395.00	intensity modulated time marks @ 10, 100, & 1000 μsec. intervals
	83YZ946	differential amp, for 83YZ945: vert. chan. freq. resp. d.c.—100 kc., 0 to —3 db; sensitivity, 1 p.p.v./in.; input Z, 1 meg., 40 $\mu\mu$f.								$ 54.50	5000:1 diff. ratio
	83YZ948	dual-trace preamp for 83YZ945: vert. chan. freq. resp. d.c.—10 mc., 0 to —3 db; sensitivity 50 p.p.mv./cm.; input Z, 1 meg., 40 $\mu\mu$f.								$79.95	switching rate: 100 kc. chopped or alternate sweeps
CONAR	250	flat 13 cps-2.5 mc., down 3.5 db @ 4.5 mc.	.023 r.m.s. v./in.	—	flat 20 cps-90 kc. down 3 db @ 250 kc.	1 r.m.s. v./in.	—	10 cps-500 kc.	5"	$ 89.50	
EICO	425	5 cps-500 kc. usable to 2.5 mc.	.05-.1 r.m.s. v./in.	1	5 cps-500 kc.	.05-.15 r.m.s. v./in.	1	15 cps-75 kc.	5"	$ 44.95	
	460	flat d.c.-4.5 mc. down 10 db. @ 10 mc.	25 r.m.s. mv./in.	3-35	flat 1 cps-400 kc.	.6 r.m.s. v./in.	5-35	10 cps-100 kc.	5"	$ 79.95	.06 μsec. rise time
FEILER	TS-7	20 cps-75 kc.	.5 r.m.s. v./in.	1-50	—	.5 r.m.s. v./in.	1-50	10 cps-32 kc.	5"	$ 46.50	
HEATH	10-10	d.c.-200 kc. (2 db point)	.1 p-p v./¼"	3.6-35	same as vert.	same as vert.	3.6-35	5 cps-50 kc.	3"	$ 79.95	
	10-21	2 cps-200 kc. ± 2 db	.25 r.m.s. v./in.	10-20	same as vert.	same as vert.	10-20	20 cps-100 kc.	3"	$ 49.95	
	10-30	3 cps-5 mc. +1.5 db to —5 db	.025 r.m.s. v./in. @ 1 kc.	3.3-12	1 cps-400 kc. ± 3 db	.3 r.m.s. v./in. @ 1 kc.	4.9 @ 1 kc.	10 cps-500 kc.	5"	$ 69.95	.08 μsec. rise time
	OP-1	d.c.-4.5 mc. within 6 db	a.c.-coupled .01 p-p v./cm.	3.6-2.8	d.c.-600 kc. within 6 db	.2 p-p v./cm.	1-37	2 msec./cm. 1 μsec./cm.	5"	$184.95	.1 μsec. rise time
	OR-1	d.c.-200 kc. 1 db point	.1 p-p v./cm.	3.6-28	same as vert.	same as vert.	3.6-28	5 cps-50 kc.	5"	$119.95	
PACO	S-50	5 cps-1.2 mc. ± 3 db, to 2 mc. ± 6 db	90 r.m.s. mv./in.	1.5-25	± 6 db to 700 kc.	250 r.m.s. mv./in.	10-25	20 cps-150 kc.	5"	$ 54.95	
	S-55	a.c. & d.c. within 5 db @ 5 mc.	25 r.m.s. mv./in.	1.5-23	within 3 db 1 cps-400 kc.	.6 r.m.s. v./in.	5-23	10 cps-100 kc.	5"	$ 95.95	.08 μsec. rise time
PRECISE	300K	d.c.-5 mc. ± 3 db	3.9 p-p mv./cm.	—	—	—	—	1 cps-80 kc.	7"	$129.95	
	308K	d.c.-5 mc. ± 1.5 db	10 p-p mv./cm.	—	—	—	—	1 cps-80 kc.	8½"	$139.95	
	315K	a.c.-coupled within + 6 db to 500 kc.	250 mv./in.	—	—	250 mv./in.	—	10 cps-100 kc.	5"	$ 59.95	
	3151K	flat to 5 mc.	10 mv./cm.	—	—	10 mv./cm.	—	—	5"	$ 69.95	
RCA	WO-33A	flat 5.5 cps-5 mc. within —3 db	.3 p-p v./in.	1-50	flat 3.5 cps-350 kc. within —6 db	.9 r.m.s. v./in.	10-	15 cps-75 kc.	3"	$ 79.95	wideband response .1 μsec. rise time
		3 cps-1.5 mc. flat within —6 db	.01 p-p v./in.	1-50	flat 3.5 cps-350 kc. within —6 db	.9 r.m.s. v./in.	10-	15 cps-75 kc.	3"	$ 79.95	narrow band response .1 μsec. rise time
RADIO SHACK	TK-102A	10 cps-3 mc. ± 5 db to 5 mc.	100 r.m.s. mv./in. single trace; 200 r.m.s. mv./in. dual trace	500 k. single trace; 100 k dual trace	flat to 100 kc. —6 db @ 1 mc.	100 r.m.s. mv./in.	—	10 cps-100 kc.	5"	$ 79.95	
	TK-109	d.c.-75 kc.	25 r.m.s. mv./in.	5-100	20 cps- 70 kc.	.6 r.m.s. v./in.	.5-100	20 cps-20 kc.	3"	$44.50	

TRANSISTOR TESTERS

Mfgr.	Model	Tests: Shorts	Tests: Gain	Tests: Leakage	Tests: Forward & Reverse Current	Voltage-Current Ranges	Price	Remarks
ALLIED	83Y149	X			X		$ 8.95	checks leakage-to-gain ratio
EICO	680	X	d.c. beta directly—2-30, 2-300 a.c. beta indirectly	I_{cbo}, I_{ceo}	X	50, 500 μa., 5, 50, 500 ma.	$25.95	d.c. voltage ranges 5, 50 v.; three res. ranges, 2000, 200 k, 20 meg.
EMC	210		d.c. in three ranges	X			$ 7.95	
	212		d.c. in three ranges to 200	X		80 ma., 12 v.	$13.50	checks transistors as a.c. current amplifiers & in-circuit
HEATH	IM-30	X	d.c. beta directly 0-300 d.c. alpha directly 0-.9967	I_{cbo}, I_{ceo}		15, 150 μa., 1.5, 15, 150 ma., 1.5, 15 a., 1.5, 5, 15, 50, 150 v. (100 k ohms/volt)	$54.88	collector current to 15 a.; provision for external d.c. supply
	IT-10	X	X	X	X		$ 6.95	

TUBE TESTERS

Mfgr.	Model	Type: Emission	Type: G_m	Tests: Shorts, Opens, Leakage	Tests: Grid Current	Tests: G_m	Line-Voltage Adjust	Charts	*Sockets	Meter Scale	Special Tube Tests	Price	Remarks
ALLIED	400	X		shorts only				book	7- & 9-pin miniature oc., lok	good-bad	—	$ 17.95	
	600A	X		X			X	roll	4, 5, 6, 7L, 7S, oc., lok, 9, com., nov., nuv., 10	good-bad	CRT with adapter	$ 38.95	counter model $34.95
	2500		X		X	X	automatic	roll	3-pin, 3 & 4 pin transistors, 3, 4, 5, & 6 pin med., 7L, 7S, 8-pin subminiature, oc., lok, 9 & 10 pin miniature, nuv., nov., com., 8-pin acorn	good-bad % deviation of G_m from normal	photo tube, VR's, thyrotrons, transistors, vibrators, "eye," CRT with adapter	$ 99.50	variable bias supply voltage; voltmeter & ma. tip jacks; checks for gas, heater-cathode shorts
EICO	625	X		X			X	roll	4, 5, 6, 7L, 7S, oc., lok, nov.	good-bad	VR's, "eye," CRT with adapter	$ 34.95	
	666		X			X	X	roll	4, 5, 6, 7L, 7S, miniature 7- & 9-pin, subminiature 5, 6, 7-pin (in-line base), oc., lok.	good-bad	CRT with adapter, VR's, "eye," ballast tube	$ 69.95	direct indication of leakage in ohms; transistor leakage and beta test
EMC	205	X		X			X	roll	9 sockets	good-bad	"eye," VR, CRT with adapter	$ 34.50	
	209	X		X				book	7- & 9-pin miniature, oc., lok.	good-bad	CRT with adapter	$ 25.90	rejuvenates CRT's
	211	X		X				book	7- & 9-pin miniature, oc., lok.	good-bad	—	$ 14.90	
	213	X		X				book	7- & 9-pin miniature, com., nuv., nov., 10-pin, oc., lok.	good-bad	VR's, "eye"	$ 18.90	$21.90 in wood carrying case
	301	X		X				book	7- & 9-pin miniature, oc., lok.	good-bad	CRT with adapter	$ 32.60	$33.20 in wood cabinet; rejuvenates CRT's
	302	X		X				book	7- & 9-pin miniature, oc., lok.	good-bad	CRT with adapter	$ 47.90	$49.90 in wood cabinet; rejuvenates CRT's
HEATH	TC-3	X		X			X	roll	4, 5, 6, 7L, 7S, 7 subminiature, oc., lok., 9-pin miniature	good-bad	CRT with adapter	$ 39.95	
	TT-1		X	X	1/4 μa. sensitivity	X	X	roll	4, 5, 6, 7L, 7S, 7- & 8-pin subminiature, oc., lok., 9-pin miniature, com., nuv., nov., 10-pin	0-3000 μmhos, VR test volts, 0-1 v. a.c.	VR's, low-power thyratrons, "eye" tubes	$134.95	
LAFAYETTE	KT-209	X		X				book	7 sockets	good-bad		$ 17.95	
OLSON	KB-142	X		X				book	7 sockets	good-bad		$ 17.95	
PACO	T-60	X		X			X	roll	7- & 9-pin miniature, oc., lok.	good-bad	VR's, "eye," CRT with adapter, gas rectifiers	$ 42.95	
	T-61	X		X			X	book	7- & 9-pin miniature	good-bad	CRT with adapter	$ 53.95	24-socket "speed check" tester
	T-61F											$124.95	self-service "drugstore" tester; same specs as T-61
PRECISE	111K		X	X		X		roll	4, 5, 6, 7L, 7 medium, 7-pin miniature, 7-pin in-line, oc., lok., nov., subminiature 8-pin		CRT with adapter	$ 99.95	
RADIO SHACK	TK105	X		X				book	7- & 9-pin miniature, oc., lok.	good-bad		$ 15.95	
	TK-108	X		X			X	roll	4, 5, 6, 7L, 7- & 9-pin miniature, oc., lok., com., nuv., 10-pin	good-bad	CRT with adapter	$ 49.95	
	TK-113		X	X		X	X	roll	4, 5, 6, 7L, 7S, 7 subminiature, oc., lok., 8-subminiature, 9- & 10 miniature, nuv., nov., com.	good-bad 0-30,000 μmhos		$ 99.95	tests transistors & zener diodes; fil. current indicated on meter

*com. = compactrons; nuv. = nuvistors; nov. = novar; oc. = octal; lok. = loktal.

GENERAL PURPOSE V.T.V.M.'s

Mfgr.	Model	Ranges* d.c., a.c. (r.m.s.)	Ranges* Ohms/ mid-scale	No. of Ranges	D.C. Input Res. (meg.)	A.C. Input Z (meg.-$\mu\mu$f.)	Accuracy (full-scale) D.C.	Accuracy (full-scale) A.C.	Frequency Response	Price	Remarks**
ALLIED	83Y125	1.5-1500	1000/10 1000m./10m.	7	11	—	± 3%	± 5%	30 cps-3 mc.	$25.95	db range—10 + 65; a.c. p-p ranges 4, 4000
ARKAY	VT-10	3-1500	1000, 1000m.	7	11	—	—	—	30 cps-5 mc.	$25.95	db range—10 + 58
CONAR	211	3-1200	1000/10 1000m./10m.	6	12.2	1.5-	—	—	—	$31.95	
EICO	221	5-1000	1000, 1000m.	5	25	3-	± 3%	± 5%	20 cps-200 kc.	$25.95	db range—20 + 55
	214	—	—	—	—	—	—	—	—	$34.95	same as 221 but 7½" meter
	222	3-1500	1000m.	5	11	1-	± 3%	± 5%	30 cps-3 mc.	$27.95	p-p with special probe
	232	1.5-1500	1000m.	7	—	—	—	—	30 cps-3 mc.	$29.95	a.c. p-p ranges 4, 4200
	249	—	—	—	—	—	—	—	—	$39.95	same as 232 but 7½" meter
EMC	106	1.5-1000	1000, 1000m.	5	16.5	2-	—	—	25 cps-100 kc.	$23.90	db range—24 + 55
	107	1.5-1000	1000, 1000m.	6	16.5	1.5-	—	—	—	$34.50	a.c. p-p ranges 4, 2800; capacity 50 $\mu\mu$f.-5000 μf.; inductance 1.4-140,000 hy.
	107A	—	—	—	—	—	—	—	—	$36.50	same as 107 but 6" meter
FEILER	TS-9	5-1000	1000m.	5	26	3-	± 2%	± 2%	—	$22.95	db range—20 + 16; 0-1 ma. d.c. range
GROMMES	VTVM	—	—	—	—	—	—	—	—	$27.95	
HEATH	IM-10	1.5-1500	1000/10 1000m./10m.	7	11	1-30	± 3%	± 5%	25 cps-1 mc. ± 1 db	$32.95	db range—10 + 65
	IM-11	1.5-1500	1000/10 1000m./10m.	7	11	1-35	± 3%	± 5%	25 cps-1 mc. ± 1 db	$29.95	
LAFAYETTE	KT-174	1.5-1500	1000, 1000m.	7	11	150 v.-1.3 meg; 500v., 1500 v.-1.5 meg; other scales 50-83 meg.	± 2%	± 5% (5v.) ± 3% (others)	20 cps-4 mc. ± 1 db	$44.50	low a.c. ranges 50, 150, 500 mv.; 4.2, 4200 p-p ranges
	KT-202	3-1500	1000/10 1000m./10m.	7	11	—	—	—	30 cps-5 mc.	$25.95	db range—10 + 18; a.c. p-p ranges 8, 2000
OLSON	KB-140	3-1500	1000/10 1000m./10m.	5	11	—	—	—	30 cps-5 mc.	$24.95	db range—10 + 58; a.c. p-p ranges 8, 2000
PACO	V-70	1.5-1500	1000/10 1000m./10m.	7	11	—	—	—	40 cps-4 mc. ± 1 db	$31.95	db range—6 + 66; a.c. p-p ranges 4, 4000
PRECISE	904K	1.5-1500	1000/10 1000m./10m.	7	—	—	—	—	—	$39.95	
	909K	5-1000	1000/10 1000m./10m.	5	25	—	—	—	—	$29.95	
	9071K	5-1000	1000/10 1000m./10m.	5	25	—	—	—	—	$39.95	7½" meter
RADIO SHACK	R94LX070	1.5-1500	1000/10 1000m./10m.	6	11	—	± 3%	± 5%	flat to 2 mc.	$44.95	15, 150 mv. ranges; .15, 5 a. a.c. ranges; 0-1600 w. a.c. ranges 15, 30, 60 watts across 16, 8, 4 ohm leads
	R94L078	3-1500	1000/10 1000m./10m.	7	11	—	± 3%	± 5%	flat to 3 mc.	$26.95	db range—10 + 38; a.c. p-p ranges 8, 2000
RCA	WV-77E	1.5-1500	1000/10 1000m./10m.	7	11	—	± 3%	± 5%	40 cps-5 mc. ±5 db on 1.5, 5, 15 v. ranges	$29.95	a.c. p-p ranges 4, 4000
	WV-98B	1.5-1500	1000, 1000m.	7	11	.83-70	± 3%	± 3% (± 5%, 1.5-5v.)	30 cps-3 mc.	$62.50	a.c. p-p ranges 4, 4200 WV-98C same but with .5 v. d.c. range

*Figures are highest scale markings for lowest and highest ranges.
**Peak-to-peak ranges, where shown, are true readings of complex waveshapes.

A.C. POWER SUPPLIES

Mfgr.	Model	Output Voltage	Output Current	Meter Ranges V.	Meter Ranges A.	Price
EICO	1073	0-140	1, 3 a.	140	1, 3	$35.95
	1078	0-140	2.5, 7 a.	140	2.5, 7	$42.95
HEATH	IP-10	90-130 in .75 v. steps	300 w. (cont.) 500 w. (inter.)	90-140	—	$54.95
OLSON	T-281	0-140	5 a.	0-140	—	$19.95
RADIO SHACK	TK-106	0-150	5 a.	0-150	—	$23.95

GRID-DIP METERS

Mfgr.	Model	Range (mc.)	No. of Bands	Power	Price	Remarks
ALLIED	G-30	1.5-300	6	a.c.	$22.95	
EICO	710	.400-250	8	a.c.	$29.95	
HEATH	HM-10	2.7-270	—	batt.	$34.95	uses tunnel diode
PACO	G-15	.400-250	8	a.c.	$31.95	has crystal socket

D.C. POWER SUPPLIES

Mfgr.	Model	Output Voltage Ranges	Current Ranges (amps) Continuous	Intermittent	Meter Scales	Price	Remarks
ALLIED	83YX129	8, 15	15 (6 v.) 10 (12 v.)	17.5 (6 v.) 12.5 (12 v.)	15 v. d.c. 20 v. d.c.	$37.95	
EICO	1020	6, 30	150 ma. (0-12 v.) 200 ma. (12-24 v.) 300 ma. (24-30 v.)		6 v. d.c. 30 v. d.c.	$19.95	.005% 120 cps ripple at full load
	1050	8, 16	10 (8 v.) 6 (16 v.)	20 (8 v.) 12 (16 v.)	20 v. 20 a.	$29.95	not recommended for transistor work; accessory filter #1055 available
	1060	8, 16	10 (8 v.) 6 (16 v.)	20 (8 v.) 10 (16 v.)	20 v. 10, 20 a.	$38.95	ripple 16 v. range: 3% @ 2 a., 1% @ 6 a., 1.5% @ 10 a.; 8 v. range: 1.5% @ 2 a., 2% @ 6 a., 4.5% @ 10 a.
	1064	8, 16	10 (8 v.) 6 (16 v.)	20 (8 v.) 10 (16 v.)	20 v. 10, 20 a.	$43.95	ripple same as 1060; lightweight version of 1060
ELECTRO PRODUCTS	KPS-2	16, 20	5 (12 v.)	—	12 v., 10 a., 75 ma.	$44.95	ripple .15% @ 75 ma., .5% @ 5 a.; 0-20 v. range is for transistor circuitry
EMC	905	6, 12	—	—	2 meters	$28.90	with extra filtering for transistor applications $34.90
HEATH	BE-5	8, 16	10 (6 v. unfiltered) 5 (6 v. filtered) 5 (12 v.)	15 (6 v. unfiltered) 7.5 (12 v. unfiltered)	2 meters	$44.95	ripple .3%
	PS-4	0-400 v. 0 to −100 v. (bias voltage)	100 ma. 1 ma.	125 ma.	150, 400 v. 150 ma.	$56.95	6.3 v. @ 4 a. a.c. output; ripple 10 mv. d.c. output impedance 10 ohms; output regulation 1% from no load to full load, ± .5 v. for ± 10 v. line voltage variation from 117 v.
PACO	B-10	8, 16	10 (8 v.) 6 (16 v.)	20 (8 v.) 12 (16 v.)	2 meters	$43.95	low ripple output; 8 & 16 v., 5 a., 3%
	B-12	0-400 v. 0 to −150 v.	150 ma. 2 ma.	—	150, 400 v. 200 ma.	$69.95	6.3 v. @ 3 a. and 12.6 v. @ 3 a. a.c. outputs; d.c. output impedance 10 ohms; regulation .33% from no load to full load; .4% for ± 10 v. line voltage variation from 117 v.
PRECISE	711	15 v. 30 v. 110-180 v.	10 10 .075	20 20 1	— —	$59.95	90-140 v. a.c. (isolated) output @ 1 a.; Model 713 90-140 v. a.c. @ 3 a. output $69.95; other a.c. output on both models: 24 v. @ 20 a., 90-140 v. @ 10 a. continuous (not isolated)
	760	140-450 v. 0- ± 1000 v. @ 1 ma.	100 ma.	—	2 meters	$49.95	6.3 v. @ 4 a. and 375 v. @ 50 ma. a.c. outputs; ripple .01%
RADIO SHACK	TX-114	2-16 v. 4-30 v. 115-180 v.	15 15 .5	20 20 .75	multi-range meter	$69.95	95-145 v. a.c. (isolated) output @ 3 a. continuous, 4 a. intermittent; 95-145 v. a.c. (not isolated) @ 5 a. continuous, 20 a. intermittent; high-voltage d.c., partly filtered, 2-16 v. d.c. well filtered

SIGNAL TRACERS

Mfgr.	Model	Indicators Speaker	Eye	Test Speaker Function	Out. Trans. Function	Wattmeter Function	"B+" Output	Component Noise-Test Function	Price	Remarks
ALLIED	83Y135	X	X	X	X	X	X	X	$26.50	
CONAR	230	X	X						$39.95	calibrated attenuator for gain measurement
EICO	145A	X		X	X		X	X	$19.95	
	147	X	X	X	X	X	X	X	$24.95	
EMC	802	X	X	X	X		X		$24.95	generates 400 cps and modulated 455 kc. signals
FEILER	TS-1K	phone							$ 6.75	meter, phone, battery extra
	TS-3K	X							$22.75	can be used to convert v.o.m. to r.f. v.t.v.m.; battery operated TS-2K $17.95
	TS-5K	X							$20.45	can be used to convert v.o.m. to r.f. v.t.v.m.
GROMMES	202K	X	X	X	X	X	X	X	$37.50	response to 300 mc. with Model B probe
HEATH	T-4	X	X	X	X		X	X	$19.95	
LAFAYETTE	KT-208	X							$19.95	also signal gen., see listing; output for v.t.v.m. & phones
OLSON	KB-141	X							$19.95	also signal gen., see listing
PACO	Z-80	X	X	X	X	X	X	X	$32.95	calibrated attenuator for gain measurement

SWEEP AND MARKER GENERATORS

Mfgr.	Model	Freq. Range	No. of Bands	Output Voltage	Z	Sweep Width	Cal. Marker Ranges (fund.)	No. of Bands	Provision for Marker Crystals	Provision for Ext. Markers	Price	Remarks
ALLIED	83YX123	200 kc.-250 mc.	4	.15		0-13 mc.	—	—	2	yes	$44.95	
EICO	360	500 kc.-228 mc.	—	—	—	0-30 mc.	—	—	1	no	$34.95	
	368	3-216 mc.	5	—	50Ω	0-15 mc.	2-225 mc.	3	1	yes	$69.95	
HEATH	TS-4A	3.6-220 mc.	4	.1	50Ω	0-42 mc.	19-60 mc.	1	1	yes	$54.95	
PACO	G-32	3-220 mc.	5	—	—	0-20 mc.	—	—	1	yes	$85.9[illegible]	marker adder

AUDIO GENERATORS

Mfgr.	Model	Range	No. of Bands	Output Max. Volts	Output Load Ω	Output Waveforms	Accuracy	Distortion	Price	Remarks
ALLIED	83YX137	20 cps-1 mc.	5	10	—	sine	—	.25% from 100 cps through audible range into high Z	$35.95	
EICO	377	20-200 k (sine) 60-50 k (square)	4	10	1000	sine-square	± 3%	less than 1%	$31.95	
HEATH	AG-9A	10 cps-100 kc.	4	1 v. 10 v.	600 10,000	sine	± 5%	less than .1% from 20-20,000 cps	$39.95	output meter calibrated in volts and db
	AG-10	20 cps-1 mc.	5	10 v. (sine & square)	high Z	sine-square	± 1.5 db 20 cps-1 mc.	.25% from 20-20,000 cps	$49.95	square-wave output voltage is p-p; rise time .15 μsec.
PACO	G-34	6 cps-750 kc.	6	10 v. (sine) 18 v. (square)	600 600	sine-square	—	—	$64.95	square-wave output voltage is p-p; rise time .15 μsec.
PRECISE	635	20 cps-200 kc.	5	—	—	sine-square	—	—	$39.95	

A.C. V.T.V.M.'s

Mfgr.	Model	Range* A.C. (r.m.s.) v.	No. of Ranges	A.C. Input Z (meg.—μμf.)	Accuracy (full-scale)	Frequency Response	Price	Remarks
ALLIED	83YU608	.003-300	11	(3-300 v.) 10-15 (.003-1 v.) 10-25	—	20 cps-100 kc. ± 1 db 100 kc.-2.5 mc. ± 1.5 db	$129.50	db range—65 + 53; amp. output .09 v. (29.5 db gain); auto. range selection
	83YU978	.003-300	11	see above	—	30 cps-300 kc. ± .5 db 20 cps-2 mc. ± 1 db 17 cps-4 mc. ± 1.5 db	$ 89.95	db range—65 + 53; amp. output .08 v. (28 db gain)
ARKAY	AV-20	.01-300	10	1 meg. @ 1 kc.	—	10 cps-400 kc. ± 1 db (.01-100 v. range) 10 cps-40 kc. ± 2 db (300 v. range)	$ 29.95	db range—52 + 52
	AW-30	5 mw.-500 w.	6	4, 8, 16, 600 ohms	—	10 cps-250 kc. ± 1 db	$ 29.95	audio wattmeter 25 w. continuous, 50 w. intermittent
EICO	250	.001-300	12	10-15	± 3%	10 cps-600 kc. ± 0 db	$ 49.95	amp. output 5 v.; max. gain 60 db
	255	.001-300	12	10-15	± 3%	10 cps-600 kc. ± 0 db	$ 44.95	db range—80 + 52
	260	.01-1000	11	2-15	± 4%	10 cps-150 kc. ± 0 db	$ 49.95	wattmeter ranges (7) .15 mw.-150 w.; loads: 4, 8, 16, 600 ohms @ 40, 80, 40 + 40 watts
HEATH	IM-21	.01-300	10	(10-300 v.) 10-12 (.01-3 v.) 10-22	—	10 cps-500 kc. ± 1 db 10 cps-1 mc. ± 2 db	$ 33.95	db range—50 + 50
RADIO SHACK	G94L027 (TK-111)	.01-300	10	1 @ 1 kc.	—	10 cps-400 kc. ± 1 db (.01-100 v. range) 10 cps-40 kc. ± 2 db (300 v. range)	$ 31.95	db range—52 + 52

