Electronics World

OCTOBER, 1963
50 CENTS

ODERN BATTERIES: Types and Applications

)LID-STATE 3-WATT CB-HAM TRANSMITTER

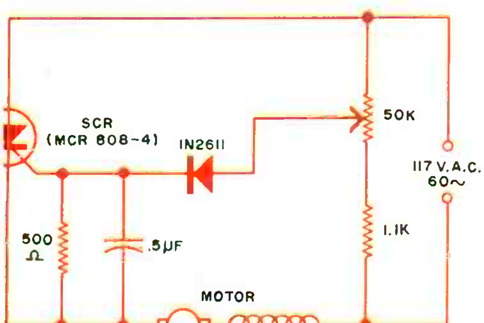
.F. POWER OUTPUT MEASUREMENTS

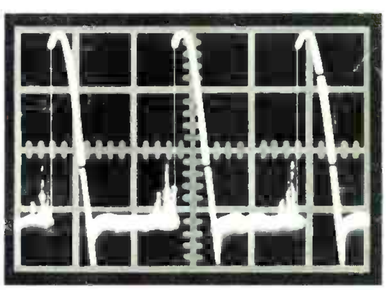
)W TO SELECT A CLOSED-CIRCUIT TV CAMERA

SILICON CONTROLLED RECTIFIERS FOR HOME AND INDUSTRY

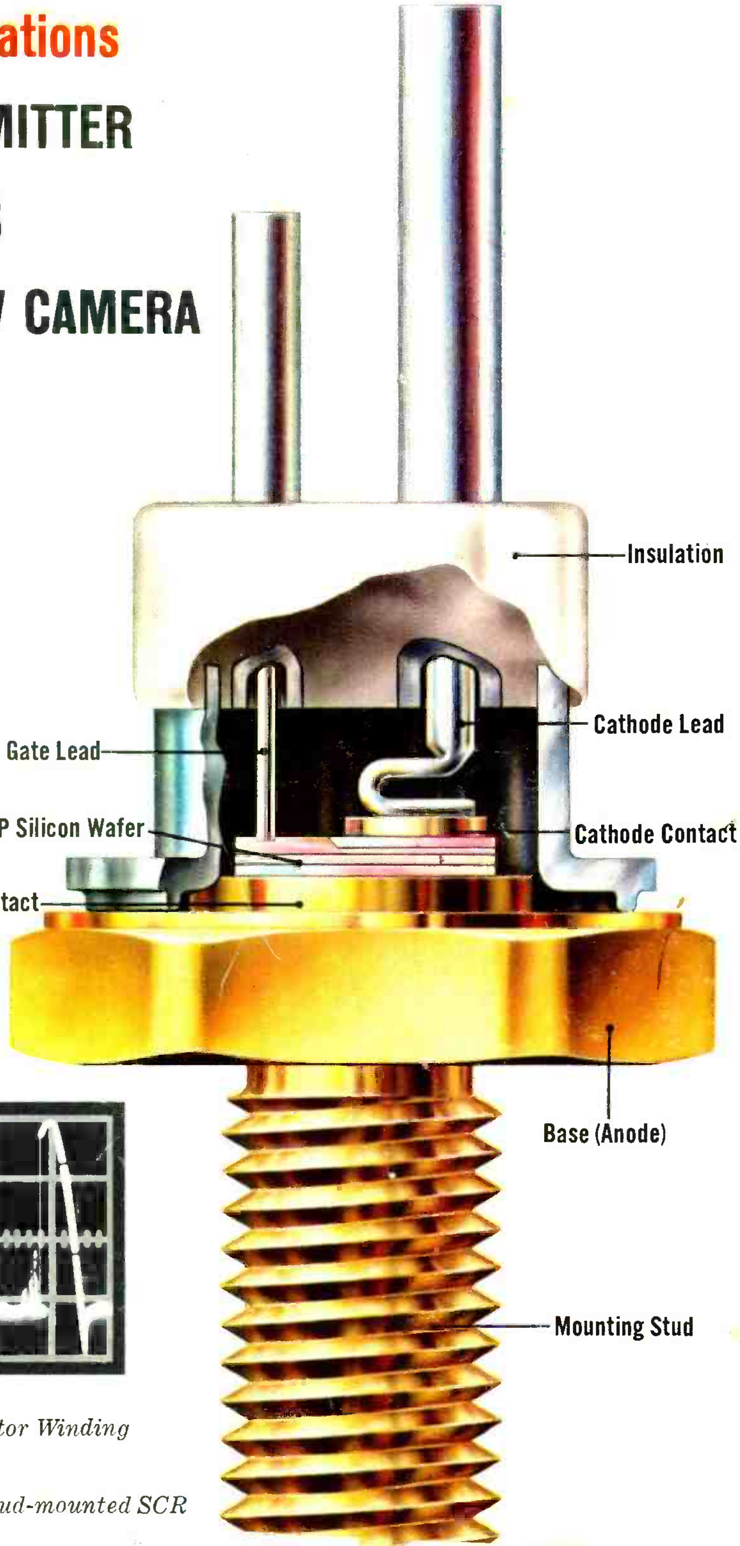
Low-cost Press-fit 18 amp. SCR

Diamond-package 20-25 amp. SCR





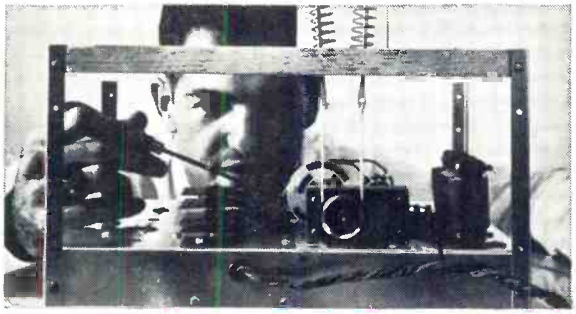
Half-Wave Motor Speed Control Circuit and Waveform Across Motor Winding



Cut-away of Stud-mounted SCR

High-current (300 amp.) Industrial SCR

NCEL-AT-ANY-TIME”
S THE GUESSWORK



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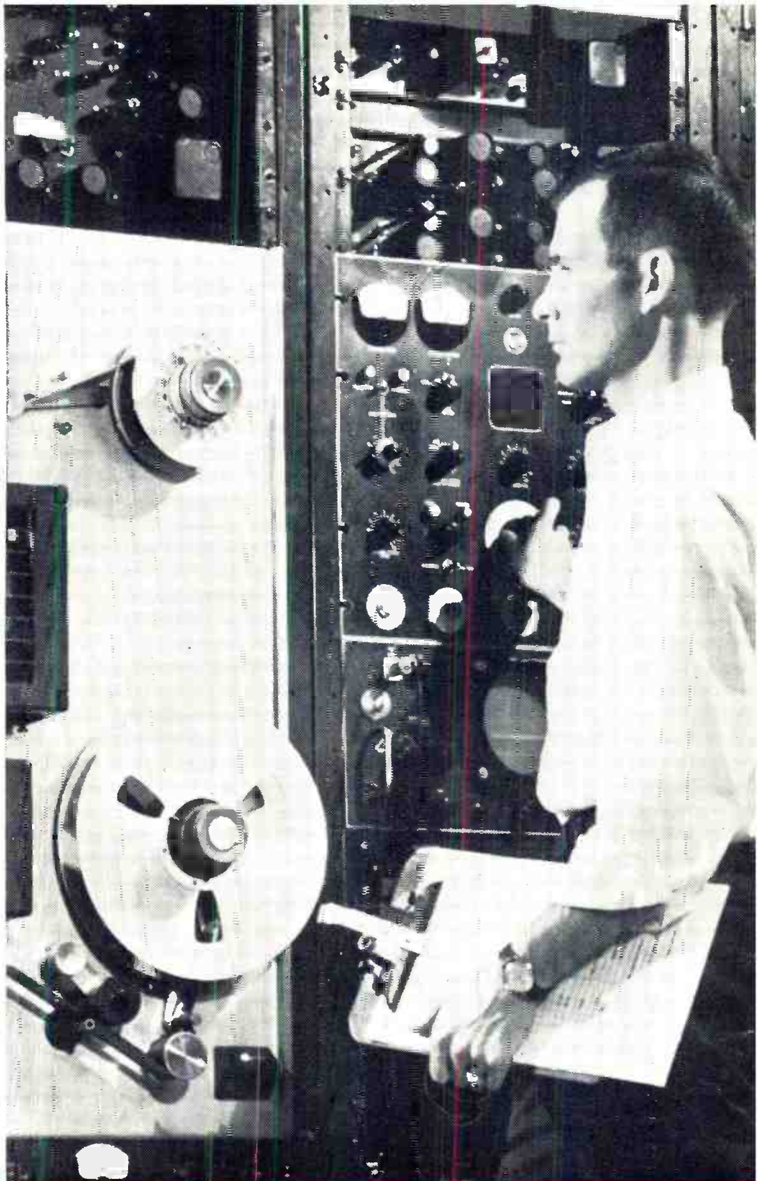

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As a reader of this magazine, you realize what a growing and expanding industry Electronics is today. That's why so many ambitious men are enrolled for NRI's specialized instruction plans. If you are asking yourself, "Am I capable of learning Electronics?" or "Does NRI have the exact training plan I need?"—NRI now makes it possible for you to get the answers *without risk.* NRI's special Cancel-At-Any-Time agreement lets you enroll and start your training *without* obligating you to continue. With NRI you sign an agreement—*not a contract.* If for any reason you decide you do not want to continue your training, all you do is notify NRI and you are not obligated for payments beyond that time. Mail the postage-free form for complete information about NRI's 9 specialized instruction plans and NRI's exclusive Cancel-At-Any-Time agreement.

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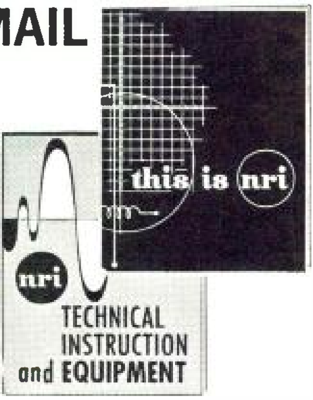

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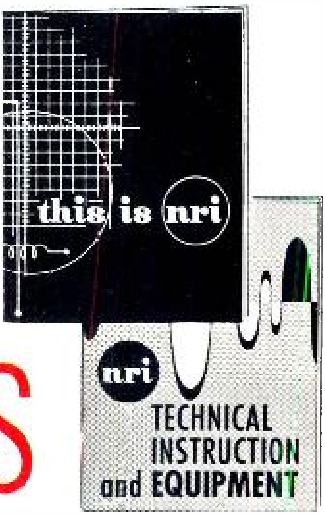

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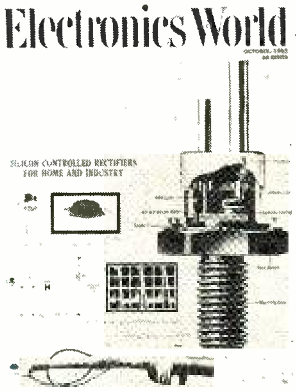
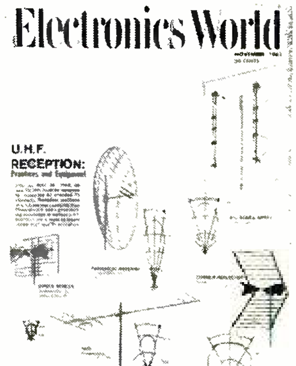
OCTOBER 1963
VOL. 70 NO. 4

MONTHLY FEATURES



OUR COVER shows the internal construction of a much-enlarged stud-mounted silicon controlled rectifier. For clarity we have exaggerated the thickness of the silicon wafer and its contacts. Also shown are two full-sized photos of Motorola's new low-cost and diamond-package SCR's. A circuit using one of these to control the speed of an appliance motor is illustrated along with the output waveform. An example of a high-current industrial type is the 300-amp. G-E SCR at the bottom of our cover. We have shown this unit about ⅔ full size. For details, see story on page 27. . . . . (Cover illustration by Otto E. Markevics.)

COMING NEXT MONTH



JET COMMUNICATIONS
The fact that reliable and precise electronic navigational and communications equipment is so readily available makes jet transport feasible. Without such equipment, jet travel would be neither safe nor practical.

TRANSISTORIZED TACHOMETER
If you are a boating fan or like to act as your own "auto mechanic," here is a compact, portable tachometer with both 0-1250 and 0-5000 rpm ranges which can be built at low cost from standard parts.

WHICH TAPE TO USE?
Measurable performance differences, even though moderate or slight, are significant to the serious recordist. Here is an illuminating report on a sampling of tapes which were compared for response, distortion, and output level. The results may surprise you!

ELECTRONICS LAB TECHNICIAN
What are the duties, responsibilities, technical requirements, and rewards of this important R & D post? An up-to-date survey on the current status.

U.H.F. RECEPTION— PRACTICES & EQUIPMENT
With all-channel TV sets a legal requirement by the end of April 1964, many of the techniques and problems involved will need answers before this deadline. Jack Beever of Jerrold covers much of the ground in this article.

CHOOSING A TWO-WAY RADIO SYSTEM
Before any businessman decides to install a two-way radio system, he must have the answers to questions regarding range, frequencies, and equipment. Part 1 of this two-part series by H. H. Rice of Motorola outlines these basics while Part 2 will cover specific recommendations.

PHASEMETER FOR A.F.
If you need a lab type instrument for evaluating performance of amplifiers, preamps, crossovers, etc., try this tested circuit for a meter covering the 20-50,000 cps range.

All these and many more interesting and informative articles will be yours in the NOVEMBER issue of ELECTRONICS WORLD . . . on sale Oct. 17th.

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Dick Nyholm, Radio & TV, 108 N. Lower Ave., Centralia, Washington

"Television antennas represent an important part of my business. Since handling Winegard Colortrons, my business has increased greatly. Seems that one person tells another and your advertising also pays off."

Edwin L. Fisher, Fisher Appliances, Inc., 107 N. E. Front Street, Milford, Delaware

"During the thirty-one years I have been in the Radio and Appliance business few new items have been so immediately successful as your Colortron antenna.

"Our sales of color television testify that your new Colortron antenna has been the answer. In fact we will not sell a customer if they are not willing to install a proper type antenna to operate the new color set.

"Hoping this letter will encourage you to further efforts in developing more new products."

Ken Kesler, Electromatic, Inc., 237 N. E. Broadway, Portland 12, Oregon

"We have used the Winegard assortment of antennas for over three years and find that whatever situation we encounter, Winegard has the answer.

"We have been especially pleased with the WINEGARD COLORTRON which we have used extensively since Color TV has come into its own."

Ray Summers, Ray Summers, Inc., Louisville, Illinois

"We live in an area which has the poorest television reception in the State of Illinois. There are no stations closer than 100 miles. Our TV and antenna sales have more than doubled since using the Winegard Colortron as it has improved reception to the point where we can get good reception from several channels."

George W. Terry, Terry's Electric, McLean, Texas

"I am so pleased with the new Winegard Colortron antennas that I would like to tell you about the reception we have here in McLean, Texas.

"We have these antennas as far as 100 miles from our local stations in Amarillo, Texas and the customers are overjoyed with the reception.

"We have installed over 200 Winegard Powertrons and Colortrons on a money back guarantee. As yet we haven't had the return of even one antenna!"

Twin City Radio & TV, Inc., 97 National Avenue, Chehalis, Washington

"We are especially pleased with Winegard Colortrons and the Nuvistor amplifier is the best by far. Keep up the great engineering and your fine advertising-both help us sell more antennas and boosters."

THEY SAY IT BETTER THAN

Some of America's leading dealers tell why they think Winegard Colortrons are

Dave Tucker, Avon Television Co., 189 Bway, Amityville, New York

"We here at Avon T.V. have used many different antennas for our color installations and have found that for best all around results in color as well as black and white reception the Winegard Colortron is superior in every respect."

Roy Sahlin, Central Television & Appliance, 911 Chehalis Ave., Chehalis, Washington

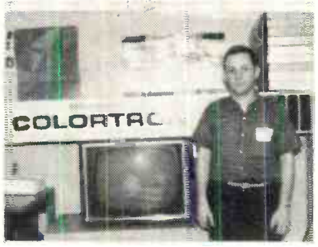
"Finest piece of equipment we have worked with in electronic field. The Winegard Colortron and all Winegard products have no competition."

Charles Dumaine, Dumaine Antenna Service, 735 Woodtick Road, Waterbury, Conn.

"Among the top three antennas I have found it to be the best for any reception. The AP220N Nuvistor Amplifier is tremendous in controlling both high and low channels; eliminating all types of interference. Being an exclusive Winegard dealer, I make between 30 to 40 installations per week of the Winegard Colortron and Amplifier. The people for whom the installations were made are all well satisfied with the performance; bringing more business my way than I can handle."

J. C. McNiven, The Gester-McNiven Co., 305 N. Tower, Centralia, Washington

"We feature Winegard Colortrons because they have helped us immeasurably to sell more color sets. They really bring in a magnificent color picture and black and white is also the best. Finest antenna on the market, and we've tried them all."



William D. Miles, Miles Electronic Co., Baxley, Georgia

"We are over one hundred miles from the nearest commercial station. We have tried most of the so-called color antennas. Thanks to Winegard's high signal-to-noise ratio and high directivity Winegard is the only acceptable antenna-booster combination which was found to meet our 'customer's satisfaction' requirements. Beautiful color is being received now with the Colortron."

Walter Finkbeiner, 107 New Jersey Ave., Absecon, New Jersey

"I have found the Winegard Colortron and Electronic Power Pack to be the most powerful antenna in our fringe area. Colortron antennas make a perfect combination with our Admiral Color television installations.

"I install Colortrons on trial and have not lost a sale to date."

Leonard P. Hellenthal, Nielsen & Neilson, Inc., 1462 Glendale Blvd., Los Angeles 26, California

"I am extremely happy to inform you that we have been a constant user of the Winegard line of antennas and related products for six or seven years.

"We are now moving into the Colortron series which we find to be another added improvement in new type hardware and improved over-all performance.

"As you know, our clients in this area consist of many television and movie stars as well as prominent city officials. We are, therefore, of necessity, quite concerned about the equipment we use and its performance. We are looking forward to future success with this newer series of antennas and amplifiers."

G. Borders, Borders Radio & TV Service, Flora, Illinois

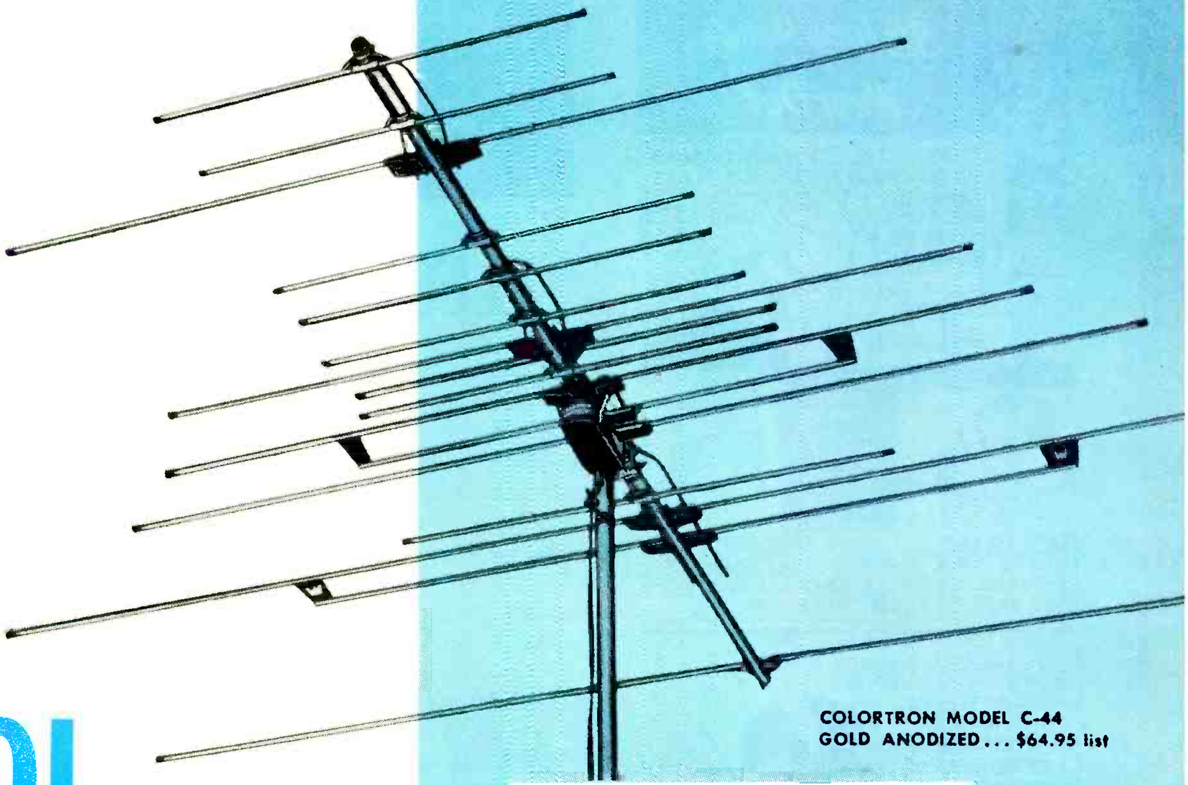
"In my opinion, the Winegard Electronic Antenna is perhaps the finest piece of equipment I have worked with in the last thirty years."

J. A. Etchison, Etchison Brothers Appliances, Flora, Illinois

"The new Winegard Colortron with the twin nuvistor amplifier permits us to give our customers the best television reception ever!"

Berkeley M. Phelps, TV & Radio Repair, Washing on Depot, Conn.

"The high gain of Winegard antennas and boosters give the customer excellent pictures on channels that were not usable before. Winegard equipment does not require sales pressure —seeing is believing!"



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the world's finest TV antennas...

Jack Ross, Smith's Home Furnishings, Portland 2, Oregon

"This is hilly country, with lots of tall trees. We install and service thousands of sets a year. We've found many real problem areas—where only a Winegard Colortron antenna with Nuvistor amplifier will pull in the kind of picture a set owner has the right to expect. We recommend Colortron to our customers — especially to the many people now buying Color TV."

If you haven't tried Winegard Colortron antennas or Colortron Nuvistor amplifiers, we hope you will try a few soon.

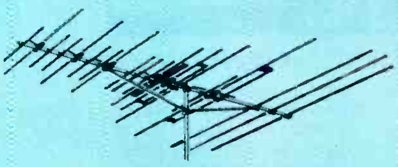
We feel confident there is nothing on the market that can match them for performance and quality. Write for technical bulletins or ask your Winegard distributor.

David B. Newman, Radio Service Co., 262 Ninth St., Astoria, Oregon

"With the new Colortron TV antenna and Stereotron FM antenna and matching Nuvistor boosters we have obtained excellent reception of the Portland, Oregon TV and FM stations. We are 100 miles from Portland with the coast range of hills between us. We also obtain good results from Seattle, 150 miles away. These are the finest antennas on the market today!"

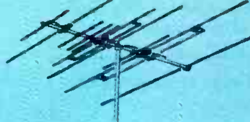
Takes up to 400,000 Micro-volts input—Model AP-200N $39.95 list

COLORTRON Twin Nuvistor AMPLIFIER



MODEL C-43 $51.90 list

MODEL C-42 $34.95 list



MODEL C-41 $24.95 list

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For the record

WM. A. STOCKLIN, EDITOR

ELECTRONICS IN THE HOME

THE electronics industry recently received a challenge worthy of further comment. L. Berkeley Davis, vice-president of the *General Electric Co.*, accepting the Medal of Honor Award of the Electronic Industries Association at its 39th Annual Convention, challenged the industry to invent a new home product comparable to radio and television.

In elaborating on his proposal for a new product search, Mr. Davis observed that the electronics industry "must offer the consumer something else that the American home will need. I don't know what it is," he said, "but I challenge you to find it. The electronics industry can and must develop a new device to make home life easier and more pleasant."

The electronics industry today is a \$13-billion industry and Mr. Davis forecasts that this will increase to \$21-billion in the next two years, then to \$22.5-billion by 1970 and to \$34-billion by 1975.

Growth in the industrial and military electronics areas seems to be assured over this period. However, in the consumer-products field there must be greater creative effort in developing new products in order to show any appreciable growth in the future.

It seems inconceivable that the industry could ever again develop a single product with an impact comparable to that which our present TV set has had. All is not lost, however, since there are many products, both in and out of the laboratories today that, as a group, could surpass our present radio and TV industry. There is no reason why we couldn't develop an "All-electronic Home of the Future."

It would employ:

Electronic Cooking: In addition to the radar range, what about induction heating for keeping food warm?

Electronic Refrigeration and Cooling: Thermocouple devices can be used.

Ultrasonic Washers: For clothes, dishes, and perhaps for bathing?

Cordless Telephones: Could work on the already familiar induction principle.

Solar Panels: Could operate many small appliances.

Electroluminescent Lighting: Although light level is still too low, the future holds great promise.

Electronic Light Dimmers: The silicon controlled rectifier is already playing a role in this area today.

Electronic Precipitators: Could clear house of cooking and tobacco odors.

Ultrasonic Tools: Drills and scrapers for example.

Radio-Controlled Toys: Particularly for bedridden children.

Cordless Power Tools: Particularly suited for outdoor use.

Tape Recorders: To record and playback pictures and sound on your TV set.

Fuel Cell Power Supplies: Particularly suited for picnics.

Three-Dimensional TV.

TV on the Wall: Using flat picture tubes.

Although all of these devices are being worked on today to some extent, no single manufacturer is working on all of them. We feel sure that Mr. Davis had in mind a new item or group of similar devices that would be ideally suited to the radio and television set manufacturer. Unfortunately, this is hard to come by. But couldn't set manufacturers diversify their operations and develop the "electronic home" theme? Or perhaps it takes a company that is more diversified than one that simply manufacturers radio and TV sets alone. Such companies as *RCA*, *G-E*, and *Westinghouse* — who make many home appliances other than radio and TV sets—have already started to move in this direction.

It actually would require the facilities of quite a large and diversified company in order to advertise and promote this theme. Remember when owning the only TV set on the block was such a status symbol? Perhaps owning the "All-electronic Home of the Future" will be tomorrow's status symbol for the home-owner of the future. ▲

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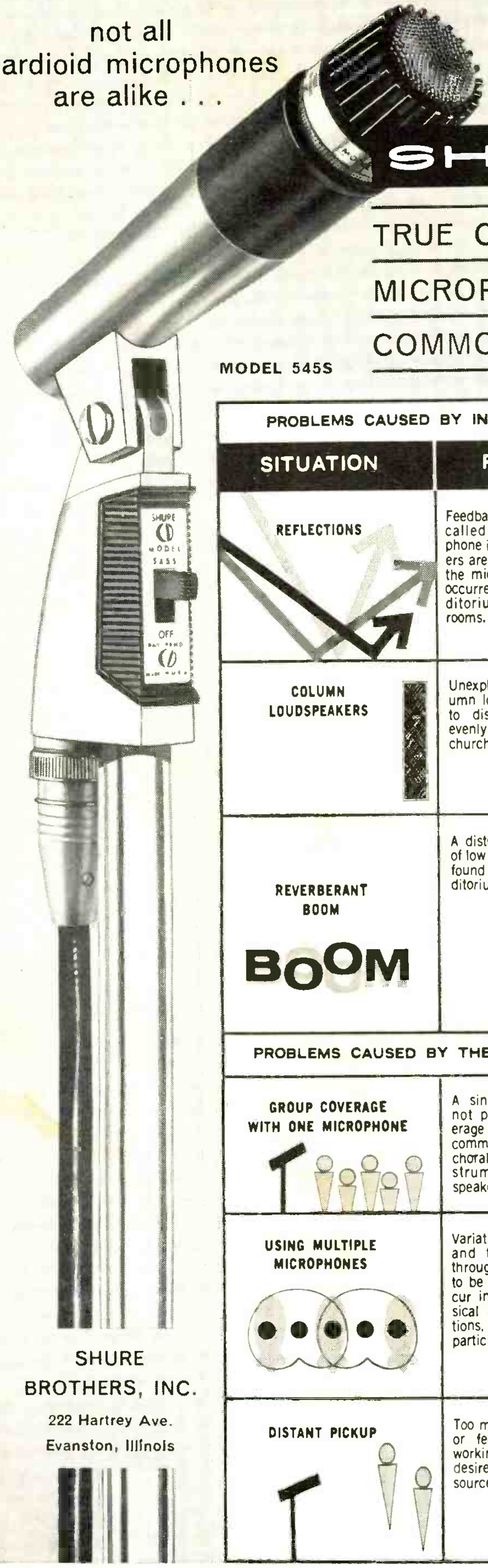
cardioid microphones
are alike . . .



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SHURE UNIDYNE III

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

MODEL 545S

PROBLEMS CAUSED BY INEFFICIENT REJECTION OF UNWANTED SOUNDS BY THE MICROPHONE

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

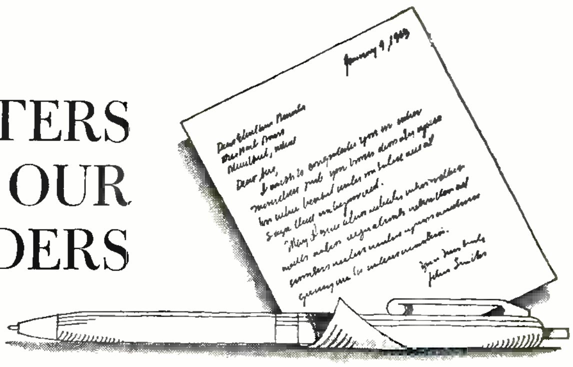
PROBLEMS CAUSED BY THE MICROPHONE'S INEFFECTIVENESS IN PICKING UP THE DESIRED SOUND

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

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

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

LETTERS FROM OUR READERS



TECHNICAL WRITERS

To the Editors:

The article by Cyrus Glickstein on potential electronic technical writers (May issue) was both interesting and informative. I would, however, like to be given the opportunity to comment on one or two points that Mr. Glickstein made and briefly cover one other area of military writing that he did not mention.

In discussing military technical writing, job opportunities at equipment manufacturers, technical writing firms, and contract job shops were covered. Nothing, however, was said about the military technical writing career available in the Federal Government. Military technical writers in the Government enjoy many advantages not available in commercial organizations. These include:

a. Working with the ultimate user (hence finding out how the product is received after ultimate completion).

b. Job security and above-average fringe benefits, pay scales from $4565 to $12,620 for the tyro up to the senior writer. Supervisory positions have pay scales that range from $11,150 to $19,270.

c. Military writers work very closely with their colleagues in the engineering areas and are exposed to a wide variety of equipments and hence subject-matter disciplines.

Addressing attention to the disadvantages of military technical writing cited by Mr. Glickstein, *i.e.*, very little direct contact with equipment and standardized format—in Federal employment the converse is generally true. Our writers are required to work with the equipment to generate procedural information and their efforts are later verified against the equipment by a verification team before a book is given final approval. As to standardized format, Government-prepared technical manuals, and training manuals for that matter, are written to many different types of formats with informal users' brochures including cartoon treatment and very simplified explanations of technical equipment.

All the foregoing, coupled with the fact that the Government writer has numerous opportunities to travel to interesting (and, to be honest, some uninteresting) parts of the country, makes the grass look pretty green on this side of the fence and we would hope that your readers, in considering technical writing as a profession, will give serious thought to the advantages of working for one of the activities of the United States Government.

H. L. SHIMBERG, Chief
Publications Division
U. S. Naval Ordnance Laboratory
White Oak
Silver Spring, Maryland

* * *

ELECTRON MICROSCOPY

To the Editors:

With reference to the article "Advances in Electron Microscopy" by Ken Gilmore (July 1963 issue), may we call your attention to the fact that some of the information quoted is not quite accurate.

On page 21, Mr. Gilmore states that Ernst Abbe was a British scientist. Enclosed is a publication of our principals in Germany, on page 10 of which you will find a history of our factory and Ernst Abbe.

May we point out that the wavelengths of visible light are between 4000 and 7000 angstrom units. Light microscopes, that is, microscopes with glass lenses, can only operate in the range between 3500 and 7000 angstrom units. The lower limit is determined by the absorption of the glass lens or lenses, and the upper limit is given by the sensitivity of the human eye. The so-called ultraviolet light microscopy is applicable between 2400 and 3800 angstrom units.

The first electron microscope with electrostatic lenses which produced an image of the cathode was developed in the AEG Research Institute in Berlin in the early '30's. This instrument can still be seen in the Deutsches Museum, Munich. The inventor of the electrostatic lens is Dr. Mahl and the inventor of the electromagnetic lens is Dr. Ruska, both working in the same Institute.

The formation of the electron image depends on the varying speeds of the electrons after having passed the specimen. The absorption of the electrons should be prevented, as much as possible, because of the increase of the temperature and damage to the specimen. Electrons with different speeds or

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TRANSISTOR RADIO ANALYST

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Complete Transistor Radio Service Shop in One Instrument

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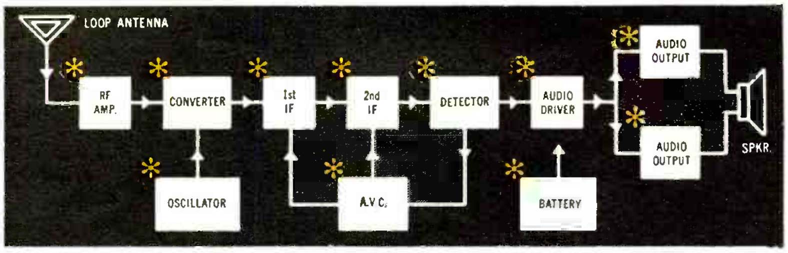
Check all circuits - Pinpoint any trouble ... in minutes

Now you *can profit* from transistor radio servicing! This amazing new B&K "960" ANALYST gives you *everything* in *one* complete easy-to-use instrument. Makes transistor radio servicing *quick and easy*. Nothing else is needed except the transistor radios themselves waiting to be serviced. Brings you new customers for service, parts, and batteries. Makes this new business *yours*.



EASILY TROUBLE-SHOOT ANY STAGE BY UNIQUE POINT-TO-POINT SIGNAL INJECTION

The ANALYST gives you a complete signal-generating source for point-to-point signal injection. Easily enables you to trouble-shoot any transistor radio—check all circuits stage-by-stage—isolate and pinpoint the exact trouble in minutes.

Supplies modulated signals, with adjustable control, to check r.f., i.f., converter, and detector. Supplies audio signal to check audio driver and audio output. Provides unmodulated signal to test local oscillator. Provides separate audio low-impedance output for signal injection into loudspeaker voice coils to check speaker performance.

BUILT-IN METERED POWER SUPPLY FOR EASY SERVICING

Makes it easy to operate radio under test, while you inject your own signals. Provides from 1 to 12 volts in 1½ volt steps. Supplies all bias taps that may be required.

SIMPLIFIES IN-CIRCUIT TRANSISTOR TEST WITH NEW DYNA-TRACE SINGLE-POINT PROBE

Unique single-point probe needs only the one contact to transistor under test. No longer are three wires required to connect to emitter, base, and collector. Gives fast, positive meter indication. Saves time. Makes trouble-shooting simple and easy.

BUILT-IN VTVM

Includes high-input-impedance vacuum-tube voltmeter, which is so necessary for transistor radio servicing.

TESTS ALL TRANSISTORS OUT-OF-CIRCUIT

Meter has "Good-Bad" scale for *both* leakage and beta. Also has direct-reading Beta scale, calibrated 0-150. Assures quick, accurate test. Also automatically determines whether transistor is NPN or PNP. Meter is protected against accidental overload and burn-out.

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CIRCLE NO. 107 ON READER SERVICE PAGE

velocities give different focal planes, and the so-called contrast diaphragm or objective aperture diaphragm will catch the electrons with the lowest speed.

Whether a specimen can be seen or not depends not only on the thickness, but also on the atomic weight of the material. Therefore, an organic specimen, for example, can be "shadowed" with heavy metals and the surface can be examined much better. The platinum layer of more than 25 angstrom units is absolutely non-transparent for electrons.

Dr. W. E. Degenhard
Scientific Director
Carl Zeiss, Inc.
New York, N. Y.

According to the interesting booklet that Dr. Degenhard sent along with his letter:

"The firm of Carl Zeiss was founded in 1846 by Carl Zeiss, a mechanic in the University of Jena [in Germany] . . . Zeiss impressed the physicist Ernst Abbe, then professor at the University of Jena, with his ideas. After many years of painstaking research, Professor Abbe succeeded in establishing the mathematical formulas for computing microscopic objectives, an achievement recognized by science as fundamental since it created the basis for the development of the optical industry. Ever since, all optical instruments throughout the world are manufactured in accordance with the mathematical formulas computed by Ernst Abbe."

Thanks also to Dr. Henry E. Puro, of the Detroit Dept. of Health, and other readers, including one who worked for Professor Abbe, for correcting us.—Editors.

* * *

OSCILLOSCOPE PHOTOGRAPHY

To the Editors:

In an informative article on oscilloscope cameras in the March issue of your magazine, the author mentions the disadvantage of the *DuMont* Model 302 camera in reversing the scope trace. Being familiar with the techniques of photographing a myriad of waveforms using the instrument that is attached to the camera in question, the reversal problem can be eliminated easily. Simply invert the waveform with the normal-invert switch that is mounted on the plug-in amplifier. If a normal-invert switch is not contained in the oscilloscope, merely reverse the input leads to the vertical amplifier and place the input on d.c. (direct coupled).

Paul J. Rosa
Stamford, Conn.

Here's a case where two wrongs do make a right. The mirror reverses the photo for the camera, but the technique suggested by Reader Rosa brings the pattern aright again.—Editors. ▲

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NEW!

UCS-6 CS-4 CS-3 CSO-6

The Big Plus—Uniline Sound Columns

Performance is the big plus when you install University Uniline Sound Columns. Unlike conventional columns, Uniline employs specially-designed speakers with higher power handling capacity. "Acoustic-Tapering — *another University exclusive*, prevents excessive high frequency beaming and assures a uniform sound volume within its fan or beam. The result—higher intelligibility, optimum sound dispersion at all frequencies, greater listening comfort. All individuals hear the same sound! The table below shows complete specifications for all Uniline Sound Columns, including the new weatherproof model CSO-6 for outdoor installation. For complete PA Loudspeaker Catalog, write Desk S-10.

	UCS-6 Full Range Music and Speech	CS-4 Full Range Music and Speech	CS-3 Music and Speech	CSO-6 Full Range Music and Speech
speakers	6 extended range 8"	4 extended range 8"	8 special multi-design	6 extended range 8"
frequency range	55—17,000 cps	70—17,000 cps	150—10,000 cps	55—17,000 cps
power capacity	150 watts IPM*	80 watts IPM*	25 watts IPM*	150 watts IPM*
impedance	16 ohms	8 ohms	16 ohms	16 ohms
vertical angle	16°	22°	22°	30°
horizontal angle	120°	120°	120°	120°
dimensions	59¼" x 10⅞" x 9 1/16"	40⅜" x 11" x 9 1/16"	48" x 7½" x 8¾"	60¼" x 11⅞" x 7¾"
shipping wt., lbs.	61	46	33	61

*Integrated program material.

UNIVERSITY LOUDSPEAKERS *Division of Ling-Temco-Vought*, Oklahoma City, Oklahoma

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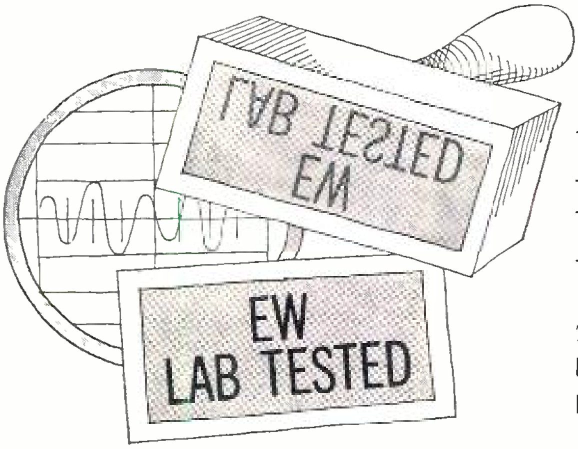


HI-FI PRODUCT REPORT

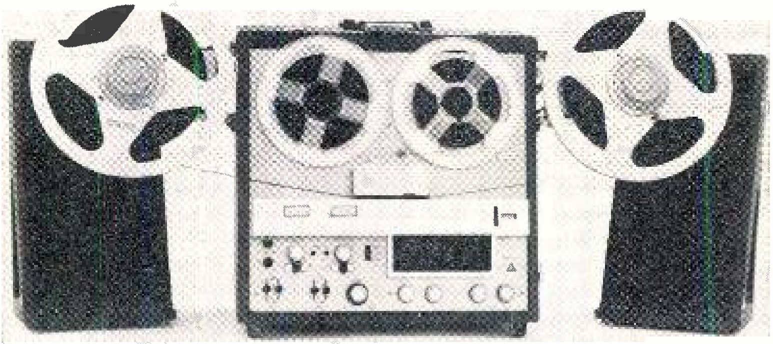
TESTED BY HIRSCH-HOUCK LABS

Bell RT-360 "Professional" Tape Recorder

Koss "PRO-4" Stereo Headphones

Bell RT-360 "Professional" Tape Recorder

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



THE *Bell* RT-360 "Professional" tape recorder is a two-speed machine (3.75 and 7.5 ips) with three motors. It has electro-dynamic braking, using a d.c. current through the motor windings to stop the tape smoothly. There are no belts or clutches which might require periodic maintenance. Possibly the most interesting feature of this new recorder is its ability to copy tapes without the need for an additional playback deck. We will discuss this in detail later in this report.

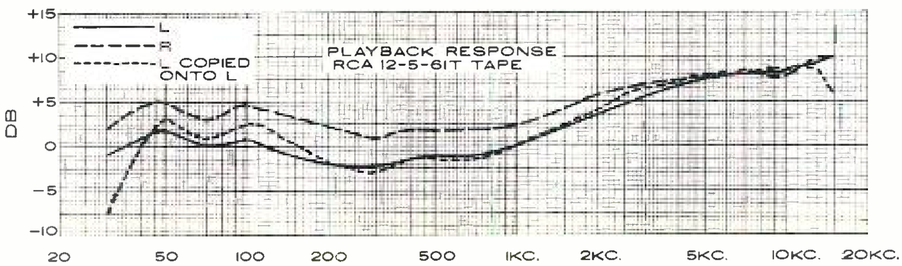
The recorder is equipped with three separate sets of stereo heads, as well as separate recording and playback amplifiers. A full complement of controls, in duplicate for the two channels, provides for input selection (microphone, auxiliary, and magnetic phono cartridge) and monitoring from input or from the tape playback heads, as well as playing mono tapes through both channels. There are separate recording and playback level controls, recording equalization selectors, and two illuminated level meters, which read both recording and playback levels.

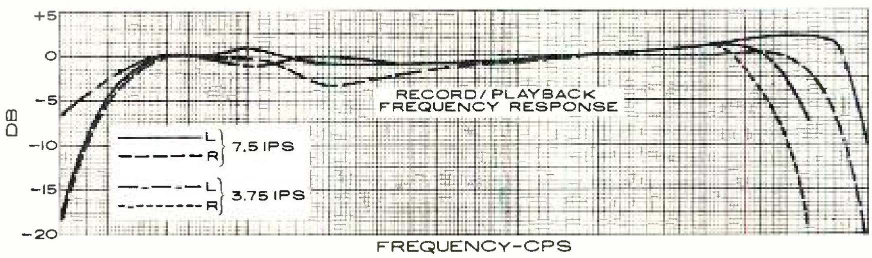
In addition to high-impedance outputs from the playback amplifiers, the recorder has a built-in dual 8-watt amplifier, with its own volume and tone controls. Two detachable 6" x 9" monitor speakers, which form the cover of the portable carrying case, can be separated by as much as 12 feet with the cables supplied. External speaker systems can also be driven. A jack is supplied for plugging in either low-impedance or high-impedance stereo headphones. A switch cuts off the speakers whenever headphones are employed, if desired.

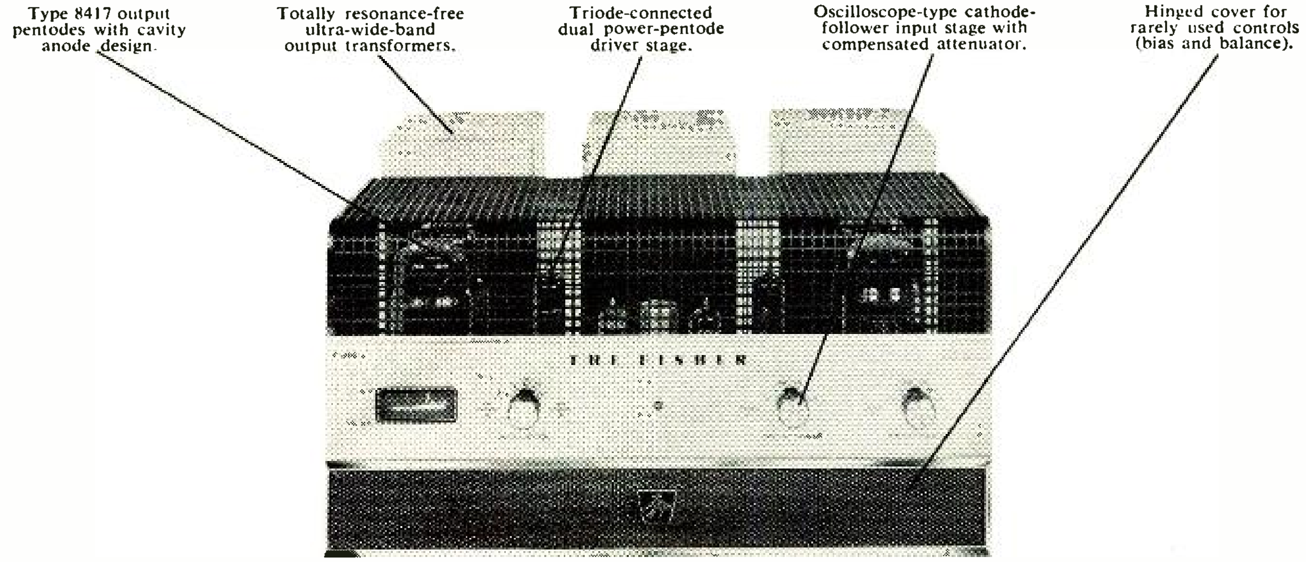
The transport operation is controlled by a group of seven "piano-key" push-buttons. The "Standby" button turns on the motors and amplifiers and must be operated before switching from any mode of operation to any other. Two buttons select the desired tape speed. The "Run" button places the tape in normal motion. The usual "Fast Forward" and "Rewind" functions are included. An "Off" button shuts off the entire unit.

The RT-360 has a small red slide switch with positions marked "Normal," "Duo-Sound," and "Duplicate/Echo." In the "Duo-Sound" position, a portion of the output of one playback amplifier may be fed to the input of the other channel's recording amplifier. This gives a delayed echo-like effect, which is intended to impart a pseudo-stereo character to mono recordings. In the "Duplicate/Echo" position, a portion of each playback amplifier output is fed to the recording input of the same channel. This adds a controllable amount of echo to the recordings.