*Figures are highest scale markings of the lowest and highest ranges

CAPACITOR CHECKERS

Mfgr.	Model	Out or In-Circuit Check	Capacitance Test Range	Resistance Test Range	Power-Factor Function	Test Voltages	Tests: Shorts	Tests: Open	Price	Remarks
ALLIED	83Y119	in	20 μμf.-2000 μf.				X	X	$14.95	
	83Y124	out	10 μμf.-1000 μf.	100 ohms-5 m.	0-50%	50, 150, 250, 350, 450 volts d.c.	X	X	$19.95	
ARKAY	CA-40	out	1 μμf.-1 μf.						$29.95	
CONAR	311	out	10 μμf.-1500 μf.	1 ohm-150 m.	0-50%	0-450 volts d.c.	X	X	$21.95	
EICO	955	in	.1 μf.-50 μf.			6.3 v. a.c.	to 2000 μf.	from 5 μμf.	$19.95	
EMC	801	in	10 μμf.-5000 μf.	.5 ohm-500 m.	0-60%	0-500 volt d.c.	to 20 μf.	from 50 μμf.	$24.95	will not check electrolytics for short
HEATH	C-3	out	10 μμf.-1000 μf.	100 ohms-5 m.	0-50%	25-450 v. d.c.	X	X	$19.50	
	CT-1	in					to 20 μf.	from 50 μμf.	$ 8.49	
	IT-11	out	10 μμf.-1000 μf.	5 ohms-50 m.	X	3-600 v. d.c.	X	X	$29.95	direct reading scales; Input provision for 10 kc. signal
PACO	C-20	out	10 μμf.-2000 μf.	.5 ohm-200 m.	0-60%	0-500 v. d.c.	X	X	$23.95	bridge circuit for determining transformer turns ratio
	C-25	in	2 μf.-400 μf.				X	from 5 μμf.	$19.95	
RADIO SHACK	TK-112	in	4 μf.-400 μf.				X	X	$19.95	

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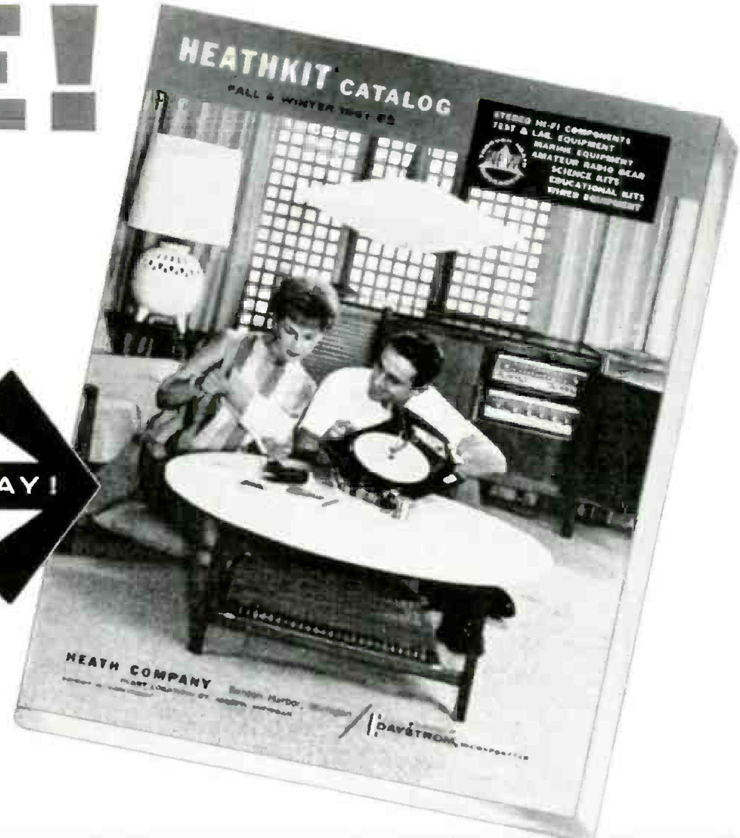

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Assembled AJW-41, $18 mo. **$189.95**

CB TRANSCEIVER: Low-cost, two-way radio! Crystal controlled superhet receiver and transmitter; squelch and automatic noise limiter; Push-to-Talk microphone; built-in AC power supply; provision for plug-in DC supply.
Kit GW-12A (AC only) 8 lbs. $5 mo. **$39.95**
Kit GW-12D (AC & DC) 11 lbs $5 mo. **$44.95**

MARINE RADIO TELEPHONE: Factory wired and tested! 50-watt transmitter. 5 crystal-controlled transmit and receive channels. Covers 2-3 mc marine and standard broadcast bands. Built in vibrator power supply. An outstanding value! 25 lbs.
Assembled MWW-11A, no money down, $24 mo. **$259.95**

TUBE CHECKER KIT: Latest design. Tests all tubes including Compactron, Nuvistor, Novar and 10-pin miniatures! Built-in roll chart. Individual tube element switches. Perfect for service. 11 lbs.
Kit IT-21...no money down, $5 mo. **$44.95**

SSB MOBILE AMATEUR TRANSMITTER: 90 watt input, 80 through 10 meters, crystal bandpass filter, dual conversion heterodyne circuitry, automatic level control, switch selection of USB, LSB and CW, VOX or PTT operation. 19 lbs.
Kit HX-20, No money down, $19 mo. **$199.95**

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V.O.M.'s

Mfgr.	Model	Ranges* A.C.—D.C.	Ohms/ mid-scale	D.C. Current †A.C. Current	No. of Voltage Ranges	Sensitivity ohms/volt D.C.	A.C.	Accuracy D.C.	A.C.	Price	Remarks
ALLIED	83Y128	1-5000	1000/60 1 meg./1500	a.c. & d.c. 1, 10, 100 ma., 1 a.	7	1 k	1 k	± 2%	± 2%	$16.95	db scale—20 + 69
	83Y140	2.5-5000	2000/12 20 meg./120 k	.1, 10, 100 ma., 1, 10 amp.	6	20 k	5 k	± 2%	± 2%	$29.95	db scale—20 + 63; output function
	83Y708	5-500 15-500 (a.c.)	30 k/1200	5, 10, 100 ma.	5	1 k	—	—	—	$ 9.95	
CONAR	240	6-600	1000, 10 m.	—	3	20 k	5 k	—	—	$17.95	
EICO	536	1-5000	5000, 1 m.	a.c. & d.c. 1, 10, 100 ma., 1 a.	7	1 k	1 k	—	—	$12.90	db scale—20 + 69; with 1% res. Model 526
	565	2.5-5000	2000, 20 m.	100 μa., 10, 100, 500 ma., 10 a.	6	20 k	5 k	—	—	$24.95	db scale—12 + 55; output function; with 1% res. Model 555
	566	1-5000	5000, 1 m.	1, 10, 100 ma., 1 a.	7	1 k	1 k	—	—	$14.90	db scale—20 + 69; output function; with 1% res. Model 556
EMC	102K	6-3000 12-3000 (a.c.)	1000, 1 m.	6, 30, 130 ma., 1.2 a. †30, 150, 600 ma.	5	—	—	± 2%	± 2%	$12.50	
	103K	6-3000	1000, 1 m.	6, 30, 120 ma. †30, 150, 600 ma.	5	—	—	—	—	$14.90	db scale
	109K	6-3000 12-3000 (a.c.)	20 k-20 m. (3 ranges)	6, 60, 600 ma.; †30, 300 ma., 3 a.	5	20 k	10 k	—	—	$19.25	db scale
HEATH	IM-20	15-500 (d.c. only)	—	1 ma.	4	1 k	—	± 10%	—	$14.95	cap. & res. substitutions; signal generator
	M-1	10-5000	3000/30 300 k/3000	10, 100 ma.	5	1 k	1 k	± 2%	± 2%	$19.95	
	MM-1	1.5-5000	—20 m.	150 μa., 15, 150, 500 ma., 15 a.	7	20 k	5 k	—	—	$33.95	db scale—10 + 65; output function; polarity rev. switch
LAFAYETTE	TK-10	10-1000	10 k, 1 m.	500 μa., 10, 250 ma.	5	20 k	10 k	—	—	$11.95	db scale—20 + 36
PACO	M40	1.5-6000 3-12k (a.c.)	2000/8.5 20 m./85 k	60 μa., 1.5, 15, 150 ma., 1.5, 15 a.	7	20 k	10 k	—	—	$31.95	db scale; output function
RADIO SHACK	694L079	1-5000	1000-1 m.	a.c. & d.c. 1, 10, 100 ma., 1 a.	7	1 k	—	—	—	$16.95	db scale—20 + 69; output function
RCA	WV-38A	.25-5000 2.5-5000 (a.c.)	2000/12 20 m./120 k	50 μa., 1, 10, 100, 500 ma., 10 a.	d.c.—8 a.c.—6	20 k	5 k	± 3%	± 5%	$29.95	db scale—20 + 50; output function; polarity rev. switch

*Figures are highest scale markings for lowest and highest ranges.

CAPACITOR & RESISTOR SUBSTITUTION & DECADE BOXES

Mfgr.	Model	Resistance: Range (ohms)	Steps	Decades	Tolerance	Wattage	Capacitance: Range	Steps	Decades	Voltage Rating	Tolerance	Price
ALLIED	83Y138	—	—	—	—	—	.0001 μf.-.22 μf.	18	—	600 v., .15 & .22 μf. are 400 v.	± 20%	$ 5.95
	83Y139	15-10 k 15 k-10 m.	18 18	—	± 10%	—	—	—	—	—	—	$ 5.95
EICO	1100	15-10 m.	—	multiples of 15, 22, 33, 47, 68, 100 ohms	± 10%	1	—	—	—	—	—	$ 6.95
	1120	—	—	—	—	—	.0001 μf.-.22 μf.	18	—	600 v.	± 10%	$ 5.95
	1140	—	—	—	—	—	—	—	—	—	—	$13.95 (combination of 1100 & 1120)
	1171	0-99,999	1 ohm	5	½%	1	—	—	—	—	—	$19.95
	1180	—	—	—	—	—	100 μμf.-.111 μf.	100 μμf.	3	350 v.	± 10%	$14.95
EMC	900	15-10 m.	2	—	± 10%	1	.0001 μf.-.22 μf.	18	—	—	—	$10.25
HEATH	CS-1	—	—	—	—	—	.0001 μf.-.22 μf.	18	—	600 v., 400 v. for three highest steps	—	$ 5.50
	DC-1	—	—	—	—	—	100 μμf.-.111 μf.	100 μμf.	3	—	± 1%	$17.95
	DR-1	1-99,999	1 ohm	5	± ½%	—	—	—	—	—	—	$22.95
	RS-1	15-10 m.	36	—	± 10%	1	—	—	—	—	—	$ 5.50
PACO	CD-3	—	—	—	—	—	.0001 μf.-.111 μf.	.0001 μf.	3	350 v.	—	$19.95
	RD-5	0-111,110	1	5	± ½%	—	—	—	—	—	—	$24.95
	SC-1	—	—	—	—	—	.0001 μf.-22 μf.	—	—	100-470 μμf., 500 v. .001-.22 μf., 600 v.	± 5% ± 10%	$ 9.95
	SR-2	15-10 m.	36	—	± 10%	1	—	—	—	—	—	$ 9.95

UNCLASSIFIED TEST EQUIPMENT

Audio Analyzer

Heath: Model AA-1, $54.95. a.c. v.t.v.m. freq. resp. 10 cps-100 kc. ± 1 db; range .01, .03, .1, .3, 1, 3, 10, 30, 100, 300 r.m.s. v.; input impedance 1 meg. or 4, 8, 16, or 600 ohms. Wattmeter: 10 cps-50 kc. ± 1 db.; .15, 1.5, 15, 150 mw., 1.5, 15, 150 w.; 4, 8, 16, 600 ohm internal loads, 10,000 ohms across external load. IM analyzer: high-pass filter, 2000-12,000 cps, low-pass filter 10-600 cps; 1, 3, 10, 30, 100 per-cent full scale. Input impedance a.c. v.t.v.m., 1 meg. or 4, 8, 16, or 600 ohms switch-selected. Internal-generator frequencies: 60 cps, 6 kc. DBM: −40, −30, −20, −10, 0, 10, 30, 40, 50. Reads from −65+52 dbm. Accuracy: a.c. v.t.v.m. and wattmeter within 5% full-scale; IM analyzer within 10% of full-scale.

Battery Tester

Eico: Model 584, $9.95. Test positions (volts): 1.5, 4.5, 6.0, 7.5, 9.0, 22.5, 45, 67.5, 75, 90, spare.

CRT Checker

Eico: Model 630, $13.95. Bridge circuit measures peak beam current.

Bar and Dot Generators

Eico: Model 352, $14.95. TV channels 2-6; 16-23 vertical bars, 13-22 horizontal bars; output voltage .4 mv.

Heath: Model CD-1, $64.95. TV channels: 2-6. Output voltage 100-100,000 μv. Sound carrier: crystal-controlled, unmodulated, 4.5 mc. away from picture carrier. Positive or negative video output variable from 0-10 v. p-p open circuit. Modulation: white-dot pattern, cross-hatch pattern, horizontal bars, vertical bars, 10 vertical color bars, shading bar pattern.

Electronic Switches

Eico: Model 488, $23.95. Switching rate 10-2000 cps continuously variable in 3 ranges. Frequency response d.c.-30,000 cps (−2 db); maximum gain 10 times (continuously variable gain control); input impedance 100,000 ohms; max. input at greatest attenuation 400 v. p-p; output impedance 50,000 ohms.

Heath: Model S-3, $21.95. Freq. resp. to 100 kc. ± 1 db.

Filament Tester

Eico: Model 612, $3.95. Checks filament continuity. Sockets are provided for 9 pin, octal, loctal, and 7 and 9-pin miniature tubes. Adapter provided for checking 14-, 12-, and 8-pin picture tubes.

Flyback Transformer and Yoke Testers

Allied: Model 83Y118, $21.95. Indicates shorts in coil with a "Q" greater than 1, and inductance from .0003-2 hy. Checks continuity of circuits with 0-.5 meg. resistance.

Eico: Model 944, $23.95. Checks all flyback transformers and yokes in- or out-of-circuit.

Harmonic Distortion Meter

Heath: Model HD-1, $49.50. Frequency 20-20,000 cps in three ranges; distortion 1, 3, 10, 30, 100 per-cent full-scale; voltmeter 1, 3, 10, 30 volts full-scale; input resistance 300,000 ohms; minimum input voltage for distortion measurements 0.3 v.; output voltage for monitoring 2.5 at full-scale meter reading. Meter scales calibrated in volts r.m.s., per-cent distortion, and db. When used with Heathkit AG-92 or AG-10, the HD-1 will measure harmonic distortion at any frequency between 20 and 20,000 cps.

Impedance Bridges

Eico: Model 950B, $19.95. Measures capacity from 10 μμf.-5000 μf. in four ranges, resistance from .5 ohm-500 meg. in four ranges. Comparator ratio from .05-20 (400 to 1). D.c. polarizing voltage 0-500 v.

Heath: Model IB-2A, $69.95. Measures resistance from .1 ohm-10 meg., capacitance from 100 μμf.-100 μf., inductance from .1 mhy.-100 hy., dissipation factor .002-1, storage factor ("Q") .1-1000. Built-in 1000 cps generator and provision for input from external generator.

Paco: Model C-20, $23.95. Capacitance 10 μμf.-2000 μf. in four ranges, resistance .5 ohm-200 meg., capacitor leakage test at 500 v. Ratio tests from .05-1 and 20-1 on capacitors, inductors, and resistors; power factor range from 0-60% at .1 μf.-2000 μf.

Q Meter

Heath: Model QM-1, $54.95. Frequency: 150 kc.-18 mc. in four bands. Inductance: 1 μhy.-10 mhy. "Q"; 250 full scale x 1 or x 2. Capacitance: actual, 40 μμf.-450 μμf.; effective, 40 μμf.-400 μμf.

RF Power Meter

Heath: Model PM-2, $12.95. Frequency range 100 kc.-250 mc., sensitivity .3 v. r.m.s. at antenna input terminals for full-scale deflection.

SWR and Z Bridge

Allied: Model Z-52 (83Y253), $6.95. Measures SWR from 1-150 mc. and indicates impedance on frequencies up to 100 mc. Can be used with 20-400 ohm lines.

Vibrator Tester

Emc: Model 906, $17.05. Checks 6- and 12-volt vibrators with external power supply. Six sockets. The Model 905-6A, a combination of the 906 and the 905 battery eliminator, costs $44.90.

Voltage Calibrators

Allied: Model 83Y136, $12.95. .01-100 v. square-wave output.

Eico: Model 495, $12.95. Semi-square (clipped sine-wave) output waveshape at line frequency. 0-.1, 0-1, 0-10, 0-100 p-p v. Dial reading accuracy ± 5%.

Heath: Model VC-3, $14.95. Fixed p-p outputs of .03, .1, .3, 1, 3, 30, and 100 volts at approx. 1 kc.

Manufacturers of Kit Test Equipment

Allied Radio Corp.
100 N. Western Avenue
Chicago 80, Illinois

Arkay International, Inc.
88-06 Van Wyck Expressway
Jamaica, N.Y.

Conar Instruments Div.,
National Radio Institute
3939 Wisconsin Avenue
Washington 16, D.C.

Eico Electronic Instrument Co., Inc.
3300 Northern Blvd.
Long Island City 1, N.Y.

Electro Products Laboratories, Inc.
4501 North Ravenswood Avenue
Chicago 40, Illinois

EMC
Electronic Measurements Corp.
625 Broadway
New York 12, N.Y.

Feiler Engineering & Mfg. Co.
8026 N. Monticello Avenue
Skokie, Illinois

Heath Company
Benton Harbor, Michigan

Lafayette Radio Electronics Corp.
111 Jericho Turnpike
Syosset, L.I., N.Y.

Olson Electronics, Inc.
260 S. Forge Street
Akron 8, Ohio

Paco Electronics Co., Inc.
70-31 84th Street
Glendale, L.I., N.Y.

Precise Electronics & Development Corp.
76 E. Second Street
Mineola, L.I., N.Y.

Grommes: Precision Electronics, Inc.
9101 King Street
Franklin Park, Ill.

RCA: Radio Corporation of America
415 S. Fifth Street
Harrison, New Jersey

Radio Shack Corp.
730 Commonwealth Avenue
Boston 17, Mass.

DELCO RADIO SERVICE HINT

Output loading of transistorized sets for GM cars presents a problem. Solve it with a special jog.

WHEN BENCH work is needed on *Delco* auto radios used in *General Motors* cars from 1957 on, an unwary technician may get into trouble that can be avoided. Many of the sets have transistor output stages with transformers mounted on the speaker frames rather than on the chassis. There is a tendency to connect the removed radio, without a transformer, directly to a bench speaker.

Note what happens when this is done: With 1 ampere of current through it, the speaker begins to get warm. Collector voltage in the output stage increases to twice its normal value, erroneously indicating a defective transistor. Soon the speaker becomes quite hot and sound becomes distorted—as does the voice coil!

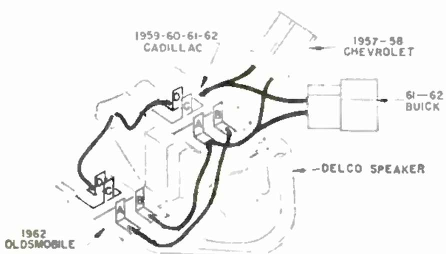


Fig. 1. Speaker-transformer test panel.

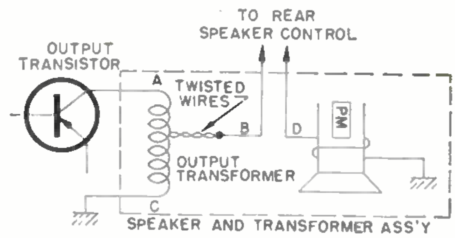


Fig. 2. Schematic for the test assembly.

The obvious solution is to use an external output transformer. Specifically, a universal speaker-transformer assembly that is convenient to use with all models involved is suggested. Layout for the test board is shown in Fig. 1. The speaker (*Delco* part 6109) has a mounting bracket for the output transformer (part 7274608). The set of four connectors to match all radios involved (used in *Buick*, *Cadillac*, *Chevrolet*, and *Oldsmobile* vehicles) is part 1221768. Schematic for the test board is shown in broken lines in Fig. 2, with connections identified for the four-prong *Cadillac* connector. Note that, although the *Oldsmobile* connector is physically similar to the one for *Cadillac*, connections *A* and *B* are interchanged. To avoid improper operation, make sure the correct connector is used when a set is taken from one of these two autos.

The assembly can be made a permanent part of the auto-radio test bench. Building a separate panel, however, as shown in Fig. 1, provides the advantage of being able to take it out to the car for substitution checks without removing the radio. ▲

"If that fellow ever calls back, tell him I am dead!"

Distortion in Speakers

(*Continued from page 29*)

large cone excursions without mechanical suspension bind. The maintenance of a uniform magnetic field over the voice-coil path therefore becomes especially important. This is achieved by overhanging the voice-coil past the gap, that is, making the voice-coil longer than the gap, so that the same number of turns remain in the gap when the voice-coil moves axially.

Fig. 6 plots distortion *vs* frequency (valid reporting of speaker distortion must make reference to the frequency range covered) for an acoustic suspension system in which a one-inch-long voice-coil rides in a half-inch-long gap, providing a uniform magnetic field for half-inch voice-coil excursions. The scope trace shown inset in Fig. 6 is of 30-cycle speaker output at 20-watts input.

At any one moment half of the voice-coil turns of the above speaker are inactive, ignoring fringing of the field, which is to say that half of the amplifier output signal voltage falls across a dead part of the coil. To throw away half of the voltage is to throw away three-quarters of the power, since power varies as the square of the voltage. It is this voice-coil overhang factor that is primarily responsible for the relatively low electroacoustic efficiency of the *AR*, *KLH*, and *Heath* acoustic suspension speakers, rather than design elements inherent in the acoustic suspension system itself. Efficiency is sacrificed for low distortion.

Rigorous Distortion Measurements

The bass distortion levels in loudspeakers are generally high enough so that the non-rigorous methods described at the beginning of this article are adequate to reveal orders of magnitude of distortion, particularly in comparing different speakers. Careful measurement under controlled anechoic conditions are nevertheless a necessity when accuracy is desired. Such methods were used to secure the data of Fig. 6. The same test conditions described in connection with frequency response measurements in an earlier article ("Loudspeaker Testing and Measurement" by Edgar Villchur, October 1961 issue of this magazine) are needed here. There must be control of the solid angle into which the speaker radiates, there must be a free-field environment down to the lowest frequency of interest, and there must be a minimum distance between the speaker and the microphone.

Decreasing the solid angle into which the speaker faces increases fundamental bass output and decreases distortion. Testing a speaker in an uncontrolled acoustical environment brings into play standing-wave effects, which can seriously affect the ratio between fundamental and harmonic sound intensities at the microphone position. EIA standards call for a microphone-speaker distance at least three times the diameter of the speaker's radiating area to avoid the effect of the near field, which does not accurately represent the actual radiated sound energy.

Treble Distortion

The measurement of high-frequency distortion requires more sensitive techniques than those employed for the bass range. A very small distortion percentage in the treble may, because of the high orders of harmonics involved (fifth, seventh, etc.), have a pronounced subjective effect, while a greater distortion percentage of lower harmonic orders may be inaudible.

Standard intermodulation measuring equipment does not help because the frequency separation of standard test signals is so great as to apply the lower frequency test signal to the woofer and the higher frequency test signal to the tweeter system. By definition there can be no intermodulation between two signals reproduced through separate distorting devices, and the excellent reading we will get with such test frequencies will merely reflect the benefits, in reduced intermodulation distortion, of assigning parts of the spectrum to different speakers.

High-frequency speaker distortion can be tested by the CCIF intermodulation measuring technique, in which the spectrum is swept with closely spaced test frequencies. Both test signals are then

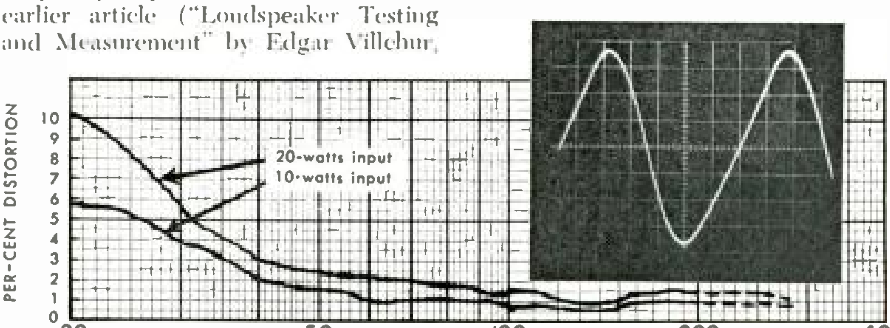


Fig. 6. Harmonic distortion for an acoustic-suspension system. The scope trace shows a 30-cps acoustic-output waveform at a power input of 20 watts.

reproduced simultaneously by the same speaker unit.

Another and very effective method is to sweep the speaker system with a sine-wave signal generator and to listen. Even though results can be affected by an uncontrolled listening environment, the ear is surprisingly accurate and effective in this application. It is usually able to detect high-frequency distortion before aberrations are visible on a scope trace. The ear will probably provide better information than an analyzer that reads total harmonic distortion, since the latter cannot, as can the ear, differentiate between orders of harmonic distortion.

A word of warning must be inserted at this point: High-frequency speakers are not designed to take too much single-frequency input electrical power. A 10-watt input at 10,000 cps does not create a very loud sound in a living room, even if there is no speaker attenuation, but it may damage or destroy a tweeter. It is a good idea to limit continuous input power to about 5 watts.

The analyzer used for the displays of Figs. 5A and 5D sweeps the speaker over its frequency range and displays the different harmonic orders of distortion. It is the workhorse instrument for checking treble distortion at *Acoustic Research*, combined with sweep-ear tests. Fig. 5A is a photograph of this instrument's screen display of the output of a rejected distorting *AR* tweeter. The blip at 1000 cycles is the input and the fundamental; each blip to the right represents successive harmonic distortion products. Second-harmonic distortion is most apparent, but does not represent the real trouble. Distortion products in the 10-kc. region are intolerably high for these harmonic orders. The waveform of the 1000-cycle output (Fig. 5B) appears perfect and would not lead one to suspect trouble, but a tone-burst picture with 10.6-kc. input (Fig. 5C) clearly shows unacceptable ringing.

The corresponding set of photos in Figs. 5D, 5E, and 5F represents the performance of an acceptable *AR* tweeter. There is still measurable second-harmonic distortion, but nothing significant above that. The high-frequency tone burst picture is clear of ringing. The sine-wave display, on the other hand, looks no different from that of the defective tweeter and the measured total r.m.s. harmonic distortion—about 2 per-cent at this, the most critical frequency range—was not very much lower than that of the distorting tweeter.

It is of interest that the distortion of the rejected tweeter, whose objective display required so much sophisticated test equipment, would be clearly audible to anyone on a sweep listening test.

The design battle against all types of loudspeaker distortion is by no means ended. It has proceeded slowly, probably because it is too often ignored. ▲

Product Test Report

(*Continued from page* 20)

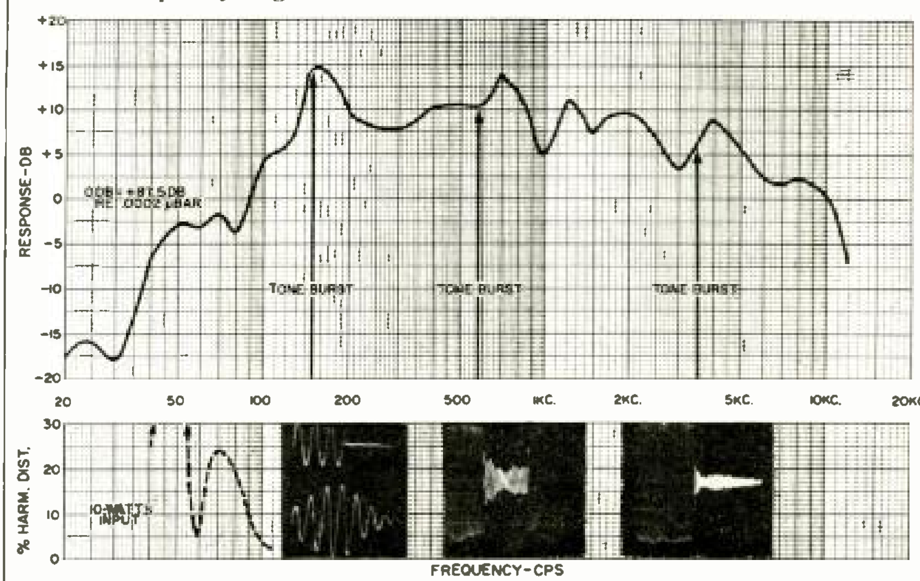
bass boost without excessive distortion.

At the high end, the output dropped sharply above 10,000 cps. The sparkle and crispness which are associated with good response in the 10- to 20-kc. region are not present in this speaker's sound. It is not likely that their absence would be noticed by most listeners, however, except by direct comparison with a wide-range speaker system. The restricted high-frequency response of this speaker is actually a desirable feature, helping to balance the absence of deep lows.

The tone-burst photos show that the system has rather good transient response at 3.5 kc. (This is typical of its performance throughout most of the high-frequency range.) At 580 cps, there is some loss of transient response, with ringing continuing steadily between bursts. At the worst point, the response peak at 150 cps, the transient performance is completely degraded. On this photo we show the electrical-input waveform as well as the acoustic-output waveform from the speaker, revealing its slow build-up and decay.

We tested two units for this report. The first one became damaged, possibly due to excessive electrical input during our tests. The second unit, covered in this report, did not suffer any ill effects. Incidentally, the 10-watt input used in our response measurements below 1000 cps (1 watt above 1000 cps) produced a sound pressure level considerably in excess of what would be utilized in the home.

At its low price, the *Cabinart* "Mark I" is a really good value. It sounds altogether pleasing and listenable, especially with some bass boost and will offend no one's ears. Of course, it is not the equal of systems selling for several times as much. It would not be reasonable to expect it to be. It should be especially well suited for use as an extension speaker or in a budget-priced music system. It is doubtful if there is any other speaker system at or below its price which can do any better than the "Mark I." ▲



STRETCH THAT WIRE!

By HOWARD S. PYLE, W7OE

DO YOU ever get tired of the sag which occurs in the ordinary soft-drawn copper wire which so many hams use for antennas? Not only does it look bad but as it sags it stretches and your carefully measured length increases by as much as several feet, upsetting your resonance calculations.

Would you like to keep it taut and up where it belongs? You can. Before erection, wrap one end of your antenna wire around the front bumper of your car, pass the opposite end around the base of a convenient utility pole and back slowly away to pick up the slack. Keep going slowly and carefully for a few feet and your soft-drawn wire will become "hard-drawn" and as straight as a length of rigid pipe.

Just be sure that your wire is a few feet longer than the finished length you want, to allow for wrapping around the bumper and the pole. Use caution not to pull so fast or so far that you break the wire. This is a sure-fire method for stretching and hardening any wire size from No. 4 to No. 14, bare or insulated.

The same scheme works equally well with copper tubing. What starts out as soft-drawn (most of it is sold that way) becomes a rigid, hard-to-bend pipe which won't stretch in service after giving it the bumper treatment — ideal, incidentally, for up-a-pole verticals. ▲

CB JAMBOREE

THE 10-99 Citizens Radio Club, Inc. is sponsoring its Second Annual CB Jamboree on Sunday, June 3rd at Irvine Park in Orange County, California.

Facilities at the park include boating, biking, horseback riding, golf, and picnic grounds. Approximately 25 manufacturers and distributors of CB gear and accessories will be represented at the event.

Additional information from Picnic Committee, 10-99 CB Radio Club, 2314 Newport Blvd., Costa Mesa, Calif. ▲

Automated Testing

(*Continued from page* 53)

scopes and other products—including new "Robotesters." The equipment thus keeps an eye on its own production!

When a deviant reading is obtained in some set-ups, accessory tapes are activated through an auxiliary unit. Punched to handle various "reject" situations, these alternate tapes determine what action to take. In effect, they make decisions.

One manufacturer of digital computers has successfully experimented with another elaboration. Normally that old-fashioned entity, the human being, analyzes equipment on which automatic testing is to be used and carefully determines the test program for it. The latter is then perforated on a tape. In this case, the raw schematic of the equipment is fed to a computer which, after speedy analysis, comes up with an exhaustive test program for the tape. Going further, when errors in production show up, they can be recorded in detail by an accessory "Roboprinter" and then subjected to a computer for analysis and interpretation Thus the corrective measures can be determined automatically

With the development of such "closed-loop" systems, one begins to anticipate a rather complete technical "society," consisting of non-human elements, in which the equipment virtually ignores the existence of man. Consider the capable technician in the left-hand segment of the photo at the beginning of this article. He is recording valuable "reject" data as it comes up and then keying the "Robotester" to "proceed" with subsequent tests. Now he too can be cut out of the picture.

Impact on Manpower

Some inroads possible in the future may seem too visionary for present speculation. It is nevertheless obvious that the role of automation will be far more extensive than was once recognized and that the role of man will be correspondingly affected. For the sake of an orderly future, it is certainly important to think ahead. Since automatic testing is a relatively new inroad, its impact can provide useful clues.

Whatever the long-term effects may be, serious employment dislocation has not been an immediate result. The presently gradual rate at which automatic-testing is being accepted facilitates adjustment. When it is adopted because of a shortage of trained personnel, there is no manpower to replace.

In other cases, a manufacturer is enabled to handle an increased work load, undertake new products or activities, or expand output following product improvement and cost reduction. His manpower needs may increase rather than dwindle. It is not a new notion that automation, which eliminates old jobs, also creates new ones.

Where personnel requirements have been cut, the process has been sufficient-

ly slow to be offset by normal attrition: those who retire or quit their jobs are simply not replaced. In these cases and others where the number employed remains stable, there is nevertheless a change in the character of the manpower pool. Unskilled jobs tend to be eliminated first. New positions need specialists. Re-training becomes important. Technicians should take note of this. Constant rounding-out and upgrading of knowledge is the best safeguard against the future.

Early reactions of those directly involved are interesting. Some production-line workers welcome automatic testing because they find more errors with greater speed, and a capable operator likes to have a good efficiency record. Quality-control and test engineers or technicians may be pleased for similar reasons. Good troubleshooters often appreciate being relieved of the part of their work that they consider drudgery. But these are cases where the equipment assists rather than replaces the man. The broader dilemma is illustrated by the sometimes contradictory viewpoint of labor. Although automatic facilities are often welcomed for taking the tedium out of existing jobs, as noted, they are sometimes resisted for fear they will throw men out of work.

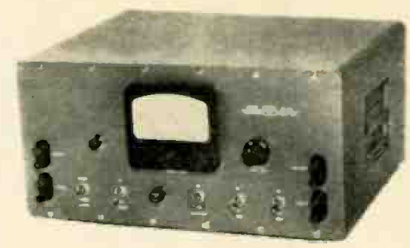
Because there are so many variables, a precise projection of the future course is not easy. It is technically feasible that we will have plants, in a few years, with completely automatic self-testing and troubleshooting control ranging from selection and assembly of basic components to the finished product. In addition Lawrence H. Lippert, automation engineer at *Lavoie*, points out that automatic testing is taking over some "gray matter" jobs now performed by skilled workers, not just tedious chores. Where does manpower fit into such situations?

It may be hopeful to look upon the growth of automation as constituting a second industrial revolution. In the early stages of the first revolution, which also saw the replacement of manual labor by machinery, we know that displaced workers often stoned factories and machines, out of fear for their own security. Yet, in the long run, the benefits included more jobs, better jobs, shorter hours, and richer lives. Automation, which ultimately exists and grows because it is a superior servant to man, may be leading in the same direction. But, as the road to the goal was often painful in the first industrial revolution, it may also be difficult in the second.

To prevent or minimize the painful aspects, intelligent planning for change must replace accidental, random growth. We must all re-educate ourselves, for orderly development is a common burden. Those in industry, labor, the government, and education have much work ahead. Although answers do not come quickly or easily, constant awareness of the mutual, long-range objectives is essential. Also essential is continuing alertness to changes and new effects as they occur, and a sincere effort to understand them. ▲

Calbest MX 625 SG

Fisher 300

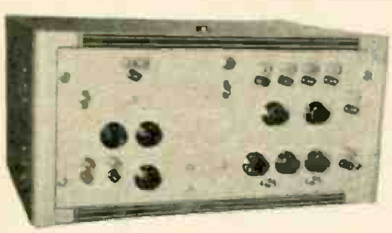


Crosby SG-292

Signal Generators for FM Multiplex

By LEONARD FELDMAN

Why and when is this new test instrument necessary? What will it do? Here are the answers, a discussion of ancillary equipment that may be required, and explanations of how six models operate.



American Laboratories FMX-101

Scott 830

Boonton 219-A

MULTIPLEX receiving equipment, either FM-stereo adapters or complete FM-stereo receivers, is being offered to the public in constantly increasing quantity. At this writing, some 71 FM stations have "gone stereo" and as you read this, it can safely be said that *that* number has gone up. FCC spokesmen have predicted that some 200 to 300 stations will be broadcasting stereo programs by year-end. They have even gone so far as to say that in four or five years virtually all FM stations will be broadcasting stereo programs full or part time.

Just as the radio and TV industry engendered a large family of test instruments, so too has the budding multiplex-stereo industry encouraged the development and marketing of specialized test equipment known as multiplex generators or FM-stereo signal generators. Seven generators that range from about $500 to $1000, are now available.

Naturally, every *manufacturer* of multiplex adapters and FM-stereo receivers must equip his lab, production-line test positions, and service department with one or more multiplex signal generators. Many manufacturers, in fact, had to design and build their own generators in order to quickly "tool up" for adapter and receiver production last year. Some of these designs ended up as commercial products and will be discussed here.

The earlier, more expensive generators, such as the *Scott* Model 830 and the *Crosby* Model SG-292, were first sold to other manufacturers and laboratories so they could start production of multiplex receivers and adapters. Generators of recent vintage (and considerably lower price tags) incorporate features intended to make the instruments more attractive to service organizations and technicians.

Why They're Necessary

Certainly an investment of $500 in a single piece of test equipment requires serious consideration by the owner of a one-man service business. There is little question in anyone's mind that FM stereo is going to be big business. Literally millions of FM receivers and tuners now in the hands of the public are prospects for conversion to stereo by the addition of a multiplex adapter. Furthermore, the new receivers with built-in multiplex circuitry are just beginning to make a dent in the home-entertainment market.

In terms of conversion and installation work, an FM-multiplex signal generator is certainly *not* required equipment. On the whole, adapters are made to connect to existing equipment easily and quickly; initial touch-up alignment can be accomplished by listening to on-the-air stereo transmissions. But before long, hi-fi service technicians will be confronted with regular service calls. While much adapter repair work will require the normal routine of all electronic servicing (the usual troubles such as defective tubes and components, opens, shorts, etc.), there can and will

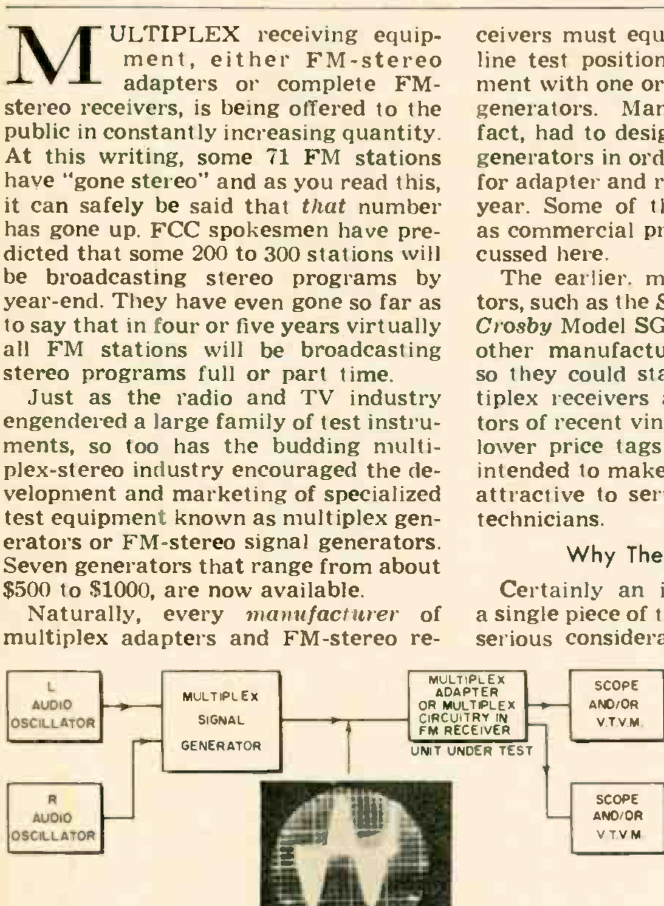


Fig. 1. Set-up for multiplex-circuitry checks only. Inset shows waveform of left-only output of multiplex generator.

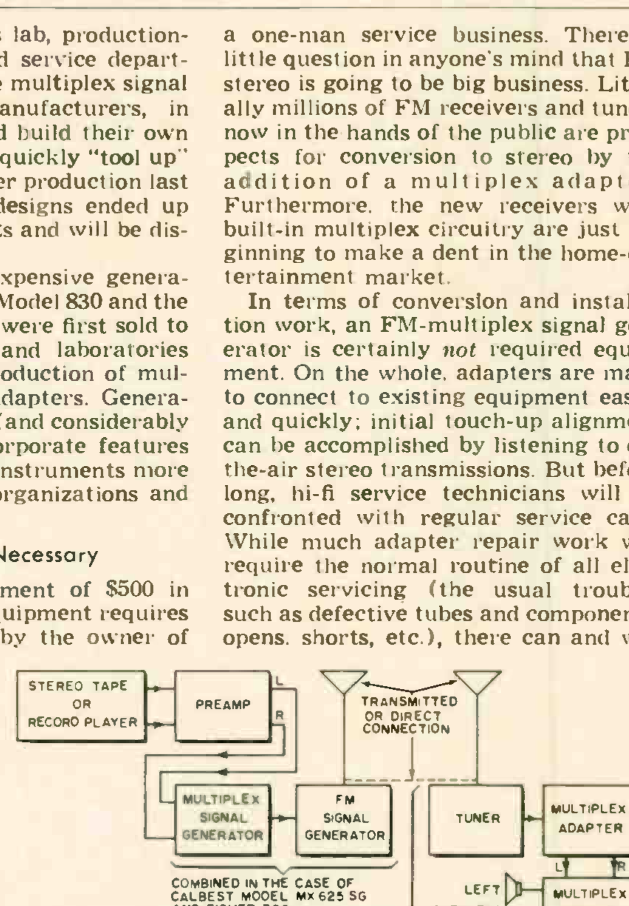


Fig. 2. Set-up for evaluating performance of complete receiving system. The a.f. oscillators may be used for L and R inputs.

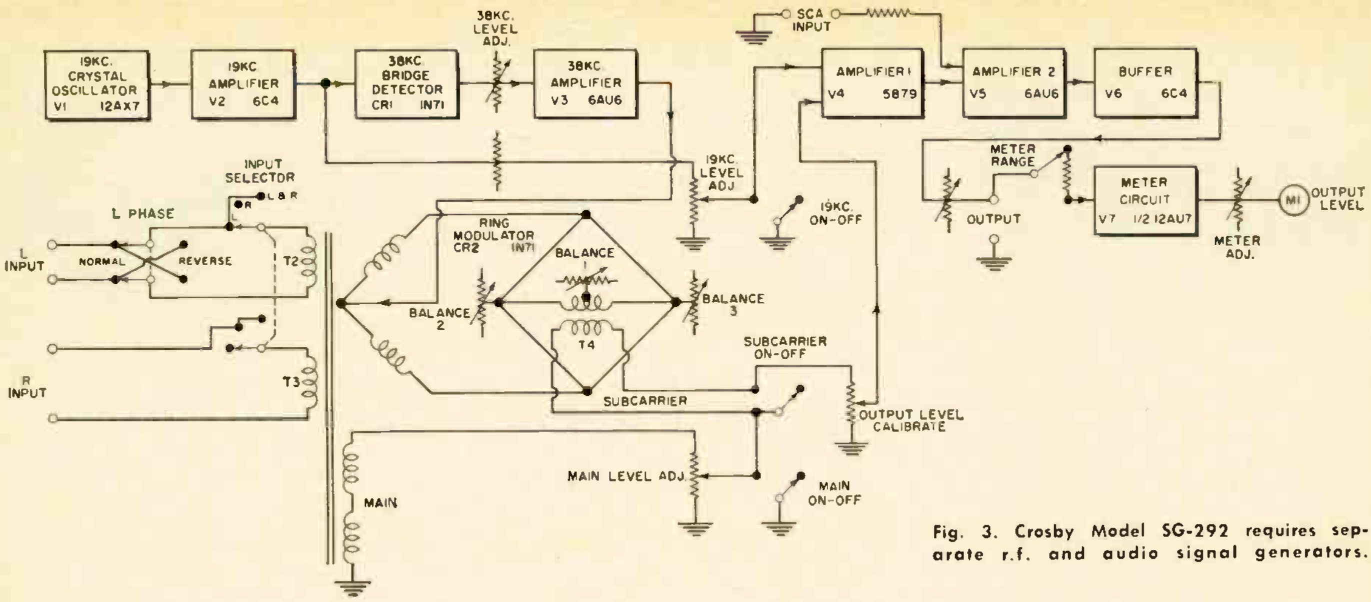


Fig. 3. Crosby Model SG-292 requires separate r.f. and audio signal generators.

be more subtle troubles (lack of separation, beats, whistles, motorboating, and the like), peculiar to the FM-stereo composite signal that can only be duplicated and analyzed by injecting a ready-made stereo signal from one of the generators to be discussed here. The technician will have to judge, from his previous volume of hi-fi work and his anticipated work with FM-stereo equipment, whether or not an investment in a stereo signal generator will make sense now or a little later.

In general, FM-stereo signal generators are of two different designs. The first, which is essentially an audio generator, is shown in a typical set-up in Fig. 1. Here, it is used to produce just the composite signal as it would appear at the multiplex jack of a receiver or tuner. Such a generator is useful for checking *only* the multiplex circuitry of a receiver or an adapter and *excludes* r.f. checks. As a result, relationships between tuner performance and the multiplex circuitry performance are not taken into account. The test set-up of Fig. 1 is used by manufacturers producing so-called "universal" adapters that are designed for use with different tuners and receivers. Such a signal generator would be adequate for the technician who has eliminated the tuner or receiver as a possible source of trouble by substituting another adapter in place of the one that is inoperative.

Fig. 2 illustrates a more elaborate test set-up in which r.f. transmission and reception have been simulated. Here, the composite stereo signal frequency-modulates the signal produced by an r.f. generator. The r.f. output is then sent to the receiver (either directly to the antenna terminals or by means of low-level radiation over a distance of several feet). The receiver output goes to the multiplex adapter circuitry and then to a meter or a scope if needed. This test set-up enables you to perform a complete system check in which all elements from antenna through audio are included.

Of the seven generators, three (*Calbest* Model MX 625 SG, *Hickock* 725, and *Fisher* Model 300) have a built-in r.f. generator. These multiplex generators may be used in the test set-up of Fig. 1 or Fig. 2 *without* a separate FM r.f. generator. The *Crosby* SG-292, *Boonton* 219-A, *Scott* 830, and *American Laboratories* FMX-101 signal generators can only be used in the test set-up of Fig. 1 and *require* a *separate high-quality* FM r.f. signal generator in order to be used in the test set-up of Fig. 2. The most important requirement of an FM r.f. generator is that it be capable of being externally modulated by frequencies from 50 cps to 100 kc. with little or no attenuation or phase shift at any of those frequencies. An FM r.f. generator that does not meet these specifications will cause reduced channel separation measurements that might be erroneously attributed to the adapter or receiver but which, in fact, would be caused by the signal generator.

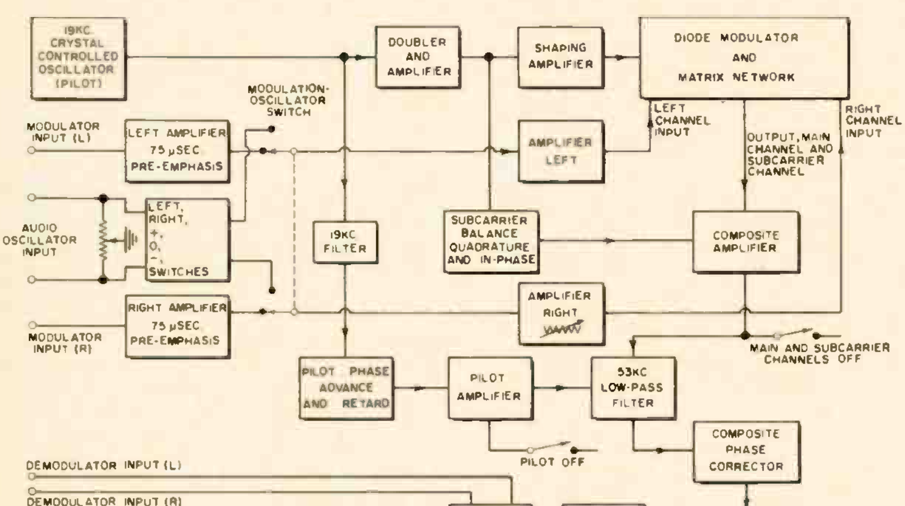


Fig. 4. Scott Model 830. The output of a separate oscillator that has a 59-75 kc. range may be added to the test-signal output to simulate a 10% SCA modulation level.

Crosby Model SG-292

Fig. 3 is a block diagram of the *Crosby* Model SG-292 multiplex signal generator. Left and right audio signals are applied to the "L Input" and "R Input." With the "L Phase" switch in "Normal" and the "Input Selector" switch set to "L & R," the "L Input" and the "R Input" signals are added to produce an "L + R" signal (mono) and an L − R signal (difference). The difference signal, along with the internally generated 38-kc. signal, is used to modulate "Ring Modulator CR_2," the output of which consists of the desired carrier-suppressed, double-sideband information corresponding to L − R audio. An internally generated 19-kc.

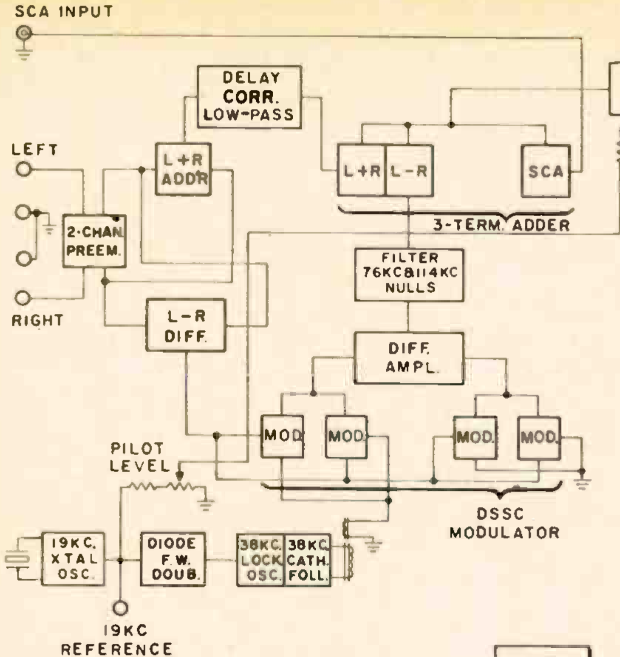


Fig. 5. Boonton Model 219-A includes a 1-kc. audio generator. Panel meter indicates level of parts of composite signal.

signal is produced by "19-kc. Crystal Oscillator V_1," amplified by "19-kc. Amplifier V_2" and doubled by "38-kc. Bridge Detector CR_1." The 38-kc. signal is amplified by "38-kc. Amplifier V_3" and applied to "Ring Modulator CR_2." The 19-kc. pilot carrier, main-channel audio, and subcarrier sideband components are added at "Amplifier 1 V_4." The entire composite signal is then fed to "Amplifier 2 V_5" which is also used as an adder for the "SCA Input" (background-music channel). The composite signal is coupled to "Buffer V_6" and then to a front-panel output connector through an output-level control. The signal at the output is monitored by means of a fairly critically damped meter circuit.