Thus far, the unit would seem to be a machine of better-than-average flexibility. Adding the optional Model DK-1 motor accessory kit broadens its usefulness still more. These are outboard reel motors, which can be operated either alone or with the normal reel motors. Standard 10½" NAB reels can be mounted on the Model DK-1 motors by means of accessory hubs which are also available. The index counter is the only portion of the normal recorder which is



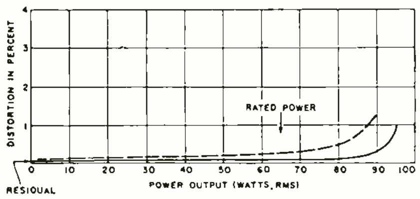




150 Watts of the cleanest audio power ever produced!

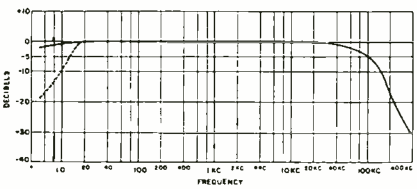
The Fisher K-1000 is a challenge to the severest critics and most discriminating judges of professional sound reproducing equipment, both as to specifications and listening quality. Its music power rating is 150 watts IHF Standard, with *both* channels driven. The RMS power rating, again with both channels driven, is 130 watts (65 watts per channel). However, as a glance at the intermodulation curve will show, each channel will deliver 80 watts at 0.5% IM distortion, thus indicating the extreme conservativeness of the official rating.

Total Harmonic Distortion at 1 kc: Solid Line Intermodulation Distortion (60 cps/7 kc, 4:1): Dotted Line



The output stage of the K-1000 is engineered around the newly developed 8417 beam power pentodes, *never before used in any electronic device.* Designed specifically for use in this amplifier, the 8417 offers extreme linearity, resulting in greatly reduced distortion, and has unusually low drive-voltage requirements, permitting the previous stages to 'coast' at their lowest possible distortion levels. The unique *cavity anode* design of the 8417 is an important factor of its superior performance characteristics.

Frequency Response (0 db = 4 watts)
Subsonic Filter: Dotted Line



Each pair of 8417's in the K-1000 drives a giant output transformer via plate-cathode coupling – a modified and improved 'ultra-linear' configuration that provides 12 db of the most desirable and stable type of negative feedback in the output stage. The custom-wound output transformers are unlike all others in that their response rolls off below 5 cps and above 200 kc without the slightest peaks or dips. (See the frequency response curve.) This results in exceptional stability and superb square wave reproduction.

The driver stage, too, is entirely novel. A triode-connected 6HU8 / ELL80 dual power pentode circuit developed by Fisher engineers is capable of delivering 40% more drive to the output stage than is required – and at a remarkably low impedance. The result is very low distortion, the fastest possible recovery time, great stability and hence outstanding transient response.

For the pre-driver and phase inverter stage, an ECC83/12AX7 dual triode is used in a DC-coupled cathodyne configuration characterized by extremely low distortion and phase shift. A feedback loop from the output transformer secondary to the pre-driver cathode provides 17 db of distortion-reducing feedback.

The input stage of the K-1000 is of a type widely used in laboratory oscilloscopes but never before in high-fidelity amplifiers. A compensated input attenuator in conjunction with a cathode-follower circuit permits adjustment of the input signal from 0 db to –12 db in closely calibrated 3 db steps without the slightest effect on input impedance and frequency response. This feature in effect provides five different input sensitivities, ranging from 0.5 to 2.0 volts (for full rated RMS output), so that the preamplifier volume control can be operated strictly within its optimum range.

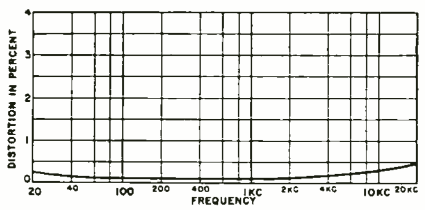
A switchable subsonic filter has also been designed into the input stage, in keeping with the widely held engineering opinion that, for the majority of practical applications, response should be flat down to 20 cps only and then fall off as rapidly as possible. (See dotted part of frequency response curve.)

The power supply of the K-1000 is one of the most elaborate ever used in a stereo power amplier. Regulation and filtering are of the highest order and all silicon diodes as well as filter capacitors are most conservatively operated.

Bias is readily adjustable on each channel by means of the built-in laboratory-type calibration meter, but the controls for these rarely needed adjustments are ingeniously concealed behind an attractive hinged cover – another Fisher exclusive.

Now you can be sure your home-built unit will perform as perfectly as though it were factory-wired. Fisher has devised what is now the **StrataBalance Technique†**, a simple testing procedure which, by the use of an ordinary light bulb, enables the builder to attain precise and absolute balance of the push-pull circuitry of the K-1000.

Total Harmonic Distortion (One Channel) at 65 watts RMS
(Note that from 20 cps to 10 kc distortion does not rise above ¼% even at maximum rated power.)



The K-1000 StrataKit is priced at only \$279.50*. It is also available factory-wired as the SA-1000, priced at only \$329.50*. Both carry the famous Fisher Warranty for all tubes, diodes and parts for a period of one year from date of purchase.

FREE! \$1.00 VALUE!
The Kit Builder's Manual, a new illustrated guide to high fidelity kit construction.

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The Fisher

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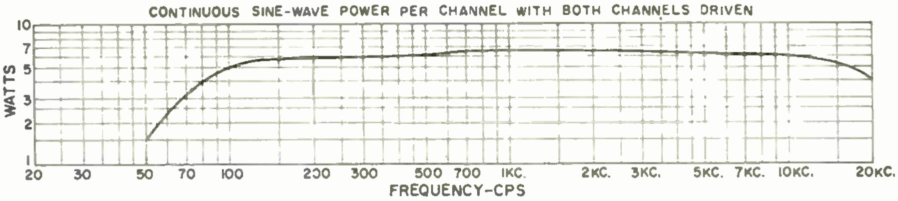


not operative when using the outboard motors.

To copy a tape, the original tape is placed on the regular reel hubs and threaded over special guides so that it contacts only the playback heads. The blank tape is mounted on the Model DK-1 reel motors and passed through the tape guides against the erase and record heads but bypassing the playback heads. Both tapes pass between the capstan and its idler wheel. By suitably adjusting the recorder's controls, the original tape is copied onto the reel of blank tape that is being used.

Playing back the *RCA* 12-T-61T 7.5-ips standard tape, the recorder showed a response within ±2 db from 30 to about 1500 cps, rising to about +10 db at 15,000 cps relative to the 1000-cps level. The over-all record/playback response at 7.5 ips, using Type 1861 "LR" *Audiotape*, was flat within ±2 db from 35 to 17,000 cps on one channel and to 13,000 cps on the other channel. The difference was apparently due to a variation in head-gap alignment on the two channels. The playback and record heads were aligned for best response on one channel. When the channel responses are balanced, the upper limit would be about 15,000 cps. At 3.75 ips, the record/playback response was within ±2 db from 28 to 10,000 cps on the better channel, which is still a very good response for this tape speed.

The wow and flutter were, respectively, 0.08% and 0.31% at 7.5 ips and 0.06% and 0.2% at 3.75 ips. The signal-to-noise ratio was 47.5 db with the "noise" being largely a little 60-cps residual hum.

The amplifiers had a very flat response and delivered 6.5 watts per channel with both channels driven, or 8 watts with only one channel operating. Their low-frequency power capability was very limited, resulting in high IM distortion with the standard SMPTE low-frequency signal of 60 cps. This was not particularly audible in the small monitor speakers, which sounded about as good as most such speakers incorporated in portable tape recorders for home use.

The magnetic phono cartridge inputs apparently have little or no equalization, depending on the cartridge inductance for much of the playback equalization. This limits its usefulness to a few cartridges with appreciable inductance and a high output of at least 12 millivolts. The "Aux" and microphone inputs have equal (and high) sensitivities of 3 millivolts. The "Aux" inputs have level adjustments which enable them to accommodate signals of 1 volt or more without overloading the input circuitry.

We used the accessory Model DK-1 motors to copy our *RCA* test tape and measured the response playing back the copy. This proved to be almost identical to the original, except for a slight loss below 40 cps and above 13,000 cps. On music tapes there was no audible difference between the original and copy tapes.

The over-all listening quality of the *Bell* RT-360 was very good, with only a slight increase in hiss level and brilliance distinguishing the recorded from the original. The "Duo-Sound" seemed to confuse the sound and did not, in any sense, impart a feeling of stereophony. Moderate amounts of echo, when added, were occasionally beneficial. Its unique usefulness as a tape-copying system, plus its generally high level of performance, make this recorder an interesting addition to any good music system. Our chief criticism of its operation is that the recording switching does not automatically shut off. It is easy to accidentally erase a new recording on its first playback, in spite of the two red recording warning lights. The "piano-key" buttons which work well also require a rather high pressure in order to operate them.

The price of the basic recorder unit is $449.95 while the price of the optional motor kit is $49.95. ▲

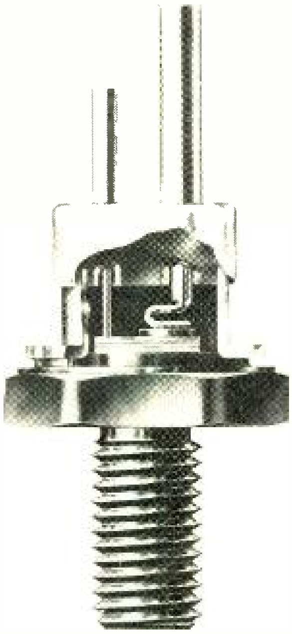
Koss "PRO-4" Stereo Headphones

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

THE new *Koss* "PRO-4" stereo headphones are a top-performance design, suitable for professional applications such as monitoring during recording sessions, and are ideal for private listening in the home.

The drivers in the phones are similar to miniature dynamic speakers, about 1 inch in diameter. The interior of each earpiece is fully padded with plastic foam and the driver itself is mounted in a separate compartment vented to the interior of the headpiece through two small holes. The front of the driver is also loaded with plastic foam. The headpieces are designed to give wide-range frequency response, with a maxi-

(*Continued on page 75*)



scr

SILICON CONTROLLED RECTIFIERS NEW APPLICATIONS IN THE HOME

By LOTHAR STERN / Motorola Semiconductor Products Inc.

Already used in industry for power-control applications, recent drastic price cuts make the SCR attractive for use in electrical appliances and lighting circuits for the home.

Editor's Note: The operating principles of SCR's, as described here, are the same whether these semiconductor devices are used to control large amounts of current in an industrial application or smaller current in a home appliance. Because of recent price reductions, the technician can expect to see more of these devices, not only in industrial plants, but also in high-volume-produced electrical appliances for home use. Although some of the highest current SCR's used in industry may cost several hundred dollars each, the 18-amp. units discussed below are priced as low as $1.80, in quantities of 5000.

ALL too often there is a substantial lag between the development of a new device and its actual commercial use in applications for which it is obviously well suited. Such has been the case with transistors in television applications where, until recently, the cost of a TV transistor complement has been considered too high in comparison with vacuum tubes to offset the apparent advantages of transistorization. It has also been the case with the silicon controlled rectifier (SCR) which has found widespread use for power-control applications in industrial equipment, but whose cost has been too high for the consumer mass market despite the operating improvements and flexibility it offers for both large and small home appliances.

Now that SCR prices have been suddenly and drastically reduced, at least for original equipment manufacturing purposes, there has been a dramatic increase in interest in such devices for the electrical appliance market. By the end of the year, a number of manufacturers are expected to introduce SCR-controlled appliances in what may well prove to be a new and major breakthrough of electronic applications in the home.

Basically an SCR is a four-layer *n-p-n-p* device (Fig. 1) whose primary application is in electronic switching and power-control circuits.

As a rectifier, the SCR will conduct current in only one direction. But, unlike a conventional rectifier, which begins to conduct almost the instant its anode becomes even slightly positive with respect to its cathode, the SCR will remain nonconductive, even in a forward direction, until the anode voltage exceeds a certain minimum value called the "forward breakover voltage" (V_{BO}). Moreover, the value of V_{BO} can be varied through the injection of a signal to the third or *gate* element of the device which governs the amplitude of the anode voltage needed to cause conduction or firing. It is this characteristic which makes the SCR an ideal switch or power-control device, especially in high-power circuits.

In electronic switching, the SCR can successfully replace thyratrons, vacuum tubes, and power transistors. In electromechanical equipment, it replaces switches, relays, variable autotransformers, rheostats, and timers. As safety devices they can take the place of fuses and circuit breakers. Moreover, they can duplicate the functions of magnetic amplifiers and saturable reactors and can serve as high-speed protective devices and as lightweight, compact power controls. It is in the area of power control that they are likely to make their greatest impact on the appliance market.

With SCR control it is possible to continuously vary the amount of current supplied to an electrical appliance, thereby providing a precise degree of control over the output of light and heat and over the speed of universal motors. While it may appear that similar control can be provided by a conventional rheostat, the SCR can accomplish this without the power wasting effect of rheostats and, in higher power devices, it can be less expensive and is much smaller and lighter than an equivalent rheostat would be in a similar application.

How It Works

For an over-all indication of how an SCR operates, consider the voltage-current relationship of the device as illustrated in Fig. 2. In this diagram, the gate terminal is considered to be open-circuited, or shorted to the cathode, and external voltage is applied only to the anode-cathode terminals. Under these conditions, it is evident that the reverse-bias voltage-current relationship (anode negative with

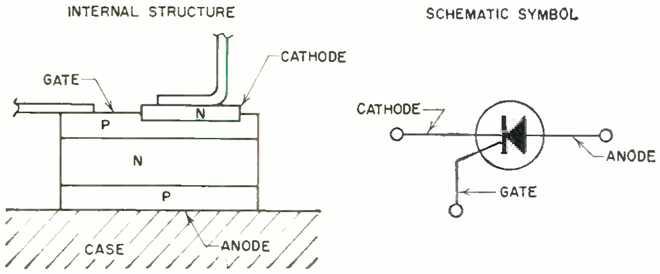


Fig. 1. Simplified cross-sectional drawing showing the internal structure of the all-diffused silicon controlled rectifier.

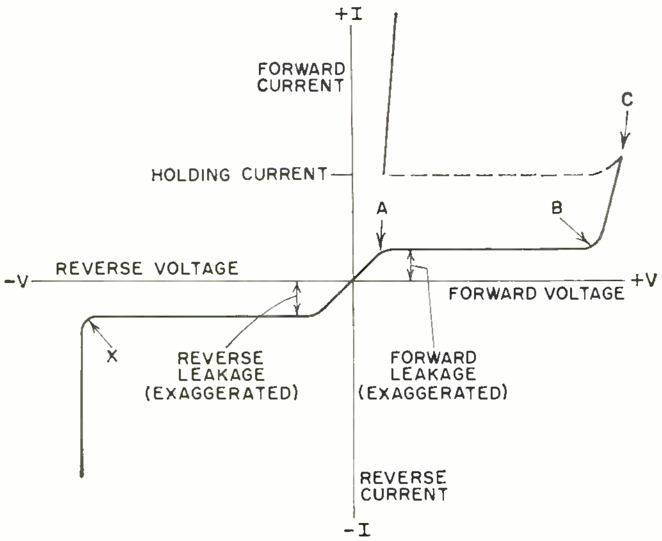


Fig. 2. Curve showing the anode-cathode characteristics of controlled rectifier with gate open or shorted to cathode.

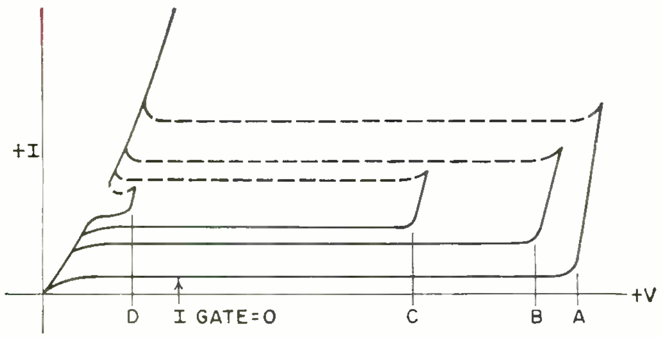


Fig. 3. Static characteristics with various gate currents.

respect to cathode) is identical to that of a reverse-biased conventional rectifier. As the reverse voltage is increased beyond the breakdown level, the semiconductor junction goes into avalanche and is usually destroyed because of the excessive junction temperature created by the relatively high power dissipation (voltage-current product).

Under forward-bias conditions, however, the characteristics curve is entirely different. As forward bias is increased, in the region from A to B, there is virtually no current flow through the device (except for a small leakage current similar to the reverse leakage current).

At point B, the *forward breakover voltage*, an avalanche action takes place and current tends to rise very rapidly. But, if the external load resistance is low enough to permit a rise in current to point C, an unusual "switchback" effect takes place. At the *breakover-current* value, point C, the voltage across the rectifier suddenly drops to a very low value, and the device acts very much like a conventional rectifier. The internal resistance of the device becomes very low and the current is limited primarily by the applied voltage and the external load resistor.

Note here the difference between the reverse and forward characteristics of the SCR. In the reverse direction, when the avalanche breakdown voltage (X) is exceeded, the reverse current rises rapidly but the voltage across the device itself remains essentially at the breakdown value. The power dissipated in the rectifier, therefore, is extremely high and the device is usually damaged irreparably. For this reason, a rectifier or SCR is never operated beyond its reverse-breakdown point.

In the forward direction, due to the switchback phenomenon, the internal resistance of the SCR suddenly switches from a very high to a very low value. Thus, in a circuit containing an SCR in series with a load resistor, the voltage across the SCR in a conductive state is negligibly small and current through the device can reach extremely high levels before rated junction temperature is exceeded.

From the foregoing discussion it can be appreciated that the SCR, with the gate open or shorted, acts very much like a voltage-operated switch (provided the operating voltage is in the forward direction). At voltage levels below the breakover point, the switch is open, and beyond the breakover point the switch is closed. To cause a change in the switch position from "off" to "on," it is merely necessary to increase the source voltage, say, from zero to the breakover-voltage value.

To cause a change in the switch position from "on" to "off," however, is quite another matter. In the "on" condition, the voltage drop across the SCR is extremely low and almost the total applied voltage appears across the external load resistor. Reducing the applied voltage does not materially change the voltage drop across the SCR. It does, however, reduce the current through the load resistance and, equally, through the series-connected SCR. Hence, as the voltage is reduced, current in the circuit decreases until a value is reached which is not sufficient to sustain the avalanche condition within the SCR. Below this current value, called "holding current," the SCR again reverts to its high-resistance condition and the switch is shut off.

Using the Gate Terminal

At this point one might logically ask, "What is the value of this type of performance?" It must be admitted that applications for this characteristic are indeed limited. There are some possible uses, as voltage-operated safety devices, for example, but the SCR's function for even these uses can be greatly improved by using its third or *gate* terminal.

Consider now the *theoretical* static characteristics of the SCR which are often used to explain its operation with various current levels injected into the gate terminal, as shown in Fig. 3. With no gate current applied, the anode voltage must reach point A before breakover occurs. Now, if a small amount of voltage is applied to the gate so that the gate terminal is positive with respect to the cathode, gate current flows and the forward breakover voltage of the rectifier anode is reduced to point B. If the gate current is increased further, anode breakover occurs at point C and, for still higher levels of gate currents, the SCR characteristics approach those of a conventional rectifier, point D.

The word "theoretical" has been emphasized in the above paragraph because this type of explanation can lead to erroneous assumptions regarding actual applications for the devices. It leads to the assumption, for example, that the SCR could be held at just below the breakover point for a certain anode potential by the application of a specified value of d.c. gate current. In actual practice, however, this is not the case. While the phenomenon of Fig. 3 can be readily observed, the gate-current range over which anode breakover is reduced from its open-gate value to virtually zero is extremely small. Moreover, this gate-current range varies from one device to another so that no accurate specifications of this type can be developed.

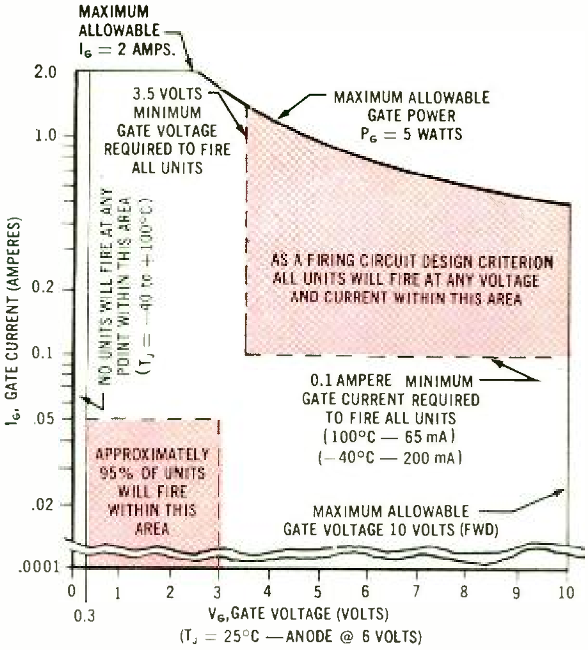


Fig. 4. Gate firing characteristics of type MCR-808 SCR's.

Therefore, the conventional method of operating SCR's is to supply a gate signal of sufficient amplitude to assure firing of all devices. A plot as illustrated in Fig. 4 for Type MCR-808 devices, clearly shows the magnitude of gate voltage and current needed for reliable triggering. For these units it is seen that a gate signal of 3.5 volts and 0.1 ampere will trigger all devices of this type, although triggering for most devices can be achieved with much lower gate signal values.

An important point here is that the amount of gate current required to change the V_{BO} point from its zero-gate-current value to almost zero is very small—on the order of milliamps. And, since the SCR in the breakover or "on" condition can handle many amperes of current, the current gain of the device is quite high. In this respect the device acts very much like a sensitive relay where a small amount of current through the relay coil can control a much larger current in the relay contact circuit.

There is, however, a major and important difference between the operation of a relay and an SCR. With a relay, the contacts will close as soon as an activating current is applied to the relay coil and they will remain closed only *as long as the activating coil current is present*. With an SCR, the "contacts" will close (the resistance between cathode and anode is reduced to a very low value) as soon as the required gate current is applied, but they will remain closed (the SCR will remain in a breakover condition) even if the gate current is removed. Once fired, the gate loses all control and the "switch" will remain in a "closed" or latched state irrespective of any current or voltage applied to the gate terminal.

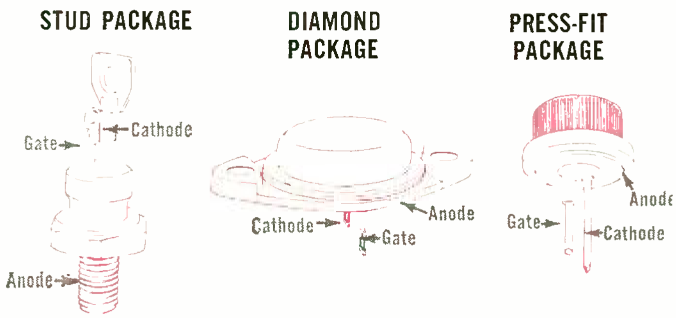
The only way to turn off an SCR that is in the "on" state is to reduce the anode current below the level of the holding current needed to sustain anode conduction. This, in a d.c. circuit, can be accomplished in a number of ways, such as mechanically interrupting the load current, reversing the voltage polarity from anode to cathode, shunting the major portion of the load current around the SCR, or by means of commutating capacitors or the use of *LC* circuits in the load circuit.

For a.c. circuits, which are of primary interest in the home appliance field, the SCR is turned off at the end of each positive-going half-cycle of applied anode voltage.

Ratings & Packages

Today's SCR's are available with maximum forward-current ratings ranging from approximately 1 amp up to as much as 300 amps and with reverse breakdown voltage ratings from 25 to 1500 volts. Forward breakover voltages are normally much higher than reverse breakdown ratings so that a device that will break down under relatively low reverse voltages may be able to successfully block forward voltages of several hundred volts. Since the cost of SCR's increases with increasing reverse-voltage ratings, it is often desirable to design circuits in which the reverse voltage is prevented from appearing across the SCR anode-to-cathode terminals. This can be done by shunting the SCR with a conventional diode, connected in such a way that the diode conducts when the voltage across the SCR tends to reverse direction. In this way, the maximum reverse voltage across the SCR will be equal to the forward-voltage drop of the diode—on the order of a fraction of a volt—and, in many instances, the cost of the SCR-diode combination will be less than the cost of an SCR with a high reverse-voltage rating.

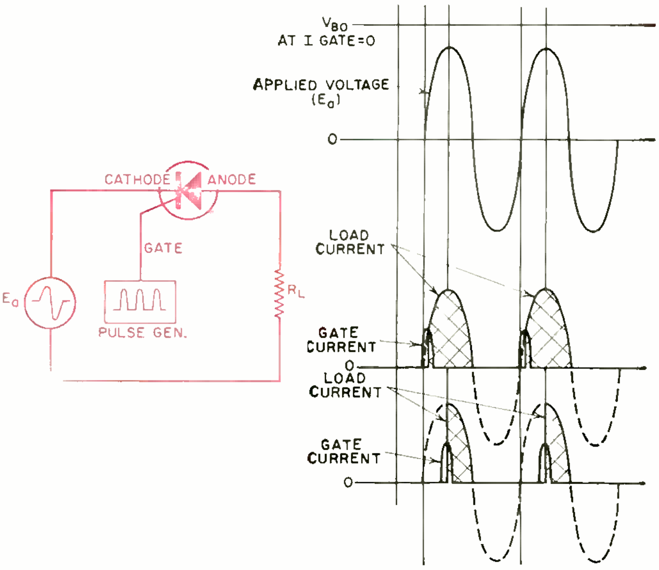
While high-current SCR's are required for many industrial applications, devices with current ratings in the 10- to 25-ampere range are most likely to meet the need of the appliance industry. Units of this type are available in three basic packages with a variety of mounting possibilities, including the single-hole-mount stud package, the popular diamond package, and the highly versatile press-fit package. It is the press-fit package, designed specifically for high-



	STUD PACKAGE	DIAMOND PACKAGE	PRESS-FIT PACKAGE
Maximum Forward Anode Current Rating	25 amps. r.m.s.	20, 25 amps. r.m.s.	18 amps. r.m.s.
Maximum Peak Forward Anode Voltage Rating	600 v.	600 v.	600 v.
Maximum Peak Reverse Anode Voltage Rating	20, 50, 100, 150, 200, 250, 300, 400, 500 v.	25, 50, 100, 200, 300, 400, 500 v.	25, 50, 100, 200, 300, 400 v.

Fig. 5. Typical specifications for various SCR packages. These types are suitable for use in home appliances.

Fig. 6. A simplified circuit which shows power control.



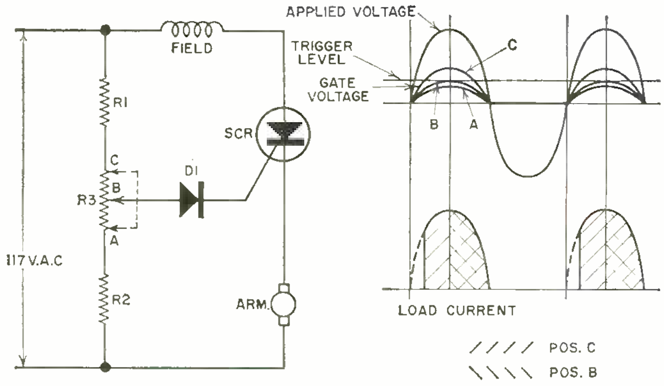


Fig. 7. A simple half-wave motor speed control circuit.

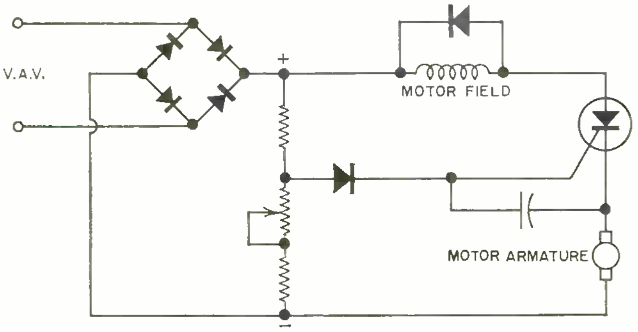


Fig. 8. Circuit that permits the control of both alternations. Diode across motor field protects circuit from reverse voltages.

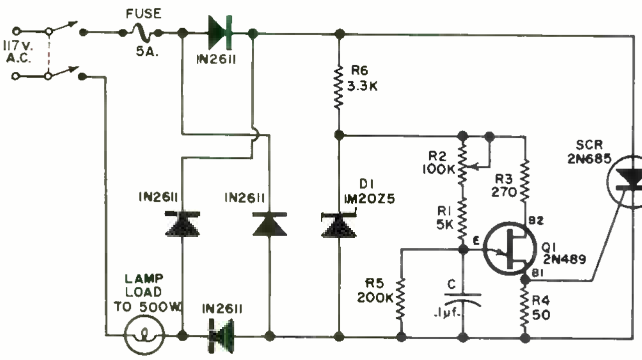
volume, low-cost production, that is largely responsible for the SCR price reductions that have recently been announced. Typical case configurations and their respective internal connections are illustrated in Fig. 5.

Principles of SCR Power Control

To understand how the electrical characteristics of silicon controlled rectifiers are generally employed for power-control purposes, consider the simplified schematic of Fig. 6. Here the SCR is connected in series with a load resistance and an a.c. power source. A separate pulse circuit supplies positive-going trigger pulses to the SCR gate.

The SCR is selected to have a V_{BO} rating that is higher than the peak value of the applied a.c. anode voltage. This means that under conditions with no signal applied to the gate, the SCR will remain in the off condition at all times and no current will flow through the load (except for some slight forward and reverse leakage currents).

Fig. 9. SCR controlled light-dimmer circuit. Although much simpler circuits can be used for this purpose, including the circuits previously shown for motor-speed control, this circuit provides a full range of light-brightness control. This arrangement employs a full-wave bridge rectifier, a zener diode (D1) to clip and regulate the voltage applied to unijunction transistor Q1, and an SCR. By varying the value of R2, the charging rate of C can be controlled so that the trigger pulse across R4 can appear at any point of each applied half-cycle. This results in complete control over the SCR.



If a gate trigger pulse of sufficient amplitude is applied at the beginning of the positive-going anode cycles, the breakover voltage of the SCR can be reduced to the point where breakover will occur almost at the beginning of the anode cycle. The SCR, therefore, is turned on and will remain in the on condition for the remainder of the positive half of the anode cycle even though the gate trigger pulse is removed. Load current will follow the positive-going anode voltage, being limited principally by the value of the load resistance. During the negative portion of the anode voltage, load current will be cut off entirely, irrespective of any gate signal.

If the gate trigger pulse is delayed so that it occurs, for example, at the peak of the positive anode cycle, the SCR will conduct for only a quarter of a cycle. By introducing a variable phase shift between anode and gate signals, complete control can be achieved over the positive half cycle of anode voltage. For equipment whose output depends on the *average value* of the load current (such as the light from an incandescent bulb, the heat from a heating element, or the speed of a universal motor), this provides the means for controlling the output from zero to some maximum value.

Of course, for a simple half-wave circuit the maximum output will not be as great as if both halves of the anode cycle were utilized. Maximum control can thus be obtained by using SCR's in full-wave or bridge circuits.

Typical Circuits

A simple SCR control circuit, in this case a motor-speed control for electrical appliances, is shown in Fig. 7.

In this circuit, the anode-cathode terminals of the SCR are connected in series with the motor field and armature across the 117-volt a.c. line. Resistors *R1* and *R2* in series with potentiometer *R3* represent a voltage divider from which the gate signal is derived.

Values for the resistive divider are calculated so that, with the variable arm of *R3* in position A, the amount of gate current is not great enough for SCR triggering even at the maximum instantaneous anode potential. With the control advanced to point B, enough gate current would flow at the peak of the cycle to trigger the device. At that point, field current would flow during 90° of the applied voltage. At point C, the firing potential would be reached sooner so that load current would flow for perhaps 130° or more of the applied voltage. This circuit offers control over almost half of the positive-going portion of the applied voltage. During the negative half cycle, SCR current is cut off.

Diode *D1* is inserted in the gate circuit to block the application of excessive reverse current to the gate electrode which could result in damage.

A more elaborate circuit, one that permits the control of both halves of the applied voltage cycle, is shown in Fig. 8. Here, a full-wave rectifier bridge is employed in such a way that the voltage applied to the divider and SCR circuit is pulsating d.c. comprising both halves of the input cycle. Operation otherwise is similar to the previous circuit. The utilization of the entire input cycle in this bridge circuit permits higher maximum motor speeds and smoother operation than obtainable in the half-wave configuration.

One advantage of SCR control is that the circuits often can be designed to accomplish additional functions. This is illustrated in the above designs, patented by Momberg and Taylor of *Singer Mfg. Co.*, where the SCR is connected between the motor field and armature. In this type of connection, for all but the maximum-speed setting, voltage feedback from the motor tends to keep the motor speed constant under varying loads—an advantage that is of considerable importance in the power tool field.

In each of these circuits, of course, the load may be a heat- or light-producing appliance provided that the current rating of the SCR is high (*Continued on page* 82)

RIPPLE-FILTER DESIGN CHART

By A. L. TEUBNER

Performance of single-section choke-input filters can be determined readily by use of straightedge.

THE chief characteristic of a power-supply filter is, of course, how well it filters—how little a.c. ripple voltage is present at the output terminals. This chart makes it easy to check the usefulness of a particular combination of L and C without long calculations or impedance diagrams.

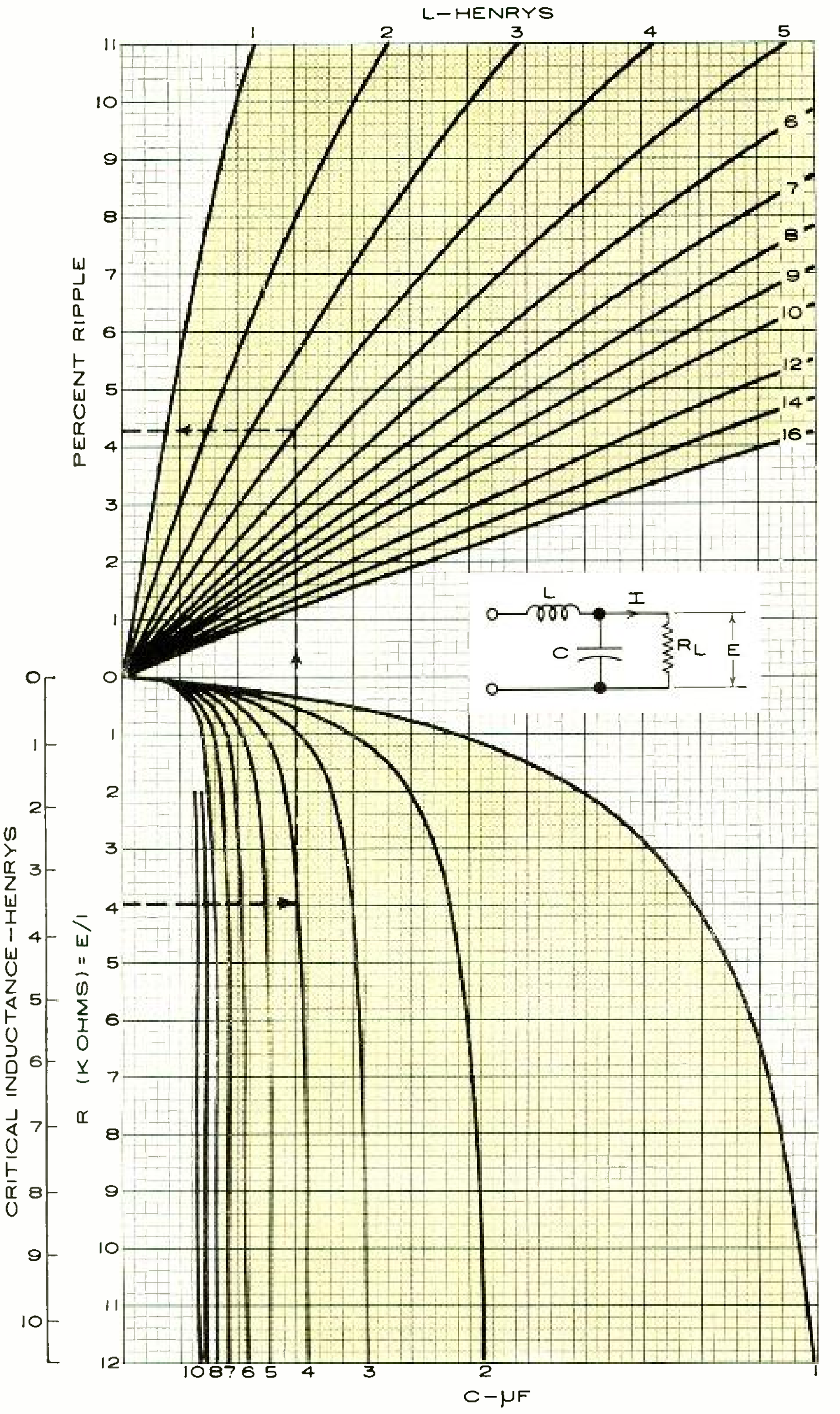
The chart is constructed to represent a single-section choke-input LC filter like the circuit shown on the chart. The resistor R_L represents the total effective load resistance connected to the power supply: the supply voltage divided by the full load current. The bleeder resistor can be included in the calculation of load resistance if desired; the effect that it will have on the filtering depends on the curvature of the "C" curve being used. The answer obtained is the percent ripple, which is defined as the r.m.s. value of the output ripple voltage, times 100, divided by the d.c. voltage.

An additional scale for critical inductance is placed just beside the resistance scale. This is the minimum value of inductance that should be used to prevent the output voltage from rising toward peak a.c. voltage when small current is being drawn, such as when the load is removed and only bleeder current flows.

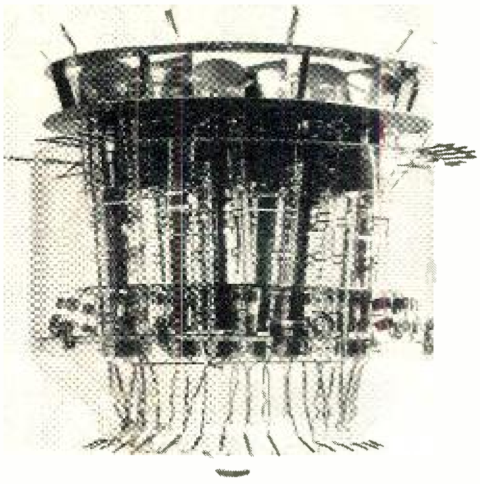
The simplest problem that can be solved with this chart is shown by the following example, which is illustrated on the chart itself. Suppose that you need a 100-volt power supply that will deliver 25 ma. full load and you want to know whether a 4-henry choke and a 4-μf. capacitor will give sufficient filtering. Dividing voltage by current gives a load resistance of 4000 ohms. The horizontal line passing through 4k ohms on the R_L scale cuts the 4-μf. C curve at some point. A vertical line is drawn from this point upward until it cuts the 4-henry L curve in the top section of the chart. Then a horizontal line is drawn through this new point, and the answer is read where it cuts the "% Ripple" axis—in this case, 4.3%. Whether this is sufficiently small depends on the equipment using the supply.

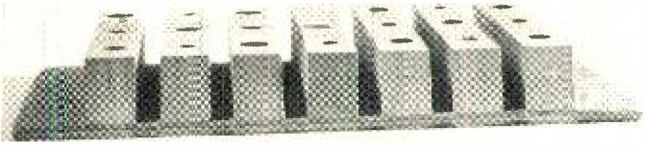
The filtering ability of a two-section choke-input filter can be determined by using the nomogram twice, once for each LC section; converting the two values of percent ripple to decimal fractions; multiplying them together; and then multiplying the product by 100 to obtain an over-all percent ripple output. The same value of R_L can be used for both sections with small error. By repeating the construction in the example above, you can check the filter's performance for varying load currents. If a swinging choke is used, a similar series of constructions will show its effect, if the proper L curve is used for each value of load current.

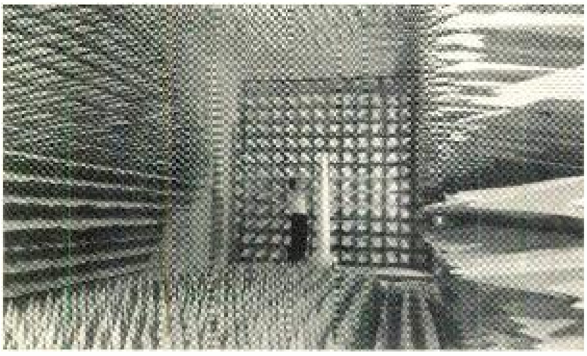
In constructing a chart such as this, it has been necessary to ignore certain problems, such as choke, transformer, and rectifier voltage drops; choke core saturation; bleeder current; and component voltage and current ratings. To completely analyze a power supply you must, of course, take these into account. However, this chart can provide quick, easy solutions for the problem of filter design, and save a lot of "calculations." ▲



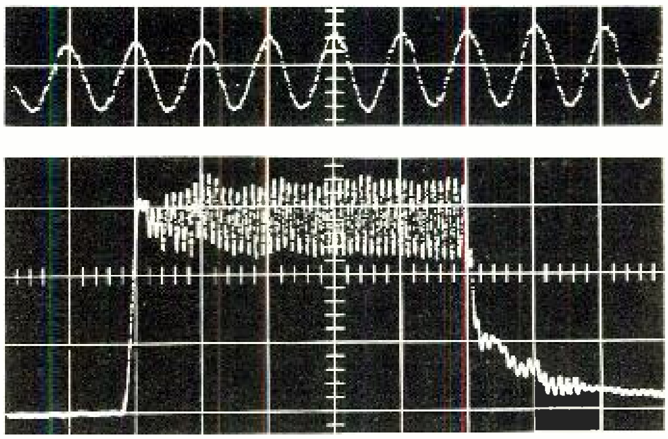
RECENT DEVELOPMENTS in ELECTRONICS



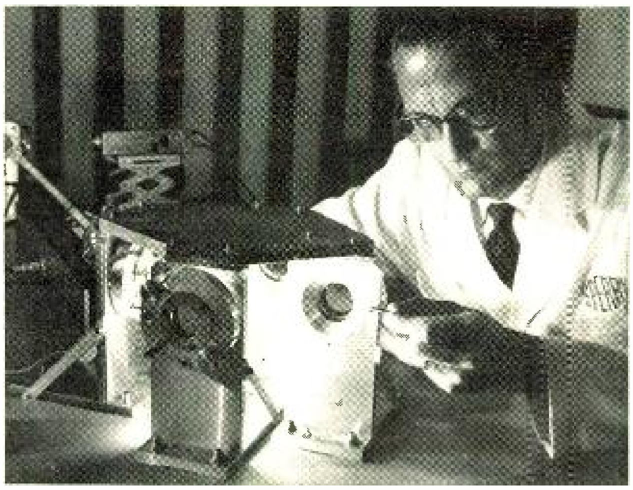




Six-Gun CRT. (Above) This six-in-one electron gun is part of a cathode-ray tube being manufactured by Sylvania for use in airborne countermeasures equipment. The use of a multi-gun makes possible simultaneous displays on one 10 by 12 inch rectangular tube faceplate. The complete tube is 21 inches long and uses electrostatic focus and deflection.... **Rubber-Spiked Dead Room.** (Top left) Over 2500 man-made foam-rubber spikes are used in this r.f. anechoic chamber to help engineers simulate what a missile in space will look like to a radar operator on earth. The energy-absorbent polystyrene pedestal at the rear is nearly invisible to radar. It will be used to support small ICBM anti-radar gear which can be mounted on missiles to jam enemy radar. Using radar located at the other end of the chamber, engineers will be able to calculate with models how well their equipment will work in space. B. F. Goodrich fabricated the chamber for the Sperry Gyroscope Company.... **Color-Tube Faceplates.** (Bottom left) The stacks of phosphor-coated "saucers" are a small part of the inventory of faceplates for cathode-ray tubes that will soon be producing color-TV pictures. The funnels for the tubes are shown in the background. The photograph was taken at RCA's Lancaster, Penna. plant for which an $11.6-million expansion program is planned. A portion of the appropriation will be spent on a new 46,000 square foot building that will be utilized for color-television picture-tube design and engineering.

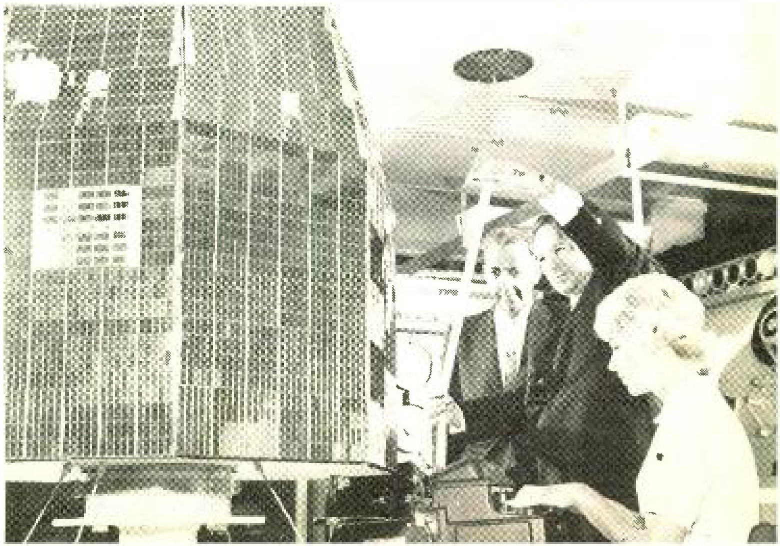


Microwaves Produced by D.C. Field. (Right) The discovery that microwaves can be generated simply by passing an electric current through a small block of gallium arsenide at room temperature was reported recently by an IBM scientist. Frequencies ranging from 500 to 6500 mc. have been produced, with peak power output of ½ watt at 1000 mc. So far only pulsed operation has been achieved. Note the oscillations produced along the top of the pulse shown in the lower scope trace. The upper waveform is a magnification of these oscillations. Over-all power conversion efficiency from d.c. to a.c. in the samples measured so far is 1 to 2%. The effect was discovered while measuring resistivity of the material as a function of electric field.



Lasers in the Laboratories. Photo at top left shows Sperry scientist adjusting mirrors that make counter-rotating laser beams bounce around a ring to sense and measure changes in direction. Called a laser gyroscope, the device is being developed as a space-guidance instrument that may rival the mechanical gyro. It can now detect motion slower than one-half a degree per minute. Photo shows the laser gyro's beam-combining mirrors arranged to prevent mode coupling, the reflection of light at one wavelength back into the cavity to interfere with light at the other wavelength. The center photo shows a laser being optically phase modulated. The scope in the spectrum analyzer shows the carrier flanked by the two sideband frequencies produced. The modulator consists of an electro-optical crystal in a resonant cavity driven by the r.f. power oscillator at the upper right in the photo. The changing field in the crystal causes its refractive index to vary thereby altering the phase of the coherent light passing through it. The setup shown is being worked on in a Westinghouse laboratory. The laser in the bottom photo is being developed by G-E as a new tracking system to find and follow airborne targets. The unit emits high-energy pulses of light at the rate of 40 per second. Previous lasers of this type have been able to reach rates of only 10 pulses per second and for only short periods of time.

Automatic Typesetting Via Satellite. (Right) A news story, computer-processed for immediate typesetting, was recently transmitted by way of the "Relay" communications satellite from this country to newspapers in England and Scotland. The story material was sent overland from Chicago to an RCA computer at Camden, N.J., where the copy was properly hyphenated and spaced to conform with newspaper column width. From Camden, the signal travelled to Nutley, N.J., where it was transmitted to the "Relay" satellite, thence to the Manchester "Guardian," Glasgow "Herald," and the Edinburgh "Scotsman." The resultant incoming perforated paper tape was fed directly into automatic typecasting machines. Photo shows the outgoing tape being prepared at Chicago. At the left is a full-scale replica of the "Relay" satellite used.



MODERN BATTERIES

The right battery in a particular application can last up to ten times longer than one chosen at random. Here is an explanation of the many types of batteries currently available, how they work, and where they can be used to the best advantage.

By JOHN R. COLLINS

IF you have not followed recent battery developments, you may be surprised at the variety now available and the jobs they can do. The differences are not simply a matter of size, voltage, or capacity. Batteries are specially tailored for constant or intermittent use, for light or heavy current drain, for long-term stability, or for dependable performance under rugged conditions. The right battery for a particular application may last ten times as long and represent a significant savings over a battery selected at random. Conversely, it is uneconomic to use a more expensive battery where a conventional type will do as well.

Much of the current interest in batteries stems from military and space needs. In addition, the low power consumption of transistors has given impetus to the production of small batteries needed to operate portable radios, television sets, and communications equipment. Also, the normal human desire to avoid extension cords and to use self-contained power sources wherever possible has led to cordless power tools, electric shavers, model automobiles and boats, portable dictating machines, electronic photoflash equipment, and many other battery-operated devices in both industrial and consumer fields.

It is interesting to note that despite the high level of battery performance already achieved, there is room for much improvement. Many electrode materials are capable of far greater efficiency than those now used. The difficulty is finding practical combinations of anode, cathode, and electrolyte materials which will work well without introducing unwanted side effects. Lithium, sodium, and potassium, for example, have theoretically high ampere-hour capacity and e.m.f., but cannot be used with aqueous electrolytes. Other anode materials are limited by excessive polarization and corrosion. The search continues, however, and experimental batteries presently in the laboratory stage may one day replace some of the types now in general use.

Definitions

Strictly speaking, a battery is a combination of two or more individual cells, connected in series, parallel, or series-parallel to give the desired voltage and current capacity. The term is applied loosely, however, to single cells. Dry cells have four major components: the anode, the cathode, an electrolyte, and a depolarizing agent. The last is a chemical added to the cell to counteract undesired effects of chemical changes that occur when current is drawn. Polarization usually involves hydrogen accumulation at an electrode, which increases the internal resistance of the cell and causes a drop in working voltage unless it is removed.

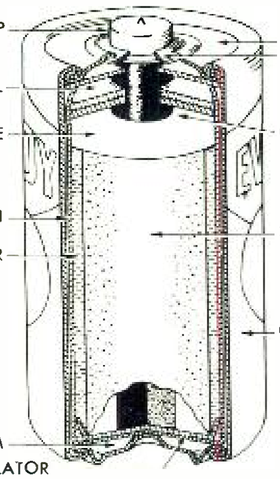


Fig. 1. At present, the carbon-zinc cell is the most popular type of primary cell, accounting for bulk of dry cell sales.

Batteries are divided into two broad classes: primary and secondary. Primary batteries convert chemical energy to electrical energy through a process that is not easily reversed. They are therefore discarded when useful amounts of energy can no longer be drawn from them. Secondary batteries use reversible chemical reactions, permitting them to be recharged and re-used many times. Recharging is accomplished by passing current through the battery in the direction opposite to the discharge current, thus restoring the chemicals to their original state.

It is also common to classify batteries according to their intended use. "A" batteries are low-voltage types designed to supply current for the filaments of electron tubes, "B" batteries are high-voltage types intended as plate voltage sources, while "C" batteries are used for grid voltage supplies or in instruments such as ohmmeters.

The voltage of a cell is independent of its size, and is determined by the electrode materials and the electrolyte. Working or closed-circuit voltage will normally be somewhat less than open-circuit voltage due to *IR* drop in the internal resistance. Capacity is a measure of the stored charge and is usually stated in ampere-hours.

Battery efficiency is a measure of total power in relation to size and it is usually expressed in watt-hours per pound (wh/lb.) Theoretical efficiency is often much greater than that actually achieved, because voltage and current may decline to unsatisfactory levels before the chemicals in the cell are completely used.

Carbon-Zinc Cells

The carbon-zinc or Leclanche cell (Fig. 1) is by far the most popular type of primary battery, accounting for about 90 percent of U.S. dry cell production. Originally invented in crude form almost a century ago, it has been vastly improved but still retains the same essential elements.

The anode or negative electrode is composed of high-purity zinc that also serves as the container for the cell. Purity is important, since small particles of other metals result in the formation of many small cells on the inside surface of the zinc can. When this happens, the zinc is eaten away whether the cell is in use or not, and the small currents thus produced weaken the cell and waste the chemicals. This process is called "local action."

The cathode (positive) electrode is a carbon rod made by mixing coke or graphite with pitch and heat-treating the mixture to make the electrode conductive. A metal cap which serves as the external contact is fitted to the rod. The depolarizing agent, called "bobbin," is a homogeneous mixture of about 90 percent manganese dioxide and 10 percent carbon black (which is added to increase conductivity) moistened with ammonium chloride. The electrolyte is a jelly consisting of ammonium chloride and zinc chloride, usually mixed with wheat flour or cornstarch. Inhibitors such as chromic salts are added to prevent corrosion of the zinc can.

The initial open-circuit voltage of a carbon-zinc cell is about 1.5 volts. Where higher voltages are needed, cells are connected in series to form batteries. For this purpose, it is customary to construct individual flat cells, as shown in Fig. 2, that contain the same elements as the cylindrical cells. They are sealed in plastic envelopes and are arranged in stacks. The entire assembly is then enclosed in a container with terminals connected to the top and bottom of the stack. Common ranges are 22½, 45, and 90 volt batteries, made up of 15, 30, and 60 cells respectively.

Since the zinc can forms one of the electrodes and the zinc itself takes part in the chemical reaction, it is possible for a puncture to develop in the container. To prevent this, some manufacturers place the entire cell in a steel tube insulated from the zinc electrode.

Mercury Batteries

The mercury battery was developed for practical use during World War II and has since undergone continued improvement. It consists essentially of an amalgamated zinc anode, usually in the form of either a finely divided powder or a pressed shape, a cathode consisting of a mixture of red mercuric oxide with about 5 percent graphite which is molded under pressure into a shaped structure, and an electrolyte of potassium hydroxide containing zinc oxide. The electrodes are separated by two materials—a cellulose membrane to immobilize the electrolyte, and a porous plastic membrane between the cellulose and the cathode.

Like Leclanche types, mercury batteries are made both in tubular-shaped single cells and in stacks of flat cells. The voltage of each cell is about 1.35 volts, and as many as 72 cells may be stacked to form a 97.2-volt battery for a portable transmitter.

A mercury battery has far greater capacity than a Leclanche battery of the same size, since there is complete utilization of 80 to 90 percent of the active materials. Moreover, it will maintain a much more stable voltage over its life span, as illustrated in Fig. 3. For this reason, they are sometimes used as a voltage reference instead of a standard cell, and are often employed in *pH* meters and test instruments where stability is important. Because of their long life and constant output, they are widely used for hearing aids, transistor radios, and portable communications equipment such as walkie-talkies.

Care should be taken never to exceed the recommended maximum current drain of a mercury battery. If current is drawn too rapidly, the depolarizer cannot take care of the hydrogen, causing a reduction in battery efficiency and a drop in the over-all working voltage.

Alkaline Batteries

Where especially high current drains are encountered, the alkaline-manganese dioxide-zinc battery is an excellent choice. It differs from the Leclanche cell primarily in the highly alkaline electrolyte used. The two principal features are a manganese dioxide cathode of high density in conjunction with a steel can that serves as a cathode current collector, and a zinc anode of extra-high surface area in contact with the electrolyte. These features, coupled with the use of a highly conductive potassium hydroxide electrolyte, give these cells very low internal resistance and high service capacity. They are usually hermetically sealed.

The cells are rated at a nominal 1.5 volts. The ampere-hour capacity is relatively constant over a wide range of

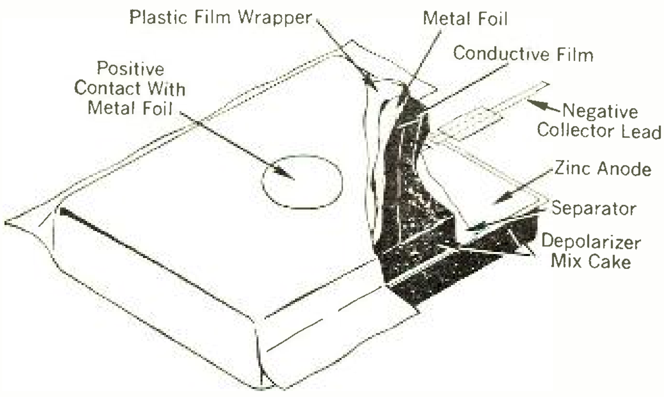


Fig. 2. Typical flat cell sealed in a plastic bag can be stacked to make various battery voltages and currents.

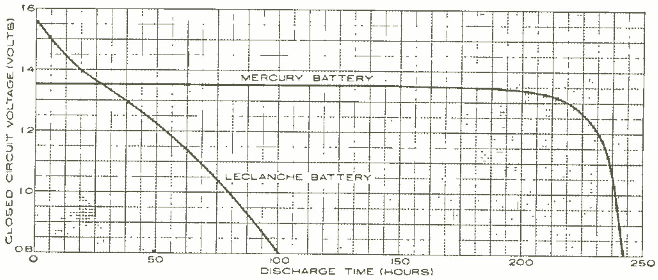
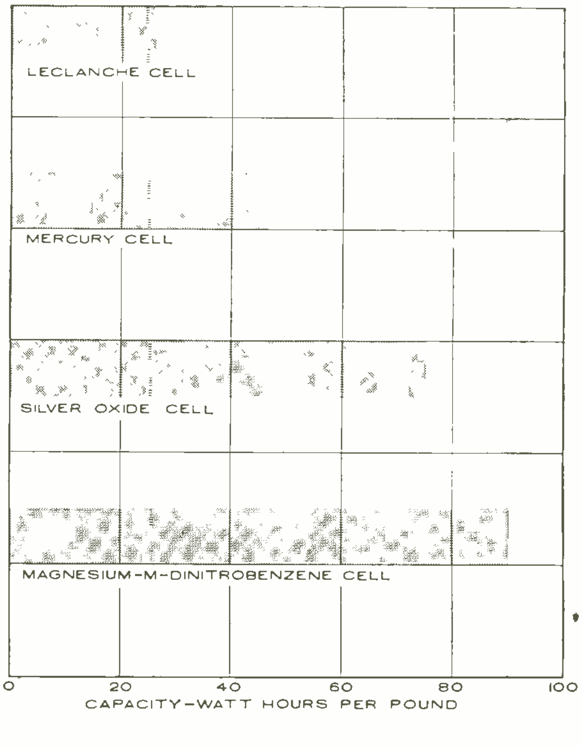


Fig. 3. Discharge curves of penlight-size Leclanche and mercury cells through 150-ohm resistors show that mercury cells maintain a more stable voltage over their active lifetime.

Fig. 4. Comparison of efficiencies of various types of cells shows that modern ones have double the capacity of the old.



current drains and a large number of discharge schedules.

Alkaline batteries are cheaper than mercury batteries although more expensive than Leclanche types. However, heavy current drain impairs the efficiency of Leclanche batteries to such an extent that only a fraction of their energy can be utilized. The primary advantage of the alkaline battery is its high efficiency despite continuous or heavy current drain. Under such conditions, it will provide more than ten times the service of the standard dry cell of equal size. It also works well under conditions of light current drain and intermittent use, but since the cost is greater it is cheaper to use Leclanche cells for normal service.

Alkaline batteries have made possible battery-operated

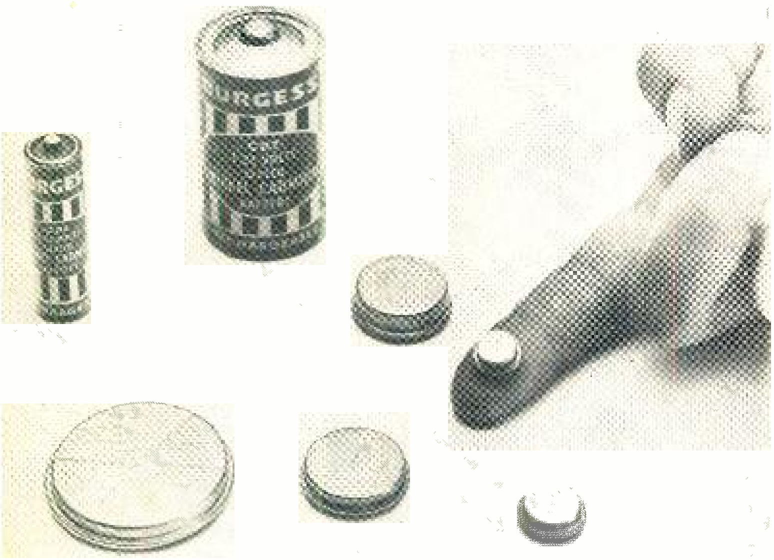


Fig. 5. Various sizes of nickel-cadmium cells can be packaged to make higher battery voltages. The cells are rechargeable.

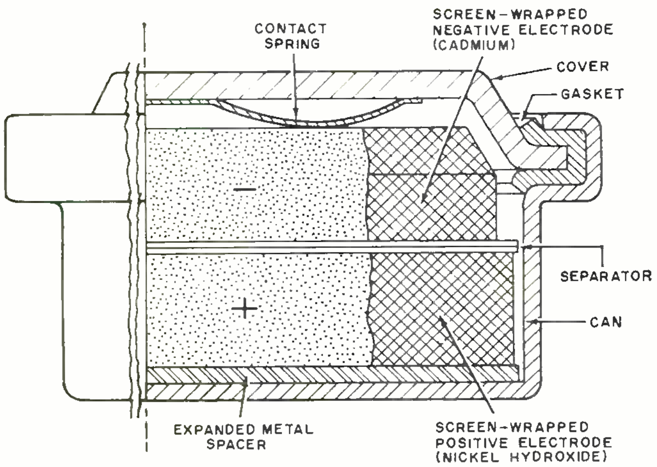


Fig. 6. Cutaway view of a typical nickel-cadmium button cell.

devices that were previously considered impractical because of lack of suitable power source. They are ideal for cranking motion picture cameras, for operating portable tape recorders, and for powering the motors of models and toys. When used for electronic photoflash units using transistor or vibrator circuits to step up low-voltage d.c. to the high voltage needed to charge the flash capacitor, they will give two or three times as many flashes as either photoflash or general-purpose cells. They easily handle current drains that strain the capacity of other types of batteries.

Silver-Oxide Batteries

The development of the silver oxide-alkaline-zinc (Ag_2O-KOH-Zn) battery represents a major advance in miniaturization. They provide higher voltage and greater milliwatt-hour ratings than any other commercially available batteries of equal size. The silver-oxide battery consists of a depolarizing silver-oxide cathode, a zinc anode of high surface area, and a highly alkaline electrolyte. In hearing-aid batteries, the electrolyte is potassium hydroxide, which provides maximum power at the required current drain. Sodium hydroxide is used in the tiny batteries used in electric watches.

The open-circuit voltage of the silver-oxide cell is 1.6 volts. At typical current drains, the operating voltage drops to 1.5 volts. The impedance is low and uniform, and does not change materially until the useful life of the cell is over. Such batteries can therefore be used as a reference voltage source in instruments.

Shelf life of silver-oxide cells is excellent. Even after storage for a year at 70 degrees F. they will maintain 90 percent of their service life. Their performance is also good at low temperatures. This is accounted for in part by the relatively large surface area of the anode, which permits many times the service capacity at low temperatures as other types of batteries of comparable size.

Experimental Cells

Anode materials are selected, as far as possible, on the basis of their theoretical ampere-hour per pound capacity. Hydrogen, rated at 12,000 ah/lb. (compared to 372 ah/lb. for zinc) is by far the best choice from this standpoint, but is not used because of the practical difficulty of constructing a battery with a gaseous electrode. The limitations on using lithium, sodium, and potassium were mentioned before. Beryllium, rated at 2695 ah/lb., is toxic and expensive.

Because magnesium, rated at 999 ah/lb. is inexpensive and easy to handle, it is receiving increased attention as an anode material. Various cathode materials have been employed with it, especially metallic oxides, including those of silver, mercury, and copper. These have permitted high discharge currents with little polarization and have been quite successful.

A very promising experimental cell has been constructed using a magnesium anode, an m-dinitrobenzene cathode, and a magnesium perchlorate electrolyte. It provides a useful discharge current, relatively constant voltage, and a very high efficiency of about 90 wh/lb. (Fig. 4). Preliminary tests indicate good shelf life and reliability.

Nickel-Cadmium Secondary Cells

Although lead-acid automotive storage batteries are by far the most common secondary batteries, they are far less important in electronics than the small, hermetically sealed nickel-cadmium cells (Fig. 5) used in equipment ranging from hearing aids to space vehicles. For space use, nickel-cadmium cells are kept continuously charged by silicon solar cells that convert the sun's energy into electricity. For hearing aids, they are made in tiny button shapes and can be conveniently recharged.

In the charged condition, the positive electrode of a nickel-cadmium cell is nickelic hydroxide, while the negative electrode is metallic cadmium. The electrodes in both the button and cylindrical cells consist of molded screen-encased active materials (Fig. 6). The electrolyte is potassium hydroxide. The operating voltage under normal discharge conditions is about 1.2 volts.

Nickel-cadmium cells in hermetically sealed units are especially desirable, since it is never necessary to add electrolyte and there is no danger of spilling or leaking. Their design is not easy because during the latter part of the charge cycle and during overcharge, nickel-cadmium batteries generate gas; oxygen at the nickel electrode, hydrogen at the cadmium electrode.

A conventional vented battery will liberate fumes through a valve. To hermetically seal a cell, it is necessary to develop a means of using up the internal (*Continued on page* 99)

CHECKING STEREO SEPARATION AND PHASE

By RALPH GLASGAL

Construction details on a simple device for monitoring dynamic separation and phase with music-signal input.

IN his article "A Dimension Control for Stereo" (ELECTRONICS WORLD, April, 1961), the author showed how stereo directionality and presence are directly related to the *separation ratio*. The higher the separation ratio, the greater the stereophonic sound spread seems. The separation ratio is defined as the ratio of the average difference signal to the average sum signal. As their names imply, sum and difference signals are obtained by adding or subtracting the left and right channel signal voltages. In mathematical symbols, the separation ratio (S.R.) may be expressed as $S.R. = (L-R)/(L+R)$.

When a monophonic disc is played with a stereo pickup through a balanced in-phase stereo playback system and listened to from a central location *via* two loudspeakers, all the sound will appear to originate from a single point between the loudspeakers. This lack of sound spread is to be expected since a monophonic recording contains no separation information. The separation ratio for a monophonic recording must therefore be zero. This means that $L-R$ is zero and $L+R=2R$ or $2L$.

When the difference signal is equal to the sum signal the separation ratio is equal to one. This occurs when the left and right channel program materials are totally unrelated, for only completely random and uncorrelated signal voltages can have equal average sum and difference voltages. Tapes made with microphones spaced too far apart, or pseudo-stereo records made with each channel recorded at a different time or location exhibit separation ratios of 1. Stereo recordings of two instrumentalists, one in each channel, may also approach a separation ratio of 1 quite closely. For a separation ratio of 1, a centrally located listener hears two distinct sound sources from two fixed points. Altering the channel balance or phase under these circumstances has no effect at all on the apparent location or character of the two sound sources.

A separation ratio of about .8 to .9 seems to provide the best compromise among directionality, separation, and center instrument presence. Recording of solo instruments centrally located usually have separation ratios smaller than average, while recordings of small combos often have ratios larger than average. In a sense, the separation ratio is a measure of center signal volume, for the more center signal information there is, the smaller the separation ratio even though there is no center information at all. This condition is approximated by the recording session layout in which closely spaced microphones are recording two groups of widely spaced instrumentalists.

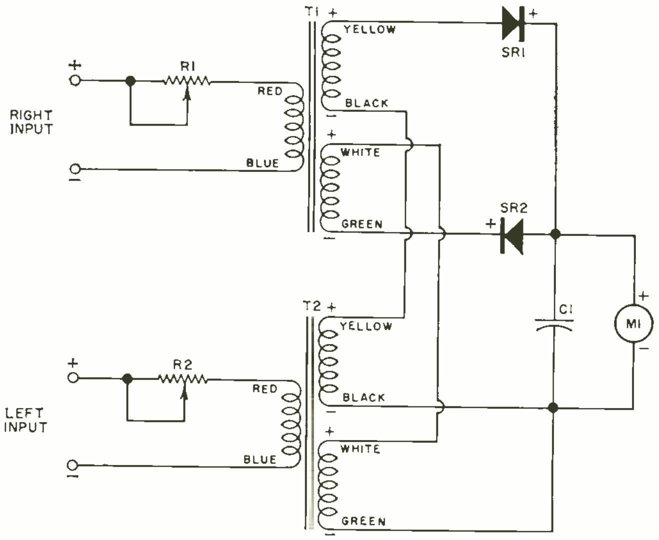
It is possible to produce separation ratios greater than 1. In this case the difference signal is greater than the sum signal. This is the situation that exists when correlated stereo program sources are being reproduced out of phase. (See "Phasing the Stereo System," ELECTRONICS WORLD, November, 1961.) With a separation ratio greater than one it is possible to produce sound images that appear to originate from points separated by more than the distance between reproducing loudspeakers. Separation ratios greater than 1 do not occur naturally. There is no possible microphone or instrumental arrangement that can produce two signals with separation ratios greater than 1; therefore such ratios can only be the result of signal manipulation after recording or an inadvertent out-of-phase condition. Since center instrument volume is inversely proportional to the separation ratio, high separation ratios indicate greater and greater attenuation of the center program material, resulting in the all too familiar "hole-in-the-middle" effect.

Measuring Techniques

It is evident then that separation ratio measurements can be a useful tool in phasing stereo equipment and an aid in the adjustment of recording setups and separation controls. The separation ratio of stereo recordings was first measured by viewing the sum and difference signals simultaneously on an oscilloscope, with the sum signal connected to the horizontal input and the difference signal applied to the vertical input. A camera is used to take a time exposure of the resulting pattern on the oscilloscope screen. The left and right signals may be used directly if the resultant picture is then rotated 45 degrees. A completely circular pattern represents a separation ratio of 1, a horizontal pattern a ratio of less than 1, and a horizontal straight line a ratio of zero. Ratios greater than one produce an oval pattern that is wider vertically than horizontally. It can be seen, however, that this method of determining the separation ratio is rather cumbersome and time-consuming.

Fig. 1 is a simple circuit that measures the separation ratio of any program material on a continuous basis and also indicates the phase of the program material. The circuit contains only passive devices and requires no external power supply for operation. (*Continued on page* 98)

Fig. 1. Complete circuit diagram of the phase meter described.



R1,R2—50,000 ohm pot
C1—20 μf., 3 v. non-polarized elec. capacitor (can use polarized capacitor also)
M1—50-0-50 or 100-0-100 d.c. micro-ammeter (Lafayette TM-13 or TM-24)
T1,T2—Stepdown trans. 10,000 ohm pri. to 2000 ohms for each sec. (Stereosonics z18-3210. Available by mail at $2.00 per pair from Stereosonics, Inc., Box 4205, Long Island City 4, N.Y. Can also use two transistor driver transformers, such as Lafayette TR-46, for each. Primaries connected in parallel.)
SR1,SR2—5 ma. high forward conductance germanium diode (1N295 or equiv.)

TRANSISTORS FOR HI-FI *Panacea or Pandemonium?*

By D. R. von RECKLINHAUSEN, A. W. LINDER & E. H. L. MASON / H. H. Scott, Inc.

Part 2. The transformer myth, germanium vs silicon transistors, semiconductor protection, and the design of a new integrated hi-fi stereo amplifier are covered.

Editor's Note: Last month the authors discussed some of the facts and fallacies pertaining to the use of transistors in hi-fi amplifier circuits. The reason advanced for superior "transistor sound" was that the semiconductor amplifier is able to produce more available music power than a tube amplifier. This concluding Part 2 goes into additional misconceptions and winds up with details on a practical transistor amplifier design.

WHEN designing transistor equipment, an engineer has to keep a number of factors in mind. First, transistors are current amplifiers instead of voltage amplifiers; transistors need a base bias current the same way tubes need a bias voltage for their control grids. Second, transistors have typically 3 to 1 tolerances in current gain (β). In contrast, the tube's voltage amplification factor (μ) is normally held to a $\pm$20% tolerance. Since frequency response of transistors depends on their gain, properly designed feedback loops will provide the correct response. These feedback loops should also include d.c. feedback so that shifts in operating point can be compensated. Third, the maximum operating voltage of transistors is approximately one-tenth that of tubes, therefore, the impedance level of operation is correspondingly lowered, with a consequent increase in the values of the coupling capacitors that are required.

General Design Considerations

Since a transistor amplifier has to be used with external signal sources, level controls are definitely needed to bring the high peak output voltage of tube equipment to a level that can be handled by transistors. In addition, high input impedance is required so that accessory tube units are not driven into distortion by being loaded with a very low load impedance. This is one factor that has been neglected by many designers. Others have tried to overcome this by inserting relatively large resistors in series with the transistor amplifier inputs. This raises the hiss level of the transistor amplifier unduly. After all, the tube units driving the cables to the transistor amplifier have low internal impedance (by virtue of feedback) and this low internal impedance serves to keep the noise level of the transistor amplifier low. The high input impedance cannot be achieved without adding an extra stage, but eliminating this stage would be false economy.

Another mistake often made by designers of transistor equipment is to use the low input impedance of transistors as a means of roll-off to provide high-frequency equalization in magnetic phono preamp circuits. This works satisfactorily if the preamplifier is designed to work with only one particular model of cartridge. Since high-fidelity equipment may be used with cartridges of all makes, impedances, and configurations, these cartridges must also be accommodated. First, the input impedance of a preamplifier for magnetic cartridges should be on the order of 47,000 ohms. Cartridge manufacturers seem to have agreed on this load as proper termination for their cartridges to remove residual resonances. Second, a level control is required in any proper amplifier design to accommodate the output voltages of various cartridges. To achieve the proper input impedance, all equalization must, therefore, be performed in a feedback loop. The preamplifier circuit diagram in Fig. 1 shows a design that takes the above factors into account. Fig. 2 shows the following tone-control network used in conjunction with the preamplifier.

Protection of Transistors

As mentioned in Part 1, transistors do not have a current-limiting mechanism. The only thing that ultimately limits current, when the transistor is driven with maximum base current, is the saturation resistance of the transistor itself. Therefore, transistors have to be operated carefully so that overdissipation does not occur, particularly in power output stages. It should be emphasized that there is no zero voltage grid-bias protection as with tubes.

Overload kills transistors quickly. The small junction area of a transistor is limited in temperature rise which, when exceeded, causes "punch-through" (in effect, a short-circuit). This happens extremely rapidly. Anyone who has worked with tubes is generally warned by a glowing plate when dissipation has been exceeded; yet the tube is not destroyed because it can take such an overload for a reasonable length of time. With transistors, there is not enough time to pull the plug.

Therefore, transistors, and in particular power transistors, need protective circuitry which prevents overdissipation. Thermal switches and additional transistor circuitry have been tried with partial success. Fuses have also been used for this purpose. Ordinary fuses are much too slow; they have blowing times on the order of milliseconds to seconds. Even fast instrument fuses are too slow. They normally protect moving-coil volt and ampere meters. Recently, a series of extremely fast-blow fuses has been developed with blowing times fast enough to protect power transistors. These are the only ones suitable for this purpose.

In designing a power amplifier, one should know how much output power will result and also how much dissipation occurs within the output transistors themselves. For example, an ideal class-B circuit will operate at its maximum power output with a theoretical efficiency of 78%. At approximately 40% of maximum output power, the efficiency of this circuit is reduced to 50% and maximum heating occurs when operating into a resistive load. Also, it should be remembered that when transistors operate into a purely reactive load, this reactive load cannot dissipate any power whatsoever; yet the same maximum voltages and currents still occur within this impedance. All this current and voltage has to come from the d.c. power supply. Therefore, all power drawn from the supply has to be dissipated within the output stage itself. This is when maximum heating occurs. When this fact is neglected, disappointingly short transistor life will result.

Current limiting in a transistor output stage can be produced by limiting the amount of drive current. This is not a safe design for production because transistor current gains have their customary 3 to 1 spread, resulting in a 3 to 1 spread in collector current of the output transistor, and therefore a 3 to 1 spread in dissipation. Again, proper protection is an absolute "must" in such a circuit.

The Output-Transformer Myth

In high-fidelity equipment, the three standard loudspeaker impedances (4, 8, and 16 ohms), have to be accommodated. But, a transistor power amplifier has only one optimum load impedance for best performance. If it is desired to have equal and rated output into all of these standard impedances without discrimination, it is necessary to have some means of impedance matching. External transformers can be used for such a purpose, but these transformers may not be of a high enough quality to satisfy the most critical needs. Therefore, the best idea is to have a bifilar-wound autotransformer built into the amplifier to eliminate the problem. The response of such a transformer, when well designed, exceeds 4½ decades in frequency. In contrast, the frequency range between 20 and 20,000 cycles is only 3 decades.

It is expected at this point to see some raised eyebrows because transformers seem to have come into some disrepute. If a transformer is designed properly, the distortion it introduces is insignificant compared to the distortion present in the program material or the rest of the high-fidelity system. After all, program material travels through at least 5 transformers before reaching the listener's high-fidelity equipment. This occurs even when receiving a live broadcast from a local FM broadcast station having its transmitter and studio equipment in the same building.

Customarily in broadcasting, a larger number of transformers are used. For example, Boston's local high-fidelity stereo music station, WCRB, is perhaps typical. When making a local live announcement, 23 *transformers per channel* are between the announcer's microphone and the transmitter output. When making a live broadcast of the Boston Symphony Orchestra, a total of 33 *transformers* is involved, and this station meets all the FCC required frequency response and distortion specifications with ease. When making recordings, by the time the disc or tape has reached the listener's home, the sound on it has traveled through an average of more than *10 transformers* per channel. Therefore, one or two additional transformers will not make any difference providing these transformers are of acceptable quality.

Choice of Output Circuits

When designing the output stage of an amplifier, an engineer has the choice of several circuits. He can follow the circuits, for example, as shown in the *General Electric* transistor manual. These same circuits have appeared in a number of magazines. Here, each power transistor or parallel pair of output transistors needs a direct-coupled driver stage and two such sets with a pre-driver transistor comprise the basic amplifier. This is a somewhat dangerous circuit because failure of any one of the four to six class-B transistors involved may cause the failure of either most or all of the other transistors. In addition, only high-voltage transistors can be used in such a circuit. What's more, all have to be very carefully matched to each other to achieve satisfactory results.

The output stage can also be designed with a driver transformer acting as a phase inverter. This is a considerably safer circuit since the failure of any one transistor can, at most, take only one more into its grave. Also, the phase shift of the full circuitry is more controllable and therefore feedback can be more easily applied, resulting in much better performance. Also, the bias of each output stage can be adjusted separately,

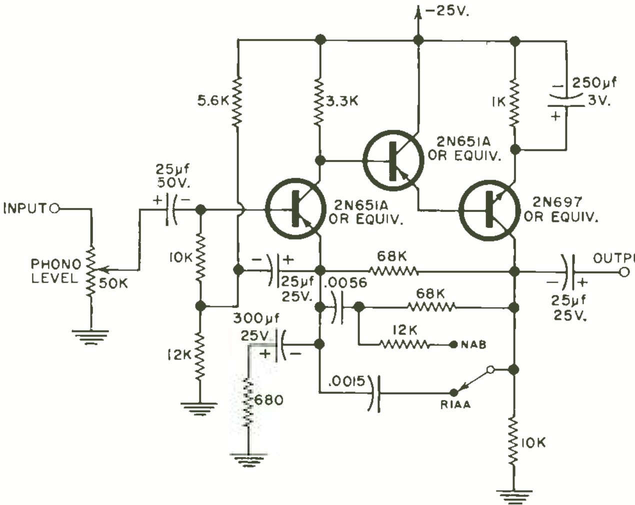


Fig. 1. Phono preamp circuit showing feedback equalization.

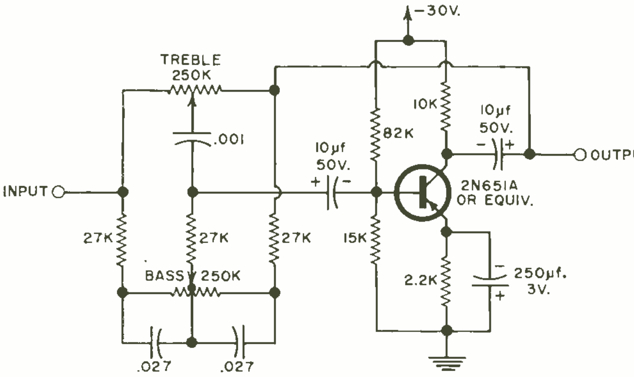
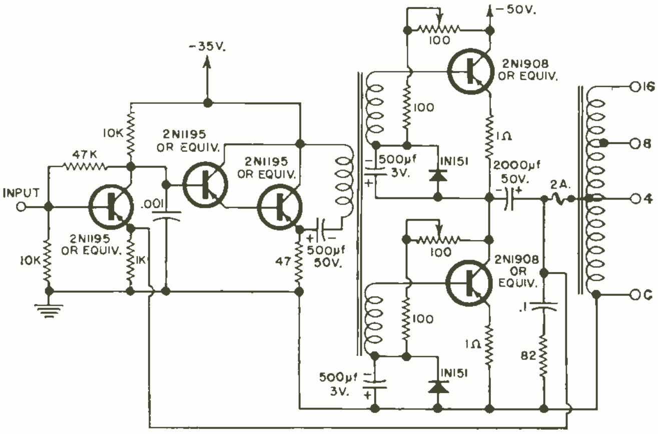


Fig. 2. Schematic diagram of the tone-control section.

Fig. 3. Driver, output-stage circuitry discussed in text.



such as is done in high-quality tube amplifiers. This results in a further reduction of distortion. In addition, less transistor matching is required. A still further reduction in distortion occurs because all driver transistors are operated class A. A good driver transformer for such a circuit has a frequency response flat over 5 decades.

Distortion at low listening levels is of great importance since most listening is done at low volume. Of course there will always be a few people who consistently listen at loud levels, but chances are they are in the minority. Obviously, the transistor amplifier has to perform satisfactorily at loud listening levels too, but the quality of performance at low listening levels brings out the difference between a good design and a marginal one. To achieve such low distortion, the output transistors have to be matched not only in current gain but also in input impedance over the entire expected current range of operation. In a transformer-driven output stage, only two

Over-all and inside rear views of the transistor stereo amplifier.

transistors per channel need such matching. In direct-coupled circuitry, anywhere between four and six transistors per channel require such matching. If any transistor failure occurs with the necessity of replacing others, fewer difficulties can be anticipated with a transformer-driven output stage than with a direct-driven output stage.

Temperature compensation is needed in a power-output stage since transistors change their characteristics with temperature. The best means for accomplishing this is to use temperature-sensitive bias-compensating diodes plus bias-adjustment controls. Fig. 3 shows such an output stage design.

Germanium or Silicon Transistors?

There has been considerable argument as to which transistors are better for audio use. The battle between germanium and silicon types rages back and forth. At the present time, here are the results which can be expected with the various types. When talking about alloy transistors, the silicon alloy transistor is better. It has a cut-off frequency (where gain is 3 db down) somewhere between 15 and 25 kc. In contrast, germanium alloy transistors have a cut-off frequency between 3 and 8 kc. This causes distortion at frequencies above one-half this cut-off frequency because feedback has to be reduced to maintain amplifier stability with reactive loads. In addition, the current gain of silicon transistors is very low, certainly too low to provide an adequate amount of feedback even at lower frequencies. Furthermore, tolerances of silicon transistors are higher than for germanium.

Fortunately for high-fidelity purposes, germanium diffused-junction transistors have become available. These transistors are best for audio purposes because their cut-off frequency is well above the audio-frequency range. Also, their current gain is very high and their phase shift is less than 90 degrees to well above AM broadcast frequencies. This permits a feedback design for good stability with all reactive loads. At the present time, this cannot be done satisfactorily with silicon transistors because of their lower gain and greater phase shift at very high frequencies. Even an additional stage of gain would not help, because the added phase shift at high frequencies would not permit more feedback. It is hoped and expected that in the future silicon transistors will become available that will overcome the above drawbacks.

The desired power output also determines the supply voltage required for the output stage and the regulation needed. At the same time, the choice of the output voltage permits inclusion of an adequate safety margin for proper operation. The pre-driver transistors should have extremely wide bandwidth and have gain-bandwidth products extending into the several hundred megacycle region. This permits design of the over-all circuitry with minimum phase shift and adequate gain. All of this allows an amplifier to be designed which can maintain a high degree of stability.

Power Supply and Preamplifier

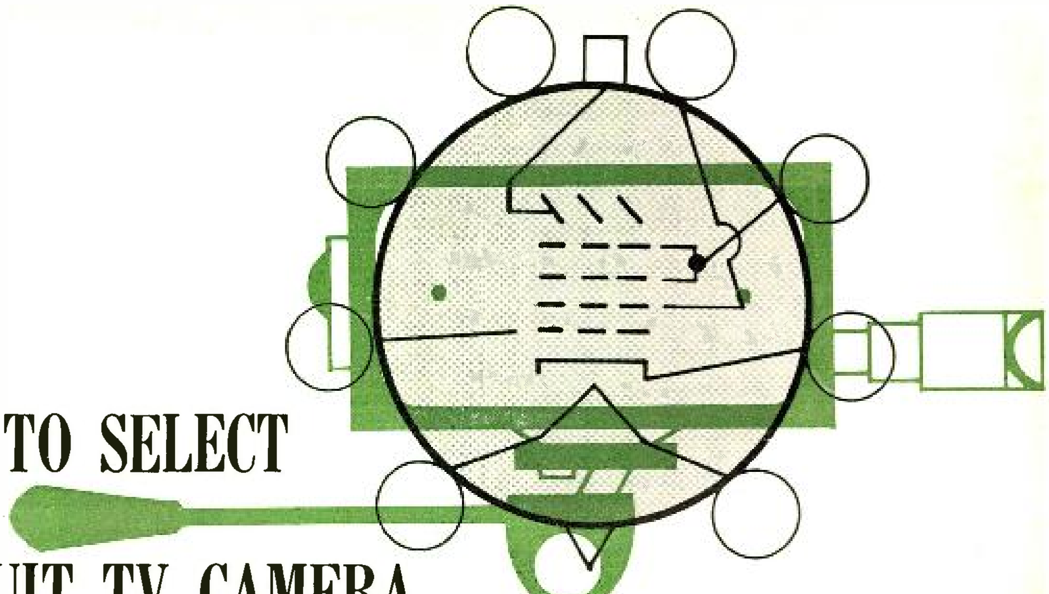
In the design of preamplifiers, extensive feedback should be used. This reduces distortion and stabilizes gain. For example, tone controls and low-frequency sharp-cut-off filters should be in feedback loops so that over-all gain and frequency response is maintained under all conditions. In addition, level controls should be provided so that a wide range of input voltages from various sources can be accommodated. The impedance of the amplifier at its various inputs should be such that all cartridges, magnetic or ceramic, and all high-level sources can be accommodated without mismatch. All these requirements have been met in the amplifier whose circuit diagrams are shown in Figs. 1, 2, and 3. These circuits are schematics of the various sections discussed above. Interconnections and other details have been omitted for simplicity. Two identical channels are used for stereo.

The power supply for the amplifier output stage is not regulated because of the high power that would be dissipated by the regulator circuit itself. However, the supply has a low internal impedance permitting adequate output under both music-power and steady-state conditions. One single-ended supply is used rather than two supplies such as are found in many transistor amplifiers. We decided to use a large coupling capacitor from the output stage to the load and thereby avoid any direct current in the loudspeaker voice coil. Such current would tend to pull the loudspeaker cone away from its normal position. In addition, the maximum energy which could be stored in the resonant impedance of a loudspeaker system or improper external matching transformers cannot be higher than the energy stored in the output coupling capacitor. Such energy would have to be dissipated within the output transistors when overdriven. Limiting this energy is a further way of protecting the output transistors.

All low-level stages operate from a regulated portion of the power supply. Hence, they are not subject to supply-voltage hum and power-line or low-frequency transients due to the variable power supply load imposed by class-B operation of the output stages of the transistor amplifier.

Amplifier Construction Requirements

Adequate heat sinks must be provided for the output transistors. At a music-power level of 30 watts per channel or even somewhat less, the chassis is an inadequate heat sink. If heat sinks are too small, the temperature of the output transistors will rise excessively, resulting in their possible destruction. Of course, allowance (*Continued on page 64*)



HOW TO SELECT A CLOSED-CIRCUIT TV CAMERA

By WILLY SANDER / Sr. Project Engineer, CCTV, Blonder-Tongue Laboratories, Inc.

Factors to be considered for various applications. The types of vidicon tubes, cameras, and their characteristics.

CLOSED-circuit television (CCTV) is a modern method of communications which offers an almost unlimited variety of applications. It is presently being used in business, industry, banking, and education—almost anywhere where an extra pair of remotely located "eyes" can be employed. Whether it be for surveillance, security, remote observation of hazardous machinery, or signature identification, CCTV has been found to be a very useful as well as an economical tool.

With recent advances in CCTV technology, the cost of installing and maintaining the equipment has been significantly reduced. Modern cameras offer not only low initial cost but also almost full automatic operation, making them practically as easy to use as a home television receiver.

Cameras and Light

The most important piece of equipment in any CCTV installation is the camera. Today one can buy a CCTV camera for a price ranging from approximately $500 to $5000 and more. In order to select the right camera for any installation, one must be aware of what features are necessary for a given application and what features are unimportant. Before attempting to select a camera we must first investigate the requirements of the application.

The first and most important thing to be considered is light. How much light is available on the scene to be televised? Does the light vary during the time the camera is in use? What are the maximum and minimum expected light levels reflected from the scene?

Many of the cameras on the market today use the most sensitive vidicons available, such as the 7735-A or the 7325. These vidicons, when used in conjunction with a well-designed low-noise camera and a fast lens, will yield usable pictures with as little as ½ footcandle reflected light. A "usable picture" is usually defined as one which has a small (but not objectionable) amount of noise. While this type of reproduction is adequate in many cases, it is often foolish to live with such performance when, with the addition of some inexpensive lighting, one can get excellent performance.

There is another important factor which becomes objectionable at low light levels and this is *lag*. Lag can best be described as the apparent transparency of objects which move rapidly across the field of view of the camera. In modern cameras with automatic light-level compensation the more light reflected from the scene the less ghostly moving objects will appear. This effect is also a very important function of the type of vidicons used. Some types are less subject to lag than others. Even within one type of vidicon, one can expect wide variations from unit to unit.

Now let us consider light-level variations. Many of today's cameras contain what manufacturers call "automatic light-level compensator" circuitry. This circuitry really adjusts the target voltage on the vidicon automatically as the light level changes and is, therefore, more properly called "automatic target compensation (ATC)." Most manufacturers incorporating this circuitry claim between 1000:1 and 4000:1 allowable light-level changes for practically no change in the picture quality. These numbers are greatly dependent on the method of measurement but no industry standard has been established as yet. In general, one can assume that the light cannot be less than that advertised for a usable picture and can increase by the stated ratio. In other words a camera which yields pictures with ½ footcandle of reflected light and has 2000:1 ATC range can be used up to 1000 footcandles without re-adjustment.

In all of this discussion concerning light we have thus far ignored a very important factor—the lens. As in photography, the *f*-stop of the lens plays a very important role. Most industrial television cameras are furnished with an *f*-1.9 lens. When a manufacturer claims ½ footcandle usable sensitivity, he usually means with the standard lens as supplied, opened to its largest *f*-stop. If any other stop is used, the rules of photography apply, that is, twice as much light is needed for every *f*-stop that the lens is closed.

To summarize our discussion on light; we must consider the scene to be televised from the standpoint of always having an adequate amount of light available for a suitable picture. This amount may be more than that advertised for a suitable picture especially if fast motion is expected in the scene. The light variations on the scene must fall within the capabilities of the camera to respond. The scene should

Table 1. Horizontal and vertical field coverage for lenses.

Distance	10 FEET		20 FEET		40 FEET		60 FEET		80 FEET	
	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.
LENSES:										
½" wide-angle	10′	7.5′	20′	15′	40′	30′	60′	45′	80′	60′
1" normal	5′	3.7′	10′	7.5′	20′	15′	30′	22.5′	40′	30′
3" telephoto	1.6′	1.2′	3.3′	2.5′	6.6′	5′	10′	7.5′	13.3′	10′
6" telephoto	.8′	.6′	1.7′	1.25′	3.3′	2.5′	5′	3.7′	6.6′	5′

DISTANCE	f-1.5	f-2.5	f-4.0	f-5.6
3′	2.8-3.25 ft.	2.6-3.4 ft.	2.5-3.8 ft.	2.3-4.2 ft.
10′	8-13.4 ft.	7-17.5 ft.	5.9-31.7 ft.	5.1-260 ft.
25′	15.2-70 ft.	12 ft.-inf.	9.2 ft.-inf.	7.4 ft.-inf.
50′	22 ft.-inf.	16 ft.-inf.	11.2 ft.-inf.	8.6 ft.-inf.

Table 2. Depth of field for 1-inch lens on a vidicon camera.

be uniformly illuminated and all of the rules that apply to photography will also apply to television.

Environmental Conditions

The environment in which a camera is to operate must either be suitable or adjusted by means of enclosures for proper operation. The first thing to consider is temperature variation. Is the camera operated outdoors? What temperatures are expected during the seasonal variations? These factors are of utmost importance because a camera, as any piece of electronic equipment, can only operate within a limited temperature range. Many of the cameras on the market are suitably compensated to operate between a range of 10 and 131 degrees F. Whether or not a housing is necessary depends on the climate of the area where the installation is made. Even if a housing is not required because the camera temperature range is adequate, the camera must be shielded from the direct rays of the sun as well as from rain, salt spray, and dust. Enclosures containing thermostatically operated heaters for use in cold climates as well as fans for use in warm environments are available. These same housings can be purchased with a number of accessories, such as windshield wipers, defrosters, which may be helpful.

If a camera is to be operated in an atmosphere containing explosive gases, such as may be found in a refinery or a hospital operating room, an explosion-proof housing will be required. This housing seals the camera from the gases, thereby eliminating the hazard of ignition.