Scott Model 830

The block diagram of Fig. 4 shows the *Scott* Model 830 multiplex signal generator. One output of the "19-kc. Crystal-Controlled Oscillator" is used as the pilot carrier; the other output is doubled in frequency by the "Doubler and Amplifier" to produce the 38-kc. subcarrier which is then amplified by the "Shaping Amplifier." The "Shaping Amplifier" output drives the "Diode Modulator and Matrix Network" which consists of two diode bridges. These bridges are also driven by the "Left Channel Input" and "Right Channel Input" signals. The composite output is a signal made up of the L + R subcarrier and the sidebands of L − R with virtually no 38-kc. subcarrier present. Sideband harmonics are eliminated by the "53-kc. Low-Pass Filter" following the "Composite Amplifier."

The pilot carrier signal which origi-

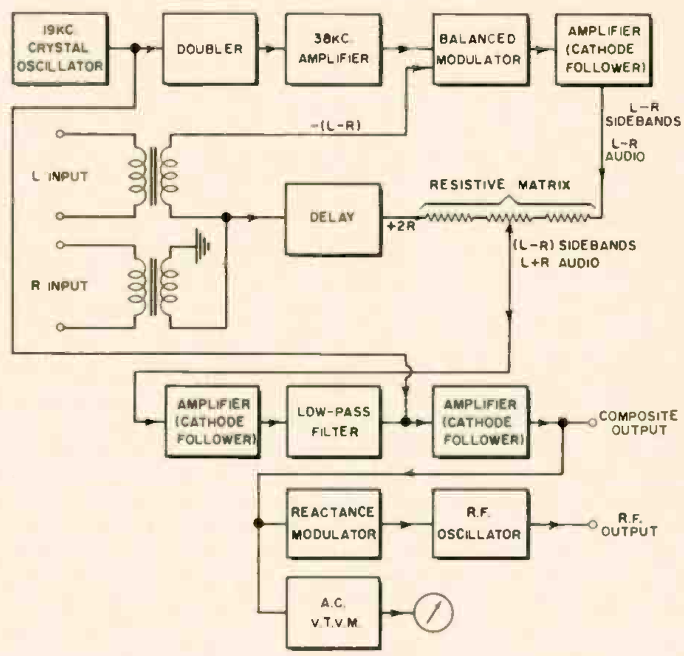


Fig. 6. The Calbest Electronics Model MX 625 SG includes an r.f. signal generator with an 88-90 mc. range. Output level is from 1000 to 5000 microvolts. Output of "L input" and "R input" transformers is applied as the audio modulation of "Balanced Modulator" circuit section.

The Hickock Model 725 FM multiplex signal generator was introduced too late to be included in the block diagram discussions. A photograph of the unit was not available either. However, its specifications are included below.

Manufacturer	Model	Price	R.F. Signal	Pre-emphasis	Composite Output Level	R.F. Output Level	Output Level Meter	Pilot Carrier	SCA Input	Audio Oscillator	Circuit Approach	Required Ancillary Equip.
American Laboratories 340 Ridge Street Newark 4, New Jersey	FMX-101	$595	FM signal generator required	75 μsec. in or out	0–5 r.m.s. v.	—	no	crystal-controlled variable	yes	external	time division and matrix	scope, v.t.v.m., FM signal generator, level meter
Boonton Radio Corp. 50 Intervale Road Boonton, New Jersey	219-A	$750	FM signal generator required	75 μsec. in or out	0–7.5 p-p v.	—	yes	crystal-controlled variable	yes	1 kc. plus external	matrix	scope, v.t.v.m., FM signal generator
Calbest Electronics 4801 Exposition Blvd. Los Angeles 16, Calif.	MX 625 SG	$495	included (88-90 mc.)	—	0–1 r.m.s. v.	1–5 mv.	yes	crystal-controlled fixed	yes	external	partial matrix	scope, v.t.v.m.
Crosby Teletronics Corp. 135 Eileen Way Syosset, N.Y.	SG-292	$750	FM signal generator required	—	0–10 r.m.s. v.	—	yes	crystal-controlled variable	yes	external	matrix	scope, v.t.v.m., FM signal generator
Fisher Radio Corp. 21-21 44th Drive Long Island City 4, N.Y.	300	$495	included (100 mc.)	75 μsec. in or out	0–6 p-p v.	100 mv.	yes	crystal-controlled variable	yes	1 kc., 8 kc. plus external	time division	scope, v.t.v.m.
Hickock Electrical Instrument Co. 10514 Dupont Avenue Cleveland 8, Ohio	725	$400	included (92-104 mc.)	—	0–4 r.m.s. v.	.002–1 mv.	no	crystal-controlled fixed	built-in	400 kc., 1200 kc., plus external	—	scope, v.t.v.m., level meter
Scott, H. H., Inc. Instrument Division 111 Powdermill Road Maynard, Mass.	830	$900 (less in quantity)	FM signal generator required	75 μsec. in or out	0–5 r.m.s. v.	—	no	crystal-controlled variable	no	external	time division	scope, v.t.v.m., FM signal generator, level meter

Table 1. The primary specifications and prices of the seven currently available FM-multiplex signal generators.

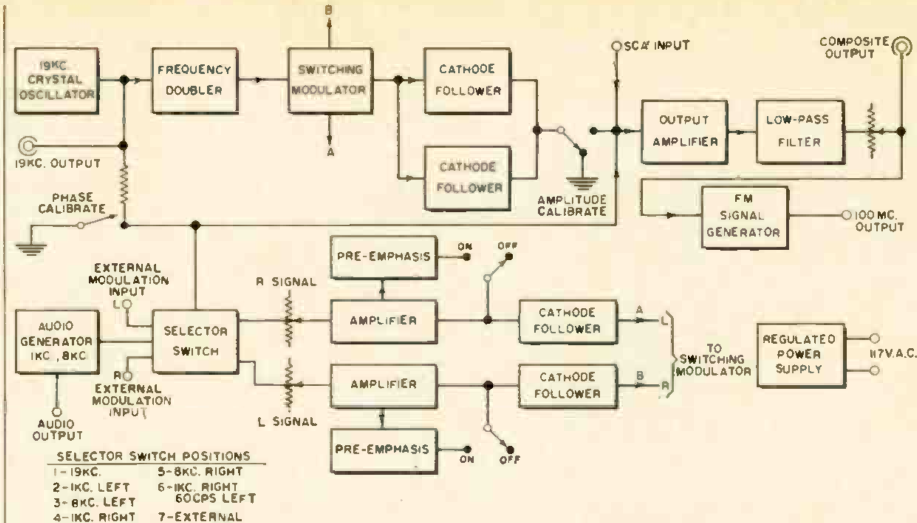


Fig. 7. Fisher Model 300. Self-contained, it does not require external audio or r.f. generators. Panel meter indicates peak-to-peak voltage of composite output signal.

nated at the "19-kc. Crystal-Controlled Oscillator" is phase-corrected and filtered, then added to the composite signal at the "53-kc. Low-Pass Filter" input. In addition to program inputs from tape or disc recordings, the Model 830 has provisions for audio oscillator inputs and can be set up for the following signal conditions: ± L, R = 0; ± R, L = 0; L = −R; R = −L; and L = R = 0.

To facilitate the use of ancillary instruments, two cathode-follower stages are provided for connecting an oscilloscope and a v.t.v.m.

Boonton Radio Model 219-A

Fig. 5 is a block diagram of *Boonton Radio* Type 219-A multiplex signal generator. A difference signal, derived from the special "L − R Diff." amplifier modulates the double-sideband, suppressed-carrier ("DSCC Modulator"). The L + R audio is passed through a time-delay network ("Delay Corr. Low-Pass") and added to the L − R sidebands and the SCA signal. The composite signal is formed by the 19-kc. pilot carrier from the "19-kc. Xtal Osc." Pilot level can be varied with a front-panel control. Other features include a two-scale meter for setting the levels of parts of the composite signal, and an internal 1-kc. audio-tone generator for "quick checking" of equipment. Of course, external audio oscillators or program sources may be connected too.

Calbest Model MX 625 SG

The next block diagram, Fig. 6, is of the *Calbest Electronics* Model MX 625 SG multiplex signal generator. Left- and right-channel signals are fed to it at the "L Input" and "R Input" terminals and are added by two transformers in such a way as to produce a − (L − R) voltage. This audio-frequency signal is fed to the "Balanced Modulator" where the 38-kc. component from the "38-kc. Amplifier" only is cancelled out. The output of this modulator, then, consists of L − R suppressed-carrier sidebands and L − R audio. These signals are added in a resistive matrix to + 2R to produce a signal consisting of L − R double-sideband components, plus L + R main-channel audio. This composite signal (still less the pilot carrier) is amplified by the "Amplifier (Cathode Follower)," fed through "Low-Pass Filter" to remove all frequencies outside the desired 53-kc. bandwidth, and is then combined with the 19-kc. signal from the "19-kc. Crystal Oscillator." The "19-kc. Crystal Oscillator" also supplies a pilot-carrier.

Besides being available at the "Composite Output" terminals (for direct connection to multiplex adapters or the multiplex circuitry of complete receivers), the composite signal is also applied internally to the r.f. signal generator

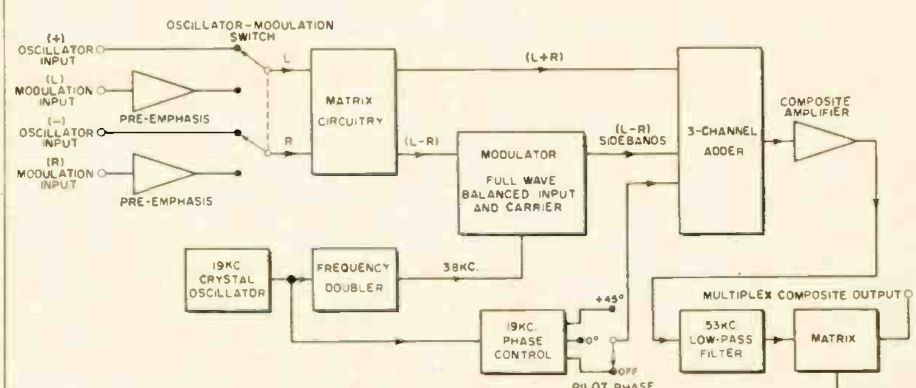


Fig. 8. American Labs. Model FMX-101. Difference audio signal is sampled at 38 kc. by full-wave, diode-bridge modulator that suppresses the carrier and the audio inputs.

section where a locally generated signal between 88 and 90 mc. is frequency-modulated by the "Reactance Modulator." The r.f. output signal is available at a level of between 1000 and 5000 μv.

Fisher Model 300

The *Fisher* Model 300 multiplex signal generator, shown in block-diagram form in Fig. 7, also includes an FM r.f. signal generator tuned to about 100 mc. so that a separate FM signal generator is not required for complete system checks. A selector switch chooses combinations of internally generated 1- or 8-kc. tones for left and right inputs. The left and right signals (after suitable amplification) are applied at "A" and "B" on the "Switching Modulator," which also receives a 38-kc. signal from the "Frequency Doubler."

The composite output of the "Switching Modulator" goes to a pair of cathode followers, after which the 19-kc. pilot carrier signal and the "SCA Input" signal (if desired) are added. The total signal is then amplified, filtered, and fed to the "Composite Output" terminals and to the internal FM signal generator section. Provision for accurate adjustment of phase and amplitude of the 19-kc. pilot carrier is made on the front panel and is facilitated by the self-contained output-level meter.

American Labs. FMX-101

The final multiplex generator to be discussed is the FMX-101, manufactured by *American Laboratories* and shown in the block diagram of Fig. 8. Left- and right-input signals (either from an audio generator or from program sources) are applied to the "Matrix Circuitry" which produces L + R and L − R signals. The sum (L + R) signal is fed to the "3-Channel Adder" while the difference signal is sampled at a 38-kc. rate in a full-wave diode-bridge modulator ("Modulator"). This modulator suppresses both the carrier and the L − R audio and develops a "(L − R) Sidebands" only output signal. The modulator output, the 19-kc. pilot carrier, and the main-channel (L+R) audio are applied to the "3-Channel Adder" to form the composite signal which is then amplified by the "Composite Amplifier" and fed through the "53-kc. Low-Pass Filter."

Front-panel selector switches permit the choice of inputs to either channel, "on-off" switching of individual channels, and selection of 0° or +45° pilot-signal phase shift. SCA input terminals are also provided.

All the features of these generators are summarized in Table 1. The design and performance optimization of multiplex receiving equipment cannot be reasonably accomplished without one of these generators. Admittedly, technicians called upon to service the new FM multiplex receivers and adapters may well conclude that such equipment belongs only in laboratories or manufacturing plants. On the other hand, the use of one of these signal generators may well cut down "trial and error" time to a point where the instrument will pay for itself in very short order. ▲

NEW PAY-TV TO BE TESTED

System does not require a coin box or unscrambler at TV set. Central office equipment bills subscriber on basis of time special speaker is on.

Tape-programmed equipment at right determines who of up to 10,000 subscribers have their company-supplied speaker turned on.

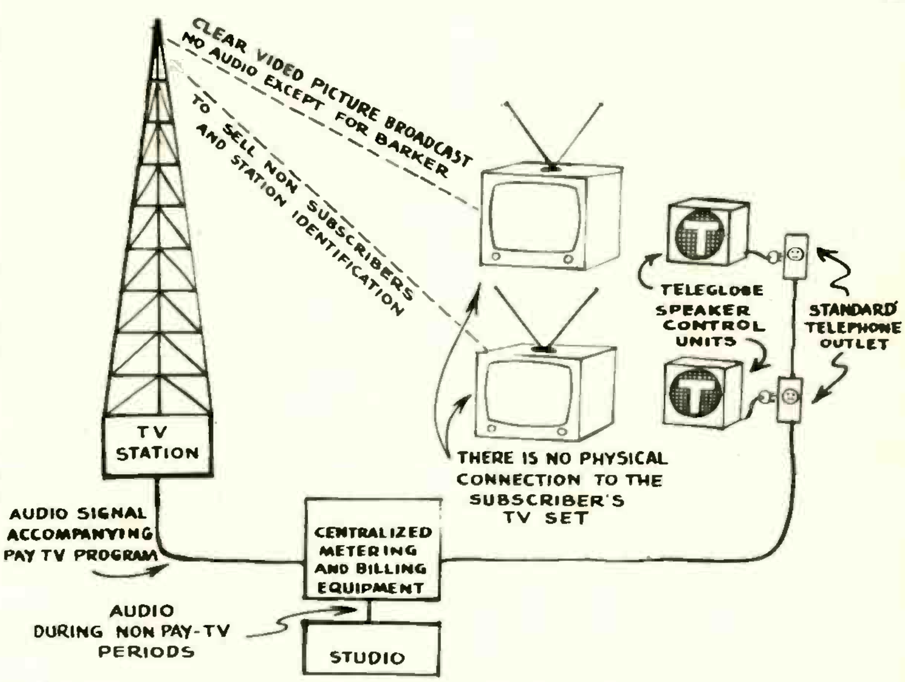
An application was filed recently with the FCC for authorization to conduct a three-year test of the *Teleglobe Pay-TV* system over the facilities of KTVR channel 2, Denver, Colo. by the *Gotham Broadcasting Corp.* and the *Macfadden-Bartell Corp.*

The new pay-TV system differs fundamentally from other pay-TV systems in that it does not require a coin box or a decoder in the subscriber's home. The system's concept is based on centralized billing of subscribers from a central office where electronic equipment is utilized to determine which subscribers are watching a program and for how long. The system separates the video signal from the audio signal at the broadcasting station. The former is transmitted unscrambled; the latter is sent from the TV station over leased telephone lines to a subscriber's home. A flick of a switch on a *Teleglobe*-installed speaker, which is plugged into an outlet on the telephone line, turns on the audio from the central office. A record is made at the central office of the time the speaker is on. A monthly billing based on information gathered during listening hours is then made by the company.

A tape-programmed line monitor, which is said by the firm to be able to determine which of up to 10,000 subscribers' speakers is turned on is the heart of the system. Further details of the device's operation were not disclosed. The results of line checks are transferred to punched cards.

The firm feels that this pay-TV system will be financially successful because it introduces a teasing element that can induce the non-paying viewer to tune in the pay-TV program. This is accomplished by making announcements of coming shows and films by transmitting audio on the TV channel during the non-pay-TV periods. During the day, popular and classical music is broadcast by the TV station in addition to the announcements of coming programs.

In addition, spokesmen for the firm feel that the absence of sound when it is possible to view a program is the greatest incentive to get a viewer to become a subscriber. ▲



Teleglobe system proposed for test on channel 2 in Denver. Decoder might be installed between antenna and TV set if sports promoters want additional "safety" feature.

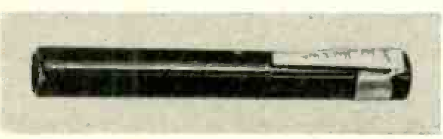
The Dosimeter

(Continued from page 43)

between the center wire and the outside shell. Some of the chargers on the market use a 180-volt battery. Others use flashlight batteries and a transistorized high-voltage supply to generate up to 180 volts. Line-voltage-operated chargers are not used since in any emergency power would be one of the first utilities to be lost.

A charger consists of a source of voltage, a potentiometer, and a small lamp. A recessed set of outer and inner contacts, in what is called the charging well, contact the outer shell and the charging contact of the dosimeter as it is pressed into the well. Care must be taken not to exert excessive pressure which might damage the diaphragm. While the dosimeter is being charged, one looks through the eyepiece and reads the illuminated scale. The potentiometer is then adjusted until the quartz fiber appears directly over the zero mark on the scale. Fig. 2 shows how different charging voltages on a 200-mr. dosimeter affect the position of the fiber and the corresponding scale reading.

The reduction in voltage may not always be caused by radiation. It is possible for the chamber in which the electroscope is located to develop a leak.



Typical dosimeter looks like ball-point pen. It can be clipped in your pocket.

If moisture enters the chamber, the charge can leak off.

Dosimeters are accurate to ±10% and generally hold their charge to within 1% for 24 hours. Small amounts of natural radiation and some electrical leakage within the chamber, however, will cause a reading to appear after a few days.

The only maintenance required is cleaning the eyepiece with a lens tissue and keeping the charging contact free from dirt and dust. Never use a sharp instrument to clean the contact or the diaphragm will be damaged. Cleaning solutions other than plain water should also be avoided since some of them might affect the diaphragm material.

The dosimeter is intended to measure the total radiation dose to which an individual has been exposed and does not indicate the strength of the radiation source. It is not sensitive to *alpha* or *beta* radiation. Whenever dangerous radiation is suspected, a dosimeter will warn its wearer of overexposure. However, more complex instruments are required to measure the intensity of the radiation and to locate its source. ▲

In-Home TV Service

(*Continued from page* 49)

gle instrument he has with him will be used for such checks and he must familiarize himself with the readings he can expect. Both a.c. and d.c. voltages will be checked. The test points and the range of variation of voltages that will be found at these points are listed for reference in Table 1. Test-point locations are indicated in the block diagram of Fig. 6. These standards were based on a random sampling of receivers in good operating condition.

The v.o.m. used had a d.c. sensitivity of 20,000 ohms/volt and an a.c. sensitivity of 5000 ohms/volt. The a.c. readings were taken with the "output" function, in which an internal capacitor blocks any d.c. component that may be present at the test point. This will be standard practice in in-home checks. Note that a.c. readings are generally much lower on the v.o.m. than on the v.t.v.m. More than one factor is involved, but the fact that the former instrument has no peak-to-peak calibration accounts for much of this difference. There is much better correspondence between d.c. readings on both meters, although the effects of differences in circuit loading can be seen at some points.

As to a.c. voltages on the v.t.v.m., these were read on the peak-to-peak scales of an instrument designed for such use. If the technician's instrument does not have these scales, it may at first seem that the figures in the table may simply be converted, by multiplying each by .35, to obtain the corresponding values that would be read on the r.m.s. scales. That is not necessarily true however. A true peak-to-peak v.t.v.m. not only has appropriate a.c. rectifiers, it is also designed so that the time constant in the rectifier filter will respond to maximum signal amplitude even on relatively narrow pulses. While it is true that v.t.v.m.'s in general tend to incorporate peak-to-peak rectifiers, the time constant may not be calculated to take the true measure of a short-term pulse.

Nor can the v.t.v.m. user, in the latter case, use the a.c. v.o.m. figures as a standard for comparison, since the two systems are quite different in the a.c. function. Fortunately, there are alternatives. The specifications, schematic, and service manual for the meter will yield information on the rectifier system and its characteristics, possibly with some notes on peak-to-peak readings. This data can be taken into account along with the frequency and waveshape of the signals known to exist normally at a.c. test points. Finally, the range of normal readings can be determined in a practical way on any specific instrument, without complicated analysis, by using it to sample appropriate test points on a number of normally operating receivers.

The voltages at test points *1, 2, 3, 4,* and *8* are developed in the receiver when it is processing incoming signal. For these checks, then, the TV set must be tuned to an active channel. Readings at other points will be in the same range whether a transmission is being picked up or not.

The presence of a voltage in the proper range at a test point simply indicates the presence of a signal and that the stage is passing signal. However, the quality of the signal (correct waveshape, frequency) cannot be determined with nothing more than a meter. This important limitation is the reason that the fully equipped bench in the service shop is still necessary. Nevertheless, a good technician who acquires experience with the home-call technique will be able to complete a wide range of repairs in the customer's living room quickly, reliably, and economically. ▲

EXTENDING LIFE of the VOLUME CONTROL

By **DONALD W. MOFFAT**

Simple hint to overcome noisy tuner controls.

WHEN using a tuner in a hi-fi system, the usual procedure is to turn its volume control all the way up and then use the control on the amplifier or preamplifier to set volume. In that way, noise and hum picked up in the inter-unit wiring will be kept to a minimum.

If the tuner "on-off" switch is mounted on the volume control, it is then necessary to rotate the control through its entire range when turning the tuner on, and again when turning it off. After being subject to maximum wear in this manner, the control is quite likely to become noisy.

To extend the life of the control, simply interchange all wires on the two end tabs of the control, leaving the center tab alone. This makes the control work backwards and maximum volume is at the full counterclockwise end, just after the switch clicks on. If you should ever want to use the control at less than maximum volume, it still works as before, except in the opposite direction.

Another difference you might notice if using the control at less than maximum setting is that the change in setting is not as effective in all portions of the control. Some tuners are carefully designed so that volume control sensitivity, as far as the ear is concerned, is the same throughout the entire control. After reversing the wiring, you might notice that a small change in volume control setting has more effect on the volume at one end than at the other end, depending on how it is used in the circuit.

If the control is tapped for a tone compensation network, reversing the connections might change the frequency response, although there should be no difference if the tap is at or near the middle. Many circuits use taps to keep the frequency response independent of setting, and since you will be keeping the control at maximum, the location of the tap is unimportant. ▲

Mac's Electronics Service

(*Continued from page* 42)

that he had to be very careful in working on the power supply. With all that capacity in there, if the bleeder resistor happened to open, current stored in the capacitors could kill him in an instant, even though the machine had been disconnected from the line for hours or even days. This seemed to impress the electrician, and he left.

"I had my ohmmeter that puts 400 volts across the probes on the higher resistance ranges; and I found that when I put this voltage across the bleeder resistor, the measured resistance went down to around 1000 ohms, even when re-checked with a low-voltage, low-ohms range; but shaking the power supply around would cause this value to increase erratically. Application of high voltage would bring the resistance reading back down.

"Next I disconnected the filter capacitors one at a time and found they were okay. By unsoldering leads and testing resistances, I traced the low resistance right down to the filament connections of the 866 sockets. The rectifier filaments were heated with a separate transformer, and when the filament winding of this transformer was entirely unsoldered from the sockets, a low resistance was indicated between the winding and the chassis.

" 'Well, there you are,' I told the man smugly. 'Quite obviously you have a short circuit in the filament winding. A new filament transformer will solve your trouble.'

"He said he was glad we'd found the trouble so quickly and started looking around the transformer for a part number. 'I wonder what these two wires are for,' he said as he pointed at a couple of wires coming out of holes beneath the filament transformer. They went to separate and otherwise vacant connections on a two-lug tie-point mounted near the rectifier sockets. One wire came out the same hole as the filament winding leads, and the other emerged with the 117-volt primary leads.

"About this time I noticed a little black smudge around the mounting foot of the tie-point, and I began to get that chilly feeling up and down the spine I always have when I suspect I have goofed. A closer look revealed a blackened, charred area on the Bakelite tie-point between the mounting foot and the nearest connecting lug, the same lug to which the wire coming from the filament lead hole was connected. I picked up the diagonal cutters and snipped that lead loose. The short circuit between the filament winding and the chassis was gone!"

"That wire was really an unused center-tap of the filament winding, I suppose," Mac said with a sympathetic grin. "Since it carried the full high voltage, it was arcing to the grounded foot of the tie-point and had established a carbonized path. Wrestling the chassis around would knock a little carbon dust loose and change the resistance of the path until the application of high voltage from your ohmmeter probes brought it back down. What was the other wire, a tap on the primary to compensate for low line voltage?