Another factor which could be considered part of the camera environment is the source of power for the unit. There are few areas, if any, where the line voltage cannot be expected to vary a few volts during the day. Voltage regulation of the camera's power supply is an absolute necessity for all applications. A camera is very sensitive to voltage variations. Units which do not have regulated power supplies will give an out-of-focus, unusable picture if the line voltage changes as little as 5 volts. If in doubt, the best test is to actually change the line voltage by means of a variable autotransformer and observe the picture quality. Cameras which have properly designed regulated power supplies will not defocus over a supply voltage change of 100 to 130 volts. In interlaced cameras, it is also of interest to note whether the counter circuitry is stable. The picture should not tear, bounce, or be affected over the expected supply voltage changes, or there will be periods when the camera will either be unusable or require re-adjustment.

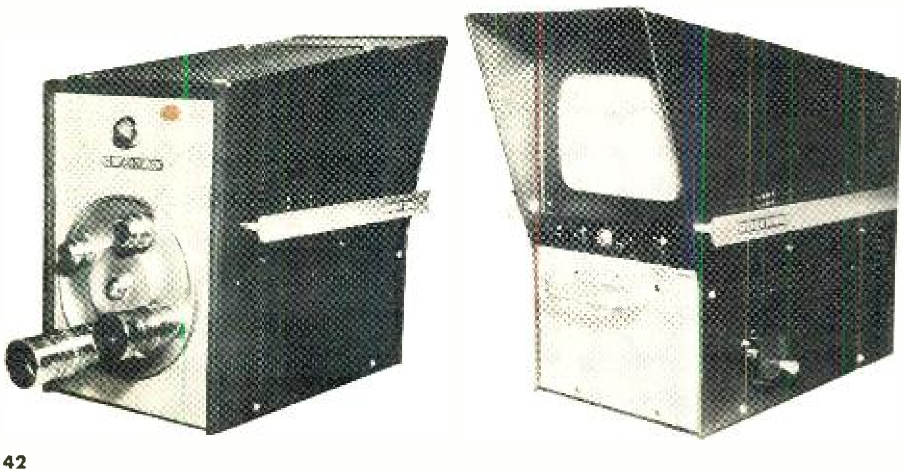
The resolution of a camera is a measure of its ability to reproduce fine detail. Resolution is usually measured in both the horizontal and vertical directions. As a frame of reference, the best possible home television set would have a resolution of 350 lines in both the horizontal and vertical directions. This limitation is placed upon the receiver by the method of transmission used in this country. Most low-cost home receivers are not capable of fully reproducing the transmitted picture to its maximum detail. The average receiver probably has a horizontal resolution of 275 lines and a vertical resolution, when suitably interlaced, of 350 lines. When using the standard 525-line scanning system, the vertical resolution of a fully interlaced camera is approximately 350 lines. Cameras using random interlace may, depending on conditions, give 350 lines of vertical resolution but usually can be expected to give only 175 lines. The horizontal resolution may vary anywhere from 300 lines to 700 lines depending on the camera design.

In order to achieve perfect interlace and thus get the full 350 lines of vertical resolution, both horizontal and vertical sweep frequencies must be derived from the same source. In random interlace cameras these two frequencies are not in any way related to each other. If, for example, we have the vertical frequency locked to the power line and the horizontal derived from a stable oscillator, we cannot guarantee interlace. At best there will be times when the camera is interlaced and times when it is not. The sets of horizontal scanning lines will drift with respect to each other due to power-line frequency and phase variations. When we have interlace, we have 350 lines of resolution and when we have positive pairing we have only 175 lines.

To select the right camera for the job we must again consider the requirements. If we want to use the camera for surveillance, security, or other applications which do not involve the necessity of reproducing fine detail, a random interlaced camera with a horizontal resolution of 400 lines will probably be adequate. If, on the other hand, the reproduction of detail is important, such as in signature transmission for banks, a fully interlaced 600-line horizontal resolution camera must be used.

One of the important factors concerning resolution is often neglected. The resolution advertised by CCTV manufacturers is measured in the center of the picture. Normally the resolution at the corners of the picture is less than that found in the center. It is only in very sophisticated equipment that one finds the corner resolution in the horizontal direction is on the order of 500 lines or better. This factor is very important in the transmission of printed matter which extends to the corners of the picture. While it can be very legible in the center, the corners may be unusable. The best way to determine whether a piece of equipment is adequate as far as resolution is concerned is to actually take a unit and duplicate the conditions under which it is expected to be used.

Front and rear views of a typical four-lens viewfinder closed-circuit TV camera.



Linearity and *geometric distortion* are measures of how well a camera reproduces the shapes of the objects. Everyone is probably quite familiar with this effect which is often found in older, poorly maintained television receivers. People get fatter as they move from the left of the screen to the right. Rolling titles change height as they move down the TV screen. All these effects are due to poor linearity and/or geometric distortion. Probably the most obvious and striking example of this is the circle which looks more like an egg than a circle. While 1% or 2% distortion is excellent, 5% is still quite acceptable for most non-critical applications but here again there is nothing like an actual demonstration to determine how strict the requirements of the job will be. Next, let us consider the types of vidicons.

Types of Vidicons

The vidicon tube is the most expensive single part of a camera. It is literally the "eye" or pickup device. There are many different types of vidicons on the market, all of which have their merits and shortcomings depending on the application. While most manufacturers sell their cameras with the vidicon type which, in their opinion, is best suited for "all-purpose" use, many of them have options whereby they will supply a different type on request.

With the advent of the low-cost camera, the class B vidicon has become very popular in the lower priced cameras. A class B vidicon (sometimes called commercial grade) is really a class A, or first quality, vidicon which was rejected for minor flaws. These flaws usually consist of small spots in the picture, poorer shading (uneven picture brightness), etc. Class B vidicons, when used in well-designed cameras, are capable of giving excellent pictures, usable for most applications.

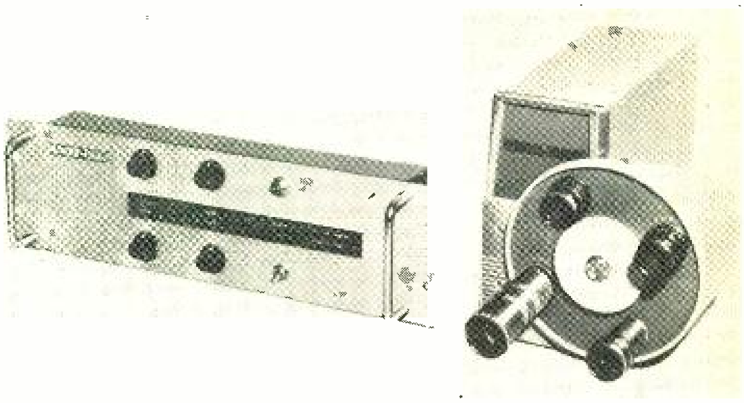
The class A vidicon is generally used in the higher priced cameras and exclusively in studio cameras. Of the most popular vidicons there are four types which are commonly used for CCTV cameras. The 7735-A is a high-sensitivity, low-lag vidicon. The 7038 is a medium-sensitivity, extremely low-lag vidicon. It requires an average of four to five times more light than the 7735-A. The 7325 is a high-sensitivity, higher lag unit while the 1319 is a class B high-sensitivity, higher-lag tube.

Vidicon manufacturers are constantly striving to improve their devices. The quality of a given vidicon type of today is subject to change without notice as manufacturers improve their techniques.

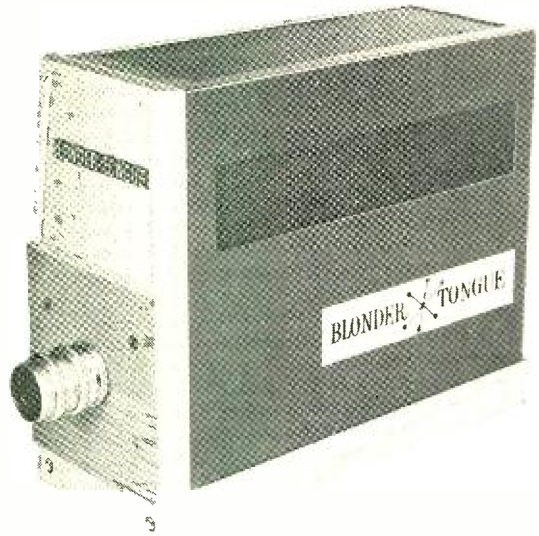
The selection of the best vidicon for the job is not a simple task, although in most applications any one of the above-mentioned types will perform successfully. There are installations where proper selection of a vidicon type may make the difference between a good picture and a barely passable one. Since vidicon characteristics change from time to time, it is best to consult with the camera manufacturer for recommendations concerning which type will best meet particular requirements. Vidicons need careful handling. They are very expensive to replace and somewhat delicate. While a vidicon, when properly operated, can give a few thousand hours of useful life, it can also, when subject to misuse, be damaged beyond repair in a few seconds. The vidicon photoconductive layer is very sensitive to strong lights and can be permanently scarred if pointed directly at the sun or other high intensity light source. A camera should be installed so that it is impossible for the sun or direct reflections of the sun's rays to strike the lens. It is also strongly recommended that all types of light sources be kept out of the field of view of the camera.

Besides lag, which we have already discussed, vidicons are also prone to image retention. This effect, popularly called "burn-in," exhibits itself as a retained image on the vidicon. It remains even when the scene is changed. Some vidicon types are more prone to this effect than others and large variations can be expected within the same vidicon type. It is recommended that the camera lens be capped when the unit is not in use in order to minimize this effect. The vidicon can retain any image any time there is a light striking the photoconductive surface even though the camera may be off. If it is impractical to cap the lens of the camera when not in use, it is advisable to frequently change the scene by moving the camera to minimize the danger of image retention. Even with all these problems, the vidicon is an excellent image pickup tube and the most economical to operate.

There are a number of accessories which can be used in



A remote CCTV camera shown here with its control panel.



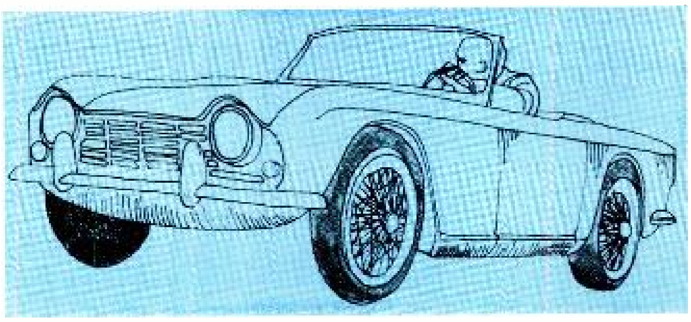
Typical example of low-cost, automatic industrial TV camera.

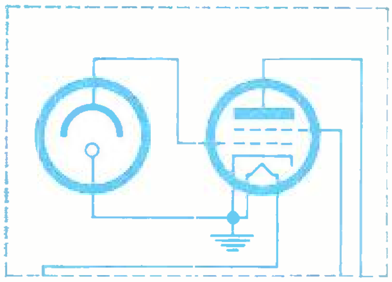
conjunction with a camera. A large selection of wide-angle, telephoto, and zoom lenses is available for use with any camera. As in photography, the selection of lens depends on the area of coverage required (see Tables 1 and 2). Zoom lenses, although higher priced, offer an excellent method of continuously controlling the area that is to be viewed.

Pan and tilt mechanisms enable the user to move the camera laterally and vertically from a remote location thereby allowing him to view a large area, one segment at a time, with a single camera. Remote optical focus is an option available from many manufacturers and enables one to view both close and far objects with equal sharpness. Remote or manual turrets are also available as a quick method of selecting up to four lenses for different areas of coverage.

Modern cameras with automatic target compensation are designed so that they require a minimum of adjustment. In most applications, once a camera has been installed and properly adjusted it requires no further care except for routine maintenance. There are few, if any, controls that must be handled by the user and even those are of such a nature that they require no special training for proper operation. A stable automatic camera operating over the recommended range of light and temperature, does not need any adjustments. It is for this reason that in 90% of the applications it is not necessary to have the camera operating controls remoted. Many of the cameras have no controls accessible to the user other than the "on-off" switch.

There are some philosophical questions still to be discussed on the relative merits of an all-transistor *versus* a vacuum-tube camera. The design of a transistor camera involves many serious problems (*Continued on page* 65)





NOVEL ELECTROMETER TUBE

By C. E. ATKINS / Tung-Sol Electric Inc.

Description and operation of a rugged yet ultrasensitive low-voltage tube that is employed for automatic headlight control and for industrial equipment.

An important, although little known, vacuum tube is holding its own in competition with semiconductors. This is the *Tung-Sol* Type 7851 electrometer tube. When it is necessary to respond to currents as low as a few micromicroamperes and do this repeatedly with accuracy and dependability over long periods of time, this tube is still without a peer in its price class. (It sells to manufacturers for a little over a dollar.) This tube is useful in all forms of instrumentation where small currents are involved. It is employed in measuring apparatus and in transducers in the electro-medical field but its principal use (one which provides the volume required to establish its relatively low price) is in conjunction with a vacuum photocell in the beam depressor (or as it is more commonly, although incorrectly, called "headlight dimmer") used on *Cadillacs* and other *General Motors* cars. This equipment is called the "Autronic Eye" or, more recently, "Guidematic Power Headlight Control" after the *Guide Lamp Division* of *General Motors Corporation* which developed and manufactures it. This application is typical of the commercial usefulness of the tube.

The Tube Itself

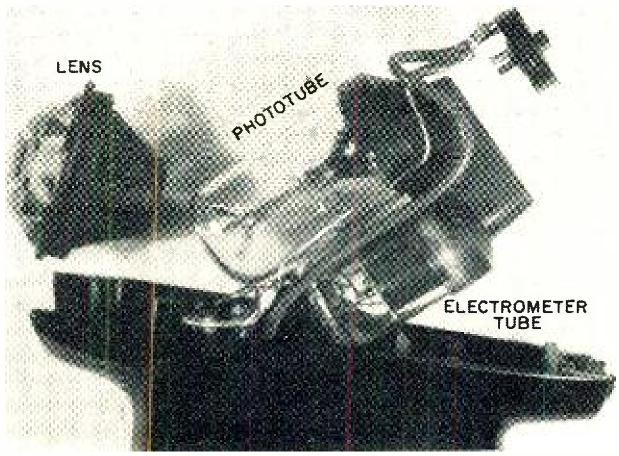
The electrometer tube is of the 7-pin button-stem miniature type with the control grid brought out through the top of the envelope. Its heater takes 200 ma. at 2½ volts and under these circumstances its cathode temperature runs about 100°C. cooler than the average vacuum tube. This feature calls for cleanliness and astute processing by the manufacturer in order to achieve good emission at this low temperature. With a cool cathode the possibilities of grid emission and leakages due to contamination from cathode throw-off are practically eliminated.

The 7851 is a tetrode in which it is possible to maintain a high plate impedance with a knee in the plate family occurring at approximately ½ to 2 volts on the plate. The characteristic curves that are shown in Fig. 1 illustrate this particular point.

It will be noted that the plate current is only a few microamperes. The recommended maximum plate potential is only 12 volts. By operating at low voltages it is possible to avoid ionizing the residual gas inside the envelope. Gas ions are harmful because they add to the grid current and it is imperative that the grid current be made vanishingly small in electrometer tubes.

Stray light can cause grid current by inducing photoelectric emission from grid or grid supports and so it is customary to use the tube in the dark. Furthermore, stray light from the heater will also do this so it is important that the cathode sleeve be pinched and care must be taken to avoid stray light emanating from the bottom legs of the heater.

Pickup unit has been disassembled to show its two vacuum tubes.



The low temperature operation of the cathode is, of course, very helpful in this respect. The writer has found tubes with very high input impedance in the order of a million megohms or more which will drop to a few megohms when the heater voltage is elevated by as little as 20 or 30 percent.

Moisture is also quite a hazard since condensation of water vapor can cause conducting films over the surface of the glass envelope between the grid-cap and the grounded base leads. It is sometimes necessary to use special potting compounds to protect the grid lead from moisture-laden atmospheres.

The importance of the electrometer tube in the auto headlight beam depressor stems from the fact that it permits use of a vacuum phototube which, while very stable, is relatively insensitive. Many attempts have been made to use semiconductors as photo sensors and some of these are orders of magnitude more sensitive than the vacuum phototube. However, they require temperature compensation and protection from heat and sunlight so that, thus far, they have proved to be impractical. The vacuum phototube, while it is affected by direct sunlight, rapidly regains its normal dark characteristics when returned to darkness. It is not as temperature dependent as most semiconductors and reaction time is no problem whereas with solid-state devices it can be.

Because of the low light levels and the comparative insensitivity of the vacuum phototube, the current available in the average automotive application is only a few micro-microamperes. Thus, a very sensitive device like the electrometer tube is required to utilize these minute currents.

Circuit Arrangement

Fig. 2 is a schematic diagram of the automatic headlight control. As the circuit shows, the phototube is connected between the #1 grid and cathode of the 7851. With this connection the phototube current becomes the grid current of the electrometer tube, while the polarizing potential of the phototube is the grid-cathode potential of the 7851. The voltage available to energize the phototube is in the order of 2 volts and this is due to the escape velocity of the electrons emitted from the heated cathode of the electrometer tube.

There are approximately 8 volts on the screen grid whereas the plate is fed from the 8-volt source through a 1.5-megohm load resistor.

The plate of the electrometer is coupled directly to the control grid of the 12K5. The 12K5 is a space-charge grid power tube which was used in automobile radios to drive the power transistor in hybrid sets. (The first grid is the space-charge grid which is connected to the 12-volt supply. The second grid is the actual control grid.) In this system the tube is used to control a sensitive relay which, in turn, operates a power relay energizing the headlamps.

The operation of the system is as follows. The light from the headlights of an oncoming car causes the photocell to generate a voltage that makes the grid of the preamp tube less negative. This change is amplified by this tube which then applies a negative voltage to the 12K5 amplifier grid. As a result, the sensitive relay is de-energized. This, in turn, energizes the power relay which depresses the car's headlights (that is, changes from upper beam to lower beam).

As the dotted lines in Fig. 2 indicate, the equipment is built in two assemblies, a phototube unit which serves to pick up and respond to light from oncoming cars and, second, an amplifier unit which translates signal information from the pick-up unit into a control for the power relay.

Sensitivity of the system is controlled by adjusting the screen-grid potential of the electrometer tube. In fact, the sensitivity of the response to screen potential is utilized to change the operating level of the system once it has switched to low beam. A provision of this kind is necessary because after two approaching cars dim their headlights there is far less light so the sensing facility must become more sensitive in order to keep the system on lower beam. Under these conditions the shunting effect of the power relay is removed from the screen-grid circuit of the electrometer tube, thus raising its screen voltage and increasing its sensitivity.

Because of the wide voltage excursions sometimes occurring in the electrical systems of automobiles, a ballast lamp is provided to maintain the critical supply voltages (which are mainly the heater and screen potentials of the electrometer tube) at a value close to 8.0 volts although the system potential may vary from 11 to 16 volts. Potentiometers are provided to achieve the necessary sensitivity control for the "dim" and "hold" conditions. ▲

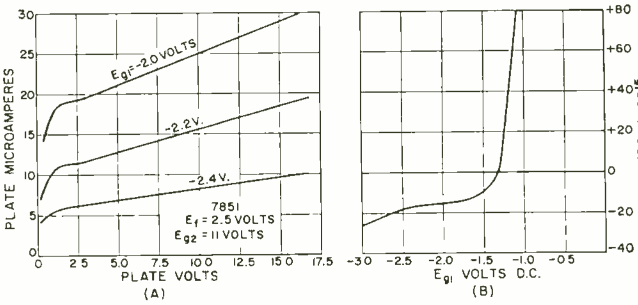


Fig. 1. Plate and grid characteristics of electrometer tube.

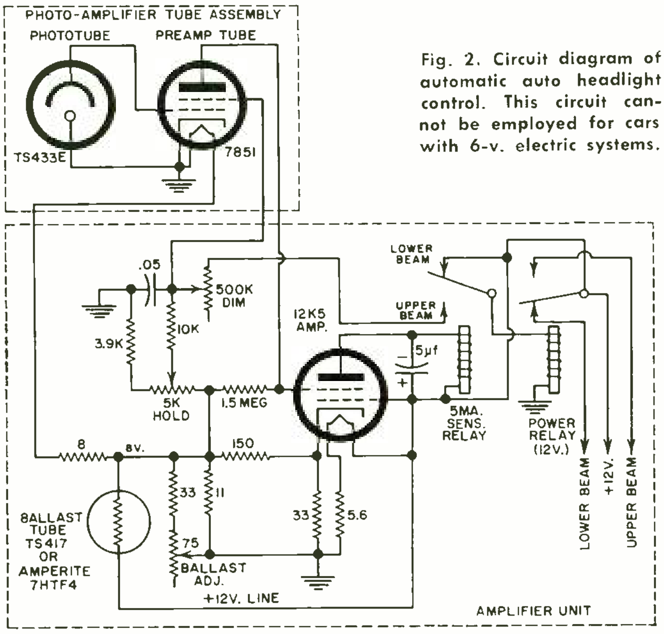
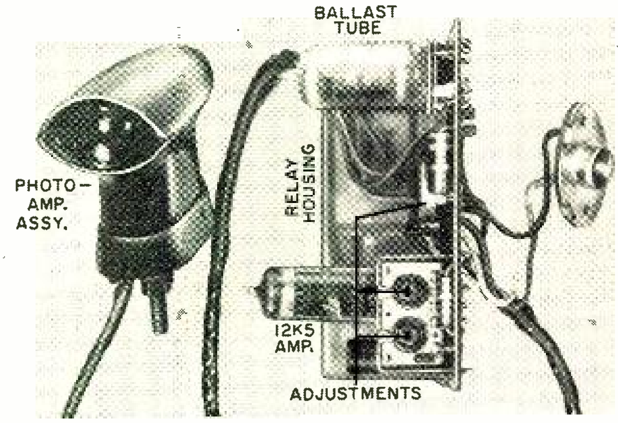


Fig. 2. Circuit diagram of automatic auto headlight control. This circuit cannot be employed for cars with 6-v. electric systems.

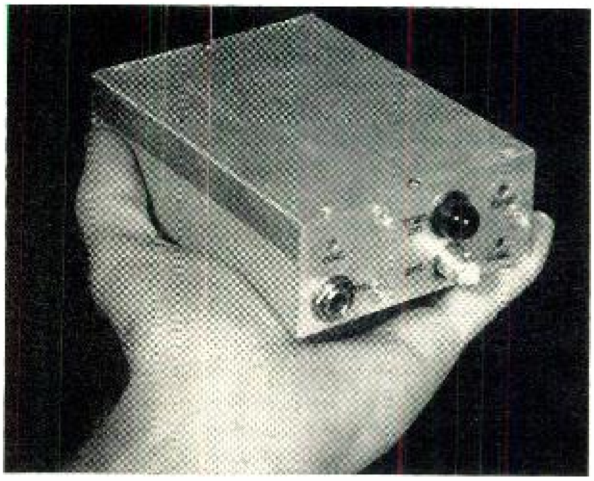


The headlight controller consists of two units. The one at the left picks up the light from an oncoming car while the assembly at right controls relay that operates the lights.

SOLID-STATE 3-WATT CB-HAM TRANSMITTER

By THOMAS J. BARMORE

Construction of a miniature mobile rig for 10 or 11 meters that features an unusual circuit design.



The entire transmitter is housed within a 1 x 3 x 4 inch case.

IN the past several years, transistorized transmitters operating in the 30-mc. region have progressed from the familiar 100-mw. type to those having a power of several watts. Most of this progress has been due, in large part, to Citizens Band equipment, since it has a greater market appeal. Most of these "new-breed" transmitters, however, are quite expensive because of design costs and the expense of a different and new set of components.

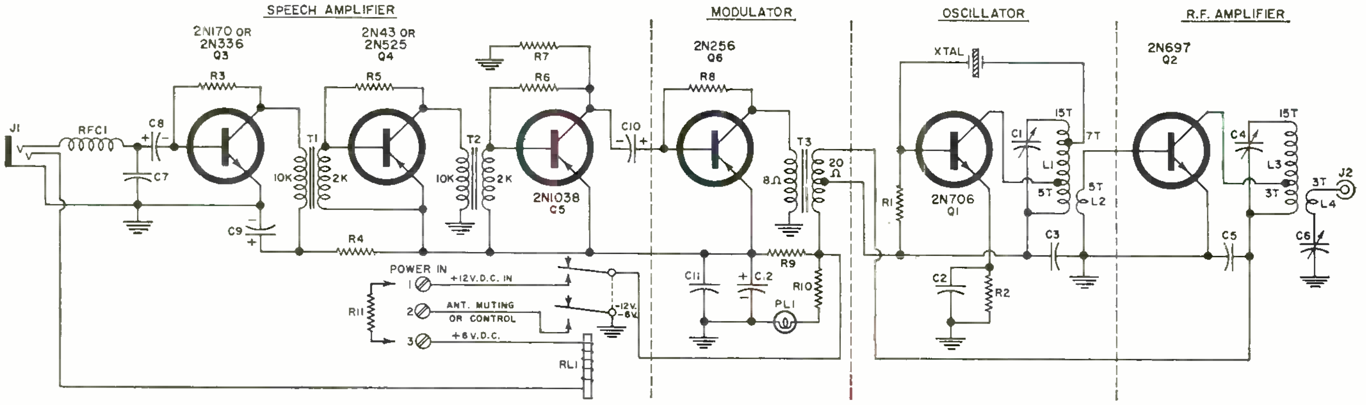
The transmitter to be described is intended as a mobile unit, but the builder may use it as a basis for a hand-held transceiver or as a portion of a base station for either CB or 10-meter amateur service. The r.f. portion of the unit has an average modulated power input of over 3 watts and will deliver about 2 watts into a 52-ohm load. Frequency stability, using a .005% crystal, is well within the tolerance specified by the FCC for Citizens Band operation despite the unusual system of modulation used. The whole transmitter, including the modulator and control circuitry, is packaged into a space measuring about 1" x 3" x 4." The design is such that the circuit components can be purchased for about $35, not including the cost of the microphone.

The circuit (Fig. 1) may appear to be a bit unusual in several respects; namely, both the oscillator and the final stage are modulated and, in addition, a class A amplifier is used as a modulator instead of the more usual class B configuration.

First, a transistorized class C amplifier, upon application of amplitude modulation, tends to saturate on modulation peaks. This saturation causes a reduction in the current gain of the transistor. This produces a modulation envelope similar to that seen in downward or negative modulation. By reducing the final-amplifier modulation and modulating the oscillator about 25%, total modulation still remains at 100%, but without the disadvantages found in single-stage modulation as mentioned above.

Second, in addition to proper positive modulation, the useful range of any transmitter depends on the audio system used for modulation. Importance must be placed on systems which have low distortion, since the distortion of a transmitted signal seriously hinders the intelligence of the received signal. Since the transmitter described here is intended for mobile installations, high intelligence, and in-

Fig. 1. Circuit diagram of rig shows that the output of the class A modulator is applied to both oscillator and final stages.



R1,R5—10,000 ohm, ½ w. res.
R2—47 ohm, ½ w. res.
R3—68,000 ohm, ½ w. res.
R4—1000 ohm, ½ w. res.
R6—3300 ohm, ½ w. res.
R7—82 ohm, ½ w. res.
R8—820 ohm, ½ w. res.
R9—2.5 ohm, 3 w. res.
R10—150 ohm, ½ w. res. (for G-E 48) or 30 ohm, ½ w. res. (for G-E 328)
R11—12 ohm, 1 w. res.
C1,C4—7-45 pf. trimmer (Centralab 822-BN)
C2,C3—.01 µf. disc ceramic capacitor
C5—.005 µf. disc ceramic capacitor
C6—8-50 pf. trimmer (Centralab 823-DN)
C7,C11—50 pf. disc ceramic capacitor
C8—1 µf., 30 v. elec. capacitor
C9—10 µf., 10 v. elec. capacitor
C10, C12—68 µf., 30 v. elec. capacitor
(Capacitance of electrolytics not critical)
L1—15 t. #20, ½" i.d., 16 t./in., tapped at 5 & 7 t. (Air Dux 416T)
L2—5 t. #20 insulated, closewound on cold end of L1
L3—15 t. #20, ½" i.d., 16 t./in., tapped at 3 t. (Air Dux 416T)
L4—3 t. #20 insulated, closewound on cold end of L3
RFC1—R.f. choke, 50 t. #30 enam. scramble-wound on 10 meg., ½ w. res.
Xtal.—27 to 30 mc. third overtone crystal
RL1—D.p.d.t. miniature 6 v. relay (Potter & Brumfield KM11D)
J1—Three-circuit phone jack
J2—BNC coax connector
PL1—Miniature 6 v. pilot lamp (G-E 328 or G-E 48)
T1,T2—Interstage trans. 10,000 ohms to 2000 ohms (Stancor TA-35)
T3—Transistor output trans. 8 ohms to 20 ohms c.t. (Stancor TA-12)
Q1—2N706
Q2—2N697
Q3—2N170 or 2N336
Q4—2N43 or 2N525
Q5—2N1038
Q6—2N256
2—Heat sinks (see text)

expensive construction, a class A configuration is used as a modulator since it offers the lowest distortion, least thermal drift, and a minimum of components over class B configurations.

R.F. Section-Oscillator: The oscillator employs a 2N706 as a grounded-emitter Pierce oscillator. Bias for this stage is furnished by resistor $R1$, while resistor $R2$ and capacitor $C2$ form a network to prevent thermal runaway. Capacitor $C3$ places the cold end of $L1$ at ground potential, while $L1$ itself is tapped to match the very low output impedance of $Q1$. The output of the oscillator stage is link-coupled *via* the 5-turn link $L2$ and is fed directly to the base of the final amplifier.

R.F. Section-Amplifier: The r.f. amplifier employs a 2N697 (normally used in high-speed switching applications) as an unneutralized grounded-emitter, non-linear amplifier. Bias for class C operation is obtained merely because of the base characteristics of a silicon transistor. In operation, the transistor will not "turn on" until the base-emitter junction voltage is above about 0.6 volt. Voltages developed across the coupling link $L2$ and hence the current through it, is only slightly above this cut-off point, thereby causing class C operation of the stage.

Collector impedance is matched through utilization of the tap on $L3$, while capacitor $C5$ places one side of $L3$ at r.f. ground potential. Antenna coupling is accomplished through the use of the series-tuned circuit consisting of link $L4$ and trimmer $C6$.

Speech Amplifier: The speech amplifier employs one *n-p-n* and two *p-n-p* transistors, $Q3$, $Q4$, and $Q5$ in a straightforward configuration. Resistors $R3$, $R5$, and $R6$ provide bias current for each stage, while coupling between stages is accomplished by transformers $T1$ and $T2$. Resistor $R4$ and capacitor $C9$ form a decoupling network to isolate the first stage of the amplifier from the succeeding two stages. Choke $RFC1$ and capacitor $C7$ comprise a simple low-pass filter to prevent amplifier oscillation due to r.f. pickup. The output of this amplifier, which is about 0.5 watt, is developed across $R7$ and coupled *via* capacitor $C10$ to the base of $Q6$.

Modulator: The modulator, again, is conventional, with bias furnished by resistor $R8$. Transformer $T3$ matches this stage to the r.f. amplifier with an impedance of 20 ohms and to the oscillator with 5 ohms. Its primary impedance is 8 ohms. Resistor $R9$ and capacitors $C11$ and $C12$ serve as an audio and r.f. bypassing network to isolate the modulator from other circuitry.

Control: Power to the transmitter is controlled by the s.p.s.t. switch on the crystal or ceramic microphone which, in turn, actuates relay $RL1$. One set of the contacts on this relay serves to switch voltage to the unit, while the other set may be used either to mute a receiver by grounding the antenna or as a switch to control other circuitry.

There are several ways in which the transmitter may be powered:

1. 12-volt system. Jumper a 12-15 ohm, 1-watt resistor between terminals 1 and 3 to supply voltage to relay $RL1$.
2. 6-volt system. Place a straight wire jumper between terminals 1 and 3. The r.f. output, however, will be reduced to about 0.5 watt.
3. 6-volt system, auxiliary supply. Those builders who wish to maintain a full 3 watts output but still operate with the transmitter on a 6-volt electrical system, may construct a simple 12-volt d.c. supply using the power available in a standard car radio (Fig. 2). In this supply, power from the secondary of the vibrator transformer (or transistorized converter transformer) is stepped down to about 12 volts, rectified, and used to supply power to the transmitter circuitry only. The relay supply voltage still remains at 6 volts.

Construction

The transmitter is constructed in a modular manner, using four decks: front panel, r.f. section, modulation-speech amplifier, and rear panel-control. (*Continued on page* 85)

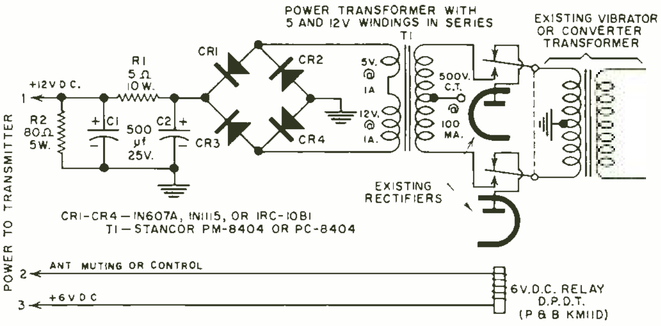


Fig. 2. Power supply using car radio's vibrator transformer.

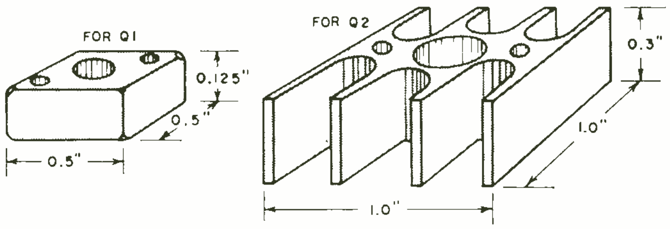
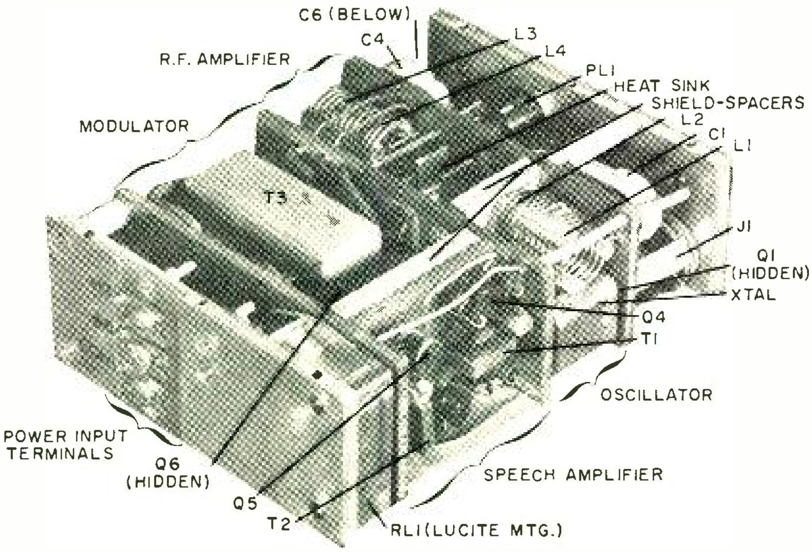


Fig. 3. Heat sinks used by the author for the r.f. transistors.

By using printed circuits for the r.f. section, modulator, and speech amplifier, the author achieved a very compact package.



SPECIFICATIONS

Modulator-speech amplifier (5 watt output, 1 kc.)	
Power gain	110 db
Frequency response	100-5000 cps
Harmonic distortion	3%
Transmitter (unmodulated)	
Power input	3 watts
Power output	1.9 watts
Transmitter (modulated 30% with 1-kc. sine wave)	
Average power input	3.14 watts
Average power output	2.0 watts
Peak power input	3.6 watts
Peak power output	2.3 watts
Current drain (12-volt system)	
Without pilot bulb & relay	0.80 amp.
With pilot bulb & relay	1.30 amp.
Frequency modulation at 100% modulation	
Modulation frequency	Carrier shift
400 cps	27 cps
4 kc.	78 cps

(A) (B)

Fig. 1. (A) Usual cramped scale and (B) the linearized scale.

AUDIO OUTPUT POWER METER

By K. BERRY

Construction of a linear-scale meter that can be used to measure up to 50 watts power across 4, 8, or 16 ohms

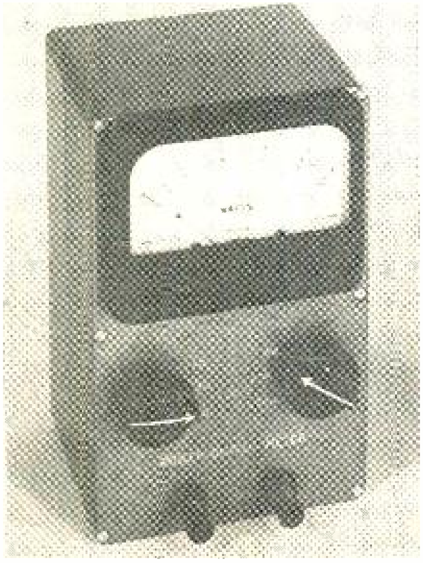
THE meter to be described was developed to enable the power output of audio amplifiers to be measured. It is suitable for use with amplifiers having output impedances of 4, 8, or 16 ohms and will measure powers of between ½ and 50 watts. A feature of this design is the fact that the meter has a near-linear scale as opposed to the more usual square-law scale associated with such instruments.

Basic Principle

The power dissipated in a resistor is given by the expression $P = E^2/R$ watts, where R is the value of the resistor (in ohms), and E is the voltage developed across it (in volts). Thus if it is desired to measure the output power of an amplifier, a resistor whose value is the same as the output impedance of the amplifier should be connected to the output terminals of the amplifier and an a.c. voltmeter connected across it to measure the voltage developed. The power dissipated in the resistor can then be calculated. If, however, the meter were so calibrated, then the power developed could be read off directly.

If the voltmeter used has a linear scale, the power calibration tends to be cramped at the top end of the scale, as shown in Fig. 1A. In this design, the voltage applied to the rectifier bridge which feeds the moving-coil meter has been deliberately kept as small as possible. Consequently, the diodes are being worked over the non-linear portion of their characteristics. Since this approximates a square-law curve, this largely cancels the cramping effect normally found at the top end of the scale. This can be seen by comparing the scale illustrated in Fig. 1B with that shown in Fig. 1A.

Meter constructed by author measures 7¼ x 4⅝ x 4 inches.



Circuit Description

The schematic of the wattmeter is shown in Fig. 2. The appropriate load impedance is chosen by *S1A* and *S1B*. The voltage developed across the load is applied to one of nine potentiometer networks (the required network being selected when the impedance and power range switches are set). The output from the potentiometer networks is fed to the bridge rectifier, *CR1* through *CR4*, and then to the meter *M1*, a 0-1 milliammeter. A 250-ohm rheostat, *R23*, is connected in series with the meter. This has been included to enable an adjustment to be made in the linearity of the scale since this will vary slightly depending on the type of diodes used.

The use of nine separate potentiometer networks instead of the more usual series (multiplier) resistors is explained by the necessity to keep the resistance in series with the bridge low and comparable on all ranges. This results in a common calibration for all ranges.

The specifications are as follows: impedances 4, 8, and 16 ohms; power ranges 0-5, 0-20, 0-50 watts; and an over-all frequency response of 10-20,000 cps ± 0.5 db.

Components and Construction

The choice of components should give little difficulty. The load resistors (*R1* through *R4*) consist of two 10-ohm resistors each shunted by a 39-ohm resistor, giving effectively two 8-ohm "units." These are parallel connected to give an impedance of 4 ohms and series connected for 16 ohms, while for 8 ohms just one of the "units" is used. This method was chosen in preference to the use of three separate resistor combinations since it saves both cost and size.

The power rating of the resistors will depend on the use to which the wattmeter is to be put. If it is desired to measure an output power of 50 watts continuously at any of the three possible impedances, then each 8-ohm "unit" must be capable of dissipating 50 watts. If, however, the restriction of limiting the power measured on the 8-ohm range to 25 watts continuous, 50 watts intermittent is accepted, then the rating of each 8-ohm "unit" need only be 25 watts. If it is possible to obtain 8-ohm, 25- or 50-watt resistors readily, then one of these can be used for each of the "units" mentioned above. Another suggestion is to use 10-ohm adjustable power resistors rated at 30 to 60 watts and set the sliders for 8 ohms.

The prototype meter used standard commercial vitreous wirewound resistors. Although such resistors are inductive, measurements show that errors due to self-inductance are negligible up to 50,000 cps. There is, however, no reason why high-power carbon composition resistors should not be

4-OHM IMPEDANCE						8-OHM IMPEDANCE						16-OHM IMPEDANCE					
E (volts)	P (watts)	E	P	E	P	E	P	E	P	E	P	E	P	E	P	E	P
4.02	5	8.04	20	12.7	50	5.7	5	11.4	20	18	50	8.04	5	16.12	20	25.5	50
3.6	4	7.2	16	11.4	40	5.12	4	10.24	16	16.1	40	7.2	4	14.4	16	22.8	40
3.11	3	6.23	12	9.85	30	4.41	3	8.82	12	13.95	30	6.23	3	12.46	12	19.7	30
2.53	2	5.12	8	8.04	20	3.6	2	7.2	8	11.4	20	5.12	2	5.25	8	16.12	20
1.8	1	3.6	4	5.7	10	2.53	1	5.12	4	8.04	10	3.6	1	7.2	4	11.4	10
1.265	½	2.53	2	4.04	5	1.8	½	3.6	2	5.7	5	2.53	½	5.12	2	8.04	5

Table 1. Calibration voltages have been corrected by applying 0.9 form factor.

VOLTAGE	METER READING
8.04	1
7.2	0.81
6.23	0.61
5.12	0.40
3.6	0.19
2.53	0.09
0	0

Table 2. Scale readings versus d.c. voltages.

used if this is preferred or they are more readily available.

The germanium diodes used in the prototype were *Mullard* Type 0A70's. These are general-purpose point-contact diodes and any similar diodes should prove suitable.

The meter is a rectangular 0-1 milliammeter with a d.c. resistance of 50 ohms, but any 0-1 ma. meter should be equally satisfactory for this purpose.

The prototype audio output power meter shown in the picture was housed in a case measuring approximately 7¼" x 4⅝" x 4" with four small rubber feet to prevent damage to itself or any polished surface upon which it might be placed.

Calibration

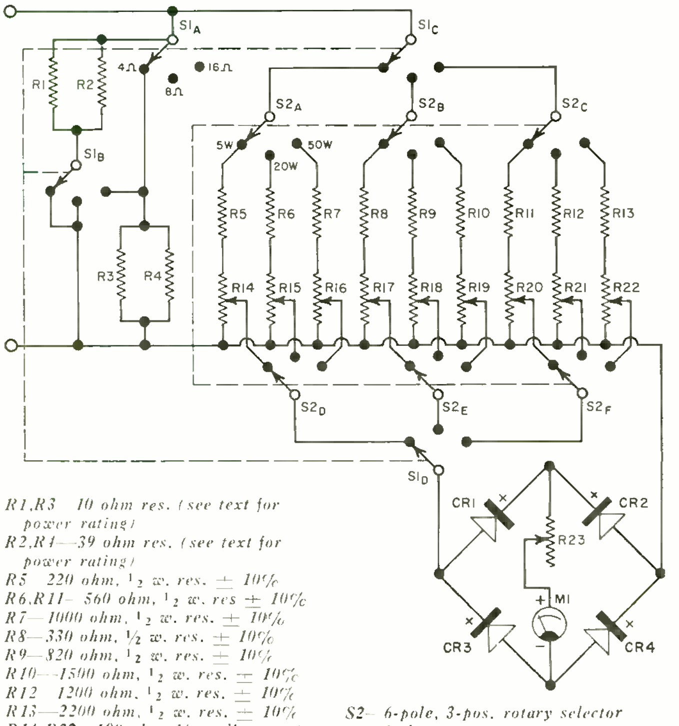
When the instrument has been assembled and wired, it is necessary to calibrate it by adjusting resistors *R*14 through *R*22 inclusive. This, fortunately, is quite a simple matter and requires only the use of an accurate d.c. voltmeter. This meter is used to measure the voltage applied to the terminals of the wattmeter. Before commencing calibration, the lead to S1*A* should be unsoldered so that the load resistors are disconnected. A variable d.c. voltage is then applied to the wattmeter as shown in Fig. 3. This can be obtained from a battery and potentiometer but a reversing switch *must* be included and a reading obtained with the voltage applied to the wattmeter both "forward and reverse." The average of these is the correct meter reading. (This procedure takes account of differences in diode forward resistance.)

The voltages developed across the 4-, 8-, and 16-ohm resistors for all three power ranges have been calculated and are given in Table 1. Note that the figures shown take into account the fact that a d.c. meter is used, which responds to the average value of voltage rather than the r.m.s. value. Hence, all readings obtained in the calculations using the basic formula have been multiplied by the form factor ($E_{r.m.s.}/E_{avg.} = 0.9$) to get the values shown in the tables.

The first step in the calibration process is to set the rheostat controlling linearity (*R*23). Having adjusted *R*23 for zero resistance, set the d.c. voltage applied to the wattmeter to 8.04 volts. Switch the wattmeter to measure 5 watts at 16 ohms and adjust *R*20 until the meter reads full scale. Then reduce the d.c. voltage to 7.2 volts and note wattmeter reading, and so on down the first voltage column under the "16-ohm impedance" portion of Table 1. When the linearity control is correctly adjusted, the results obtained should be similar to those given in Table 2. If the readings obtained are lower than these, set *R*23 (linearity) to its mid-position and re-adjust *R*20. Repeat the comparison of meter readings and applied voltage. If the readings are still low, then *R*23 must be further increased, while if the readings are high, *R*23 must be reduced in value. This procedure may sound complex but, in practice, it takes only about 10 minutes.

When the linearity control has been set, the table of applied voltage *vs* meter reading should be put to one side as this is required for absolute calibration of the meter. This may be done by drawing a calibration curve or, alternatively, the scale can be removed from the meter and re-calibrated by hand. This latter method is preferable, but great care must be exercised.

The only remaining task is to set the rest of the range potentiometers as follows:



R1,R3—10 ohm res. (see text for power rating)
R2,R4—39 ohm res. (see text for power rating)
R5—220 ohm, ½ w. res. ± 10%
R6,R11—560 ohm, ½ w. res ± 10%
R7—1000 ohm, ½ w. res. ± 10%
R8—330 ohm, ½ w. res. ± 10%
R9—820 ohm, ½ w. res. ± 10%
R10—1500 ohm, ½ w. res. ± 10%
R12—1200 ohm, ½ w. res. ± 10%
R13—2200 ohm, ½ w. res. ± 10%
R14-R22—100 ohm, ¼ w. linear taper pot.
R23—250 ohm, ¼ w. linear taper pot.
S1—4-pole, 3-pos. rotary selector switch
S2—6-pole, 3-pos. rotary selector switch
M1—0-1 ma. moving-coil meter
CR1,CR2,CR3,CR4—Germanium diode (Mullard 0A70 or 1N57, 1N89, 1N198, 1N297, 1N298A)

Fig. 2. Schematic of power meter shows individual calibration pots.

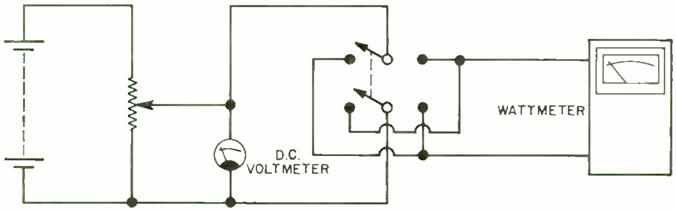


Fig. 3. Calibration setup includes a polarity-reverse switch.

1. Set the meter to measure 5 watts at 4 ohms, apply 4.02 volts and adjust *R*14 for full-scale deflection.
2. Set the meter to measure 20 watts at 4 ohms, apply 8.04 volts and adjust *R*15 for full-scale deflection.
3. Set the meter to measure 50 watts at 4 ohms, apply 12.7 volts and adjust *R*16 for full-scale deflection.
4. Set the meter to measure 5 watts at 8 ohms, apply 5.7 volts and adjust *R*17 for full-scale deflection.
5. Set the meter to measure 20 watts at 8 ohms, apply 11.4 volts and adjust *R*18 for full-scale deflection.
6. Set the meter to measure 50 watts at 8 ohms, apply 18 volts and adjust *R*19 for full-scale deflection.
7. Set the meter to measure 20 watts at 16 ohms, apply 16.12 volts and adjust *R*21 for full-scale deflection.
8. Set the meter to measure 50 watts for 16 ohms, apply 25.5 volts and adjust *R*22 for full-scale deflection.

The lead to S1*A* should now be reconnected and the audio output power meter is ready for use. ▲

AUDIO TONE-BURST GENERATOR

Audio systems are usually tested with either sine or square wave signals. Gating an audio signal on and off provides a truer representation of music.

By THOMAS E. REAMER

THE audio test generator described in this article is a precision instrument that gates an incoming waveform from an external source into a series of alternate signal bursts and quiescent periods. The gated signal may be repetitive waveforms such as sine, square, and saw-tooth or random waveforms such as speech, music, or white noise. A gated sine wave is particularly suited for evaluating performance of audio amplifiers, loudspeakers, tape recorders, multiplex adapters, tuned audio amplifiers, high- or low-pass *LC* filters, crossover networks, or other audio components.

The gated sine wave is intermediate between a continuous sine wave and a square wave having some of the characteristics of each. It is similar to the sudden attack by a performer on a musical instrument and is consequently a truer representation of music than is a square wave.

The instrument provides five gate periods from 16 to 0.3 milliseconds in duration and the gating period can be varied +0% to −10% by a repetitive external signal resulting in the precise locking of the two frequencies and a stable display on the oscilloscope screen. The gate is opened and closed at the zero a.c. voltage base line of the incoming waveform thus providing an uninterrupted transition from the sine wave to the horizontal blanking pulse and again to the sine wave. A switching circuit is provided for continuous or gated waveforms to the output. A scope monitor switch permits rapid A-B viewing of the output waveform before and after passage through the circuit under test. Level controls and a symmetry control complete the front-panel layout.

Circuit Operation

Schmitt trigger multivibrator *V1* (Figs. 1 and 2) is triggered by the incoming sine wave from the external generator. Correct operating point is determined by the d.c. voltage from the arm of *R2* and to a lesser degree by *R6*. These controls determine the point on the sine wave at which triggering and subsequent gating occur and are normally adjusted for operation at the input signal zero a.c. voltage base line.

Front-panel layout with the generator controls identified.

SPECIFICATIONS

INPUT:

(a) External Signal Generator: Impedance 3500 ohms at 1 kc. Requires 5-9 v. r.m.s. from a variable-frequency or closely stepped audio generator.

(b) External Input: Impedance 3.3 megohm at 1 kc. 10 v. r.m.s. max.

OUTPUTS:

(a) Internal Source: Impedance 3500 ohms at 1 kc.
Continuous waveform (sine-wave input): 0-5.7 v. r.m.s., 20 cps to 50 kc. Adds 0.4% HD at 1 kc.
Gated waveform (sine-wave input): 0-2.65 v. r.m.s. (0-16 v. peak-to-peak) at 8 v. r.m.s. input. 67 cps to 20 kc. (usable to 50 kc.).

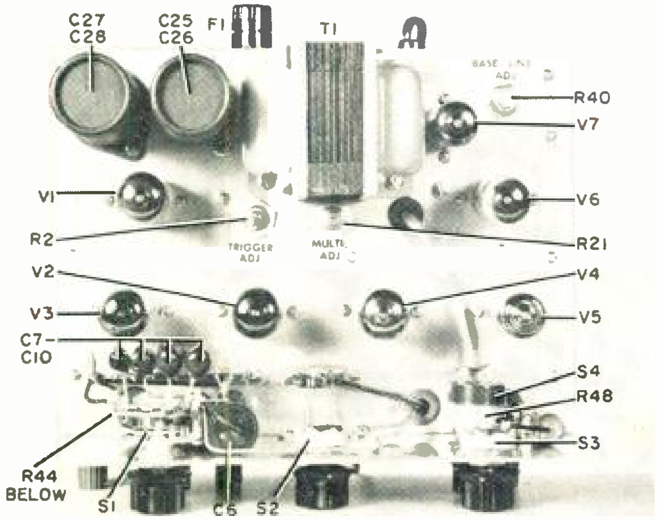
(b) External Source: Impedance 5500 ohms at 1 kc. Adds 0.2% HD at 1 kc. Maximum output 0.86 times input voltage.

(c) External scope sync voltage output.

PERFORMANCE:

(a) Gate Periods: 16, 6, 3, 0.6, 0.3 milliseconds nominal. Varied +0 to −10% by external generator frequency.

(b) Duty Cycle: 50% for gated wave. Synchronizes from one to a large number of repetitive incoming waves.

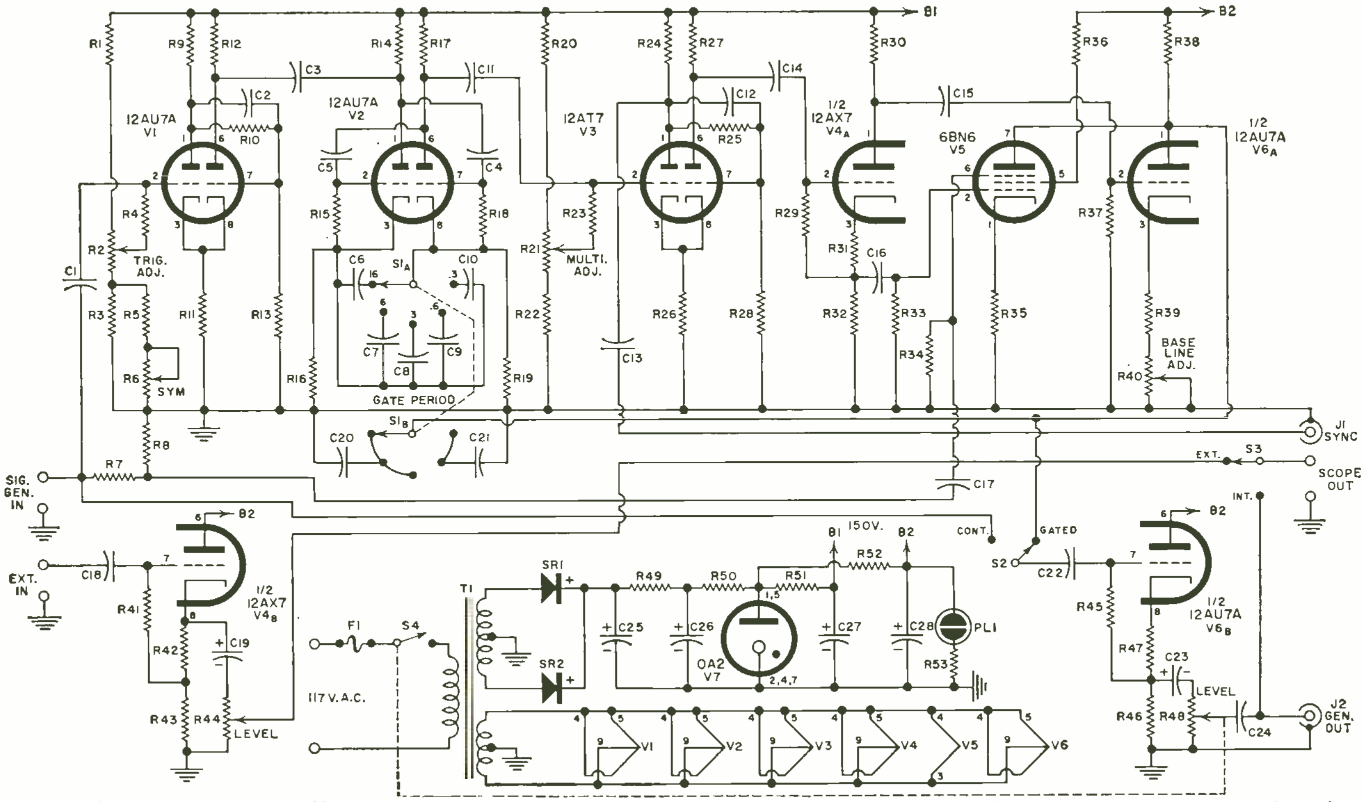


Three adjustment controls are located on top of the chassis.

The square-wave output of *V1* is differentiated by *C3* and *R14* and the resulting sharp positive and negative pulses are routed to gate multivibrator *V2*. The frequency of *V2* is controlled principally by the gate period timing capacitors *C6* through *C10* but may be varied 10% by the synchronizing pulses from *V1*. A plot of gate period and frequency *vs* timing capacitance is given in Fig. 3. Locking *V2* to the frequency of *V1* is necessary for subsequent precise gating of the sine wave. The somewhat distorted square wave from *V2* triggers a second Schmitt trigger *V3* to produce a clean symmetrical square wave for gating purposes.

The d.c. level of *V3* is determined by *R21*. The square wave from the second plate of *V3* goes to phase splitter *V4A*. The non-inverted output of *V4A* is fed to a control grid of gating pentode *V5* while the inverted output goes to the grid of *V6A*. The gating circuit of *V5* and *V6A* was chosen from several available methods' because of the relative absence of switching transients and complete obliteration of the external signal generator during the blanking period.

Gate operation is as follows: the external sine wave, attenuated by *R7* and *R8*, is connected to the upper control



R1, R16, R19, R20, R53—100,000 ohm, ½ w. res.
R2—25,000 ohm, ½ w. linear pot.
R3, R7—47,000 ohm, ½ w. res.
R4, R23, R29, R33, R37, R45—1.5 megohm, ½ w. res.
R5—470,000 ohm, ½ w. res.
R6—500,000 ohm, ½ w. linear pot.
R8, R14, R17, R24, R27, R36—10,000 ohm, ½ w. res.
R9, R12, R22, R26—68,000 ohm, ½ w. res.
R10, R25—220,000 ohm, ½ w. res.
R11, R13, R28—150,000 ohm, ½ w. res.
R15, R18—10 megohm, ½ w. res.
R21—25,000 ohm, ½ w. linear pot.
R30, R32, R43, R46—22,000 ohm, ½ w. res.
R31, R39, R42, R47—2200 ohm, ½ w. res.
R34, R41—1 megohm, ½ w. res.
R35—330 ohm, ½ w. res.
R38—6800 ohm, ½ w. res.
R40—5000 ohm, 4 w. linear pot.
R44—100,000 ohm, ½ w. linear pot.
R48—50,000 ohm, ½ w. linear pot.
R49—2000 ohm, 10 w. wirewound res.
R50—3000 ohm, 10 w. wirewound res.
R51, R52—220 ohm, 1 w. res.
C1, C11, C17, C18—.1 μf., 200 v. capacitor
C2—10 pf., 500 v. mica capacitor
C3—100 pf., 500 v. mica capacitor
C4, C5—.005 μf., 1000 v. ceramic capacitor, ± 10%
C6—1 μf., 200 v. capacitor, ± 10%
C7—.25 μf., 200 v. capacitor, ± 10%
C8—.1 μf., 200 v. capacitor, ± 10%
C9—.022 μf., 400 v. capacitor, ± 10%
C10—.01 μf., 400 v. capacitor, ± 10%
C12—20 pf., 500 v. mica capacitor
C13—500 pf., 1000 v. ceramic capacitor, ± 10%
C14, C15, C16, C22, C24—.5 μf., 200 v. metallized paper capacitor
C19, C23—10 μf., 50 v. elec. capacitor
C20—.001 μf., 1000 v. ceramic capacitor, ± 10%
C21—300 pf., 1000 v. ceramic capacitor, ± 10%
C25-C26—30/30 μf., 350 v. elec. capacitor
C27-C28—20/20 μf., 250 v. elec. capacitor
S1—D.p. 5-pos. rotary switch
S2, S3—S.p.d.t. rotary switch (Centralab 1460 or equiv.)
S4—S.p.s.t. line switch (on R48)
T1—Power trans. 117 v. pri.; 250-0-250 v. @ 40 ma., 6.3 v. c.t. @ 2 amps (Triad R4-A or equiv.)
SR1, SR2—Silicon diode, 750 ma., 600 p.i.v. (1N2071)
J1—Banana jack
J2—Phono jack
PL1—NE-2 neon lamp
F1—0.5 amp "Slo-Blo" fuse
V1, V2, V6—12AU7A tube
V3—12AT7 tube
V4—12AX7 tube
V5—6BN6 tube
V7—0A2 tube

Fig. 1. Schematic and parts list for the audio tone burst generator. An external audio source provides signal being gated.

grid of pentode *V5* and the gating square wave from *V4A* to the lower grid. The sine wave is blocked from the plate of *V5* when the square-wave voltage to the lower control grid is negative and passed when the grid is above cut-off (gate open). If this were the entire gating circuit, the plate voltage of *V5* would decrease when the gate was open and increase when closed thus creating a pedestal.

To eliminate this undesirable effect, the plate of triode *V6A* is directly connected to the pentode plate and resistor *R38* is shared by both tubes. The triode grid is controlled by the inverted gating square wave from *V4A*. The net result is that the triode plate draws current when the gate is closed and prevents a voltage increase at the pentode plate thus eliminating the pedestal. The triode plate current is controlled by the cathode base line resistor *R40*. The output of the gating circuit passes through switch *S2* to cathode follower *V6B*, designed to pass a wide frequency range, then to output jack *J2*. Waveform selector switch *S2* is used to select the gated or continuous waveform from the generator. The scope monitoring switch *S3* selects either the generator output or the output of the amplifier or other system under test. The latter signal is connected to the "Ext. Input" terminals and passes to cathode follower *V4B*, level control *R44* and to the scope through *S3*. This arrangement provides for quick A-B viewing of the signals of interest.

The scope sync output pulse from the first plate of *V3* is available at *J1* and may be connected to the scope external trigger input.

Capacitors *C20* and *C21* are connected to the output of the gate circuit through the second section of the gate period switch *S1* and are used to reduce or eliminate switching transients from the gating circuit. The capacitance must be carefully selected as too large values attenuate the desired high-frequency output of the gated waveform.

The power supply is a conventional, regulated full-wave system with two outputs at approximately 150 volts each.

Alignment

Allow five minutes warmup, then set "Gate Period" switch on front panel to 3 msec. and apply a 1500-cps, 8-volt r.m.s. sine wave to the "Sig. Gen." terminals. Connect an oscilloscope to pin 6 of *V1* and set front-panel "Symm." control to mid-range and adjust "Trigger Adj." (*R2*) on the chassis for a symmetrical square wave. Move the scope lead to pin 6 of *V3* and adjust "Multi. Adj.", *R21* on the chassis, for a symmetrical waveform. This adjustment is quite broad.

Connect the scope to the front-panel "Scope Output" terminals, set the "Waveform" switch to "Gated," "Scope Source" switch to "Internal," connect the "Sync" output to the scope external sync terminals and observe the waveform.

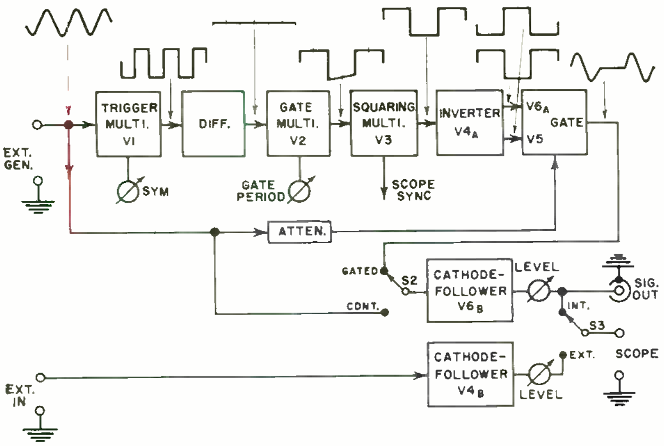


Fig. 2. Generator timing is shown by significant waveforms.

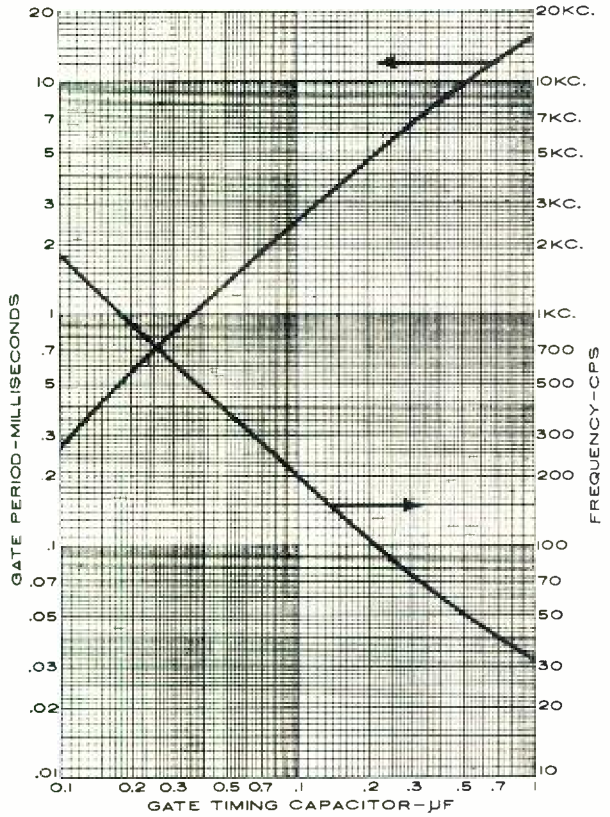


Fig. 3. Gate frequency and period vs timing capacitor value. Gate periods other than used by the author may be selected.

Adjust $R40$ "Base Line Adj." (located on chassis) so that the horizontal line falls midway between the peaks of the gated sine wave. If necessary, vary the input frequency slightly and re-adjust "Trigger Adj." to obtain a smooth transition between the sine wave and the flat portion of the gated wave. The "Trigger Adj." control determines the transition at the beginning of the burst while the external generator frequency determines the transition at the end of the burst.

Set the front-panel "Gate Period" switch for 0.3 msec. and the input frequency to approximately 19 kc. Rotate front-panel "Symm." control for best symmetry; its action is similar to that of "Trigger Adj.".

Reset "Gate Period" for 16 msec. and the input frequency to 170 cps. Adjust "Symm." control for the best waveform. If the range of this control is insufficient for both high and low frequencies, re-adjust "Trigger Adj." a small amount and repeat the high- and low-frequency tests. Except for frequency extremes, it will not be necessary to adjust the "Symm." control in normal operation. Check operation of "Waveform" switch at "Cont." and operation of "Scope Source" at "Ext." with a signal connected to the "Ext. Input" binding posts.

Instrument operation is straightforward. A variable-frequency oscillator or a switch-selected generator such as the *Heath* IG-72 is connected to the front-panel "Sig. Gen." terminals and the 5- to 9-volt r.m.s. signal at the desired test frequency is applied. If the wave pattern from the burst generator is unsymmetrical, adjust the external oscillator frequency to obtain a smooth transition at the end of the burst. The most stable pattern has an odd number of peaks at the top and an even number at the bottom. At frequency extremes, adjust the "Symm." control for a smooth junction at the beginning of the burst. "Level" control $R48$, on the front panel, is used to adjust instrument output. Do not decrease the voltage level of the external audio oscillator.

A test setup for checking audio amplifier performance with the tone-burst generator is shown in Fig. 4A. A range of sine-wave test frequencies in bursts of five to twenty cycles is preferable. Significant observations are the number of cycles required to attain steady-state conditions at the start and end of the burst. Overshoot and undershoot, as illustrated in Fig. 5, should be noted. In addition, ringing or self-excited oscillations may occur at the end of the burst. Ringing frequency often differs from the burst frequency. The setup shown in Fig. 4A can also be used to check a crossover network. The latter is inserted with loading resistors between the amplifier output and the burst generator. Test frequencies and burst-length conditions are similar to those for amplifier testing. Ringing may occur at the 3-db point with conventional *LC*-type networks. (*Continued on page* 76)

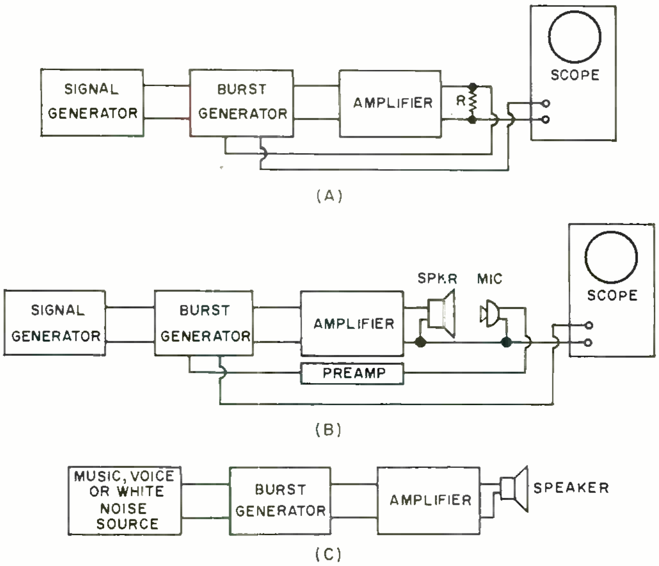
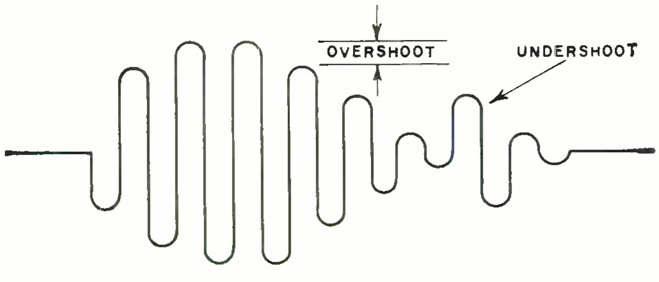


Fig. 4. Suggested test setups. (A) For audio amplifier testing. A crossover network or high- or low-pass filter may be connected between amplifier output and burst generator. A tape recorder may be substituted for the amplifier. (B) Amplifier and loudspeaker setup. The microphone is placed three feet from the speaker on axis. (C) Gating random waveforms may be used to check intelligibility of gated voice at 50% duty cycle and can also produce some unusual sound effects.

Fig. 5. Overshoot and undershoot distortion of a gated waveform often shows up during over-all testing of audio system.



R.F. POWER OUTPUT MEASUREMENTS

Such measurement on communications transmitters is now specified by FCC for many radio services. Methods and types of equipment are described.

By R. L. CONHAIM

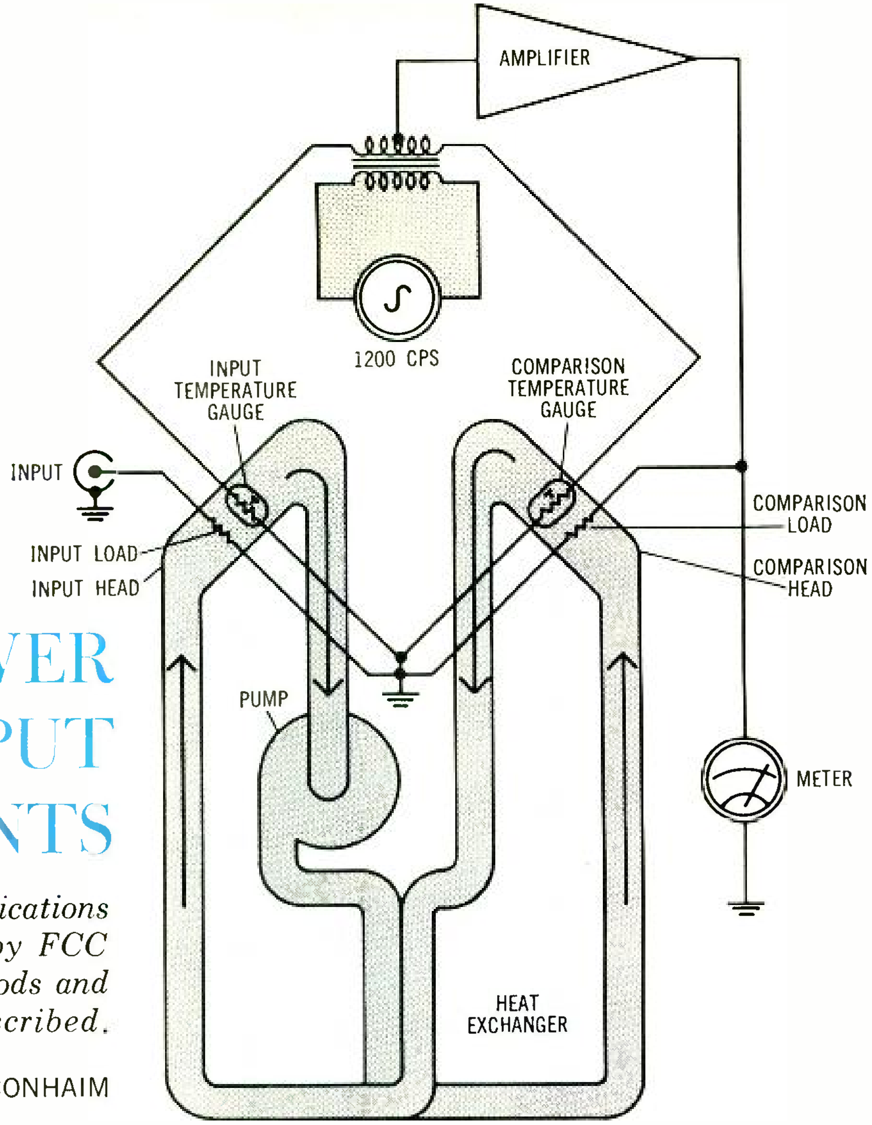


Fig. 1. Simplified diagram of a calorimeter power meter.

ALTHOUGH power *input* is often used as a measure of transmitter capabilities, the measurement of r.f. power *output* is becoming increasingly important. In some cases, power output measurements are demanded by the FCC or are required as part of the technical specifications for various services. Domestic Public Radio Services, Aviation Radio Services, and proposed Citizens Band class D requirements all specify maximum power output. Broadcast stations—AM, FM, and TV—are all required to measure and monitor power output. In addition, power-output measurements can give an over-all check of the efficiency of a transmitter especially when compared with previous readings, and some methods even allow a rough check of modulation capabilities. In some types of instruments, feedline and antenna efficiencies can also be computed or directly read in terms of v.s.w.r.

The reading of r.f. power is by no means as simple as reading power at d.c. or low-frequency a.c. Electrodynamometer-type wattmeters, such as are used to read power at 60-cycle a.c. are completely unusable at radio frequencies. As a result, r.f. can only be read by some form of conversion—either converting the r.f. by rectification to d.c. or by converting to some other form of energy and then calibrating the indicating instrument in terms of r.f. watts. Let's consider a few of the more common basic methods.

Calorimeter Wattmeters

One common and accurate method is called the calorimeter technique in which the r.f. power is converted to heat. In these instruments, some medium for absorbing heat is required. Water, oil, ammonia, and solid dielectrics have all been used, depending on the type of calorimeter and the amount of power which must be dissipated. These systems employ either a static or circulating medium, and a thermopile or other temperature-difference device which indicates such differences on electrical current-reading meters calibrated in watts. Most such instruments, while quite accurate, are slow since time is required to heat the dissipative medium.

One calorimetric power meter, the *Hewlett-Packard*[1] 434A, employs an unusual technique in which a self-balancing bridge is combined with a highly efficient heat transfer resulting in a response time of 5 seconds or less. As can be seen from the simplified diagram of Fig. 1, the unknown r.f. power is checked against a 1200-cps comparison power in the bridge circuit. Two temperature-sensitive resistors serve as gauges. In operation, the unknown r.f. heats an input load resistor. This resistor and one gauge are in close thermal proximity so that heat generated in the input load heats the gauge and unbalances the bridge. The unbalanced signal is amplified and applied to the comparison load resistor which is in close proximity to the second gauge, and nearly rebalances the bridge. The meter measures the power supplied to the comparison load to rebalance the bridge. Efficient heat transfer from the loads to the temperature gauges is accomplished by immersing the components in an oil stream. While quite accurate and reasonably fast for a calorimetric system, this instrument will read powers only to 10 watts, at frequencies from d.c. to 12.4 kmc. Being a laboratory instrument, it is quite costly for applications involving routine service work.

Photometric Methods

Converting the r.f. power to light has been used and is known as the *photometric* technique. In some applications,

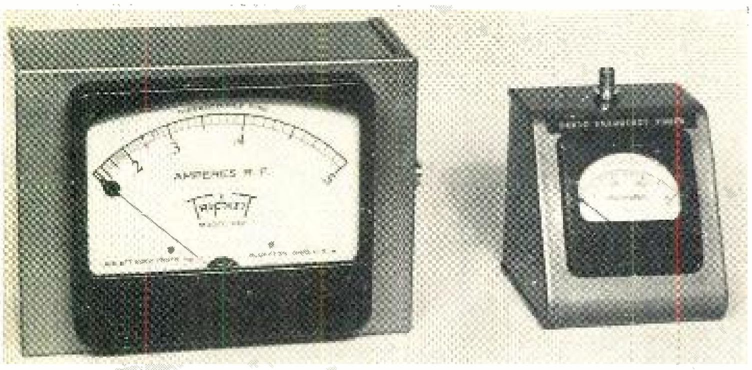


Fig. 2. Typical panel-type thermo-ammeters mounted in cases with built-in dummy loads. Power is computed from $P = I^2/R$.

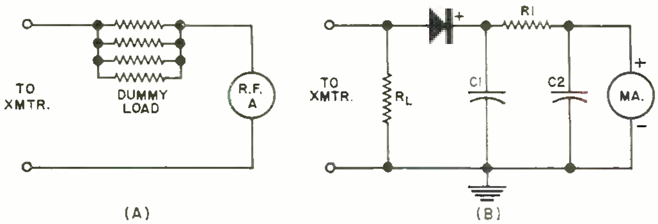


Fig. 3. (A) Thermo-ammeter schematic showing use of dummy-load resistors. (B) The basic peak-reading r.f. voltmeter.

FULL-SCALE VALUE	EQUIVALENT FULL-SCALE R.F. POWER 52-Ohm Load	72-Ohm Load
115 ma.	0.68 w.	0.95 w.
150 ma.	1.17 w.	1.62 w.
250 ma.	3.25 w.	4.5 w.
500 ma.	13 w.	18 w.
1 amp.	52 w.	72 w.
1.5 amp.	117 w.	162 w.
2 amp.	208 w.	288 w.
2.5 amp.	325 w.	450 w.
5 amp.	1300 w.	1800 w.
8 amp.	3328 w.	4608 w.
10 amp.	5200 w.	7200 w.

Full-scale values as low as 10 ma. and as high as 15 amps. are available from some manufacturers. External thermocouples are offered by some firms for use with their meters.

Table 1. Common thermo-ammeter full-scale currents, powers.

a special lamp containing two identical filaments is used. One filament is fed from the source of unknown r.f. power, while the other is fed from d.c. or low-frequency a.c. When the two filaments are of equal brilliance, the r.f. power is assumed to be the same as the d.c. or low-frequency a.c. power. A single filament lamp, read by a photocell, may also be used but some method of calibration is required. These photometric systems have limited usefulness because lamp filaments make poor dummy loads. They have considerable reactance above 2 mc. and the resistance may vary with the amount of current passing through the filament of the lamp.

Thermo-Ammeters

The r.f. current measuring systems which employ thermocouple ammeters, or thermo-ammeters as they are usually called, are quite accurate in common usage and make one of the simplest instruments when only r.f. power transferred into a dummy load or into an antenna system is to be measured.

Thermo-ammeters consist of a thermocouple and a d.c. moving-coil meter movement. The thermocouple is made of two dissimilar metals, joined at one end. If the junction of these metals is heated, a d.c. voltage is produced at the free terminals. This voltage is proportional to the heat difference between the hot and cold ends. A practical thermocouple meter consists of a heater through which the r.f. current flows, a thermocouple attached to the heater element, and a d.c. moving-coil meter connected to the free ends of the thermocouple. The d.c. voltage at the free ends causes direct current to flow through the meter which is calibrated in r.f. current. Power is then computed from Ohm's Law, $P = I^2R$, where R is the value of the load resistor used.

Because deflection of the meter is proportional to the amount of heat in the heater wire, which is proportional to the square of the current passing through it, the thermo-ammeter has a square-law scale. In this type of scale, the lower end is quite crowded. For best accuracy, the full power should be read at about 70% of full scale, but the meter is readable over the range of 3 or 4 to 1, that is, a thermo-ammeter with a full scale of 1 ampere can be read down to about 0.3 ampere. Such ammeters cannot be shunted for use on other ranges, since any shunt will make the meter quite frequency sensitive. Thermo-ammeters are good up to about 200 mc. depending on the construction of the heater wire. Some thermo-ammeters are made with a thin-wall, hollow heater wire which behaves much like a waveguide, making the instrument usable at higher frequencies.

Regular thermo-ammeters are made by a number of meter manufacturers. In appearance, they look like any other panel meter, except for the square-law scale. They are comparable in price to other good-quality panel meters. Fig. 2[2-3] shows two such units. The larger meter provides a more easily read scale. Both have proved quite accurate and easy to use with CB transmitters when equipped with proper dummy loads. They may also be used in series with the center conductor of a coaxial cable as an indicator of power being transferred to the antenna. However, they should not be used with the antenna feedline as a load for tune-up purposes. When used in this way, they may have a tendency to add forward and reverse currents, giving a false indication of output power, resulting in mistuning of the transmitter coupling circuits. They are also useful as a rough indication of modulation capabilities since speaking or whistling into the transmitter microphone will cause the meter to move up scale.

Fig. 3A is a schematic of a typical thermo-ammeter with dummy load. The load is made up of 2-watt carbon resistors in parallel. The closer the resistance of the dummy load matches the antenna feedline impedance, the more accurate will be the readings on the thermo-ammeter. For up to 8 watts, three 5% 220-ohm and one 5% 200-ohm carbon resistors (all rated at 2 watts) in parallel, will come close to approximating a 52-ohm load. For higher power transmitters, parallel resistor combinations can be made in the same way.

Special non-inductive carbon resistors are available for this purpose or standard commercial dummy loads can be used. If the load is constructed, leads should be kept as short as possible and adequate ventilation allowed for heat dissipation.

Fig. 4. A typical commercial dual-range r.f. wattmeter unit.

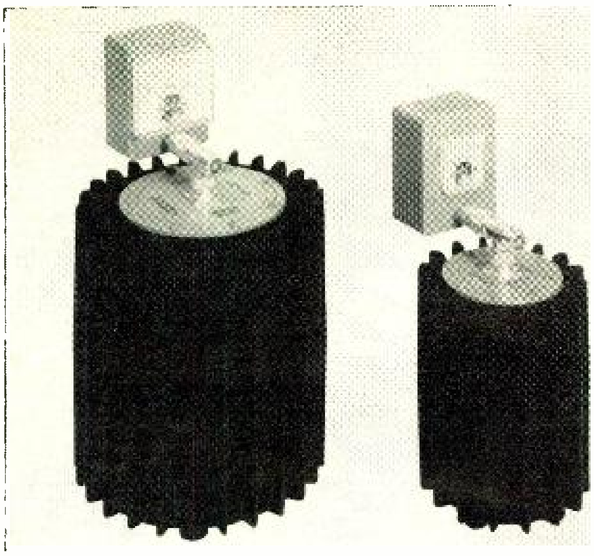


Fig. 5. These Cesco absorption wattmeters use circuits of the type shown in Fig. 3B. Units are available for powers up to 1500 watts. The dummy load resistors that are used are special non-inductive types that are submerged in oil.

For power up to 13 watts into 52 ohms, a 0 to 500-ma. meter will serve quite adequately. Table 1 lists commonly available full-scale values, together with interpreted wattage ratings for both the 52- and 72-ohm loads.

R.F. Voltmeters

Radio-frequency voltmeters are commonly used as r.f. power measuring devices. Power is derived from the Ohm's Law formula, $P=E^2/R$. In some commercial models, these units are combined with systems which also read v.s.w.r. directly or indirectly, or both forward and reflected power. Crystal diodes are commonly used, but since such rectifiers have a tendency to vary in resistance with applied voltage, a swamping resistor ($R1$ in Fig. 3B) is used. The time constant of $C1$-$R1$ is made large with respect to the period of the lowest radio frequency to be measured. This condition can be met if $R1$ is at least 10,000 ohms and $C1$ is 1000 pf. $C2$ merely provides additional r.f. filtering for the meter. Such voltmeters have to be calibrated and for this reason are not too popular as construction projects.

A typical commercial meter, the *Electro Impulse Laboratory*[4] Model AM-6 is shown in Fig. 4. This meter is useful over the range 100 kc. to 200 mc. It is a dual-range type, employing a voltage divider for full-scale values of 1.5 to 6 watts, and a full-scale accuracy of 5%. The voltage-divider characteristics are such that the voltage divisions are the same for d.c., 60-cycle a.c., or r.f. This makes for easy calibration and checking against known standards. Other models are made for full-scale wattage readings up to 1500. This meter is intended for transmitter measurements only and cannot be employed for feedline or antenna measurements.

Other examples of this type of device, but able to measure higher powers, are shown in Fig. 5.

Reflectometer and In-Line Meters

These instruments are bridge-type voltmeters, consisting of one or two voltmeters, and employing resistor, resistor-capacitor, or capacitor bridges. Rather than being directly connected to the feedline or transmitter, they employ a short length of coaxial line and a pickup loop so that energy is induced by mutual inductance and capacitance from the traveling r.f. wave. When two bridges or detectors are used, the instruments can be made to read either forward or reflected waves on the feedline and can thus be calibrated in both watts and v.s.w.r. In some commercial instruments, the pickup device is a special element which can be placed in the instrument in one of two ways so that the forward or reverse waves can be read merely by reversing the element physically.

A typical reflectometer circuit is shown in Fig 7. For relative readings and the computation of v.s.w.r., no special calibration is required. But for accurate power measurements, the instrument must be calibrated for each specific frequency range, or furnished with plug-in elements for different frequencies and different power ranges. Because instruments of this type draw relatively little power, they may be left in the feedline as permanent power monitors or to determine antenna conditions.

Fig. 6 shows a typical in-line instrument manufactured by *Cesco*[5] and calibrated in power for CB use. This is a basic dual-bridge instrument with a single indicator. Forward or reverse power is selected by a switch. The v.s.w.r. is read by adjusting a potentiometer for full-scale reading in the forward direction, then switching to the reflected direction and noting the reading directly in v.s.w.r. Like all diode-type instruments, it shows few effects from sidebands and so is not particularly useful for indicating modulation conditions. This instrument may also be used for measuring relative field strength.

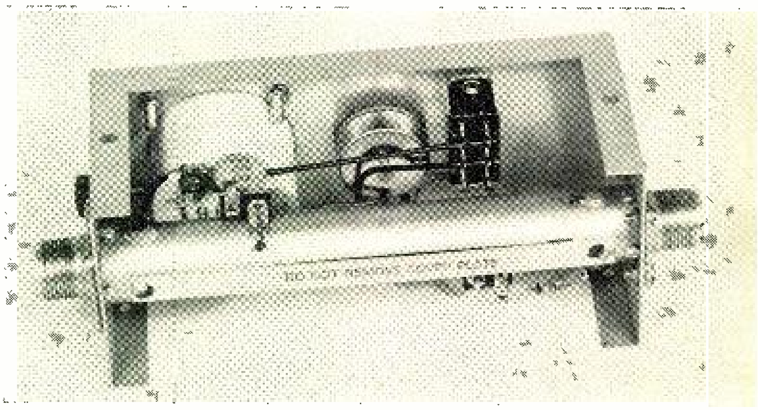
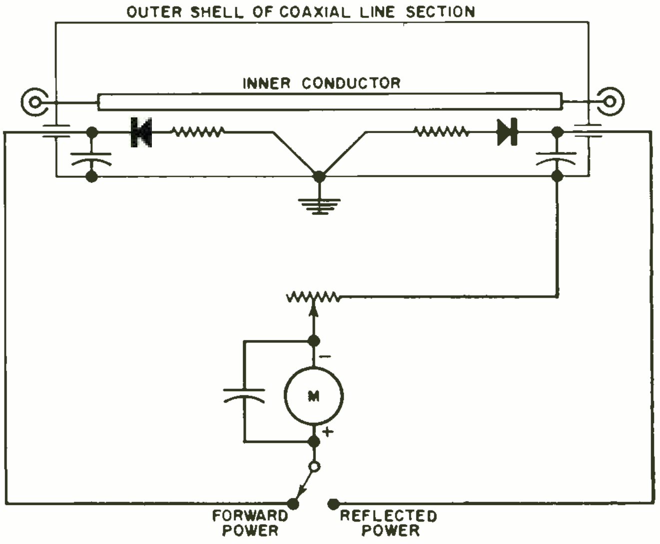


Fig. 6. Internal view of in-line r.f. wattmeter for CB.

One of the in-line-type instruments most popular with manufacturers and professional service engineers is the *Bird*[6] "Thruline" wattmeter, dubbed the "Birdie" by many of its users. This instrument has a number of unique features and, as a professional instrument, enjoys widespread use in both military and civilian applications.

This wattmeter employs changeable plug-in elements, provided in a variety of ranges, for different frequencies and different power applications. Elements are made in six fre-

Fig. 7. Basic circuit diagram of a reflectometer unit.



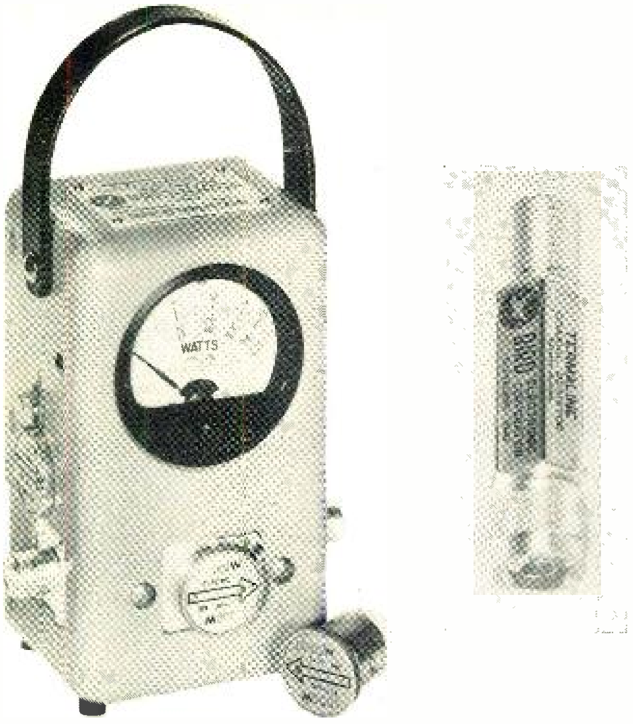


Fig. 8. (Left) "Thruline" wattmeter with changeable power element. (Right) A coaxial dummy load resistor rated at 5 watts.

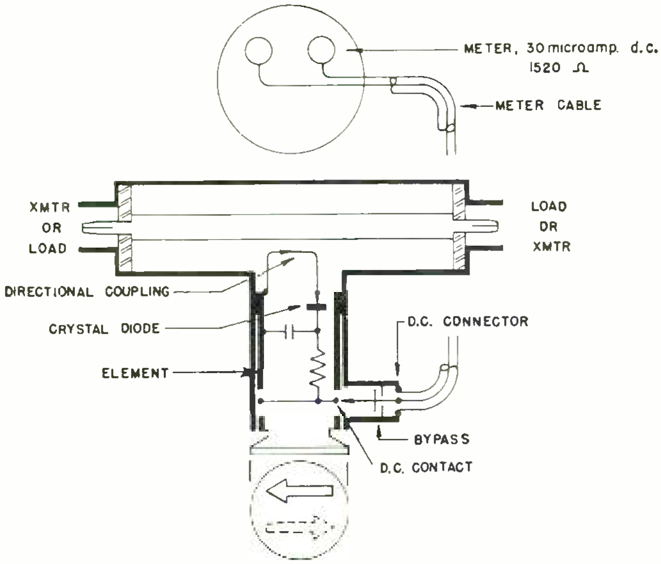
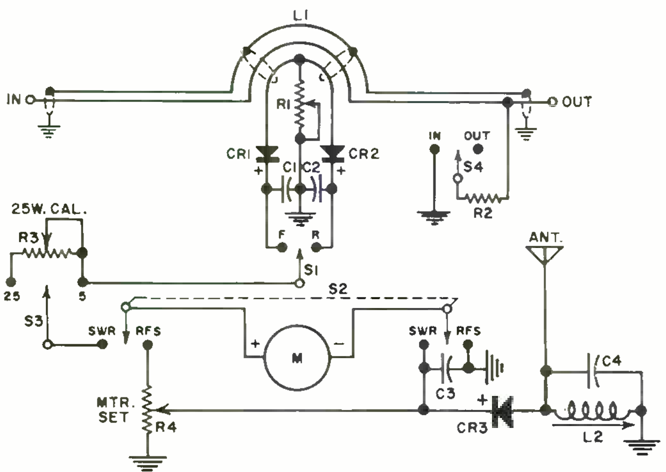


Fig. 9. Simplified schematic of Bird wattmeter. R.f. power can be measured in either direction depending on the plug position.

Fig. 10. Schematic diagram of the General Radiotelephone multi-function unit. Device can also be used as field-strength meter.



quency bands from 2 to 1000 mc. and in various power levels from 5 watts full-scale to 1000 watts full-scale, with an accuracy of 5% of full-scale. This instrument and a coupling element are shown in Fig. 8 (left). A simplified schematic is given in Fig. 9. A coaxial resistor, designed to be used as a dummy load for transmitter bench checks is shown in Fig. 8 (right). These resistors are made in a variety of power ratings. The one shown is an air-cooled, deposited-carbon type designed for 5 watts dissipation.

The *Bird* wattmeter consists of a short, uniform section of air line, the characteristic impedance of which is exactly 50 ohms. The coupling element is prominently printed with an arrow indicating the direction of the traveling wave being read. Energy is produced in the coupling element by both mutual inductance and capacitance from the traveling waves of the line section. Inductive currents flow according to the direction of the wave. Capacitive currents are independent of traveling-wave direction. Therefore, assuming the element remains stationary within the air line, current produced from the waves of one direction will add in phase, while those traveling in the opposite direction will subtract in phase. As a result, and because of the design of the element, only the wave desired (forward or reflected) will be read, while current from waves of the opposite direction will be cancelled out almost entirely. A directivity always higher than 35 db will result. While v.s.w.r. can be computed with this instrument, the manufacturer recommends the user think in terms of power ratios, forward to back. A ratio of 10% gives a v.s.w.r. of less than 2 to 1 which is, for all practical purposes, a good antenna installation in communications work. Lower standing-wave ratios yield little in the way of improved performance, although in TV, v.h.f. omnirange transmitters, and FM multiplex systems, the lowest possible standing-wave ratio is desired.