"That's right, and the annoying part is the manufacturer's diagram showed neither tap. Quite possibly the original filament transformer had no taps, but when the factory ran out of that type and started using a new tapped model, no one bothered to change the diagram. Anyway, it was stupid to tie that hot wire to a low-voltage tie-point. I cut both leads loose and taped the ends carefully. The power supply was connected to the amplifier and the machine turned on. About thirty seconds later the automatic delay relay closed and threw on the high voltage. The fuse didn't go. The technician thought the waveform as shown on the monitoring scope wasn't quite perfect; so we changed the 866's that had taken quite a beating during the fuse-blowing, and that restored perfect operation.

"I figure I learned three important things from that one service call," Barney said slowly. "First, don't trust manufacturer's diagrams. Second, remember the shop electrician may resent your being called in; so try to mollify him if you can. Third, most important of all, be doggone sure of your diagnosis before you give it. I should have asked myself about those two wires instead of letting the technician ask me."

"You will next time," Mac said with a comforting smile. ▲

DIAL-CORD SUBSTITUTE

By ELWOOD C. THOMPSON

THE following dial-cord substitution can be a cure-all in instances where you have a "tough" problem of this type. After several dial cords had been installed in a communications receiver, we came up with the idea of using stainless steel surgical wire as a substitute. It won't contract or expand under heat and it won't corrode or rust. It can also be soldered very easily.

The best types for a sturdy application are preferably size "O" with size "OO" running a close second. It comes in small 16-foot spools and may be obtained from your local medical-supply house. ▲

"We're forced to modify our corporate name . . . due to the speed laws."

Technicians in Industry
(*Continued from page* 51)

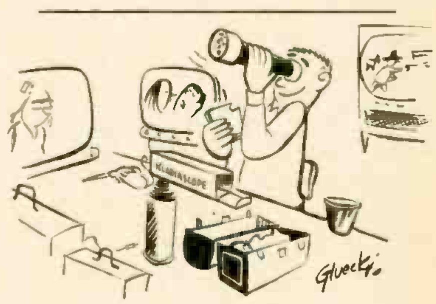
state that present hardware has just about scratched the surface of potential applications. Certainly we can see that there is still a growing demand for present products. And there are many tasks we have yet to accomplish with products still on the drawing boards. Thus it is probably safe to assume that laboratories and plants will expand. These expanded facilities mean new jobs. And these openings are tending toward a higher proportion of skilled personnel. In many cases this skill can be equated more with technical know-how (a technician) than with machine operation.

The dynamic nature of basic technology suggests another reason for enthusiasm by technicians who want to get ahead. As new technologies, new components, new ways of harnessing the electron come on the scene, every professional and technical employee must be given an opportunity to familiarize himself with the subject. Even today, most companies in the data processing industry have established educational programs within their plants and laboratories. These programs are specifically designed so that employees can be exposed to a broad spectrum of subjects that might help with their work.

In the Endicott laboratory, for instance, a formal technician training program held in spring and fall semesters includes a math review, mechanics, electrical circuits, transistor circuits, physics, magnetics, measuring instruments, and computer design and technology.

This orientation toward education reflects the need for employees with greater knowledge. This may mean that a specific technician can become an increasingly skilled technician capable of working in a number of different areas, therefore worth more to his company.

This all adds up to a promising future for electronic technicians in the computer business, with recognition and income reflecting their increased importance. Technicians, like guards and tackles, probably get less than their share of praise, but engineers can no more do the job alone than the backfield can play football without a line. Because of the complexity of the technologies with which we deal, the engineer-technician team is indispensable. For both halves of the team, the future promises to be alive with challenge and opportunity. ▲



ELECTRONIC CROSSWORDS

By BRUCE BALK

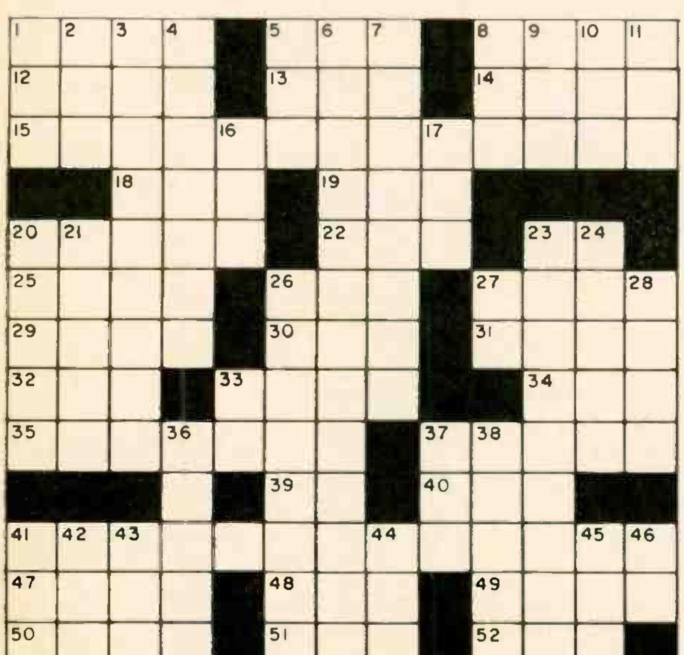
(*Answer on page* 106)

ACROSS

1. Absorbed.
5. Type of circuit employing a screen-grid tube (abbr.).
8. Communications satellite program.
12. Self-produced (comb. form).
13. Tear.
14. Units of conductance.
15. Apparent change in frequency due to motion of source or observer of sound.
18. See 5 Across.
19. A test instrument (abbr.).
20. Long-persistence screen.
22. Delay.
23. Short laugh.
25. Actuate a switch.
26. Allow.
27. Type of storage circuit.
29. Prisoners (slang).
30. State of water.
31. Lily.
32. Employ.
33. Obligation.
34. Presidential initials.
35. Combination of instruments used for servicing electrical equipment.
37. Energy per unit time.
39. A crystal cut.
40. Prefix meaning "oxygen when it replaces carbon."
41. Tuner.
47. Exploring cell.
48. Gold (Sp.).
49. Room used to test acoustical devices.
50. Lids.
51. An addition to a letter (abbr.).
52. One of the time belts (abbr).

DOWN

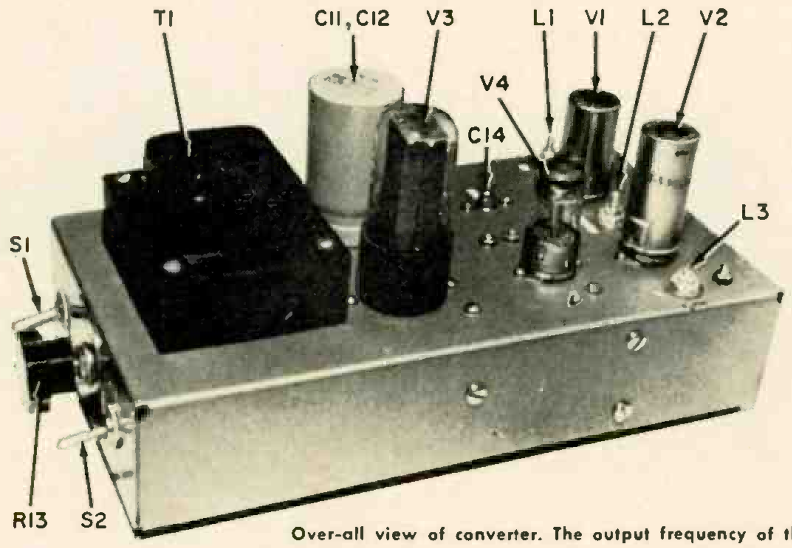
1. Branch agency of the FCC.
2. Fuss.
3. Coaxial cables.
4. Metal parts of some vacuum tubes.
5. Poetic for "before."
6. Drilling tools used on chassis.
7. Uses radio equipment.
8. Voltage (abbr.).
9. Technical degree (abbr.).
10. This (Latin).
11. East (German).
16. Actress Myrna.
17. Atmospheric condition.
20. Crystal which vibrates below 500 kc.
21. Eaten away.
23. Lengths of electromagnetic antennas.
24. Radio tube electrode.
26. Lowering of voltage in transmission.
27. Chemical element (abbr.).
28. Cell used as a light valve.
33. Chemical element (abbr.).
36. Excursions.
37. American author.
38. Element used to coat filaments and cathodes.
41. Inductor which allows direct current to pass and blocks certain frequencies (abbr.).
42. Wing-like part.
43. Angle at which a needle points to the earth's magnetic center.
44. Lettuce.
45. Consume.
46. Street (abbr.).



BAND-SCANNING 10-11 METER CONVERTER

Construction of circuit that automatically sweeps 10-m. ham and Citizens Radio bands. Permits monitoring of all channels by tuning through 1800 kc. in 15 seconds.

By J. C. FISCHESSER



Over-all view of converter. The output frequency of the unit shown is 6 mc.

ONE OF the most unprofitable pursuits in amateur radio is to sit for hours tuning a receiver back and forth across a dead band. This device—dubbed the "Band-Watcher" by the author—does this job for you automatically on ten meters—a band which is not open very often in the evening hours. It will also tune eleven meters, which is handy if you want to monitor all Citizens Band channels simultaneously in an area where these channels are only infrequently used.

The "Band-Watcher" is basically a ten-meter converter which tunes itself repeatedly across a band of frequencies. The only unique feature of the converter is the manual-automatic tuning circuit. This circuit, shown within the dashed area in the schematic diagram (Fig. 1), uses a variable capacity diode—the same type semiconductor used in the Mavar or parametric amplifiers. Those operating v.h.f. can readily adapt this automatic circuit to tunable converters which they may already have.

How It Works

Charge carriers (holes and electrons) normally exist at the junction of a diode. When a reverse-bias voltage is applied to the diode, these carriers are pulled away from the junction, thus creating a "depletion area." The size of this area varies according to the magnitude of the applied bias—the greater the bias, the larger the depletion area. The capacity of the diode varies inversely as the size of the depletion area; therefore, the capacity can be controlled by a variable voltage source.

The variable bias voltage in the "Band-Watcher" is obtained from both a manually operated pot in a voltage divider circuit and from an *RC* relaxation oscillator. The latter circuit develops a saw-tooth voltage which automatically shifts the capacity of the diode. Since the diode is in parallel with the tuned circuit of the local oscillator, any change in diode capacity causes a change in converter tuning.

Construction

The "Band-Watcher" as well as its self-contained power supply is built on a standard 9½" x 5" x 2" aluminum chassis. This size can be reduced substantially if a separate power supply is available. Power requirements are 250 volts at 40 ma. and 6.3 volts at 1 amp. The power transformer came out of the junk box and thus happened to be larger than necessary to provide these requirements.

Shielding for the converter stages was made out of scrap aluminum. Antenna and output receptacles are of the auto-radio type, which are inexpensive and adequate in this application.

Since the r.f., mixer, and i.f. coils are commercial units, no fabrication is involved. The links for the r.f. (L_1) and i.f. (L_2) coils were wound with #24 cotton-covered enamel wire, because that is what happened to be available. If you have wire reasonably close to these specifications, use it.

To make the oscillator coil (L_4), cut a 12-turn section from a *B & W* No. 3007 "Miniductor." A hot razor blade will cut through the insulating strips. Carefully unwind one turn at each end to serve as the connecting leads. Cut the fourth turn from one end at the top of the coil and unwind for a half turn in both directions; these wires serve as the other two connecting leads.

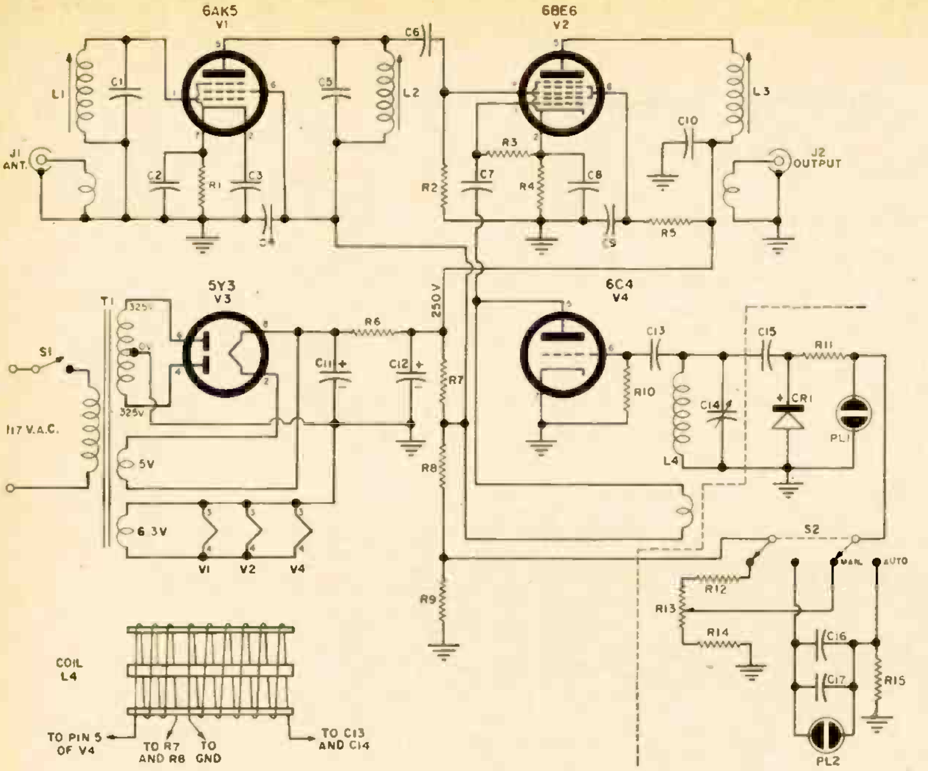
The two capacitors, C_{16} and C_{17}, in the *RC* relaxation oscillator should be good quality paper or oil-filled units. Electrolytics will not work properly.

The "Varicap" diode should be installed with the brown-band end (cathode) connecting to the junction of C_{15} and R_{11}. As with all semiconductors, care should be exercised in soldering the leads to avoid overheating the diode. The "Varicap" should not be mounted close to a 60-cycle a.c. field, since this will cause hum in the output of the converter. Incidentally, the neon lamp, PL_1, provides protection for the "Varicap" should the bias voltage become too high.

Adjustment

The "Band-Watcher" is designed to work into a receiver which is capable of tuning to 6 mc. This can be the regular station receiver or one of the popular surplus command receivers, such as the BC-454 or BC-455. Coax should be used between the output jack of the converter and the antenna terminals of the receiver.

As a starting point for alignment, all adjustments—r.f., mixer, and i.f. coils; oscillator variable capacitor; and manual tuning pot—should be centered. The manual-automatic switch, S_2, should be in the manual position. With a good antenna and a little luck, you may be



R_1—220 ohm, ½ w. res.
R_2—1 megohm, ½ w. res.
R_3—22,000 ohm, ½ w. res.
R_4—150 ohm, ½ w. res.
R_5, R_8—22,000 ohm, 1 w. res.
R_6, R_7—3600 ohm, 10/12 watt wirewound res.
R_9—27,000 ohm, 1 w. res.
R_{10}—47,000 ohm, ½ w. res.
R_{11}, R_{15}—10 megohm, ½ w. res.
R_{12}—2.7 megohm, ½ w. res.
R_{13}—2.5 megohm linear taper pot
R_{14}—150,000 ohm, ½ w. res.
C_1, C_5, C_7—47 μμf. mica or ceramic capacitor
C_2, C_3, C_4, C_8, C_9, C_{10}, C_{15}—.001 μf. ceramic capacitor
C_6, C_{13}—100 μμf. mica or ceramic capacitor
C_{11}, C_{12}—10/10 μf., 450 v. elec. capacitor
C_{14}—25 μμf. variable capacitor (Hammarlund APC-25 or equiv.)
C_{16}, C_{17}—1 μf., 200 v. paper or oil-filled capacitor (see text)
PL_1, PL_2—NE-2 neon lamp
L_1—Cambridge Thermionic LS3-30 (.45-.7 μhy.) with 4 t. link of #24 s.c.e. wire, closewound
L_2—Cambridge LS3-30 coil (.45-.7 μhy.)
L_3—Cambridge Thermionic LS3-5 (30-70 μhy.) with 15 t. #24 s.c.e. wire, jumble-wound as link
L_4—9 t. B & W "Miniductor" #3007 (see text and detail drawing at lower left above)
S_1—S.p.s.t. toggle switch
S_2—D.p.d.t. toggle switch
T_1—Power trans. 325-0-325 v. @ 40 ma.; 5 v. and 6.3 v. windings (see text)
CR_1—Variable capacity diode (Pacific Semiconductors "Varicap" V-15E, see text)
J_1, J_2—Shielded-lead jack (auto radio type)
V_1—6AK5 tube
V_2—6BE6 tube
V_3—5Y3 tube
V_4—6C4 tube

Fig. 1. "Band-Watcher" uses a variable-capacity semiconductor diode, driven by a saw-tooth signal, for automatic tuning of the band.

able to find the middle of the ten-meter band or the Citizens Band just by carefully tuning the oscillator capacitor, C_{14}, and listening for signals.

If not, use a strong signal in the center of the desired band for setting C_{14}. This signal can be obtained from a grid-dip oscillator, signal generator, or the station transmitter. Once the oscillator has been set to receive a signal in the middle of the band, the r.f., mixer, and i.f. coils may be peaked for maximum signal strength. This peaking is best accomplished with weak signals.

Operation

Once alignment is completed, the "Band-Watcher" is ready for automatic operation. When switch S_2 is thrown to the automatic position, signals will be heard briefly in succession as the unit tunes across the band. It takes 15 seconds to cover about 1800 kc. on the ten-meter band.

This scanning rate may be slowed down if desired by adding capacity in parallel with C_{16} and C_{17}. An additional 10 μf. will permit whole sentences to be heard as the "Band-Watcher" tunes across a station.

The manual tuning range is about 2500 kc. when centered on 28.85 mc. This means that the manual tuning rate is somewhat faster than it should be for easy tuning. Bandspread could be added by using a vernier dial for the pot, R_{13}; however, since the "Band-Watcher" is supposed to supplement rather than replace the regular station receiver, the additional cost was not considered justified.

For those who are interested in restricting the frequency swing of the unit to the width of the Citizens Band, the circuit shown in Fig. 2 is suggested.

Modifying Existing Equipment

Those who prefer to modify converters or receivers which they already have can use the same basic auto-tune circuit as the "Band-Watcher." Very little space is needed to add the variable capacity diode, ceramic disc capacitor,

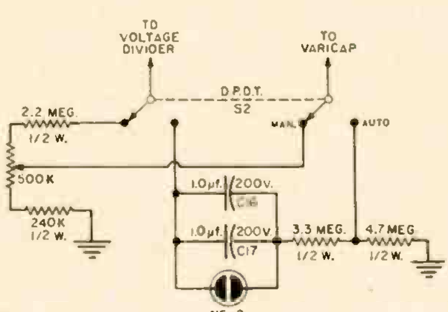


Fig. 2. Alternative bias circuit for restricting frequency swing to Citizens Band.

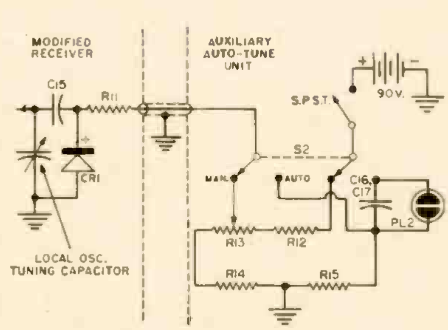


Fig. 3. Suggested circuit for modifying existing receivers. Component values for the "Band-Watcher" may be used as starting point. Some experimenting will probably be necessary, however, to achieve the desired frequency swing.

and resistor (CR_1, C_{15}, and R_{11}) to the receiver being modified; the rest of the circuit can be built into an auxiliary unit located any reasonable distance from the receiver. Shielded wire should be used between the receiver and auxiliary unit to prevent hum pickup. (See Fig. 3.)

You don't have to buy a "Varicap" if you already have a diffused-junction silicon diode lying around. Chances are it will work well in the circuit. Just be sure that the peak-inverse-voltage rating of the diode you use is at least 100 volts. *International Rectifier Corporation* makes a variable capacity diode called a "Semicap" which costs very little and could be used as a substitute. The "Semicap" works fine in the "Band-Watcher" with no other circuit changes; however, as might be expected, the frequency swing is somewhat different.

The frequency deviation of the auto-tune circuit will depend on the diode, the bias voltage, and the LC ratio of the local oscillator in the receiver. Therefore, you will probably have to experiment with resistance values other than those used in the "Band-Watcher" when adapting the circuit to existing equipment.

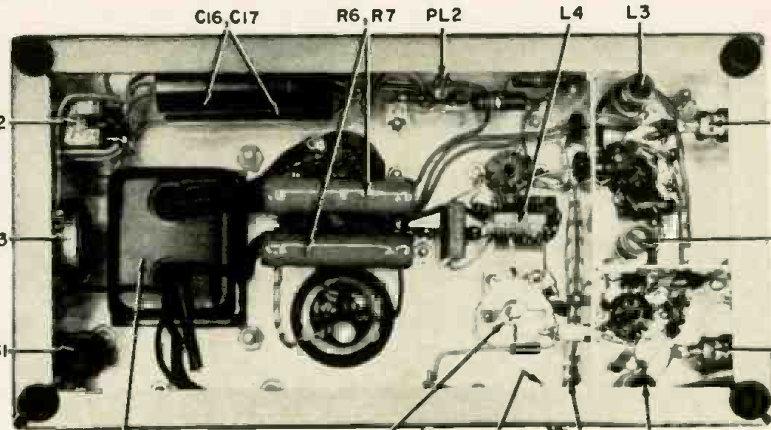
The back resistance of most silicon diodes is so high that practically no reverse current flows. Thus, a 90-volt battery is an ideal substitute for deriving bias voltage from the receiver power supply. The resistance of the voltage divider used for manual tuning should be high enough to limit the current flow to less than 1 ma.

Some local oscillator circuits may not work with the additional loading imposed by the variable capacity diode. This can be determined only by experiment. Remember, however, that the "Q" of the diode varies with the magnitude of the bias voltage—the higher the bias, the higher the "Q" and the less loading on the local oscillator. Therefore, bias should be applied when checking local oscillator operation with the diode in the circuit.

Don't forget that the diode adds capacity to the tuned circuit of the local oscillator and that the receiver dial will read higher in frequency than it should after the auto-tune modification has been applied. The receiver should be recalibrated with the manual-automatic switch in the manual position and with the manual tuning pot in the position which supplies maximum bias voltage to the diode. A little experimentation will show where the receiver dial should be set in order to cover the desired band of frequencies in the auto-tune mode.

Once in operation, the "Band-Watcher" can be a real boon to those who want to keep an ear on a quiet band and still get something done on workbench projects. More important, perhaps, the "Band-Watcher" offers a practical introduction to the variable capacity diode—a semiconductor which is certain to appear in many home-brew and commercial circuits in the future. ▲

Under-chassis view of the author's home-built automatic band-scanning converter.



New Telefunken U.H.F. TV Antenna

By **HANS F. KUTSCHBACH**

THE engineers of the German firm Telefunken have recently introduced a new type of television antenna for the home. This new u.h.f. antenna is shown in the photos below.

The use of such an antenna makes expensive rooftop antennas unnecessary in strong-signal u.h.f. areas. The antenna requires no installation. It is placed in the neighborhood of the TV set and connected into the back of the TV set.

The antenna is housed in a plastic cabinet which has been decorator-styled. It is also being offered wired with a light bulb to give the appearance of a table lamp.

The antenna itself actually consists of a broadband dipole and capacitively coupled reflector. The antenna is directional and provides reception with minimum ghosts. The antenna is merely rotated until the best picture is obtained. The plastic box housing the circuit measures 33 cm. x 16 cm. x 13 cm. (12½" x 6¼" x 5" approx).

The antenna is made by Telefunken GmbH, 76 Gottinger Chaussee, Hannover-Linden, West Germany. ▲

Calendar of Events

MAY 21-24
1962 Electronic Parts Distributors Show. Sponsored by EP&EM, EIA, PACE, WEMA, and ERA. Conrad Hilton Hotel, Chicago. Open only to qualified industry members.

MAY 22-24
National Microwave Theory & Techniques Symposium. Sponsored by PGMITT of IRE. Boulder Laboratories of National Bureau of Standards, Boulder, Colorado.

MAY 23-25
11th National Telemetering Conference. Sponsored by ISA, ARS, IAS, AIEE, IRE. Sheraton-Park Hotel, Washington, D.C.

MAY 24-26
Seventh Region Conference. Sponsored by the Seattle Section of IRE. "Space Communications." Seattle, Washington. Program information from IRE, 1 E. 79th St., New York 21, N.Y.

MAY 31-JUNE 7
International Television Conference. Sponsored by Electronics and Communications Section of the Institution of Electrical Engineers. Institution Bldg., Savoy Place, London W.C. 2, England.

JUNE 11-15
Technical Writers' Institute. Rensselaer Polytechnic Institute, Troy, N.Y. Information on course from Prof. Jay R. Gould, RPI, Troy, N.Y.

JUNE 12
Regional Technical Conference. Sponsored by Society of Plastic Engineers, Inc. Statler-Hilton Hotel, Boston. Conference to feature discussion of re-inforced plastics for space age and new electronic applications. Details from Robert D. Forger, 65 Prospect St., Stamford, Conn.

JUNE 20-22
Printed Circuit Symposium. Sponsored by California Circuits Assn. and Stanford University. Dinkelspiel Auditorium, Stanford U campus. Program details from California Circuits Assn., P.O. Box 1412, Palo Alto, California.

JUNE 24-28
Music Industry Trade Show. Sponsored by the National Association of Music Merchants. Hotel New Yorker, New York City.

JUNE 25-27
Sixth National Convention on Military Electronics. Sponsored by Professional Group on Military Electronics of IRE. Shoreham Hotel, Washington, D.C. Details from John J. Slattery F315, The Martin Co., Baltimore 3, Maryland.

JUNE 25-30
Symposium on Electromagnetic Theory and Antennas. Sponsored by the IRE. The Technical University of Denmark, Copenhagen. Information from IRE, 1 E. 79th St., New York 21, N.Y. ▲

UNSOLDERING ON PRINTED BOARDS

By **JAMES W. BURLINGAME**

An unusual technique which offers a number of advantages to those whose work involves PC boards.