The r.f. line section of the *Bird* wattmeter may be removed and permanently installed in the transmission line. The d.c. meter is connected by cable to this line and may be installed at considerable distances from the line section. Cable lengths up to 25 feet are available from the manufacturer, although any shielded cable such as RG-58/U may be used.

Another instrument employing the reflectometer principle, but also including a built-in load resistor and a field-strength meter, is the *General Radiotelephone*[7] Model 615. This instrument is calibrated for 27 mc. but may be used in the range 27-54 mc. As a power meter, it will read either power in the feedline, forward or reflected, or power absorbed by a calibrated internal load resistor. Power may be read on either a 5- or 25-watt scale. A peaking coil is provided for field-strength measurements on frequencies higher than 27 mc. A schematic of this instrument is shown in Fig. 10.

The Slotted Line

At frequencies in the u.h.f. range, the slotted line is often used, especially for reading v.s.w.r. While this type of instrument measures with a high degree of accuracy, it is quite expensive since it is a precision-machined device slightly longer than one-half wavelength. Consequently, it is considered impractical at frequencies below 460 mc. It is certainly not something that can be constructed in the shop, unless precision machine tools are available. Basic information on slotted lines can be found in standard texts.

Selecting & Using R.F. Power Meters

The type of wattmeter you select will depend on many factors—your intended use, your pocketbook, accuracy desired, the band on which you are operating, as well as other considerations. You can pay as little as $19.95 for a factory-assembled and calibrated CB instrument to as high as $1600 and more for a laboratory calorimeter. In between are the professional standards used by manufacturers and communications engineers, ranging in (*Continued on page* 100)

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JOHN FRYE

What factors affect the resistance of a ground? How is such resistance measured and a low-resistance ground obtained?

DOWN-TO-EARTH DISCUSSION

BARNEY, a little late to work this bright October morning, went bustling into the service department only to discover his employer was not there. His relief was short-lived, though, for Mac came backing through the rear door paying out a couple of heavy insulated wires in front of him.

"There you are!" Mac exclaimed, glancing over his shoulder. "Let's see now: we can't say the alarm didn't go off, the car wouldn't start, or a train across the track held you up, can we? We've already used those."

"Aw get off my back, will you?" Barney pleaded. "Can I help it if our dog got sick in the night and I had to drop him off at the vet's? Where do those wires go? What are you going to do with them?"

"Allowing you to change the subject, they go to a couple of rods driven into the earth out back, and I'm going to use them to measure the resistance of our service bench and lightning arrester grounds."

"Why?"

"Because our personal safety and the safety of our equipment depends in a large measure on having low-resistance grounds."

"They have low resistance all right," Barney assured him. "The wires going to them take care of that."

"I'm afraid not. While actually the resistance of a ground is made up of the resistance of the lead, the resistance of the rod, the resistance of the rod-to-earth contact, and the resistance of the earth surrounding the rod, the resistance of the first three is insignificant when compared to the fourth, which is ordinarily so much higher."

"You mean the contact resistance between rod and earth is low?"

"Right. Bureau of Standards tests show that if the rod is free of paint or grease and the earth is packed close around it, contact resistance is negligible. Now to understand earth resistance, picture the ground rod as surrounded by successive shells of uniform-resistance earth of equal thickness. The first shell, the one nearest the rod, will have the smallest cross-section of soil at right angles to the current flowing out from the rod; so it will have the most resistance. The next shell with a larger cross-section will have less resistance. As we keep adding shells farther and farther from the rod, the cross-section of each shell increases and its resistance goes down until we finally reach a point where the addition of more shells adds next to nothing to the resistance of our ground."

"How far from the ground rod is that point?"

"Ninety percent of the total electrical resistance is generally within a radius of six to ten feet from the rod."

"I suppose the kind of soil has a lot to do with the resistance."

"It does. The Bureau of Standards found the least resistance in soil made up of fills containing more or less refuse such as ashes, cinders, and brine waste. An average ground in this material tested 14 ohms. Clay, shale, adobe, gumbo, loam, and slightly sandy loam came next with an average ground resistance of 24 ohms. Mixing this same soil with varying amounts of sand, gravel, and stones shot the resistance up to 93 ohms. Finally, when only sand, gravel, or stones with little or no clay, or loam constituted the earth, the resistance rose to 554 ohms."

"Guess if we want a really good earth ground we should set up in the middle of the city dump," Barney observed. "Does the dampness of the earth affect the resistance?"

"Yes. When the moisture content of the soil falls below 20%, the resistance goes up rapidly. For example, a given sample of soil with 10% moisture has a resistance of about 350,000 ohms per cm.^{3} Increasing moisture to 20% brings this down to 10,000 ohms per cm.^{3} and increasing it to 35% cuts this to 5000 ohms per cm.^{3} Moisture content of the soil varies from about 10% in dry seasons to around 35% in wet seasons, averaging out at around 16 to 18 percent. That's why the resistance of a driven ground will often more than double from a wet spring to a dry fall."

"How about temperature? Does it affect the resistance?"

"I'll say; especially when the ground freezes. The resistance of a soil sample with a stable moisture content rose from 200 ohms per cm.^{3} to 500 ohms per cm.^{3} as the temperature fell from 70° F. to 35° F.; then it really took off. At 20° the resistance was up to 6000 ohms per cm.^{3} and at zero it was more than 40,000 ohms per cm.^{3} Where the ground freezes, it's especially important the ground rod be long enough to reach below the frost line. In fact, the ground rod should be long enough to reach down to the permanent moisture level of the soil anyway. The top soil has the most resistivity and is subject to wide variations in resistance with changing seasons. The greatest reduction in resistance is ordinarily encountered in going down the first six feet, but the eight-foot rod is the most popular. In most—though not all—cases, this length of rod will reach permanent moisture."

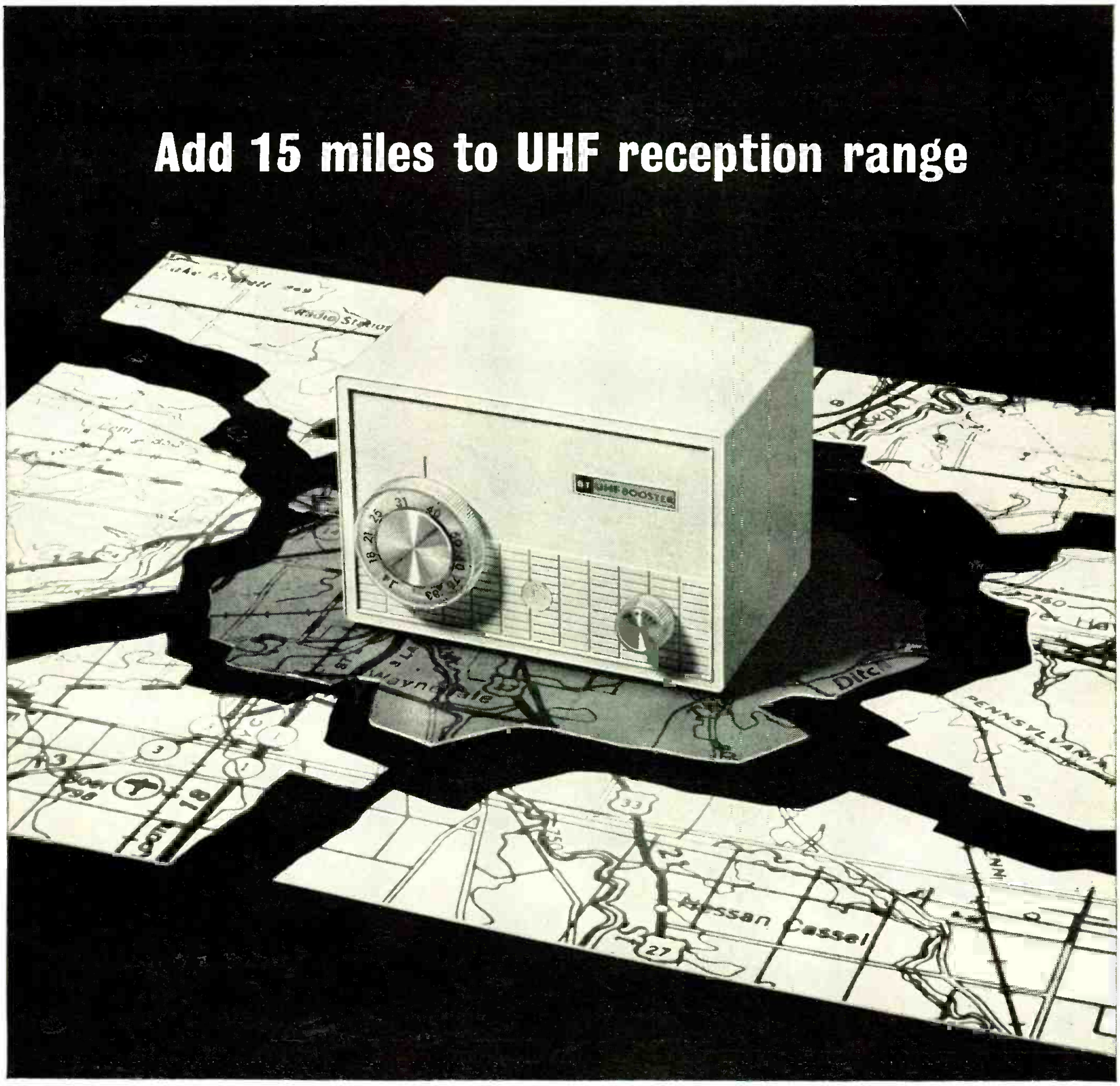
"Does the size of the rod have anything to do with the ground resistance?"

"Not a whole lot. A comparison between ½-inch and 1-inch rods driven into the earth reveals the latter, with twice the diameter and four times the area, decreases the resistance only about 10%. In general, the rod need only be large enough and strong enough to withstand driving without bending."

"Where you getting all this dope on grounds? You got awful smart all at once."

"I've been reading a booklet called 'Practical Grounding' published by the *Copperweld® Steel Company*, Wire and Cable Division, Glassport, Pa. They send this free for the asking. Also I've been studying 'A Manual on Ground Resistance Testing' published by the *James G. Biddle Co.* of Philadelphia and intended for users of the Megger® ground testers manufactured by that company. Thanks to these two authorities, I feel well-grounded on the subject."

"Oh brother! Let's get on with the testing," Barney suggested, making a wry face at the pun. "How come you need two more grounds to test the one here in the shop?



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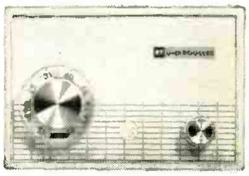

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Why don't you just measure the resistance between our ground and a water pipe?"

"Because a water pipe ground has resistance, too; and when you measure the resistance between two grounds you simply get the series resistance of both grounds and don't know how much of the total resistance belongs to the ground you're trying to measure."

"So how are you going to get around this?"

"I'll show you. Write down on the blackboard measurements taken between pairs of grounds as I make them with the v.o.m. Call our bench ground 'A' and those two outside grounds 'B' and 'C.' Here we go:

	Stray d.c. voltage	Stray a.c. voltage	Average ohms
A-B	.04	.15	80
A-C	.045	.5	85
B-C	.08	.6	95

"Notice I took two readings of each resistance, reversing the probes and averaging the readings to nullify the effect of the stray d.c. voltage. We see the resistance of A + the resistance of B = 80 ohms. A + C = 85 ohms. Adding these two equations together, we get: 2A + B + C = 80 + 85 or 165 ohms. From that let's subtract the equation: B + C = 95 ohms. That leaves: 2A = 70 ohms, or A = 35 ohms. We've 'used' the other two grounds to get at the resistance of A and then made them cancel themselves out! For good accuracy, the resistance of the auxiliary grounds should approximate that of the one being measured and they should be at least 20 feet from that ground and from each other in order to prevent overlapping of their 'effective resistance areas.'"

"Hey, that's neat! I see, though, the presence of that stray d.c. voltage kind of messes things up."

"You're right, and it and the stray a.c. voltage are almost always found in some degree between two rods driven into the earth. We can get away from the d.c. by using a.c. and computing the resistance. We simply use an a.c. ammeter to measure the amount of current a given amount of a.c. voltage sends through a pair of rods. The resistance is equal to E/I. Or we can use a Wheatstone bridge operating on an alternating current of say 1000 cycles and balance the bridge with a pair of headphones. This last method would get away from any errors introduced by stray 60-cycle a.c. between our rods. In either case, we would do the computation exactly as we did when we measured resistance with the v.o.m."

"You spoke of a 'Megger' instrument designed to measure ground resistance. Does it use one of the methods we've just been talking about?"

"No, it uses still another 'fall-of-potential' method in which an auxiliary ground rod is driven some distance away from the ground to be measured and another rod is driven about half way between the two grounds. An a.c. current is fed through an ammeter to the ground being measured and the farthest test ground. Voltage appearing between the ground being measured and the mid-point ground is read with a high resistance a.c. voltmeter. The resistance wanted will equal the measured voltage divided by the measured current.

"The 'Megger' uses this basic method to give a direct reading of the ground resistance. It consists essentially of a hand-cranked d.c. generator whose output flows through the current coil of an ohmmeter and then goes to a current reverser that changes it into a.c. to be applied to the farthest-apart grounds. The a.c. voltage appearing between the center ground and the ground being measured is fed back through a potential commutator that restores it to d.c. for application to the potential coil of the ohmmeter."

"Hold it!" Barney interrupted. "That makes two ohmmeter coils."

"There *are* two coils. This ohmmeter is like none you ever saw. A low-resistance current coil and a high-resistance potential coil are mounted on the same shaft that moves the pointer and they work in opposition in the field of a permanent magnet. No hair-springs keep the pointer at one place. It assumes a position dictated by the ratio of the current through the current coil and the voltage applied to the potential coil. The ohms scale is much more nearly linear than that of our v.o.m. The current reverser and the potential commutator are mounted on the same shaft as the generator armature and so are synchronized for all hand-cranked speeds. Changing the voltage and frequency of the output of the instrument by turning the crank at different speeds has no effect at all on the resistance reading.

"To use the instrument, you only have to run leads from three binding posts to the proper grounds. One test ground should be about 50′ from the ground being tested, and the other should be at 100′. These auxiliary ground rods need only be driven 2′ or 3′ deep. You turn the crank and read the resistance of the ground directly on the meter. If stray a.c. makes the reading erratic, you simply turn the crank faster or slower to shift the test frequency away from the 60-cycle stray current."

"If a fellow was going to do a lot of ground testing or needed high accuracy, that would be the ticket," Barney observed; "but these other computa-

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tional methods will work fine for us. How low a resistance do you need, and how do you go about lowering the resistance of a ground that is too high?"

"Electrical codes require the resistance of a driven electrode shall not exceed 25 ohms, but the lower the better. Ours, as you can see, is not low enough after the prolonged drought. I think I'll first try going deeper with 'Copperweld' Sectional Rods that are threaded on both ends so one can be driven full length into the earth, another screwed on the top with a special coupler, that driven full length, and so on. Low-resistance soil is often encountered 20′ to 40′ below the surface. In a typical test, a ground that measured 270 ohms at 8′ measured only 10 ohms at 40′.

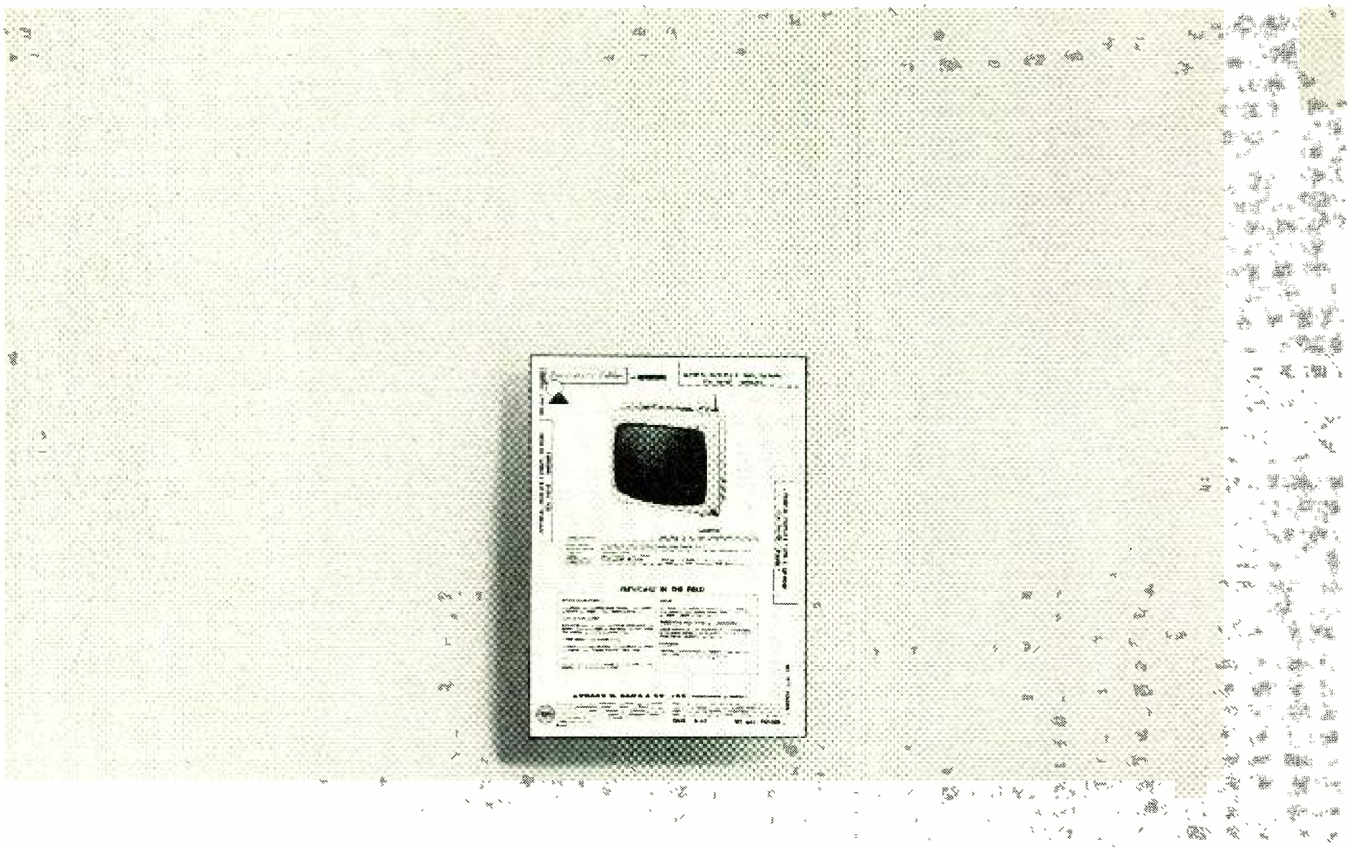
"Another possibility would be to drive several other 8′ rods and connect them to our present ground. If these new grounds are kept at least 5′ from our present ground and from each other, three more rods should cut our ground resistance to about one-third its present value.

"Or we could chemically treat the ground around our present rod to lower its resistance. This should be done by digging a foot-wide-foot-deep circular trench out about a foot and a half from the rod and filling it with magnesium sulphate, copper sulphate, or ordinary rock salt. This works best where the ground resistance is quite high. The improvement fades away with time unless the treatment is renewed every few years."

"A ground always seemed such a simple thing to me," Barney said with a sigh. "You just drove a rod into the earth and that was it. Now it seems terribly complicated."

"There is no such thing as a simple subject," Mac parodied; "there are just uninformed people!" ▲

"I don't service the sets . . . I just take 'em in and out."



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CIRCLE NO. 149 ON READER SERVICE PAGE

Transistors for Hi-Fi

(Continued from page 40)

has to be made for installation of the amplifier in relatively high ambient temperature which might exist in a cabinet where other equipment is also dissipating power. Large, finned heat sinks are the best solution to such a problem.

Transistors will not last forever. Reports in engineering journals show various causes of transistor degradation with transistor life estimated to be thousands to ten thousands of hours of operation. Contamination or impurities in manufacture have been cited as causes, sometimes aggravated by repeated heating and cooling. Soldering to transistors, if not properly done, can cause failure. For this reason, the use of sockets is recommended. Military equipment uses sockets unless a whole subassembly is made for depot or factory service instead of field maintenance. In case of equipment trouble, a whole subassembly is customarily replaced. However, such procedure would not be good economics for consumer equipment.

Circuit sections must be separated for minimum electrical and thermal interaction. The use of full-sized, rather than undersized, components for proper electrical operation (such as adequate voltage and temperature ratings on capacitors) requires more room. Such conservative ratings should apply to all components.

The photos show views of such an amplifier. The output transistors are mounted on large finned heat sinks at the back of the unit where maximum air circulation provides adequate cooling even when the amplifier is installed in an accessory case or furniture. The driver and regulator transistors are bolted directly to the heavy-gauge chassis. This provides adequate cooling of these transistors which are operated below their dissipation ratings. All low-level transistors are mounted on military-grade printed-circuit board, with their sockets located near the controls for minimum interaction due to wiring.

The frequency response and the distortion characteristics typical of this amplifier were shown in Part 1 (Fig. 4 and the curve of the well-designed transistor amplifier in Fig. 2). The power output at the "difficult" high audio frequencies is far in excess of the amount needed for high-quality listening and is available with very low distortion.

Transistor amplifiers can be designed to provide performance worthy of the name "high fidelity." Low distortion at all operating levels, full power output throughout the audio spectrum for all standard low impedances with the same overload capabilities for all, low hum and noise, high flexibility, safety of operation, and reliability have been achieved. Unfortunately, the cost of semiconductors and other components results in a higher price for transistor equipment than for a tube amplifier of similar rating. However, since the available audible music power of the transistor amplifier with normal loudspeaker loads is considerably higher, such an amplifier represents a good investment of the hi-fi dollar. ▲

CCTV Camera

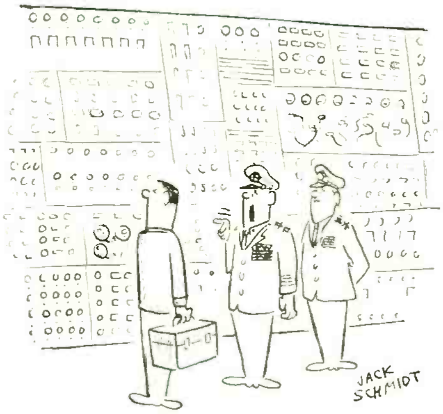
(*Continued from page* 43)

concerning temperature stability of the circuits. It is possible, however, to design very stable all-transistor cameras which will operate over a large range of temperature variations. There are some such cameras on the market which have performed successfully for years. The almost non-existent aging characteristics of transistors make an all-transistor camera very desirable if one considers that the circuits, if properly designed, will operate for years without re-adjustment. Other obvious advantages of transistorization are smaller size and lower power consumption. An all-vacuum-tube camera can, theoretically, operate over a wider range of temperatures than a transistor unit. It does, however, require the usual maintenance and re-adjustment that any vacuum-tube equipment needs.

Appendix

Light meters are available which will read light directly in footcandles. Most ordinary photographic light meters are not so equipped. The following procedure will allow you to read the number of footcandles available on a given scene with a photographic light meter:

1. Set light meter film speed to ASA 100.
2. Read scene illumination (incident or reflected).
3. Read appropriate shutter speed for an *f*-stop of *f*-5.6.
4. Convert to footcandles by using the formula: *footcandles (incident or reflected)*=.25 / *shutter speed.* ▲



"We fed everything into it. It classified the material 'top secret' . . . and now it won't tell us a thing!"

DIODES REGULATE POWER SUPPLY

By ROBERT K. RE

REGULATION and protection of low-voltage power supplies is somewhat hampered by lack of suitable low-voltage components operating below 2.3 v.

By using ordinary diodes having fairly sharp characteristic curves (Fig. 1A), and connected as shown in Fig. 1B, low-voltage supplies can be regulated and protected at a nominal cost.

Under normal conditions, the diodes conduct a small amount of current and act like the commonly-used pre-load or bleeder resistors that both improve the regulation and discharge the filter capacitors when the power is removed. Whenever the output voltage tends to rise, the diodes conduct heavily and keep the voltage from rising excessively. In this case they are acting like an over-voltage protection circuit. Unlike other over-voltage circuits, the diodes quickly resume their normal conduction as soon as the over-voltage disappears.

Conversely, a drop in output voltage

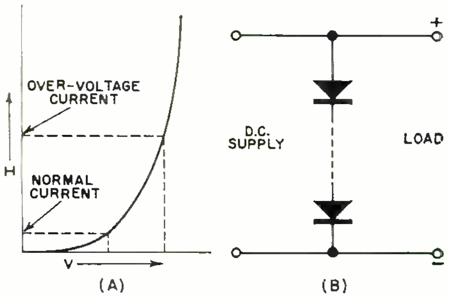


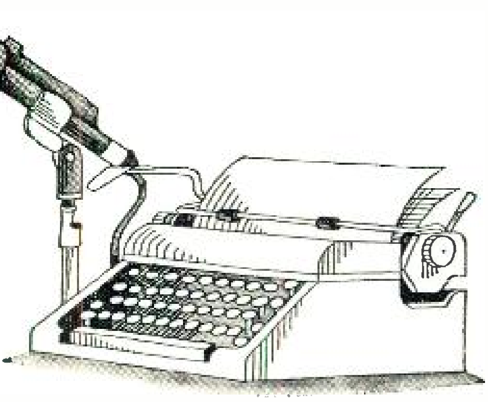
Fig. 1. A typical diode characteristic curve (A). Method of connecting into a low-voltage supply for regulation (B).

reduces the current flow through the diodes, thus again they assist regulation. In both cases, the diodes act like a shunt regulator. Their low impedance helps lower the output impedance of the supply and in this way, act like filter capacitors. Because diodes conducting in their forward direction are fast acting, transients are quickly suppressed.

As an example—suppose you wanted to regulate 1.0 volt. A single germanium or silicon diode will not work as either will be highly conducting at this voltage. Two silicon diodes at 1 v. will not conduct too much current but at about 1.4 v., they will slip into heavy conduction. For closer control, a germanium and a silicon diode would do the job.

For normal circuit voltages, choose the diode types and quantity such that about 10% of the total load current flows through the diodes. Last, the power rating of each diode used should be considered. It must be able to dissipate the peak power occasionally expected. ▲

RADIO & TV NEWS



THE country's TV set manufacturers are starting to step up the tempo of their changeover to full production of all-channel TV receivers although the effective date of the all-channel law isn't until April 30, 1964.

The EIA Consumer Products Division claims that 20% of black-and-white sets produced this year will be all-channel equipped. As of the end of June, the rate of all-channel set production was 11.5% of all black-and-white sets, up 9.2% from 1962.

However, all is not roses either. There is a chicken-and-egg relationship between broadcasters and set owners and the industry is depending heavily on the FCC as well as the broadcasting industry, to help make the all-channel law produce the expected expansion of TV.

Unless considerable numbers of new u.h.f. stations are established within the next few years, many purchasers of all-channel sets will be paying for a number of TV channels which they may never have the opportunity to use. These, as well as a number of other all-channel TV set customers, may start to complain about increased prices of sets as a result of the all-channel law.

According to Morris Sobin, president of *Olympic Radio and TV* and chairman of the EIA Consumer Products Division, one action that Congress might take to offset the expected price increase is to eliminate the 10% manufacturers Federal excise tax on TV sets equipped with all-channel tuners.

Removal of the tax would assist in reducing the retail price of all-channel sets to about the same level as present v.h.f.-only sets. The viewer who lives in an area where there is no u.h.f. would not feel that he is being penalized the extra cost for the additional u.h.f. channels.

Pay U.H.F.?

In a recent speech, Gerald A. Bartell, president of *Macfadden Teleglobe Corp.*, the company planning to bring pay-TV to Denver, Colorado late this summer stated ". . . pay television will eventually offer a wide variety of entertainment to a potential audience of more than 15 million TV homes, representing more than 50 million people." He continued, "A fully developed pay-TV system would enable a motion picture like 'Cleopatra,' costing an estimated 40 million dollars to pay all its obligations and come out with a profit after a single run on pay-TV."

Towards the latter part of his speech, Bartell also said, "With almost 1500 u.h.f. channels in the U.S. lying fallow, the FCC has indicated its interest in allocating certain of these channels to pay-TV across the country. Now, it's up to Denver and Hartford. If pay-TV succeeds in those markets, the FCC will, in all likelihood, open pay-TV to the entire country."

Teeny TV

The pendulum is starting to swing again. Not too many years ago, TV sets were of the 10-inch or less variety. As public interest grew, picture tube size grew. In fact, the picture size grew right out of the cathode-ray tube and a number of home projection sets came into existence. Large and cumbersome, like the dinosaur, they mysteriously vanished from the scene.

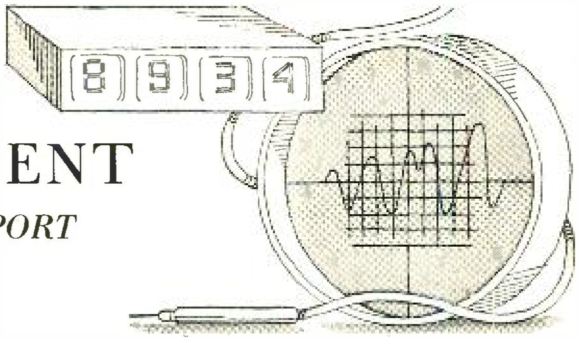
At present, we are in the realm of the 23-inch screen. Over the past year or so, there appeared signs that the pendulum is about to start swinging again when several TV sets having screens 11 inches or less (some going down to 5 inches) made their appearance.

The latest entry into the small-set race is from the *Realtone* stable. They are planning to introduce a 9-inch set at approximately $79.95 that will be retailed through supermarkets some time in the spring of 1964. Also on the drawing board is a 6-inch, transistorized, all-channel (including u.h.f.) portable that they want to pass on to the customer at $150 or less. This set will also hit the stores in the spring.

A spokesman for the company foresees that lightweight portables may follow the same pattern as transistor radios and the introduction of these sets at promotional prices will make them personalized items for every member of the family, with a sales potential of 15 to 20 million units per year. ▲

TEST EQUIPMENT

PRODUCT REPORT



GC Electronics 36-616 CRT Tester & Rejuvenator

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

A USEFUL piece of test equipment for the TV service technician is a unit that will check color and black-and-white picture tubes and, if such tubes are defective, attempt to rejuvenate them. The new *GC Electronics* Model 36-616 is just such a unit. The arrangement of controls, the common-sense sequence of the function-selector switch, and the use of a number of indicator lights and meter on the front panel results in an extremely easy-to-operate tester. The instrument not only checks and rejuvenates CRT's with the usual 6.3-v. heaters but also 2.5 and 8.4-v. types as well. On color tubes, each gun is checked separately.

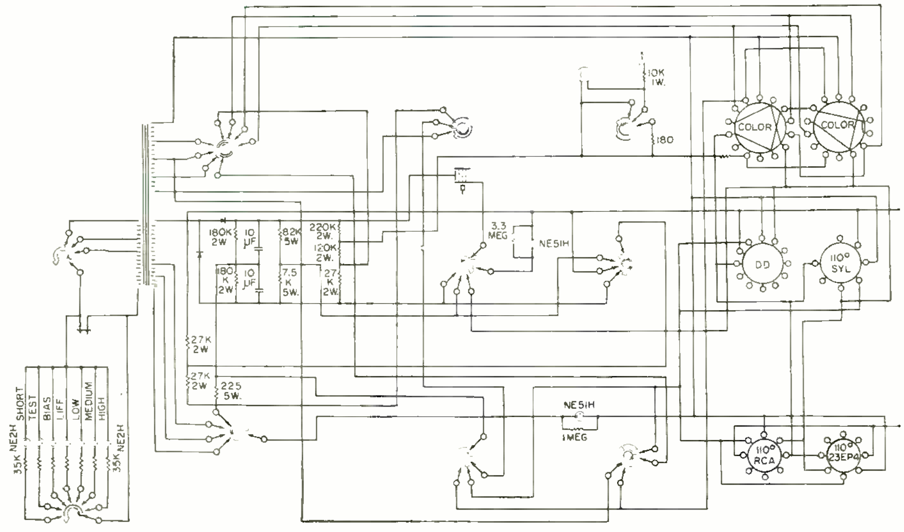
As a tube checker, the Model 36-616 tests for continuity between the base pins and the elements within the tube, for heater continuity, and for shorts and leakage between the picture-tube elements. If there is no leakage, the tube is then checked for emission between cathode and second anode. If the meter reads in the "Good" area, over 250 μa. of current is flowing and the tube is considered to be satisfactory. Next, a grid-bias test is made by observing the amount of voltage required to cut off the beam. Then, a life test is performed in which the heater voltage is switched off and the time required for the emission to fall to zero is measured.

If the picture tube being checked shows low emission or interelement leakage, the rejuvenate feature of the instrument is used. It should be understood that any rejuvenation technique carries with it certain risks. This is true since elevated voltages are temporarily applied to the picture-tube elements. If the tube is not in a useful condition, however, then certainly nothing is lost by the rejuvenation attempt. This same situation applies to all CRT rejuvenators.

This particular instrument uses two methods of attempting to restore emission. In one the tube's heater voltage is raised by 40 percent (in one position of the function switch) or by 80 percent (in another position of the switch). The second technique is to apply a high-voltage d.c. pulse between the grid and cathode.

By applying elevated heater voltage to the CRT for perhaps 10 to 30 minutes, it is often possible to cause some active material in the cathode to move toward the surface and restore emission. If this method does not show results, it is time to press the red push-button marked "Rejuvenate." Now a high-voltage pulse is applied that should result in high momentary emission current that may decontaminate the cathode surface and restore emission to normal. While using either of the techniques just described, it is well to recheck the condition of the tube to see what is happening.

The instrument comes with a combination cable which permits testing of any black-and-white or color picture tube on the market today. The cable and sockets are stored in a compartment in the unit's convenient carrying case. Price is $69.95. ▲



Sencore CA122 Color-Circuit Analyzer

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

ONE of the required pieces of test equipment for servicing and adjusting the circuits in a color-TV receiver is some sort of color-pattern generator. There are three main types of such generators; they are (1) the NTSC type, (2) the continuous-rainbow type, and (3) the gated-rainbow type. The NTSC generator provides fully saturated color-bar signals along with the brightness pedestals required. Such generators are quite elaborate, fairly expensive (around $500-$600 or more), and, according to *RCA* color-TV service data, "are not required and not used in any service adjustment procedures in color receivers." These generators would be useful in laboratory or color-receiver development and design work. For general service use, the somewhat simpler, less expensive rainbow types are common.

Both the rainbow types mentioned above usually employ the "offset-subcarrier" principle. Here a subcarrier signal, frequently crystal-controlled, is produced by the generator. This is offset 15,750 cps below the normal frequency of the 3.58-mc. subcarrier oscillator used in the color-TV set. When the two signals are mixed in the receiver, a difference frequency is produced in which there is a one cycle beat note for each complete horizontal scanning period. Therefore, there is a constant change in the relative phase of the two signals, from 0° to 360°, during every horizontal scanning line of the picture. This phase change produces a rainbow of color as the electron beam sweeps across the color picture tube. In the continuous-rainbow generator, this entire sweep of gradually changing color is displayed. In the gated type, the rainbow display is turned on and off by means of a square wave so that a series of well-defined bars is produced. When this is done, it is easy to pinpoint specific color signals and adjust the color-TV circuits.

This latter type of generator, of which the new *Sencore* Model CA122 is an example, can be used for checking and adjusting any type of color receiver. Adjustments can be made in the user's home without an oscilloscope, or in the service shop with the aid of a scope. The instrument is extremely versatile and the large number of test signals that it generates permits a set to be checked all the way from the antenna terminals to the tri-color picture tube.

There are six test-pattern signals produced by the analyzer. A replica of each one of these appears in a small window beside the pattern-adjust switch. First, there are ten standard color bars. These are crystal-controlled gated bars of the *RCA* type with a 30-degree phase change between them. Second is a shading-bar pattern in which the color is removed and the bars change brightness level from black through gray to white. This pattern is useful in making color-temperature adjustments. Third and fourth are patterns consisting of white horizontal lines alone and white vertical lines alone. Fifth and sixth are cross-hatch and dot patterns. These last four patterns are used to make height, width, and linearity adjustments on both monochrome and color sets. On the color sets they permit adjustments to be made of static and dynamic convergence and color purity. The later check is facilitated by the three color-gun interrupter switches built into the generator.

All video signals are available either directly or they may be used to modulate a built-in two-band r.f. generator. One of these bands is from 50 to 90 mc. so that signals can be injected on TV channels 2 through 6. The other band is from 20 to 50 mc. for signal injection in the i.f. range. A 4-step fixed attenuator may be switched to provide 2000 μv. for the front end, 1000 μv. of i.f. signal for the first i.f. stage, 10,000 μv. for the second, and 100.000 μv. for the third i.f.

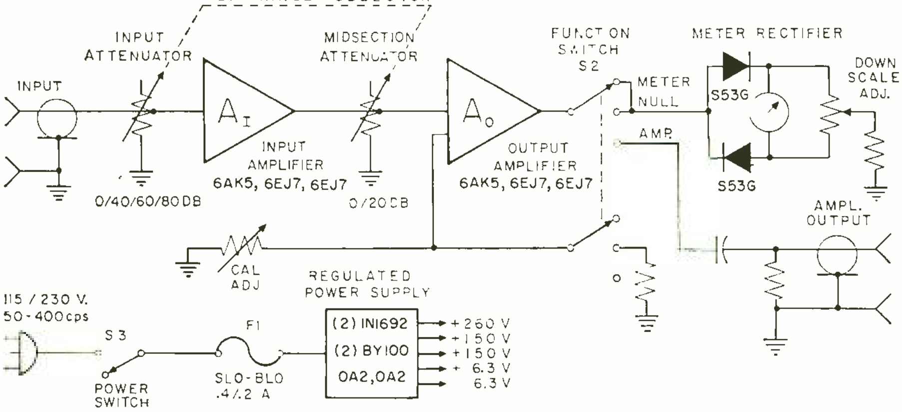
Sync stages can be checked by using the horizontal and vertical sync signals generated by the unit. These signals, like the video signals, are adjustable over a large amplitude range and with either positive or negative polarity. The audio i.f. stages can be checked by a crystal-controlled 4.5-mc. signal while the later audio stages can be checked with the 900-cps audio signal provided.

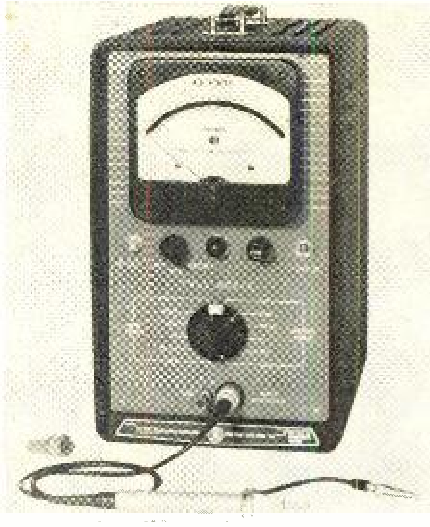
Enhancing the convenience and portability of the unit is the use of a large carrying handle, the fairly light weight (15 lbs.), and the fact that all the leads can be stored inside two large compartments in the rear of the instrument. The color-circuit analyzer is available at distributors for $187.50. ▲

Ballantine Model 314A Video V.T.V.M.

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

BALLANTINE, famous for its vacuum-tube voltmeters for 25 years, has added Model 314A to its line of meters. This instrument is said to be the most sensitive of any wide-band voltmeter available here or abroad. It is an improved version of the Model 314, which has been popular for 7 years. The 314A measures voltages down to 30 microvolts (in "Null Detector" mode) and up to 1000 volts with its 10-meg probe, at frequencies from 10 cps to 6 mc. Hence, it has been termed a "video voltmeter." The 3-db bandwidth is 2 cps to 10 mc. Basic accuracy is 2% of the actual reading at any point on the scale





up to 2 mc. The error does not exceed 5% of the actual reading up to 6 mc. The instrument responds to average values of input voltage and is calibrated in terms of r.m.s. values of a sine-wave voltage.

The new meter has a 5-inch voltage and db scale. Having only one voltage scale means less possibility of reading error and permits voltages to be read accurately and precisely over the entire scale. The movement of the needle is the same for a given change in voltage at the bottom as at full scale. It differs from a zero-reading linear meter in that in the latter the ability to distinguish small percentage differences becomes negligible near the bottom of the scale. The manufacturer's log scale indicating meters are all individually hand-calibrated in order to obtain optimum accuracy.

The design of the Model 314A includes a large amount of feedback in the amplifier so that the guaranteed accuracy is maintained for more than 3000 hours between calibrations or tube change. The diagram shows a simplified schematic of the unit. There are two wide-band attenuators, one at the input, and one between the two amplifiers. It is essential that the frequency response of the attenuators and amplifiers be flat and stable for long periods of time to a degree that is completely unnecessary in ordinary amplifiers.

The instrument may also be used as a precision, wide-band 60-db amplifier having an output from the receptacle on the front panel of 2 volts corresponding to full-scale reading on the meter. Its internal source impedance is about 700 ohms. The frequency response is ±1 db from 10 cps to 6 mc. It has a low noise level at full gain, with the input open-circuited, of less than 25 microvolts.

Precision resistors (available as separate accessories) having values from 0.01 ohm in decade steps to 1000 ohms, may be plugged into the front of the v.t.v.m. when it is desired to measure current. Since $I = E/R$ and R is unity, or a decade multiple, the voltage reading will be equal to the current, provided the decimal is properly located. For example, if the one-ohm resistor is used and the reading is 100 μv., the current is 100 μa. If the resistor is 0.01 ohm and the reading is 100 μv., the current is 1 μa. A high-voltage probe, which may be used to measure voltages to 10,000 v.r.m.s. or 20,000 v. p-p is also available separately. It is calibrated to have an 80-db attenuation; hence, a reading of 1 volt on the voltmeter would mean 10,000 volts input to the unit's probe.

The Model 314A is currently available in portable or in relay-rack versions. The price of the portable unit, including the regular probe, is $300. ▲

THE CASE OF THE MISSING PULSES

By AARON A. EDWARDS / Technical Research Laboratories

FOR a particular purpose, a scope was set up to have trace initiation by a pulsed signal with an unshuttered, moving strip film camera furnishing a film record of the events displayed on the scope trace. For the problem at hand, the sweep duration chosen was 500 microseconds per centimeter, or a total sweep of 5000 microseconds for the 10-centimeter trace.

A very perplexing thing was revealed upon examination of the film record. Although it had been intended that every pulse should appear, it became apparent that a considerable number of pulses in the pulse train under study were missing. Even though the film display indicated no spacing variations, the fact remained that a substantial number of pulses were being lost. A close inspection revealed that every third pulse was unaccounted for. With this fact as a clue, it was quickly deduced that the missing pulses were occurring during scope retrace time. No one had considered the pertinence of the relatively high amount of time consumed in the retrace. For this particular scope and sweep speed setting, the retrace time is 500 microseconds—about 10% of the actual trace time of the oscilloscope.

For the pulse period being analyzed (2670 microseconds), the third pulse is inevitably lost as it occurs during the retrace time. During this period, the trace is blanked and is dead time insofar as the recording of any particular waveform is concerned.

Such sources of error should be recognized during any quantitative analysis and calculation performed on the film strip thus obtained. ▲

EW Lab Tested

(Continued from page 22)

mum of smoothness and freedom from peaks and holes in the over-all acoustic frequency response of the stereo phones.

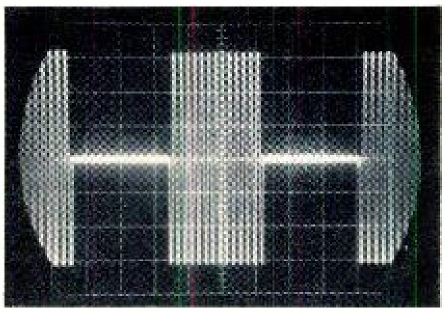
The earpieces are made of a light, high-impact plastic. One of the most important characteristics of headphones, if they are to provide good bass response, is a tight seal around the ear. These phones have one of the best seals we have seen. The vinyl ear cushions are partially filled with a liquid and mold themselves firmly but gently around the ear. External sounds are almost totally excluded when the phones are worn. The shape of the cushions and the padded headband is such that the phones feel comfortable even after long periods of use.

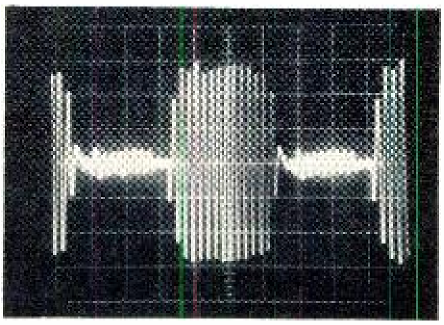
The rated frequency response of the phones is 30-20,000 cps. We listened to the output of an audio oscillator to obtain a rough idea of their response and, within the limitations of our ears, they seemed to live up to their specifications. An audible 30-cps tone could be heard, with remarkably little doubling, and the response was audibly smooth all the way up to 15,000 cps, which is very likely the upper limit of our hearing. The efficiency of the phones is apparently adjusted to match the output of a typical power amplifier and we found that a dual 30-watt amplifier did not tend to overload the phones. Of course, even the least powerful amplifier is adequate to drive them properly.

Listening to various programs from a stereo receiver showed that the phones have a full, nicely balanced sound which is subjectively very similar to that of good-quality speakers. High-frequency hiss seemed to be more audible than on speakers, an effect which we have noticed on almost any headphone with extended high-frequency response. The phones would seem to be an excellent choice for anyone wishing to enjoy the best listening quality *via* headphones.

The price of the *Koss* "PRO-4" phones is $45.00. ▲

Tone Burst Generator
(*Continued from page 52*)





Gated 1 kc. at 16 msec. direct from generator (top). After passing through an amplifier, speaker, and microphone (lower).

A tape recorder can be substituted for the amplifier in Fig. 4A. The burst is recorded on a section or a continuous loop of tape and played back for observation of the waveform. This is a severe test for the input and output amplifiers and the tape heads. Bursts at frequencies around 10 kc. are often unrecognizable.

Valuable information on loudspeaker performance may be obtained with the setup shown in Fig. 4B. The microphone and preamplifier should be of good to broadcast quality. The degree of speaker cone damping is observed between the tone bursts. Insufficient damping is particularly noticeable at low frequencies if speaker cone movement is not abruptly stopped. A high flux density speaker magnet and a very-low internal resistance amplifier are essential to good performance. Tone bursts are useful for adjusting the amplifier damping (negative feedback) controls when available.

Random waveforms can be gated with the tone-burst generator by following the setup shown in Fig. 4C. Music or spoken words, gated at 16 or 6 msec. remain intelligible despite the loss of 50% of the signal. Background noise in this application is reduced by adjustment of the "Base Line Adj." control. White noise from a random-frequency generator may be gated to produce an "outer space" sound effect. Many other applications will occur to the reader when using the tone-burst generator. ▲

REFERENCE

1. Millman and Taub: "Pulse and Digital Circuit," McGraw-Hill Book Co., 1956.

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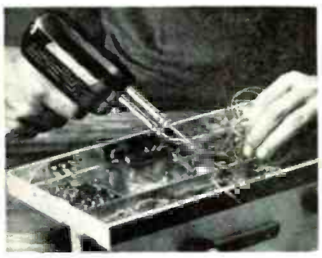

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CIRCLE NO. 160 ON READER SERVICE PAGE

ADD A TV D.C. RESTORER

By CHARLES ERWIN COHN

Accurate rendition of the gray scale, neglected in most TV receivers today, can be restored by adding a single stage.

ALTHOUGH it was regularly used in the earliest TV sets, the d.c. restorer is a neglected feature in today's receivers. The omission is regrettable, since the circuit makes a valuable contribution to picture fidelity. However, it is not difficult to add.

The need for d.c. restoration stems from the manner in which signal is generally applied to the picture tube. To simplify comparison, assume the detector's video polarity is such that a positive signal (Fig. 1) corresponds to black information, with smaller voltages corresponding to lighter gray shades until white is reached with the smallest voltage. If this signal is directly coupled from detector to picture tube, a given voltage always corresponds to the same shade. Reproduction of the black-to-white scale would then always be correct, provided only that the receiver's brightness control is properly set.

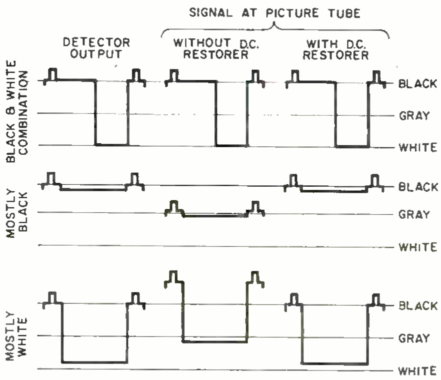


Fig. 1. Comparison of detected video, unrestored, and restored CRT signals for three conditions of gray-scale content.

While some sets use d.c. coupling, most avoid certain complications with *RC* coupling. D.c. level of the signal is thus removed through the coupling capacitor, with the average amplitude of any signal being placed at the same level. This permits standard black level to shift, depending on make-up of the signal at any given moment.

Fig. 1 illustrates this action for typical signals. The first line shows a signal with blacks and whites evenly distributed. Average level to the CRT, without restoration, is where it should be. Signal in the second line is mostly black. When capacitor coupling, however, moves the average level down toward gray, the scene is reproduced lighter than it should be. Also, with sync pulses not reaching the black level, retrace lines become visible. With mostly white signal (3rd line), the shift toward gray makes the picture darker than it should be.

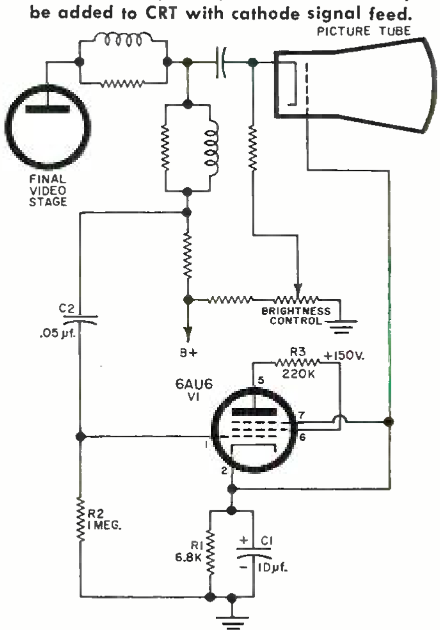
Where neither direct coupling nor a d.c. restorer exists, the latter can be added. The circuit senses the sync pulses, which are always at the same level just beyond black, and adjusts CRT bias accordingly to compensate for the shift produced by capacitive coupling.

The circuit of Fig. 2, easy to install in an existing set, can be used wherever video signal is applied to the picture-tube cathode and the brightness control is also located there. This arrangement is usual. The circuit requires the addition of only one tube, two capacitors, and three resistors. These are given as *V*1, *C*1, *C*2, and *R*1 to *R*3. Other parts, in the existing circuit, are shown to indicate connection points.

With the large cathode resistance, *R*1, *V*1 is almost cut off. Positive video signal is applied to its grid. Without *C*1 in the cathode, *V*1 plate current would increase as video becomes more positive, the cathode voltage following the grid voltage. However, *C*1 charges cathode voltage to the most positive part of the signal, the sync pulses, and holds *V*1 cut off over the rest of the cycle. The voltage on *C*1 is applied to the CRT grid. Thus the CRT grid-cathode potential is always constant on a sync pulse.

Between sync pulses, *C*1 slowly discharges through *R*1. The time constant of this combination is comparable to the duration of one frame, so that the circuit

Fig. 2. A single-stage restorer that may be added to CRT with cathode signal feed.



will not respond to more rapid changes in average level. However, the time constants of the coupling circuits in the video amplifier are sufficient to hold the black level for one frame.

Installation of the circuit poses no special problems. For $V1$, use that variant of the 6AU6 whose heater characteristics can be most conveniently incorporated into the set's heater circuit. Some point having no more than 150 volts of "B+" must be found for plate and screen supply. Note that $C2$ is connected directly to the end of the video-amplifier plate load resistor closer to the plate and after any of the peaking coils. This minimizes the effect of the added stray capacitance on the high-frequency response of the video amplifier.

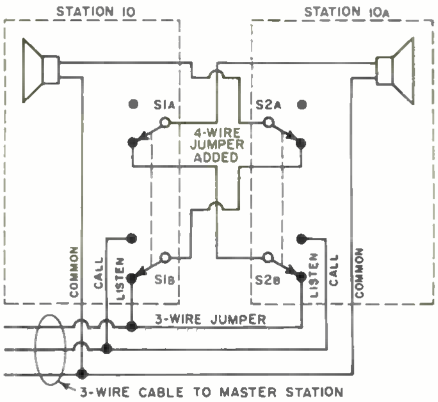
The CRT grid is removed from its existing connection and taken to the cathode of $V1$. Many sets have retrace blanking circuits connected to this grid. Such blanking should not be necessary after the revision, with the black level held where it belongs. However, if blanking should still be needed, it can be retained by connecting in the CRT grid lead a resistance approximately equal to resistance to ground of the previous grid circuit and returning the blanking-pulse connection to the grid of the CRT. ▲

ADDING INTERCOM SUB-STATION

By SIDNEY CLAIRE

AFTER completing the installation of a ten-station intercom system, the customer asked the author whether or not it would be possible to squeeze in one more station. Since ten was the maximum number of stations that could be handled, this posed quite a problem as the author didn't want to make drastic modifications of the master unit.

In the case of this particular intercom system, if the speakers are paralleled there will be serious feedback through the system when one of the paralleled speakers goes to "call." The circuit arrangement shown in the diagram solved the problem. There is negligible added loading on the line. And, in this case, the chance of the two tandem speakers going to "call" position at the same time is almost nil. ▲



S1, S2 WERE S.P.D.T. CHANGED TO D.P.D.T.

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Carl J. Meyers, center, Vice President and Manager of Operations and Engineering; and Woody Crane, left, Chief Engineer of Television, discuss WGN's wire and cable needs with Belden sales engineers, who, on behalf of Belden distributors, have just toured the new facilities.

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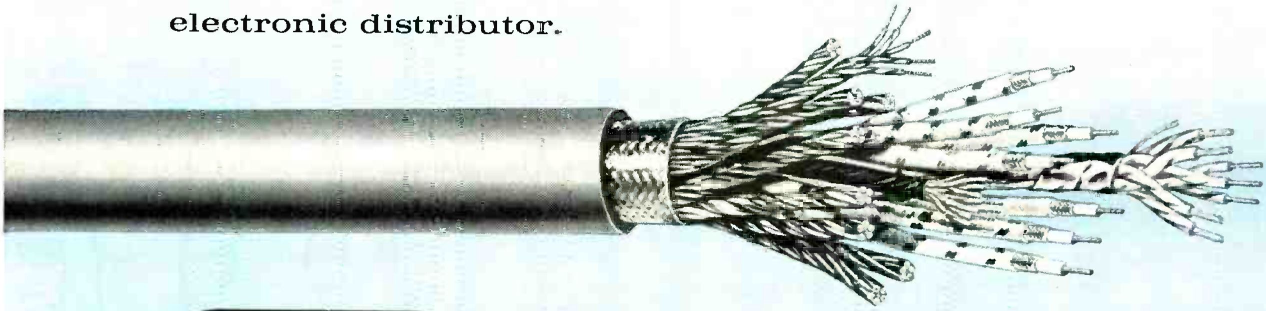

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CIRCLE NO. 108 ON READER SERVICE PAGE

Silicon Controlled Rectifiers

(*Continued from page* 30)

enough to handle the required full-load current.

Since the minimum conduction angle in the above circuits is 90°, these do not offer continuous control from zero to maximum. There are other configurations, however, that do provide this feature. One such circuit is shown in Fig. 10. With this type of connection, changing the setting of potentiometer *R* varies

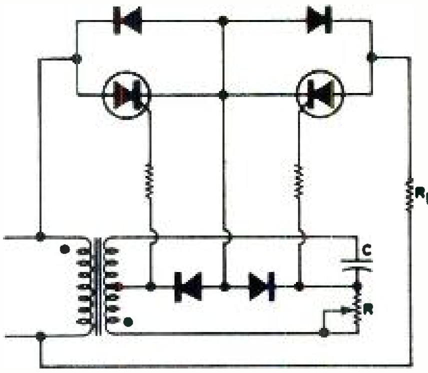


Fig. 10. Circuit permitting control over entire half cycle of applied voltage.

the phase angle between the SCR anode and gate voltages from zero to 180°, thus controlling the firing point of the SCR's over an entire half cycle.

In this circuit, the value of *R* must be at least ten times the reactance of *C* at the operating frequency. With a minimum-resistance setting of *R*, the gate circuits are connected across the lower half of the center-tapped transformer winding and the voltage applied to the gates of the SCR's is in phase with the anode voltage. The SCR's conduct for nearly 180° on alternate half cycles. With maximum setting of *R*, the reactance of *C* can be considered negligible and the gate circuits are effectively connected across the opposite half of the transformer winding. The voltage applied to the anodes and gates are nearly 180° out of phase and virtually no conduction takes place. With intermediate settings of *R*, conduction angles ranging from near zero to almost 180° can be achieved.

Unijunction transistors and four-layer diodes (similar to SCR's but without the gate-trigger provisions) may be used to provide turn-on pulses for SCR circuits. Such devices are normally employed in relaxation oscillator circuits with variable pulse spacing so that triggering may occur at any point of the SCR anode cycle. A typical circuit using unijunction transistor triggering is shown in Fig. 9.

With SCR control, every electric light switch in the home becomes a potential light dimmer that provides continuously variable operation from full off to full on. A high-power bulb in a child's nursery may be adjusted to give plenty of light during play hours, but it can be turned down to just a glimmer for night-light purposes. In living and dining rooms, light dimmers can provide just the right degree of illumination to fit any mood and, for amateur puppeteers, the basement rumpus room can be converted into a theater, complete with theater as well as stage light dimming equipment.

SCR control can increase the functions and conveniences of kitchen electrical appliances. Electric ranges with SCR control can match the infinite heat selection of gas equipment, electric toasters can become more efficient and far more reliable, electric mixers and blenders, automatic refrigerators and freezers, even dishwashers, can benefit from the variable current capabilities of SCR circuits.

In the workshop, SCR circuits in electric power tools can convert a particular implement into a multi-purpose device. Drills and saws can be adjusted for just the right speed for virtually all types of materials and, with feedback circuitry, can provide constant torque irrespective of load. Soldering irons with heat control can be used for a variety of purposes other than soldering and every piece of electrical equipment that runs too fast, gets too hot, or burns too bright for a particular application can benefit.

These applications, of course, are in addition to those where SCR's can replace relays or contactors in equipment where the reliability and ruggedness of semiconductor devices have decided advantages. While these advantages, with yesterday's high-priced SCR's, seemed rather vague, today they take on a new significance. And, for the electronics engineer and technician, the widespread application of SCR's in volume-produced electrical equipment promises another, as yet unexplored, field of operation with new opportunities for all. ▲

"We've found that occasionally we have to jog its memory."

ELECTRONIC CROSSWORDS

By JOHN D. OWENS

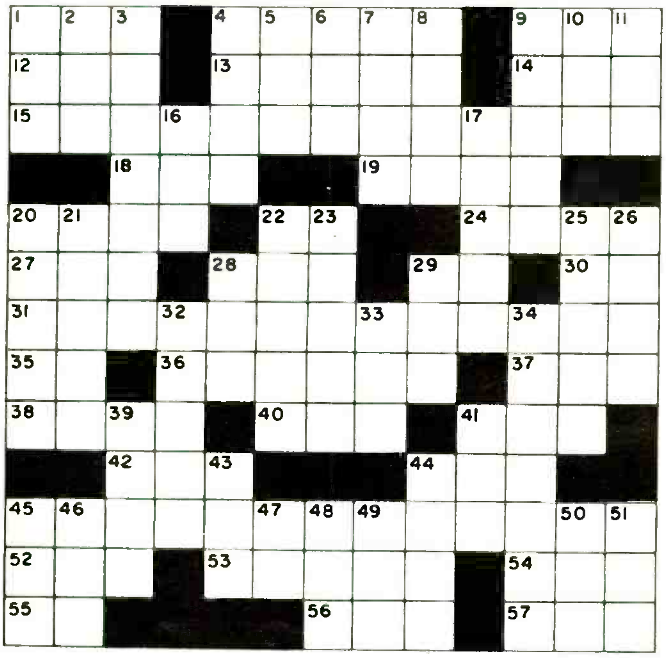
(*Answer on page* 110)

ACROSS

1. Incombustible residue left after burning.
4. Types of potentiometer used primarily as an attenuator.
9. Slang for equipment.
12. Chemical suffix denoting salt.
13. Type of FM detector circuit.
14. One (Scots).
15. Circuit having parallel R and C in one arm; series R and L in the opposite arm.
18. Unrefined metal.
19. .... conductors: class of solid materials characterized by high resistance.
20. Gentlewoman.
22. You (German).
24. One electrode of a battery.
27. Island (French).
28. Tolerance value of silver in the resistor code.
29. That is
30. Like.
31. Device having a tungsten filament and containing mercury or argon.
35. Altitude (abbr.).
36. Visible lines on a TV screen.
37. Secret agent.
38. Care for.
40. Consumed.
41. Geological formations (abbr.).
42. Teleost fish.
44. Day (Spanish).
45. Material used to maintain high frequency stability in a vacuum-tube oscillator of a transceiver.
52. Part ownership in a business enterprise (abbr.).
53. Term used to indicate that current is being taken from a voltage source.
54. Former name of the industry's engineering society (abbr.).
55. Frequency bandwidth.
56. American poet.
57. System based on primary units of length, mass, and time (abbr.).

DOWN

1. Goal.
2. Depot (abbr.).
3. Six-electrode vacuum tubes.
4. Elm or oak.
5. Friend.
6. Big body of water (abbr.).
7. Fishes in a particular way.
8. Angry (slang).
9. Receiver (colloq.).
10. Common word ending.
11. Make a right turn.
16. Sour.
17. Urge.
20. Operates photoelectric relay.
21. Winged.
22. Polyphase winding connection.
23. Dark.
25. Artificial illumination sources.
26. Catch sight of.
28. Twitch.
29. Suffix denoting chemical compounds.
32. Type of volume control.
33. First woman.
34. Possessing non-directional characteristics.
39. Close by.
41. Prefix meaning "not."
43. British for "Inc."
44. Unit of force.
45. Confirmation of radio communication among hams.
46. New channels (abbr.).
47. Metallic element (abbr.).
48. Top of a tube.
49. River, in Spain.
50. Silver (abbr.).
51. The (French).



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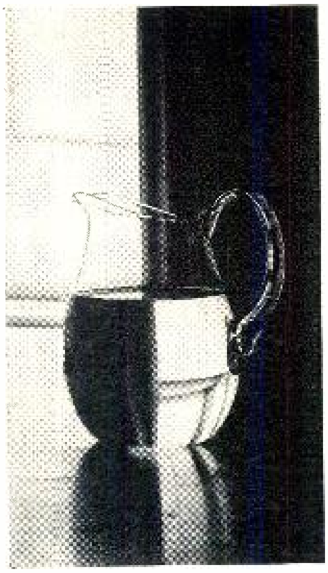

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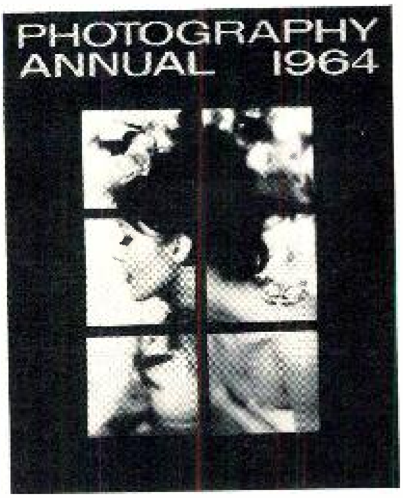

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3-Watt CB-Ham Transmitter
(*Continued from page* 47)

The front panel contains the microphone jack $J1$, the antenna jack $J2$, the transmitter "on" light, and access holes for tuning the oscillator, final amplifier, and antenna circuits. Immediately behind this panel is the printed-circuit board carrying the r.f. section. One half of this board contains the oscillator, while the other half is used for the final amplifier. The speech amplifier-modulator assembly is mounted between this deck and the rear panel which supports relay $RL1$ and the power input terminals. The speech amplifier is placed on a small 1.4" x 1.6" printed-circuit board and separated from the modulator and transformer $T3$ by an aluminum panel 0.125" thick. The whole speech amplifier-modulator is enclosed on three sides with aluminum panels for shielding. For the same reason, the printed-circuit boards used are double-sided; one side for circuitry and the other for shielding. Conventional point-to-point wiring may also be used. In this case, a little more room would probably be required.

Since transistors $Q1$, $Q2$, and $Q6$ dissipate almost 10 watts, they must be mounted so as to radiate this heat. The heat sink for $Q1$ is small, consisting only of a square of aluminum measuring 0.5" x 0.5" x 0.125", while the heat sink for $Q2$ is somewhat larger (see Fig. 3). It may be machined from a piece of aluminum 1" x 1" x 0.5", using a flat and round file. $Q6$ does not require a prepared heat sink, but rather is mounted on the small panel separating the speech amplifier from $T3$.

Each section of the transmitter should be tested before assembly to insure proper operation. The speech amplifier-modulator should develop 10 volts r.m.s. across a 20-ohm load with an input of 0.5 mv. r.m.s. The r.f. portion of the transmitter may be functionally tested with a G-E #47, 6-8 volt pilot lamp as a dummy load. Two watts of power consumed by this bulb should cause it to be somewhat above its normal brilliance.

Once the transmitter has been assembled, alignment is best done using a field-strength meter and a 0-500 μa. meter. Using the field-strength meter and a pickup loop of 5 turns, adjust capacitor $C1$ until the oscillator has maximum output. Once this is done, rotate the screw on capacitor $C4$ until the emitter current of $Q2$ is minimum. A corresponding rise in field strength should be noticed at this point. The last step consists of loading the antenna by adjusting capacitor $C6$ for maximum field strength. Application of modulation should cause the field strength to increase. If not, capacitors $C1$ and $C4$ may have to be retuned slightly. ▲

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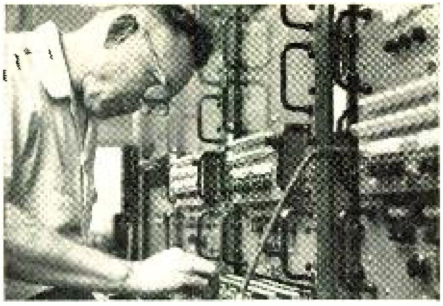

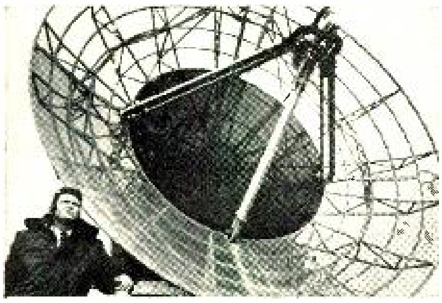

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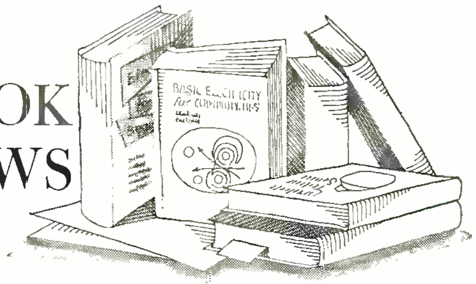

"INDUSTRIAL X-RAY HANDBOOK" by Allan Lytel. Published by *Howard W. Sams & Co., Inc.* 280 pages. Price $7.95.

This volume provides broad coverage of the industrial and commercial uses of x-ray radiation. The nine chapters include an introductory section, generating radiation, detecting radiation, basic principles and applications, electronic equipment and techniques, medical equipment, industrial and commercial uses, laboratory uses of radiation, health physics, gamma-ray equipment, gamma exposure time computation, and exposure factors.

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"PRINTED AND INTEGRATED CIRCUITRY" by T. D. Schlabach & D. K. Rider. Published by *McGraw-Hill Book Company, Inc.* 400 pages. Price $13.50.

Two specialists from *Bell Telephone Laboratories* have collaborated in presenting the fundamental aspects of printed and integrated circuitry from the viewpoint of the materials and processes involved. They provide a unified treatment of each of the diverse disciplines—mechanical and electrical engineering, graphic arts, chemistry, metallurgy, ceramics—which affect the materials engineering, design, manufacture, and evaluation of such circuitry.

The text is divided into four sections dealing with the properties of the insulating substrates, the processes leading to a completed printed-circuit assembly, the decision-making aspects of the subject, and, finally, integrated circuitry and a discussion of past and current approaches to miniaturization and microminiaturization.

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"ELECTRONIC INSTRUMENTATION" by Sol D. Prensky. Published by *Prentice-Hall, Inc.* 528 pages. Price $13.35.

Since the field of electronic instrumentation has all but outstripped available literature on the subject, this book will be welcomed by a widely diversified group of scientists, engineers, technicians, and service personnel.

The text material is divided into three sections dealing with the basic principles underlying electronic measuring and test instruments; testing and procedures for applying appropriate instruments in the major fields of electronics.

power, high-frequency communications, and industrial monitoring for control or automation; and instrument function with emphasis on significant performance factors including capabilities within equipment tolerances and precise calibration procedures.

Instrument applications, with special attention to modern examples, is a separate and valuable chapter which concludes this volume. A number of appendices covering Thevenin's circuit theorem, a bibliography, a directory of manufacturers, and a glossary of instrumentation terms are also included.

* * *

"SERVICING MADE EASY" by Wayne Lemons. Published by *Howard W. Sams & Co., Inc.* Two volumes (Auto Radios—$2.95), (TV—$2.95).

Both these volumes are characterized by the author's lucid and down-to-earth presentation of service material. No time is wasted on extraneous material and the troubleshooting procedures are direct and to the point. Service faults are clearly described in terms of symptoms and ways for getting at the root of the trouble with the least time and effort.

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"DIODE CIRCUITS HANDBOOK" by Rufus P. Turner. Published by *Howard W. Sams & Co., Inc.* 125 pages. Price $2.50.

In this volume the author has assembled a wide variety of electronic circuits—some old and some new—designed or redesigned around modern diodes. There are eight chapters covering circuits for receivers, transmitters, audio, power-supplies, control, instruments, computers, and for a number of experimental projects.

By working through the text carefully, the reader will have a practical knowledge of diode functions and applications since the circuits included represent a generous sampling of the uses for conventional diodes, either alone or in conjunction with transistors, varactors, and tunnel diodes. ▲

LOW-COST SOLID-STATE POWER SUPPLY

By GARY A. LEHMANN / Sylvania Electronic Systems

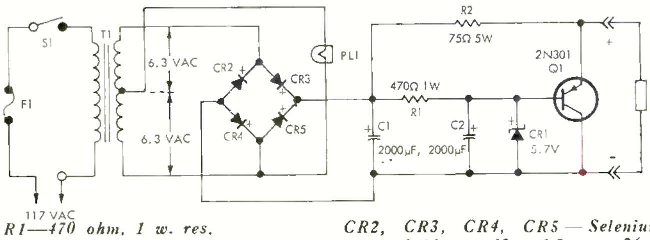
Design and construction of well-regulated, low-ripple, short-circuit-proof supply delivering 6 volts at 200 ma.

THE inherently low power requirements of transistors have revitalized interest in battery power supplies. But even with the availability of the new alkaline energizers and the resurrection of the Edison cell for electronic use, some of the undesirable facets of battery operation remain. Inexpensive primary batteries, such as the zinc-carbon type, show a gradual voltage drop during their service life. Secondary batteries, such as lead-acid and alkaline cells, bring the inconvenience of recharging and of dealing with corrosive solutions. These are just some of the reasons for adopting a reliable a.c.-line-operated power supply.

The power supply to be described was originally designed to energize a secondary frequency and time standard. Output voltage varies 0.6% for line-voltage variations between 105 and 125 volts with constant load; load variations from 0 to 200 ma. are regulated to within 0.2%. The a.c. ripple is down to 2.7 mv. r.m.s. or 0.004% at a load of 100 ma. This performance, together with lack of sensitivity to short circuits in the load, makes the supply attractive for bench use where it can replace lantern batteries or other electro-chemical energizers for all but the most exacting pure d.c. work. The newcomer in electronics who has not yet accumulated a supply of used parts can finance this project for about $15.00. For the technician or hobbyist with a well-stocked junk box, this cost could easily be reduced by at least one half.

Circuit Selection

Since the supply is meant to replace a battery with a constant non-adjustable voltage, and since simplicity and low cost were prime objectives, a shunt-regulator circuit seemed



R1—470 ohm, 1 w. res.	*CR2, CR3, CR4, CR5—Selenium bridge rectifier, 1.5 amp., 36 v. a.c. max. (International Rectifier J14C1 or equiv.)*
R2—75 ohm, 5 w. wirewound res.	*T1—Fil. trans. 117 v. pri.; 12.6 v. @ 2 amp sec. (Stancor P8130 or equiv.)*
C1—2000 µf., 25 v. elec. capacitor	*Q1—Power transistor (2N301 or 2N307)*
C2—2000 µf., 6 v. elec. capacitor	
F1—¼ amp. fuse with mounting	
S1—S.p.s.t. toggle switch	
PL1—6.3 v. pilot light (No. 47)	
CR1—250 mw. zener diode, 5.7 v. nominal (1N706)	

Fig. 1. Circuit diagram of author's shunt-regulated supply.

advantageous. Although series regulators with adjustable output voltages may be more attractive for certain applications, their design is more complex and their cost is higher. Unless current-limiting features are included, the series-regulating transistor is usually destroyed before the fuse can blow in case of an accidental short-circuit. A shunt regulator is inherently short-circuit-proof and its shortcomings are outweighed by its simplicity, ruggedness, and low cost.

Because zener voltage regulators of the required capacity are, as yet, somewhat expensive, the circuit as shown in Fig. 1 was selected. *Q1* acts as an emitter-follower whose input voltage is the breakdown voltage of *CR1* which may be a low-current inexpensive type. R_L represents the load resistance for this emitter-follower. *Q1* may be any one of the popular car-radio power-amplifier types, such as a *Sylvania* 2N301 or 2N307, with a collector dissipation of 8 to 10 watts. Zener diodes between 150 and 250 mw. are suitable for *CR1*.

For a good approximation, it can be assumed that the source impedance of this power regulator will be less than that of the breakdown diode alone but cannot be less than the saturation resistance of *Q1*. Typical zener diodes of the 250-mw. type have a dynamic impedance of 2 to 5 ohms. Since the saturation resistance of a typical power transistor such as the 2N301 is less than 1 ohm, this promises better regulation for varying load current than that offered by the diode alone. However, because *CR1* is still performing the regulating action for variations of the d.c. voltage from the bridge rectifier d.c., *Q1* will not offer any improvement in that respect over a simple shunt-regulated power supply using a breakdown diode of higher current capacity.

As can be seen from Fig. 1, a short in the load will only reduce the collector current of *Q1* to a minimum while open terminals result in maximum collector current. The latter can be limited to a safe level by selecting proper circuit values.

Because of the current amplifying action of *Q1*, the collector current of *Q1* is determined to a greater degree by base bias than by the emitter-to-collector voltage. If this base bias were pure d.c., the collector current would be almost pure d.c. even though the emitter-to-collector voltage may contain considerable ripple. Thus, with a d.c. bias at its base, *Q1* has a filtering effect comparable to that of a capacitor. It can be seen from Fig. 1 that *Q1* is biased by the breakdown voltage of *CR1*. Furthermore, *R1* and *CR1* form a voltage divider as far as any ripple is concerned. The ratio of dynamic impedance of *CR1* to *R1* is indicative of the ratio by which the ripple content is divided, hence is indicative of the filtering action.

Since the design objective is direct current with a minimum of ripple, it appears worthwhile to take advantage of the "capacitor booster" effect of *Q1* and add a capacitor across *CR1*. Using a somewhat oversimplified approach, a 2000-µf. capacitor in the base of *Q1* would have the effect of $2000 \times h_{fe} = 2000 \times 70 = 140{,}000$ µf. in the collector circuit of *Q1*. This is a formidable figure. Unfortunately, the internal base and emitter resistances of *Q1* are in series with this "virtual" capacitor thereby reducing its filtering action.

To investigate long-term stability for the supply voltage, a number of factors must be considered. The operating voltage of a zener regulator diode varies with the operating temperature. This temperature depends, among other things, mainly on the power dissipation which is the product of zener voltage and zener current, and on the ambient temperature. Fortunately for diodes in the 5- to 6-volt range, the temperature coefficient is quite low—on the order of -0.0 to $+0.02$ percent per degree C. Another important item is the base-to-emitter voltage of *Q1* (V_{be}) which also varies with temperature. The zener diode coefficient of temperature is low, and the device has low thermal capacity; operating temperature is reached soon after turn-on.

Q1 is derated considerably; therefore, the temperature of its junction does not rise appreciably and a small heat sink does not take long to assume a temperature balance. The base-to-emitter voltage has a negative coefficient of approximately -2.5 mv./°C for germanium and also varies with the collector current. Typical V_{be} is 0.3 volt which is only 5% of the total emitter-to-collector voltage. With only a moderate increase in junction temperature it can be expected that the voltage drift due to variations of V_{in} will be considerably less. (Actual figures taken after construction were approximately 0.05% change during the first 15 minutes. After this period, output voltage remains essentially stable.

Since both series as well as shunt-regulator circuits operate by varying the voltage drop across an internal resistor, to keep the voltage drop across a varying load resistance constant the input voltage to the regulator circuit must always be in excess of the output voltage. As a good rule-of-thumb, the input voltage should be 50 to 100% higher than the output voltage. For a supply voltage of 6 volts, a 12.6-volt, 2-ampere filament transformer (a standard item) is selected. As long as sufficient surplus voltage is available and selenium bridge rectifiers are more reasonably priced than their silicon counterparts, a selenium stack, full-wave bridge type, rated at 36 volts a.c. and 1.5 amp (max.) is chosen. This keeps operating temperature and aging problems to an absolute minimum.

Construction

The circuit was wired and evaluated under varying load and a.c. line conditions. The predicted performance was realized. The power supply was mounted on the chassis that was selected to carry the various modules of the secondary frequency and time standard, mentioned earlier. A phenolic circuit board carries *R*1, *R*2, *CR*1, the bridge rectifiers, and *Q*1 with its heat sink. To conserve space, the transformer, fuse, and filter capacitors were mounted below the chassis.

The actual output voltage of the power supply turned out to be 6.3 volts. Standard zener diodes are sold with a 10% voltage tolerance. Units with closer tolerances carry a much higher price tag. For the specific application of this power supply, the 0.3-volt increase in output voltage was of no consequence. ▲

WHAT IS Q ?

By JOSEPH TUSINSKI
Senior Technical Instructor
Technical Institute, Norfolk College of William and Mary

A review of an important circuit concept for the technician who wants to brush up on his theory.

THE CONCEPT of "Q" is probably one of the most misunderstood in electronics and yet it might be considered just as important as Ohm's Law. The average technician will state that it is a "figure of merit" or possibly the ratio of inductive reactance to the resistance of a circuit. The first definition is, of course, true in all situations; however, the second definition will hold only for a specific case.

The restrictive definition of "Q" is brought about by the early training a technician receives in the study of tuned circuits. In this study the resistance of a circuit is distributed in the inductive branch of the circuit, as shown in the equivalent circuit of Fig. 1B. This is

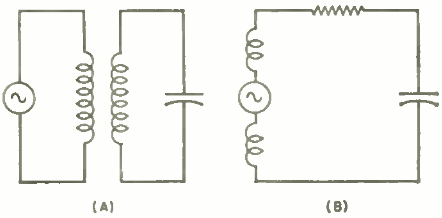


Fig. 1. Tuned circuit and its equivalent.

normally the condition that would exist in a conventional tuned circuit, and other possibilities that could exist are disregarded either temporarily or permanently.

The resistance is depicted as a lumped unit in series with the remainder of the secondary series-resonant circuit. The secondary is considered a series-resonant circuit by virtue of the induced voltage, which is considered to be in series with the inductance.

Energy & Power

If we may think of "Q" in terms of the *energy-storing ability* of a circuit instead of X_L/R, then a feeling for what "Q" actually means will result. It may be stated that "Q" is a ratio of the energy stored in the circuit to the energy that is being lost in the circuit. The power that is lost is usually in the form of heat.

The reader may have noticed the use of the words "power" and "energy" in the preceding statements. It should be remembered that energy is the ability to do work; whereas power is the time rate of doing work. The reactive elements have the ability to do work if some load (resistive) is applied to them. The resistance of the circuit dissipates this energy in the form of heat, *i.e.*, the energy lost is the power it takes to produce the heat. When dealing with very low voltages this heat, of course, is of a magnitude that may not be felt with the fingers.

Referring to Fig. 1B, it is obvious that the only factor common to all of the elements in the circuit is the current, where the voltage is in series with the circuit. Then applying our definition to the circuit we may say that the "Q" of the series circuit is the ratio of the reactive power to the real power or

"Q" = *reactive power/real power.*

The reactive power may be expressed as I^2X_L and the real power may be expressed as I^2R for the inductive branch. The "Q" of the capacitance branch may also be stated as I^2X_C/I^2R, but in this case the resistance of the capacitive circuit at the lower radio frequencies may be considered zero. Therefore:

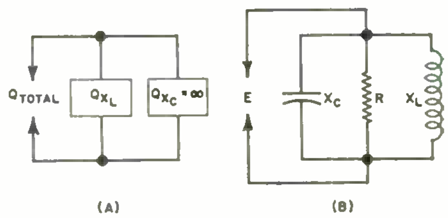
"Q" $= (I^2X_L)/(I^2R) = X_L/R$

and: $(I^2X_C)/(I^2R) = X_C/R = \infty$.

It can be seen that the expression is the very familiar X_L/R, but what about the capacitive element? Actually this situation may be likened to two resistors in parallel. This is shown in Fig. 2.

The "Q" of the capacitive branch is considered to be infinite at the lower frequencies where the resistance of the circuit is low. The "Q" of the inductive branch is considered to be finite and therefore is the controlling factor in respect to the energy-storing ability of the circuit.

Fig. 2. Parallel-circuit equivalents.



Let us now examine the case of a parallel circuit in which the voltage is applied across both L and C. Let us assume that the resistance of the circuit appears in parallel with the circuit as shown in Fig. 2B.

In this case, the resistance of the inductor, which is still present, will be considered to absorb negligible power compared to that absorbed by the parallel resistance. This time the voltage is common to all elements of the circuit and we will use E^2/R and E^2/X to determine the power and "Q" of the circuit.

In this case, either X_L or X_C may be used to determine the reactive power (energy) for in a resonant circuit the total energy is either stored in the magnetic field of the inductor or one-half cycle later it will be all stored in the electric field of the capacitor. Then:

"Q" = *reactive power/real power*

$= (E^2/X_L) \; / \; (E^2/R)$.

Inverting and then multiplying,

"Q" $= (E^2/X_L) \times (R/E^2) = R/X_L$.

From this result it may be seen that the definition stated earlier for the case of a series resistor is just the inverse of the definition developed for the case of a parallel resistor. Note further, that for maximum "Q", the resistor value should be as low as possible in the series case and as high as possible in the parallel case.

The "Q" of a circuit may be determined by measuring its effectiveness in a circuit. A high-"Q" circuit will respond very sharply at its resonant frequency and the voltage or current will be "Q" times the applied voltage or current. Typical values of "Q" may average about 100 at the lower frequencies, and may

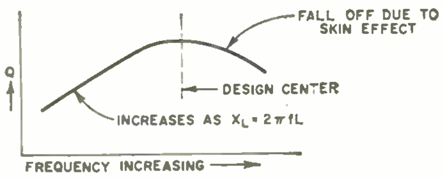


Fig. 3. Variation of "Q" with frequency.

reach 300 or more in some transmitter tank circuits. One reason for the higher "Q's" in transmitter tank circuits is the use of large conductors which have a lower a.c. resistance.

The "Q" of a typical resonant circuit may vary over a band of frequencies as shown in Fig. 3.

As mentioned, the "Q" may be determined by a measurement of the circuit response, that is, how sharply the circuit responds at its resonant frequency. The "Q" may be determined by measuring the half-power (-3 db) response of a circuit, *i.e.*, where the current or voltage of the circuit drops to .707 of the current

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Name ______________________________
(please print)

Address ______________________________

City ____________________ Zone ______ State ______ or voltage at resonance. Between the half-power points a certain range of frequencies has been covered and, by definition, this is termed the "bandwidth" of the circuit. This is shown in Fig. 4.

From the response of the circuit, the "Q" may be expressed as: "Q" = *resonant frequency/bandwidth* or

"Q" = f_r / ($f_2 - f_1$).

For example, if a circuit would be assumed to be tuned to 1000 kc. and the

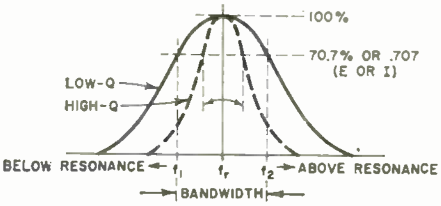

Fig. 4. Higher "Q's" mean narrow bandwidths.

half-power points were measured at 1005 kc. and 995 kc., the "Q" of the circuit would be: 1000 / (1005 − 995) = 1000 / 10 = 100.

A great number of commercial "Q" meters base their operation on this simple fact, while others work on a pre-calibrated method of measuring the degree of response of a circuit or component on the resonant rise of voltage appearing across the circuit or component. ▲

TESTING USED TUBES

By THOMAS R. HASKETT

EVERY service shop gradually acquires a stock of used but undiscarded tubes.

There are legitimate occasions for using them, if their condition can be verified. For example, suppose a reconditioned TV set is being sold for $40. It is economically unsound to insert many new tubes as needed replacements, whereas good used ones conform to an honest description of the merchandise. The problem is passing judgment on doubtful stock rather than using it.

Even a good tube tester is not always conclusive. The method recommended here provides added evidence along with speed and efficiency, especially with an accumulation. First, used tubes are sorted according to type. Then they are tried in a receiver.

Consider a batch of old 5U4's, for example. Start by hanging a voltmeter across the set's filtered "B+" output; then take a reading with a new 5U4 (or more than one) to determine normal voltage. Next run the doubtful 5U4's through the rectifier socket, one after another. Check voltage and such points as changes in raster size, focus, and brightness. This is a practical and dynamic test.

The method works with other tubes and functions. The criteria—such as signal strength, noise, sync stability, and audio output—depend on normal applications of the type. The test is efficient because a number of similar tubes can be checked and compared in quick succession. It is reliable because actual working conditions are used instead of arbitrary ones. Finally, a tube that fails need not continue to take up space and gather dust, because it can be discarded without guilt or doubt. ▲

"-TRON" TEASERS -AN ELECTRONIC QUIZ

By ROBERT K. RE

How many electronic devices do you know that end with the suffix "-tron"? Check your knowledge of the field with this quiz.

QUITE a few devices used in electronics today were named using the suffix "-tron" (electron, cyclotron, etc.). Out of the many words with this ending, can you match each "-tron" listed below with its proper definition or description? Then check your answers on page 110.

A. Thyratron	G. Charactron	M. Strobotron
B. Klystron	H. Phantastron	N. Trochotron
C. Cryotron	I. Ignitron	O. Monotron
D. Tonotron	J. Magnetron	P. Parametron
E. Megatron	K. Chromatron	Q. Compactron
F. Dekatron	L. Dynatron	

1. This special tube is used to generate TV test signals when stations are off the air. ( )

2. A gas-filled device, this counting tube is widely used in digital circuits. ( )

3. High currents are rectified in the electroplating industry with this mercury-cathode diode. ( )

4. Much older than a tunnel diode, this four-electrode tube exhibits negative resistance in oscillator circuits. ( )

5. Widely used in r.f. circuits, this u.h.f. transit-time triode is called a "lighthouse" tube because of its shape. ( )

6. Once fired, the grid in this gas-filled tube ceases to have control over plate current until plate voltage is removed. ( )

7. This is the general name for beam-switching tubes. It describes the path of the electron in the tube. ( )

8. Operating near absolute zero temperature, this super-conducting switching element shows great promise for new computers. ( )

9. This linear sweep generator, once triggered, will keep itself turned on until the sweep is completed. ( )

10. Crossed magnetic and electric fields are the key to the operation of this high-power, high-frequency oscillator. ( )

11. A new device, this special CRT is a direct-viewing storage tube. Information can be stored for long periods, yet quickly erased. ( )

12. This new class of computer circuits uses multiple phase "clock" signals to perform majority logic operations. ( )

13. Having one or more tunable cavities, this high-frequency tube "bunches" the electrons to produce oscillations. ( )

14. This neon lamp is capable of generating short bursts of high-intensity light. ( )

15. A special color CRT, this tube has only one gun and uses phosphor strips in place of phosphor dots. ( )

16. Using a special mask and beam-shaping plate, this CRT can generate symbols on its face. ( )

17. This new 12-pin subminiature, multi-function vacuum tube is finding wide use in electronic equipment. ( ) ▲

Checking Separation

(*Continued from page 37*)

Each input goes to the primary of a stepdown input transformer. These transformers have two equal secondary windings. Sum and difference voltages are formed by putting one secondary winding from each transformer in series with each other, one connection series-aiding and the other series-opposing. The two diodes and non-polarized electrolytic capacitor rectify the sum and difference voltages and produce the average peak voltage. If the sum voltage is consistently larger than the difference voltage the voltage across the capacitor will be positive. If the two voltages are the same, the capacitor voltage will be zero, and if the difference signal is greater than the sum signal, the voltage at the capacitor will be negative. A zero-center microammeter is connected across the capacitor and indicates the polarity and amplitude of the capacitor voltage.

Two series potentiometers at the input are useful for reducing the sensitivity of the circuit. The input transformers are of the stepdown type and serve to match the low impedance of the capacitor-meter load to higher impedance sources such as 600-ohm broadcast studio lines or cathode-follower outputs. The input impedance of the circuit is about 10,000 ohms at 1000 cps and .2 volt at both inputs will deflect the meter full scale.

The diodes used should be of the high forward conductance type to minimize loss of sensitivity with the low-impedance meter used here. If maximum sensitivity is not required, just about any of the germanium diodes will be satisfactory in this application.

Applications & Operation

This type of separation meter, variously called a "phase meter," a "phase coordinator," or a "phase comparator." provides a simple and effective way of comparing the phase of any two audio signals or components. It may be used to measure the phase of any two audio signals or components. It may be used to measure the phase and stereo effectiveness of stereo discs, tapes, broadcasts, and microphone setups.

To operate the meter, connect each signal channel to the input terminals, being careful to use the same terminal of both inputs for the same side of the input line. The meter is connected to the terminals of any loudspeaker or power amplifier. The 4-, 8-, or 16-ohm terminals may be used. Increasing the impedance of the tap used will increase the sensitivity of the meter. The tap should be selected to avoid excessive pinning of the meter pointer. The meter may also be connected across any 600-ohm line and is used in the same manner as a standard vu meter. Transformer input circuitry maintains the line's isolation from ground. The meter inputs may also be connected to the output jacks of almost any audio-frequency device, including preamplifiers, tape recorders, tuners, and multiplex adapters. However, it is recommended that the meter be disconnected or switched off between readings to avoid the possibility of continuously overloading these units.

With the inputs properly connected, the meter pointer will move from the center position into the in-phase or out-of-phase region of the meter scale, depending on the character of the input signals. If the pointer remains in the center area, it means that the input signals are completely uncorrelated, their phase has no significance, and the separation ratio is 1. Excessive deflection of the meter pointer in the positive direction indicates a highly correlated or monophonic record with a separation ratio close to zero. The amplitude of positive meter deflection is therefore a measure of the stereo effect and indicates a range from excessive separation to excessive blending. Any consistent deflection of the meter to the left or negative half of the scale indicates a presumably undesirable out-of-phase condition.

Every system of stereo components should be checked for proper phasing before being permanently installed. If all program sources, including monophonic ones, result in an out-of-phase deflection of the meter at the loudspeaker terminals, then power amplifiers, speaker leads, or preamplifiers are out of phase. Unless a phase switch is provided in the stereo control center this condition can be corrected only by reversing the leads to one speaker (but not to the meter). If monophonic records produce an out-of-phase indication but other program sources do not, phasing of the stereo pickup cartridge should be checked and the leads to one set of cartridge terminals reversed. Similarly, the leads from a tape playback or record head can be reversed to correct an out-of-phase condition originating there. Out-of-phase broadcasts, records, or tapes can be corrected only by installing a phase reversal switch in the system or by manually reversing the leads to one speaker for the duration of the out-of-phase program. It is also possible to phase loudspeakers by using two phased microphones and the meter.

One of the most useful applications of the separation meter is in the adjustment of the separation or dimension controls found in many multiplex tuners and adapters. Sometimes the adjustment is found on the front panel and sometimes at the rear, but in either case these controls are extremely difficult to adjust by ear using broadcast program material. With the meter, however, the adjustment can be accomplished in seconds, without special generators, using the stereo program material as broadcast. Simply rotate the control until the point where the needle tends to remain at its center position is found. This corresponds to a separation ratio of 1 and is excessive. Then turn the control the least amount that will cause the needle to flick consistently to the right. This corresponds to a separation ratio of .8 or .9 and should therefore provide the optimum listening enjoyment. This adjustment can be repeated for several stations and several different types of program material to find the best compromise adjustment, or if the meter is connected all the time, the control may be reset for each selection played. ▲

Modern Batteries

(*Continued from page* 36)

gas. This is done by designing the cell with an excess ampere-hour capacity in the cadmium electrode and arranging the geometry of the cell so that oxygen can reach the cadmium electrode. When the battery is charged, the nickel electrode reaches full charge first and starts to generate oxygen. The oxygen thus formed reacts with the cadmium to form cadmium oxide.