EXPERIENCE teaches that no service repair is any better than the caliber of workmanship involved in the job, especially in the case of printed or etched circuit board work where problems arise to try the tempers of even the best electronics technicians. The system to be described here serves to relieve some of these problems while providing the speed and quality workmanship necessary for continued business success.

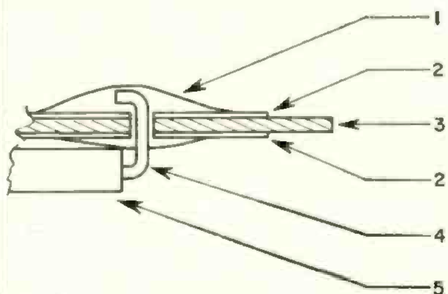


Fig. 1

Fig. 1 is a cross-sectional view of a typical solder joint. While the diagram shows a small diode or resistor it can serve for all such connections including switches, transformers, and filter capacitors. In this example, both sides of the board are etched, a further complicating factor. In Fig. 1, (1) is solder, (2) is etched wiring, (3) is Micarta or phenolic board, (4) is the component lead, and (5) is the component.

Fig. 2 shows the same connection prior to soldering. The joint was finished by applying heat and solder at points "H".

Unfortunately, solder will not flow away from a joint as easily as it flows into one, but by borrowing the wick principle used in the kerosene lamp, sufficient solder may be removed from any connection to make component removal relatively easy.

The equipment needed to apply this technique is shown in Fig. 3. (A) is a piece of copper braid such as is found in coaxial or audio cables; (B) is a stiff, non-metallic bristled brush like a paste brush; (C) is a soldering iron of sufficient wattage rating to handle the job; (D) is paste or liquid non-corrosive solder flux; and (E) is a solvent. Experience will add personal-preference items to this list.

The following is a step-by-step breakdown of the component removal process which can be used as is until the reader develops his own technique.

Step 1. Remove any protective or insulating coating on the connection to be unsoldered with the solvent and brush.

Step 2. Dip 1 to 1½ inches of braid into solder flux, preparing it to receive solder from the connection readily.

Step 3. Place the prepared end of the braid on the solder of the joint, as shown in Figs. 4A and 4B.

Step 4. Heat the braid (not the solder) as illustrated in Figs. 4A and 4B.

Step 5. Remove both iron and braid as soon as solder flows into the braid.

Step 6. Repeat Steps 1 through 5 after clipping off used braid end.

Step 7. Repeat above steps on reverse side of the board if necessary.

Step 8. Remove the end of wire projecting through board, as indicated in Fig. 4C with diagonal pliers because it is usually impossible to restore the lead to its original shape so as to allow it to pass through the hole in the board.

Step 9. Install the replacement component as near the original position as possible to maintain "lead dress," then solder.

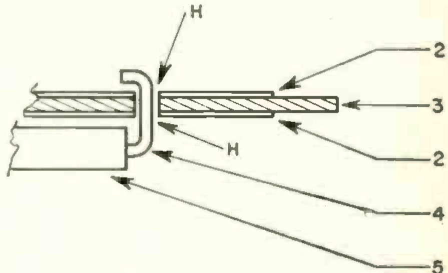


Fig. 2

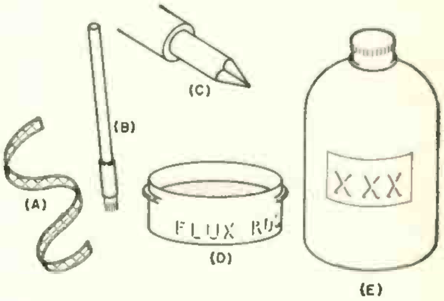
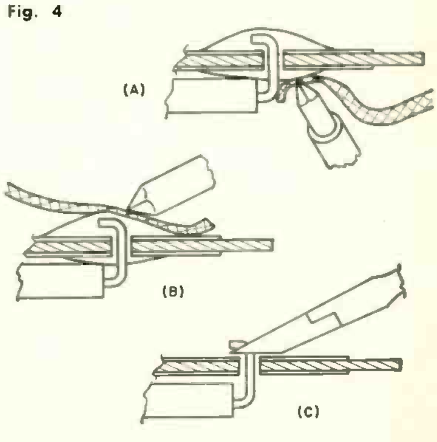


Fig. 3

Fig. 4



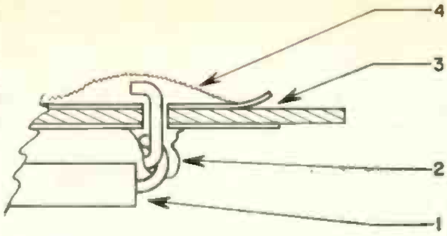


Fig. 5

Step 10. Clean work with the solvent and brush and recoat with insulating lacquer or cement.

It will be noted that this method allows removal of multi-connection units and semiconductors without special tools. However some precautions should be taken.

1. Avoid excessive mechanical stress while removing component. Sometimes heat must be applied to the component lead to free the last bit of solder.

2. Avoid excessive heat. While iron size is not overly important, *do not* use an iron of insufficient wattage rating. As much damage may be done by low temperature over extended periods of time as by excessive heat for short periods!

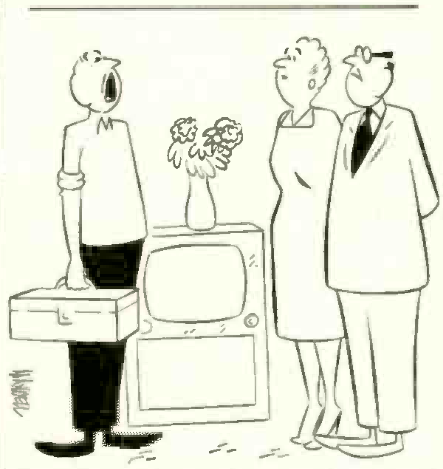
3. Know your chemicals! Discard any unknown or doubtful items to eliminate personnel and fire hazards.

4. Do not blow solder from a joint. Molten solder can damage eyes, become lodged in coils, etc.

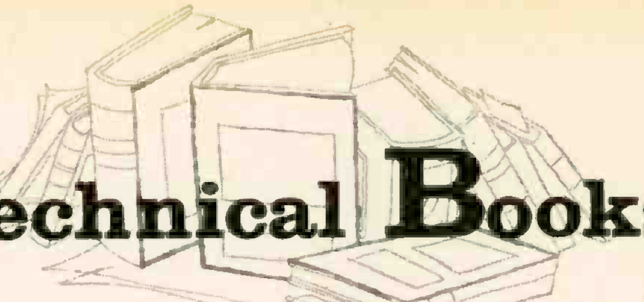
5. Do not rap board on bench to remove solder. In addition to the problems mentioned above, the board itself may be damaged in this way.

6. It is suggested that you *do not* solder a replacement component lead to an old component lead, as demonstrated in Fig. 5. This diagram shows (1) the new component, (2) a poorly executed solder joint due to oxidation of the old lead, (3) circuitry lifted where long periods of heat have been transmitted through the board and destroyed the bond between board and circuit, and (4) crystallized solder which makes the entire joint questionable, both mechanically and electrically.

A well-planned procedure, based on these suggestions, will insure topnotch workmanship, save time and tempers, and reduce printed-circuit replacement problems to a minimum. ▲



"You have a choice, of course—I can fix it cheaply or you can waste time telling me all its symptoms."



Technical Books

"THE RADIO AMATEUR'S HANDBOOK" compiled and published by *American Radio Relay League,* West Hartford, Conn. 590 pages plus data section, index, and catalogue section. Price $3.50. Soft cover.

This is the 39th edition of the radio amateur's "bible" and a good one. Users will find that the type face is more readable and that the use of non-glossy paper stock contributes to increased eye comfort and better reproduction of the many photographs and schematics used in conjunction with the text.

There are numerous revisions to keep the Handbook abreast of the latest developments in techniques and equipment. The tube characteristics and basing diagrams (always an important and highly useful segment of the book) have been enlarged and up-dated to reflect the newest developments.

As usual the new edition contains a wealth of construction data on transmitters, receivers, and ham shack accessories of all types. Special emphasis has been placed on transistorized equipment and mobile gear. There is something for every amateur in this new and up-dated version of a familiar ham shack standby.

* * *

"BENCH SERVICING MADE EASY" by Robert G. Middleton. Published by *Howard W. Sams & Co., Inc.,* Indianapolis. 156 pages. Price $2.95. Soft cover.

This book is for the professional technician who is interested in reducing unnecessary service time by eliminating random parts substitutions and getting down to the most-likely cause of the TV circuit fault.

The method, as developed by the author, can be used with any make or model TV receiver. It involves a preliminary analysis of the picture and sound symptoms, the troubleshooting of r.f. tuners, servicing the i.f. and video-detector sections, correcting video-amplifier and picture tube troubles, tracking down a.g.c. troubles, horizontal sync and vertical sweep faults, the sound and audio sections, intermittents, and low voltage power-supply troubles. The text is lavishly illustrated with scope patterns, partial schematics, and photos.

* * *

"PRACTICAL RADIO MATHEMATICS" by M. N. Beitman. Published by *Supreme Publications,* Highland Park, Ill. 30 pages. Price $.25. Soft cover.

This booklet is intended for the practical and practicing technician who encounters mathematics from time to time in the course of his service work but is too far removed from his high-school math days to remember the short-cuts which help to do the job quickly.

The book covers the mathematics of radio, the mathematics of resistors, coils and transformers, capacitors, inductance and inductive circuits, and decibels.

* * *

"TUBE REPLACEMENT GUIDE—1962 SUPPLEMENT" compiled and published by *Harry G. Cisin,* Amagansett, N.Y. 20 pages. Price $.50. Soft cover.

This brief supplement adds 1200 more direct tube substitutions to this publisher's master listing of such exchanges. Included are tubes for radio, TV, and audio applications, industrial and ruggedized tubes, military and communications tubes, U.S.-to-foreign and foreign-to-U.S. substitutes, as well as TV picture tubes which can serve as direct replacements.

* * *

"TROUBLESHOOTING WITH THE OSCILLOSCOPE" by Robert G. Middleton. Published by *Howard W. Sams & Co., Inc.,* Indianapolis. 153 pages. Price $2.50. Soft cover.

The number of oscilloscopes gathering dust on service benches is a disgrace to the industry since with a little study and practice, this most useful of all-around test instruments could be adding hours of valuable service time for the busy technician.

On the premise that most readers are not thoroughly familiar with their instruments, the author covers the basic features and operations of the scope. He discusses which probes to use, which test signals are needed, the types of waveforms to expect, and the proper interpretation of waveforms. The book also demonstrates how to determine the defective stage or section by waveform analysis and includes correct and incorrect waveforms to demonstrate the technique.

A text as basic and well-illustrated as this one is should make it easy for any technician to enlist the practical aid of a test instrument which could prove to be his most valuable ally.

* * *

"ALLIED ELECTRONICS DATA HANDBOOK" edited by Nelson M. Cooke. Published by *Allied Radio Corp.,* Chicago. 77 pages. Price $.35. Soft cover.

This is the third edition of a compact and practical handbook which carries a compilation of formulas and data most often needed in the field of radio and electronics. Rather than having to search through a shelf of engineering texts to find pertinent information, this handy manual comes up with the right data or formula in an instant.

The text is divided into five main sections covering fundamental mathematical data; decibel tables, attenuators, and matching pads; most-used radio and electronic formulas; engineering and servicing data; and log and trig tables. A master index makes the material even more accessible.

* * *

"COMMERCIAL SOUND INSTALLERS HANDBOOK" by Leo G. Sands. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 283 pages. Price $4.95. Soft cover.

With p.a. and background-music equipment installations burgeoning, more and more technicians are taking on the job of installing and servicing such systems in schools, factories, theatres, stadiums, trains and buses, etc. This condition has generated a need for a centralized source of information on commercial sound systems which is nicely met by this volume.

While written primarily for sound specialists and the technicians who handle such jobs, some of the sections will be of particular interest to those responsible for planning and authorizing such installations. Details are provided on suitable amplifiers, microphones, wire and tape recorders, record changers, loudspeakers and enclosures, distribution systems, intercoms, and control systems. Installation and maintainance of this equipment in various combinations is covered in detail.

* * *

"TUBE SUBSTITUTION GUIDEBOOK" compiled by H. A. Middleton. Published by *John F. Rider Publisher, Inc.*, New York. 64 pages. Price $.90. Soft cover.

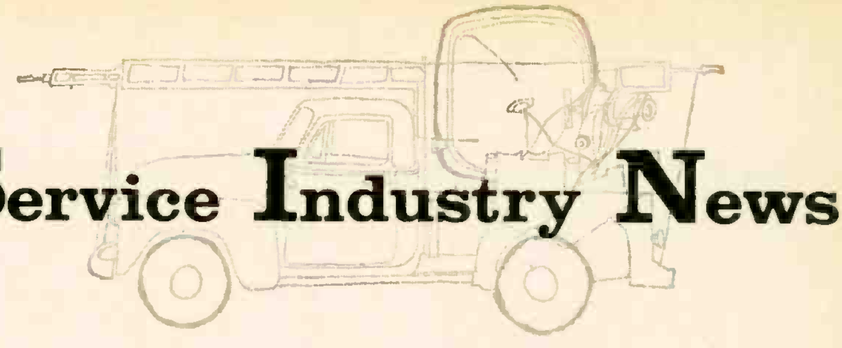
This 4" x 6" booklet packs a wealth of current data on direct tube substitutions into its modest size. Brought completely up-to-date, this pocket-sized manual covers receiving tube substitutions, picture tube substitutions, European-to-American and American-to-European substitutions, and suitable substitutions for ruggedized tubes.

* * *

"PRACTICAL TELEVISION SERVICING" by J. Richard Johnson. Published by *Holt, Rinehart and Winston, Inc.*, New York. 423 pages. Price $6.50. Revised edition.

When the first edition of the text appeared in 1949, owners of TV sets were still "inviting the neighbors" to view their new "toy." Great strides in equipment have been made in the decade plus since then and a revised and up-dated version of this basic manual was justified.

Like the earlier edition, the first ten chapters of this volume are devoted to a rigorous development of basic TV receiver operation by circuits or sections of the set. Installation of antennas and receivers, common faults, troubleshooting, wiring and repair techniques, case histories, alignment, and color television make up the balance. ▲



Service Industry News

NEVER outstanding in its ability to present a united front, the independent service industry, following a commendable period of relative harmony, is once more breaking out into factional strife. An announcement from the National Alliance of Television & Electronic Service Associations, relative to Electronic Service Dealers Association of Western Pennsylvania, reads as follows:

"After long study and deliberation, the Executive Council, with concurrence of the Internal Affairs Committee, has withdrawn recognition of ESDA-Western Pa. as an affiliate of NATESA and the territory is open to a new affiliate.

"Simultaneously, the Executive Council has offered, to most of those who in recent years were registered as NATESA associate members in the Pittsburgh area, individual membership and offers of help in formulating . . . a worthy group as the new affiliate from Pittsburgh."

Personalities and Issues

In a mailing to ESDA members, NATESA specifically referred to "repeated activities contrary to the welfare of NATESA . . . and many serious irregularities by Joseph S. Doyle." Doyle is ESDA Secretary. First response to this action from ESDA was a statement signed by the membership—specifically by all officers including Joseph Doyle and the Executive Board. It "goes on record as exposing Mr. Moch's plan to destroy each individual association that in any manner or method disagrees with him and his clique of 'brain-washed stooges.'

"ESDA was never charged, no evidence presented, nothing substantiated," the latter statement continues, "by either Moch or his stooges, either against ESDA or Doyle, but Doyle had to go, he was too close to the real truth." ESDA goes on to claim that "the axe is still out" for a number of prominent NATESA people who "cannot be brain-washed." The Pennsylvania group says it will carry on with or without NATESA but stands "ready and capable to present to . . . the fair and open-minded people of NATESA" its own side of the story.

What issue is involved? As closely as this editor can make it out, it has something to do with policy toward the admission of certain groups or companies in the Pittsburgh area. Little more can be surmised from the single reference to this situation, which appears in the ESDA statement. We do not wish to minimize the possible gravity of the issue. It may be deeply significant or inconsequential; one cannot tell from the space given to it by either party. But is not the very scantiness of the reference indicative?

A Familiar Pattern

Unfortunately, the quarrel has the early earmarks of fitting into the pattern of association battling that was evident for many years in the past: (1) Each side condemns the other and clears itself in black-and-white terms. (2) Each side claims to be acting on issues and capable of documenting its case convincingly. (3) In the deluge of charges and counter-charges, issues become submerged or completely lost, as does the evidence. (4) With more heat than light generated, the conflict centers principally about personalities (Moch, Doyle, *et al*, in this case). (5) With feelings high, virtually irreconcilable personal rifts develop that may be far out of proportion to any disunity of purpose or policy. (6) The entire industry, its ranks broken, suffers.

We are well aware that the response these remarks are most likely to generate will be additional, more vehement charges and denials from the parties involved: it has ever been thus in the past. It may well appear, from this later documentation, that one side is more to blame than another on a truly significant issue. As a disinterested party, however, we are not concerned with establishing guilt or innocence. The greater issue is unity and the greater problem is maintaining that unity for the sake of the many common goals despite differences in certain specific matters.

Was Unity Close?

It had seemed that, with many important groups once outside NATESA coming into that body in recent years, the primary objective was in sight. The prospect seemed to have improved with the ironing out of certain differences at the last convention of the national. Evidently not all of the problems were handled to the satisfaction of all members. Instead there is a rift that will probably become more serious. If a NATESA-affiliated group rivalling ESDA is established in western Pennsylvania, service-industry action will be weakened in that area. If a rival group does not develop, the national cause will be weakened by the existence of a powerful segment that has no nationwide identification.

Arbitration Proposal

What is needed is the maturity, on all sides, to develop machinery, in NATESA or outside of it, for adjudicating disputes. Perhaps arbitrators intimately concerned with the industry but not identified specifically with present, independent, service groups are called for—men of unimpeachable reputation acceptable to all sides, in this or subsequent disputes. If such a body is constituted, its efforts will be wasted if it does not have authority. The industry will have to give a little, however grudgingly. There must be a willingness to act on recommendations. Some such force is perhaps overdue. Until it comes along, service groups may now be back to devoting so much time to fighting each other that they will have neither the time nor energy for achieving the larger goals for which they were organized.

Licensing: State-wide or Local?

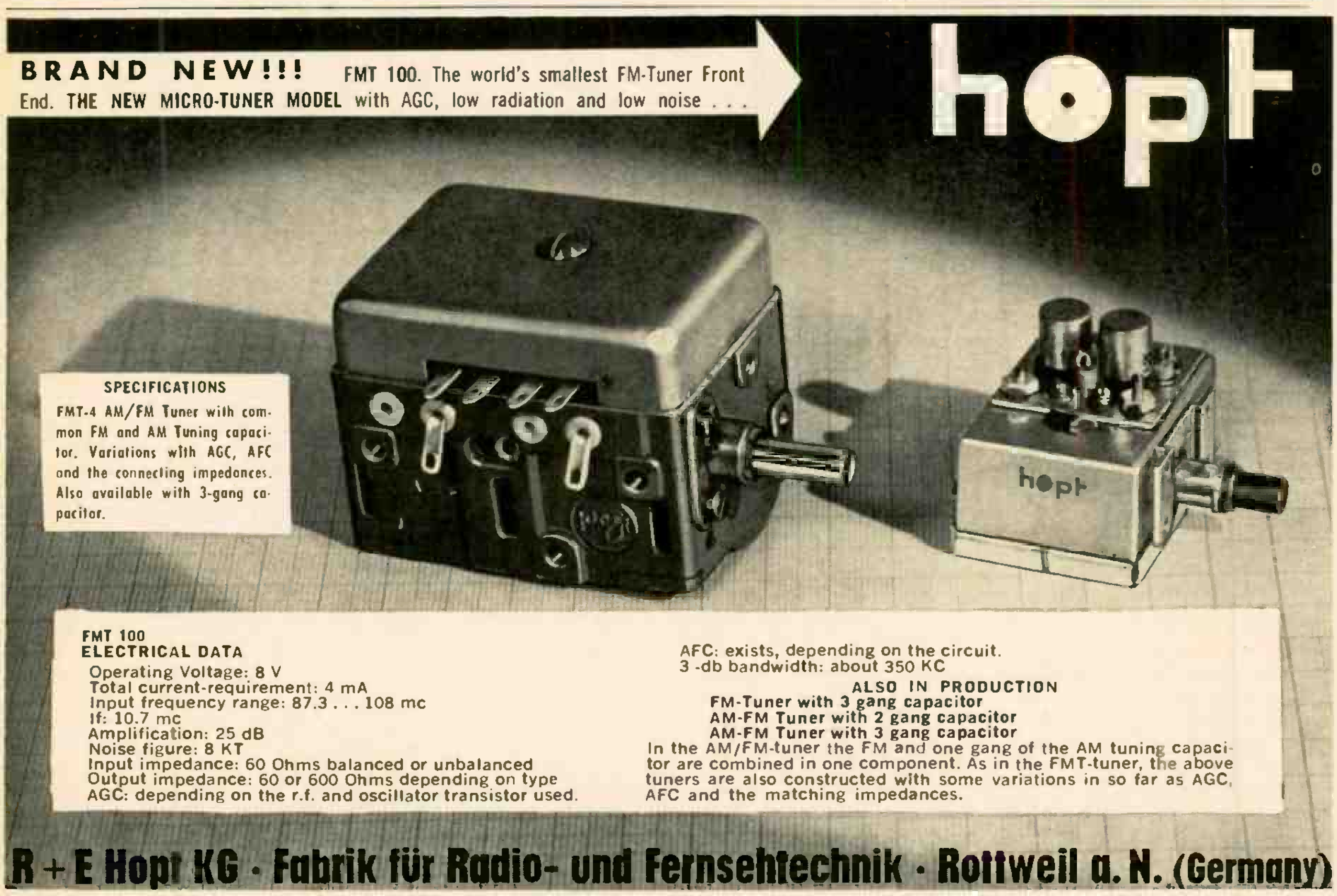
With a law for licensing service technicians in Buffalo, N.Y., now officially in the books, dealers in that city are pressing harder than ever for passage of the state law. Since the bills are virtually identical, one wonders why they should feel that so much is still at stake. This opens the entire question as to whether licensing belongs on the state or municipal level.

No matter how desirable its features, the Buffalo people feel, a local law in a city that is part of a greater metropolitan area has questionable value. Service firms in city limits often do a great deal of their business in nearby, outlying sections. Here they run into competition from firms outside the law's jurisdiction.

This pattern is not peculiar to Buffalo. In virtually every municipality that has licensing, activity for a state law increases. Why, then, do licensing advocates work for local laws altogether? In practice, it is often easier to concentrate fire on getting a city bill pushed through first. In the long view, it is hoped that the disadvantages will be temporary, as the success of a local test of regulation will be the wedge that can be used to bring about licensing on a wider scale.

Window Poster Campaign

Sprague Electric Co. has issued another in its popular series of window posters designed to build better customer relations for TV dealers and repair shops. Attractively illustrated and entitled "Five Ways to Save Money on Your TV Repairs," poster RP-26 cogently presents the arguments against do-it-yourself repairs and service "bargains." It does a good job of selling the properly equipped, properly trained, independent professional as the only man to choose. ▲



Within the Industry

HERMAN KORNBRODT has been promoted to the post of general sales manager of *Audio Devices, Inc.*, makers of magnetic tapes and recording discs. He was formerly East Coast sales manager of the firm.

Effective with his new appointment, Mr. Kornbrodt was also elected vice-president of the firm. He will be responsible for expanding the company's national sales force with a view to handling the increased demand for magnetic tape products, particularly computer tapes.

* * *

CAPITOL RADIO ENGINEERING INSTITUTE is celebrating its 35th Anniversary at a banquet to be held in Washington, D.C. on June 5th.

Admiral Arleigh A. Burke, USN (Ret.), former Chief of Naval Operations, will be the principal speaker. He is a member of the Board of Directors of CREI.

* * *

W. B. ACHENBACH has been named manager of the Columbus plant of *Kimble Glass Company*.

Following service in the Army Air Corps, Mr. Achenbach joined *Owens-Illinois* the parent company, in 1943 and later served with *Libbey Glass Division*.

In his new post as director of business planning for the television bulb and electronic component firm, he succeeds Harland Sims who is transferring to the *Owens-Illinois Corporation* Planning Division in Toledo.

* * *

CLIFFORD A. BEAN has been named manager, commercial marketing research, for *Raytheon Company*. He has been with the firm since 1957 . . . The appointment of **CHESTER KIRKA** to the post of sales manager of the new electronics division has been announced by *Research-Cottrell, Inc.* . . . **ROBERT M. JACKSON** is the new manager of advertising and sales promotion for the semiconductor division of *Sylvania Electric Products Inc.* . . . *Mepco, Inc.* has named **EDWARD L. KLEIN** executive vice-president . . . The new manager of distribution planning for *General Electric's* mobile radio equipment is **T. O. JACKSON** . . . **ROBERT M. LEWISON** has joined *Wyle Laboratories* as eastern corporate sales manager and international manager . . .

DR. BERNARD RABINOVITCH has been named to the newly created post of manager of research and development in magnetic tape and other recording media at the *Ampex Laboratories* . . . **THOMAS I. PAGANELLI** has been named general manager of *General Electric Company's* Heavy Military Electronics Department with headquarters in Syracuse.