During overcharge, the cadmium electrode is oxidized at a rate just sufficient to offset input energy, thus keeping the cell in equilibrium. The cadmium electrode never becomes overcharged, so no hydrogen gas is formed.

Silver-Cadmium Cells

Still in the developmental stage, silver-cadmium batteries promise to provide about double the efficiency of nickel-cadmium types. In working units thus far devised, 24 wh/lb. has been achieved, compared to about 12 wh/lb. for nickel-cadmium cells. Their theoretical efficiency, not yet approached in practice, is about 150 wh/lb.

Finding a suitable separator for the silver-cadmium cells has been a difficult problem. Various materials were tried, ranging from cellophane to sausage casing. However, although these prevent silver migration, they become loaded with silver and become oxidized. Multilayer membrane systems have been used, but these tend to increase resistance.

In view of the progress already made, it appears certain that silver-cadmium cells will find active use in the future. Their voltage during the first 40 percent of their discharge cycle remains constant at about 1.3 volts, but drops sharply to about 1.1 volts during the rest of the cycle. By cycling over only the first part of its capacity, good regulation can be maintained. Shelf life is also excellent, and the batteries can be made non-magnetic, an important feature for some applications. ▲

Power Output Measurements

(*Continued from page 56*)

price from $40 to $200 or more.

If you are a radio amateur or CB enthusiast, you will find the less expensive reflectometers and multi-function bridges quite adequate for your purposes. If you are a professional communications service engineer, you will probably require the higher accuracy of the more expensive instruments.

Use will also determine which type of meter you want. If you are reading strictly transmitter power capability on the bench and into a dummy load, the straightforward wattmeters are all you will need.

For base-station communications equipment employing a single frequency, feeding a high-quality resonant antenna with very low standing-wave ratio, the simple wattmeter will be sufficient. But, for multi-channel equipment, or wherever antenna matching problems may be encountered, reflectometer or in-line types of meters are much to be preferred because of their ability to read both forward and reflected waves.

Instruments of the in-line type, which are to be left in the line, should be considered as part of the transmission line when tuning a line to an antenna, especially at high v.h.f. and u.h.f. frequencies. If they are removed from the line, an equal length of coaxial cable should be fitted with the same type of connectors and installed in its place.

Where antennas require tuning, the best procedure is *not* to whack away at the feedline, inch by inch. Instead, do this: First, tune the transmitter to a wattmeter equipped with a dummy load equal in impedance to the system you are using. Next, if the antenna requires tuning, cut the antenna to the desired length for the principal frequency being used. Do not attempt to alter the design of the antenna. Install it according to the manufacturer's recommendations. If this is done, you can be fairly certain the v.s.w.r. of the antenna will be less than 2 to 1. If you measure the v.s.w.r. and find it less than 2 to 1, leave it alone. You won't improve communications noticeably by any matching techniques. But, if you are finicky about v.s.w.r. and have nothing better to do, whack away. Who knows, you may achieve what the author once heard on CB, "My v.s.w.r. is less than 1 to 1!" ▲

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3. Simpson Electric Company, 5200 W. Kinzie St., Chicago, Illinois
4. Electro Impulse Laboratory, Inc., 208 River St., Red Bank, N.J.
5. Continental Electronics & Sound Co., Inc., 6151 Dayton-Liberty Road, Dayton 18, Ohio
6. Bird Electronic Corporation, 30303 Aurora Road, Cleveland 39, Ohio
7. General Radiotelephone Co., 3501 W. Burbank Blvd., West Burbank, Calif.

Variable Electronic Gain Control

By JOHN POTTER SHIELDS

THERE are times when it is desirable to vary the gain of an audio amplifier by a d.c. control voltage as in the case of audio limiters, volume expanders, etc. The usual approach to this problem involves the use of dual-control multi-grid tubes. While these tubes do permit some degree of control, they introduce considerable distortion when operating at or near cut-off.

The circuit (Fig. 1) is capable of providing good control action and introduces very little distortion in the signal being controlled. This results from control of the audio signal by variable degeneration feedback which possesses inherent distortion-reducing qualities.

In operation, the audio signal to be controlled is applied to the grid of $V1$ *via* isolating capacitor $C1$. $R1$ is the grid-

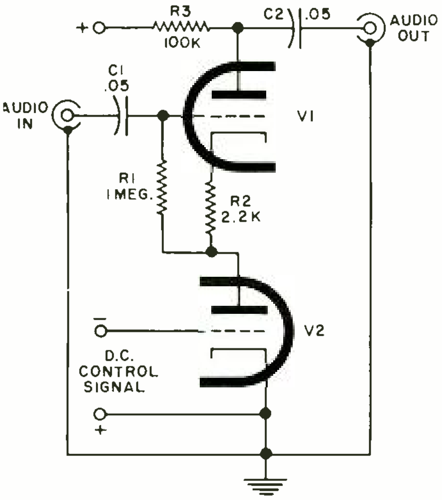


Fig. 1. Lower triode acts as a variable resistor to control audio-stage output.

return resistor for $V1$, its lower end being returned to the bottom of $R2$ which provides cathode bias for $V1$.

Instead of going to ground, the lower ends of $R1$ and $R2$ connect to the plate of $V2$, the variable degeneration d.c. control tube. $V2$ operates as a variable resistance with its value depending on its grid voltage. As $V2$ grid voltage is made increasingly negative, its effective internal resistance increases. Since $V2$ is in series with $V1$ cathode circuit, its resistance will determine the amount of degeneration and hence the gain of $V1$.

The signal appearing at the plate of $V1$ is coupled to the following stage *via* $C2$, while $R3$ serves as the $V1$ plate load resistor.

Any medium-mu triode, such as the 6SN7 or 12AU7 will work in this circuit. Plate supply voltage ranging from 90 to 250 volts will be satisfactory. ▲

NEW PRODUCTS & LITERATURE

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

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

OVERLOAD-PROTECTED V.O.M.

1 **The Triplett Electrical Instrument Co.** is now offering a new v.o.m., Model 630-PLK, with a transistorized electronic switching circuit that guards against accidental burn-outs.

The high-sensitivity unit features ±3% accuracy on d.c. and ±4% on a.c. A single selector switch provides greater ease in changing ranges. The instrument is protected from stray magnetic fields by the firm's exclusive self-shielding bar-ring movement.

The Model 630-PLK is usable with frequencies through 500 kc. A special diode network across the meter protects against instantaneous transient voltages. The transistorized switching circuit battery is checked for proper operation automatically by using the X100K ohms range. The unit measures 3-11/32" x 5½" x 7½" and comes with leather carrying handle and leads.

PORTABLE DIRECT-WRITING RECORDERS

2 **American Optical Company** is marketing a line of portable single-, two-, and three-channel direct-writing recorders for on-the-spot recording in the plant, field, or laboratory.

The Series 290 offers a unique high-torque, low-inertia pen motor along with the electronics to provide outstanding frequency response-amplitude characteristic. Frequency response is essentially flat from d.c. to 90 cps at full 30 division amplitude, down only 3 db at 125 cps.

These recorders are completely self-contained. All units offer push-button selection of four chart speeds—1, 5, 20, and 100 mm./sec. Plug-in amplifiers have a sensitivity range from 5 mv. to 5 v. per chart division. Direct-carbon-transfer writing method offers fine definition and uniformity of trace over the wide frequency range and throughout all chart speeds.

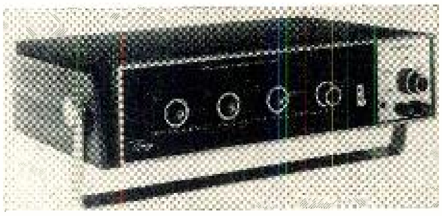
1-MC. FREQUENCY STANDARD

3 **Reeves-Hoffman Division** has developed a line of packaged frequency sources that includes completely integrated, precision crystal oscillator circuitry and proportionally controlled ovens.

One such unit is the Model S2284-1, a 1-mc. frequency standard which measures only 2" x 2" x 4.75". Stability is 1 x 10^{-10} r.m.s. per second measured over a period of one minute (with proportional control oven). Aging is 1 x 10^{-9} per day, and frequency deviation over the operating ambient temperature range of 0 to 65 degrees C is given as 2 x 10^{-8}, with reference frequency at 25 degrees C. Frequency deviation with a change of 5% in the supply voltage is 5 x 10^{-9} and the frequency trim range is sufficient for five years.

LABORATORY OSCILLATOR

4 **Optimation, Inc.** has released the Model RCD-4, an ultra-pure sine-wave oscillator featuring extremely low distortion and flat frequency response over the range of 0.1 cps to 99.9 kc. Patented circuitry produces an open-circuit output of 5 volts r.m.s. with maximum distortion of .01% from 90 cps to 20 kc., and .03% at 20 cps and 99.9 kc.



Output frequency (in calibrate position) is accurate within ±1% from 1 to 50,000 cps and within ±1.5% from 50 kc. to 99.9 kc. It is independent of line or load variations and changes less than ±.025% per degree C. Direct in-line dialing and readout provide exact resettability and fast frequency selection. Illuminated numbers and a traveling decimal point eliminate frequency reading errors.

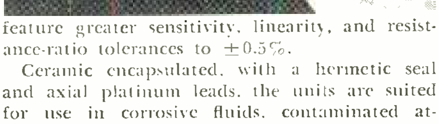
AEROSOL CONDUCTIVE PAINT

5 **Epoxy Products Incorporated** is offering silver-filled conductive paint in aerosol cans. This means of application eliminates the annoyance, waste, and inconvenience of brush-on conductive paints. Because of the added expense of the aerosol can, it is not practical for production-line application but is designed primarily for prototype, laboratory, and field use.

The coating is flexible and can be used as shielding on Mylar ribbon circuits as well as on circuit modules or components as electromagnetic shields.

ROD-TYPE THERMISTORS

6 **Thermonetics Inc.** has introduced a new series of rod-type thermistors designed for measurement and control applications in high-temperature environments up to 500° C. They feature greater sensitivity, linearity, and resistance-ratio tolerances to ±0.5%.



Ceramic encapsulated, with a hermetic seal and axial platinum leads, the units are suited for use in corrosive fluids, contaminated atmospheres, or wherever high temperatures and corrosion are encountered and close ratio tolerances desired.

VIDEO VOLTMETER

7 **Ballantine Laboratories** announces a new Model 311 video voltmeter, a linear-scale instrument designed for accurate measurements of 100 μv. to 300 volts or up to 10,000 volts with optional accessories, over a range of frequencies from 10 cps to 6 mc. Signals as low as 30 μv. can be measured in the "null detector" mode.

The indicating meter has two linear voltage scales and one decibel scale. Signal input may be made to a coaxial connector or to binding post. Conservative design results in expected life between calibrations in excess of 3000 hours. The instrument may be used as a 60-db gain amplifier over the band of 10 cps to 6 mc. Portable or rack models are available.

LOG-PERIOD ANTENNA

8 **Jerrold Electronics Corporation's** Distributor Sales Division is now marketing the new JTP Series "Paralog" v.h.f. antennas for TV and FM applications. The new antennas combine log-periodic principles and modular parasitic element systems, producing an unamplified TV antenna gain of up to 16 db while retaining the log-periodic characteristics of bandwidth and impedance.

Eleven antenna models are currently available: 7 non-amplified and 4 electronically amplified.

PRINTING TAPE PUNCH

9 **Navigation Computer Corporation** is now offering the Model 1010AN alphanumeric printed tape punch which features a full 1000-foot tape transport system, easily read bottom margin printing, 8-hole punching at 10 characters per second, and a full 49-key alphanumeric keyboard which has the complete EIA Standard nomenclature and coding.

The unit is 75% electronics, with a printed-circuit keyboard and coding matrix. All sequence timing is generated by semiconductor circuitry, hence the unit readily operates into and out of standard transistor logic levels.

FOUR-LAYER LIGHT SWITCHES

10 **International Rectifier Corporation** is offering a new series of two-terminal subminiature light-activated silicon switches, extending the light-sensitivity-to-fire range to 3000 foot-candles. Designated types FL3S1 through FL3S25, the silicon switch series offers maximum blocking voltages (forward and reverse) from 12 to 250 volts at 75 degrees C and maximum transient peak reverse voltages from 20 to 350 volts at 75 degrees C.

TV CAMERA TUBE

11 **Amperex Electronic Corporation** has entered the TV camera tube field with the Type 8483, a one-inch vidicon capable of 900-line resolution. Incorporating a new, low-power heater (only

0.6 watt at 90 ma.), the 8483 is especially suited for use in transistorized cameras where heat dissipation and power requirements must be kept to a minimum.

The tube can be used in black-and-white or color TV cameras in closed-circuit industrial, medical, and broadcast applications. It will produce usable pictures with face-plate illumination levels of 0.1 footcandle.

SOLDER GLASS KIT

12 **Corning Glass Works** is marketing a solder glass kit containing powdered glass and a liquid suspension vehicle, especially for college physics laboratories and other high-vacuum research facilities.

The kit provides a simple means for experimenters to build their own vacuum-tube structures out of soft glasses with expansions in the range of 80 to 100 x 10^{-7}/°C, using the solder glass to seal caps and headers to the tube body. The kit is offered in one- and five-pound sizes.

ULTRA-MINIATURE CAPACITORS

13 **Sprague Products Company** is offering a smaller, low-cost electrolytic capacitor, the Type TL "Transi-Lytic" especially for replacement applications in low-voltage circuits.

This miniature plastic-encased capacitor utilizes a special low-leakage current construction to meet the special requirements of transistor circuitry. They are available in a wide range of capacitance values in voltage ratings from 3 to 25 w.v.d.c.

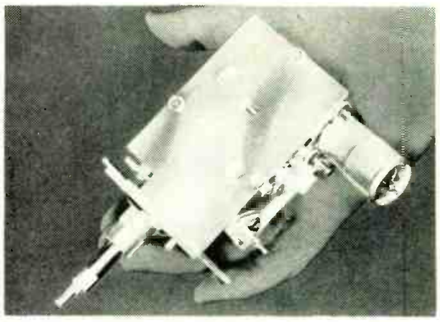
CABLE ANALYZER

14 **Micro Balancing, Inc.** has announced availability of the "Mark-75" portable transistorized cable analyzer which is capable of testing 75 circuits for continuity, shorts, and leakage resistance in two seconds.

The unit checks for circuit resistance in four ranges from 1 to 30 ohms and analyzes cables for leakage at 500 volts d.c. from each conductor to all others and ground in four ranges from 10 to 300 megohms. A wide range of "go, no-go" limits in leakage resistance and conductivity may be selected. Each circuit can be analyzed individually or in a step mode with any desired dwell time or all circuits may be checked with a single rapid stroke of the lever.

U.H.F. TV TUNERS

15 **Standard Kollsman Industries, Inc.** has engineered a new u.h.f. television tuner, Series U, for the OEM market. Features are extremely low noise (average 9 db), low drift, low microphonics, ease of mounting, compactness, and long



life. They will fit all receivers using the standard 43-mc. i.f. The Model U uses a 6DZ4 oscillator tube and silicon diode mixer. For u.h.f. converter manufacturers, the company is offering a comparable unit as the Model UC.

DESOLDERING IRON

16 **Enterprise Development Corp.** is offering its Model 100-A desoldering/resoldering iron which is designed to reduce the time for electronic circuit repairs. Requiring only one hand to operate, the iron features a unique and simple vacuum pickup of melted solder that leaves terminals and mounting holes clean. With solder extracted, parts can be removed quickly and without damage. Resoldering may then be done with the same iron.

U.H.F. CONVERTER

17 **Sony Corporation of America** is now offering an all-transistorized u.h.f. converter, Model VUC-1W. The new unit has been designed so that all-channel reception is possible on the firm's "Micro-TV" Model 5-303W or the 8-inch TV Model 8-301W.

The converter weighs 13 ounces and is available with carrying case and antenna. Its power is supplied from the TV set. Although the converter has its own attached u.h.f. antenna, jacks are provided for an external antenna in fringe areas.

ELECTRONIC ANSWERING DEVICE

18 **Phonomatic, Inc.** is now marketing the "Phoneminder Secretary," an electronic answering machine that answers an office phone automatically. One of the answering units being offered allows the reception of recorded messages from anywhere in the world. By dialling the office number, while out in the field, and pressing the button on a cigarette-package-size remote control unit, a coded signal repeats the previously recorded messages.

HI-FI — AUDIO PRODUCTS

SLIM SPEAKER KIT

19 **Fisher Radio Corporation** has added a slim-line speaker to its line of "Stratakits" as the KS-2.

This 3-speaker system features a 12" free-piston woofer with a half-roll cotton surround and 6 lb. magnet structure. Free air resonance is 25 cycles. The 5" mid-range has a butyl-coated surround and is sealed off in back to avoid interaction with

CIRCLE NO. 156 ON READER SERVICE PAGE

the woofer and tweeter. The 3" cone-type tweeter is a hemispherical dome bonded directly to a 1" voice coil with a 2 lb. magnet structure. The 3-way LC network crosses over at 1200 and 2800 cps and has continuously variable tweeter level control.

Frequency response is 35 cps to beyond audibility. Power handling capability ranges from 10 watts minimum up to 60 watts.

HEADPHONE ADAPTER

20 **Permoflux Corporation** is currently marketing the "Permadaptor" which matches dynamic headphones to preamplifier outputs of audio equipment, provides safety from overload

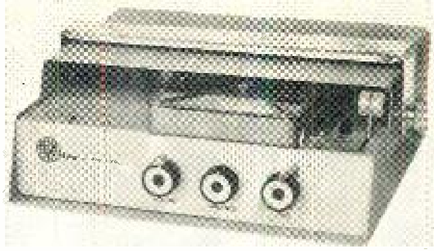
burnout, produces adequate volume, and eliminates power amplifier hum and signal distortion.

The unit is fully transistorized and is universally adaptable to all audio preamplifiers.

CAR/MARINE TAPE PLAYER

21 **Viking of Minneapolis, Inc.** has developed the "Auto-Tape 500," a fully transistorized stereo tape cartridge handler designed for all mobile applications. It requires no attention during operation.

The unit may be installed in any vehicle with



12-volt d.c. battery or generator. It will play all sizes of the firm's endless loop cartridges to provide up to two hours of quarter-track pre-recorded stereo programs at 3.75 ips. The solid-state amplifier incorporated in the player provides 2 watts per channel. Frequency response is 60-10,000 cps ±3 db. Speaker output impedance is 3-4 ohms. Speakers are not included.

AUTOMATIC TURNTABLE

22 **United Audio** has introduced an automatic turntable, the "Dual 1009" auto/professional, which features a dynamically balanced tonearm that can track and trip below ½ gram and thus use the highest compliance cartridges made today. The tonearm has virtually frictionless pivots and ball bearings and can be precision balanced by means of a rotating counterweight. Stylus force is applied directly at the pivot by a coiled mainspring.

The unit provides variable speed control over a 6% range for all four speeds and incorporates a built-in switch for turning the amplifier off after play.

BATTERY-POWERED SOUND SYSTEM

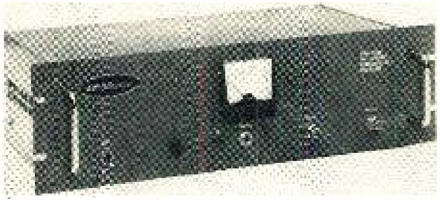
23 **Perma-Power Company** is offering a completely portable, battery-powered, self-contained sound system as the "Roving Rostrum."

Designated Model S110, the unit provides 25 watts of audio power yet weighs only 22 pounds. It is powered by long-lasting flashlight batteries. The system is housed in a single luggage-style case equipped with retractable legs for reading height adjustment.

Included are a low-impedance omnidirectional dynamic microphone and two accompanying speakers; one built with the reading table and one in the cover. The speakers can be used together or separated. A special anti-feedback housing allows high volume without howls.

RE-BROADCAST RECEIVER

24 **McMartin Industries, Inc.** is now in production on the TBM 1500, an FM stereo rebroadcast receiver. The frequency response of the receiver permits an FM station to re-transmit an FM stereo program directly without first demod-



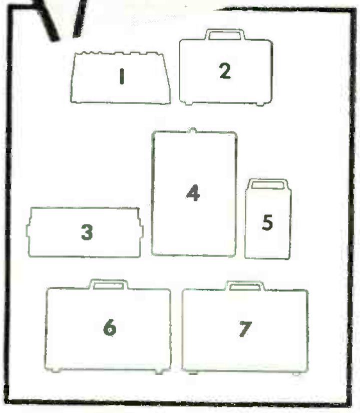
ulating and then regenerating the composite waveform. In this way, the need for an FM stereo generator, stereo receiver, and associated audio equipment is eliminated. The r.f. sensitivity is 1 μv. for 30 db of quieting; output frequency response is 20-100,000 cps ± .5 db.

TRANSISTORIZED INTERCOM

25 **Rauland-Borg Corporation** has recently introduced an all-transistorized intercom-program control center as the Model S300.

Designed specifically as a control center for low-cost school communication and program systems, the unit can also be used for industrial paging and background music system applications.

equip yourself for professional stereo/hi-fi service with HEATHKITS



The test set-up above can be yours for no money down, and as low as $27 per month!

Heathkit, world-leader in kit-form electronics, makes it possible for you to enter the profitable field of Audio and High Fidelity servicing with a minimum investment in test instrument facilities! Equip now with the outstanding selection of service instruments shown above for complete audio and hi-fi servicing . . . all units are professionally designed for years of dependable trouble-free performance, with all the latest design and operational features for maximum versatility and convenience. Best of all, you save up to 50% or more by doing the easy assembly yourself!

Heathkit test equipment is widely acclaimed by service technicians everywhere across the nation for their excellent quality, versatile performance, and conservatively rated specifications . . . features that emphasize their high value and assure you of top service facilities at all times. Order your complete Heathkit service lab now and see why so many technicians have come to rely on Heath for professional quality at lowest cost.

Complete lab above consists of:
1. Heathkit IM-30 Deluxe Transistor Tester, $54.88. **2.** Heathkit IG-72 Audio Generator, $41.95. **3.** Heathkit IM-13 Deluxe Service Bench VTVM, $32.95. **4.** Heathkit IO-12 "Extra-Duty" Wide Band 5" Oscilloscope, $76.95. **5.** Heathkit IM-21 Laboratory AC VTVM, $33.95. **6.** Heathkit IM-22 Audio Analyzer, $56.95. **7.** Heathkit IM-12 Harmonic Distortion Meter, $54.95.

HEATHKIT by Daystrom

SEND FOR FREE 1964 HEATHKIT CATALOG
Gives full description and specifications of units above, plus 245 others in Test, Amateur Radio, Hi-Fi, Marine, Educational and General Hobby fields of interest. Send for your free copy today and get the complete story on money-saving Heathkits.

☐ Please send free 1964 Heathkit catalog.

☐ Enclosed is $________ plus postage.
Please send models________

HEATH COMPANY, Benton Harbor 15, Mich. 49023

NAME________

ADDRESS________

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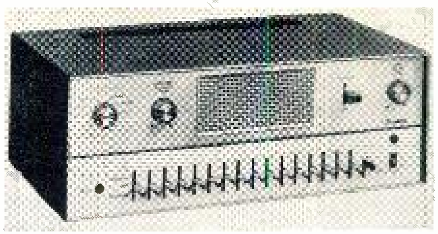
CIRCLE NO. 127 ON READER SERVICE PAGE



The unit provides 32 watts power and features low power consumption, simplified operation, reliable "talk-listen" switch, acoustic noise suppressor circuits, input for 3 low-impedance microphones and 3 high-impedance auxiliaries, plus 16 station selector keys.

A complete line of accessories, including additional switching facilities, voice call-in facilities, an annunciator light facility expander, and an AM-FM tuner, are also available.

EQUIPMENT CABINET

26 **Audio Originals** has a new audio component cabinet on the market which features drawers to house the equipment rather than doors. Two large drawers are provided with mounting board for changer/turntable with the second

drawer adaptable for either record storage or installing a tape recorder. Drawer fronts can be supplied in either cane cloth or matching wood veneers.

Over-all dimensions are 41" long x 30" high x 19½" deep. The enclosure comes in oiled walnut or fruitwood finishes.

DEEP-WATER HYDROPHONE

27 **ACF Electronics Division** has introduced an advanced deep-water hydrophone which features minimum motional noise and maximum underwater acoustic sensitivity.

The Model LM-1 is intended for use in oceanographic research and submarine detection. It provides the following advantages: reduced sensitivity to accelerations; built-in low-noise field-effect-transistorized preamplifier; stability of acoustic sensitivity at high ambient pressures; wide-band transmission transformer for rejection of unwanted common mode interference; pressure housing for operations to depths down to 37,000 feet; and internal power regulators and electrical calibration circuitry.

TURNTABLE/CHANGER

28 **Elpa Marketing Industries, Inc.** is handling distribution of the new **Thorens TD-224** "Masterpiece," a turntable/automatic record changer combination which will play records individually or change records automatically by means of a

unique record feed-in arm. Record stacking is completely eliminated on the turntable.

Also incorporated is the BTD-12S tonearm, a built-in continuous record-cleaning device, and an illuminated stroboscope.

CB-HAM-COMMUNICATIONS

FIXED-STATION ANTENNAS

29 **The Finney Company** is now offering a new line of fixed-station antennas consisting of 11 models. Certain models are gamma matched for 50 ohms, others for 300 ohms. Among the various models are those for 6 meters, 2 meters, and ¼ meter. Some are 6 and 2 meter combinations. A feature of these new antennas is gold corodizing for maximum weather resistance.

R.F. DIP OSCILLATOR

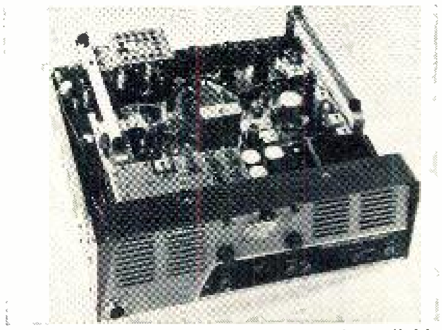
30 **Waters Manufacturing, Inc.** has announced the availability of a completely portable, transistorized r.f. dip oscillator, tradenamed "Little Dipper."

The new instrument performs all the functions of a grid-dip oscillator, an absorption wavemeter, and with its built-in audio modulation, a signal generator for field use. Its compact design permits one-hand operation.

A stabilized MADT transistor r.f. oscillator covers 2-230 mc. Frequency accuracy is ±3%. The circuit uses 7 coils, each carrying its own linear scale.

U.H.F.-FM TWO-WAY RADIO

31 **Communications Company, Inc.** has a new line of u.h.f.-FM 400-420 mc. and 450-470 mc. two-way radio equipment in full production as its "Comco 684" series. The "Ultra Basecom" is housed in a modern low-silhouette cabinet (photo) while the companion "Ultra Fleetcom" mobile units combine with the transmitter to provide high transmitter powers for extended-range operation. The mobile units are compact, lightweight, and combine the control head, speaker, and transistor power supply in one small assembly no larger than a conventional speaker



case. The all-transistor power supply is available for operation from 6/12 volts d.c., 12 volts d.c., or 24 volts d.c. The mobile package for either dash or trunk mounting includes a high-gain rooftop antenna.

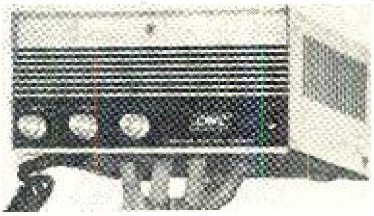
The base and mobile transmitters provide a full 20 to 25 watts output with all stages protected by fixed bias. All stages are metered and the transmitter meets all EIA specifications and FCC requirements for operation in Public Safety, Industrial, Land Transportation, and Citizens class A services.

25-WATT V.H.F. MOBILE

32 **Canadian Marconi Company** has recently introduced a new compact 25-watt v.h.f. mobile radio unit as the DT34.

Claimed to be the smallest and lightest in its class, the unit measures 10½" x 9⅛" x 4½" and weighs 10½ pounds. It is available for either trunk or front mounting.

The transmitter and receiver are mounted on a common chassis. The receiver employs frame-grid tubes for its r.f. amplifiers while the trans-



mitter uses the company's new high-level. wide-angle phase modulator. A full-size transmitting tube is employed as a power amplifier. The unit features fully transistorized power and control circuits, filament voltage regulator. and transistor burn-out protection. Offering up to four r.f. channels. it also has an access socket that permits connection to selective-call or tone-call units and other accessories.

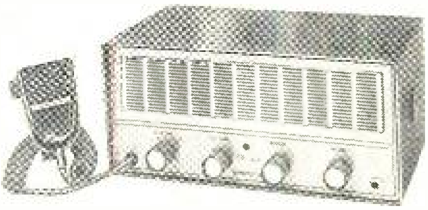
CB BASE-STATION ANTENNA

33 **Hy-Gain Antenna Products Corporation** is now offering a new and improved model of its CLR colinear antenna as the CLR II. This new base-station antenna delivers 8 db of omni-directional gain to double the effective radiated power of the antenna. It develops 3.4 db of omni-directional gain in measured field-strength intensity through utilizing the maximum legal aperture and thus capturing the greatest amount of signal area.

The radiator is 19 feet. 10 inches high and is electrically extended to ⅝ wavelength. Full quarter-wave horizontal radials at the bottom of the unit provide a quarter-wave ground-plane system. A built-in static arrester greatly reduces atmospheric noises and prevents static build-up in the receiver.

HEAVY-DUTY CB UNIT

34 **Hammarlund Manufacturing Company** has designed a new CB transceiver. the CB-Six, for commercial and industrial CB communications. This heavy-duty unit features six crystal-



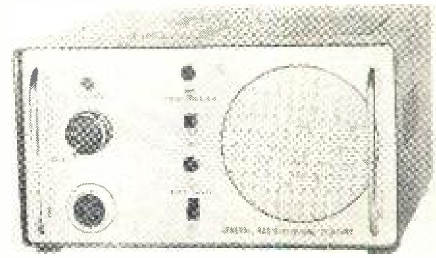
controlled channels for receive and transmit and a built-in power supply which operates from 12 volts d.c. and 117 volts a.c. for both mobile and/or base station use.

A ±3 kc. vernier tuning control for the receiver section permits peak tuning while preserving crystal stability. Complete interchangeability is also featured. Standard equipment includes ceramic microphone. crystal for one channel. a mobile mounting bracket. and both 12- and 117-volt power cables.

BASE/MOBILE STATION

35 **General Radiotelephone Company** is now marketing a new FM combination base or mobile two-way radio for business-industrial applications.

Known as the FM 120. the new unit is a 60-watt input transceiver in the 150-171 mc. band category. The station has a dual power supply



(117 volts a.c. or 12 volts d.c.) which permits the transceiver to be switched from base-station use to mobile applications. The FM 120 measures 4¼" x 8" x 10½" and comes with an exclusive "Snap-Rak" mounting feature which permits replacement and interchange of units in 30 seconds without tools.

CB TRANSCEIVER

36 **Inter-Mark Corp.** is now offering a 1-watt, fully transistorized, portable CB transceiver as the "Cipher 1000."

This single-channel, crystal-controlled unit is powered by twelve "D" cells and uses 15 transistors. It can receive and transmit up to 10 miles

on land and over 20 miles on water. The unit weighs 7 pounds.

The transceiver features press-to-talk switch, "on-off" power switch. squelch and volume controls, earphone and jack. external antenna jack, shoulder strap. and whip antenna. It is housed in an all-metal case with a palm-size microphone.

FM TRANSCEIVER LINE

37 **The Hallicrafters Co.** has entered the FM two-way radio market with a line of units for business and industrial applications.

The first two models in the new line are narrow-band transceivers for mobile and base-station use in the 148-174 mc. frequency range. The units are designed to operate in the Business Radio Service or in any of the other available land-mobile services.

The Models CSB-30-2 (base station) and CSM-30-2 (mobile) use vacuum tubes except that the latter's power supply is transistorized. The base station operates on a.c. and the mobile unit on 12 volts d.c. Both have an r.f. power output of 30 watts.

GENERAL-COVERAGE RECEIVER

38 **Hammarlund Manufacturing Company** is offering a significantly improved version of its HQ-180 amateur-band and general-coverage receiver as the Model HQ-180A.

The new model is continuously tunable from 540 kc. to 30 mc. and features calibrated bandspread on all amateur bands within this range.

New features include increased electrical and mechanical stability; a new silicon rectifier power supply for cooler. more efficient operation: 500 and 3.2-ohm outputs; accessory power supply for converters; and a three-position switch for selecting fixed or tunable b.f.o. The HQ-180A is a triple-conversion receiver from 7.85 to 30 mc. and a dual-conversion unit from 540 kc. to 7.85 mc.

MANUFACTURERS' LITERATURE

PHOTOELECTRIC COMPONENTS

39 **Farmer Electric Products Company** has issued a new 32-page catalogue which describes a complete line of photoelectric and automation components made by the firm. Included are miniature tubular scanners. proximity sensors, miniature scanners. explosion-proof scanners, long-range systems. scanner relay systems. electronic timers. "Rototimers." and electronic relays.

A detailed description is given for each item along with dimensional drawings, photographs, electrical specifications, installation procedures, adjustments, weights, and prices.

P.A. EQUIPMENT CATALOGUE

40 **Harman-Kardon, Inc.'s Commercial Sound Division** is now offering a 20-page catalogue describing amplifiers and systems for industrial applications.

The new publication, designed as a technical "how-to" manual and reference guide for buyers of commercial sound components, shows how to evaluate amplifiers and how to design and use a commercial sound system.

The catalogue carries a sound-system chart to help determine the audio power required for typical applications in restaurants, auditoriums, stores, offices, hospitals, and churches.

ELECTRONICS CATALOGUE

41 **Lafayette Radio Electronics Corporation** has announced publication of its 1964 catalogue, a 122-page listing of items of interest to all in the electronics field.

Included in this illustrated catalogue are kit and assembled units for hi-fi: tuners, amplifiers, preamps, tape recorders, turntables, speakers, and microphones. A wide selection of CB equipment, ham gear, test equipment, tools, p.a. equipment, books, radio & TV components are also pictured and described for maximum ease in ordering.

COLLEGE-SCIENCE FILMS

42 **Bell Telephone Laboratories** has announced the availability of two new college-science films, one in the field of physics and the other in physical chemistry.

The film, "Principles of the Optical Maser" is a 16 mm., sound, color presentation that runs for 30 minutes. It offers the fundamental physical concepts of the optical maser. Dr. C. G. B. Garrett is the narrator. The second film, "Physical Chemistry of Polymers" is a lecture-demonstration by Dr. F. H. Winslow and runs 21 minutes in 16 mm. color and sound.

Both films will be available from local **Bell Telephone** business offices on a free loan basis.

FREQUENCY-CONTROL DATA

43 **Hill Electronics, Inc.** has just published a 44-page handbook and catalogue which lists standardized crystals, filters, and frequency sources. The handbook, with illustrated design parameters, is divided into three major sections covering crystals ranging from 400 cycles to 100 mc., filters ranging in center frequency from below 1 kc. to over 20 mc., and frequency sources ranging from 1 cps to over 250 mc.

MAGNETIC TAPE DATA

44 **Ampex Corporation** has released a 12-page catalogue on magnetic tape for instrumentation applications. The bulletin presents a description of all of the firm's instrumentation tapes with their performance and physical characteristics. A section is included on how to select the proper tape while another section covers instrumentation tape accessories.

TRANSFORMERS & COILS

45 **Stancor Electronics, Inc.** has issued a new 48-page catalogue listing 1500 replacement transformers and coils for television, radio, high-fidelity, and stereo applications.

The catalogue contains complete specifications and additional information to aid the technician in the selection of the proper unit. An output transformer chart lists 260 home-entertainment tubes and the specific transformers to be used with each.

CONNECTOR SELECTOR

46 **Microdot Inc.** is now offering a unique "connector selector" circular sliderule which enables the design engineer to choose from 40 parts in designing his own crimp-type connector. Over 120 combinations of wire size, mating, and mounting styles are available. Also offered are data sheets giving specifications, drawings, and other features of the "Microcrimp" line.

R.F. INSTRUMENT LINE

47 **Ferris Instrument Company** has just published a six-page short-form catalogue which describes in detail the complete line of precision r.f. instruments currently in production. The list carries several recent additions to the line, including crystal-controlled spot-frequency calibrators for CB equipment, ASA-standard radio noise meters, and several new r.f. signal generators for aircraft and mobile communications.

ZENER CROSS-REFERENCE CHART

48 **National Transistor** is offering copies of its new zener diode cross-reference chart, B-106, which lists approximately 300 EIA-registered zener diodes by wattage and zener voltage and gives the company's nearest equivalent type. Standard polarity, tolerance, and physical dimensions are given on zener diodes in the 2, 3½, 10, and 50 watt families.

NEEDLE REFERENCE GUIDE

49 **Sonotone Corporation** has issued a cross-reference brochure which lists over 1400 phonograph models now in use in which the firm's "Sono-Flex" phono needle can be installed. The listing, SAH-71, is presented by manufacturer (or brand name) and model number. Details on this new flexible, virtually unbreakable needle are also included in the guide.

P.A. EQUIPMENT

50 **Bell Public Address** has issued a new catalogue covering its line of public-address equipment and an extensive line of accessories. Pictured and described in minute detail are amplifiers in the 10, 20, 35, 75 watt class; ruggedized 40 and 80 watt units; transistorized units rated

at 30 watts for mobile and fixed use; tape decks; turntables; portable speakers; microphones; speakers; connectors; miscellaneous accessories; and other units comprising a complete system.

SERVO MOTOR CATALOGUE

51 **Vernitron Corporation** has published a four-page brochure carrying detailed data and specifications on the electrical and dynamic performance of its new line of control servo motors.

The catalogue which includes characteristics charts and dimensional line drawings, is a ready-reference for designers of servo amplifiers and automatic control systems.

HOME-STUDY COURSE DETAILS

52 **RCA Institutes, Inc.** has announced a new and advanced method of teaching electronics in home-study courses to be known as "Autotext." The new method involves programmed learning in which each step is carefully coordinated with statements, questions and answers, plus photos, practice lessons, and work kits.

This new program is covered in the school's "Your Career in Electronics," a 66-page catalogue which is available on request.

TOWER LIGHTING EQUIPMENT

53 **Rohn Manufacturing Co.** is offering a four-page catalogue sheet covering its line of lighting equipment for installation on antenna towers and other structures where required.

Pictured and described in detail are the B-1 300 MM code beacon for use on TV, microwave, and transmission line towers; obstruction lights as warning of hazards to aerial navigation; beacon flasher units; and junction boxes. Complete tower lighting kits are also covered.

COMPONENTS CATALOGUE

54 **I.E.H. Manufacturing Co., Inc.** has an 8-page catalogue available designed especially for radio and TV service technicians. Included in the catalogue are CRT brighteners, test instruments, couplers, antenna switches, service extension leads, electronic hardware CRT accessories, and CRT adapters.

PORTABLE INSTRUMENT LINE

55 **Westinghouse Scientific Equipment Dept.** has issued a four-page bulletin which describes a series of a.c. and d.c. portable electrical indicating instruments which feature a taut-band pointer suspension system.

Included in the listing are a.c. and d.c. milliammeters, ammeters and voltmeters, and r.f. (thermocouple-type) ammeters and milliameters.

Please Note: Item 36 appearing in the September issue (page 101) should have included the information that **Knight Electronics Corp.** is a division of **Allied Radio Corporation.** ▲

Answer to Electronic Crosswords

(Appearing on page 83)

A	S	H	■	T	P	A	D	S	■	R	I	G
I	T	E	■	R	A	T	I	O	■	A	N	E
M	A	X	W	E	L	L	B	R	I	D	G	E
■	■	O	R	E	■	■	S	E	M	I	■	■
L	A	D	Y	■	D	U	■	■	P	O	L	E
I	L	E	■	T	E	N	■	I	E	■	A	S
G	A	S	F	I	L	L	E	D	L	A	M	P
H	T	■	A	C	T	I	V	E	■	S	P	Y
T	E	N	D	■	A	T	E	■	M	T	S	■
■	■	E	E	L	■	■	■	D	I	A	■	■
Q	U	A	R	T	Z	C	R	Y	S	T	A	L
S	H	R	■	D	R	A	I	N	■	I	R	E
L	F	■	■	■	■	P	O	E	■	C	G	S

PHOTO CREDITS

Page	Credit
20	Bell Sound System, Inc.
27	Motorola Inc.
36	Burgess Battery Company
40	H. H. Scott, Inc.
42, 43	Blonder-Tongue Laboratories, Inc.
44, 45	Tung-Sol Electric Inc.
53	Hewlett-Packard Company
54 (Fig. 2, left)	The Triplett Electrical Instrument Co.
54 (Fig. 2, right)	Simpson Electric Company
54 (Fig. 4)	Electro Impulse Laboratory, Inc.
55 (Fig. 5)	Continental Electronics & Sound Co., Inc.
55 (Fig. 6)	General Radiotelephone Co.
56	Bird Electronic Corporation
70 (left)	GC Electronics
70 (right)	Sencore
74	Ballantine Laboratories
75	Koss Electronics, Inc.

Answers to "-tron" Teasers

(appearing on page 97)

1. O	7. N	13. B
2. F	8. C	14. M
3. I	9. H	15. K
4. L	10. J	16. G
5. E	11. D	17. Q
6. A	12. P	

ELECTRONICS MARKET PLACE

RATE: 60¢ per word. Minimum 10 words. December issue closes October 5th. Send order and remittance to: ELECTRONICS WORLD, One Park Ave., N. Y. C. 16, N. Y.

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USED Correspondence Courses and Books sold and rented. Money back guarantee. Catalog Free. (Courses Bought.) Lee Mountain, Pisgah, Alabama.

ELECTRONICS! Associate degree—29 months. Technicians, field engineers, specialists in communications, missiles, computers, radar, automation. Start February, September. Valparaiso Technical Institute, Dept. N, Valparaiso, Indiana.

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TRANSISTOR Course—Gain Practical, broad knowledge about transistors: Principles, Construction, Specification, Application. Complete home study course. Individualized instruction. Licensed State of Pennsylvania. Free information. Price School, 2710 Laurel, North Hills, Pa.

DRAFTING Home Course $15.00 (Blueprint Reading, Electronic, Mechanical, Architectural, Art). Prior Inc., 23-09 169 Street, Whitestone 57, New York.

TEST Equipment. Frequency meters, signal generators, scopes. Many other electronic components. Echols Electronics, P.O. Box 5522, Arlington 5, Virginia.

ENGINEERING and Art Degrees earned through home study. Electronics, mechanical, liberal arts, major accounting. When writing specify course desired. Pacific International College of Arts & Sciences, primarily a correspondence school. Resident classes also available. 5719-C Santa Monica Blvd., Hollywood 38, California.

FOR SALE

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Parabolic Reflectors, Picture Catalog 10¢. Meshna, Malden 48, Mass.

INVESTIGATORS, free brochure, latest subminiature electronic listening devices, Ace Electronics, 11500J NW 7th Ave., Miami 50, Florida.

TV Tuners—Rebuilt or Exchanged $9.95 complete—all types—fast, guaranteed service. Send tuner with all parts to: L. A. Tuner Exchange, 4611 West Jefferson Blvd., Los Angeles 16, California.

MILITARY Discount—Name Brands Free Recording Tape and Stereo Handbook. Include Rand and Serial Number. Electronics International, Inc., Box 3066, Charlottesville, Virginia.

Save dollars on radio, TV-tubes, parts at less than manufacturer's cost. 100% guaranteed. No rebrands, pulls. Request Bargain Bulletin. United Radio 1000-W, Newark, N.J.

CANADIANS—Giant Surplus Bargain Packed Catalogs. Electronics, Hi-Fi, Shortwave, Amateur, Citizens Radio. Rush $1.00 (Refunded). ETCO. Dept. Z, 464 McGill, Montreal, Canada.

TRANSISTORIZED Products importers catalog, $1.00. Intercontinental, CPO 1717, Tokyo, Japan.

"LISTEN-in-coil" picks up any telephone conversation in vicinity. No connection to telephone necessary. Easily concealed. $2.98 complete. Consolidated Acoustics, 1302R, Washington St., Hoboken, N.J.

CONVERT any television to sensitive, big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco, Box 10563, Houston 18, Texas

GARAGE Door Openers $60. Radio Controls. Sales. Service. Sefton, 8309 Fenton Street, Silver Spring, Maryland.

CB transmitters $6.00. Other bargains send 10¢ for list. Vanguard 190-48 99th Ave., Hollis 23, N.Y.

GREATEST Buys! Electronic surplus list 10¢ Western Electric Mercury Wetted Relay SPST 5 AMP Contacts, Only $2.95 Postage Paid 2 for $5. ($15. Value) Fertik's, 9th Tioga, Phila. 40, Pennsylvania.

DIAGRAMS for Repairing Radios $1.25, Television $2.50. Diagram Service, Box 1151E, Manchester, Conn.

REVERBERATION Units (Hammond) with transistorized preamplifier $22.95, without preamplifier $19.95 latest type, free details, Harvey Organ Electronics, Box 268, Harvey, Ill.

TUBES

TUBES—TV, Radio, Transmitting And Industrial Types At Sensibly Low Prices. New, Guaranteed, 1st Quality, Top Name Brands Only. Write For Free Catalog or Call WAlker 5-7000, Barry Electronics Corp., 512 Broadway, New York 12N, N. Y.

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FREE Catalog—name brand tubes 65% discount, phono needles 80% or more discount, phono cartridges, picture tubes 75¢ inch, parts, parts kits, silicon and selenium rectifiers, transmitting tubes, 7" T.V. test tube $6.99, imported batteries, tube testers etc. Want to swap or sell tube inventory? Send us your offering. Arcturus Electronics Corp., Dept. Z.D., 502 22nd St., Union City, N.J.

WANTED

CASH Paid! Sell your surplus electronic tubes. Want unused, Clean radio and TV receiving, transmitting special purpose, Magnetrons, Klystrons, broadcast types. Want military and commercial lab/test equipment such as G.R.H.P., AN/UPM prefix. Also want commercial Ham Receivers and Transmitters. For a Fair Deal write: Barry Electronics Corp., 512 Broadway, New York 12, N. Y. (Walker 5-7000).

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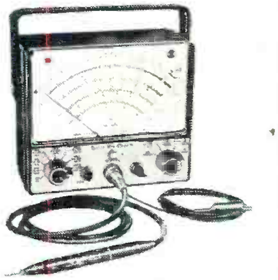

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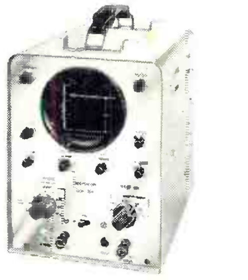

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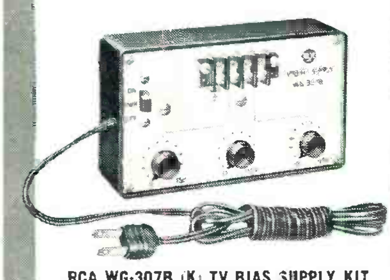

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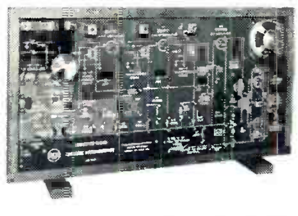

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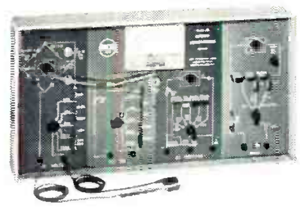

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