* * *

MIRATEL ELECTRONICS, INC. has purchased all inventory, equipment, and product rights of **MORROW RADIO COMPANY** of Salem, Oregon . . . **RESISTOR CHEMICAL COMPANY, INC.** has acquired management control of **CWS WAVEGUIDE CORP.**, Lindenhurst, L.I. manufacturer of microwave components for the radar and communications industry . . . **FISHER RADIO CORPORATION** has announced the formation of **FISHER RADIO INTERNATIONAL** to handle the world-wide export of the products of the parent company . . . **BROWNE ELECTRONIC LABORATORY** has purchased the entire electronic division of **NOBLES ENGINEERING AND MANUFACTURING COMPANY.** All manufacturing and sales are being transferred to the parent company's plant at 1607 E. Lake Street, Minneapolis 7, Minn. . . . Stockholders have voted approval of a change of company name from **ELECTRONIC INSTRUMENT CO., INC.**, to **EICO ELECTRONIC INSTRUMENT CO., INC.** to take advantage of consumer familiarity with the firm's trade name . . . Merger of **MICRODOT, INC.** and **VAREC, INC.** has been announced by the two firms . . . **GLOBE ELECTRONICS COMPANY** has merged with **G.C. ELECTRONICS COMPANY** of Rockford, Ill., with headquarters in Rockford . . . **MM ELECTRONIC ENCLOSURES, INC.** is the new corporate name of **MM ENCLOSURES, INC.** of Hicksville, N.Y. . . . **DATA SENSORS, INC.** has announced the formation of a new Systems Division with headquarters in Gardena, California . . . **INDUSTRIAL ELECTRONIC HARDWARE CORPORATION** has acquired **RAYPAR ELECTRONIC CORPORATION** of Chicago . . . **GENERAL TIME CORPORATION** has completed arrangements to acquire **BARTH ENGINEERING AND MANUFACTURING CO.** of Meriden, Conn. Terms of the agreement were not made public . . . **G-V CONTROLS INC.** of Livingston, N.J. has purchased **UNI-SEAL, INC.** of Garwood, N.J. . . . **FANON ELECTRONIC INDUSTRIES, INC.** and **MARK SIMPSON MANUFACTURING COMPANY, INC.** have announced the merger of their two name brands into "Fanon-Masco."

* * *

DR. ELMER W. ENGSTROM, president of *Radio Corporation of America*, was named winner of the EIA Medal of Honor, an annual award presented by the Electronic Industries Association to an outstanding man who has rendered "distinguished service contributing to the advancement of the electronics industry."

Dr. Engstrom joined *RCA* in 1930 and has served his company, and the industry as a whole, in a variety of important posts. He was elected executive vice-president for research and engineering in 1954 and became president of the company in 1961.

He is also the recipient of a number of other awards and honors.

* * *

JOSEPH KELLEY, JR. has joined *Telecomputer Corporation* as vice-president for corporate development with headquarters in Washington, D.C.

Mr. Kelley has 20 years experience in private industry and the U.S.A.F. He served in the Air Force from 1941 to 1953 during which time he was project engineer on theoretical research programs at Massachusetts Institute of Technology and the University of California.

He holds B.S. and M.S. degrees in aeronautics and is a registered professional engineer in Ohio.

* * *

ASSOCIATION OF ELECTRONIC PARTS & EQUIPMENT MANUFACTURERS, INC. has moved into new offices in Suite 1710, Hartford Building, 100 S. Wacker Drive, Chicago . . . **CENTRALAB** has established a new headquarters building for its distributor division in suburban Menomonee Falls, Wisconsin, close to the firm's four present Milwaukee plants . . . **ELECTRO-VOICE, INC.** has completed the move into its new 28,000-square-foot addition in Buchanan, Michigan . . . The **CINCINNATI DIVISION** of **THE BENDIX CORPORATION** has purchased a 46-acre tract of land for the construction of a new plant that will permit consolidation of its present operations. Occupancy is scheduled for late this year . . . **CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA LIMITED** has begun construction on a thermoelectric materials plant at Trail, British Columbia . . . **PACKARD BELL COMPUTER CORPORATION** has activated a new research and development center at 325 N. Muller Ave. in Anaheim, California . . . **GENERAL MATERIALS CORP.**, wholesaler of electronic parts, has entered the retail sales field with a store at 211-15 W. Madison St., Chicago . . . **TEXAS RESEARCH AND ELECTRONIC CORPORATION** has relocated its Advanced Electronic Division in new quarters at 6612 Denton Drive, Dallas 35, Texas . . . **CAHN INSTRUMENT COMPANY** has just completed new and larger quarters at 15505 Minnesota Ave., Paramount, California.

* * *

WESTON INSTRUMENTS DIVISION has established a new district office in Orlando, Florida at 1224 E. Colonia Drive to meet the growing need for electrical and electronic capabilities and service in the area . . . Formation of an Electromechanical Products Division has been announced by **STACKPOLE CARBON COMPANY** with Franklin H. Kilpatrick in charge . . . **MOTOROLA INC.** has established a Solid State Systems Division with headquarters in Phoenix . . . **ELDRE COMPONENTS, INC.** has added **ALLIED SOLDERING AND BRAZING CORPORATION** as a division with headquarters in Rochester, N.Y.

* * *

JACK W. SHERIFF has been appointed director of marketing for *The Daven Company*, Livingston, N.J.

The move is an intra-company promotion for Mr. Sheriff who was director of planning and development for the electronics group of *General Mills, Inc.*, the parent firm.

In his new post, Mr. Sheriff will be responsible for sales, marketing and advertising on the company's complete line of electronic products.

* * *

EDWARD L. ALLMAN has been named to direct the Manchester, N.H. plant of *The Daven Company* . . . *Babcock Electronics Corporation* has named **RALPH BRAVERMAN** to the newly created post of engineering manager . . . **RICHARD C. HAHN** has joined the staff of *CBS Laboratories* as manager, program development, for the acoustics and magnetics branch . . . **WILLIAM C. WEBER, JR.** has resigned his post as executive director of the Electronic Representatives Association . . . **SOL HEYTOW** has been appointed director of research and development of *Estey Electronics, Inc.* . . . *FXR* has announced the appointment of **CHARLES C. CAMILLO** to the post of vice-president, engineering of the r.f. products and microwave firm . . . The Council of The Institution of Electrical Engineers (Great Britain) has appointed **DR. GEORGE F. GAINSBOROUGH** to succeed **W. K. BRASHER** as secretary . . . **KENNETH A. NORTON** of the Boulder Labs of NBS, has been awarded the Gold Medal for Exceptional Service by the U.S. Department of Commerce for his outstanding contributions and leadership in the field of radio propagation research .

* * *

VICTOR G. KOCENKO has been named director of manufacturing for the *Weston Instruments Division-Newark*, a subsidiary of *Daystom, Incorporated*.

He moves to his new position from the post of factory manager, a position he has held since last July. Mr. Kocenko joined the company in 1951 as a time-study engineer and became supervisor of parts manufacturing in 1958.

He attended Stevens Institute of Technology and Newark College of Engineering. ▲

INVITATION TO AUTHORS

Just as a reminder, the Editors of ELECTRONICS WORLD are always interested in obtaining outstanding manuscripts, for publication in this magazine, covering the fields of audio and high-fidelity and radio-TV-industrial servicing. Articles in manuscript form may be submitted for immediate decision and projected articles can be outlined in a letter in which case the writer will be advised promptly as to the suitability of the topic. We can also use short "filler" items outlining worthwhile shortcuts that have made your servicing chores easier. This magazine pays for articles on acceptance. Send all manuscripts or your letters of suggestion to the Editor, ELECTRONICS WORLD, One Park Avenue, New York 16, New York.

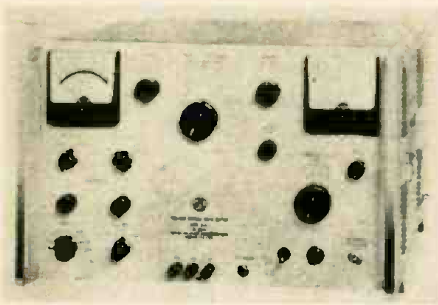
New Products and Literature for Electronics Technicians

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 108.

TELEMETERING GENERATOR

1 **Boonton Radio Corporation** is now offering a new telemetering signal generator. Type 202-J, which is specifically designed for the testing and calibration of telemetry receivers operating in the 215-260 mc. band.

The new generator features less than 1½%



FM non-linearity at 150-kc. deviation, a peak-to-peak deviation meter, 1-mc. FM modulation bandwidth, automatic r.f. level set which eliminates the need to re-adjust the carrier monitor meter as frequency is varied over the band, and a calibrated electronic tuning vernier. FM or AM modulation may be obtained from either the internal modulating oscillator or an external source. Pulse modulation is also available.

PORTABLE MEGOHMMETER

2 **Alameda Tool Engineering Corporation** is now offering an accurate, portable megohmmeter as its Model AS102. The instrument is battery operated and measures 6" x 3" x 3". The unit is self-calibrating and is simple enough to be operated with one hand.

LABORATORY ELECTROMETER

3 **Gyra Electronics Corp.** is now marketing its Model E-102 electrometer for research. The new instrument is capable of measuring small increments of current to help in predicting insulation life, in detecting thermal currents in contacts of dissimilar metals, and conductivity of evaporated films.

Range of the new instrument is 1 ma. to 1

$\mu\mu$a. with an output of 10 mv. for driving a strip recorder in addition to a direct-reading panel meter. It is supplied on a 3½" standard rack-panel chassis. The unit operates from 105 to 125 volt, 50-60 cycle source and is offered in fast or slow response characteristics, the latter for measurements of r.m.s. current containing an a.c. component.

TUNNEL DIODE ADAPTER

4 **Wayne Kerr Corporation** has recently introduced a tunnel diode adapter which is designed to be used in conjunction with the firm's ratio-arm transformer bridges for the measurement of the junction capacitance of tunnel diodes. Previously, this was a difficult measurement because of the negative conductance characteristics of tunnel diodes, their inherent loading problems, and small values of capacitance.

The unit is intended to enable engineers to design tunnel diodes with a faster switching time. This, in turn, will lead to faster switching speeds of a digital computer in communicating information between its various parts.

INFRARED SIGNAL GENERATOR

5 **Telewave Laboratories, Inc.** has announced the development of a calibrated infrared signal generator, Model 501.

The instrument provides a tunable infrared source of variable wavelength from 1 to 14 microns and calibrated power to 10 microwatts. Highly stable square-wave modulation is available from 2 to 2600 cps and a synchronous reference signal is provided for low-level integrating measurements. The infrared output signal is available at the operator's discretion as either a point source radiator or a collimated beam.

The generator is a portable instrument with its own internal blower fan for cooling.

LIQUID INSULATION

6 **Beaver Laboratories, Inc.** is now marketing an easy-to-use and unique liquid insulating compound that is designed to solve difficult electrical and moisture insulation problems.

"Liqui-Tape" is pliable yet hard. It will not crack, chip, or peel. Electrical insulation properties of 700-volts-per-mil-per-application are standard. Additional applications can be used to increase the amount of insulation.

MILLIMICROAMMETER

7 **Dynatran Electronics Corporation** has recently introduced its Model 1811A millimicroammeter which provides 12 overlapping current ranges, to measure low-level d.c. currents from less than 1 millimicroampere to 3 milliamperes.

The instrument features a high-gain feedback amplifier design with chopper stabilization which results in a small full-scale voltage drop and eliminates the need for zero adjustment. The 4½" rectangular meter is protected from burnout due to overloads and the built-in current shunts can safely withstand overloads of 60,000 times full-scale current at the lowest current range and 120 times full-scale current at the highest current range.

TEST MESSAGE GENERATOR

8 **Howard Instrument Co.** is now marketing the Model 200 test message generator for testing systems using 2 to 8 channel parallel data. Capable of generating an arbitrary message of up to 30 8-bit characters, this test message generator has the same electrical specifications as the firm's 600 series and can be used to replace eight Model 630 single-channel simulators.

ACCELEROMETER/AMPLIFIER

9 **Electra Scientific Corporation** is now offering its Series 6000 accelerometer and transistorized a.c. laboratory amplifier to provide precision measurement and analysis of shock and vibration.

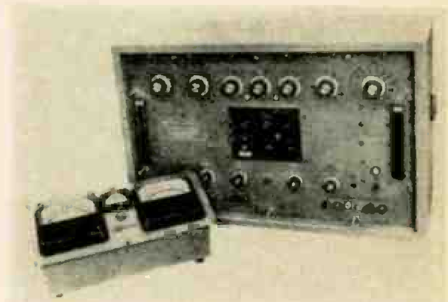
Featuring 1150 $\mu\mu$f. internal capacity, the units operate over a range of −350 to +500 degrees F at 80 and 140 kc. seismic resonant frequencies. Minimum sensitivity levels are 5, 10, 15, 20, and 30 mv./g.

The units are suited for complex vibration studies such as power density spectrum analysis. They easily accommodate simultaneous excitation of random input to the system under test in several modes of vibration and all degrees of freedom.

PORTABLE CALIBRATOR

10 **Weston Instruments Division** has announced a new ruggedized calibration instrument which provides precision a.c. and d.c. voltage and current outputs for standardizing electrical instruments at direct reading accuracy of ± 0.5%.

The Model 76 also provides direct calibration



of 50, 60, and 400 cycle wattmeters at unity power factor. The major equipment assembly, measuring approximately 32" x 24" x 19", provides switching and dividing circuits for supplying the required a.c. and d.c. outputs, and a resistance bridge for making precision resistance measurements and for use as a precision decade resistor on d.c.-microampere and a.c.-milliampere ranges.

TRANSISTORIZED PREAMP

11 **Jerrold Electronics Corporation** is in production on a transistorized antenna preamplifier, the "Powermate" Model APM-101.

The unit's compact, lightweight construction permits its mounting directly on the antenna boom for maximum signal boost. Signal gain, through use of the preamplifier, averages 13.9 db at channel 13 and 18.25 db at channel 2. Operating at less current than an electric clock, the unit's remote a.c. power supply provides 15 volts. The 300-ohm antenna line carries the 15 volts to the preamp as well as the signal down from the preamp.

An aluminum weatherproof housing protects the transistor unit from the elements and helps eliminate signal interference. Two TV sets or one TV and one FM set can be fed by the dual outputs.

DATA ACQUISITION SYSTEM

12 **Genisco, Inc.** is offering a new high-speed version of its analog-to-pulse duration data acquisition system which is specially designed for process control applications.

The new unit adds the advantages of a sampling rate of 200 channels-per-second to the accuracy and stability of the original APD system. The solid-state instrumentation system directly converts a low-level electrical input signal to a pulse linearly related in duration to the input signal amplitude. It is applicable with d.c. voltage, low-impedance sensing instrument sources such as thermocouples, resistance thermometers, and strain-gage transducers.

KILOVOLTMETER

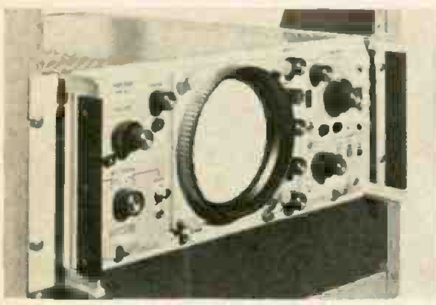
13 **Plastic Capacitors, Inc.** is now marketing the Model VM105 kilovoltmeter. A 50-μa. meter movement with a knife-edge pointer and mirrored scale provides voltage ranges of 0 to 1 kv., 0 to 5 kv., 0 to 10 kv., and 0 to 20 kv. Full-scale accuracy is 2%. Meter protection and a high-voltage cable and probe are provided.

The instrument is housed in a cabinet measuring 6" x 8" x 8". Weight is 7 pounds.

SOLID-STATE SCOPE

14 **Allen B. Du Mont Laboratories** has recently introduced a portable oscilloscope which includes all the capability of heavy, bench-model high-frequency instruments. The Model 765 features a sensitivity of 5 mv./cm. and a bandwidth of 25 mc. (useful to about 40 mc.).

The new "PortaScope" is encased in an unbreakable fiberglas case with a rugged handle for maximum carrying ease. During use, the handle



serves as the tilt stand to elevate the control and display panel. Space is provided in the lid of the carrying case for accessories such as probes, cables, and connectors.

The complete use of solid-state circuitry, utilizing silicon transistors, makes this unit suitable for computer maintenance, flight and pre-flight testing, military field testing, etc. Weight of the main frame is 27 pounds.

MUTUAL-CONDUCTANCE TUBE TESTER

15 **Heath Company** is now offering a mutual-conductance tube tester in kit form as the Model TT-1A. The circuit features a built-in adapter for testing compactrons, nuvistors, novars, and 10-pin miniature tube types. The tester will indicate G_m to 24,000 μmhos, includes an ultra-sensitive grid-current test, and provides a direct-reading ohmmeter leakage test.

Provision has been made for mounting future tube sockets to minimize obsolescence.

COUNTER/TIMER FREQUENCY METER

16 **Transistor Specialties, Inc.**, is now offering its Model 373 counter/timer for the measurement of frequencies up to 10 mc. and time intervals from 1 μsec. to 10 seconds. By restricting the crystal "clock" circuitry to 1 mc. and employing only a single-signal channel, significant economies are effected. The instrument provides full self-testing as well as frequency-standard output, consisting of every decade of frequency from 1 mc. to 0.1 cps, derived from the crystal "clock."

MEGOHMMETER

17 **Electrospace Corporation** has added a dual-range megohmmeter to its line of equipment for laboratory and production-line test applications.

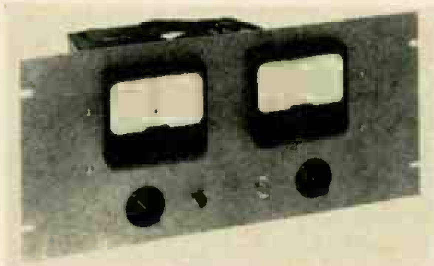
The Model 651 voltage ranges cover an expanded scale of 0-1000 volts a.c. and d.c. and 0-5000 volts a.c. and d.c. Insulation resistance megohmmeter ranges provide up to 10 million megohms at direct potentials continuously variable from 10 to 500 volts d.c.

Range accuracies are 3% of full-scale for a.c. and d.c. kilovolts, 2% for d.c. volts, 3% and 5% for megohm scales, and 10% maximum for leakage current control.

IONIZATION GAGE

18 The Fredericks Company is marketing a new low-cost cold-cathode ionization gage which has been ruggedly designed for industrial applications and is capable of vacuum measurements from 10^{-2} to 10^{-7} mm Hg.

Designated the "Televac" Model 7A, the instrument is said to be especially useful in such applications as vacuum metallurgy, electron beam welders, vacuum welding, vacuum brazing and evaporating, vacuum sintering and annealing, particle accelerators, and missile launch instrumentation.



The cabinet-mounted version measures 7⅛" high, 14¼" wide, and 10" deep.

50-MC. OSCILLOSCOPE

19 Hewlett-Packard Company has recently introduced its Model 175A 50-mc. oscilloscope which features modular construction for bench or rack, providing easy access for servicing. The instrument provides full 6 x 10 cm. display on an internal graticule CRT with no parallax and no astigmatism.

Internal sweep is in 21 calibrated ranges, vernier provides continuous adjustment between calibrated ranges and extends the slowest sweep to 15 sec./cm. The horizontal passband is d.c. to 300 kc.

BETA BACKSCATTER GAGE

20 Twin City Testing Corporation is introducing a beta backscatter gage which is being marketed as the "Betascope."

The instrument provides accurate thickness readings for commercial, industrial, and research

laboratories where exact measurements of coating, foil, and film thicknesses are of prime importance. Among the coatings which can be measured with this instrument are gold on printed circuit boards, silver on copper, rhodium on nickel, metallic oxides on mylar, glass, and other substrates. Measurements are accurate, rapid, and non-destructive.

STANDING-WAVE AMPLIFIER

21 FXR Division of Amphenol-Borg Electronics Corp. is now marketing its No. B813T transistorized standing-wave amplifier. Full-scale maximum error is only ± 0.05 db at 5 db. The calibrated range of the instrument is 75 db.

This portable unit, line or battery powered, incorporates a number of new design features: special circuitry and controls for normal, expanded, and compressed scale readings (gain is normalized on switching); bolometer resistance checking, protection, and current adjustment: selective meter damping; bandwidth selection and frequency peaking; and range selection in 5 db steps.

MULTI-CHANNEL GALVANOMETER

22 Electro Magnetic Instrument Co., Inc. has announced the availability of a new series of curvilinear or rectilinear multi-channel galvanometers. These direct-writing instruments permit simultaneous multiple recording, feature interchangeable plug-in pen motors with a peak-to-peak pen movement of 2 inches and a wide range of undamped frequencies. The alternating pen lengths give complete freedom of movement to adjacent pens.

The MC series is available as standard items in 2, 4, 6, 8, and 10 channel packages and can be furnished with up to 32 channels on special order.

H.F. VOLTMETER/AMMETERS

23 Esterline Angus Instrument Co., Inc. is now offering rectifier-type a.c. recording voltmeters with ranges between 0-150 and 0-800 volts and a.c. recording ammeters with current ranges between 0-1 and 0-10 amperes to operate on frequencies up to 10,000 cps.

Applications for these new units include monitoring induction heating and high-frequency welding. They can also be used in studies of line, bus, and feeder voltage records on power systems and plant distribution systems, checking faults, investigating customer complaints, detecting operating troubles, and testing safety equipment.

TRANSISTORIZED SIGNAL GENERATOR

24 GC Electronics, Inc. is now marketing a specially engineered signal generator which has been designed to facilitate repairs on transistor radios, auto radios, conventional broadcast sets, and hi-fi stereo equipment.

The No. 36-564 is suitable for both a.f. and r.f.-i.f. and features variable output level with a 400 cps (approx.) audio signal generated. The unit is powered by a 6-volt battery, contains two transistors, and has an "on-off" switch on the control pot. The instrument weighs 1 pound and measures 5" x 5" x 1⅞".

GAUSSMETERS

25 Instrument Systems Corporation is now manufacturing a new line of gaussmeters designed for magnetic field and flux density measurements between 100 and 20,000 gauss.

Operating without amplifiers, the Model A-101 and A-102 gaussmeters utilize Hall-effect devices as probes. Model A-101 has ranges of 0-1000-2000-5000-10,000 gauss and Model A-102 of 0-2000-5000-10,000-20,000 gauss. These portable units are accurate within 1.5% of full-scale up to 16,000 gauss and 3% of full-scale from 16,000 to 20,000 gauss.

MILLIVOLT SOURCE & METER

26 Abbey Electronics Corp. has developed a dual-purpose instrument combining the functions of a high-resolution d.c. voltage and current source with a precision nulling-type voltmeter.

Operating as either a source or a meter, the Model SM-4 has an absolute accuracy of 0.025% of reading ± 500 μv. from zero to 1 volt and 0.025% of reading ± 5 mv. from 1 to 10 volts. In either mode, the resolution is better than 500 μv. on the 1-volt range and better than 5 mv. on the 10-volt range.

IGNITION ANALYZER

27 Lafayette Radio Electronics Corporation is now offering an easy-to-use auto ignition analyzer, the Model TE-40.

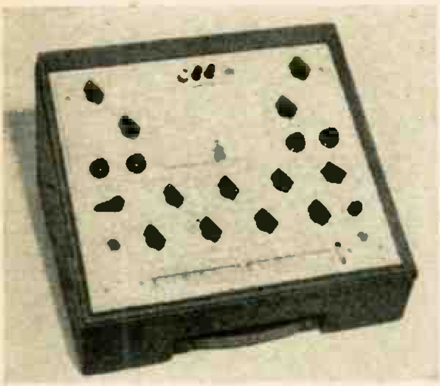
The unit can be used to localize trouble in coils, sparkplugs, points, condensers, etc. The sensitive vacuum-tube voltmeter section measures up to 30,000 volts without circuit drain. It features a special capacitance clip which enables the operator to make high-voltage measurement (including surges) without danger of shock.

The instrument is powered from the 12-volt car battery and may be used with all 4, 6, and 8 cylinder engines.

TRANSISTOR TESTER

28 RD Instruments Division of Hickok Electrical Instrument Company is now offering its Model 1880 dynamic beta transistor tester.

Designed to test either silicon or germanium transistors, the new instrument measures a.c. beta,



d.c. beta, leakage, and many other transistor characteristics. A roll chart lists data for beta and leakage tests on more than 1550 transistors. Accuracy is ± 3%.

AUTOMATIC 10-LINE SCANNER

29 Radiation at Orlando has developed an automatic 10-line scanner, Model 7210, that does not affect the signals it samples. Designed for telegraph work, the new unit eliminates cumbersome patch cord changes, allowing faster traffic with no interruptions and less chance for error.

The instrument allows 10 individual circuits, either polar or neutral, to be scanned sequentially. Each circuit is scanned for a preselected time interval, with five scanning rates available manually.

CIRCUIT TESTER

30 Electro-Mation Company is now offering a unit which has been designed specifically for checking electrical circuits in all voltage capacities on production lines for automotive, appliance, control, and instrument circuitry.

The test handle of the circuit tester serves as the control. Indicator lamps and meter indicators on the tester face panel offer quick signals and readings, reducing inspection time to a minimum. The handle provides female jacks for multiple jumper leads for inspection of a variety of circuits and types of harnesses.

SWEEP SIGNAL GENERATOR

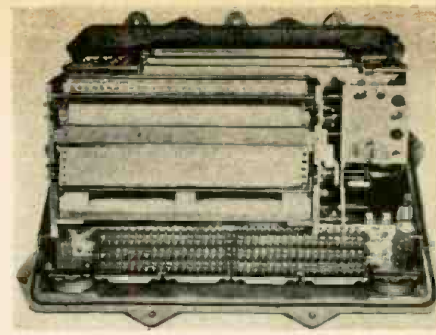
31 Northeastern Engineering, Inc. is offering a wide-range, high-stability electronic sweep generator as its Model 501.

The instrument provides a signal source for visually aligning narrow-band communications equipment and checking bandpass characteristics of amplifiers, communications receivers, and filters. Fundamental frequency range is from 100 cps to 32 mc. with .5 volt r.m.s. output into a 50-ohm load. Output signals are available at any frequency within the range and give a c.w., narrow-sweep frequency band, and a wide-sweep frequency band.

EVENTS RECORDER

32 Weston Instruments Division has a new recorder available for monitoring and recording up to 50 events, with simultaneous time indications and a maximum recording rate of 10 events-per-second on each channel.

The Model 6382 is a high-environment, direct-



reading instrument for use in complex, multi-input control systems as required, for example, in process industries where repetitive and progressive operations are necessary.

All electronic components are solid-state, with modular subassemblies which permit individual replaceability of components without skilled adjustment. Operating power requirements are 115 volts, 60 cps, 800 watts with an event input range of 3-115 volts, a.c. or d.c.

ACOUSTIC SENSOR

33 Atlantic Research Corporation is now offering a new acoustic sensor which is a transducer that senses dynamic pressures and provides a measurable electrical output in response. Its small size makes it suitable for point measurement of acoustic and ultrasonic energy. Designed as a high-intensity noise microphone, it features a completely encapsulated sensitive element 1/16" x 1/16" mounted on the end of a 4" stainless steel stem. Sensitivity is −124 db, reference 1 volt/microbar, capacitance is 240 μμf.

SYNCHRO TESTER

34 Computer Sciences, Inc. has added the Series 300 synchro tester to its line of standard laboratory and field-test equipment for mainte-

nance and checkout of servo and data-transmission systems.

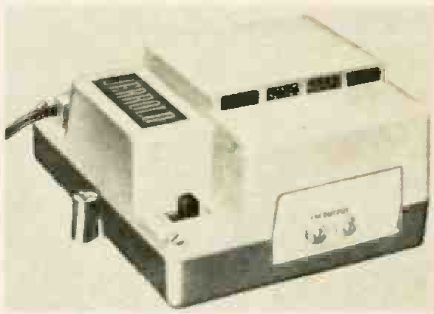
The new unit is designed to reduce the time required for troubleshooting and locating defective synchros and synchro transmission within a system, and to expedite zero alignment. Models 301 and 302, for 400 cps and 60 cps applications respectively, can function as a transmitter and/or receiver.

Integral to the tester is a four-foot molded cable with five clip-on leads. The tester is approximately 2¼" in diameter, 3½" long, and weighs slightly over one pound.

HI-FI—AUDIO PRODUCTS

FM RANGE EXTENDER

35 **Jerrold Electronics Corporation** is now marketing a new FM antenna amplifier which is said to be capable of doubling the primary reception range of FM tuners and receivers. The Model FMX range extender provides a mini-



mum of 20 db gain over the entire FM band and eliminates background noise and drifting of the signal.

The unit may be installed anywhere in the home between the antenna and FM tuner. It operates from 117-volt, 60-cycle a.c.

MULTIPLEX ADAPTER KIT

36 **Lafayette Radio Electronics Corp.** is now offering a low-priced FM multiplex adapter kit which is designed to operate with any of the firm's recent tuners or any quality wide-band FM or FM-AM tuner with or without multiplex jacks.

Coils are pre-aligned and only minimum adjustments are required. The KT-220 is self-powered and may be remotely connected to the tuner. Complete assembly instructions come with the kit.

NEW TURNTABLE DESIGN

37 **Rek-O-Kut Co., Inc.** has introduced its Rondine 2, which features a unique turntable design involving an integrated turntable with motorized, independent tonearm.

The new unit is only 14½" x 14⅞". The turntable is built to aircraft tolerances and features a heavy, cast turntable platter, custom-built hysteresis synchronous motor, belt-drive system, and heavy steel deck plate.

The motor-driven tonearm is factory installed and features the firm's exclusive operating designs such as "Micropoint" and "Omni-Balance." The tonearm tracks at 1 gram or less and is machined to precise tolerances. The "Auto-Poise" allows the tonearm mechanism to operate independent of the turntable motor. A heavy-duty cam is

driven by an independent synchronous motor to program the sequence of events which take place when the arm is in motion.

MULTIPLEX STEREO MODULATOR

38 **American Laboratories** is now offering its newly developed Model FMX-101 FM multiplex stereo modulator which generates an output signal composite audio and stereo subchannel in accordance with the FCC rules.

The modulator features time-division multiplexing in the double-sideband suppressed-carrier modulator. Other features include front-panel control of main, subcarrier, and pilot channels, and selector switches for rapid scope checking of waveforms.

STEREO REMOTE CONTROL

39 **Stereosonics, Inc.** is now offering a universal remote control unit which is designed to operate any component or console system over distances of up to 800 feet. Models RM-2 and RM-3 permit continuous control of both volume and tuning as well as "on-off" operation. It can be connected either electronically or mechanically (by means of an accessory shaft cable). Any number of remote switch control centers may be used with a single slave motor chassis. No audio signals pass through long cables and no distortion, noise, or loss of frequency response is introduced.

AUDIO GENERATOR

40 **Lafayette Radio Electronics Corporation** has introduced a low-cost, factory-wired sine-square wave generator as its Model TE-22.

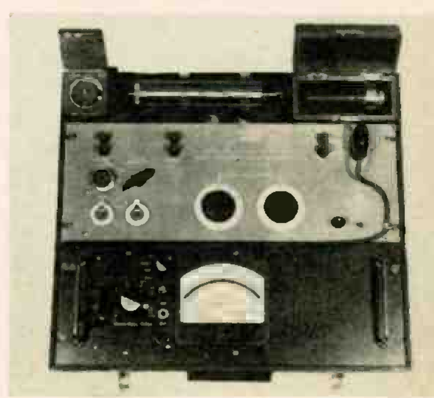
Combining two instruments in one, the generator provides suitable square-wave tests of audio amplifiers, TV audio circuit tests, checking out of frequency response, etc. Response is 20 to 20,000 cps ± 1.5 db in four bands; usable square-wave response is 20-25,000 cps. The large etched circular dial is vernier tuned.

The instrument is housed in a steel case with leather carrying handle. It measures 7" x 10½" x 5⅜".

SOUND-PRESSURE MEASUREMENT

41 **Massa Division of Cohu Electronics, Inc.** is now offering a portable sound-pressure measurement system, the GA-1040.

The new instrument can be hand-carried to any location for complete and convenient sound-



pressure analysis. To attain its frequency range extending to 100 kc. and beyond and 100-db dynamic range, topping at 200 db, the GA-1040 uses the firm's Model M-213 ADP crystal microphone. A high-impedance cathode-follower preamp, a 60-db amplifier-power supply, and a sensitive direct-reading a.c. vacuum-tube voltmeter comprise the balance of the system.

CB-HAM-COMMUNICATIONS

TRANSISTORIZED GRID-DIPPER

42 **PEL Electronics** is now offering a completely transistorized grid-dip meter for applications in circuit alignment, measuring resonant frequencies, checking antenna resonance, locating parasitics, etc.

The small size, 14-ounce unit and internal battery permit one-hand operation in tight corners. Plug-in coils feature epoxy coating with banana plugs for dependability. The dial scale is easily matched to the coil by letter coding.

CB BASE STATION

43 Miratel Electronics, Inc. is now marketing a deluxe CB base and mobile unit as the CR117. The receiver circuit is a superhet with five crystal-controlled channels. There is a.v.c. on all r.f. and i.f. stages. The transmitter also has five crystal-controlled channels, a modulation meter, plus 12AT7 speech amplifier with microphone jack on front panel.

A data sheet on this new unit is available on request. It contains complete specifications and details on operation.

TRANSISTORIZED DEPTH FINDER

44 MED Electronics, Inc. is now offering a new transistorized depth and fish finder which features a number of design refinements. Measuring only 5"x 5"x 6" over-all and weighing less than 5 pounds, the unit is suitable for use on small as well as large boats.

The edge-lighted dial is calibrated to 100 feet with an exclusive "expand" control permitting depth measures in the 100 to 200 foot and 200 to 300 foot range. The Model 20 will operate on an external power source and accept any power input from 6 to 14.4 volts.

NEW HAM TRANSMITTER

45 Globe Division of GC-Textron Electronics is now offering the Model HG-303 amateur radio transmitter which will operate on a nominal input power of 75 watts and covers the bands from 80 through 10 meters.

Modulator construction permits housing the unit in a total space of only 4⅝" high x 9⅛" wide, and 9½" deep. Circuit details will be supplied by the company on request.

CB TRANSCEIVER

46 Eico Electronic Instrument Co. Inc. is now offering a new and improved version of its #770 series of CB transceivers. The new units are now supplied with a retractable coiled cord and push-to-talk ceramic-element microphone.

The series provides the maximum authorized input of 5 watts on any four of 23 FCC-approved, crystal-controlled CB channels. The entire transmitter oscillator circuit and r.f. final is premounted, prewired, and sealed at the factory, complying with FCC regulations.

MARINE RADIOTELEPHONE

47 Heath Company has just introduced a new 50-watt marine radiotelephone in kit form. The circuit features a 50-watt long-range transmitter, five crystal-controlled transmit and receive channels, an 8-transistor receiver, plus built-in heavy-duty vibrator power supply.

The unit also covers the standard broadcast and 2-3 mc. marine bands. It will also double as an 8-watt deck hailer or p.a. amplifier.

The kit comes with complete instructions for installation.

NOISE SUPPRESSOR KIT

48 Raytheon Company is now marketing a "do-it-yourself" noise suppressor kit for use with any brand CB transceiver. For ordinary engine noise, the standard kit provides generator and spark coil capacitors and distributor and spark-plug suppressors along with the necessary mounting hardware and complete instructions.

NOISE ELIMINATOR & SQUELCH

49 Lafayette Radio Electronics Corp. has added the Model HE-55 "Squelcher" to its line of equipment for the radio amateur.

The instrument serves as a noise eliminator and squelch and is designed to improve the reception and reliability of all superhet transceiv-

(Continued on page 106)

ELECTRONICS MARKET PLACE

RATE: 60¢ per word. Minimum 10 words. July issue closes May 3rd. Send order and remittance to: ELECTRONICS WORLD, One Park Ave., N. Y. C. 16, N. Y.

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"FREE—R.C.A., G.E. etc. tubes catalog. Discount to 75% from list. Picture tubes at 75¢ inch up. Parts, parts kits at 1/10 original cost. Needles, tube testers, silicons, seleniums 7" TV bench test tube—$6.99—and more." Arcturus Electronics Corp., E.W. 502-22nd Street, Nion City, New Jersey.

SIGNAL Generator—Measurements Model 84—300-1000 M.C. Engineering, Research purposes $500.00 others. O'Keefe Surplus Aircraft, Box 284, Stanhope, New Jersey.

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DON'T Buy Hi-Fi components, kits, tape, tape recorders until you get our low, low return mail quotes. "We Guarantee Not To Be Undersold." Wholesale catalog free. Easy time payment plan, 10% down—up to 24 mos. to pay. Hi-Fidelity Center, 220NC E. 23 St., New York 10, N. Y.

SELF-Hypnosis. New concept teaches you quickly by tape or LP-record. Free literature. McKinley Publishers, Dept. T6, Box 3038, San Bernardino, California.

4/TR Stereo Tapes—bought, sold, rented, traded! Free Catalog/bargain closeouts. (Columbia) 9651 Foxbury, Rivera, California.

SAVE 30% Stereo music on tape. Free bargain catalog/blank tape/recorders/norelco speakers. Saxitone, 1776 Columbia Road, Washington, D.C.

HIGH-FIDELITY

PROMPT Delivery, We Will Not Be Undersold. Amplifiers, Tape Recorders, Tuners, Etc. No Catalogs, Air Mail Quotes. Compare. L. M. Brown Sales Corp., Dept. W, 239 E. 24 St., N. Y. 10, N. Y.

DISGUSTED with "HI" Hi-Fi Prices? Unusual Discounts On Your High Fidelity Requirements. Write. Key Electronics, 120 Liberty St., New York 6, N. Y. Cloverdale 8-4288.

RECORDERS, Components! Free wholesale catalogue! Carston, 125-R, East 88, N.Y.C. 28.

PRICES? The Best! Factory-sealed Hi-Fi Components? Yes! Send for free catalog. Audion, 1038R Northern Blvd., Roslyn, N.Y.

GOVERNMENT SURPLUS

JEEPS $278, Airplanes $159, Boats $7.88, generators $2.68, typewriters $8.79, are typical government surplus sale prices. Buy 10,001 items wholesale, direct. Full details, 627 locations, procedure, only $1.00. Surplus, Box 789-C97, York, Penna.

PATENTS

PATENT Searches, $6.00. For free Invention Record, and "Information Inventor's Need," Write: Miss Heyward, 1029 Vermont Avenue, N.W., Washington 5, D.C.

MUSIC

SONGWRITERS, with publisher contacts, want song ideas. Share royalties. No fees. Send poems: Songwriters' Associates, 1650 Broadway, N.Y. 19-V.

SHOPPING GUIDE CLASSIFIED

A HANDY GUIDE TO PRODUCTS, NOT NECESSARILY ELECTRONIC, BUT OF WIDE GENERAL INTEREST.

PHOTOGRAPHY-FILM, EQUIPMENT, SERVICES

SCIENCE Bargains—Request Free Giant Catalog "CJ"—144 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts. War surplus bargains. Edmund Scientific Co., Barrington, New Jersey.

STAMPS AND COINS

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HELP WANTED

HIGH Paying Jobs in Foreign Lands! Send $2.00 for complete scoop! Foreign Opportunities, Box 172, Columbus 16, Ohio.

EARN Extra money selling advertising book matches. Free Samples furnished. Matchcorp, Dept. MD-12, Chicago 32, Ill.

EDUCATIONAL OPPORTUNITIES

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TAKE Bachelor's and Master's Degree correspondence courses from leading universities! Directory of 6,000 courses—$2.00. College Research, North Highlands 15, California.

BUSINESS OPPORTUNITIES

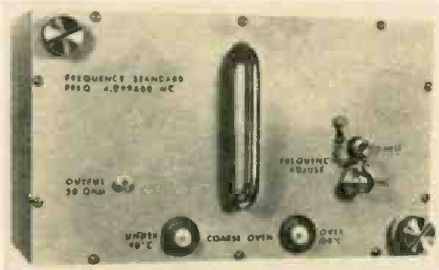
SECOND Income From Oil Can End Your Toil! Free Book and Oilfield Maps! National Petroleum, Pan-American Bank Building—PP, Miami 32, Florida.

MAKE $25-$50 Week, clipping newspaper items for publishers. Some clippings worth $5.00 each. Particulars free. National, 81-DG, Knickerbocker Station, New York.

ers. It effectively reduces ignition noise and quiets the receiver when no signal is being received. The circuit uses two tubes and is housed in a cabinet measuring approximately 2½" x 3-1/16" x 4¼".

FREQUENCY STANDARD

50 **Reeves-Hoffman Division** is now offering its Model S1455, a 4.999600-mc. crystal-controlled frequency standard which is designed as an aid to precise navigation and for use as a master



oscillator of "Transit" operational test equipment. Operating ambient temperature range is from 0 to 60 degrees C.

The oscillator measures 5" x 5" x 8½", including hardware it weighs 8 pounds. Operation is at 12 volts d.c. regulated to 1% or better or 28 volts d.c. regulated to 5%.

TRANSMITTER/ANTENNA TEST SET

51 **Electro Impulse Laboratory Inc.** is in production on its TAS Series transmitter and antenna test set which is designed specifically for tuning transmitters and antennas since the instrument is capable of measuring transmitted and reflected power as well as v.s.w.r. A coaxial switch permits adjustment over the transmitter under non-radiating conditions by switching to a dummy load. The transmitter can then be switched to the antenna and the antenna tuned for minimum reflected power. The instrument can also be used as an antenna switch for multi-band operations and simultaneous monitoring of transmitted power.

V.H.F. MONITOR RECEIVERS

52 **The Hallicrafters Co.** is now offering three new base-station v.h.f. radio receivers for monitoring public service, industrial, and aircraft communications. Two are split-channel FM units and the third is a highly selective AM receiver.

Each has two drift-free, crystal-controlled channels as well as full-range manual tuning.

The Model CRX-1 is a narrow-band, triple-conversion FM receiver for 30-50 mc.; the Model CRX-2 is for FM reception from 151-174 mc.; while the Model CRX-3 is a dual-conversion AM receiver tunable over the range of 108-135 mc.

MANUFACTURERS' LITERATURE

PANEL INSTRUMENTS

53 **Weston Instruments Division** has issued a new circular entitled "Stock Panel Instruments" which discusses the features and specifications of a complete line of panel meters available as stock items.

Features of the meters, such as standardization of appearance and construction, self-shielded mechanisms, spring-back jewels, and long-term stability are detailed. Complete dimensions required for specifying are also provided.

TEST & MEASURING EQUIPMENT

54 **Industrial Instruments, Inc.** has issued a condensed, four-page catalogue which provides specifications on a line of electrical/electronic test, measuring, and control equipment. Units illustrated include low-resistance ohmmeters, wide-range megohmmeters, voltage breakdown testers, and resistance and capacitance decades as well as limit bridges and automatic equipment for factory service.

ANTENNA DATA PACKAGE

55 **Hy-Gain Antenna Products** is now offering a package of data sheets covering a comprehensive line of antennas for a wide variety of communications, CB, SWL, and entertainment applications.

Polar patterns, electrical and mechanical specifications, and photographs of the various units are included on the individual sheets comprising the data package.

PHOTOCONDUCTOR PAMPHLET

56 **Sylvania Electric Products Inc.** has issued a new pamphlet which outlines photoconductor characteristics and provides all electrical and mechanical details on the firm's line of photoconductor devices. The pamphlet places special emphasis on the 8100, a device whose spectral response approximates that of the human eye.

TEFLON TERMINALS

57 **Alisco Company** is offering a 12-page easy-to-use reference manual which provides complete engineering data and tabulations for over 500 different types, sizes, and configurations of teflon terminals, including miniature, subminiature, stand-offs, feedthroughs, plugs, and connectors. ▲

PHOTO CREDITS

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48 (bottom)	Don Bosco, Inc.
50, 51	IBM
52, 53	Lavoie Laboratories, Inc.
55, 56	Beckman Instruments, Inc.

Answer to ELECTRONIC CROSSWORDS

(Appearing on page 85)

R	A	P	T	■	E	C	O	■	E	C	H	O
I	D	I	O	■	R	I	P	■	M	H	O	S
D	O	P	P	L	E	R	E	F	F	E	C	T
■	■	E	C	O	■	C	R	O	■	■	■	■
D	E	L	A	Y	■	L	A	G	■	H	A	■
T	R	I	P	■	L	E	T	■	T	A	N	K
C	O	N	S	■	I	C	E	■	A	L	O	E
U	S	E	■	O	N	U	S	■	■	F	D	R
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R	A	D	I	O	R	E	C	E	I	V	E	R
F	L	I	P	■	O	R	O	■	D	E	A	D
C	A	P	S	■	P	S	S	■	E	S	T	■

Instrumenting the Shop
(*Continued from page* 32)

filtered output should be bought so that it can also be used to power transistor and hybrid receivers.

If you go into communications servicing, you will also need a highly accurate high-frequency *frequency meter* and an *FM deviation meter*. The actual types purchased will depend largely on the type of the communications equipment you work with. (For a more complete discussion of needs, see "Test Equipment for Communications Servicing," on page 44 of this issue.)

Industrial Requirements

By the same token, in industrial electronic servicing the kind of specialized instruments you will need will depend largely on the equipment you are servicing. Quite often the instruments you need can be borrowed from the industrial company's lab; but you should have your own high-current "snap-around" *ammeter*, a *stroboscope*, and a sensitive *wavemeter* for checking on the frequency and r.f. leakage of electronic heaters.

Combination Instruments

In many cases, two, three, or even more service instruments can be had in a single case. This often saves both bench space and money, but it also has some drawbacks—especially in a shop with two or three technicians. There the technician using only one of the instruments ties up the others. In some instances—not all—some desirable features of individual instruments are sacrificed in creating the union. Where there are no such sacrifices, the user must weigh for himself the convenience and advantage of integral construction and use, on the one hand, against the possibility that he may want to use certain portions separately.

Deluxe Equipment

Before closing I must mention a couple of more interesting instruments. One, which I shall call a *special TV analyzer*, is a kind of miniature station that generates its own test pattern by using a transparent slide and a flying-spot scanner. By-products of this process are signals and waveforms that duplicate those found at practically every point in a properly operating TV receiver. To use the instrument, you simply substitute the signal or waveform from it for the one that should be appearing in a suspected circuit and observe the effect on the test pattern appearing on the picture tube of the receiver. Available are r.f., i.f., composite sync, a.g.c. pulse, frequency-modulated audio, horizontal and vertical drive, and picture-tube modulation signals. For good measure, the instrument even has a high-voltage-transformer and yoke tester!

The other instrument, an *NTSC standard color-bar and dot generator,* is actually a miniature color TV station that produces an output signal corresponding to one transmitted by a TV station. It has both r.f. and video output. This is the instrument for the perfectionist color-TV technician who can afford it and who has the other high-quality instruments to complement it.

This by no means exhausts the catalogue of service equipment. There is much more, and new instruments are coming on the market weekly; but I have tried to mention the ones my experience has taught me are the most useful in a wide variety of service situations.

Some new technicians become "instrument happy." They spend a disproportionate amount of their capital for complicated, expensive equipment they do not know how to use. They seem to feel that if they just buy enough gadgets, the gadgets somehow will do their service work for them.

Others take the opposite tack. They try to do all their servicing with a beat-up v.o.m. They argue that, if you really know what you are doing, you don't need a great many service instruments.

Both are wrong. Service instruments will never do your thinking for you. They simply collect data and present it to that marvelous computer: the technician's mind. But for that mind to function efficiently and to come up with the right answers the data fed to it must be as exact and precise as possible —which is another way of saying the technician needs the best instruments he can afford and knows how to use! ▲

ADVERTISERS' INDEX

JUNE, 1962

Advertisers listed below with code numbers have additional information available on their products in the form of catalogues and bulletins. To obtain more detailed data, simply circle the proper code number in the coupon below and mail it to the address indicated. We will direct your inquiry to the manufacturer for processing.

The coupon below can also be used to obtain additional information on the new product items shown on pages 98 through 106 as well as on the ads as listed above.

N **6**

VOID AFTER JUNE 30, 1962

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STREET NO. ______________________

CITY ______________ ZONE ______ STATE ______________

ADVERTISED PRODUCTS (SEE INDEX ABOVE)

100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
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MAIL TO **ELECTRONICS WORLD** P.O. BOX 212 VILLAGE STATION NEW YORK 14, N.Y.

INDICATE NUMBER OF ITEMS REQUESTED ☐

Make sure that your name and address are printed clearly.

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- NO RESIDUE
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WORLD'S LARGEST MANUFACTURER OF TELEVISION TUNERS

EXTRA VALUE AT NO EXTRA COST
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The V·O·M with the EXTRAS!

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RCA WV-38A
VOLT-OHM-MILLIAMMETER

- 1.0 volt and 0.25 volt DC ranges!
- Big easy-to-read 5¼" meter!
- Non-breakable plastic case; no glass to crack or shatter!
- Frequency response of low AC ranges is flat within 1 db to 800,000 cycles!
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- Rugged, scuff-proof, stain-resistant laminated vinyl carrying case. Optional equipment. Only $4.95*.

Factory wired and calibrated **$43.95***

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RCA WV-77E
VOLTOHMYST®

Measures AC and DC voltages to 1500 volts; resistance from 0.2 ohm to 1,000 megohms. Separate scales, 1½ volts rms and 4 volts peak-to-peak for accurate low AC measurements, color coded scales for easier readings.

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RCA WV-98B
SENIOR VOLTOHMYST®

Measures AC and DC voltages (3% accuracy full-scale); resistance from 0.2 ohm to 1,000 megohms. Measures peak-to-peak values of complex waveforms. Rugged cast aluminum case, field-tested etched circuits. Big 6½" meter.

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RCA SCOPES

WO-91A 5-INCH OSCILLOSCOPE

High-performance, wide-band oscilloscope especially suited for color-TV, black-and-white TV, and other electronic applications. Dual bandwidth (4.5 Mc with 0.053 volt rms/in. sensitivity and 1.5 Mc with 0.018 volts rms/in. sensitivity). Internal calibrating voltage and calibrated graph screen. Includes special direct/low-cap shielded probe and cable.

Factory wired and calibrated **$239.50***

WO-33A SUPER-PORTABLE OSCILLOSCOPE

A low-cost all-purpose scope you can carry anywhere—only 14 pounds—designed for in-the-home servicing of black-and-white and color-TV, audio and ultrasonic equipment. High gain and wide bandwidth to handle the tough jobs! Rugged and compact—3" graph scale screen.

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complete with low-cap/direct input probe and cable.

KIT ONLY $79.95*

RCA GENERATORS

WR-64A COLOR-BAR DOT/ CROSSHATCH GENERATOR

Gives you all essential Color-TV test patterns; Color-bar signals for checking, adjusting and trouble-shooting Color-TV circuits; dot and crosshatch pattern signals for adjusting convergence in color receivers and for adjusting linearity and overscan in both color and black-and-white receivers. Designed for in-the-home or shop servicing.

Factory wired and calibrated **$189.50***

WA-44C AUDIO GENERATOR

Generates sine and square wave signals for testing audio systems. Frequency range: 20 cps to 200 Kc. Used in the measurement of intermodulation distortion, frequency response, input and output impedances, speaker resonance, speed of recording and playback mechanisms, transient response, phase shift, etc.

Factory wired and calibrated **$98.50***

WR-49B SIGNAL GENERATOR

For alignment and signal tracing of AM, FM and AM/FM receivers, low-frequency signal tracing and alignment of TV vf/if amplifiers. Six ranges—85 Kc to 30 Mc. Internal 400 cps modulation. Low rf signal leakage!

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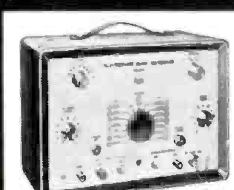

WR-69A TELEVISION/FM SWEEP GENERATOR

For visual alignment and troubleshooting of TV rf/if/vf circuits and other electronic equipment IF/video frequency ranges 50 Kc to 50 Mc, TV channels 2 to 13, plus FM range—88-108 Mc. Sweep width continuously adjustable to 12 Mc.

Factory wired and calibrated **$295.00***

WR-99A CRYSTAL-CALIBRATED MARKER GENERATOR

Supplies a fundamental frequency rf carrier of crystal accuracy for aligning and troubleshooting color-TV, black-and-white TV, FM receivers and other electronic equipment operating in 19 Mc to 260 Mc range.

Factory wired and calibrated **$242.50***

*User Price (Optional)

Every RCA test instrument brings you extra value at no extra cost, and there's one to help you with every job. See your Authorized RCA Test Equipment Distributor for full information on any instrument.

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